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Proceedings

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Contents

Contents

pages

Contents

Preface to the Proceedings 2008

The 2008 International Cotton Conference, Bremen, is the 29th in a series that is one of the primary meeting points for cotton specialists worldwide. Besides the Conference itself, many committees like the CSITC Task Force, the ITMF Committee on Cotton Testing Methods and the CICCA Working Group will meet in this outstanding week for cotton.

The conference is organised in a fruitful co-operation between the Fibre Institute Bremen and the Bremen Cotton Exchange. Our objective is to present the current status of important developments starting with the cotton production and ending in the textile process and markets. Despite the broad range of interesting topics, cotton quality and testing are still the heart of the conference.

One centre of attention of the conference is the sustainable cotton production and processing, covering not only environmental aspects, but with the same importance social and economical aspects. A panel discussion will highlight the different angles of view.

The development in China is of great interest for everybody being involved in cotton and textiles. Thus cotton production, testing and processing in China will be presented as well as research results from this region.

Besides China, reports will be given covering all cotton producing and cotton processing continents of the world, and will give cotton specific views on globalisation.

For cotton testing, the focal point will be the testing itself as well as the indispensable worldwide harmonisation of testing.

The final session will follow the tradition in Bremen to review some of the latest developments in fibre processing, and several of the major machinery builders have again be invited to describe their progress in improving the transformation from cotton to yarn.

We would like to thank all the authors for their work and for delivering their manuscripts for these Conference Proceedings. The written proceedings are worthy of study, as many of the manuscripts contain much more details than can be exposed in the limited time available for oral presentations.

A great deal of hard work has been done by many people behind the scenes. So we would additionally like to express our gratitude to all those who contributed to the overall organisation of the conference.

Axel Drieling
Faserinstitut Bremen e.V.
(Fibre Institute Bremen)

Jan B. Wellmann
Bremer Baumwollbörse
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Lead Author Index

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Session I: Global View on Cotton

- ***The consumer‘s role in ensuring fair working conditions in the textile***
  Tanja Busse
- ***Update on costs of producing cotton in the world***
  Rafiy Chaudhry
- ***Comparative analysis of cotton sector reforms in Africa and their impact on cotton quality***
  Colin Poulton
- ***Experiences with the relocation of textile production to India***
  Werner Braun
- ***Recent developments in cotton production and cotton processing in China***
  John Cheh
- ***The international year of natural fibres***
  Brian Moir

THE CONSUMER'S ROLE IN ENSURING FAIR WORKING CONDITIONS IN THE TEXTILE INDUSTRY

T. BUSSE
Author and Journalist, Hamburg, Germany

Editor's Note

A written paper was not provided by the author prior to the conference.

UPDATE ON COSTS OF PRODUCING COTTON IN THE WORLD

M. R. Chaudhry
Head, Technical Information Section
International Cotton Advisory Committee

The International Cotton Advisory Committee (ICAC) has been studying the cost of cotton production since the early 1980s. Survey is undertaken every three years and government agencies in the ICAC member government countries are the primary sources of information from most countries. Thirty-one countries that planted 30.1 million hectares, 88% of world cotton area in 2006/07, participated in the survey published in October 2007. The data from all countries are for the crop season 2006/07.

WORLD AVERAGE

The average of all countries that participated in the survey showed that farmers spent US$717 to produce one hectare of cotton. This does not include cost of land rent but includes all inputs and operations up to the harvesting of seedcotton. The average cost of producing a kilogram of seedcotton came to US$0.34, which is only one cent higher than the cost in 2003/04.

The addition of ginning, economic and fixed costs determine the total cost per hectare and per kilogram of lint. The gross cost (including land rent and without excluding seed value) per kilogram of lint in the world averaged US$1.64 in 2006/07. The value of seed sold after ginning may be significantly lower or higher than the cost of ginning. Thus, a net cost has been calculated excluding land rent and seed value from the total cost. The net cost of producing lint per hectare came to US$767/ha. The net cost of producing a kilogram of lint averaged US$1.04 compared to US$1.01 in 2003/04 and US$0.83 in 2000/01

COST OF PRODUCTION BY REGION

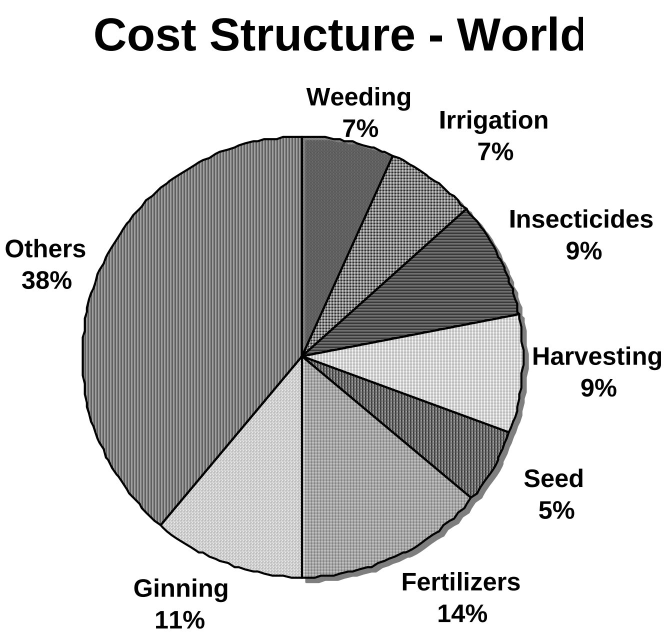
The thirty-one countries participating in the survey were divided into six groups: North America, South America, Asia, Australia, West Africa and other Africa. The most money was spent in Australia to produce and harvest a hectare of cotton. Three West African countries participated in the survey, and on average, farmers spend US$391 to produce a hectare of cotton. The expenses of producing one hectare of seedcotton were close to double West African costs in Asia, almost three times in Australia and 12% higher in other African countries. However, the average cost of production of seedcotton among regions was close, except in Australia, and ranged from 29-36 cents/kg of seedcotton. However, the cost of production of lint varied greatly among regions. It was most expensive to produce a kilogram of lint in North America, followed by West Africa in 2006/07. The cost of production per kilogram of lint was the least in other Africa, US$0.80/kg.

Cost of production of Cotton by Region (US$)

Region	Net Cost/kg Seedcotton (Land rent not included)	Net Cost/kg Lint (Land rent & seed value not included)
North America	0.29	1.43
South America	0.31	1.01
Asia	0.36	0.94
West Africa	0.35	1.32
Other Africa	0.32	0.80
Australia	0.19	1.23

COST STRUCTURE

The four major inputs are planting seed, irrigation water (if cotton is irrigated), insecticides and fertilizers. On average, farmers spent US$69 per hectare to purchase planting seed. The cost of planting seed included seed delinting and treatment with fungicides, if any. The average cost of planting seed came to 9 US cents per kilogram of lint. The cost of irrigation was US$110 per hectare, or 11 cents per kilogram of lint. Insecticides are used in almost every country, and the only exception seems to be Syria. The average cost of insect control was US$101/ha or 14 cents per kilogram of lint. The cost of fertilizers is on the increase, and in 2006/07 averaged 23 cents per kilogram of lint. The cost of weed control operations, which comprised hoeing, inter-culturing and herbicides, was 11 cents/kilogram of lint. The



cost of harvesting averaged 14 cents per kilogram of lint. The cost of ginning came to US$0.11/kilogram of lint. The share of individual inputs/operations in percentage of gross cost under irrigated conditions is given in the chart above. A major portion of ‘others’ comes from land rent, economic costs and fixed costs.

INTER-COUNTRY COMPARISONS

Although there were not many differences among regions, the cost of producing a kilogram of seedcotton varies greatly among countries within regions. The cost of producing a kilogram of seedcotton was as low as 12 cents/kg in Ethiopia and 14 cents/kg in Tanzania and high as 76 cents/kg in Nigeria. The cost of producing a kilogram of seedcotton was over 55 cents/kg in Israel, Mexico (Sonora), Myanmar, Sudan (irrigated Barakat and Acala) and Turkey (GAP, Ege and Akdeniz).

The data from 12 major cotton producing countries representing various regions and production systems indicated that it was most expensive to produce seedcotton in Turkey followed by Syria, 57 cents/kg and 53 cents/kg respectively. It cost 36 cents, 25 cents and 29 cents to produce a kilogram of seedcotton in China (Mainland), India (North) and Pakistan (Punjab), respectively.

The net cost (total cost less land rent and income from seed sold after ginning) of producing a kilogram of lint also showed differences among countries. It was most expensive to produce a kilogram of lint in Bulgaria. The cost of producing a kilogram of lint was over two US$ dollars in Bulgaria and Israel (Pima). The net cost per kilogram of lint in the USA was US$1.42/kg, US$1.52/kg in China (Mainland) and US$1.63 in Turkey (GAP). The net cost/kg was only US$0.67 in Pakistan. Assuming the ginning cost in India equivalent to the cost in Pakistan, the net cost in the North region of India equated to US$0.50/kg of lint. Net cost per kilogram of lint was lower in India due to recent increases in yields. The cost of production data from Kazakhstan, Tajikistan and Uzbekistan showed that the cost of producing a kilogram of lint was the lowest in the Central Asian countries as a region in 2006/07.

COSTS OF INDIVIDUAL INPUTS

Experiments have shown that maximum benefits of a good insect control and optimum fertilizer use can best only be achieved if weeds are properly removed from the field. Weeds can be removed manually, mechanically or chemically through use of herbicides. Biological control of weeds has not progressed very well it is yet not popular in any country. Weed control costs per hectare were the highest in Turkey in 2006/07. Higher cost per hectare on weed control could be due to high weed infestation, high cost of labor/mechanical operations and also high cost of herbicides. In Turkey, herbicides are used on over 90% of the cotton area but cost of weed control is not high due to high cost of herbicides but due to high cost for manual/mechanical weed control. Weed control costs were also comparatively high in Uzbekistan where herbicide use is still not popular. Weeds may not be a serious problem in Kazakhstan as least amount of money was spent on weed control. Herbicides are not used in Kazakhstan.

The world average on insect control costs should be viewed in the light of the fact that 36% of the world cotton area was planted to biotech varieties in 2006/07 and most of the biotech area was under varieties with insect resistant gene/genes. Otherwise also, it seems that the insect pressure is decreasing in most countries. India and Pakistan are the only major cotton growing countries where more recently a new pest has been noticed on cotton. The mealy bug is on increase for the last two seasons in Pakistan and has also been noticed to affect significant area in India. The mealy bug is sucking insect that feeds mostly on branches and main stem. The affected plants remain stunted, and the shoot tips develop a bushy appearance. A mealy bug attack results in retarded growth and late opening of bolls, thus, affecting the yield badly. Countries/governments are encouraging non-chemical control measures, which along with better insecticides is reducing the use of insecticides. Insect control costs are the highest in Australia followed by Turkey and Brazil. Among 11 countries discussed extensively with regard to input costs, least amount of money was spent on insect control in Kazakhstan and Uzbekistan. It is long known that cotton growing countries in the Central Asian region have good biological control system and sever winter also helps them to breakdown the insects lifecycle.

Regarding fertilizers, nitrogen is a must and is always applied to cotton, partly before planting but most of the time before and during flowering. Phosphorous is applied before planting and potassium is not applied in all countries. Fertilizer costs were the highest Brazil, China (Mainland) and Turkey where US$400-450 were spent on fertilizers. Fertilizer costs were lowest in the Northern region of India because of no use/need of potassium in areas where cotton follows wheat and most optimal use of nitrogen fertilizers.

Among major cotton producing countries, irrigation of cotton was most expensive in Turkey and least expensive is Kazakhstan and Uzbekistan. Cost of harvesting was calculated on the basis of per kilogram of seedcotton. It is already known that machine picking is less expensive compared to hand picking. On the average 17 US cents were spent to pick a kilogram of seedcotton in the GAP region of Turkey. Hand picking of cotton in China (Mainland) was as less expensive as machine picking in Brazil. Hand picking is expensive in Egypt but Egypt is not considering moving to machine picking.

The ginning costs included transportation of seedcotton to gin and classing and grading charges. Ginning costs were minimum in China (Mainland) as ginning is subsidized by the government. Ginning costs were equal and the highest in Cameroon and GAP region of Turkey. Otherwise there were lesser differences in ginning costs compared to other inputs and operations.

SEED VALUE AFTER GINNING

Cotton is grown primarily for lint, but seed also has a value. The ICAC survey on cost of production showed that on average a cotton grower makes US$237/ha from selling seed after ginning. A kilogram of seed fetched 18 US cents per kg, which is a good income for the grower. The data by region showed that cotton seed has a higher value in Other Africa and Asia where a kilogram was sold at 22 cents/kg and 20 cents/kg respectively. A kilogram of cotton seed after ginning was sold at 13 cents in North America (average of Mexico and USA) and 10 cents/kg in South America (average of Argentina, Brazil and Colombia). Farmers may not be selling seed directly but they share the benefit if it is sold at a higher price. Cottonseed prices are the lowest in West African countries where a kilogram of seed is sold at 7 cents/kg.

On average, a sample of cotton seed yields 16% oil, 27% hull, 46% cottonseed meal, and 8% linters and there is always some trash, which is estimated at 3%. Cotton seed oil makes about one-fifth of total food oil production in the world. Cotton seed oil ranks second among the five major oil seeds, which are soybean, cotton seed, peanut, sunflower and rape seed oil. In some countries like India and Pakistan where soybean yields are not very high, cotton seed is the main source of vegetable oil. Linters, meal and hull have their own multiple uses. Gossypol contents in the seed are injurious for non-ruminants and have limited the use of cotton seed. Now, biotechnology applications have developed a genotype that has gossypols in all plant parts except seed. The technology is not commercially available yet, but the technology has already been patented. It is a great opportunity for West African countries to enhance the use of cotton seed and secure additional income for cotton growers.

DATA LIMITATIONS

There are a number of caveats that compromise the data on cost of production. The major drawback is that complete data are not available from all countries. There are certain inherent limitations, e.g., seedcotton yield is not estimated in Australia and the USA, inputs may be subsidized, and custom ginning is not available in many countries. Production systems are different and the methods of collecting the data in various countries are not the same. Countries estimate cost of production in local currencies, while ICAC data are compared in US dollars; thus, exchange rates have an impact on cost comparisons. But, ICAC’s survey is the only source of cost of production data in the world and provides the best comparisons.

Comparative Analysis of Cotton Sector Reforms in Africa and their Impact on Cotton Quality

Presented on behalf of Research Team by
Colin Poulton (SOAS, University of London)

Bremen, 3rd April 2008

Outline

1. Introduction
2. Market Context
3. Historical Background
4. Conceptual Framework
5. Comparative Analysis: Core Activities and Service Delivery
6. Comparative Analysis: Performance Outcomes
7. Conclusions: performance by sector type

Objectives of the Study

- Comparative analysis of the lessons from cotton sector reforms implemented in SSA countries during the last 20 years
- 9 countries cases : Tanzania, Uganda, Mozambique, Zimbabwe, Zambia, Mali, Burkina, Benin, Cameroon
- Comparison across WCA and SEA (new)
- Understand
  - How a sector's history and current structure influence the set of feasible reform paths
  - How the path chosen influences the types of challenges a sector might have most difficulty meeting (e.g. quality, productivity, competitive prices to farmers)
- Identify the range of institutional responses that have emerged to meet common challenges under different settings
- Through this, to provide a stronger analytical basis for public and private stakeholders to design their country's reform path

Market Context

- Price Trends
  - Decline of 55 percent between 1960-64 and 1999-2003 in real prices of cotton (similar to other major export commodities)
  - Driven by annual average yield gains of 1.8%, but stagnant per capita demand (competition from man-made fibres).
- Subsidies to OECD producers
  - Full removal could raise world price by 10-15%, but progress slow
- Exchange rate for WCA countries
  - Depreciation 1995-2001, but dramatic appreciation since 2002: in real terms, now back at 1995 levels
- Demand Side: Increasing Importance of Lint Quality
  - Inherent fibre characteristics and hand picking should generate premium
  - Africa not capitalizing on its comparative advantage: contamination!
- Valorization of by-products

Historical Background : WCA Summary

- Single-channel, vertically integrated system in most countries
  - To be credited for strong growth in output during the 1960-2000 period
    - WCA/SSA world market share up from 3 to 15%
  - Also growth in yields until mid-1980s
  - Critical functions secured for small farmers (input credit, extension services, even rural development)
    - Major argument justifying the limited structural reforms so far
  - Recently, new price setting mechanisms to provide flexibility w.r.t world prices, although these still need refinement
- But:
  - Stagnation of yields, innovation, investment : threat to LR competitiveness
  - Currently financially unsustainable (heavy deficits borne by public budget and periodic bailing out of cotton companies)
    - Low world price, CFA/dollar appreciation, high costs, farmer price expectations

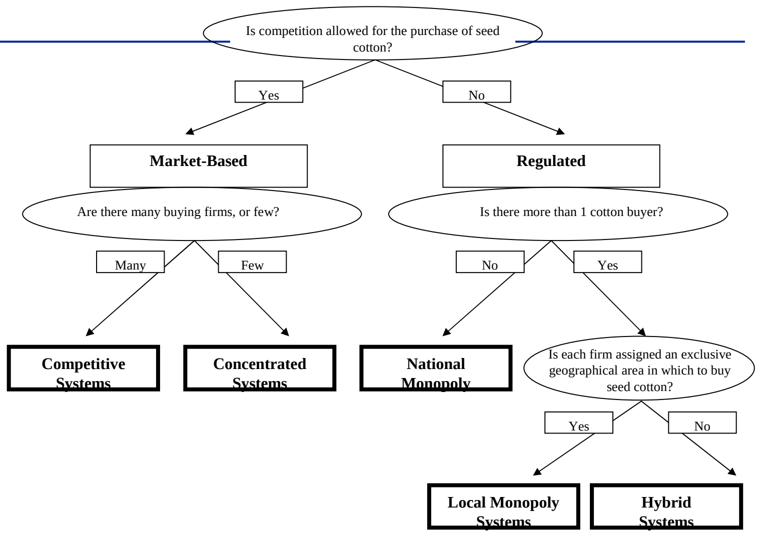
Historical Background : SEA Summary

- Different background, structural reforms of the 1990s, great institutional diversity
- Trade-off between competition & coordination
  - Highly competitive sectors (TZ, UG) struggle with input provision, quality, and productivity
  - Concentrated sectors (ZM, ZB) perform better on all these measures, but at expense of seed cotton pricing?
- Persistent institutional innovation (private and public) in search of effective coordination
- New entry into concentrated sectors (ZM 2001, ZB 2006)

Conceptual Framework

4 steps:

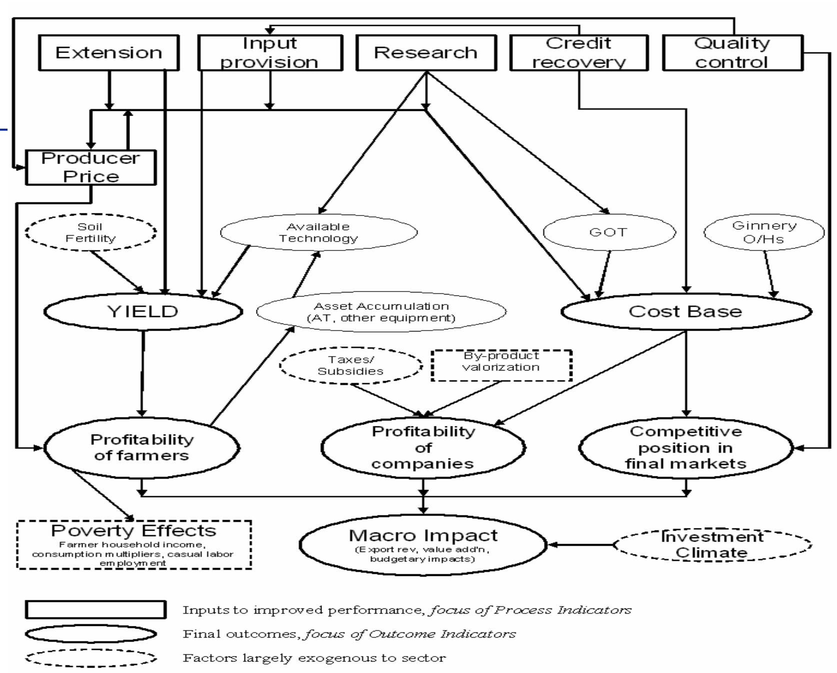
- Typology of Cotton Systems (see Chart on next slide)
  - National Monopoly
  - Local Monopoly (Concession)
  - Concentrated
  - Competitive
  - Hybrid
- Mapping SSA Cotton Sectors (see Chart on following slide)
- Indicators of Performance (see Chart on following slide)
  - Process: Core activities and Service Delivery (prices paid to farmers, input credit delivery, quality, valorization of by-products, research)
  - Outcomes: yields and returns to farmers, value addition, efficiency and competitiveness, macro-impact
- Linking Performance to Sector Types by analyzing sector performance vs the selected indicators



Location of Cotton Sectors within African Cotton Sector Typology

National Monopoly	Local Monopoly ("Concession")	Concentrated, market-based	Competitive	Hybrid
				Benin
Cameroon				
		Zambia Zimbabwe		
			Tanzania	Uganda
	Mozambique Burkina Faso			
Mali Chad* Senegal* (private)				
	Côte d'Ivoire* Ghana*			

* Not included in this study

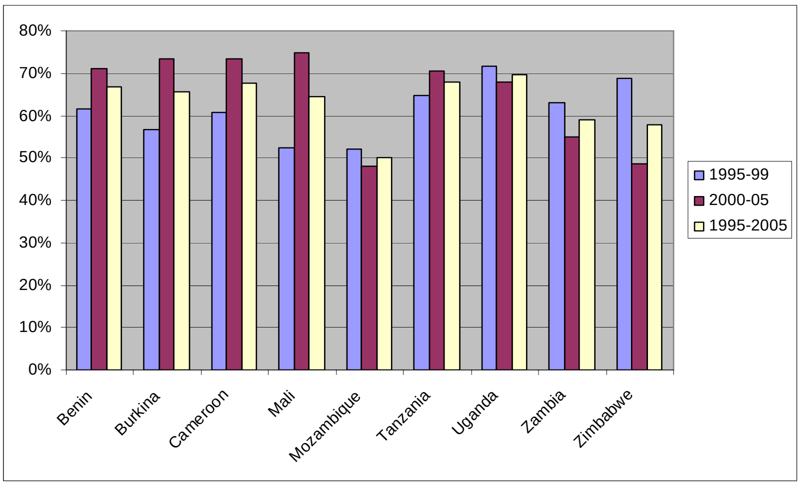


Core Activities and Service Delivery:

Prices to Farmers

- WCA price setting: administered, panseasonal, panterritorial, announced before planting, purchase guaranteed at official price
  - Move in recent years to pricing systems providing more linkage to world price and more flexibility
  - Greater farmer voice in pricing decisions
- SEA (excl MZ, UG post-2003): price leadership or competition
- Indicator: share of FOT price paid to farmers 1995-2005
  - Competitive systems (TZ, UG) best performers (68-70% of FOT)
  - Concentrated: good in post-reform years, but sharp drop since 2000s
  - WCA monopolies: very low in the 1990s, sharp rise in 2000s but in context of sector financial unsustainability

Farmer Share of FOT Lint Price, 1995-2005



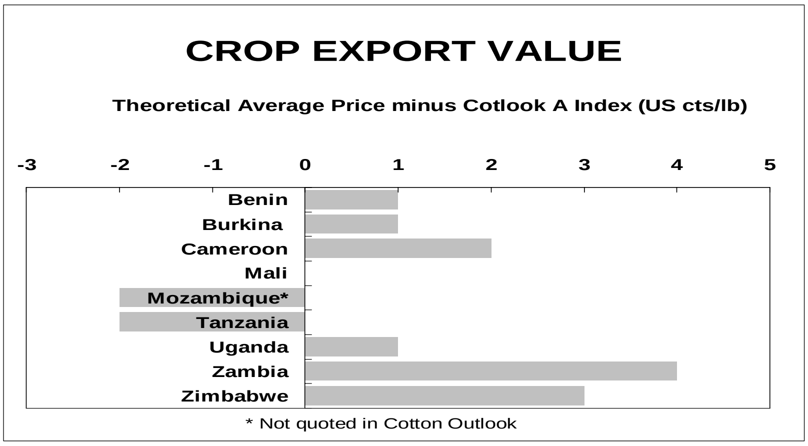
Core Activities and Service Delivery:
Input Credit and Extension Delivery

- Well developed in WCA single-channel systems and has permitted intensification
  - But yield stagnation within these systems since mid-1980s
- To the contrary, highly competitive post-reform structures in TZ and UG led to collapse of input and extension systems
- Concentrated models (ZB, ZM) have performed better, but repayment adversely affected by new entry
- Confirmation of the general hypothesis set forth in the typology:
  - Monopoly and concentrated sectors best able to ensure provision of inputs on credit and also to provide some level of extension advice
  - Provision of these services is undermined by side selling in more competitive sectors

Core Activities and Service Delivery:
Quality

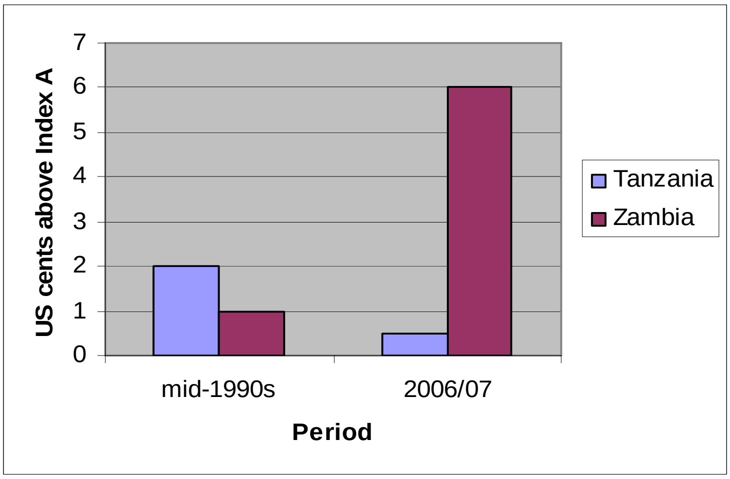
- Estimated average export price differentials across the nine countries relative to the A Index :
  - Improved in Zambia and Cameroon (reduced contamination) and, to a lesser extent, in Burkina Faso and Mozambique
  - Declined in the five other countries
- Predictions from the typology largely confirmed:
  - Best in concentrated, market-based sectors; poor in competitive sectors
  - Variable in national and local monopolies due to factors such as management culture and regulatory effectiveness
- Quality Improvement:
  - Major challenge for all cotton sectors, across types
  - Many sectors not exploiting comparative advantage
  - Potential 10-20% price gain for some sectors through better quality

Estimated Average Premium over A Index (US cents/lb), 2005/06



Source: Gerald Estur quality survey

Change in price premia for top Tanzanian and Zambian lint types, mid-1990s to 2006/07



Source: Gerald Estur quality survey

Core Activities and Service Delivery:

Valorization of by-products

- Value of cottonseed oil and cake : 20 to 25% of the value of lint
- Potentially growing markets with world market demand for vegetable oil and protein on the rise
- Currently domestic markets more profitable (import substitution)
  - Whether country is landlocked or not has big influence on price paid for cotton seed
- Cotton seed prices in Burkina and Mali should be higher
  - Landlocked, high demand for cake from livestock sectors (but also smuggled oils and difficulty of product differentiation)
  - High processing cost (high quality oils)
  - Underdeveloped markets for oil

Core Activities and Service Delivery:

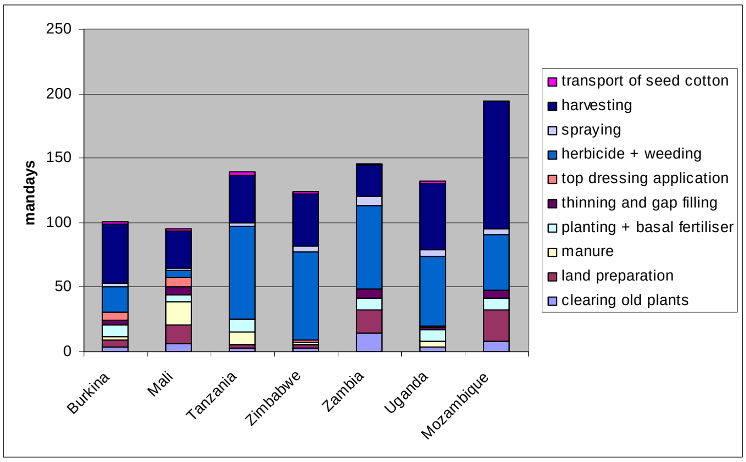
Research

- Critical for Africa's cotton sectors to improve international competitiveness and contribute to poverty reduction
- African sectors seem to be lagging behind many of their major global competitors in this critical area
- Two new technologies potentially interesting for cotton growers in Africa over the near to medium term: (i) genetically modified (Bt) cotton and (ii) low-volume herbicides
- At best, weak linkages with sector types
  - Predicted advantage of concentrated sectors in demanding and/or organizing effective research seen in Zimbabwe (c/w Tanzania)
  - Emphasis on raising GOT in WCA

Outcomes: Yields, Crop Budgets and Returns to Farmers

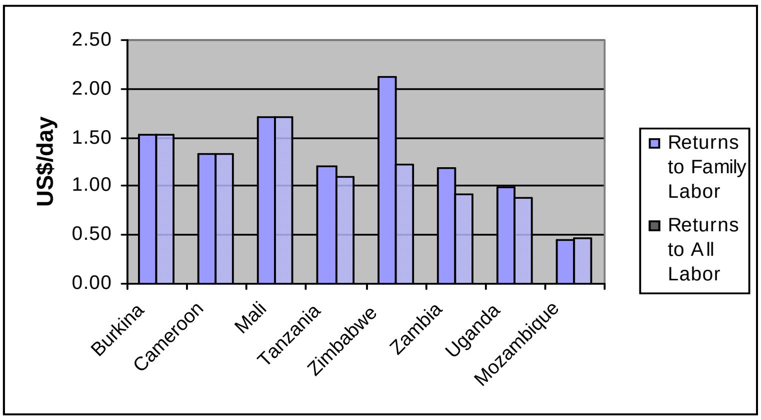
- Results confirm that performance on yield levels is
  - Strongly related to expectations and performance for input provision and extension
  - Heavily influenced by past investments (WCA)
- Yield performance in ESA is correlated with sector organization:
  - More concentrated systems (Zambia and Zimbabwe) achieve higher yields than more competitive models (Tanzania and Uganda)
- Crop budgets:
  - Much higher proportion of cotton producing households found in the higher producing groups in WCA than in ESA
  - Weighted average returns to both family labor and to all labor are higher in WCA than in ESA
  - Between 25% and 75% of cotton producing households (depending on the country) would be better off hiring out their labor than applying it to their own cotton plots

Total Labour Input into Group 1 Farms, mandays per hectare



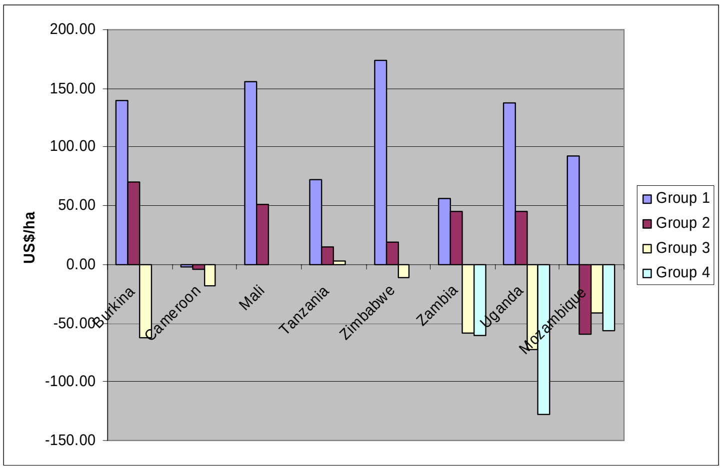
Source: project focus group exercises

Weighted Average Returns to Family Labor and All Labor in Study Countries (US$ / day)



Source: project focus group exercises

Net Margins after all Costs (including Labor), US$/ha



Source: project focus group exercises

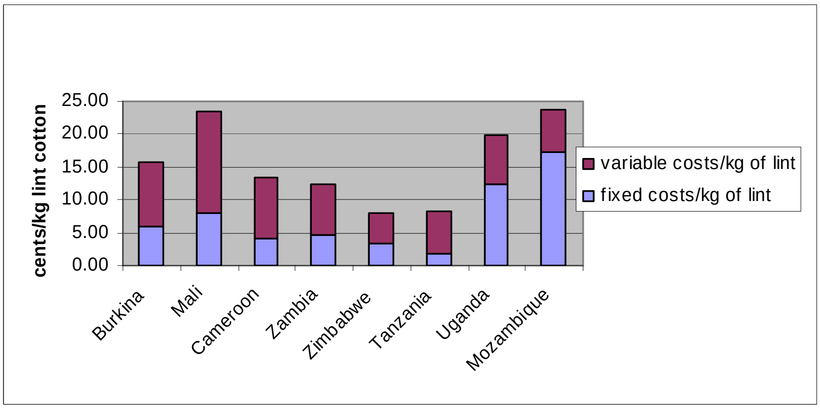
Outcomes: Cost Efficiency, Overall Competitiveness, and Macro Impact

- Ginning costs:
  - Sharply lower in market based systems (Zambia, Zimbabwe, Tanzania) than in monopoly or hybrid systems (WCA, Mozambique, and Uganda).
- Total net cost from farmgate to FOT:
  - Lower in market based systems, be they competitive or concentrated (due to lower ginning costs, lower overhead, lower financial costs, and higher sales value of seeds)
  - WCA monopolies perform especially poorly in terms of company efficiency
- WCA sectors are the least competitive, either barely breaking even (Cameroon) or generating large deficits (Mali and Burkina Faso). All ESA sectors appear to be highly competitive in world markets
- No budget support in ESA, periodic bailouts of CCs in WCA

Outcomes: Cost Efficiency, Overall Competitiveness, and Macro Impact II

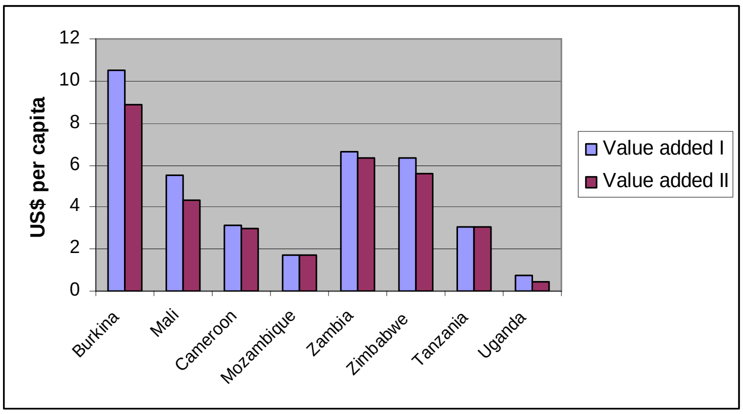
- Higher value added per ha in WCA than ESA
- Farm-level value added per kg of lint as high or higher in ESA than WCA
  - Higher soil fertility
- Higher value added at ginning level in ESA than WCA (low or negative)
- Total value added (farm and ginning levels) per capita of total population reflects size of sector
  - Burkina scores most highly

Estimated Average Ginning Costs at 2006 Capacity Utilization Rates in Study Countries



Source: company accounts (WCA), project interviews (ESA)

Total Value Added per capita by Cotton Sector, 2006/07



Provisional Conclusions: Opportunities and Challenges for African Cotton

- SSA countries could increase revenues and benefits from cotton in the future, but subject to three major challenges:
  - Achieving greater value through improved quality, marketing, and valorization of by-products,
  - Bridging performance and competitiveness gaps through farm-level productivity and ginning efficiency, and
  - Improving the sector's sustainability through institutional development and capacity-building of stakeholders, as well as strengthening of governance structures and management systems.
- These objectives are important, notwithstanding factors that are beyond the direct control of SSA governments and stakeholders: by-products, such as:
  - the evolution of the euro/$ exchange rate, and
  - the slow progress in reducing market distortions due to OECD subsidies

Provisional Conclusions: Lessons from Reform

- The analysis has revealed strengths and weaknesses in various systems, particularly when one looks at them over a long time period.
  - no one model has proven superior to all others in all respects over time, and
  - none of the systems under review offers a fully satisfactory and sustainable response to the challenges of future competition in the world cotton market.
- Clearly "reform" does not imply a movement from one stable set of rules of the game to another stable set.

Provisional Conclusions: Summary of findings for particular sector types

- WCA **national monopoly** model
  - has generated strong returns to very large numbers of farmers,
  - but poor cost efficiency has undermined these sectors' competitiveness
- **Competitive sectors**
  - are cost efficient and pay attractive prices to farmers,
  - but their inability to provide input credit and extension, or to raise quality makes them unlikely to make substantial contributions to poverty reduction
- **Concentrated sectors**
  - have performed well in quality and service delivery (input and extension), have been more efficient than the monopolies, and have also generated attractive value added per capita while making the highest contributions to state budgets,
  - but their performance on seed cotton pricing has been disappointing and they may be inherently unstable .

Provisional Conclusions: Ways forward for particular sector types

- Monopoly systems
  - Cost reduction from farm gate to FOT needs to be a top priority: greater role for private companies to achieve this
  - Price setting rules must continue to be reformed
  - Inter-professional committees and farmer organizations need to continue to be developed, with special emphasis on the operational abilities of the latter
  - Clear rules for evaluating and re-tendering concession areas need to be developed
  - Reforms in research organizations to make them more responsive to inter-professional committees
  - Allow investment in the oil sector to create more competition

Provisional Conclusions: Ways forward for particular sector types II

- Concentrated sectors
  - key challenge is to develop appropriate regulatory regime that understands strengths and weaknesses of the concentrated model
  - Concentrated sectors need barriers to entry: licensing rules that specify capabilities and conduct of firms wishing to participate in the sector
  - given problems of relying entirely on the threat of entry to discipline incumbent firms, develop formalized price setting mechanisms to replace price leadership?

Provisional Conclusions: Ways forward for particular sector types III

- Competitive sectors
  - Key state role in sector coordination, but need to strengthen the accountability of regulatory bodies towards both ginners and farmers
  - Regulatory bodies and/or ginners' associations work with other actors (e.g. local government or donors) to develop long-term programs to enhance soil fertility or promote animal traction

Provisional Conclusions: Final Reflections on Sector Types and Looking Ahead

- Some degree of convergence in the forms of cotton sector organization in Africa likely to happen over the next decade
  - Increase in the number of local monopoly systems in the short/medium term?
- Transition to concentrated systems desirable, if regulatory challenges can be overcome
- More competitive systems are probably part of the long-term future in most countries
  - Need more effective rural financial markets and farmers' organisations first

EXPERIENCES WITH THE RELOCATION OF TEXTILE PRODUCTION TO INDIA

W. Braun
Karl Otto Braun GmbH & Co. KG (KOB), Wolfstein, Germany

The following report is based on experiences Karl Otto Braun GmbH & Co. KG has made when relocating production units to India. The advantages and disadvantages of the Indian location are described as well as experiences made.

Field Report

Who is KOB?

The company KARL OTTO BRAUN GmbH & Co. KG in Wolfstein / Germany is the worldwide leading manufacturer of elastic special medical textiles.

The emphasis in the article range is on elastic bandages of all kinds. For over a hundred years the parent company in Wolfstein approx. processes 50 Mio m² fabrics annually into bandages in the fully vertically integrated textile production unit and these bandages are sold under a Private Label Trade name to all well-known branded companies in the medical sector.

Production facility in India

The tremendously increased stress of competition, initially from East Europe and today mainly from Asia compelled us to relocate parts of our production to a “Low-Cost Location” in order to react to the up to 40 % decreased market prices and to enable us to remain competitive. The position as the worldwide leader in the ancestral business shall thus be retained.

Set-up and development of KOB MT

KOB took the decision in 1997 for the location India. In Coimbatore in the south of India, in midst one of the textile centres of India, the Indian subsidiary company KOB MEDICAL TEXTILES Pvt. Ltd. was founded in 1999 and commenced its production in 2000.

KOB MEDICAL TEXTILES Pvt. Ltd. was founded as a 100% EOU (Export Oriented Unit). The set-up of the production site emerged as so positive, that we were able to exceed the cost targets, in 2003 the break-even was achieved and in 2006 the accumulated starting losses were absorbed. With the existing production costs from India, KOB is today in a position to sustain itself in the world market and to supply their customers at competitive prices.

The largest production quantity from India goes via the head office into the European market. The rest of the world is supplied directly from India.

Since the last 3 years, besides the actual production for the Head office, India has also very successfully developed the Indian Market.

Criteria for India

The deciding criteria for the location India were:

- the economic and political stability
- the reliable legal system
- the good communication in English
- the quality and availability of skilled personnel and management
- the entrepreneurial tradition and
- the development possibilities of the local market.

Negative experiences

Difficulties during the setup emerged mainly due to the sheer nontransparent bureaucracy and the commonly found corruption – to master it a good cultural knowledge and experience must exist.

The poorly developed infrastructure (power supply, water, roads) is not only a problem during the set-up period, but also poses a constant challenge for the running business.

Not to be underestimated is the longwinded and tedious way for the qualification of subcontractors such as manufacturers of packaging material or spinning mills.

The painstakingly and costly established Know-how is lost again partly due the very high fluctuation.

Positive experiences

It was advantageous, that one was able to establish a 100% subsidiary company and did not have to form a Joint Venture Business, which from our point of view is the basic requirement for a successful commitment.

10 years of tax exemption due to the foundation of a 100% EOU, also contributed during the set-up period.

Motivated skilled personnel with textile know-how were available and could be recruited. The set-up of the company went of far more smoothly, faster and effectively as planned, since highly motivated and through the parent company thoroughly trained skilled personnel was present.

Success determining factors of preparation

From the experience thus gained the following success determined factors arise for the success of an Indian engagement:

- To get to know the new location extensive information must be acquired from the various notified bodies like the German-Indian Chamber of Commerce, consultants, banks, but mainly through the personal dialogue with Indian entrepreneurs to obtain the necessary clear picture, which leads to a successful decision.

- To plan and build up at the parent company the steering and support capacities at an early stage, to contact local suppliers and qualify them, to take into account logistic risks and to search for the “right” manager as Managing Director, who pushes on the activities on the spot. One has to turn one’s attention especially on him, then the experience shows, that this position determines either success or failure. A high expertise in personnel management and professional qualification are important, but also the necessity to know the Indian culture and the capacity to think in a western way are deciding factors for success.

- In the parent company one member of the Executive Board must be personally responsible for the location and must be assisted by a team of experts in their support. The concerned persons must be acquainted with the Indian culture to ensure a good understanding. Personal visits to the location are very important and an informative reporting system has to be introduced. We had good experiences with the management of our MD after defining clear targets, whose achievement has an effect on the variable salary earned. The capacity for autonomy is facilitated and the local management is wanted.

- A Board to supervise and guide the MD was installed, which meets 2 to 4 times a year. Besides our own managers, extern managers and entrepreneurs from the Indian cultural group are members of the Board.

Our positive experience in India encourages us to expand the location further. It is intended to double our capacity during the next two years.

Experiences with the relocation of textile production to India

KOB MEDICAL TEXTILES PVT. LTD.

Perumpali, Trichy Road, Palladam – 641 622, Coimbatore Dist., Tamil Nadu, INDIA

Who is KARL OTTO BRAUN GmbH & Co. KG ?

- Worldwide leading private label manufacturer of elastic textile fabrics for the health care sector
- Fully vertically integrated production process
- Sales volume of the KOB group 2007: 81,5 Mio. €
- 734 employees at the German location
- 999 employees at the KOB-group
- 1903 founded at Wolfstein /Palatinate

Production facility in India

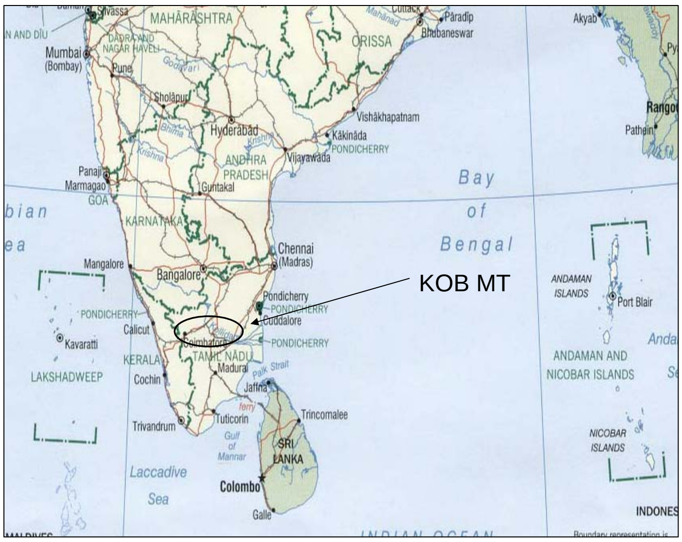
Tremendously increased **stress of competition** from Asia forces **reduction of the manufacturing costs** up to 40 %!

KOB decides to set-up an EOU as a 100 % subsidiary and an independent production location for the supply of the parent company.

Thus KOB is able:

- To **hold the full product range**
- To **grow** in the international market and
  To **regain lost markets**, in order to
- Remain **the leading manufacturer**

Location of the Indian subsidiary KOB MT, Coimbatore /Tamil Nadu



History

1996 Start worldwide search for a longterm suitable location (location criteria, preselection of countries, contacts, prestudies, travels, country profiles)

1997 **Decision** for India; search for a TOP-Management

1998 **Foundation** of KOB Medical Textiles Pvt. Ltd. as an EOU – Export Oriented Unit - and search for an adequate premises

1999 **Start of Construction**

2000 **Start of Production**

2003 **Break even**

2006 Accumulated **starting losses absorbed**!

Criteria for India

Comparing the possible location China or India, India was the winner.

Reasons:

- Economic and political **stability**
- Reliable **legal system**
- Good communication in **English**
- Quality and availability of the **management**
- **Entrepreneurial** tradition
- An almost equal level of costs as in China
- Interesting development of the local market

Negative experiences

- **Bureaucracy**
- **Corruption**
- **Infrastructure** with substantial faults (power supply, water, roads)
- Longwinded and tedious way for **qualification of subcontractors**
- Relatively high **fluctuation** of executives and skilled workers

Positive experiences

- **No JV** necessary, but a 100 % subsidiary company
- **Tax-Holiday** for 10 years, due to EOU
- **Management-Quality and** -Availability
- textile **Know How**
- Management **without expatriates** possible
- Local **market** more interesting than planned
- **Production costs** lower than planned
- **Short-term** achievment of the German **product quality** and **process management**

Success determining factors of preparation

KOB

- Intensive use of all **sources of information**
  - to gather personal experiences on-site
  - to use external consultants conditionally for guidance
- To ascertain in time country-specific **laws, rules and regulations** (authorisation procedure) as well as **fiscal effects** into the plannings
- Necessary internal capacities for **steering and support** to be planned and set up at an early stage (team of experts)

.../2

Success determining factors of preparation

KOB

- **Know how-transfer** by intensive training of the supervisors (top performers) and management

  No relocation of antiquated production technology (product quality and efficiency)
- Logistic costs **to be considered**
- **Supply risks** to be taken into account (safety stocks to be build up)

.../3

Success determining factors of preparation

- In-time search/qualifiying of local **sub-suppliers** (sometimes affects the decision of location)
- **Development of exchange rate** to be simulated
- **To find a local manager** with **high qualification** and relation to the Indian culture

  (Ideal case: Ability to think in a western way and to have know-how of the Indian culture!)

Experiences and recommendations of the operative business

- Crucial to success is the **qualitfication of the MD**
  - leadership quality
  - honesty
  - expert knowledge
  - ability to think in a western way
  - reliability
- Appointment of a **responsable MD** as well as a **team of experts** (technologist, quality management, controlling, planning) at the parent company as assistant and consultant for the subsidiary company
- Periodical personal visits to the location (Boardmeeting)

.../2

Experiences and recommendations of the operative business

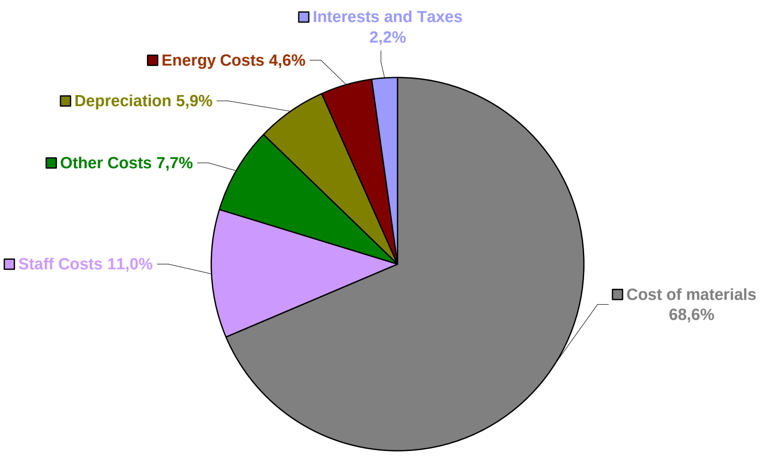
- Founding of a **Board** in order to supervise and guide the MD (Members of the Board: Members of the parent company as well as domestic managers and Indian experienced German managers / entrepreneurs
- Installation of a detailed and informative **reporting system** in order to guide the location
- Guidance of the MD by **targets** (performance-related salary)
- **Autonomy** of the location to be facilitated (local responsibility)
- **Intercultural training** of the staff at the parent company in order to improve the understanding

Investment Capacity Staff

- Manufacturing area: 6.100 m²
- Investment: 3,5 Mio. €
- Capacity p.a.: approx. 40 Mio. bandages
- 167 staff members (per Dec. 2007

  127 workers
  40 employees

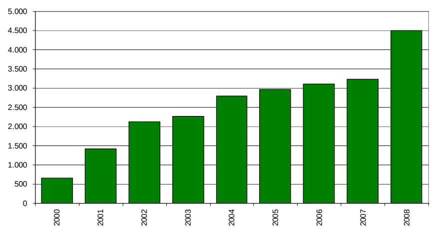
Cost allocation KOB MT - 2007



Development of KOB MT since 2000

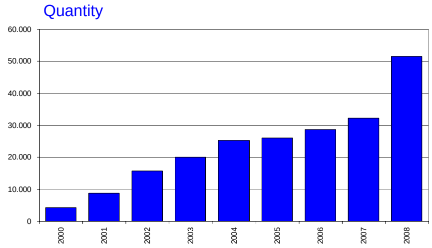
Development of Sales

Value



Sales in Tsd.-Euro

Quantity

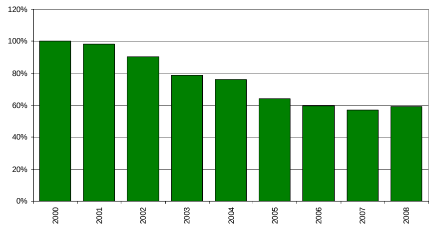


Quantity in Tsd.-pieces

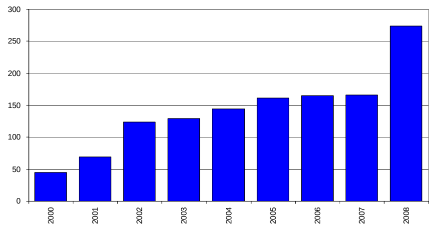
Development of KOB MT since 2000

Development

Intercompany Prices



Employees



Would we once again invest in India?

yes !

KOB MT

RECENT DEVELOPMENTS IN COTTON PRODUCTION AND COTTON PROCESSING IN CHINA

J. CHEH
Esquel Group, Hong Kong, P. R. CHINA

Editor's Note

A written paper was not provided by the author prior to the conference.

THE INTERNATIONAL YEAR OF NATURAL FIBRES

B. Moir

FAO, Rome, Italy

ABSTRACT

2009 has been proclaimed the International Year of Natural Fibres. The Year is to be coordinated by FAO, under the guidance of an international steering committee, but most of the activities will be initiated, planned and funded by individual organizations around the world. FAO seeks funding for its activities of disseminating information and coordinating the Year.

BACKGROUND

The United Nations General Assembly, in December 2006, declared the year 2009 the International Year of Natural Fibres, following a request from the Thirty-third Session of FAO Conference. In doing so, it invited FAO to facilitate the observance of the Year, in collaboration with Governments, regional and international organizations, non-governmental organizations, the private sector and relevant organizations of the United Nations system. [1] So FAO is now charged with the responsibility of coordinating the International Year of Natural Fibres.

Since 1959, the UN has designated International Years to draw attention to major issues and to encourage international action to address concerns.

More than one International Year may be declared in any one calendar year. Some recent examples are:

2009: International Year of Astronomy
International Year of Reconciliation
International Year of Natural Fibres (FAO)

2008: International Year of Sanitation
International Year of the Reef
International Year of the Potato (FAO)
International Year of Languages

2007 International Year of the Dolphin
International Year of Planet Earth (2007 - 2009)

[1] See Annex I for the text of the UN Resolution

2006	International Year of	Deserts and Desertification
2005	International Year of	Sport and Physical Education
	International Year of	Microcredit
	International Year of	Physics
2004	International Year of	Rice (FAO)
2002	International Year of	Mountains (FAO)

NATURAL FIBRES

There is a diverse range of natural fibres produced by farmers throughout the world. Natural fibres may be classified as cellulosic (from plants), protein (from animals), and mineral. Plant fibres may be seed hairs, such as cotton; bast (stem) fibres, such as linen; leaf fibres, such as sisal; and husk fibres, such as coconut. The animal fibres are wool, hair, or fur, or secretions, such as silk. The only important mineral fibre is (or was) asbestos, which because of its health problems is of little economic consequence now, particularly in consumer textiles.

Close to 30 million tonnes of natural fibres are produced annually in the world, of which cotton is dominant with 20 million tonnes, wool and jute each around 2 to 3 million tonnes followed by a number of others.

Most countries produce some natural fibres; for some developing countries natural fibres are of major economic importance, for example, cotton in some west African countries, jute in Bangladesh and sisal in Tanzania. In other cases these fibres are of less significance at the national level but are of major local importance within the country, as in the case of jute in West Bengal (India) and sisal in north-east Brazil. Proceeds from the sale and export of natural fibres often contribute significantly to the income and food security of poor farmers and processors in the least developed countries.

The uses of natural fibres range from high priced apparel to industrial applications and in most if not all of these applications they are subject to competition from synthetic substitutes.

Since the widespread use of synthetic fibres developed from the 1960s, natural fibres have faced increased competition in the market, and in many cases traditional markets have been eroded or have disappeared. Natural fibres thus face the challenge of developing and maintaining markets where they can compete effectively with synthetics. In same cases this has involved defining and promoting market niches; in others, basic R&D is needed to develop new technologies to facilitate the use of natural fibres in new applications where their natural advantages allow them to compete effectively with synthetics.

Natural fibres are generally considered to be more environmentally friendly than synthetics in their production and disposal. However, there are areas where these industries are not as environmentally clean as they might be, for example, in the use of agrochemicals on fibre crops in some countries, and the contamination of water as a result of retting. The International Year of Natural Fibres will emphasise the environmental advantages of these fibres, while seeking at the same time to promote greater realisation of their clean potential.

The world produces around 25 million tonnes of **cotton** annually. China, the United States, Pakistan, India, Uzbekistan, Turkey and Brazil are the major producers, with more than 80 countries recording some production. Global trade in raw cotton amounts to more than 7 million tonnes annually, much of which is imported by processing and manufacturing countries which subsequently re-export it in the form of textiles and clothing. Cotton is used largely for apparel, with some also used in upholstery, curtains, etc, and some in industrial applications.

FAO statistics show that in recent years annual **wool** production has been around 2.2 million tonnes, with production recorded in almost 100 countries. Australia produces around 25 percent of this total, with China, New Zealand, Iran, Argentina, the UK and India each producing more than 50 000 tonnes in 2003. Exports of greasy plus scoured wool amount to around 800 000 tonnes annually and, like cotton, much of this is imported to processing countries for manufacture and subsequent re-export (FAOSTAT). Wool is used largely for apparel, with coarser types used for bedding, for upholstery and for carpets.

Production of **jute** fluctuates from year to year, more perhaps than other fibres, influenced by weather conditions and prices. In the present decade it has ranged from 2.3 to 2.8 million tonnes. Thus the quantity produced generally exceeds that of wool, but in terms of value it ranks far below wool. India produces 60 percent of the world’s jute, with Bangladesh being the other major producer. Other countries, including Myanmar and Nepal, produce much smaller quantities. Kenaf, a fibre very similar to jute, is produced in smaller quantities of around 500 000 tonnes in a number of countries predominantly in Asia. These two fibres have very similar uses, and information on trade and consumption typically combines them. Traditionally jute and kenaf have been used to manufacture packaging materials like hessian, sacking, ropes, twines, carpet backing cloth etc. These applications have been progressively taken over by synthetic materials, and the use of jute and kenaf, in common with other natural fibres in similar markets, has declined. In recent years new technologies have been evolved for the use of jute, as a raw material in the production of high value added and price competitive intermediaries or final products. A host of innovative new products have been developed with high value-addition such as home textiles, composite materials, geo-textiles, paper pulp, technical textiles, chemical products, handicrafts and fashion accessories.

In recent years, production of **sisal, henequen and similar hard fibres** has been around 300 000 tonnes. These fibres are produced from the leaf of the agave and similar species mainly in Africa (Kenya, Tanzania and Madagascar) and Latin America (Brazil, Mexico, China, Haiti, Venezuela, and Cuba). Traditionally these fibres have been used for cordage,

Table 1: Value of global exports of selected natural fibres, 2003.

	Million $ US
Abaca (Manila Hemp), raw fibre + manufactures	**84.31**
of which the Philippines	75.17
Coir, raw fibre and manufactures	**107.02**
of which India	67.08
Sri Lanka	34.74
Cotton, lint	**8 542.2**
of which United States of America	3 453.7
Uzbekistan	705.9
Australia	595.5
Greece	388.8
Egypt	365.9
Flax Fibre+Tow+Waste	**550.9**
Hemp Fibre and Tow	**6.5**
Jute and other Bast Fibres, raw fibre + manufactures	**536.3**
of which Bangladesh	293.0
India	192.5
Ramie	**6.0**
of which China	5.8
Silk fibre	**291.8**
of which China	235.5
Sisal and Other Agaves, fibre + manufactures	**163.1**
of which Brazil	65.7
Kenya	13.4
Tanzania	9.3
Wool	**2 643.2**
of which Australia	1 474.3
TOTAL	**12 931.5**

particularly for baler twine, and for sacking, but more recently, in the face of competition from synthetic materials in these applications, they have been finding markets in a range of uses including carpets, composite materials, and paper pulp.

Table 2: Value of exports of natural fibres from the top 14 fibre-exporting countries, 2003

	Million $ US
United States of America	**3,480**
of which cotton	3,453
Australia	**2,071**
of which wool	1,474
cotton	595
Uzbekistan	**708**
of which cotton	705
New Zealand	**438**
of which wool	438
China, Mainland	**411**
of which silk	238
cotton	134
Greece	**392**
of which cotton	388
Egypt	**385**
of which cotton	365
France	**328**
of which flax	245
Belgium	**273**
of which flax	204
Mali	**229**
of which cotton	229
Brazil	**226**
of which cotton	194
sisal	65
India	**218**
of which cotton	205
Côte d'Ivoire	**178**
of which cotton	177
Turkey	**173**
of which cotton	157

Coir, the fibre from the husk of the coconut, is produced in a great many tropical countries, but reliable data are available only from the few in which coir exports and coir manufactures are of some economic significance. (In many countries, coir is produced in villages on a small scale and does not enter into national statistics).

Thus information from the major exporters (India, Sri Lanka, Thailand, Malaysia, Indonesia and a few others) indicate that annual production of coir has been around 450 000 tonnes annually. Coir is used in upholstery and mattresses, for floor mats and matting, brooms and brushes, and in cordage, but it is also finding use in some newer applications such as geotextiles and in composite materials.

Silk production has amounted to around 135 000 tonnes annually in recent years. As with many other natural fibres, China is the dominant producer with around 70 percent of global production in 2004. Other producers are mainly in Asia countries, such as India, Vietnam and Thailand, along with Turkmenistan and Uzbekistan in Central Asia, as well as Brazil Silk is produced from cocoons of the silk-producing moth, commonly called the "silkworm." The cocoon, formed from an unbroken fibre secreted from the caterpillar's body, is gathered and the fibre unwound. This unwinding or “reeling” of the fibre is, together with other elements of silk production, very labour intensive.

Hemp is a bast fibre similar to flax, kenaf, jute and ramie, used for textiles, cordage and fine paper products. The wood-like core fibre can be used for animal bedding, garden mulch, fuel and an assortment of building materials. Hemp is a distinct variety of the plant species cannabis sativa L. Although both plants are from the species cannabis, hemp contains virtually no tetrahydrocannabinol (THC), the active ingredient in marijuana. Due to the similar leaf shape, hemp is frequently confused with marijuana, and for this reason hemp production is restricted or prohibited in many countries. In 2004 some 85 000 tonnes of hemp fibre were produced globally. China produced almost half of this, with Spain, Korea, the Russian Federation and Chile being other major producers.

Abaca is produced from the leaf stalk of a plant closely related to the banana, and is native to the Philippines. Production totals around 80 000 tonnes annually, of which 70 000 tonnes is produced in the Philippines, with the remainder almost entirely in Ecuador. Only small quantities of abaca are now used in traditional cordage applications, with most being pulped for a range of speciality papers for sausage casings, tea bags, coffee filters, cigarette filters and bank notes.

Some 75 000 tonnes of **flax** fibre (linen) is produced annually, two-thirds in China, with the remainder in a number of European countries. Linen is used for a range of textile products, including clothing and other household textiles.

Other animal fibres include alpaca, cashmere, angora, mohair, and camel, of which a total of perhaps 30 000 tonnes is produced annually.[2]

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[2] Rare animal fibres: Mohair (goat): annual production around 8 000 tonnes, mainly in South Africa, USA and Turkey; Cashmere (goat): 5 000 tonnes annually in China, Mongolia, Iran and Afghanistan; Alpaca: 4 000 tonnes annually from Peru, also Chile and Bolivia; Camel: 2 000 tonnes, mainly from China, Mongolia, Iran and Afghanistan; Angora (rabbit): 8 500 tonnes annually largely in China; Llama: 500 tonnes annually in Peru, Bolivia.

OBJECTIVES OF THE INTERNATIONAL YEAR OF NATURAL FIBRES

The objectives of the IYNF have been proposed as:

- To raise awareness and stimulate demand for natural fibres;
- To encourage appropriate policy responses from governments to the problems faced by natural fibre industries
- To foster an effective and enduring international partnership among the various natural fibres industries;
- To promote the efficiency and sustainability of the natural fibres industries;

In pursuing these objectives, the IYNF will contribute to the Millennium Development Goals (MDGs) number 1 (in attacking poverty and hunger), number 7 (in contributing to environmental sustainability), and number 8 (in promoting the formation of an international partnership).

PLANNING AND ORGANIZATION

The International Year will be in 2009, but planning and coordination activities, which have already begun, need to move forward rapidly through 2008.

The IYNF project is managed under the general overview of an International Steering Committee and by an FAO task force. The major activities to be undertaken by FAO including building a partnership with which to make arrangements, providing communication content and materials, and coordinating activities. Most of the activities within the Year will be arranged and funded by international and national partners, although it is proposed that FAO itself will organise an international conference.

INTERNATIONAL PARTNERSHIPS

There is no single organization or grouping of organizations which covers a range of natural fibres. Rather there are various groups each concerned with an individual natural fibre. Inter-Governmental bodies, such as the International Cotton Advisory Committee and the International Jute Study Group, actively work to support the fibres which they cover. FAO embodies some of the international bodies which are involved in the IYNF, including the Intergovernmental Group on Hard Fibres and the Intergovernmental Group on Jute, Kenaf and Allied Fibres. There are other groups, mainly non-Governmental, with interests in various fibres, such as the International Wool Textile Organisation, which include those representing farmer/producers, as well as traders, processors and textile manufacturers. Consumer groups and retail organizations might also be included. One of the objectives of the proposed exercise is to assist in forming closer links between the various bodies covering the diverse range of fibres. Thus an international partnership has come together to serve as a steering committee for the IYNF. This Committee will provide guidance to FAO through to the end of 2009. It would be hoped that this partnership will endure beyond December 2009 to the continuing benefit of the global natural fibres industries.

FAO'S LEADERSHIP OF THE IYNF

FAO is to coordinate and lead the IYNF, working in close cooperation with an International Steering Committee. FAO's role is primarily be to communicate information about natural fibres and the IYNF, to provide communication content and material to partner organizations and to coordinate activities to be undertaken by international and national fibre organizations.

FAO proposes to undertake the following activities:

- Maintaining contact and liaising with relevant organizations in various countries, provide encouragement, support and coordination to partner organizations conducting IYNF activities.
- Preparing and disseminating information on the IYNF.
- Developing and maintaining the IYNF website, incorporating promotional material, calendar of events, international partnership.
- Official opening ceremony, November/December 2008
- Publication of a book, hold an international conference, on natural fibres.

Total costs for FAO's full-scale coordination activities are estimated at two million US dollars over the 2 year period, although considerable achievements could be realised with somewhat less.

The IYNF will be subject to general guidance of an International Steering Committee, and will be under the technical responsibility of an IYNF Coordination Unit in FAO. FAO has long experience and solid expertise with a range of natural fibres in its Trade and Markets Division, coupled with experience as lead agency of the International Year of Mountains (2002), the International Year of Rice (2004) and more recently the International Year of the Potato (2008).

We expect that all players in the natural fibres industries will benefit from the International Year of Natural Fibres, including particularly the farmers and the exporting countries. Processors, manufacturers and others in the chain will also benefit.

There will be environmental/health benefits in consuming as well as producing countries, from increased awareness / increased use of natural fibres.

FUNDING

FAO is seeking funding for its role in coordinating and providing support to IYNF activities. For International Years in the past FAO received donations of $200,000 to $500,000 from member countries. While a budget of around two million dollars for a thorough effort has been developed, a somewhat smaller amount would nevertheless allow considerable achievements to be made. In the absence of such funding, partner organizations are expected to organise their own events on their individual fibres, but the Year would lack the impact which a better coordinated event might have.

Annex I: United Nations resolution A/RES/61/189

Resolution adopted by the General Assembly

[*on the report of the Second Committee (A/61/420/Add.4)*]

61/189. International Year of Natural Fibres, 2009

The General Assembly,

Noting resolution 3/2005 of the Conference of the Food and Agriculture Organization of the United Nations, adopted on 25 November 2005,[1]

Noting also that the diverse range of natural fibres produced in many countries provides an important source of income for farmers, and thus can play an important role in contributing to food security and in eradicating poverty and hence in contributing to the achievement of the Millennium Development Goals,

1. *Decides* to declare 2009 the International Year of Natural Fibres;

2. *Invites* the Food and Agriculture Organization of the United Nations to facilitate the observance of the Year, in collaboration with Governments, regional and international organizations, non-governmental organizations, the private sector and relevant organizations of the United Nations system, and also invites the Food and Agriculture Organization of the United Nations to keep the General Assembly informed of progress made in this regard;

3. *Calls upon* Governments and relevant regional and international organizations to make voluntary contributions and to lend other forms of support to the Year;

4. *Invites* non-governmental organizations and the private sector to make voluntary contributions to and to support the Year;

5. *Encourages* all Governments, the United Nations system and all other actors to take advantage of the Year in order to increase awareness of the importance of these natural products.

83rd plenary meeting
20 December 2006

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[1] See *Report of the Conference of the Food and Agriculture Organization of the United Nations, Thirtythird Session, Rome, 19-26 November 2005* (C 2005/REP).

FASERINSTITUT FIBRE BREMEN

29th International Cotton Conference

BREMEN

April 2 - 5, 2008

Session II: Cotton Production and Ginning

- ***Ginning cotton for quality: The example of Brazil***
  Jean-Lue Chanselme
  João Luiz Pessa
- ***Experiences of Bt cotton cultivation in India***
  Charudatta Mayee
- ***Alleviating cotton stickiness - experiences and future research topics***
  Gary Gamble
- ***The market for Australian long staple upland cotton***
  Marinus van der Sluijs
- ***Development in good agricultural practices for cotton in Brazil***
  Andrew Macdonald

GINNING COTTON FOR QUALITY: THE EXAMPLE OF BRAZIL

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ABSTRACT

Cotton fibre production in Brazil is increasing regularly and is expected to reach 1.6 million tons in 2007/2008. With an export share of around 30% Brazil is taking a stronger position on the international market, selling mainly to the Far East and Pakistan, where the textile industry invests a lot in modern technology.

Brazilian cotton does have good intrinsic quality, but in order to conquer new markets and attract better prices, the grade has to be improved. Ginning has a major role to play in the production of better colour and leaf grades.

Old equiment with inappropriate sequences, and insufficient technical management and skills are the main limitations of the Brazilian ginning industry today.

Producers' associations, cooperatives and local manufacturers recently deployed significant efforts to help the Brazilan ginner to produce the quality required by the export market at a lower cost.

Research and support projects are funded in the main cotton states. A standard machinery sequence has been identified, which makes it possible to combine limited investments with improvement of one colour grade and one and a half leaf grade, without creating significantly more short fibers, and with a limited increase in neps content.

Brazilian manufacturers improved their standard machinery sequence acordingly. Ginners get individual recommendations about machinery sequence design, operation, settings and maintenance. Future training projects are being prepared.

At the UNICOTTON cooperative, gins run with an ISO 9000 certification, and the Bahia State created the "Pure Brazilian Cotton" label based on the whole production process certification. Similar initiatives are now spreading through the whole country.

INTRODUCTION

Brazil has experienced a huge increase in cotton production and export over a number of years. Although the domestic market remains significant, with a consumption of 70 % of the total fibre produced, the export market has also been high over several years, with a majority of the fibre being sold to regions where textile industries use modern technology. (Far East in particular).

In developing its export market, Brazil had to adapt the quality of its cotton fibre to match the quality requirements on the international market, thus enabling it to compete with traditional exporters (EUA, Africa, etc.).
Improvements in production practices and the shift to instrument classing were instrumental in marketing better quality Brazilian cotton.
Ginning is a critical operation for fibre quality. In all the cotton producing states of the country, producers' organisations and individual producers and ginners are working towards improving ginning equipment and practices.

CHARACTERISTICS OF FIBRE PRODUCTION IN BRAZIL

PRODUCTION STATISTICS

Starting from the 1996/97 growing season, cotton production in Brazil increased tremendously, from 0.31 up to 1.5 million metric tons (MT) of fibre, with the development of the planting area in the "cerrado" regions and the use of intensive cultivation practices. The most recent estimate for production during the 2007/08 season is 1.6 million MT of fibre (Figure 1).

Brazil started to export a part of its production once again during the 1999/2000 season, and exports represented 30 % of the total production in 2005 and 2006. Export share depends on relative prices on the domestic and export markets, but Brazil definitely wants to ensure a strong presence on the international market, with a good reputation for quality and reliability.

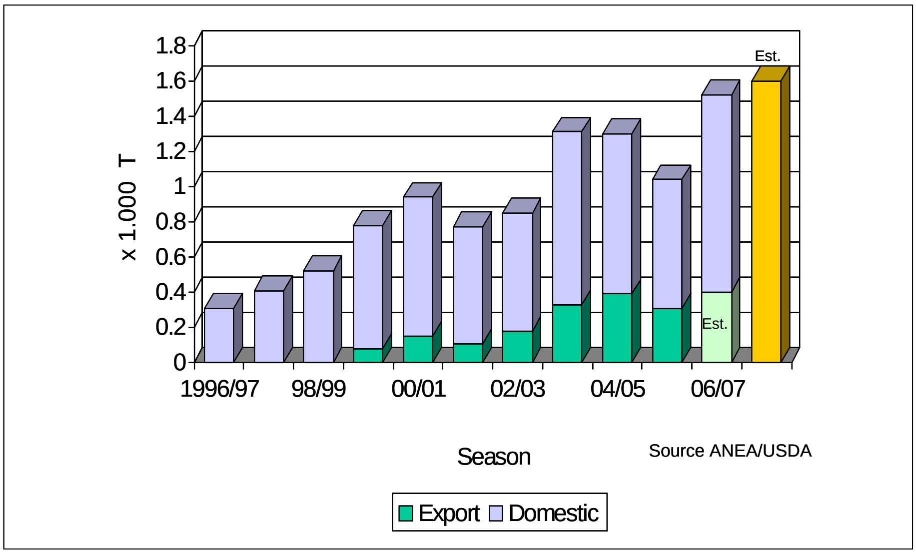

Figure 1: Trends in Brazilian fibre production and export

More than 70 % of exports in 2006 and 2007 went to the Far East and Pakistan (Figure 2), where the textile industry continues to invest in modern spinning equipment, thus increasing the demand for better fibre, mainly in terms of homogeneity, intrinsic parameters, cleanliness and neps content. More and more, the intrinsic characteristics determined by instrument classing are required.

Contaminants are the number 1 problem for spinners. Although modern spinning processes use devices to eliminate contamination, only contamination-free cotton allows the mills to run at the highest levels of productivity which is so essential for success in today's competitive textile world.

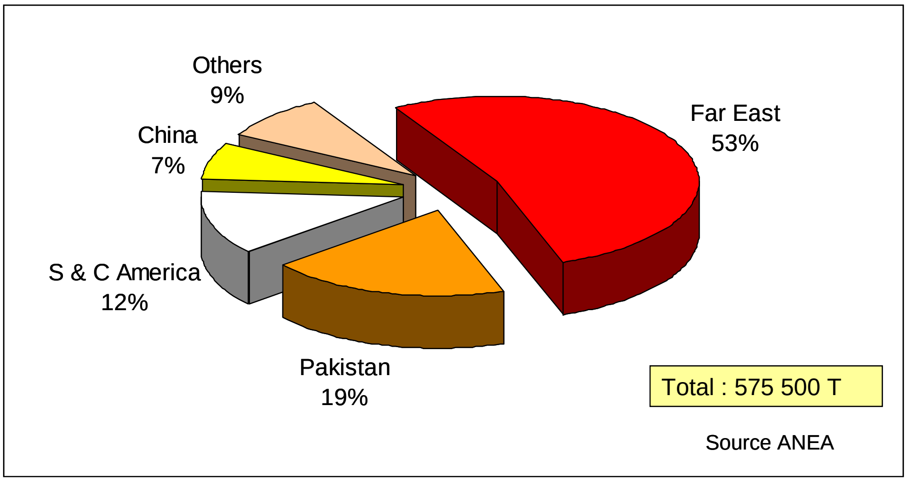

Figure 2: Destination of Brazilian fibre exports Jan. 2006 – Oct. 2007

The producer's profit is partially dependent on the fibre quality, which itself is highly affected by the cultivation practices such as variety and seed quality, fertilisation and crop protection, harvest preparation and harvest.

Brazilian fibre production shows some very interesting characteristics in length (1"1/8 and above, strength (28 g/tex and above), and micronaire. Those characteristics do contribute to the price for cotton from EUA, Australia, Africa and others. This is not always the case for the Brazilian cotton. Brazilian cotton must be promoted in order to obtain premiums for its intrinsic qualities.

QUALITY OBJECTIVES AND STRATEGIES

Contamination of cotton fibre is a recurrent and increasing problem in many growths, and the ITMF Cotton Contamination Survey (ITMF, 2005) overall average contamination rate (16 contaminants) shows a trend over the 10 past years (Figure 3).

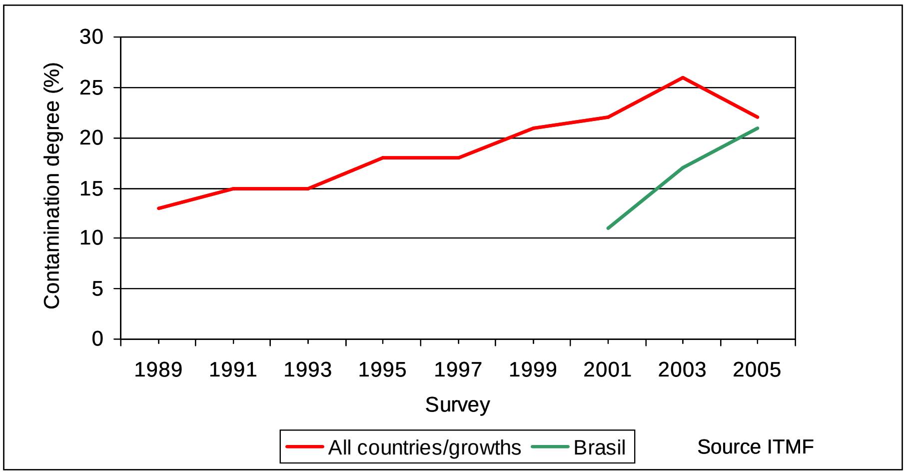

Figure 3: Cotton contamination all countries/all growths vs. Brazil

The export market demands quality and is highly competitive, with an abundant supply of cotton that combines good grades and high level intrinsic characteristics. The Brazilian fibre has the requisite intrinsic characteristics to enable it to be present on this market. However, for the time being, the image of this cotton is often adversely affected by its grade (Marquie *et al.* 2004). In particular, it is often contaminated by foreign matter of various origins. 90% of exported Brazilian cotton is of medium grades (31-4 and 41-4), whereas 90% of cotton exported from other origins is of superior grades (31-3 and better) (Fiedler, 2007). This explains why Chinese imports of Brazilian cotton remain very low, between 5 and 7%.

On average, for the 2003 and 2005 ITMF survey results, and compared to the share of contaminants for all countries and origins, Brazilian cotton is mainly contaminated by organic matter (leaves, bark, seed fragments and other plant fragments), sand and/or dust, and cotton fabrics and strings. Plastic, jute, inorganic and chemical contaminants are less than the average for all origins. (Figure 4)

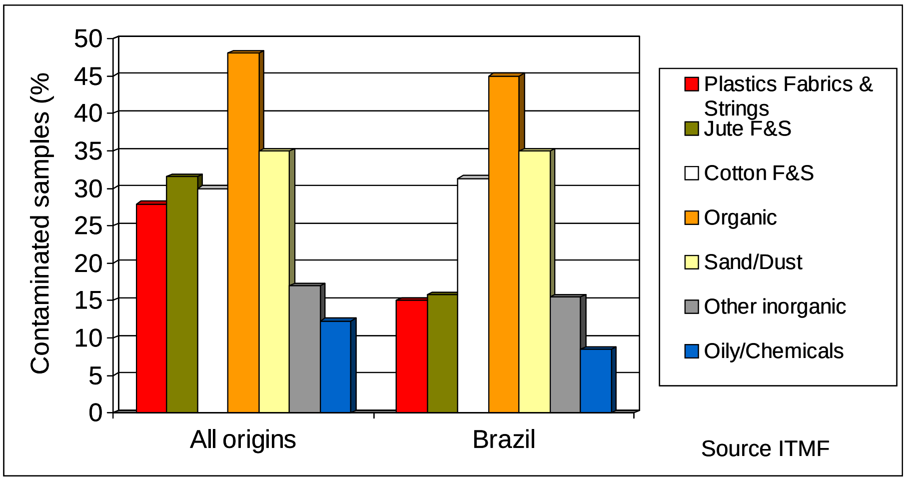

Figure 4: Main contaminants of cotton (avg. 2003 and 2005)

According to spinners, contamination by seed coat fragments (SCF) is also high, ranging over the 10 last years between 30 to 45 % in average for all origins. SCF contamination in Brazil cotton was presented by ITMF as between 33 and 50 % in the last 4 surveys (Figure 5).

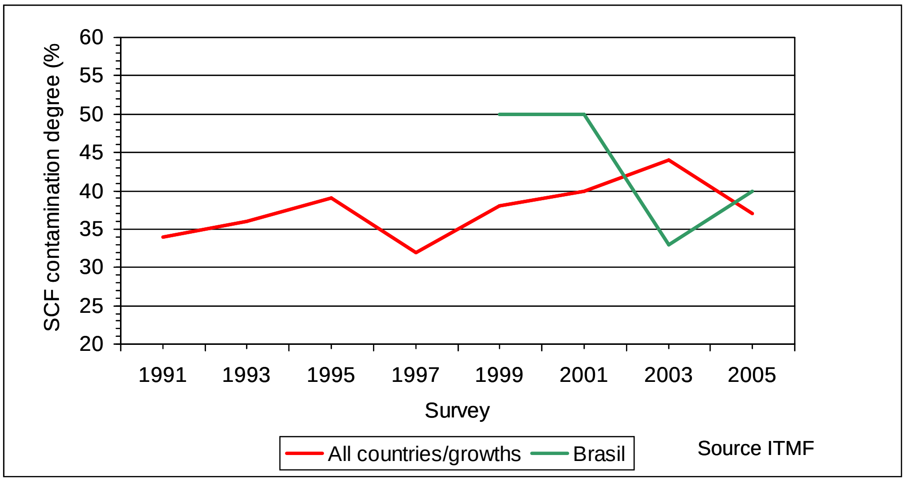

Figure 5: Seed coat fragments all countries/all growths vs. Brazilian cotton

Even though Brazilian cotton seems to have a lower than average overall rate of contamination, it can only gain new market shares and attract better prices by improving its grade. This, in turn, depends on the producers (mainly at harvest) and on ginners. The set of cultivation and industrial practices must evolve to improve the components of grade, while at the same time preserving the intrinsic characteristics.

COTTON GINNING AND QUALITY

Ginning is the operation which separates the fibre from the cotton seed. This is the first step of processing, which is essential for adding value to the crop.
By using rational practices in association with modern equipment, it becomes possible to combine profit, high rates and quality preservation. With the right ginning process, the seed is separated at reduced cost, thus giving greater value to quality potential of the seed cotton produced by the farmer.

INFLUENCE OF GINNING ON FIBRE QUALITY

Fibre quality potential is at its maximum when the boll opens. It undergoes different forms of deterioration before harvest and at the time of harvest. Ginning improves some fibre characteristics, while negatively affecting others, and as such has a very important effect on quality. The ginner plays a very important role in the quality of the fibre production.

Many fibre characteristics of commercial importance are influenced by ginning:

- Length parameters : mechanical constraints create fibre breakages, decreasing commercial length and uniformity, and increasing the short fibre content.
- Strength : ginning can affect strength by modifying the molecular structure of cellulose (excessive drying and heat).
- Contaminants : ginning eliminates a part of the vegetal and mineral contaminants, but can generate others (oils, grease) in case of poor maintenance.
- Preparation : ginning can create or increase preparation at different levels of the process, in case of aggressive treatment (excessive ginning rate, poorly maintained machinery) or too high fibre moisture.
- Neps : Fibre neps are generated by mechanical manipulations of the fibre during ginning (essentially at the gin stand and lint-cleaner). A poor harvest will increase neps in the ginned fibre. Seed coat neps (seed coat fragments) are generated in the gin stand, in particular in conditions of poor maintenance or too dry seeds.

The ginning process must be adapted to the local conditions of production that determine the characteristics of the raw material (seed cotton and fibre), and to the market requirements. So the climate, cultivation practices, species and variety are all major elements in decision-making for the design of a ginning process.

The use of available equipment must be managed according to the characteristics of the seed cotton to be ginned (intrinsic fibre quality, moisture content, contaminants) and according to the environmental conditions at the time (relative humidity, for example). To do this, the ginner must be trained and experienced, and the process must include automation and by-pass devices, so that temporarily unnecessary machines can be by-passed.

In order to make the best of the raw material, the ginner must have equipment that includes recent technological innovations, ensure that they receive a thoroughly and regularly maintenance, and are operated by skilled and trained operators.

HARVEST AND GINNING

The harvest determines the preservation of the seed cotton production available in the field and its quality. Harvest has a heavy impact on ginning and, contrary to general belief, ginning cannot totally compensate the defects of a shoddy harvest. A harvest that is poorly prepared or carried out always has negative consequences for ginning cost and on fibre quality as well (grade and intrinsic characteristics).

COTTON GINNING FOR QUALITY IN BRAZIL

THE LIMITS OF GINNING

In Brazil, old design gins are in the majority throughout the producing area (on average 85 % of the almost 260 plants). The fibre quality produced in old gins is in general more adapted to the domestic market than to the export one, with a majority of 41-4 grades showing preparation, bark and high leaf content (figure 6).

Figure 6: Cotton bale sample showing preparation, bark and other contaminants

Old gins are not adapted to the export quality objectives because they face numerous limits:

- Machinery sequences originally designed for hand picked cotton with only one stage of seed cotton drying and pre-cleaning.
- Seed-cotton moisture restoration before entering the gin is very rare.
- Lint-cleaners are undersized.
- Automation is very limited and only in exceptional cases is it possible to adjust the process according to the seed-cotton characteristics and commercial objectives.
- Ginning rates are inadequately controlled due to excessive down-times.
- Machinery wear makes it difficult to conform to settings and renders maintenance difficult.

Modern, high capacity gin plants are manufactured in the US or Brazil. Since 2000, 40 brand new plants have been constructed. Their process is technologically much advanced, with a machinery sequence that is better adapted to mechanical harvesting (moisture control, seed cotton and fibre cleaning). Modern gins are largely automated and require much less manpower.

Both old and modern gins have a common problem with managers and operators who have not been technically trained as ginning specialists, but who must be able to assess the raw material and make technical decisions accordingly. Many decisions about machinery arrangement or operating are taken empirically.

EFFORTS TO IMPROVE GINNING IN BRAZIL
Projects of the producers' association

Producers associations of the cotton states are federated in the Brazilian Association of Cotton Producers (ABRAPA). Funds provided by these producers are used for research and development. With the increase in production and export, the producers' associations, starting with AMPA no Mato Grosso State, joined by ABAPA in Bahia State and AGOPA in Goias began to finance projects and activities aimed at improving ginning, on the basis of the following principles:

- Improvement of ginning has to be done with the objective of allowing the producer to obtain the best economic result, namely to produce the fibre quality that gives the best profit margin. The ginner has to have the means to produce the quality paid by the market, at the lower production cost (Chanselme, 2006).

- At the present time, remuneration is mainly based on the grade. The strategy of improving ginning has to focus mainly on the grade for the time being (colour, foreign matter, preparation), but not to the detriment of other fibre characteristics whose value will have to be enhanced in the future, and without significantly increasing the nep content.

2 types of projects have been conducted since 2004:

- Research type projects, using pilot plants with the objective of improving ginning sequences and technology ;
- Auditing and assistance projects, based on detailed diagnoses of machinery and operation in various plants in the cotton producing area.

The project "Improvement of ginning in the old plants of Mato Grosso" was aimed at identifying a standard machinery sequence adapted to the Brazilian cottons, and able to produce an export market quality (in particular grades 31-3 or better). Results showed that limited improvements (in moisture control, seed-cotton and fibre cleaning) provide a reduction of trash in number and size, while improving the relectance, with a reasonable neps content increase (+16 %), and very low increase of short fibres (Table I). Cotton colour improved by one grade, and leaf by one and a half grades at visual classing (figure 7). The project showed the need to characterise seed cotton in order to optimize ginning operations, to train the classers, and standardise visual classing (Chanselme, Ribas and Bachelier, 2007).
The 2 main Brazilian manufacturers of ginning equipment improved their standard machinery sequence according to the results of the project.

Table I: Effect of improved ginning sequence on HVI and AFIS parameters (101 bales, FMX 966)

Characteristic	Old standard sequence	Improved sequence
Trashes (number)	4.2 a	3.6 b
Trashes (area)	0.6 a	0.5 b
UHML (in.)	1.13 a	1.12 b
SFC (w)	6.9 b	7.2 a
Rd (%)	74.0 b	76.1 a
+ b	8.8 b	9.1 a
AFIS fiber neps (cnt/gr)	370 b	412 a

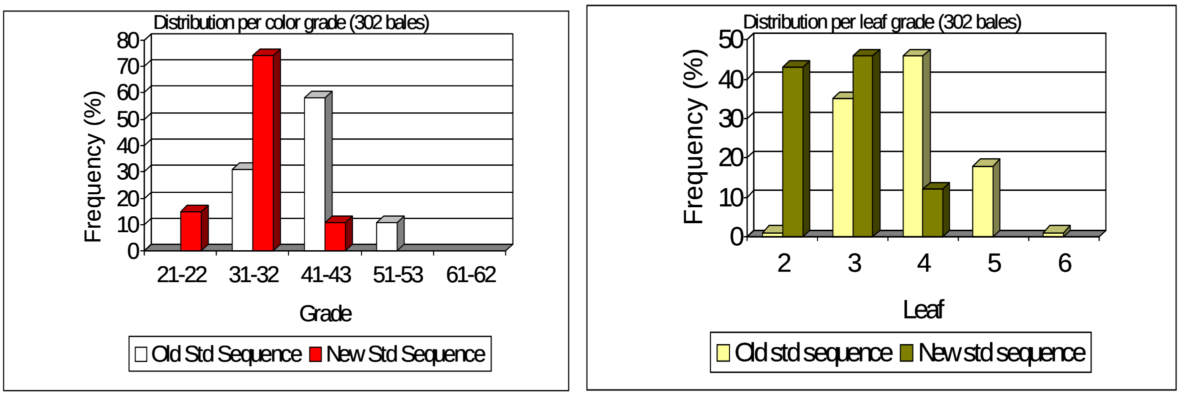

Figure 7: Effect of improved ginning sequence on visual grade (302 bales, FMX 966)

The projects on gin expertise and support in Mato Grosso, Bahia and Goias (36 plants) sought to assess the reality of ginning and its requirements, to improve the plants visited through short and medium term recommendations, and to disseminate the results of other projects. They made it possible to identify the limits of ginning in the regions, and to make recommendations for improvement for each plant about machinery sequence design, operation, settings, and maintenance, in order to be able to process any type of cotton, and produce fibre qualities required by the domestic and foreign customers. Results of those assistance projects were widely disseminated.

Future projects are being prepared:

- Gin managers and operators training by taking advantage of results of existing projects and of existing courses.
- Setting up of an integrated management system for harvesting and ginning in favour of quality and profit.

Certification programmes

UNICOTTON, a cooperative of producers based in Primavera do Leste, Mato Grosso, runs an ISO 9001 certification program, in which 7 ginning plants are involved.
The state of Bahia is involved in a total quality programme with quality labels. The "Pure Brazil Cotton" label of West Bahia is the first initiative for certifying the whole cotton production system, including ginning. Gins are involved as key operators for quality.

Ginning equipment manufacturers

The local ginning equipment manufacturers constantly improve the technology available for ginners by proposing new machines, more adapted sequences, and process automation. The BUSA Company recently inaugurated its R&D and training facility in West Bahia.

CONCLUSION

Brazilian cotton is intrinsically of high quality. Its international market share (5 to 6%) and the requirements of its main consumers show that the existing production process continues to offer good quality cotton to the market, in spite of the sharp increase in the total amount of fibre produced over the last 10 years.

Producers' and professional associations nevertheless continue to work on quality improvement, including at the ginning level, with the objective of matching the textile industry demand for a better fibre mainly in terms of cleanliness, homogeneity, short fibres, and neps content. Ginning in Brazil is improving and the search for quality is significant in terms of investment in old design process upgrading as well as in new modern ginning plants. There is also investment in research, technical auditing and support programmes, gins certification, quality label development and equipment manufacturing.

The results of some ginning research and support projects are already available to producers and ginners. By adopting them, they can vastly improve the quality of Brazilian fibre and contribute significantly to opening new markets.

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EXPERIENCES OF BT COTTON CULTIVATION IN INDIA

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ABSTRACT

Cotton is the most important commercial crop in India. It is cultivated on 9.0 m ha by more than 4.0 m small and marginal farmers. Indian textile industry is predominantly cotton-based. In recent years the cotton economy has been accelerating at a much faster pace on all criteria, viz., production, consumption, yield and export. This turn around storey is basically related to dramatic increases in yield (productivity) and production. Amongst a few factors in bringing this revolution in India, the biotech cotton referred by Bt cotton because of incorporation of Bt gene into cotton that successfully managed the key damaging pests; bolloworm, is considered a major one. Government of India permitted the commercial use of Bt cotton for farmers in April 2002 after a series of biosafety, environmental safety and bioefficacy trials for four years. The average production of Indian cotton was stagnant at 13m bales of 170 kg each with productivity of less than 300 kg lint per ha resulting into constant import for the textile industry for the last decade. In 2002, Bt cotton was planted by farmers in around 30,000 ha. The technology acceptability was so high that between 2002 to 2007, the Bt cotton acreage increased from 29,307 ha to 63,00,000 ha (that accounts for 66 per cent of total area). Bt cotton not only efficiently controlled the bollworms but reduced the pesticide use by 50 per cent and enhanced the yield from 300 kg lint per ha in 2001 to 554 kg lint per ha in 2007. The crop output has surpassed all the expectations and target projection and thus increased the export of raw cotton from 0.1 m to 6.5 m bales of 170 kg each within last six years. Imports were restricted to 0.5 m bales principally of extra long staple cottons. Bt cotton cultivation has also improved the quality as reported by ITMF survey 2005. Although criticism of the technology continues, farmers who are the primary beneficiary of Bt cotton have accepted the technology. To sustain it longer, scientists have to watch the emerging problems. The benefits of growing Bt cotton have raised hopes of commercialization of biotechnology for not only other traits like drought, disease, herbicide resistance, fibre quality in cotton but also in other crops in India.

INTRODUCTION

India has the largest cotton area with nearly 9.5 m hectare accounting for 27 per cent of the global area. It contributes 18% to the total world cotton production and now is the second largest producer after China. Cotton has a special significance in Indian economy as it contributes around 30 per cent to the agricultural gross domestic product (GDP) and provides livelihood support to 60 million people with half of this population employed by textile industry. There are more than 1.7 million registered looms, 1500 spinning units and an estimated 280 composite units.

The textile industry is predominantly cotton based and contributes 4 per cent to the total GDP, 14 per cent to the total industrial production and 27 per cent export earnings. In the context of international scenario, India is the largest cultivator of cotton, second largest producer (31.0 million sales of 170 kg each) as well as consumer (25 million bales of 170 kg each) and third largest exporter (6.5 m bales of 170 kg each).

Before 2001-02, when Indian cotton economy was in doldrums because of low production and productivity, nobody expected this kind of turn around in just six years. Amongst a few factors contributing to increase in productivity, the successful management of bollworms; the key pest damaging cotton in the field, by adoption of Bt technology is considered the most prominent factor. It is, therefore, a matter of pride that the cotton farmers have achieved a sterling success in improving productivity of cotton in recent years.

INDIAN COTTON PROFILE

Cultivation features

Cotton is planted by 4 million small and medium farmers under diverse agro-climatic and agro-practicing conditions in 9 key states from south to north. The north zone cotton area represented by the states of Punjab, Haryana and Rajasthan and is characterized by hybrids and varieties of 130-150 days duration, high mechanization, irrigation and high use of fertilizers and pesticides. The central zone constituted of three states viz. Maharashtra, Madhya Pradesh and Gujarat which accounts for nearly 60 per cent of the total cotton area of India is predominantly dependent on rain water. It is known for high penetration of hybrid technology, low inputs and deep black cotton soils. Crop duration varies from140-200 days. The south zone cotton area comprises of Tamil Nadu, Andhra Pradesh and Karnataka states and is famous for long and extra long staple cottons which are of long growing duration i.e. 160-240 days. Irrigation and other inputs are only 50 per cent of what are used in north zone. These zones though represent revenue state boundaries, the cotton production technologies are overlapping basically based on agro-ecological situations. The Indian cotton crop cultivation is the most diverse in the world, both in terms of botanical status (species) and fibre quality range. Three species of *Gossypium* contributing to the cotton trade and industrial consumption viz., *G. hirustum, G.arboreum* and *G. herbaceum* are commercially grown in the country. The fourth cultivated species *G. barbadense* which includes the highest quality of fibre with extra-long staple, is also grown as a parent in many hybrid cottons. A small area of the species in the form of variety ‘Suvin’ is currently grown in Tamil Nadu. Another unique features of Indian cotton cultivation are growing of hybrid cultivars developed from intraspecies and interspecies combinations, year long availability of cotton in the field, hand picking, intercropping and large input variation (Mayee and Rao, 2002). It is also the first crop where genetically engineered technology (GE) has been commercialized in the form of insect-resistance Bt cotton (Mayee, 2006).

Pest and protection scenario

Cotton crop suffers severe economic damage from several insect pests, diseases and weeds. The most important insect pests are sucking pest complex which includes jassids, aphids, thrips and while flies; and bollworms. The bollworm complex comprises of the American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*), spiny bollworm (*Earias insulana*) and spotted bollworm (*Earias vitella*). *Spodoptora litura*, the leaf worm is mainly a foliage feeder but occasionally damages the bolls also. The bollworms, especially *H. armigera*, have been responsible for heavy losses in yield. Annual losses caused by bollworms alone are estimated at about US $ 290-350 million despite repeated sprayings of insecticides (King, 1994, Kranthi *et al*, 2003).

Conventional pest management strategies rely heavily on the use of chemical insecticides. It is estimated that pesticides worth US $270 million are used annually in India for pest management inspite of highest awareness created for integrated pest management (IPM) and insecticide resistance management (IRM). With only 5 per cent cultivated area under cotton, nearly 50 per cent of the total pesticides are applied. It is estimated that insecticides valued at US $700 million are used on all crops annually. Of this US $350 m worth pesticides are consumed by cotton, out of which US $270 m worth chemicals are used for bollworms protection (Mayee, 2003). Since dependable alternative methods were not available, farmers had no option except ‘spray’ or ‘pray’ (Manjunath, 2005). Over the past two decades, the perplexities in pest management further complicated with more and more insect species developing resistance to the insecticides. Excess use of chemicals created the problem of insecticide resistance rendering them to be ineffective and enhancing the need of repeated applications resulting into the serious problem of economics (unprofitability) and ecology (pollution) (Kranthi, 2005). The successive cyclic national outbreaks of epidemics of *H.armigera* bollworm in 1987, 1992, 1997 and 2001 were serious warnings to scientific community to find out alternate solutions to chemical management. Since no sources of resistance to bollworm are available in the germplasm lines of cottons or its near relatives, breeding for resistance to bollworm did not yield any useful results. Therefore, efforts were directed to harness genetic engineering (GE) technology for bollworm resistance and transgenics using the known cry genes from soil bacterium, *Bacillus thuringiensis* (Bt) sub species *kurstaki.* Bt cotton thus brought a ray of hope (Barwale *et al*, 2004; Mohan and Manjunath, 2002)

BT COTTON DEVELOPMENT

Experimentations on Bt Cotton

MAHYCO, an oldest Indian Seed Company obtained the initial 10g of coker 312 Bt (Cry1c) seed from its collaborator, Monsanto USA in 1996 to commence the transgenic research in India. Within two years of importing the transgenic seeds, the company successfully incorporated it into 40 elite Indian cotton lines. By using the accelerated breeding programme and series of biotechnology tools, the company developed stable hybrids with effective toxin expression. Pre-release biosafety and environmental safety testings on aspects of pollen flow, aggressiveness, gene stability, allergenicity, toxicity to small and large animals, fish studies, protein expression, toxin in byproducts, influence on beneficial microorganisms and baseline susceptibility studies were carried out between 1997-2001 as per the guidelines of regulatory authorities established by Govt. of India (Warrier, 2006)

Nearly 500 field trials were carried out in different agro-climatic regions between 1998-2001 to assess its efficacy against bollworms and the concomitant agronomic benefits. Simultaneously, the Indian Council of Agricultural Research (ICAR), an apex federal organization in agricultural research conducted 55 multi-location field trials through their network of All India Coordinated Cotton Improvement Project (AICCIP) for assessment of bioefficacy and economic benefit (Anonymous, 2002).

These trials clearly indicated that the first generation Bt cotton hybrids provided effective control of bollworms, requiring no or fewer application of insecticides. It also showed high economic benefits to cotton farmers. It was also found that Bt-gene incorporation into Indian cotton did not have any negative effect on fibre quality parameters. Infact, because of early retention of bolls, the boll bursting commenced 15 to 20 days early and gave better quality attributes. Thus it was concluded that Bt cotton has potential to improve lives of cotton farmers through provision of favourable environment and economic benefits. It is on the strength of large amount of testing, the Bt cottons containing Cry1Ac, event Mon 531in the form of three hybrids viz. MECH-12, MECH-162, and MECH-184 were approved for commercial cultivation on April 5, 2002.

Bt technology adoption and spread

The Genetic Engineering Approval Committee (GEAC), an apex regulatory Government organization in India allowed commercialization in 2002 in central and south zones. In 2004, RCH-2 a hybrid of another company was approved in the same area. In 2005, the GEAC approved another 16 cotton hybrids including six hybrids for north zone, thus making available the technology for entire country. Realizing the potential of technology, several Indian Seed companies have already become sublicensees of the original to acquire the rights to incorporate the gene into their own products. Notwithstanding with the single gene, Bollgard II (Event 15985) having Cry 1 Ac plus Cry 2 B genes was also approved. To diversify the genic background of the Bt-gene, Cry 1 Ac developed indigenously and incorporated into cotton by JK Seeds Company as Event 1 and the GFM event of Cry 1 Ac (Chinese gene) used by Nath Seeds were also permitted in India. The public sector is also bringing Cry 1 Ac into the public bred varieties and hybrids. Currently more than 160 hybrids developed by 28 private companies have been approved for commercial cultivation (Table 1)

Table 1: Approved Bt cotton events/hybrids and number of sponsors of technology in India

Bt cotton/Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Total no. of Bt cotton hybrids	3	3	4	20	62	162
Total no. of Bt transgenic events	1	1	1	1	4	4
Total no. of companies	1	1	1	3	15	28

Approved events: Bollgard I (Mon 531), Bollgard-II (Mon 15985) Event-1 (J.K. Seeds), GFM Event (Nath Seeds)

Source: GEAC, Ministry of Environment and Forest, Govt. of India, New Delhi

Acceptance and spread of Bt cotton cultivation has been much faster than anticipated. The authors (Mayee and Rao, 2002) predicted that Bt cotton shall cover around 17 per cent of the total cotton area by 2006-07. In reality more than 40 per cent spread occurred in 2006-07 and has covered an area of 66 per cent or 6.3 m ha in the current year (Table 2) with more than 3.5 m farmers growing genetically engineered cotton. The strength of technology, therefore, proved beyond doubt. Bt cotton adoption at an annual rate of 11.05 per cent appears to be fastest for any technologies in agriculture (Table 2).

Table 2: Spread of Bt cotton in India

Year	**Area**		**% of total area**	**No. of farmers planting Bt**
	Total (m ha)	**Under Bt**		
2002-03	7.67	29,307	0.38	Few only
2003-04	7.63	85,927	1.13	≥40,000
2004-05	8.92	534,731	6.00	300,000
2005-06	8.87	1,250,833	14.10	1,000,000
2006-07	9.16	3,800,000	41.50	2,400,000
2007-08	9.50	6,300,000	66.32	≥3,500,000

Source: DOCD, (Ministry of Agriculture) Mumbai

COTTON PRODUCTION AND PRODUCTIVITY

Before Bt cotton introduction

Inspite of having the highest area under cotton in India amongst the cotton growing countries, the productivity had been consistently lowest and practically less than half of the world average (600 kg lint/ha) till 2002-02 (pre-Bt period). Although, the diverse situation in which the cotton is grown makes it difficult to expect very high productivity, but even the best of contiguous cotton area under irrigation command with better inputs in North Zone was no way better than the rainfed resource - poor areas of Central Zone. This has resulted into regular imports of raw cotton ranging from 1 to 2.5m bales and negligible exports till 2002-03 (Table 3).

Table 3: Cotton Area, production and productivity and Export-Import of cotton prior to introduction of Bt

Year	Area (m ha)	Production (m bales)	Yield (kg lint/ha)	Export (m bales)	Import (m bales)
1992-93	7.6	14.0	315	1.38	0.12
1994-95	7.9	13.9	300	0.11	0.59
1996-97	9.0	16.3	320	1.68	0.39
1998-99	9.2	15.6	287	0.10	0.79
2000-01	8.5	13.1	260	0.06	2.22
2002-03	7.7	13.6	302	0.08	1.77

Source: Agri. statistics at a glance, DOES, Ministry of Agriculture & Cooperation, Govt. of India, New Delhi and Cotton Advisory Board, Mumbai (1 bale: 170 kg lint)

After Bt cotton introduction

Increase in area under Bt cotton proportionately increased the cotton yield in all the states. With dramatic increases in Gujarat and Punjab where the rate of adoption was higher than in other states. The production and productivity of the country surpassed all the targets fixed by the Government of India for 10th plan under Technology Mission on cotton (TMC), a Govt.-sponsored programme to raise the production productivity and quality (Table 4).

Table 4: Cotton production and productivity after introduction of Bt technology

Year	Area (m/ha)	Production (m bale)	Yield (kg lint/ha)	Export (m bales)	Import (m bales)
Pre-TMC & Bt period (1992-2001)	7.90	14.80	319	0.46	0.85
2002-03	7.67	13.60	302	0.08	1.77
2003-04	7.63	17.90	399	1.21	0.77
2004-05	8.92	24.30	463	0.92	0.81
2005-06	8.87	24.40	467	4.70	0.50
2006-07	9.16	28.00	520	4.80	0.60
2007-08	9.50	31.00	554	6.50	0.50

Source: Cotton Advisory Board (Ministry of Textile, Govt. of India)(1 bale: 170 kg lint)

This has influenced the entire export-import balance in favour of export. Import is now restricted to 0.5m bales mainly of extra long staple (ELS) cotton which is due to the area and environment limitation. In the current season as per the latest estimates of Cotton Advisory Board (CAB) of Ministry of Textiles, the cotton production will be in the range of 31.0 to 32.0m bales of 170 kg each which means a national productivity of 554 kg lint per hectare. Notwithstanding the doubts raised by some organizations, the biotech cotton not only provided efficient control of bollworms leading to higher and quality yield but also reduced the number and consequently the cost of pesticide sprays.

PEFORMANCE ASSESSMENT OF BT COTTON

In series of field trials (around 500) between 1998-2001, the economic benefits due to Bt cotton cultivation was estimated to be Indian Rs. 2500 per ha due to saving of 50 per cent pesticide cost and 40 per cent yield increase. Economics of first generation Bt cotton hybrids was also calculated on the basis of 55 coordinated trials carried out by AICCIP (ICAR), where it was shown to give income benefit between US $105 to 139 per ha (Table 5).

Table 5: Economics of first generation Bt-cotton cultivation in ICAR coordinated trials, 2001 – 02

Hybrid	**Yield (Q/ha)**	**Gross Income/ha (US $)**	**Insecticide cost/ha (US$)**	**Additional Seed cost/ha (US$)**	**Net Income per ha (US$)**
MECH – 12 Bt	11.67	477.4	39.3	55.1	383.0
MECH – 162 Bt	13.67	559.2	32.1	55.1	472.0
MECH – 184 Bt	14.00	572.7	32.1	55.1	485.5
Local check (Non-Bt)	8.37	342.4	64.1	0.0	277.8
National check (Non-Bt)	7.31	299.1	45.5	0.0	253.6

Annual Report of AICCIP, 2002

Performance assessments were carried out by several organizations (Mayee, 2007). As the Bt cotton acreage enlarged and the overall production increased the controversies also diminished. As Manjunath (2005) succinctly said that as the technology wins controversy on Bt cotton wanes. There are several scientific studies carried out on the performance of Bt cotton which clearly demonstrated the benefits that were observed in pre-adoption trials. The National Centre of Integrated Pest Management (NCIPM), New Delhi carried out farmer's participatory trials on large scale where it was found that the seed yield in Bt plus IPM package was three times more than conventional cotton without IPM (Mayee, 2007). Surveys carried out for three years revealed that the number of sprays reduced by 26 – 33, which was a net saving to farmers and gain of environment. The frontline demonstrations conducted by ICAR confirmed a net increase of 34 per cent in seed cotton yield in Bt cotton hybrid over their respective non-Bt hybrids (Table 6).

Table 6: Results of frontline demonstration on cotton (2005-06)

Group	**Number of farmers**	**Area (ha)**	**Demo Yield (q/ha)**	**Local Practice Yield (q/ha)**	**% increase**
Bt hybrids (HXH)	385	151.6	23.29	17.83	30.63
Non-Bt hybrids (AXA, HXB, HXH)	400	162.8	17.42	13.62	27.94
Varieties (A, H and H)	490	211.2	13.40	10.72	24.97

Source: FLD on cotton 2005-06, MM II TMC, DAE, ICAR, New Delhi, p-63 (compiled by A.M. Narula and M.J. Chandre Gowda)

In Andhra Pradesh where maximum controversy on Bt cotton occurred, a latest socio-economic study carried out by Agro-Economic Research Centre (AERC) of the Andhra University on behalf of the State Government reported high income by Bt cotton growers under irrigated and un-irrigated situations (Table 7).

Table 7: Bt cotton performance in Andhra Pradesh

Item	Guntur District		Warangal District	
	Bt cotton	Non-Bt cotton	Bt cotton	Non-Bt cotton
Yield (kg per hectare)	3,341	2,290	2,380	1,623
Gross income (Rs per hectare)	57,307	40,348	41,817	27,969
Total cost (Rs per hectare)	30,901	31,232	34,232	28,952
Net income (Rs per hectare)	26,406	9,059	7,585	(-983)

Source: AERC, Andhra University, 2007

Reduction is pesticide consumption observed in demonstration trials has reflected in average use in pesticide quantity on cotton from 50 per cent to 30 per cent only in the last few years (Mayee, 2007). The total quantum reduction in pesticide use on cotton in India as evidenced by industry reports are compiled in Table 8 which showed that the value in rupees of pesticide usage is down from Rs 8522m to Rs 2372m from 2004 to 2006 (Table 8).

Table 8: Pesticide usage trend in cotton

Year	Pesticide worth m Rs consumed for		
	Total cotton pest management	Sucking pest management	Bollworm management
2002 (3 yr average)	14,500	3,300	9,800
2004	13,447	3,337	8,522
2005	8,782	3,525	4,145
2006	6,982	4,145	2,372

Source: Industry Reports on pesticide consumption

LESSONS LEARNT FROM BT COMMERCIALIZATION

The technology evoked unprecedented interest and emotions among a large section of Indian public including scientists, sociologist, economists, politicians, environmentalists and industry personnel. There are still some misapprehensions and issues. Although many of them can be ignored, some need attention if at all the technology has to be sustainable. The genetic background in which the gene is incorporated is often not desirable for agronomic traits and often the toxin expression levels are short-lived. Concern has also been expressed to develop the technology in true breeding varieties in order to save seed cost. Refugia technology recommended for resistance management is not usually adopted by farmers as it is cumbersome to use. Rather it is often argued that small holdings of farmers and availability of several host species susceptible to this polyphagous pest serve to function as refugia. Additional provision of the refuge with Bt cotton plant thus appears irrelevant in Indian context. Besides, there are also serious concerns of sale of illegal Bt cotton in India in direct violation to the EPA rules. A parallel industry of so called unapproved Bt cotton seed is thriving basically to counter the high cost of legal Bt cotton seeds. One of the major concerns include sale of spurious of mixed seed in the garb of Bt cotton often resulting in loss of faith in this useful technology. With approval of Bollgard II and successful establishment of new events of cry1Ac transformation, including event 1 of M/s. J.K. Seeds and GFM event of M/s. Nath Seeds, the illegal sale of unapproved Bt cotton is likely to be curtailed. Moreover, GEAC has recently taken a decision (July 2006) to go ahead with 'Event based' approval of cry1Ac Mon531 event instead of case-to-case basis, where the introgression of the same event is undertaken in different agronomic background that is presently practiced. For widespread cultivation of Bt cotton, the environment and biosafety testings shall not be necessary for the approved event and therefore quick releases based on bioefficacy will reduce the delays in bringing new germplasm in superior Bt-background. This will induce competition and curtail spread of unapproved cultivars. The success of the Bt-technology lies not only in enhancing productivity but also improving quality by reducing trash and contaminants. The 2005 ITMF survey on contamination points out to these facts. Consequently, International cotton buyers have also expressed satisfaction with the quality and now offer competitive prices, which were otherwise traditionally discounted by 5 - 6 per cent because of lower quality. In short, the Indian experience on GM cotton has demonstrated that the commercialization of biotechnology in cotton has bright prospects and farmers are keen to adopt the new technologies provided they deliver on the issues concerning the productivity and production. Analysis of decadal increment in the output growth of cotton clearly indicated that highest increments in yield and productions were achieved in the last six years when compared to all the decadal previous growth after independence of the country (Table 9)

Table 9: Decadal increment rise in cotton production and productivity in India

Decade	m bales		kg lint / ha	
	Production	**Increase**	**Yield**	**Increase**
1952-53	4.15	Base	105	Base
1962-63	6.80	+02.65	170	+065
1972-73	7.23	+00.43	175	+005
1982-82	9.90	+02.67	202	+27
1992-93	14.00	+04.10	315	+103
2002-03	13.60	-00.40	302	-013
2007-08*	31.00	+17.40	554	+278

**Latest estimates of Cotton Advisory Board (2007). Between 2002-03 AND 2007-08, the decade is incomplete as it is only six years of Bt cotton use by farmers.*

For the technology to be sustainable, likely new challenges must be mitigated. Suppression of bollworm by few genes and reduction in pesticide use is likely to make some minor pest major ones. For example, in some areas incidences of mealy bugs, thrips, miriad bugs, shoot and stem weevil have already been reported. Pink bollworm, which appears late, may also become serious. Similarly certain biotic and abiotic diseases like grey mildew, rust, parawilt and reddening have been found to damage the crop. It is a biological phenomenon that suppression of one element may provoke the others but then genetic improvement and pest management has to be a continuous process.

FUTURE SCOPE IN BIOTECH COTTON

In future the impact of biotechnology in cotton is expected to be more magnified in India. Many varieties of cotton with variants of Bt genes, like cry1Ac, cry1Aa3, cry1Aa3, cry1F, cry1a5 etc. including bivalent Bt varieties are at various stages of development. Attempts are on in different labs to exploit transgenes against sucking pest which continue to be the menace in cotton. Among diseases, leaf curl due to whitefly transmitted Gemini virus is the major limitation to cotton cultivation in north India. Research on development of transgenic cotton through RNA interference or antisense approach is under way. Attempts are being made to develop transgenic plants improved for drought tolerance. Work on development of markers for drought tolerance, better fiber quality traits and disease resistance has been initiated that would aid in marker-aided selection and molecular breeding for improved yield and quality cotton in India. Bacterial blight resistance genes in cotton are being characterized that would aid in map-based cloning. Sensitive molecular diagnostic tools have been developed for detection of major pathogens of cotton. Employment of these tools for rapid and timely detection will lead to efficient management of diseases by effectively intercepting and destroying them at source. There is also wide scope to bring in genes that will impart resistance to sucking pests and improvement in fibre quality traits. In India cotton has already become a model biotech crop, which is leading the biotech-aided crop improvement programmes.

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ALLEVIATING COTTON STICKINESS - EXPERIENCE AND FUTURE RESEARCH TOPICS

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Though cotton stickiness is manifested only in a small percentage of the world cotton crop, its presence can adversely affect every aspect of the cotton textile industry from production to yarn manufacturing. Reductions in production efficiency due to the presence of stickiness at the mill may be very costly to the manufacturer. One of the missions of the USDA-ARS is to find solutions to the problems caused by the presence of stickiness on cotton in order to sustain the marketability of cotton and cotton textiles. Such solutions may be aimed at: 1) optimizing agronomic practices, whereby stickiness may be avoided based upon efficient crop production procedures including insect eradication, 2) developing efficient, accurate and robust methods to identify the source and amount of stickiness present in a cotton bale so that mill operations will be minimally affected by the presence of sticky cotton, and 3) developing treatment procedures either in the field, at the gin, or in the mill designed to remediate sticky cotton so that it may be efficiently processed without a concomitant loss of fiber or yarn quality. Research performed at the Cotton Quality Research Station is aimed at addressing the latter two solution strategies.

CAUSES AND EFFECTS OF STICKY COTTON AT THE COTTON QUALITY RESEARCH STATION (CQRS)

By far the most common source of sticky cotton observed at CQRS is insect honeydew contamination. This contamination is caused by either whiteflies (genus *Bemesia*) or aphids (genus *Aphis*), both of which are phloem-feeding insects, and present in the cotton field subsequent to boll opening. The effects observed during processing when honeydew is present are immediate lapping and torn webs at the card, buildup of residues on carding, draw-frame and ring-spinning equipment, and frequent ends-down during ring-spinning.

The other, less common, cause of stickiness observed during opening and spinning operations at CQRS is the presence of seed meat (kernel) contamination. This contamination may arise partly as a result of excessively wet weather conditions subsequent to boll opening and prior to harvest. When the wet seed cotton arrives at the gin, the seed coats are more prone to shattering, releasing the seed meats. Further processing breaks these seed meats down to fine particles which are difficult to detect in the resultant affected bale. The effects observed during processing when seed meat is present in the lint during yarn manufacture are delayed lapping at the card due to a gradual buildup of residue, a buildup of residues on carding, draw-frame and ring-spinning equipment, and delayed ends-down during ring-spinning as a result of the slow buildup of residue.

DETECTION AND IDENTIFICATION MEASURES

In order to design strategies by which the effects of sticky cotton may be alleviated at the mill, the sticky cotton must first be detected and the source identified. In the case of whitefly honeydew contamination, either the Sticky Cotton Thermodetector (SCT) or the Minicard may be used to detect and quantify stickiness. Aphid honeydew contamination requires the use of the Minicard in order to reliably detect and quantify stickiness, since the SCT is much less sensitive to the presence of this type of honeydew. Similarly, seed meat contamination requires the use of the Minicard in order to reliably detect the contamination. Without prior knowledge of the source of stickiness present, the Minicard is the method of choice for screening potentially sticky cottons at CQRS.

Once cotton samples have been identified as being sticky, the source of the stickiness may be determined by use of High Performance Liquid Chromatography (HPLC), which allows the separation and quantification of individual sugars present. The sugar profile of whitefly honeydew is dominated by trehalulose, which is a disaccharide and liquid at normal conditions. The sugar profile of aphid honeydew is very different, comprising a large number of high molecular weight oligomers of glucose, most of which have yet to be identified. Seed meat contamination is identified by the presence of raffinose, which is the primary sugar present in the seed meat, though it does not appear to be the cause of the stickiness.

APPROACHES TO THE LOGISTICAL ALLEVIATION OF COTTON STICKINESS AT THE MILL

Once a bale of cotton has been identified as being potentially sticky, the most effective current measures which can be taken include dilution of the sticky bale in a laydown incorporating non-sticky bales. In order to minimize processing problems at the mill, a slightly sticky bale should be incorporated in a ratio of roughly 1:5 with non-sticky bales. A very sticky bale, on the other hand, needs to be incorporated at ratios of 1:20 or less with non-sticky bales. In practice, this type of bale dilution may be very difficult, especially if all bales in the laydown exhibit stickiness potential. Other measures to be taken to reduce the impact of sticky cotton once it is present in the laydown include minimizing the relative humidity of the operating environment, slowing processing speeds, adjusting crush roll settings, and maintenance of a rigorous cleaning protocol to remove residue buildup.

APPROACHES TO THE ALLEVIATION OF COTTON STICKINESS PRIOR TO THE MILL LAYDOWN

It is desirable to both detect and alleviate cotton stickiness prior to its arrival at the mill. Cotton contaminated with insect honeydew can be assessed during the ginning process due to the fact that stickiness also affects ginning equipment similarly to yarn spinning equipment. The standard action taken at the gin is to ramp up the temperature in the drying tower in order to fully dry the honeydew droplets and therefore remediate the stickiness. Following ginning and baling, however, the honeydew regains moisture and will still present problems downstream at the mill. The gin remains the most effective place in the chain of cotton processing to both detect and attempt to alleviate stickiness. Since simple drying of the sticky cotton is not effective, several strategies have been attempted to alleviate stickiness by chemical or microbiological means.

Cotton Storage

The reducing sugars glucose and fructose undergo chemical reactions with amino acids and proteins present in the cotton fiber. It has been demonstrated that prolonged storage of cotton leads to a decrease in the content of these reducing sugars (Gamble, 2007). Trehalulose, the primary sugar responsible for stickiness in whitefly honeydew, is under certain conditions also a reducing sugar. Attempts at alleviating whitefly honeydew stickiness by prolonged storage under typical temperature and humidity conditions have not been successful, however, due to the fact that trehalulose requires elevated temperatures in order to undergo these chemical reactions.

Thermochemical Degradation of Honeydew Sugars

It has been demonstrated (Gamble, 2002) that both trehalulose and melezitose, a tri-saccharide found in aphid honeydew, may be degraded via thermochemical reactions. The reaction which takes place involves a dehydration of the sugar, resulting in by-products which are non-sticky. This reaction is accelerated by the presence of an organic acid catalyst such as citric acid, and the sugars are effectively eliminated by heating at 200C for 6 minutes in the presence of a catalyst, resulting in a dramatic decrease in stickiness. The side effects of the reaction, however, preclude this method from being an acceptable method for stickiness alleviation. This is due to the fact that in addition to the honeydew sugars being degraded, the physiological glucose and fructose found on the cotton fiber also react, and all of these reactions produce highly colored by-products which, though not sticky, serve to produce an unacceptable deterioration in cotton color grade.

Microwave and Radio Frequency Heating of Sticky Cotton

Attempts have been made at CQRS to alleviate whitefly honeydew stickiness by using dielectric heating mechanisms in place of convective oven drying. By using either microwave or radio frequency radiation, it may be possible to selectively heat the droplets of honeydew while leaving the fiber relatively unaffected. In practice, microwave frequencies do not allow for homogeneous irradiation of the miniature cotton bales used, resulting in temperature hot spots within the bale which may be prone to combustion. Radio frequency radiation offers an alternative which does not present this problem. Studies conducted on miniature bales (Bargeron, et al. 2003) demonstrated that cotton stickiness could be alleviated using radio frequency (27 MHz) radiation at an intensity which caused homogeneous heating of the bales to 120-130 C for 4 hours. All of the treated bales, however, exhibited substantial increases in +b color, a negative impact deemed unacceptable.

Microbial Degradation of Honeydew Sugars

In order to alleviate cotton stickiness without the detrimental side effects of color deterioration, it may be possible to use the innate ability of some microorganisms, including those indigenous to cotton, to digest sugars. Numerous studies (Heuer and Platt, 1985; Chun and Brushwood, 1998) have demonstrated the effectiveness of such microorganisms to decrease sugar contents on honeydew contaminated cotton. The effectiveness of these treatments, however, is contingent upon the presence of moisture levels on the cotton lint in excess of 8%, potentially leading to adverse effects upon fiber quality (Chun et al, 2005). It is therefore necessary to employ microorganisms which demonstrate sugar degrading capacity at moisture levels below 8%. One such study (Funk et al., 2007) attempted to use a lacto-bacterial strain which had previously been demonstrated to metabolize sugars at low moisture contents. In this study, bales of cotton with known levels of stickiness were subjected to a spray treatment with the bacterium resulting in final bale moistures of < 7%, re-baled, and stored for periods of 20, 59, and 179 days. Following these storage periods, the bales were opened and tested for stickiness, fiber quality, and yarn processing performance. Though no adverse effects were detected in fiber or yarn quality compared with control bales, the stickiness of the bales was not mitigated to a statistically significant level.

FUTURE RESEARCH DIRECTIONS

Investigations at the Cotton Quality Research Station regarding stickiness continue, and are directed at both the detection and alleviation of cotton stickiness. Development of a chemical treatment leading to modification of sugars as opposed to their degradation would possibly result in an alleviation of stickiness without concomitant detrimental effects upon fiber properties. Dielectric, or radio-frequency, heating may potentially be optimized in order to specifically target honeydew droplets based upon their higher moisture content relative to the cotton fiber. The effect of this would be to selectively degrade only sugars present in the droplets, thus minimizing detrimental color changes to the fiber. Finally, a screening process is being pursued with the aim of finding strains of yeasts, bacteria, or fungi which can serve to metabolize honeydew secretions at moisture contents below 8%, possibly in conjunction with the addition of nitrogen containing compounds which may serve to enhance the efficacy of these microbes.

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THE MARKET FOR AUSTRALIAN LONG STAPLE UPLAND COTTON

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ABSTRACT

There is considerable interest within the Australian cotton industry for new varieties with improved fibre quality that attract a price premium. One option is Upland varieties that approach the long and fine quality attributes of Pima-type cottons. In this study a new Long Staple Upland (LS) variety; Sicala 350B, produced by CSIRO Plant Industry, was roller and saw ginned, blended in increasing proportions with Pima A8, an Extra Long Staple (ELS) Australian grown variety and subjected to spinning trials. The aim of the investigation was to examine the degree to which Sicala 350B could be used as a substitute for Pima in fine count ring spun yarns. Three blend ratios of the two cottons; 80/20, 70/30 and 60/40 Pima A8 and Sicala 350B, were spun into 10 tex (60 Ne) ring spun combed yarns and examined against yarns spun from 100% Pima A8 and Sicala 350B fibre. A comparison was also made between saw and roller-ginned Sicala 350B blended with Pima A8 in a 70/30 Pima/Sicala 350B blend ratio. Processing efficiency and yarn quality results were examined in order to judge the potential of Sicala 350B as a substitute for Pima cottons. Results indicated that a blend of 70/30 Pima/Sicala 350B did not cause a practical deterioration in yarn quality and processing performance when compared to 100% Pima. The primary advantage for the spinner is substantial savings on raw material costs.

INTRODUCTION

Australian cotton is viewed world wide as a quality fibre and as such is usually purchased at a premium for producing high quality fine count, combed ring spun yarns. However, the Australian cotton industry faces increased competition in the premium market from cotton produced in the USA, China, Brazil and West Africa. With advances in spinning technology and increased demand for higher quality products, it is expected that the demand for ELS cottons, with fibre properties as listed in Table I, will increase by 5 to 10% over the next 5 years and 10 to 20% over the next 10 years. Currently only 10% of the Australian crop falls into the ELS category and development of new LS Upland cotton varieties by CSIRO Plant Industry are aimed at increasing this proportion of the market to gain the high premiums paid for fine long and strong staple fibre.

Sicala 350B is the first commercial LS variety released in Australia and is a specialist high quality Bollgard II variety, exhibiting extremely long fibre lengths (>1¼ inches) compared with regular Upland varieties. Fibres are also typically finer and have excellent breaking tenacity (> 32 grams per tex).

Table I: Spinner's cotton fibre property requirements for ELS

Fibre Properties	Preferred Value
Length	1 7/16 inch
Uniformity	> 85%
Strength	> 38 cN/tex
Micronaire	3.5 - 4.1
Maturity Ratio	> 0.85
Fineness	140 – 160 mtex
Neps	< 200 neps/g
Ginning	Roller

The objective of this study was to determine the proportion of Sicala 350B that could be used as a substitute for Pima without compromising processing performance and the properties of fine count yarns. With Pima cotton commanding up to a 50% price premium over quality Upland growths, one of the main advantages for the spinner in substituting Pima cotton for an Upland variety are savings in raw material costs, which typically amount to between 50 and 70% of manufacturing costs in the spinning mill.

The most common yarns produced from ELS cottons are in the range of 12 tex (50 Ne) to 7.5 tex (80 Ne),which are used for fine knit and woven apparel fabric, followed by woven fabric for home furnishing such as bed sheets and towels. In recent years there has been a move to coarser Pima yarns up to 20 tex (30 Ne) and coarser for fabrics such as denim.

In this study a fine count yarn 10 tex (60 Ne) combed ring spun yarn with a twist factor (αe) of 4.0, was spun from blends of Pima A8 and Sicala 350B fibre, where the proportion of Sicala 350B in the blend was increased in 10% increments from zero through to 40%. Processing efficiency and yarn quality were measured in order to demonstrate the effect of substituting LS Upland cotton for ELS cotton in a spinning mill.

MATERIALS AND METHODOLOGY

Bales of commercially saw and roller ginned Sicala 350B cotton and roller ginned Pima A8 were processed in the cotton mill situated at CSIRO Textile and Fibre Technology (CTFT) and were grown during the 2006 season under commercial growing conditions. Roller ginning of seed cotton from the same Sicala 350B modules enabled comparisons to be made on the basis of gin treatment.

Fibre Testing

Bale samples were conditioned under standard conditions of 20°C +/-2°C and 65% +/-3% relative humidity for 24 hours and tested on an Uster Technologies 1000 High Volume Instrument (HVI). Micronaire, staple length, length uniformity, staple strength and elongation were measured (Table II).

Fibre fineness was determined using the CSIRO Cottonscan instrument, which determines fibre fineness (linear density) by measuring the length of fibre in an accurately weighed specimen of fibre snippets. Combined with an independently measured Micronaire value from the HVI, the average fibre maturity is also calculated using Lord's empirical relationship between Micronaire, maturity ratio and fineness (Table III).

Bale and manually blended fibre samples were also tested for nep, seed-coat neps (SCN) and short fibre content (SFC) by an Uster Technologies Advanced Fibre Information System (AFIS PRO) testing 5 replicates per sample (Table IV).

Table II: Fibre Results by the HVI 1000[1*]

Variety	Gin Type	Tenacity cN/tex	Elongation %	Length mm	Uniformity Index %	Micronaire (µg/inch)
Sicala 350B	Saw	32.0	2.4	31.2	81.3	4.2
Sicala 350B	Roller	33.0	5.5	33.8	85.1	4.2
Pima A8	Roller	48.1	5.8	34.0	86.8	4.2

[1]*Calibrated using HVI ICC Upland and Pima Calibration Cottons* [*] *Average of 10 tests*

Table III: Fineness[2] and Calculated Maturity Results by the Cottonscan

Variety	Gin Type	Fineness (mtex)	Maturity Ratio
Sicala 350B	Saw	192	0.82
Sicala 350B	Roller	198	0.79
Pima A8	Roller	173	0.91

[2]*Average of 5 tests*

Table IV: Nep, Seed-Coat Nep and SFC Results by the AFIS PRO[3]

Variety	Gin Type	Neps/ gram	SCN/ gram	SFC(w) %
Sicala 350B	Saw	376	44	12.9
Sicala 350B	Roller	193	43	8.0
Pima A8	Roller	190	22	3.7
80/20	Roller	185	35	4.4
70/30	Roller	176	20	4.4
60/40	Roller	182	36	7.9
70/30	Saw	372	44	12.6

[3]*Average of 5 tests*

Textile Processing

Seven gin process and blend treatments were examined in this study. The treatments examined are listed below:

A. 100% Sicala 350B cotton, saw ginned
B. 100% Sicala 350B cotton, roller ginned
C. 100% Pima A8 cotton, roller ginned
D. 80/20 Pima A8/Sicala 350B blend, roller ginned
E. 70/30 Pima A8/Sicala 350B blend, roller ginned
F. 60/40 Pima A8/Sicala 350B blend, roller ginned
G. 70/30 Pima A8/Sicala 350B blend, saw ginned

Eighty kilograms of fibre from each of these treatments was processed into yarn using machines set to industry standard settings. Production speeds were kept constant throughout the trial but machine settings e.g. draft distances, were optimised for individual blends as is accepted practice in high-quality spinning mills. Figure 1 summarises the processing steps and equipment used to convert each treatment into yarn. The four blend treatments D to G; 80/20, 70/30 and 60/40 roller and 70/30 saw-ginned, were blended prior to opening by weighing each blend component and then manually mixing them together by sandwich blending.

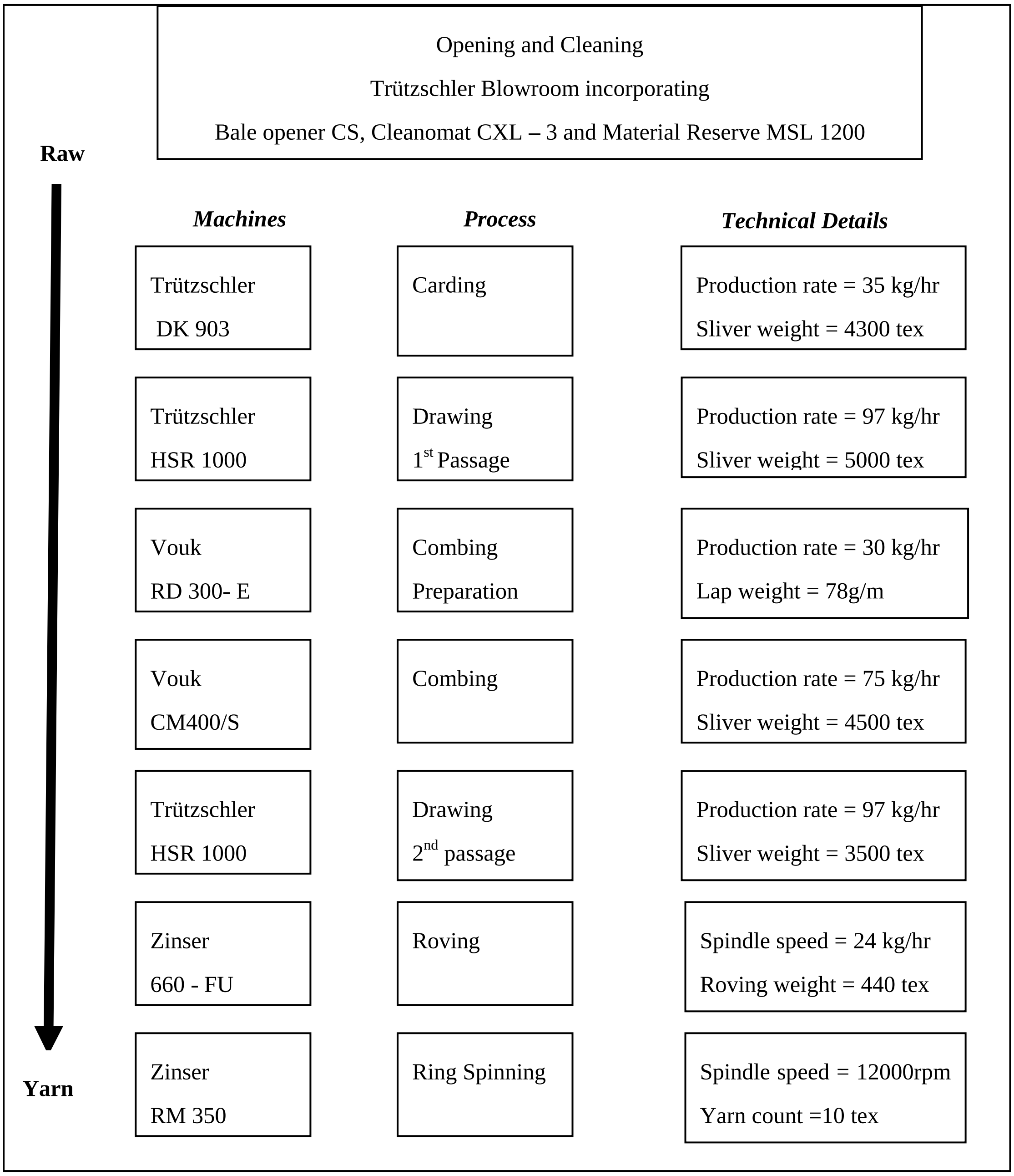

Figure 1: Yarn Processing Route

Residual trash in each fibre treatment was measured during the opening, cleaning and carding processes, using a Trützschler BR-WC Waste Collector and the amount of noil extracted during combing of each treatment was determined using the noil control program on the comber. (Table V).

Table V: Percent Trash and Noil extracted.

Variety	Gin Type	Opening & Cleaning %	Carding %	Total %	Noil %
Sicala 350B	Saw	0.80	1.29	2.09	19.7
Sicala 350B	Roller	0.76	1.87	2.63	19.4
Pima A8	Roller	0.52	1.57	2.09	14.9
80/20	Roller	0.63	1.58	2.21	17.6
70/30	Roller	0.81	1.76	2.57	18.4
60/40	Roller	0.85	1.76	2.61	19.2
70/30	Saw	0.95	1.50	2.45	19.3

Yarn Testing

Spun yarns were conditioned under standard conditions of 20°C +/-2°C and 65% +/-3% RH for 24 hours and tested for linear density (count) as per Australian Standard (AS) 2001.2.23, twist as per AS 2001.2.14, evenness, hairiness and imperfections using an Uster Technologies 4-SX evenness tester as per American Society for Testing and Materials Standard (ASTM) D1425. Tensile properties were determined using the Uster Technologies Tensojet 3, which simulates the load on yarns during modern high speed weaving, as per CSIRO Internal Method 5f. Figures 2 and 3 shows the test results for the yarns spun from each treatment.

DISCUSSION OF RESULTS

By any measure, the fibre properties of all three cottons tested in this study are considered exceptional. Whilst there were only small differences in fibre length properties between roller-ginned Sicala 350B and the Pima A8, which was also roller ginned (Table II), the Pima cotton had much higher bundle tenacity, and was inherently finer (Table III) which would have positively affected the bundle tenacity result. The Sicala 350B had relatively high bundle tenacity for an Upland cotton.

Saw-ginning the Sicala 350B significantly reduced fibre length and length uniformity and increased SFC, seed-coat neps and neps. The nominal acceptable limit for neps is 250 neps per gram of fibre. In comparison to roller ginning, saw-ginning increased nep levels in the Sicala 350B cotton by nearly 100% (from 193 to 376 neps per gram) and SFC by over 50% (from 8.0% to 12.9%).

The amount of trash extracted from each treatment during processing was generally low and similar across all treatments with only 0.5% by weight separating treatments (Table V). Trash levels appeared to be independent of ginning treatment and variety/blend.

The amount of noil extracted at the comber for each treatment increased with the amount of Sicala 350B blended in the treatment (Table V). Despite the measured differences in SFC between roller and saw-ginned Sicala 350B, both these treatments produced similarly higher levels of noil than the Pima cotton, reflecting the Pima's good length properties.

The 100% Pima cotton produced the best yarn tenacity results although there was practically no difference between 100% Pima A8 yarn and 70/30 and 60/40 Pima/Sicala 350B saw and roller-ginned yarns (Figure 2). There were significant differences in tenacity (> 8 cN/tex) between 100% Pima and 100% Sicala 350B saw and roller-ginned yarns. No difference was noted between 100% Pima A8 and 80/20, 70/30 and 60/40 blends for elongation.

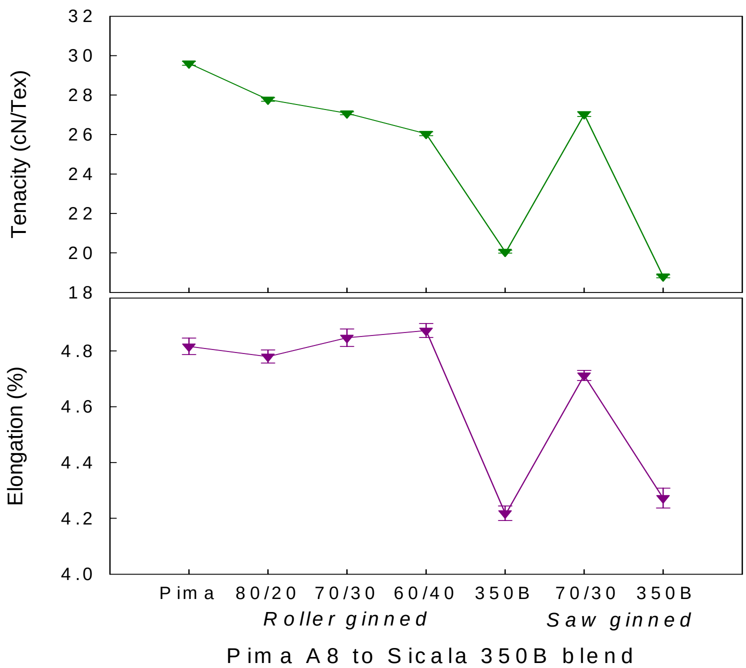

Figure 2: Strength and Elongation results for various treatments

A comparison of the yarn strength results with Uster Statistics 2007 shows that, with the exception of the 100% saw and roller-ginned Sicala 350B, the tenacity and elongation of the 100% Pima and the 80/20, 70/30 and 60/40 roller-ginned blends and the 70/30 saw-ginned blend were considered excellent, i.e. between the 25 and 5 percentile lines of all yarns produced world-wide. Yarns within these percentiles are considered high quality and are typically destined for modern high speed weaving and knitting machines and high quality apparel end-uses.

The most even yarns were produced from the 80/20 blend followed by the 100% Pima, 70/30 and 60/40 blends, with the 100% Sicala 350B roller and saw-ginned fibre producing the most uneven yarns (Figure 3). That evenness values and total imperfections, i.e. the number of thin and thick places and neps of the 100% Pima A8 yarn were somewhat higher compared with the 80/20 blend (Figure 3) and may be related to the lower percentages of noil removed from the 100% Pima treatment during combing.

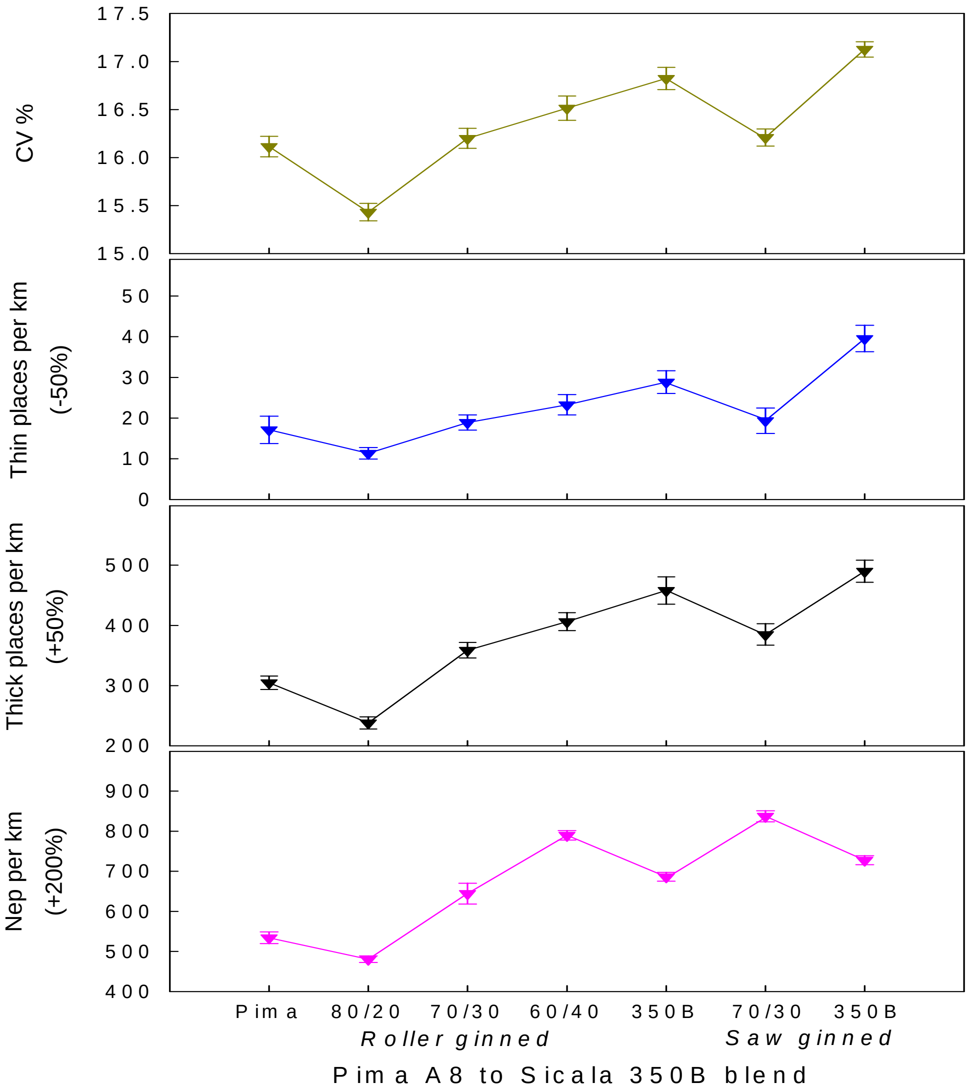

Figure 3: Evenness results for various treatments

Another important measure of cotton lint quality is processing performance. The recording of end breakages in spinning is an important measure of processing performance because it indicates whether production levels and quality standards can be achieved. The processing performance of all yarns produced was excellent (see Figure 4) with most treatments recording end break rates at less than 20 breaks per 1000 Spindle Hours (SpH).

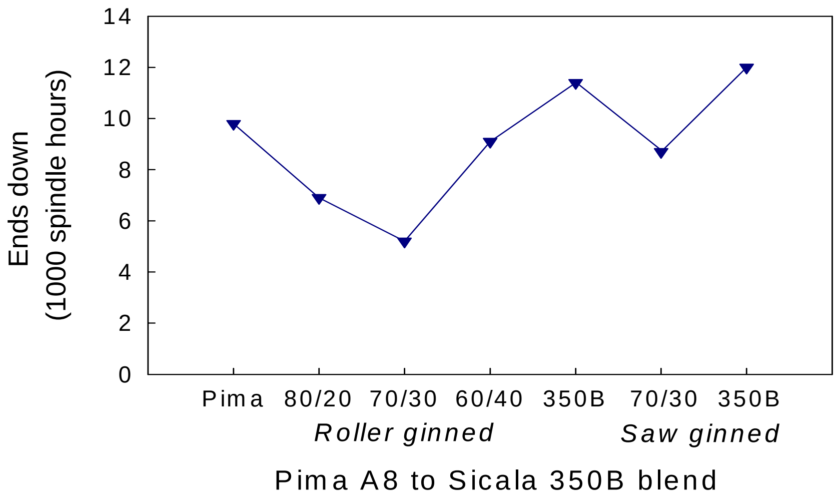

Figure 4: Ends down for various treatments

Financial Benefits

Figure 5 gives the potential saving on raw material when a spinner is able to use 30% of an LS Upland variety with ELS blend without jeopardising yarn and fabric quality and processing behaviour. The LS cotton in this model has been based on a price of 60USc/lb.

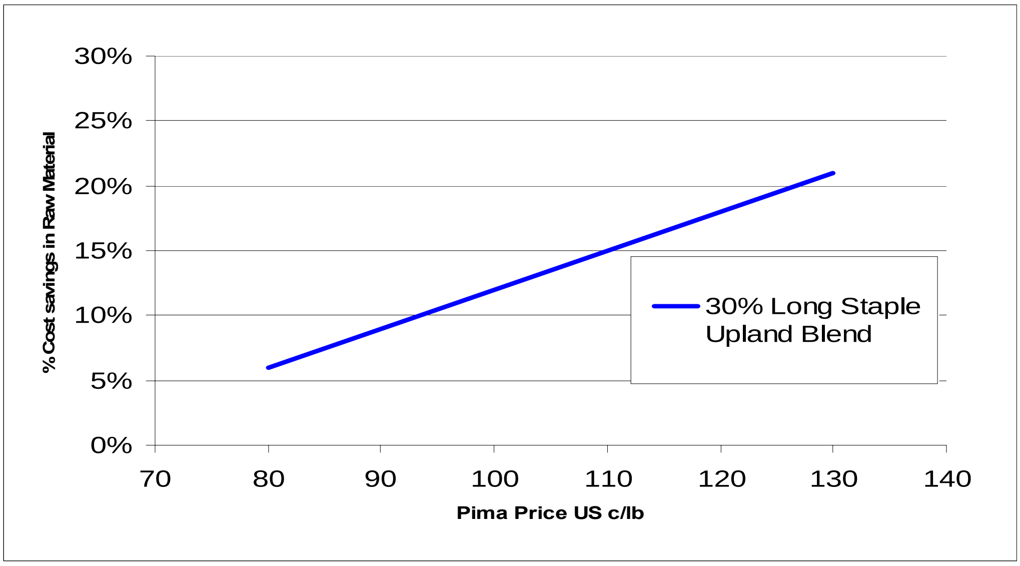

Figure 5: Cost savings when blending 30 % LS cotton with ELS cotton.

Table VI gives suggested minimum fibre properties LS cotton will need to achieve to be attractive for a spinner to allow quality and processing performance standards to be met when blending LS Upland cottons with traditional ELS cottons.

Table VI: Spinner's cotton fibre property requirements for LS cotton

Fibre Properties	Preferred Value
Length	> 1 1/4 inch
Uniformity	> 83%
Strength	> 34 cN/tex
Micronaire	3.7 - 4.2
Maturity Ratio	> 0.85
Fineness	160 – 180 mtex
Neps	< 200 neps/g
Ginning	Roller/Saw

CONCLUSION

The aim of this study was to determine the feasibility of blending LS cotton with ELS cotton without jeopardising processing performance and yarn quality of the resulting fine count yarn. The study has shown that LS cotton can be used to produce 10 tex (60 Ne) yarns using either 100% LS or blended with standard ELS cotton. As expected cotton that is roller ginned produces a longer, stronger fibre with less neps and short fibre content than saw ginned cotton, which resulted in a more even and stronger yarn, although not significantly so. Further trials conducted at CTFT have shown that as one produces finer yarns i.e. < 10 tex (> 60 Ne) differences in yarn quality between these same blend ratios become more acute. It must be further borne in mind that there are a number of commercial limitations with roller ginning; it is almost twice as expensive as saw ginning, cannot cope with large volumes, has a lower gin turn out and Upland cottons are more difficult to gin which can cause extensive damage to roller gins.

The results from this investigation also show that Pima cotton blends containing up to 30% saw or roller ginned Sicala 350B can produce fine count yarn of 10 tex that, whilst not statistically as strong as 100% Pima yarn, are not significantly different in tensile properties. Yarn evenness and imperfections were not significantly affected at any blend ratio, with the level of noil removed during combing having a more pronounced affect on these properties than the blend ratio. Although the blends do increase the amount of waste by 0.5% this is offset by the savings on raw material costs, which according to Figure 5 can amount to as much as 20%. Commercial trials will be conducted in 2008 with a large vertical textile manufacturer in Asia to verify the results achieved in this initial study.

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DEVELOPMENT IN GOOD AGRICULTURAL PRACTICES FOR COTTON IN BRAZIL

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I would like to approach the question of GAP (Good Agricultural Practice) from a rather different angle, than the rather obvious environmental approach, of which we hear so much today, but rather start out from the marketing side of the cotton business. This figures since in the end GAP is a marketing tool, a way of convincing the consumer to buy our product.

However the real difference is that I shall start with the negative cotton marketing, as we are being flooded with advertisements extolling the virtues of “alternative” cotton, without, as yet, criticizing directly the processes used in the production of cotton.

Now added to this, criticism has arrived in the form of a new force to also challenge cotton’s traditional place in the market. Organic Cotton.

For Christmas I received a garment with a label, which reads as follows.

NEXT Organic Cotton

Organic cotton is grown without using environmentally harmful chemicals and pesticides.

This product has been made with Organic Cotton.

In buying this product you are helping the environment and encouraging a more sustainable way of growing cotton world wide.

Independent farmers in developing countries around the world will benefit from you buying Organic Cotton from NEXT.

Ladies and Gentlemen, cotton, organic cotton, or genetically modified (GMO), is inert, and dead, and the method of cultivation is totally indistinguishable in the end product. So that any claims about the product being safe, environmentally friendly or even based on fair trade, is impossible to prove one way or the other. However this propaganda is very negative, since by inference conventional cotton is unsafe, environmentally unfriendly and the farmers are robbed of their production.

Today the best estimates show that only 23,000 tons of pure certified Organic Cotton is being produced, however all the retailers of the world are selling vast quantities of textiles claiming their product is organic, when in many cases it contains only small percentage of organic cotton in the blend. So the question, how that will benefit independent farmers around the world is hard to respond.

“Feel the softness and purity of organic cotton” we are told, whilst the chemicals and social conditions used in textile processing are apparently not considered in the final product, generally using chemical processes, which will surely make it totally “non-organic”.

This type of marketing is as damaging and degrading for conventional cotton, as are the so called better than “cotton” synthetic fibres

In the end whether it is man made fibres or organic it is all retailers’ propaganda and pressure for something new to force down the throats of the consumer, without any fundamentals to support their claims.

Undoubtedly the arguments for the ideals of organic cotton are valid, but little emphasis has been placed on the sustainability in terms of income, as the high cost, and the reduction in yields make it likely to become un-sustainable.

We believe that instead of misleading information, we need to emphasize and work for the sustainability of cotton growing through GAP. Undoubtedly the allegations of the extensive use of agro toxic products polluting soil and ground water have caught the media attention which needs to be placed in proper perspective.

Also certainly the concept of fair trade protecting the social aspects of cotton production is also valid; however we are convinced that these two objectives, organic principles and social responsibility, (including income) cannot be separated if we wish to achieve sustainability.

However social responsibility is not only question of fair returns for growers, there are other factors, the greatest of which, and cannot be over emphasised is education. Without education, protection of the environment is an impossibility. Therefore we must be looking at, social responsibility and sustainable principles all in one as GAP.

Even so whether we like it or not, we will have to focus on the retailers demands (in the name of their customers), and so we are posed with the question of how Brazil can meet the retailers’ challenge, and create a positive image..

Our concept of Good Agricultural Practices is built on four pillars

- Protect the health and well being of current and future generations.
- Sustain and enhance the health of soil, plant, animal, and human all as one.
- Be based on living ecological systems
- Build on relationships that ensure fairness with regard to the environment

Regarding point one, Brazil has had social programs for years to protect the farm workers, as well as GAP programs for sustainability for the other points. So, resigned now to draw closer to the retail pressure, AMPA in Mato Gross introduced amongst its members a voluntarily audit and certification system, initially covering these social aspects, and including education as a away of achieving full sustainability over the years.

To this end AMPA formed Instituto Social de Algodão, (ISA) or Institute for Socially Responsible Cotton Production, which together with the official appointed auditors will certify that the production of each bale has complied with all the requisites and rules of the program.

For example the certification specifically guarantees that no forced labour has been used, including even voluntary forced labour, and no under aged children have been employed.

To receive this certification, and have the right to place this label on all the cotton bales produced, those certified must also not have retained any portion of workers salary, benefits acquired as stipulated by law, nor withheld any documents belonging to workers, so as to force them to work or stay on the farm, either as overtime or as a disciplinary action.

The certificate also assures that there is a specific laid down policy by the farm owner. This policy stipulates the rights and responsibilities of the workers and administration staff, including the living conditions, and the services to be performed. The policy must also include the availability of professional health provisions, security, and opportunities for training, for all the employees.

The certification guarantees that there will have been no influence applied in regards to matters political, religious, or cultural orientation, and labour will have been contracted directly, not though a contractor.

There will have been no discrimination, by colour, sex, religion, social class, political inclinations, nationality, member of a union, sexual orientation, married or single or whatever motive.

The certification will have verified that all the employees respect and support the indigenous natives in region. Also encourage in regional schools, a positive attitude towards preserving the environment.

It will also be required that all labour employed in cotton gin, even if gin not the property of the certified, is supplied with appropriate clothing helmets and shoes, and receive adequate training in safety measures.

The auditors for this certification is the renowned ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS

Such programs and certification being created by private enterprise rather than governmental requirements, maintain, we believe total credibility. To obtain certification the rules have to be obeyed by all who participate, rather than following government measures, which normally result in the predictable human reaction to undermine or disobey the law.

With these programs Brazilian cotton will achieve a level of guaranteed sustainability superior even to organic or fair trade cotton. Since we shall produce cotton certified to covers all their laudable intentions even better, because apart from being sustainable the measures will be cost effective, allowing not only the rich and privileged the right to clear their conscience by paying a hefty premium for special “friendly” green products, but also the man in the street can be assured that cotton is not participating in the destruction of the social order and the environment of the planet.

Andrew Macdonald

29th International Cotton Conference
BREMEN

April 2 - 5, 2008

Session III: Panel Discussion - Sustainability in Cotton Production

Chairman:

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ACSA, Washington DC, USA

Participants:

Michael Arretz
Systain Consulting GmbH, Hamburg. Germany

Don Cameron
Terranova Ranch, Inc., Helm, CA, USA

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Mark Messura
Cotton Incorporated, Cary, North Carolina, USA

Dieter Overath
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Helvetas, Zurich, Switzerland

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29th International Cotton Conference BREMEN

BREMER BAUMWOLLBÖRSE BREMEN

April 2 - 5, 2008

Session IV: Cotton Trade, Economics, New Products

- ***Polyester staple fibre production and processing***
  Thomas Gries
- ***Detection of genetically modified cotton in raw material and cotton products***
  Lothar Kruse
  Hermann Rüggeberg
- ***Innovations for cotton products***
  Mark Messura

POLYESTER STAPLE FIBRE PRODUCTION AND PROCESSING

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ABSTRACT

The fibre structure of synthetic filaments is realized during the polymer spinning process only after the polymer is extracted through the spinneret and the properties are determined by the processing parameters selected during production. The further processes which can have an influence on the fibre properties only change the structure which was initially delivered at the polymer spinning process. The manufacturer of synthetic fibres guarantee the uniform quality of the fibres based on constant production parameters and also quality control techniques in testing laboratories. For the tests at laboratory scale fibres are tested with sample sizes of a few grams which represent 1 ppm of an entire days production. Inspite of these strict quality control parameters often fibres are manufactured where the processing properties are quite different for the same fibre type. Among other fibre parameters, the crimp and the fibre spin finish are the decisive quality parameters for PES staple fibres. Amazingly the spin finish levels vary within a single bale of fibres produced. In the AiF project 13642N the influence of the spin finish and crimp of fibres on the processing behaviour of polyester fibres was studied in details. Using methods to determine the crimp and spin finish levels of fibres the process was replicated at laboratory levels and the process behaviour were understood. In the project certain pragmatic test methods for evaluation of spin finish content and crimp were arrived upon.

INTRODUCTION

The fibre consumption is a function of the development of mankind. The increase in population is a predominant contributor to this development. In order to meet these growing requirements synthetic fibres have evolved over the years.
Polyester fibres in both the filament and staple fibre form comprise a significant share of the synthetic fibre market [John 00, Egb 97, NN 02]. For the year 2006, the sale of Polyester fibre touched about 27 Million tons which is equivalent to the sum of the consumption of all natural fibres excluding bast fibres (see fig. 1). This signifies the widespread usage of polyester fibres in the industry.

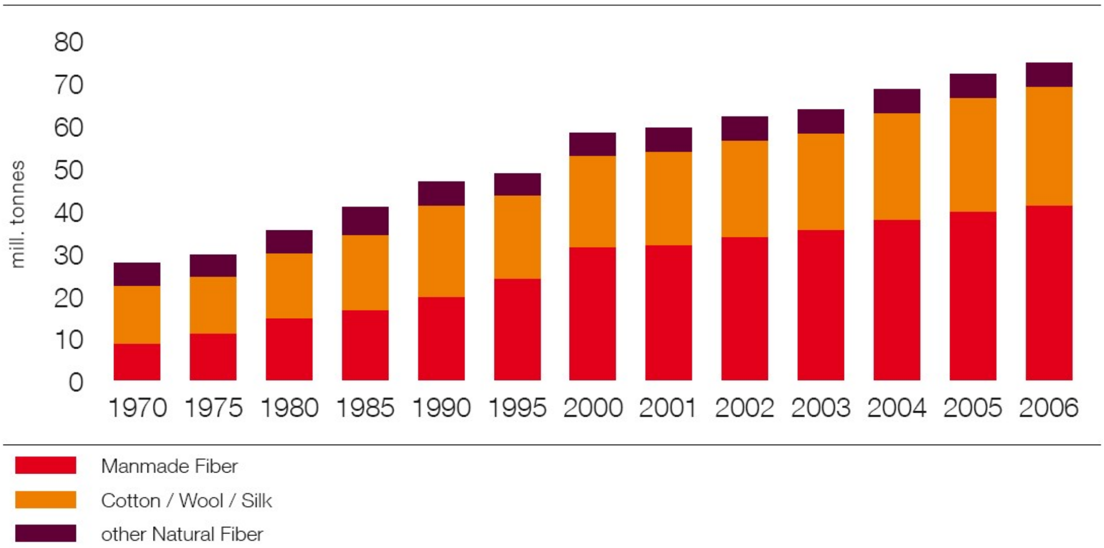

Figure 1: Worldwide fibre consumption [Oer 07]

POLYESTER STAPLE FIBRE PRODUCTION

PROCESS

The high modulus high tenacity (> 65 cN/tex) polyester fibres are commonly known as cotton type polyester fibres [Fou 95].

For the production of staple fibres the filaments are joint together into tow of up to 350 ktex at spinning rates of 1000-1500 m/min. Both direct spinning plants and extruder spinning plants are used for this purpose. The layering of the tow often place in large cans which then can be discontinuosly further processed in a fibre street (see fig.2). The continuous further processing up to the bale stage is profitable in the production of large batches and while using compact spinning plants. The tow is drawn between multiple cylinder drafting rollers whilst adding heat. Then it will be heat-set, treated with a finishing agent and crimped by means of stuffer-box. Afterwards it is cut to the required fibre length in a cutting device and is pressed into a bale form. During this process outlet speds of up to 300 m/min are reached [Tet 93].

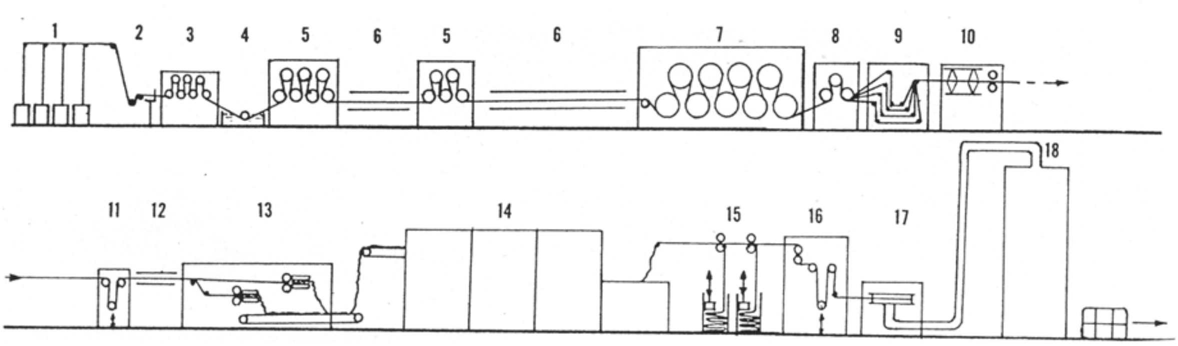

Figure 2: Scheme of a polyester fibre street [Rig 81]

FACTORS EFFECTING PROCESSING BEHAVIOUR

It is seen that crimp and spin finish have a great influence on the processing behaviour along the staple fibre processing line [Mäh 04]. These two factors will be explained in the following.

Spin finish application

The application of finish facilitates a problem free processing along the spinning line. Basically there are two ways to applicate the finishing chemicals: by applying it on the undrawn filament during the spinning process which is commonly known as spin finishing and by post finishing of the fibre tows [Fal 81].
The chemical finish on the fibres helps in reducing the dynamic friction between fibres (fibre-fibre friction) and between fibres and metal (fibre-metal friction).
It also helps in reducing static generation and protects the fibre surface.
The typical problems associated with the spin finish levels is the presence of insufficient finish or uneven finish which results in high drawing forces.
During the application of spin finish, a water based solution containing a low percentage of finishing chemicals is administered on the undrawn filament. The tow is then filled into a can and taken off for the next processing steps. The application of spin finish is necessary for a good handling of the fibre tow. Within a can the low viscous finish tends to sink down to the bottom. This can be a reason for an uneven distribution of the finish along the fibre tow. Actually this should be balanced by the following post finishing process. [Kro 07]
In the first step of the post finishing the fibre tow is pulled through a trough filled with finish. The fibre tow is then squeezed with the help of squeezing rollers. This could be a single stage process (single dip single nip) or a double stage process (double dip double nip) (Fig. 3 a). Another method of finish application is by spraying the fibres with the finish solution (b). In this method too, squeezing rollers are used to take the excess finish out of the fibres. For fibre tows normally troughs are used with finish in it [Vei 07]. At the end of the post finishing process the fibres are again either sprayed with finish before or after they are cut. Especially the spraying of finish with a concentration of 5-6 % before cutting is common. This last finishing process determines the amount of finish on the PES staple fibre [Kro 07].

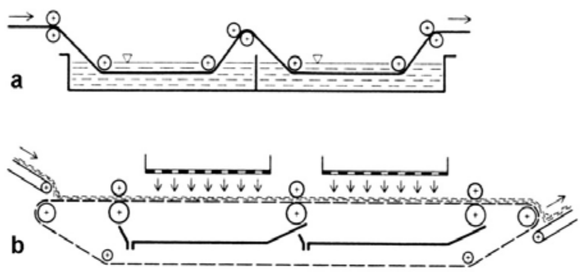

Figure 3: Schematic diagrams of methods for application of spin finish to fibre tows [Vei 07]

Crimping process

The most important crimping method for spun fibres is the stuffer box mechanism where the uncut fibre tows are crimped by applying pressure and heat. In this mechanism the fibre tow is pressed in a stuffer box with the help of rollers (see fig 4), which apply pressure on the fibres. By pressing the fibres against the feed rollers the fibre tow is folded and finally crimped.

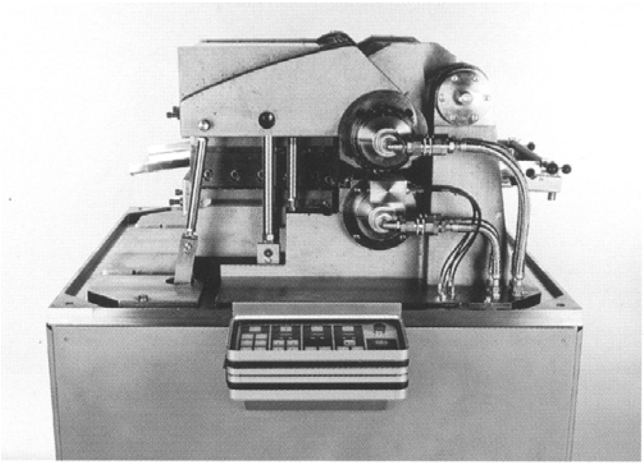

Figure 4: baltic crimper [Neu 07]

The pressure and temperature play a vital role in deciding the crimp of the fibres. These parameters can be regulated in a stuffer box. All processing parameters including the amount of fibre and the width of the fibre tow along with the temperature and pressure within the stuffer box must be held constant in order to achieve constant crimp levels.
The number of crimp structures per unit length is mainly determined by the pressure in the stuffer box. The consistency of the crimp depends on the stuffer box temperature, which helps in thermo-fixing the crimp in the fibres and the relation of the feed and delivery velocity. In order to achieve higher consistencies certain additional thermo fixation is necessary.

QUALITY ASSESMENT OF DECISIVE FIBRE PARAMETERS

In order to achieve constant quality of staple fibre yarns, the manufacturers use different quality control checks. One option is to test fibre samples, which have been taken from the production line, for properties in a laboratory. The machine parameters are then set depending on the properties which have been determined. The other option is to control fibre properties with the help of sensors and control systems.
One of the biggest disadvantages of the former method is the time lag between the analysis of products in the laboratory and the necessary correction in the machine parameters. This therefore results in a high rejection of the manufactured products. Another risk involved is the volume of the sample which had been taken into consideration. This is because a typical sample comprises of only about 8-10 g

material as against an entire days production of hundreds of tons [Sch 04]. This reflects in the fact that polyester fibres with similar test results, depict varying processing behaviour [Fis 01].
Online quality checks are employed for the following fibre parameter.

- Fibres with excessive length, which normally offer a problem (e.g. Lapping of the drawframe roller) are prevented by controlling the cutter wheel (e.g. pressure of draw roll)
- Furthermore a system can be developed which would help with the online measurement of fibre crimp. This could be accomplished with the help of an optical sensor, an intelligent camera and also a central controlling system [Sch 03]. There is also a possibility of measuring the samples at-line wherein the samples are measured for crimp levels [Tim 04]

However, there exist potential avenues for development of quality assessment techniques which have not yet been addressed.

- Normally there is no information regarding the temperature along a spinning line. Hence, there is a possibility to measure the temperature of the fibre tows before specific processes such as fibre conditioning to control the temperature homogeneity
- There is also a lack of information on the measurement of spin finish levels. The spin finish applied normally directly influences the processing behaviour of the fibre tow [Fis 01]
- The initial tension of the fibre tows before being passed through the stuffer box is not monitored. This influences the tow regularity and also the crimp levels in the fibres

PROCESSING OF POLYESTER STAPLE FIBRES

Polyester staple fibres are delivered in the spinning mill in the form of bales and are further processed in mixtures with e.g. cotton. During the processing stages some phenomenon takes place and have been clarified further on.

CHARACTERISTICS IN EACH PROCESS STEP

Disturbances and problems in the fibre processing emerge at different process stages. These problems originate through the processing properties and parameters of fibre tows. They are categorised as product specific problems (e.g. tow cutting, willingness to open, nepping potential, unevenness and problems with attenuation) and process specific problems (e.g. lapping of rollers, fibre fly, spinning breakages). The processing properties (e.g. fibre friction, electrostatic generation, gluing tendency) are influenced by many fibre specific properties. Properties such as fibre fineness, fibre tensile strength, fibre flexural rigidity, fibre cross-section, length and crimp and quantity of spin finish are the influencing factors [Egb 80, Ehr 81].

The typical processing problems of the polyester staple fibre along with their probable reasons as experienced by polyester industry are briefly described in table 1.

Table I

Machine	Position	Expected Problem	Probable Reason
Card	Upper chute	Fibres stick to the chute wall	Static generation among fibres
	Feeding plate	Chocking	Fibre lapping
	Licker-in	Fibre lapping	Lubricated fibres
	Main carding zone	Chocking	Melt points
	Fibre transfer between cylinder and doffer	Generation of neps	Uncontrolled fibre transfer
	Fleece transfer / sliver formation	Lapping	Static generation among fibres
Drawframe	Drawframe	Drafting problems	Uncontrolled attenuation of fibre slivers
	Delivery rollers	Roller lapping	Static generation among fibres Excessive heating of the rollers
	Coiler tube	Chocking	Chocking
OE- Rotor spinning	Opening roller	Roller lapping	Lubrication due to excessive spin finish
	Fibre transport tube	Chocking	Deposition of spin finishes
	Rotor	Yarn break	Deposition of spin finish in the rotor ring
	Navel	Yarn break	Melt points
Ring spinning	Drafting	Drafting problems	Uncontrolled attenuation of the roving
	Drawframe delivery roller	Roller lapping	Static generation among fibres Excessive heating of the rollers
	Spinning triangle	Yarn break	Minimal fibre fibre friction
	Traveller	Unevenness/yarn break	Melt points due to the heating up of the ring

RESEARCH AND RESULTS

In AiF project 13642N investigation were carried out to determine how the processing parameters are dependent on the levels of spin finish and crimp. The importance of the interdependence between the two properties and their influence on processing was evaluated. It was observed that there were high variations in the spin finish levels within a spinning mill (s. Fig. 5) as compared to the samples prepared in a laboratory (s. Fig. 6).

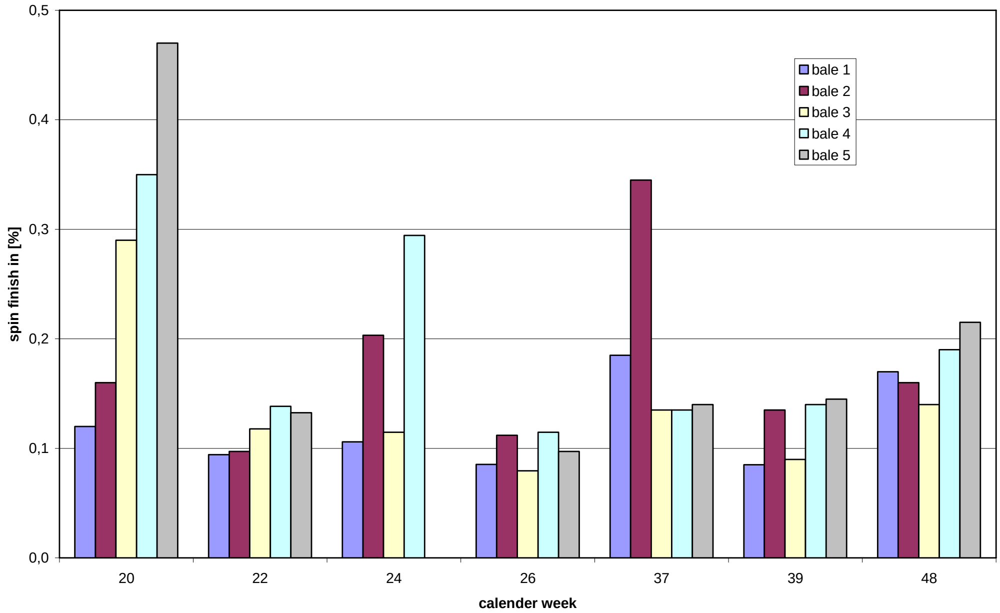

Figure 5: Spin finish levels in different bales in a fibre spinning unit

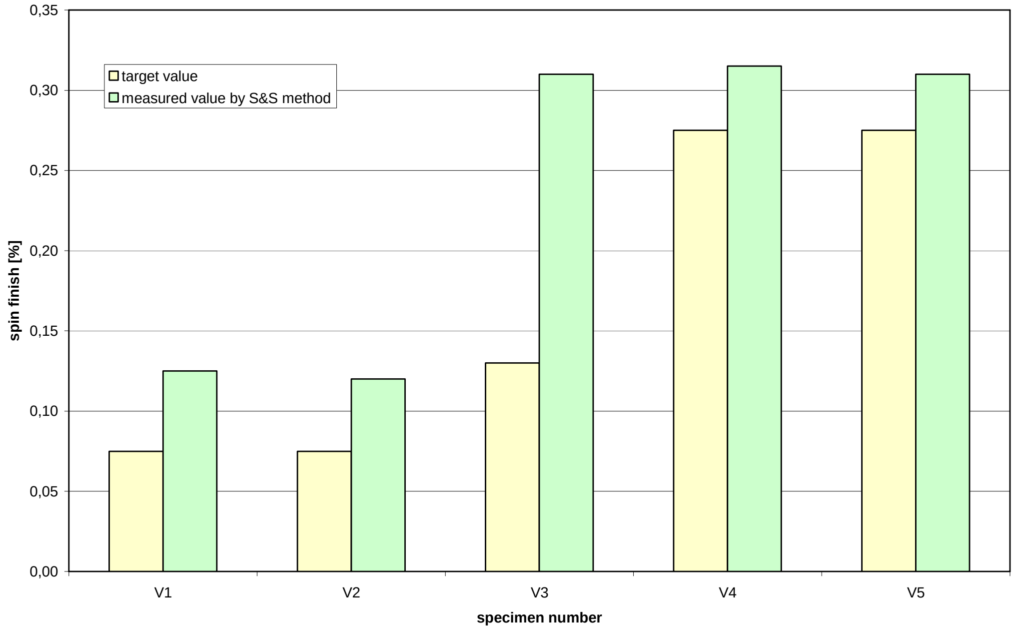

Figure 6: Spin finish levels from different production methods

The investigation of processing behaviour revealed interesting results which are summarised as follows.

The following interdependencies were observed in the **OE- Rotor spinning** process

- The spin finish level has a strong influence on the processing behaviour (e.g. roller lapping and chocking of machine parts), however it is not translated to the yarn quality
- The influence of the crimp levels on the processing behaviour is not significant because the fibres undergo drafting
- Depending on the processing behaviour, the optimal spin finish levels of fibres lie between 0.15% and 0.23%

For the ring spinning process the following interdependencies have been observed:

- Crimp and spin finish do not pose a problem during processing in contrast to the rotor spinning process
- The crimp levels have an influence on the ring yarn quality – more crimp results in a significant reduction of yarn quality
- A change in the spin finish levels does not essentially bring about a change in the yarn properties

The results from the **opening and cleaning** processes along the spinning line can be expressed as follows:

For rotor spinning the prerequisite is a sliver with high eveness. The sliver eveness does not play a crucial role for the ring spinning process. Because the properties such as fibre length, fibre hooks within the sliver are more important and influence the yarn quality.

- Spin finish and crimp influence the coefficient of variation (CV) of the fibre sliver in a contradictory way
- A rise in the spin finish amount above 0.20% has a negative influence and a crimp intensity over 14.5 crimps per 25 mm have a positive influence on the sliver quality.
- An ideal fibre for smooth processing on the Card could be characterised as having a spin finish of about 0.20 % and a crimp level of about 17 crimps per 25 mm

FUTURE SCOPE

In the Aif project 13642N certain pragmatic test methods for evaluation of spin finish content and crimp were arrived upon. These methods provide the spinner with the possibility to track down the fibre properties to his raw material. To facilitate the necessary fibre property measurements some methods are developed. Such as:

1. Investigation of the fibre sliver width (indicator of crimp)
2. Investigation of static generation (indicator of spin finish)
3. Investigation of the nepping potential of the fibres (indicator of interaction between crimp and spin finish) and
4. Investigation of the fibre metal friction (indicator of interaction between crimp and spin finish)

With the help of the these methods it is possible to mix bales with e.g. high / low level of spin finish to batch with medium levels of spin finish.

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DETECTION OF GENETICALLY MODIFIED COTTON IN RAW MATERIAL AND COTTON PRODUCTS

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Since 1996 when the first genetically modified plants (gm) were planted in the USA for commercial use the worldwide cultivation of gm plants has tremendously expanded. The complexity of global markets and the rapid expansion of genetically modified plants aggravate the problem for the industry to get pure conventional raw materials.

Genetically modified crops are mainly cultivated in the United States, Argentina, Brazil, Canada, India and China. Today gm plants are grown on nearly 110 million hectares, more than half of it in the USA. Soya, maize, rape and cotton are still the dominant gm plants but more than 150 different plants have been genetically modified so far.

Gm cotton has become widespread, covering a total of nearly 14 million hectares in 2007, or 40 percent of the world's cotton cultivation. Most gm cotton is grown in the US, China and India.

In the European Community there are clear regulations for the approval and labelling of genetically modified food- and feedstuffs. Though cotton is primarily important for the textile industry it is more than just a fibre for textiles. Cotton is also an important source of raw materials used in animal feed and for various processed food ingredients. The protein and oil-rich seeds can be processed into various side-products, e.g. cooking or frying oil, margarine, vitamin E, cottonseed meal as animal feed and food additives like cellulose or methylcellulose are used as thickeners, stabilisers, emulsifiers or fillers.

The precise and reliable identification of genetically modified components is important for legal and commercial reasons as well as in view of consumer protection.

Therefore it is of the greatest importance to have reliable, specific and sensitive analytical tools. Many areas of biomedical research, diagnostics and routine examinations are no longer imaginable without molecular biological methods. Especially the PCR method (Polymerase Chain Reaction) is becoming increasingly important. In most cases it would be impossible to detect evidence of genetic modifications without PCR, which is why this method is made imperative in national and EU-regulations.

In this presentation the principle of the analytical procedure is explained, the advantages and limitations are discussed and examples of cotton products we have analysed so far are given.

INNOVATIONS FOR COTTON PRODUCTS

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Editor's Note

A written paper was not provided by the author prior to the conference.

FASERINSTITUT FIBRE BREMEN

29th International Cotton Conference

BREMEN

April 2 - 5, 2008

Session V: Cotton Properties, Cotton Testing

- ***The ITMF cotton contamination survey 2007***
  Christian Schindler
- ***Results of a study of length and neps measurement with Premier aQura***
  Axel Drieling
- ***Improvement of maturity ratio measurement of cotton fibres***
  Piao Yan
  Zhijie Zhang
- ***On-line measurement of fibre length in the gin***
  Hossein Ghorashi
- ***Cotton fibre linear density and maturity measurement and application***
  Stuart Gordon
  Geoffrey Naylor

ITMF COTTON CONTAMINATION SURVEY 2007

C. Schindler
International Textile Manufacturers Federation
Zurich / Switzerland

ABSTRACT

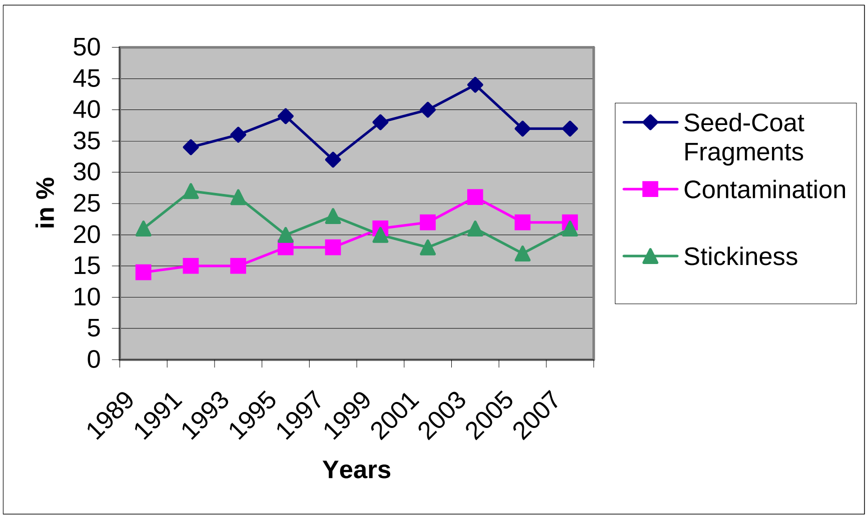
The global ITMF survey on cotton contamination in 2007 showed that in the perception of spinners from around the world contamination remains a serious problem. During the past 18 years the degree of contaminated cotton was increasing steadily from 14% to 22%. Organic matters are still the main contaminants, followed by fabrics of cotton and plastic film and strings of jute and plastic film. Cotton growths from India, Turkey and some West African countries like Togo or Mali are among the most affected ones, while cottons from the USA, Australia, Israel (Pima), Brazil and Cameroon are least affected. In the case of stickiness the situation has slightly improved in the past few years compared to previous surveys. Nevertheless, in 2007 still 21% of all cottons were reported to have moderate or serious stickiness problems. The most sticky cotton originated from Benin, Cameroon, Uzbekistan, Burkina Faso, Mali, the USA (Pima and Others) and India (J-34). Not affected at all by stickiness in 2007 were cotton varieties from Greece, India (H-4) and Turkey (Izmir). The level of seed-coat fragments in 2007 remained unchanged at 37% which was significantly lower than the record level of 44% in 2003 but still higher than the record-low of 32% in 1997. 80% of the cotton growth LRA from India was affected by seed-coat fragments, followed by medium staple cotton from Uzbekistan and cotton from Chad with 75% and Benin's cotton with 70%. On the other side of the range were the descriptions from USA-Texas High Plains (5%), Australia (11%) and USA-California (11%).

INTRODUCTION

In 2007 ITMF has once again conducted a world-wide survey on cotton contamination - the tenth survey since the set up of a solid methodological basis in 1989. The survey is based on a questionnaire and the respective answers show how cotton spinners from around the world perceive the quality of the cotton as far as contamination, stickiness and seed-coat fragments are concerned.

By looking at the latest results and comparing them with the previous ones it is possible to identify short-term changes as well as long-term developments. The main trends since 1989 are the following:

- First, the level of contamination rose from 14% to 22%, an increase of almost 60%,
- Second, with 21% the level of stickiness in 2007 rose by 4 percentage points compared to 2005 reaching the level of 1989.
- Third, the occurrence of seed-coat fragments in 2007 remained unchanged compared to 2005 at the long-term average of 37%. The lowest level of seed-coat fragments was reached in 1997 with 32%.



What was the basis of the survey and how did it change compared to the previous one?

Participation in 2007 fell from 152 to 114 spinning mills, a reduction of around 25%. The decline was mainly the result of fewer Turkish, Brazilian and Korean mills participating in the survey. The 23 countries covered by the survey represent approximately 39% of total world cotton consumption at mill level.

The 114 participating spinning mills have evaluated cotton samples from 72 varieties, of which 32 were considered for the survey. The remaining 40 varieties had to be neglected since the number of evaluations were less than 5 for each of them.

The total number of evaluated samples continued to drop to 552 from 716 in 2005, which is mainly due to rising concentration of the cotton spinning industry in cotton producing countries where mills use mostly domestic varieties. The 27 spinning mills from Egypt only evaluated 27 samples, a ratio of 1:1, the 8 Brazilian spinning mills evaluated 13 samples, a ratio of 1:1.6 and the 10 US spinning mills evaluated 31 samples, a ratio of 1:3.1. In contrast to these cotton producing countries the ratios of cotton importing countries were significantly higher. Germany had a ratio of 1:7.0, Korea of 1:7.8, Taiwan of 1:8.0 and Belgium even one of 1:10.5.

After outlining the major trends and the basic conditions let us have a closer look at the different topics: contamination, stickiness and seed-coat fragments.

Contamination

After a continuous increase of cotton contamination since 1989 the level of contamination fell for the first time in 2005 to 22% and remained at this level also in 2007. In 1989 only 14% of the cotton was considered to be contaminated by at least one of the 16 sources identified in the survey. This number rose steadily to 26% in 2003 before declining to 22%.

The biggest source of cotton contamination in 2007 remained organic matter such as leaves, feathers, paper, leather, etc. which affected 40% of all cotton. On the other side of the range only 5% of the cotton was contaminated by tar. Other sources of high contamination in 2007 were fabrics made of cotton (30% - slightly lower than in 2005), strings made of jute (29% compared to 25% in 2005) and plastic film (29% compared to 26% in 2005).

In 2007 India was the country with the highest degree of contamination. 45% of all Indian varieties were affected compared to 40% in 2005. The level of contaminated Turkish cotton fell from 45% in 2005 to 32%. The Central Asian countries were able to further reduce their contamination level from 25% in 2005 to 22% in 2007. The level of cotton contamination in Brazil dropped in the same period from 21% to 12%. In West Africa the contamination level increased slightly from 19% to 22%. At the top Israel dropped from first place in 2005 with 10% contamination down to sixth place with 9%, while the cotton growths from the USA (Memphis Territory, Texas High Plains, Others, South Eastern) and Australia showed even lower contamination levels between 6% and 8%.

Considering the main cotton growing regions in the period between 1989 and 2007 it becomes obvious that the extent of contamination has increased significantly in most regions. The development in Central Asia since 1989 shows a clear trend of deterioration, which seems to have come to an halt though on a relative high level. The same applies to Turkey though on a lower level. With the exception of 2005 the degree of contamination of West African cotton growths increased steadily between 1995 and 2007. After reaching record highs in 2005 both US and Brazilian cotton growths reported much lower levels of contamination in 2007compared to 1989. After a significant reduction in 2005 Indian and Egyptian cotton growths showed again higher levels of contamination in 2007 compared to their levels in 1989, though in the case of India the absolute level of contamination is still relatively high.

After looking at contamination let us now turn to stickiness and seed-coat fragments and their long-term trends.

Stickiness and Seed-Coat Fragments

With regard to stickiness – blue graph – one can see that there have been ups and downs in the past but that the level of stickiness fell over time. On the other hand the level of seed-coat fragments – red graph – rose most of the times and the long-term average is above the initial level in 1991. The two trend lines show nicely the decreasing level of stickiness since 1989 and the increasing level of seed-coat fragments since 1991.

Let us now look in more details at stickiness.

Stickiness

In 2007 cotton from Benin was the most affected by stickiness (60%). With 50% Cameroon cotton was perceived also as a relatively sticky cotton followed by cotton from Uzbekistan (40%), Burkina Faso, Mali and USA-Others (33%, respectively). Cotton descriptions not or hardly affected at all by stickiness came from different areas around the world: Greece (0%), H-4 from India (0%), Izmir from Turkey, (0%) and Giza from Egypt (2%).

In all the larger growing areas the level of stickiness could be reduced. The Central Asian cotton proved to be less sticky in 2007 than in 2005 - 22% compared to 29%. Stickiness of West African growths on the other hand jumped from 22% to 36%, while that of US varieties remained more or less on the same level of around 20%. Stickiness of Brazilian cotton jumped from only 12% to 29% as did cotton varieties from India though on a much lower scale – from merely 5% in 2005 to 15% in 2007.

In the historical perspective the degree of stickiness of all cotton growths covered in the survey reached 21% in 2007 which is higher than the record low of 17% in 2005 and around the average of the past 10 surveys since 1989.

Looking at the various cotton regions and using an index where the level of stickiness in 1989 is equal 100 one can see whether a specific region was able to reduce the perceived level of stickiness over time. After a continuous decline in the level of stickiness since 1999 Indian cotton growths experienced in 2007 a relative strong increase from 42% to 106%. The same applies to Brazilian and West African cotton where the level jumped from 57% and 62% to 138% and 104%, respectively. In the US the level of stickiness rose only slightly from 87% to 100% which indicates that stickiness is as much a challenge in 2007 as it was in 1989. Only the stickiness level of Central Asian cotton fell since the last survey in 2005 from 102% to 77%.

Seed-Coat Fragments

The overall level of seed-coat fragments remained in 2007 at its 2005 level. After a record high in 2003 it dropped considerably to the long-term average.

With 100% of all evaluated cotton affected Paraguay was topping the list in 2007. With 50% or more Turkish (69%), Central Asian (56%), Indian (55%), Zimbabwean (55%), West African (51%) and Nigerian (50%) cotton descriptions still showed a relative high level of seed-coat fragments. Of other major cotton areas the level in the USA dropped from 36% in 2005 to 22%. Australia was able to further reduce the level from 17% to only 11%.

The long-term development shows that only the US and Indian cottons have improved their records compared to 1991. In West African descriptions the presence of seed-coat fragments has increased strongly both compared to the index year 1991 and compared to 2005. In Brazilian cotton the presence was reduced compared to 2005 but is still slightly higher than it was in 1991. In the perception of spinners Turkish cottons have recorded the highest level with regard to the presence of seed-coat fragments since 1991. Though Central Asian cotton showed some improvements, seed-coat fragments are still a big problem. Egyptian cotton recorded a higher level though it is still considerably below the one of the index year 1991.

Summary

The results of the Cotton Contamination Survey 2007 indicate that contamination, stickiness and seed-coat fragments are still major issues to the spinning industry. While some cotton growing areas showed some major improvements, others were faced with higher level of contamination, stickiness and/or seed-coat fragments. This shows that a lot of work lies still ahead for the cotton industry as a whole to bring the numbers further down to more acceptable levels.

Cotton Contamination Survey 2007

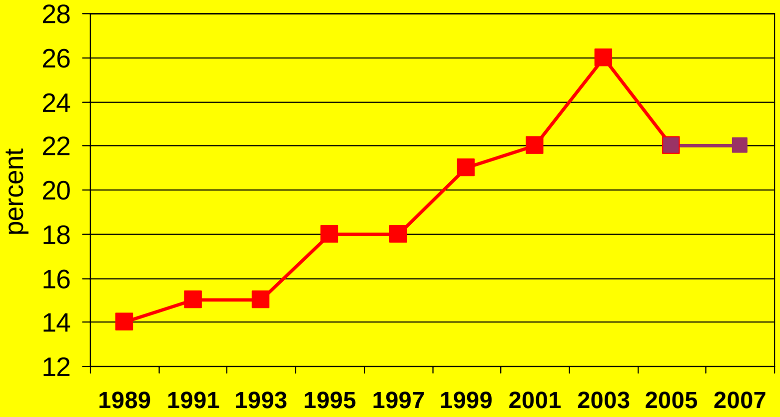
Cotton Contamination Survey

2007

1

Cotton Contamination Survey 2007

Degree of Contamination



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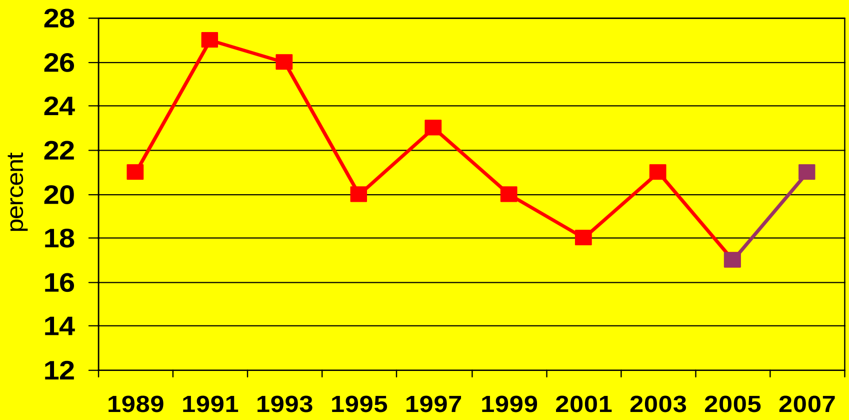
ITMF Cotton Contamination Survey 2007

Stickiness



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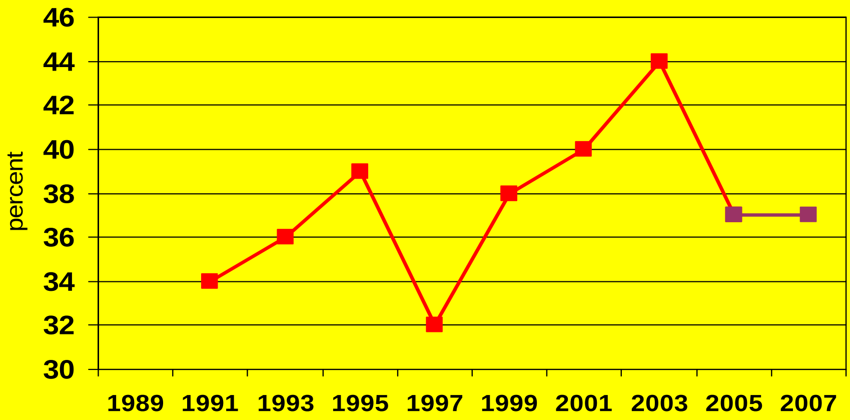
ITMF Cotton Contamination Survey 2007

Seed-coat Fragments



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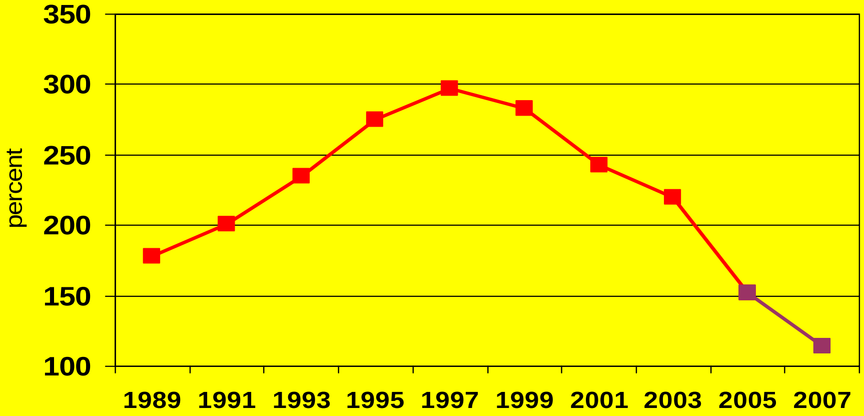
ITMF **Cotton Contamination Survey 2007**

Participating Companies



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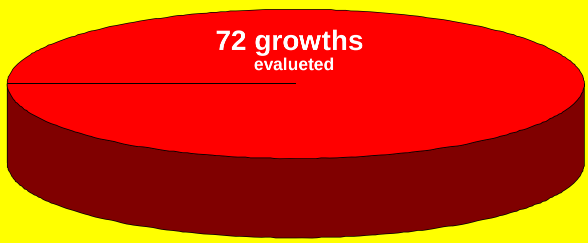
ITMF **Cotton Contamination Survey 2007**

Evaluations



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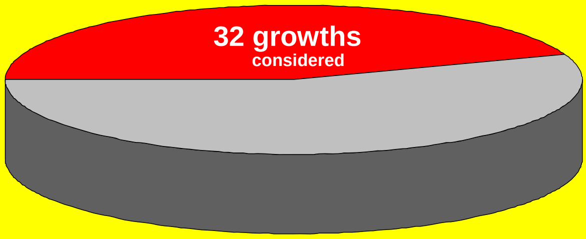
ITMF Cotton Contamination Survey 2007

Evaluations



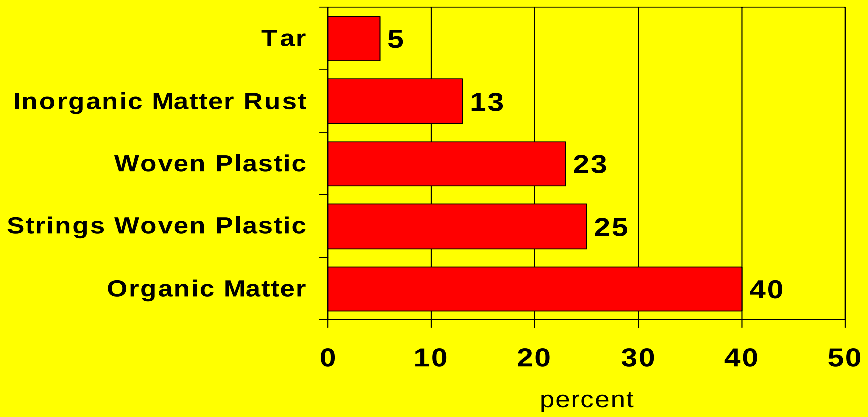
ITMF Cotton Contamination Survey 2007

Mill Location vs Sample Volume

Country	Particip. Mills	Samples	Ratio
Egypt	21	21	1:1.0
Brazil	8	13	1:1.6
USA	10	31	1:3.1
Germany	5	35	1:7.0
Korea	5	39	1:7.8
Taiwan	4	32	1:8.0
Belgium	4	42	1:10.5

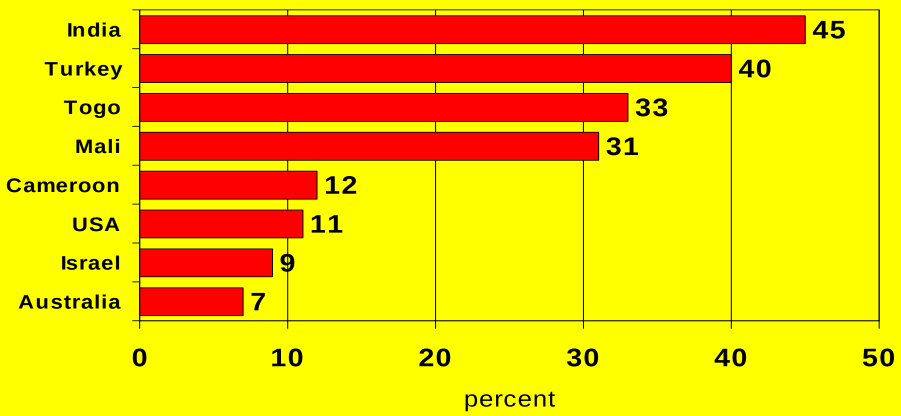
ITMF Cotton Contamination Survey 2007

Cotton Contamination by Source 2007



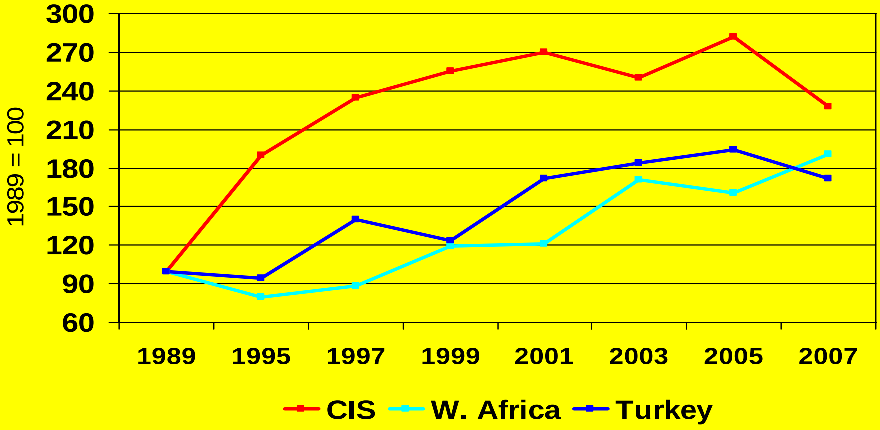
ITMF Cotton Contamination Survey 2007

Cotton Contamination by Origin 2007



Cotton Contamination Survey 2007

Cotton Contamination by Origin 2007



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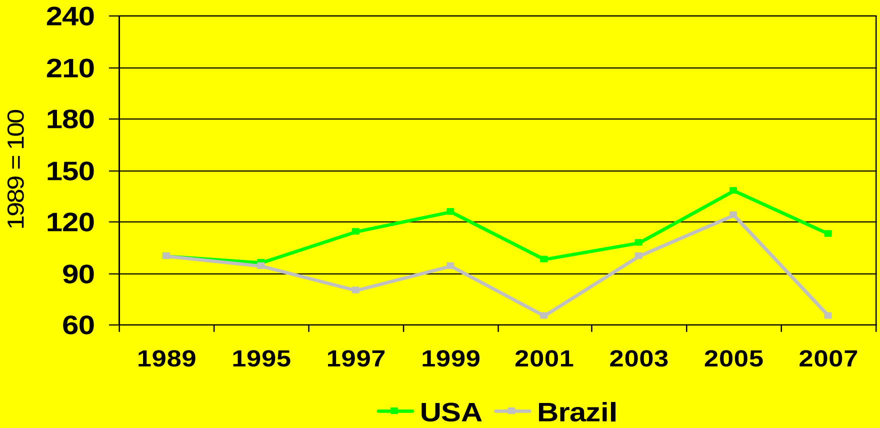
Cotton Contamination Survey 2007

Cotton Contamination by Origin



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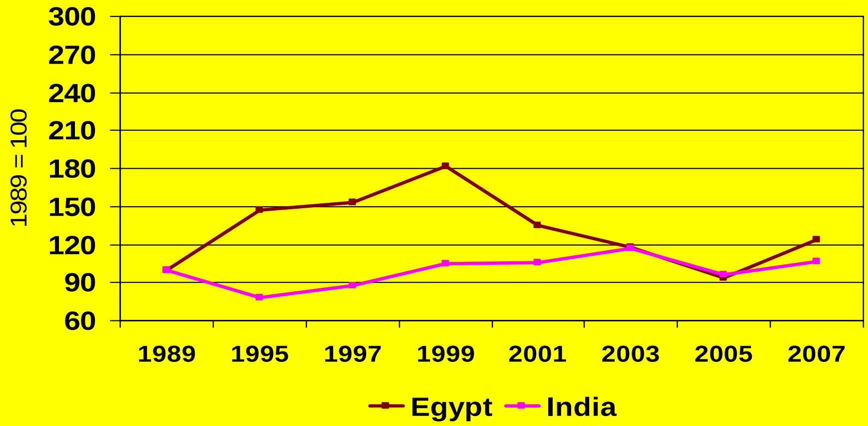
ITMF Cotton Contamination Survey 2007

Cotton Contamination by Origin



ITMF Cotton Contamination Survey 2007

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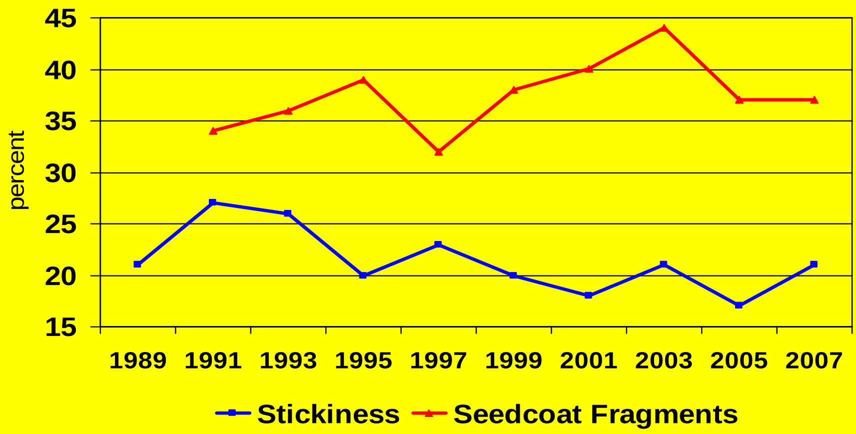
Stickiness

Seed-coat Fragments

ITMF Cotton Contamination Survey 2007

Stickines v Seed-coat Fragments



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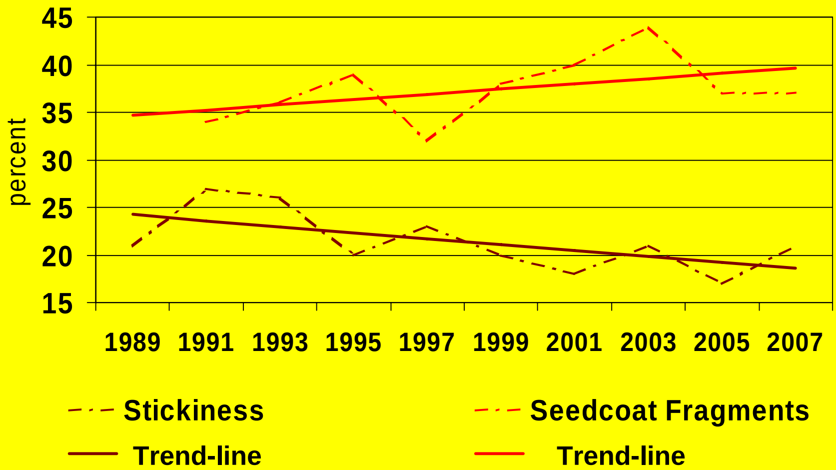
ITMF Cotton Contamination Survey 2007

Stickiness v Seed-coat Fragments



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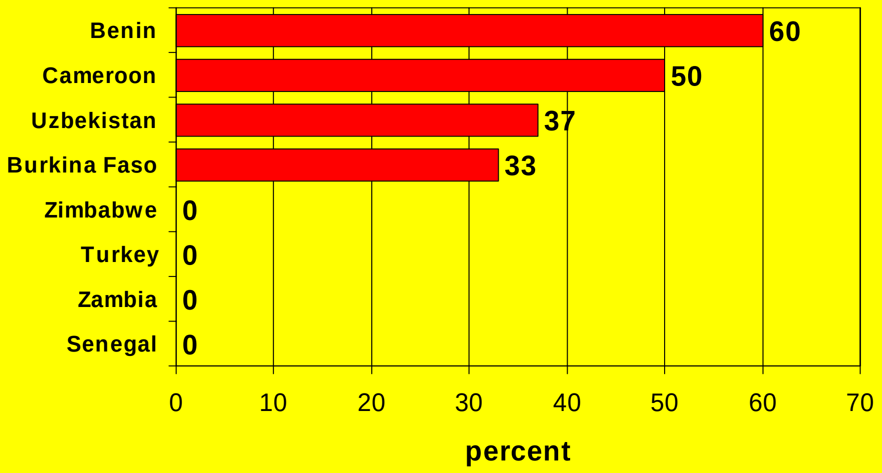
Cotton Contamination Survey 2007

Stickiness

Cotton Contamination Survey 2007

Cotton Stickiness by Origin 2007



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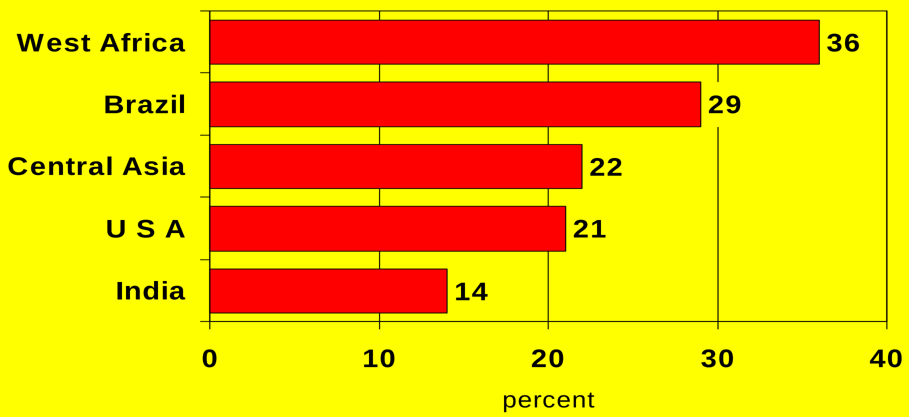
Cotton Contamination Survey 2007

Cotton Stickiness by Origin 2007



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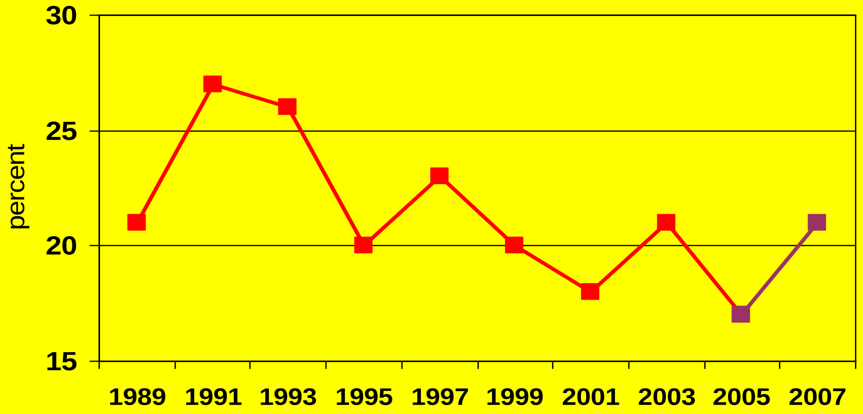
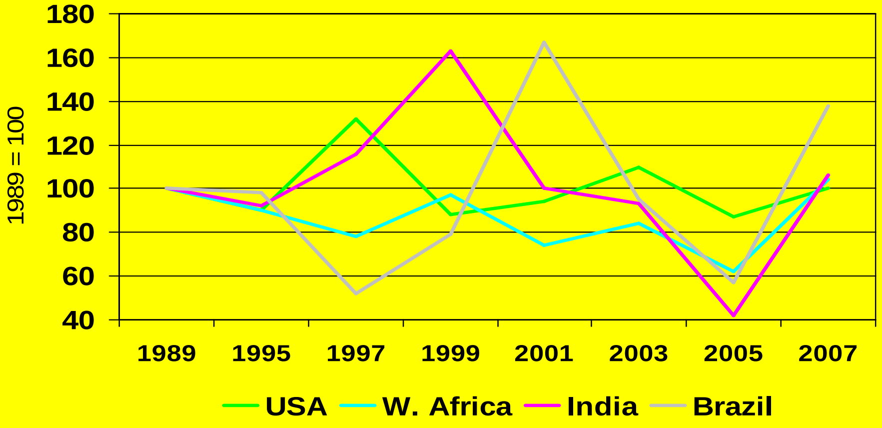
Cotton Contamination Survey 2007

Stickiness



Cotton Contamination Survey 2007

Stickiness by Origin

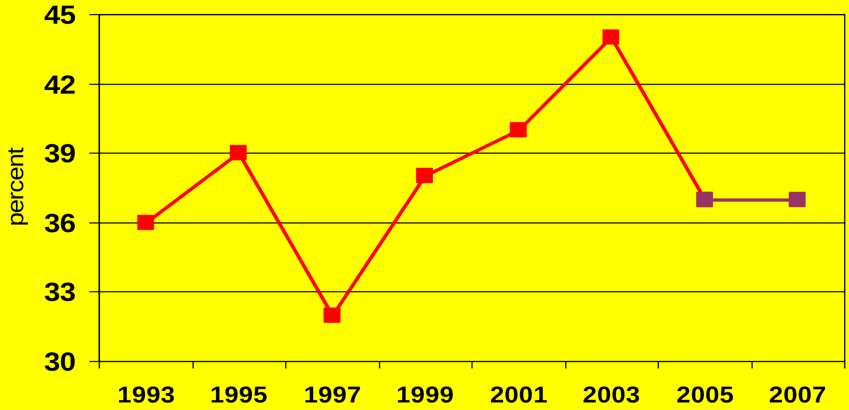


Cotton Contamination Survey 2007

Seedcoat Fragments

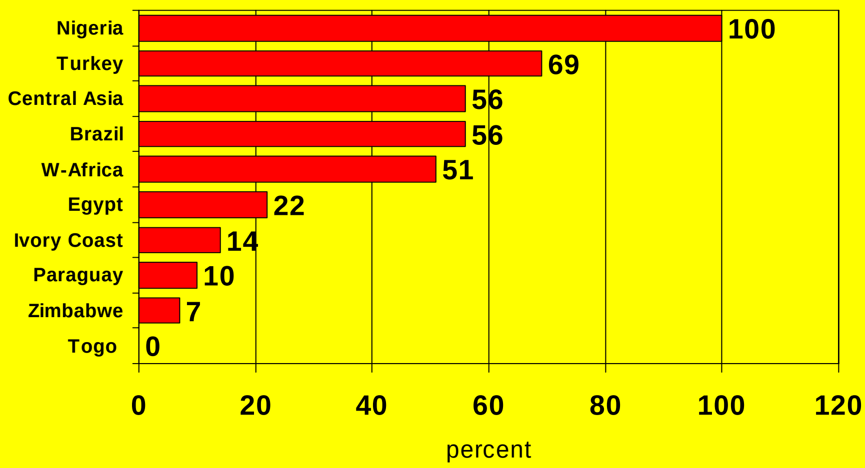
ITMF Cotton Contamination Survey 2007

Seedcoat Fragments



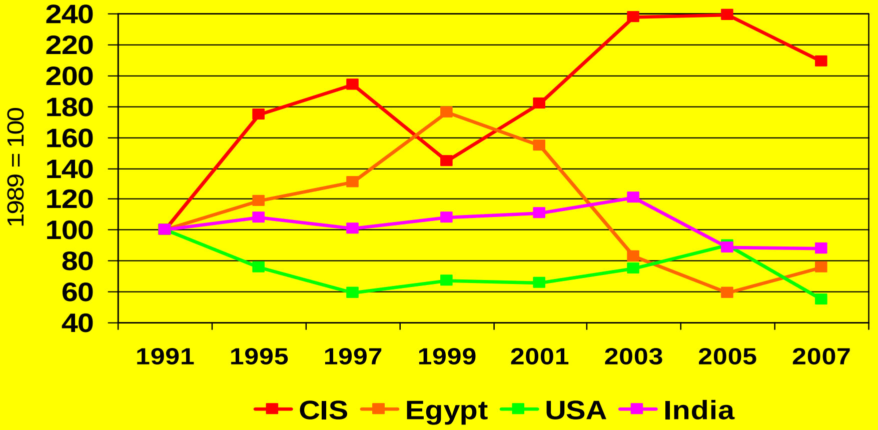
ITMF Cotton Contamination Survey 2007

Seedcoat Fragments by Origin 2007



Cotton Contamination Survey 2007

Seedcoat Fragments by Origin



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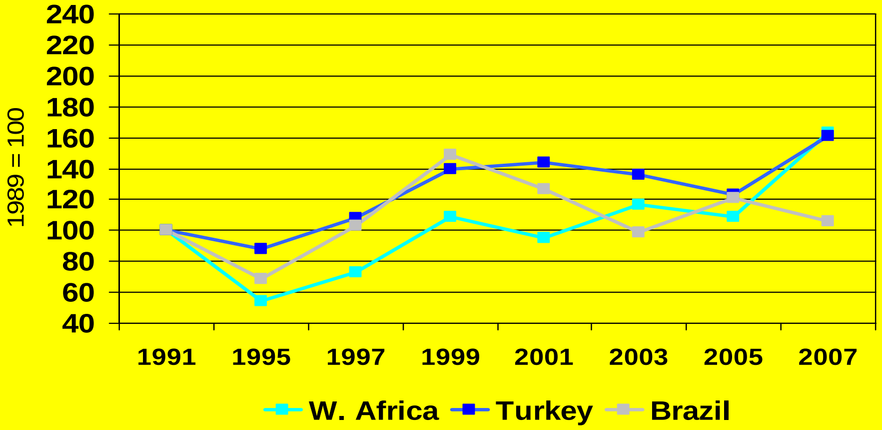
Cotton Contamination Survey 2007

Seedcoat Fragments by Origin



26

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RESULTS OF A STUDY OF LENGTH AND NEPS MEASUREMENT WITH PREMIER aQura

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INTRODUCTION

The Premier aQura is an instrument for the measurement of the fibre length distribution of cotton and for the measurement of neps in cotton. At the Bremen Fibre Institute the instrument was used for nearly two years to study its performance. The results are given in this presentation. The intention is not to give an opinion or judgement, but to deliver an objective data basis for interested laboratories to estimate the suitability of the instrument for their purpose and to form their own opinion.

NEPS AND LENGTH MEASUREMENT IN GENERAL AND WITH aQura

Neps are usually measured by opening the cotton sample and detecting the neps with optical methods. Other automatical instruments for nep measurement besides the aQura are:

- Uster AFIS
- Lintronics Fiberlab

In the aQura, neps are measured by opening the fibres. Subsequently the opened fibres are passed through a sensor including a laser and a photo cell (see figure 1). As the fibres are only measured for neps and not measured for length at this stage, the instrument is capable to testing 5g of fibres (or 10g of sliver) with each test, so that an enhanced repeatability can be expected. Neps are divided into fibre neps and seed coat neps.

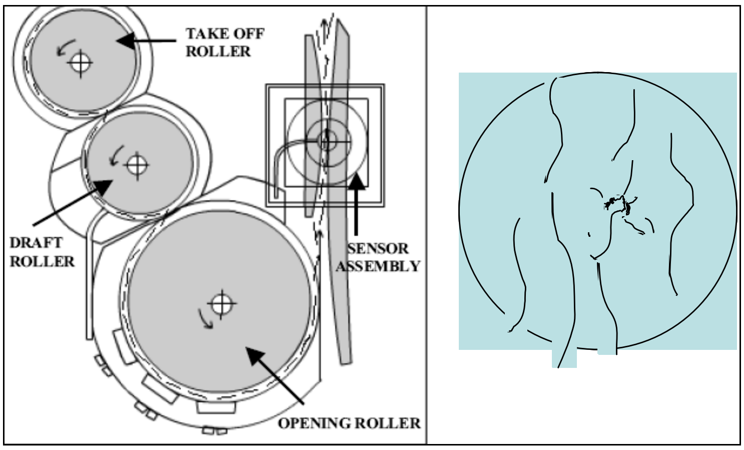


Figure 1: Fibre opening and nep detection [Premier]

For measuring the length of cotton fibres, there is a broad choice of different testing instruments, which can be distinguished by the following criteria [Drieling 2006]:

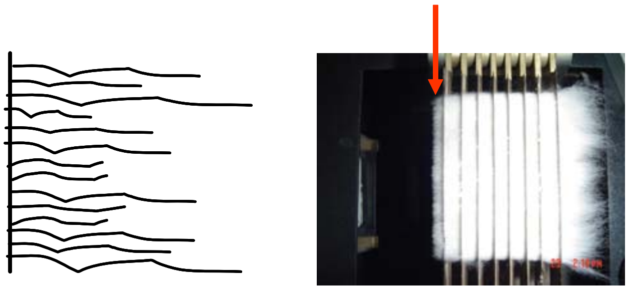
1. The degree of straightening of the fibres (curved, aligned, stretched or elongated)
2. Measurement of single fibres or fibre collectives („beards“)
3. Alignment of fibres in the collective/beard
4. Measurement of the total fibre lengths (= Staple Length) or partial fibre lengths (= Span Length)
5. The mathematical basis of the distribution diagram (by number, by cross-section, by length or by weight)
6. The used definition of the characteristic data (e.g. Upper half mean length, mean length, median)
7. The way of calibration (physically based length calibration or calibration with specifically prepared test material)

The typical instruments for length measurement can be seen in table 1. The aQura is measuring the length distribution of fibres. For this, the fibres are presented in an end-aligned beard like it is done for the Almeter or the comb sorter. The beard preparation is integrated in the automatic measurement of aQura, so that the measuring time for aQura is comparable to AFIS, and obviously lower than for Almeter or comb sorter. In comparison to High Volume Testing, the measurement time is of course definitely higher, as the length distribution of the total fibre lengths is measured instead of length parameters based on partial lengths without aligning the fibres.

Table 1: Typical methods/instruments for cotton length measurements

Method / Instrument	Details (measurement of…)
High Volume Testing and Fibrograph	• beards without end-alignment • partial lengths (span length) • no distribution
Premier aQura	• end aligned beards • total lengths (staple length) • distribution by cross section (usually named as “by number”) / distribution by weight
Uster AFIS	• single fibres • total lengths (staple length) • distribution by number / calculated distribution by length (usually named as “by weight”)
Almeter	• end aligned beards • total lengths (staple length) • distribution by cross section (usually named as “by number”) / distribution by weight
Comb Sorter	• end aligned beards • total lengths (staple length) • distribution by weight
Image Analysis [Drieling 2006] [Wang 2007]	• single fibres • total lengths (staple length) • distribution by number
Manual methods (tweezers and ruler)	• single fibres • total lengths (staple length) • distribution by number

For achieving end-aligned beards, either slivers are measured, or the fibres from the neps measurement on raw (flock) material are collected in a rotor in form of a sliver, which is then used as input material for the length measurement. The cotton sliver sample is placed in an array of needles. A fibre gripper removes loose and not aligned fibres, so that the fibres remaining are in line at one end. Then the end-aligned sample is picked, brushed and moved into the optical detection zone. The optical detector converts the obstruction to the incident light caused by the fibre beard into electrical signal, which is directly converted to the length staple diagram.



End Aligned Sample

Figure 2: Fibre length measurement on end aligned samples [Premier aQura]

MATERIALS AND METHODS

For measurements at the Bremen Fibre Institute, the following material was used:

- Raw cotton (flock): Sample material from the Bremen Round Trial
  - RM05 Central Asia (50% Length = 18.6mm)
  - RM36 US MOT (50% Length = 16.4mm)
  - additional Bremen Round Trial materials
- Sliver material:
  - FS1 combed/drafted sliver (50% Length = 28.2mm)
  - FS2 card sliver, Australian cotton, 5ktex (50% Length = 18.2mm)
  - FS3 drafted sliver (50% Length = 26.4mm)

For measurement with the aQura, usually 4 tests for each sample were carried out. For variability studies, 40 tests were done on each sample. Raw cotton (flock) samples were tested in the “Raw Cotton Mode”. Sliver samples were tested in the “Sliver Mode”, except when specifically mentioned. In the “Sliver Mode”, the sliver is directly taken for length measurement instead of using the rotor sliver.

Parameters tested with aQura were:

- Neps
  - Fibre neps [1/g] — used for evaluation
  - Fibre nep size [µm] — partly used for evaluation
  - Seed coat neps [1/g] — used for evaluation
  - Seed coat nep size [µm] — partly used for evaluation
  - Total neps [1/g] — used for evaluation
  - Average nep size [µm] — not used
- Length
  - 5% Length [mm] — used for evaluation
  - 50% Length (median) [mm] — used for evaluation
  - Effective Length [mm] — not used

- Short fibre content by number (< 12.7 mm) [%] used for evaluation
- Short fibre content by weight (< 12.7 mm) [%] partly used for evaluation
- other operator defined parameters not used

Additional measurements were for example made with AFIS. Besides the measurements, results from the Bremen Round Trial were evaluated, and a specific Round Trial for aQura instruments was conducted.

VARIABILITY OF SINGLE TEST RESULTS

For measuring the variability of the test results, each month 40 measurements were carried out on one day on the aQura for raw cotton samples and sliver samples. Tests in different months were done by different operators. Results are shown for RM36 (raw cotton) and FS1 (sliver) (see table 2).

The raw cotton sample (RM36) shows typical results for a non-homogenous cotton sample. The variability between single test results is

- for nep content approx. standard dev. 26/g resp. 8-9%CV
- for seed coat nep content approx. standard dev. 20/g resp. 12%CV
- for nep size approx. standard dev. 15 to 20µm resp. 2%CV
- for 5% length approx. standard dev. 2mm resp. 2%CV
- for 50% length approx. standard dev. 4mm resp. 4%CV
- for SFC(N) approx. standard dev. 3% resp. 9%CV

The combed sliver sample, which is more homogenous, shows the variability of the test results mainly based on the test method, and less influenced by the material:

- for nep content approx. standard dev. 1/g
- for 5% length approx. 0.26mm resp. 1.4%CV
- for 50% length approx. 0.38mm resp. 1.4%CV
- for SFC(N) approx. 1%

The variability between days is not useful here, as in practice 40 repetitions will never be tested by laboratories.

Table 2: Variability of test results for a flock sample (RM36) and a sliver sample (FS1), between single test results on the days (average of 9 days)

Sample: RM36	**Neps/g**	**NepSize**	**SC Neps**	**SCNep Size**	**Total Neps**	**5% L**	**50% L**	**SFC(w)**	**SFC(n)**
	1/g	**(µm)**	**1/g**	**(µm)**	**1/g**	**mm**	**mm**	**%**	**%**
average result	304	712	43,4	1012	347	31,09	16,27	16,89	32,70
Av. St.dev. (single results)	26,1	15,1	5,2	19,6	30,1	0,57	0,66	1,90	2,87
Av. CV % (single results)	8,6	2,1	11,9	1,9	8,7	1,8	4,1	11,3	8,8
Day a - operator 1	315	704	45	1004	360	31,22	16,43	16,46	32,01
Day b - operator 1	296	710	40	1007	337	31,05	16,13	17,23	33,26
Day c - operator 1	305	710	42	1007	347	31,08	16,46	16,48	32,05
Day d - operator 2	327	711	48	1013	375	31,11	16,21	16,92	32,71
Day e - operator 1	293	715	42	1020	335	31,12	16,17	17,30	33,51
Day f - operator 1	289	708	42	1009	332	31,16	16,37	16,45	32,23
Day g - operator 1	299	712	44	1016	342	31,14	16,47	16,44	31,90
Day h - operator 3	314	716	45	1015	359	30,90	15,86	17,87	34,02
Day i - operator 1	297	717	42	1016	339	31,06	16,29	16,83	32,63

Sample: FS1	**Neps/g**	**NepSize**	**SC Neps**	**SCNep Size**	**Total Neps**	**5% L**	**50% L**	**SFC(w)**	**SFC(n)**
	1/g	**(µm)**	**1/g**	**(µm)**	**1/g**	**mm**	**mm**	**%**	**%**
average result	8,4	641	0,9	1057	9,1	41,03	28,16	3,09	9,26
Av. St.dev. (single results)	1,2	31,8	0,5	156,2	1,4	0,26	0,38	0,40	0,99
Av. CV % (single results)	14,5	5,0	74,3	14,8	15,2	0,6	1,4	12,8	10,6

VARIABILITY OF TEST RESULTS BETWEEN DAYS / LONG TERM STABILITY

By manufacturer's recommendation, 4 subsamples are tested for each sample. Based on the 4 tests, the repeatability of the laboratory results are better than between single tests. Ideally the variability should reduce to 50%. The results for two different flock samples and two sliver samples are shown in table 3.

The results shown here can be used by laboratories to estimate the achievable variability in their lab,

- including different instrument operators,
- including possible long term drifts,
- including material variability.

The raw cotton samples (RM05 and RM36) show this typical result variability for non-homogenous cotton samples – based on 4 tests per sample:

- for nep content approx. 7 to 8 %CV
- for seed coat nep content approx. 7 to 9 %CV
- for nep size approx. 1 to 1.3 %CV
- for 5% length approx. 1 to 1.2 %CV
- for 50% length approx. 3 to 3.5 %CV
- for SFC(N) approx. 5 to 7.5 %CV

The sliver samples (FS1 combed and FS2 carded) show this typical result variability for more homogenous cotton samples – based on 4 tests per sample:

- for nep content approx. standard dev. 0.5/g to 3/g – depending on the kind of sliver –
- for SC nep content approx. standard dev. 0.2/g to 0.7/g – depending on the kind of sliver –
- for 5% length approx. 0.15mm resp. 0.4 to 0.5 %CV
- for 50% length approx. 0.2 to 0.3mm resp. 1 to 1.3 %CV
- for SFC(N) approx. 0.8%

The different results for the sliver samples do not depend on the instrument, but on the sliver preparation (carding or combing/drafting).

Table 3: Variability of test results between days with each 4 tests for raw cotton samples (RM05 and RM36) and sliver samples (FS1 and FS2),

Sample: RM05	Neps/g	NepSize	SC Neps	SCNep Size	Total Neps	5% L	50% L	SFC(w)	SFC(n)
	1/g	(µm)	1/g	(µm)	1/g	mm	mm	%	%
Average	221,9	710,4	35,4	1008,8	257,2	33,24	18,64	11,75	25,34
St.dev. (days)	16,7	8,7	3,1	10,3	19,3	0,32	0,62	1,07	1,84
CV % (days)	7,5	1,2	8,9	1,0	7,5	1,0	3,3	9,1	7,3
Sample RM36	Neps/g	NepSize	SC Neps	SCNep Size	Total Neps	5% L	50% L	SFC(w)	SFC(n)
	1/g	(µm)	1/g	(µm)	1/g	mm	mm	%	%
Average	289,5	711,1	41,8	1011,1	331,2	31,15	16,36	16,76	32,62
St.dev. (days)	21,2	9,3	3,1	9,7	23,6	0,37	0,51	1,30	1,94
CV % (days)	7,3	1,3	7,4	1,0	7,1	1,2	3,1	7,8	6,0
Sample: FS1	Neps/g	NepSize	SC Neps	SCNep Size	Total Neps	5% L	50% L	SFC(w)	SFC(n)
	1/g	(µm)	1/g	(µm)	1/g	mm	mm	%	%
Average	8,4	635,7	0,9	1055,7	9,1	41,04	28,22	3,02	9,01
St.dev. (days)	0,6	18,3	0,2	105,3	0,8	0,15	0,27	0,30	0,77
CV % (days)	7,3	2,9	26,2	10,0	8,2	0,4	1,0	9,8	8,5
Sample: FS2	Neps/g	NepSize	SC Neps	SCNep Size	Total Neps	5% L	50% L	SFC(w)	SFC(n)
	1/g	(µm)	1/g	(µm)	1/g	mm	mm	%	%
Average	52,5	592,7	6,7	934,0	59,1	33,45	18,16	15,00	30,32
St.dev. (days)	2,5	17,7	0,7	27,9	2,8	0,16	0,23	0,51	0,79
CV % (days)	4,8	3,0	9,8	3,0	4,7	0,5	1,3	3,4	2,6

The same data shows the long term stability of the test results. The variability of the data in 9 months is shown in figure 3 and figure 4. With no instrument setting changes in between, no systematic variations were found for any of the flock and sliver samples and for any of the parameters.

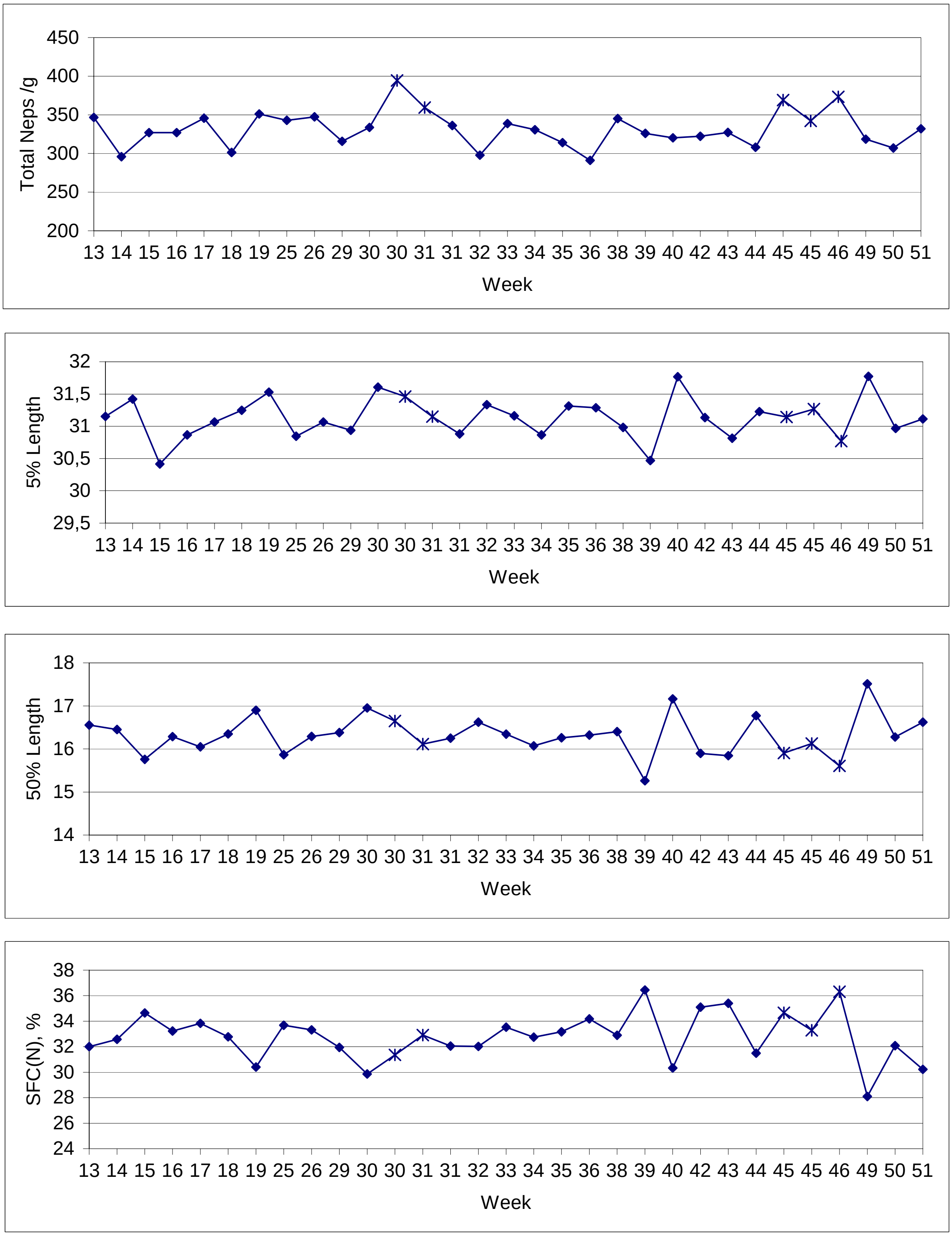


Figure 3: Long term stability of length and neps results for raw cotton material RM36

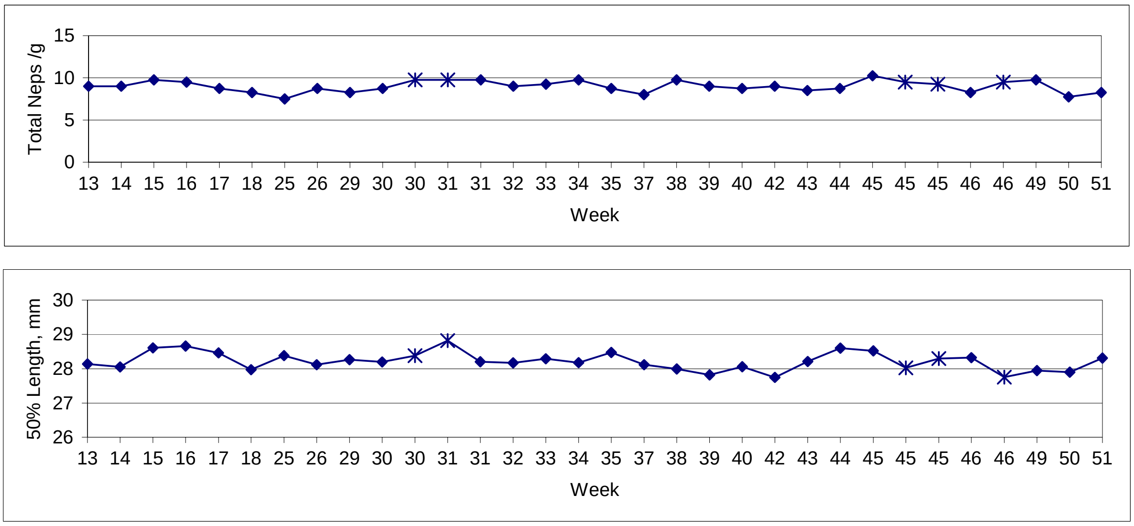


Figure 4: Long term stability of length and neps results for sliver material FS1

OPERATOR INFLUENCE

The weekly and monthly intense measurement results were mainly done by one operator, with interim measurements by two additional less trained operators. For illustrating this, the weekly results from the additional operators are marked in figures 3 and 4with a star instead of a rhomb. For the monthly results in table 2, the operators are named for the single days.

For the weekly repetitions of the measurements given in the last chapter (for all 4 samples) and figure 3 for RM36, as well as for the monthly intense measurements it can be stated:

- Based on the automatic preparation of the length beard without operator influence, the results for the additional operators do fully fit into the variation of the results of the main operator and no statistical difference is observable.
    - for length measurement on sliver material,
    - and for length measurement on raw cotton material,
    - and for nep content measurement on sliver material,

- A small operator influence caused by feeding is possible for nep content measurement on raw cotton material (see table 2 and figure 3).

INTERLABORATORY VARIABILITY

For acquiring the inter-laboratory variability of the aQura, a specific round trial was conducted in combination with the Bremen Cotton Round Trial 2007-4. For this, 20 laboratories participated, 13 from India, 6 from China and the Bremen Fibre Institute.

The sample material was identical to the current Round Trial 2007-4 (Brazilian cotton). Each lab tested the sample on aQura with 4 repetitions, like usual for the laboratories. For the analysis, outliers were detected according to Grubbs' algorithm (95%). The results are given in table 4.

Table 4: Results of a specific round trial for aQura instruments

	5.0%Length	50%Length	SFC(N) <12.7mm	SFC(W) <12.7mm	Fibre Neps/g	SC Neps/g
Average	31,41	17,58	27,79	13,61	317,65	41,30
number	18	18	18	17	20	20
min	29,86	15,42	21,71	9,45	240	20
max	32,99	19,71	34,20	19,69	427	64
St. Dev.	0,89	1,14	3,96	2,94	50,52	12,17
CV%	2,8	6,5	14,2	21,6	15,9	29,5
Comparison: CV in-lab. (based on 4 rep.)	1,1	2,6	3,4	4,4	4,5	8,3

As typically given for every kind of measurement, the inter-laboratory coefficient of variation (CV%) is noticeably higher than the CV% in one laboratory for this material.

The inter-laboratory CV% of the aQura parameters are comparable to those from other instruments.

Table 5: Results of the Bremen 2007-4 Cotton Round Trial and the aQura Round Trial on the same cotton: Comparison of CV% for aQura, AFIS and Almeter

Property	aQura	AFIS	Almeter
5% Length (N)	2.8%	2.5%	not given
Mean Length (N) / 50% Length	6.5%	5.2%	7.3%
SFC(N)	14.2%	16.3%	29.3%
SFC(W)	21.6%	21.8%	35.1%
Nep content/g	15.9%	13.8%	not given

Harmonisation activities like

- assistance by the producer
- regular participation in round trials

will help to reduce the variability.

The aQura instrument is included in the regular Bremen Cotton Round Trial from 2008 on, so that every laboratory can use the results to harmonize its instrument with the other aQura instruments in the world. And the future Round Trials will show how the variability of the aQura results will be for other samples.

COMPARISON OF aQura RESULTS TO OTHER INSTRUMENTS (BASED ON ROUND TRIAL RESULTS)

Many people are used to HVI or AFIS results. For this, it is useful to compare the aQura results with those from the other instruments. Almeter results were not regarded here, as the number of Almeter instruments used is decreasing clearly and the number of participating instruments in the Bremen Round Trial is down to 4.

It has to be stated that every instrument presented here is testing indirectly, so that it cannot be said only by a view on the results, which instrument is giving "true" and which is giving “wrong” results. Each instrument is testing with a different method, has got own influences, leading to different result levels. For a detailed comparison, these influences will have to be regarded.

To give more validity to the comparison, samples from the Bremen Round Trial were tested, and the aQura results measured at the Faserinstitut were compared with the inter-laboratory average results of all participating labs in the Round Trial. 14 samples from different origins were used.

In figure 5 it can be seen that there is a very good correlation of the aQura 5% Length results to the according results from AFIS (5% Length) [R^2= 0.96] and HVI (UHML) [R^2=0.94]. The HVI results are, caused by the definition of the parameter, typically lower than the aQura results. The AFIS results are approx. 2mm higher than aQura. To find reasons for this, the length distributions are compared later in this presentation.

For AFIS mean length compared to aQura 50% length, the correlation is slightly lower (R^2=0.88). Again, the AFIS results are approx. 2mm higher than the aQura results.

As the SFC reproducibility is usually quite low, the correlation between Short Fibre Content results from AFIS and aQura is noticeable [R^2=0.57]. AFIS SFC results are for most samples 2% to 3% lower than aQura SFC results.

The correlation from aQura to High Volume Instruments SFI [R^2=0.19] is clearly worse than the correlation form aQura to AFIS. This is based on the calculation of the short fibres in High Volume Testing instruments instead of true measurements.

For neps, the correlations between AFIS and aQura are shown for the aQura fibre nep content and the aQura total nep content. For both, R^2 is approx. 0.88. There is no clear difference in level comparing AFIS to aQura fibre nep content, whereas aQura total nep content is in average slightly higher than AFIS.

Especially for neps it is very difficult for any instrument to measure a “true” nep content, as there are no clear definitions of neps (as fibre entanglements, mechanically dissolvable neps, not dissolvable neps / knots, seed coat neps). Furthermore every mechanical opening procedure of the fibres is creating additional neps.

As the Round Trial samples allow only a limited range for the properties, additional tests were done in co-operation between Faserinstitut and another renowned laboratory. Samples from different processing steps were included, were measured at Faserinstitut with aQura and at the other lab with AFIS. Similar correlations like given in figure 5 were found in these tests for 5% length, 50% length and nep content. For the Short Fibre Content, a large increase in R^2 was found based on the broad range of the SFC results of the samples. The R^2 result for these samples increased to 0.93 (figure 6). For very high amounts of short fibres the aQura SFC results tend to a higher level than the AFIS SFC results for the samples.

In sum it can be seen that the correlation between the parameters of the different instruments is considerable.

For all length testing instruments (HVI, AFIS, Almeter, aQura etc.) it can generally be seen that

- the highest repeatability/reproducibility is given for the parameters for the high fibre lengths (5% length, UHML)
- a lower repeatability/reproducibility is given for the average length parameters (50% length, mean length)
- the lowest repeatability/reproducibility is given for Short Fibre Content parameters (SFC, SFI).

Based on the different repeatability of the data, the best correlation between aQura and other instruments is given for the parameters for the high fibre lengths, lower for the mean length parameters and lowest for Short Fibre Indices. Even the nep contents show a satisfying correlation for the raw cotton samples.

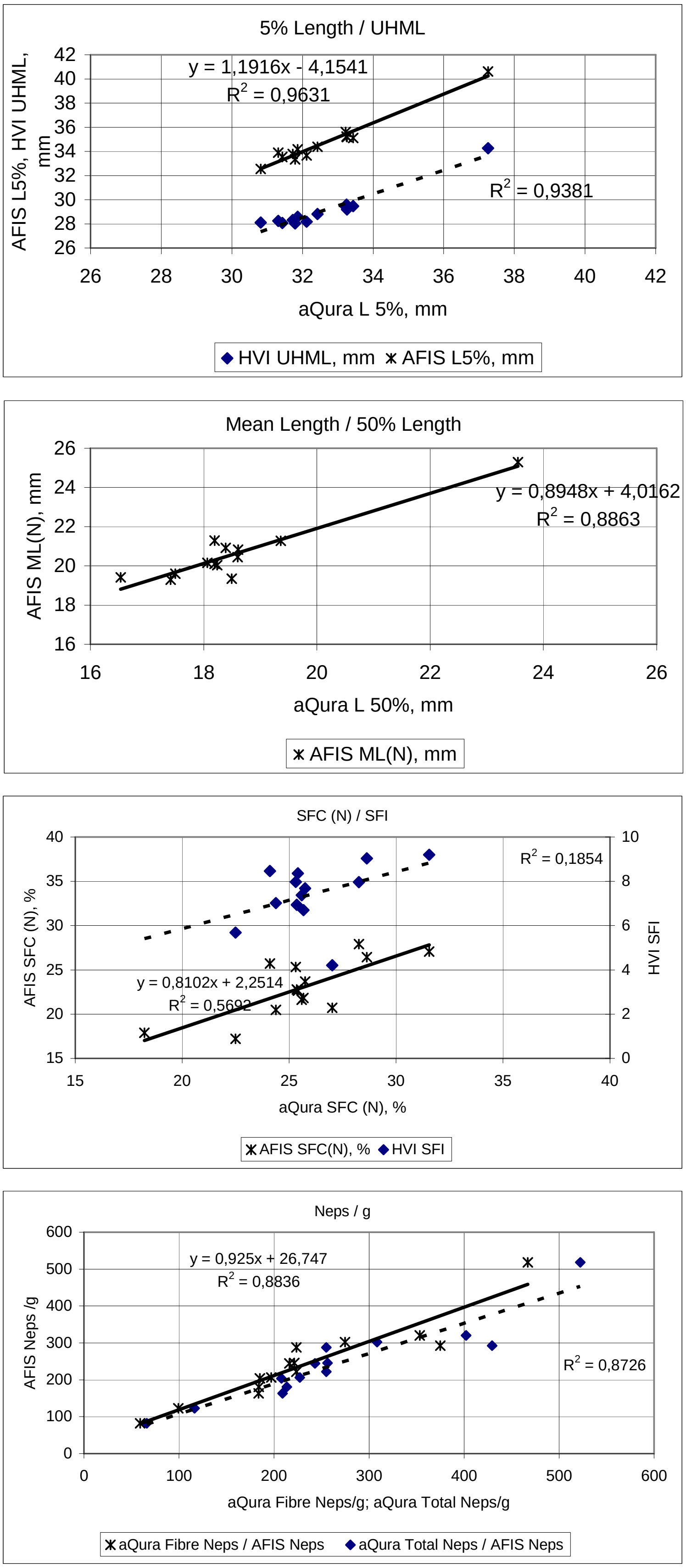


Figure 5: Comparison of aQura results with inter-laboratory average results of other instruments

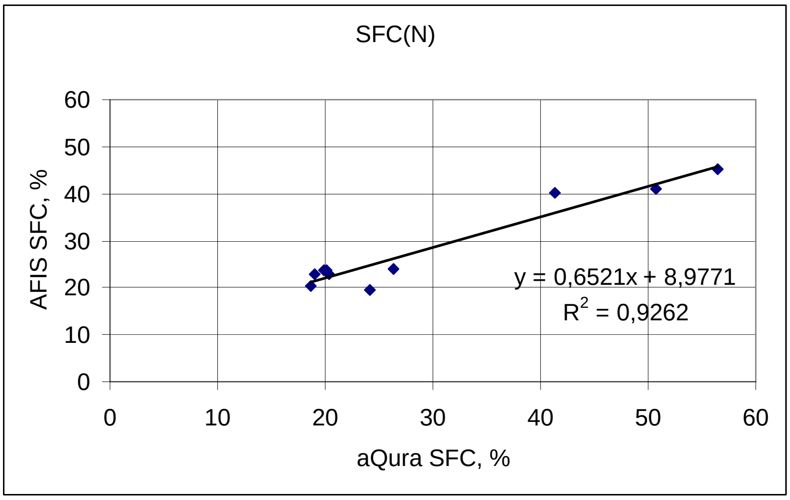


Figure 6: Comparison of aQura SFC(N) results with AFIS results on one single instrument

USE OF aQura RESULTS IN THE SPINNING PROCESS

One of the main applications for the instruments is in the spinning mills. The modification of the cotton characteristics can be followed by measurements in the consecutive steps of processing. Therefore samples from different processing steps were analysed with the aQura and in parallel with the AFIS. In figure 7, the results are given for one material during the processing. The error bars in the figure show the standard deviations of the single aQura measurements.

- 5% Length
  - It can clearly be seen, that the aQura 5% length is increasing in each processing step.
  - Similar findings can be found for AFIS, with a clearly higher level of the results.
- 50% Length / Mean Length
  - The aQura 50% length is first of all slightly sinking up to the card sliver; this might be due to fibre breakages in the blow room and carding / opening / cleaning process.
  - The aQura 50% length is then increasing with the following steps.
  - The AFIS mean length is not showing the first decrease in length.
  - The difference between both instruments is presumably caused by the different fibre preparations.
  - There is no clear level difference between AFIS and aQura in this series of tests.
- Short Fibre Content
  - According to the change of the 50% length for aQura, the short fibre content is firstly increasing slightly and then decreasing again due to the blow room and carding / opening / cleaning process.
  - AFIS is, again fitting to the mean lengths, showing a decrease of short fibres from the fist processing step on.
- Nep Content
  - The nep content, measured with aQura, is decreasing in every processing step starting with the carding chute material.
  - AFIS results show the same tendency, but show lower nep contents for the flock material, and slightly higher nep contens for the sliver material.

The clearly visible gradients of the curves and the comparably low standard deviations in the single test results show that the aQura is suitable for characterising the changing fibre properties in the different processing steps. The systematic differences between aQura and AFIS are caused by the different ways of fibre preparation and measurement. Scientifically it is interesting to find out the reasons for the differences. Practically, every spinner will learn to work with the results given of the test instrument in use. Difficulties will arise as soon as results from different kinds of instruments are mixed in discussions; this should be avoided.

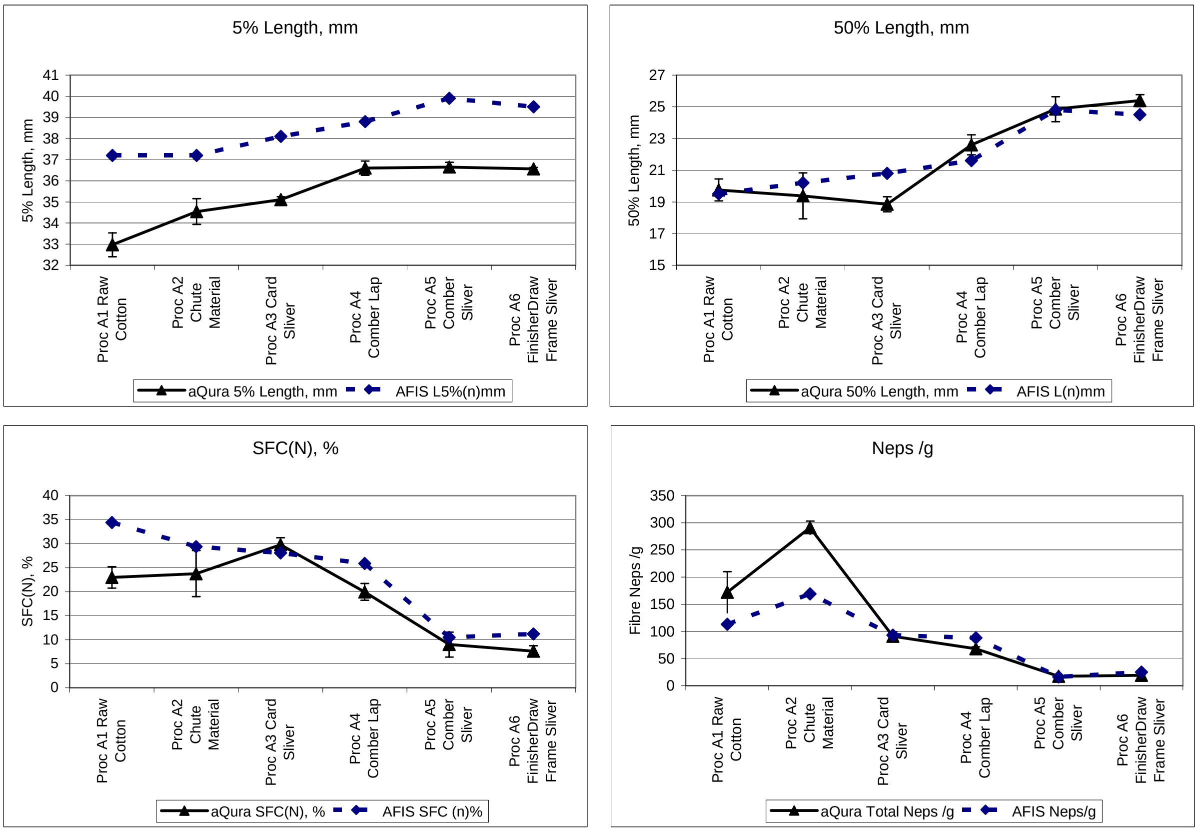


Figure 7: Variation of the fibre characteristics during processing with aQura and AFIS. *(The error bars for aQura show the standard deviations between single test results)*

LENGTH DISTRIBUTION RESULTS

The main purpose for instruments like AFIS or aQura in comparison to the High Volume Test Instruments is to obtain complete length distributions, which are a proper basis for estimating the behaviour of the cotton for spinning and for examining the influence of each processing step on the fibres. Besides the usual parameters, the whole distribution is important for the processing behaviour.

Figure 8 shows totally different length distributions for two different cottons as examples. The difference in length between both samples can not only be seen in the parameters as 50% length is 19mm respectively 24mm, but also in the whole distribution curves.

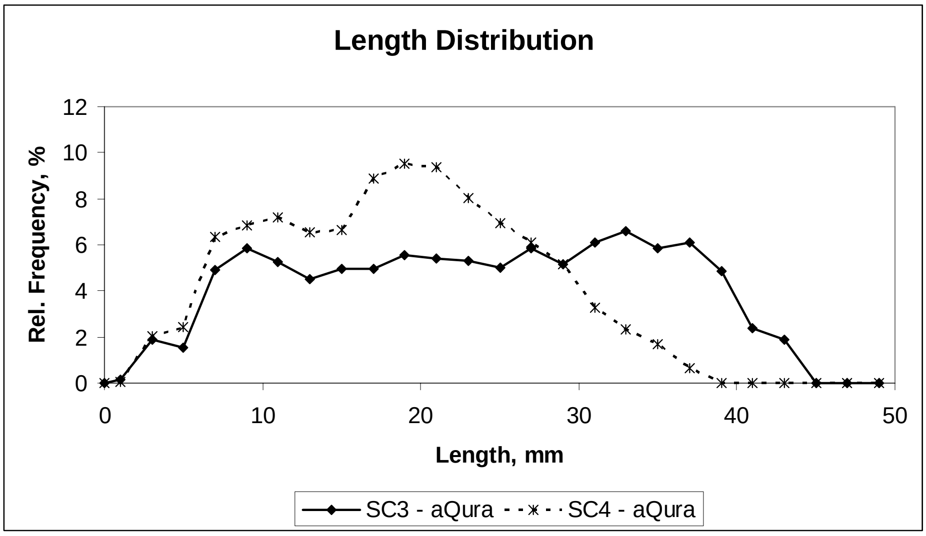


Figure 8: aQura length distributions for different raw cotton samples (50% length: 19mm and 24mm)

As the usual parameters like the 5% fibre length and the 50% fibre length are summarizing the information of many length classes, they are quite stable. For length distribution, test instruments have to prove

- that their acquired length distributions are stable
- that the acquired length distributions are reflecting the “true” length distribution.

For demonstrating the stability of the length distributions measured with aQura, figure 9 shows the distributions of 10 repetitions measured on a sliver sample. The combed sliver sample is quite homogenous, and therefore the measured distributions are relatively similar, although it is difficult to quantify “similarity”. Similar length distributions are a good basis for repeatable test results.

The main fundament for acquiring stable length distribution results is a sufficiently high number of measured fibres, which is achieved with aQura by testing beards instead of single fibres.

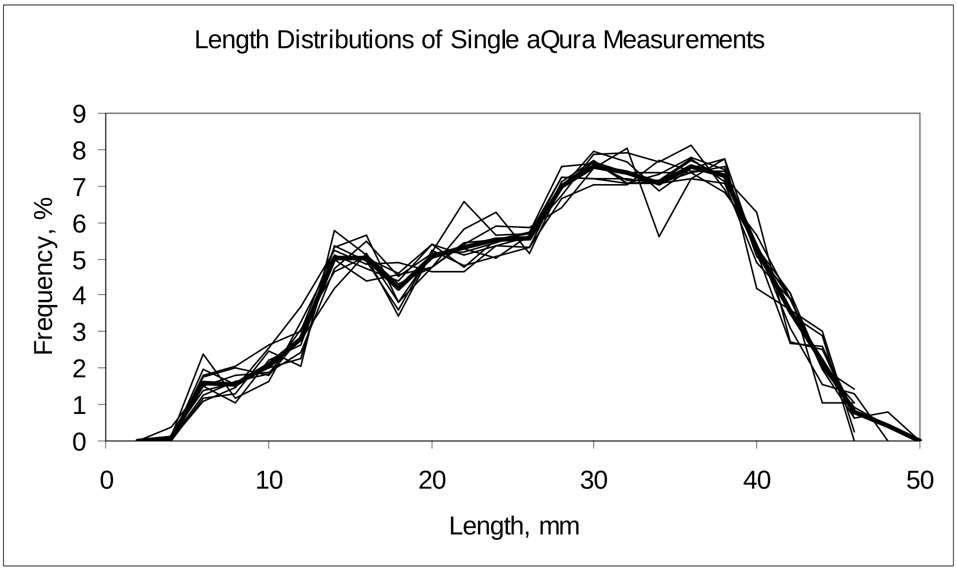


Figure 9: aQura length frequency distributions of 10 repeated measurements plus the average distribution (bold), given for sliver sample FS1

COMPARISON OF aQura LENGTH DISTRIBUTIONS TO DISTRIBUTIONS MEASURED WITH OTHER METHODS

The length distribution is strongly influenced by the testing methods. Therefore it is useful to compare distribution results to results acquired with reference test methods. A suitable way for a reference test method is the manual single fibre test using tweezers and a ruler, which is a very tedious work. Another proposed reference method is the length measurement with image analytical methods like presented in Bremen in 2006 [Drieling 2006] or by Eric Hequet *et. al.* on the Beltwide Cotton Conferences in 2007 [Wang 2007]. These methods are under development, but are yet not fixed as valid test methods.

To avoid any discussions about the true reference results here, now reference results were taken by averaging results from the manual single fibre test and from image analytical tests. Both suffer hitherto from measuring insufficient amounts of fibres due to the work necessary for this, so despite to the trueness of the results the repeatability is limited.

In figure 10, the length distributions for a drafted sliver are shown

- measured with aQura
- measured with AFIS
- measured with reference methods (4364 fibres manual testing plus 4919 fibres image analysis)

The results show good compliance for the sliver. A significant influence can be seen for AFIS, measuring very long fibres, which do not occur with any other method. This is probably basing on combined fibres detected as one fibre by the sensor in AFIS. And this is certainly impacting the correlation between the test methods.

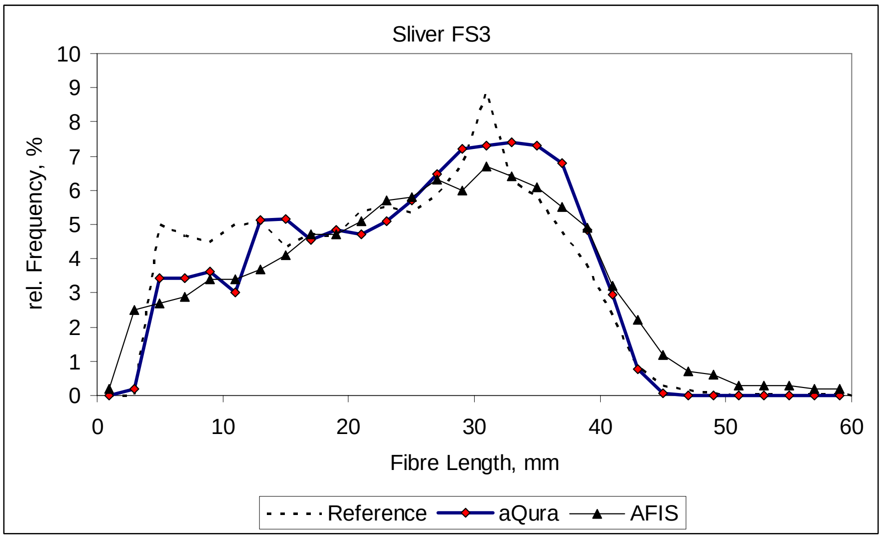


Figure 10: Length distributions for a drafted sliver with different testing methods

Figure 11 shows the length distributions based on the same methods for a raw cotton (Turkey). Unlike figure 10, the aQura length distribution features a maximum which is more shifted to the short end of the distribution, meaning that a reduced number of long fibres is measured. The same results can be found for other raw cotton samples, too.

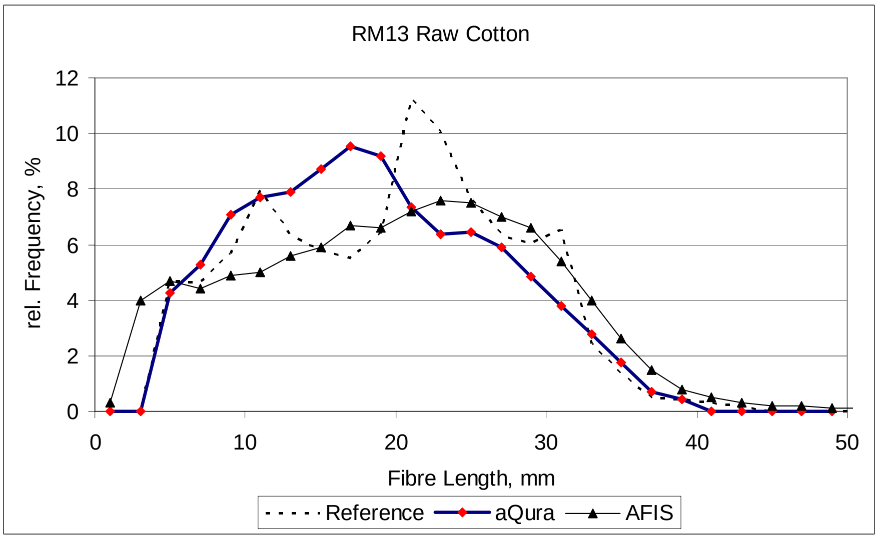


Figure 11: Length distributions for a Turkish raw cotton with different testing methods

IMPACTS ON THE aQura LENGTH DISTRIBUTION RESULTS

To find out the reason for the deviating distribution in figure 11, a part of a specific fibre beard prepared and measured with aQura was then directly measured with the manual fibre length measurement (1500 to 2100 fibres). This was repeated for a second sample. For the results it has to be kept in mind that the manual test method results are not very repeatable and consistent, so that we only get impressions but not full conclusions.

The results in fig 12 indicate again a deviation between the manual and aQura distributions. So this effect will mainly be caused on the measurement and not due to fibre preparation (fibre breakages, biased choice of fibres).

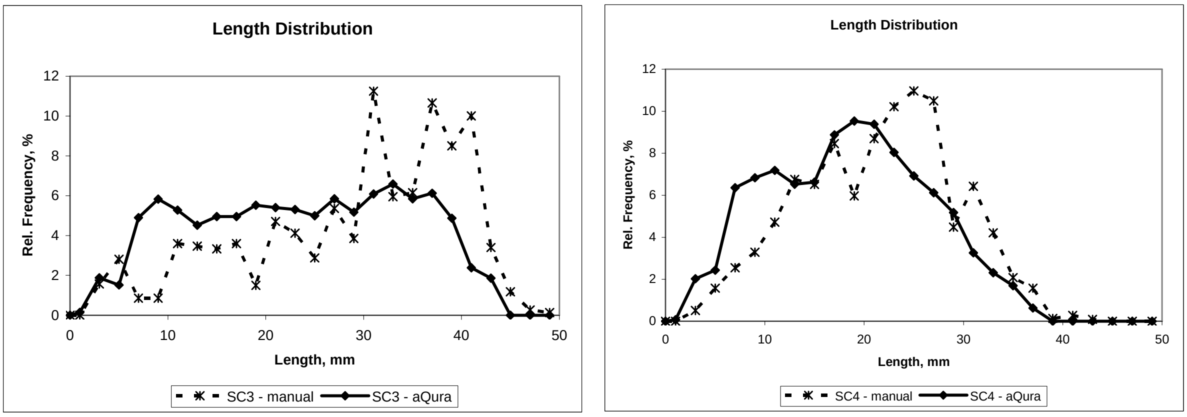


Figure 12: Length distributions on identical beards for two different cottons, each measured with aQura and with manual testing

In an additional test series, sliver sample FS1 was measured with aQura on two different ways (each 10 tests):

- in the recommended sliver mode, where the sliver is tested for length without preparation in the rotor
- in raw cotton mode, including the preparation of a new sliver in the rotor (This is not recommended for any users. All raw cotton samples have to be tested in raw cotton mode to achieve a rotor sliver for the length measurement. And all slivers have to be tested in sliver mode. The only difference is that in sliver mode no rotor sliver is formed, and the original sliver is taken for length measurement.)

For this research purpose it is useful to compare both modes in order to see the difference, as it may show influences caused by the preparation of the rotor beard.

Figure 13 illustrates the difference in the results: The distribution measured in the improperly chosen raw cotton mode is slightly different, showing a lower share of long fibres and an increased share of sorter fibres.

- The 5% Length decreased from 40.86mm to 39.6mm
- the 50% Length decreased from 27.76mm to 25.16mm
- the Short Fibre Content increased from 9.95% to 11.92%

So users should definitely take the proper mode of testing.

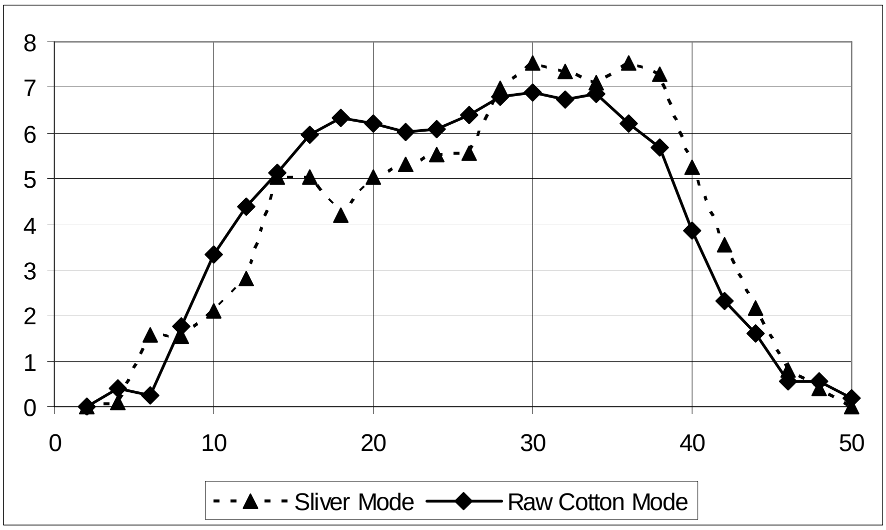


Figure 13: Sliver FS1 measured in sliver mode and in raw cotton mode

In a final test series, identical cotton material was tested with aQura in repeated passes (passing preparation and measurement 4 times) to detect e.g. fibre breakages caused by the preparation. The fibre lengths were slightly reduced (at maximum 0.5mm for 5% length and for 50% length).

In sum, the length difference between raw cotton mode and sliver mode cannot be explained with a shortening of the fibres in the preparation step. The most probable reason for the change in the length distribution is therefore based on the existence of fibre hooks in the rotor sliver. Fibre hooks are removed in aQura on the following ways:

- At the opposite side of the catch point hooks are removed using brush pressure and stretching the fibres at the measuring zone by suction.
- At the catch point the hooks are removed by suction at the gripper

Assumedly small portions of the hooks are still remaining during the length measurement despite the removal, so that some fibres are not measured in their full length. Further research can be done to minimize it.

Drafted slivers like FS1 or FS3 contain nearly no fibre hooks anymore, so that the full length is measured in sliver mode.

GENERAL REMARKS

A positive aspect of the instrument is the option of an online service,

- online service without a service technician
- trouble-shooting / the detection of instrument problems and perhaps solving them without ordering a service technician.

The software may be optimised to improve the suitability of the instrument and the convenience of the use, and the Fibre Institute is glad to give recommendations to

Premier for this. Premier already launched a new database software for additional features recently.

SUMMARY

Premier aQura is an instrument on the market for testing the length distribution and the neps of fibres in the different processing steps. The primary use of the instrument will be the monitoring of cotton processing in spinning mills.

As the instrument is not testing single fibres, but beards, the large sample size is offering the possibility to achieve improved repeatability of the results. The actual repeatability of the data is shown in the tables.

The first international Round Trial shows that efforts have to be made to improve the inter-laboratory reproducibility. The Bremen Cotton Round Trial will include aQura instruments from 2008 on.

Like for all length testing instruments, the Short Fibre Content measurement is the most critical parameter according to repeatability and reproducibility.

As test results are always depending on the test method and no suitable reference test methods are available for length and neps, the report shows the correlations between aQura and other instruments, and illustrates the suitability to test the modification of the fibre material during processing.

A more detailed analysis of the length distributions shows existing impacts on the test results. Impacts on the test results are typical for every test method, and it is useful to be aware in order to avoid misinterpretations of the results.

In sum it can be stated that we found in our test the Premier aQura instrument to be stable and repeatable - as described in the data above. It does reflect the changes in process to both neps and fibre length / short fibre content, which makes it suitable for spinning mills and cotton testing. Based on the given detailed data in this proceeding, any potential user can assess the suitability for his purpose.

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IMPROVEMENT OF MATURITY RATIO MEASUREMENT OF COTTON FIBRES

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ABSTRACT

Form a parallel cotton fibre bundle with approximate 1000 pieces between two object carriers and test the maturity ratio of cotton fibre with the testing instrument of polarized light. The paper is composed of four parts, which are conspectus, theory and system design, calculating and data processing, testing results.

Arrange approximate 1000 pieces of cotton fibres between the two object carriers in parallel order, forming a thin layer of cotton fringe, and test the maturity ratio of cotton fibre with the test set of polarized light. This measuring method presents a faster, more reliable and less assessing mistakes because of vision error for determining cotton fibre maturity than the international standard ISO4912-1981, which is "The Determining Cotton Fibre Maturity--- Microscopy with Polarized Light.

CONSPECTUS

The light adopts improved laser generator with polarisopy (the polaroid can be omitted). Double optical circuits testing is used--setting a beam splitter before the polarization analyzer at a 45 degree angle; One bunch of light representing the number of cotton fibre casts on silicon photocell; The other bunch representing the transmitted optical intension of the fibre through the polarization analyzer casts on the other silicon photocell. Both of the silicon photocells are connected to the microcomputer controller. The information can be calculated and the testing results can be presented and printed automatically. Results can also be calibrated with standard cotton fibres.

Fig1 shows the principle frame of the instrument as follows:

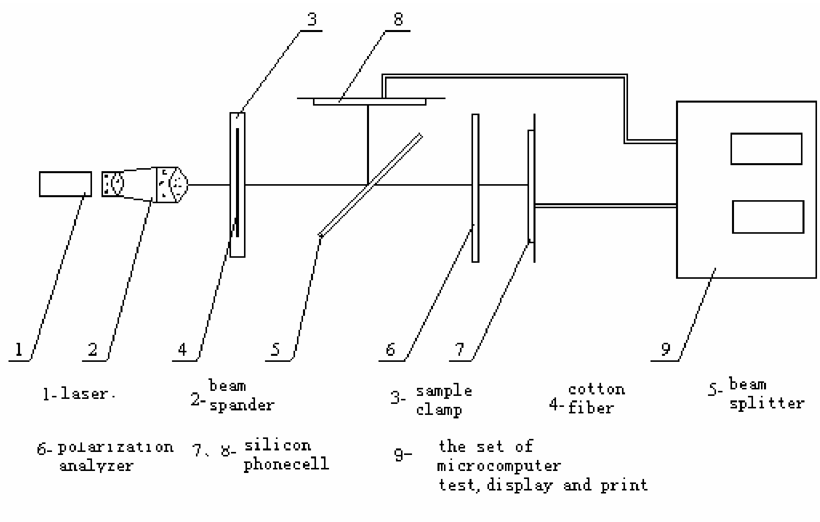

Fig 1. the principle frame of maturity instrument of cotton fibre with polarized light

The method to prepare the specimen of cotton fibres: forming a parallel fibre bundle (approximate 1000 pieces), putting straightly between two object carriers (the geometric axis be paralleled to the width of the object carriers), cutting the extra fibres out of the object carriers, putting in the sample clamp. Then the prepared sample can be tested by following steps: plugging the sample clamp into the window of the instrument (18mm*18mm), obtaining the fibre quantity of the sample and comparatively light intensity through the polarization analyzer according to the definite operating approach, calculating the maturity ratio of the sample by the microcomputer.

THEORY AND SYSTEM DESIGN

The maturity ratio is defined as the ratio of thickening of the cotton fibre to man-made standard thickening 0.577, from which we can deduce the following equations:

$$M = \frac{Q}{0.577} \quad [1]$$

$$Q = \frac{A}{A_0} \quad [2]$$

Where M ---- maturity ratio;

Q ---- ratio of cell thickening;

A ---- cotton fibre cross-section;

A_0 --- the area of a circle having the same perimeter as the fibre section;

The function between cotton fibre cross-section and cell wall thickening can be expressed as follows:

$$A=\frac{\pi}{4}(D^2-d_0^2) \quad [3]$$

Furthermore, $$t=\frac{D-d_0}{2} \quad [4]$$

where D --- theoretic diameter of the fibre in microns,

d_0 --- theoretic diameter of the secondary wall thickening in microns;

t --- wall thickness in microns;

A_0 can be known from the definition:

$$A_0=(\frac{D}{2})^2\pi=\frac{\pi}{4}D^2 \quad [5]$$

Then [2] can be derived from [3][4][5] as follows:

$$Q=\frac{4t(D-t)}{D^2} \quad [6]$$

And [6] can be given from [1]:

$$M=\frac{4t(D-t)}{0.577D^2} \quad [7]$$

$$=\frac{D^2-(D-2t)^2}{0.577D^2} \quad [8]$$

So: $$t=\frac{D}{2}\left(1\pm\sqrt{1-0.577M}\right) \quad [9]$$

In this equations, "$-$" is adopted instead of "$\pm$" because t $\leqslant \frac{D}{2}$, which is:

$$t=\frac{D}{2}\left(1-\sqrt{1-0.577M}\right) \quad [10]$$

The relationship of optical light difference and wall thickness and maturity can be expressed as follows:

$$\Delta=1000\bullet 2t(n_e-n_0) \quad [11]$$

where: Δ --- optical light difference in microns;

$n_e - n_0$ --- double-refraction of cotton fibre.

The relationship of optical light difference of double-refraction crystal and light intensity though the polarization analyzer (the light axes of polarizing lens are orthogonal with the light axes of polarization analyzer lens)can be expressed as follows:

$$I_A = I_p \sin^2 2\alpha \sin^2 \frac{\delta}{2} \qquad [12]$$

or

$$= I_p \sin^2 2\alpha \sin^2 \frac{\pi\Delta}{\lambda} \quad (\delta = \frac{2\pi\Delta}{\lambda}) \qquad [13]$$

where,

I_A --- light intensity though the polarization analyzer (transmitted light);

I_p --- light intensity of incident light;

λ --- wavelength of incident light;

α --- included angle between crystal light axes and the light axes of polarizing lens;

δ --- phase difference.

Also [14] can be given from above equations:

$$I_A = I_p \sin^2 2\alpha \sin^2 \frac{\pi \bullet 1000 \bullet \left(1 - \sqrt{1 - 0.577M}\right)(n_e - n_0)}{\lambda} \qquad [14]$$

The theoretic diameter of the fibre D and double-refraction of cotton fibre are constants in terms of a certain kind of cotton fibre. In this way, if Parameter I_p, λ and α is determined, there is a definite relationship between the light intensity of transmitted light, which is the theory we applied to fast test the maturity ratio of cotton fibre with polarized light.

Two key issues should be concerned in instrument design:

SETTING DOWN THE SCALEPLATE OF INSTRUMENT

As stated earlier Parameter Δ , ($n_e - n_0$), α are all determined, there is a sinusoid square relationship between transmitted light intensity and maturity ratio. Because there exists notable difference between upland cotton and long staple, two different scaleplates should be set down in this instrument, which are upland cotton scaleplate and long staple scaleplate.

THE AMENDMENT FOR THE AMOUNT OF FIBRE

Hypothesizing the sample we tested has the same number cotton fibre, the theory and instrument scaleplate stated above is feasible.The formulae and instrument scaleplates are determined based on a certain amount of fibre. The transmitted light intensity will change according to the amount of fibre. However, it is quite complicated and time-consuming to test the maturity ratio with the same number cotton fibres every time. Therefore, the amending coefficient should be obtained by experiment to adjust the real amending value of comparatively transmitted light intensity.

DATA PROCESSING

As the design theory stated above, the computer control circuit can be designed to realize the fast-testing fibre maturity ratio, which shows as follows:

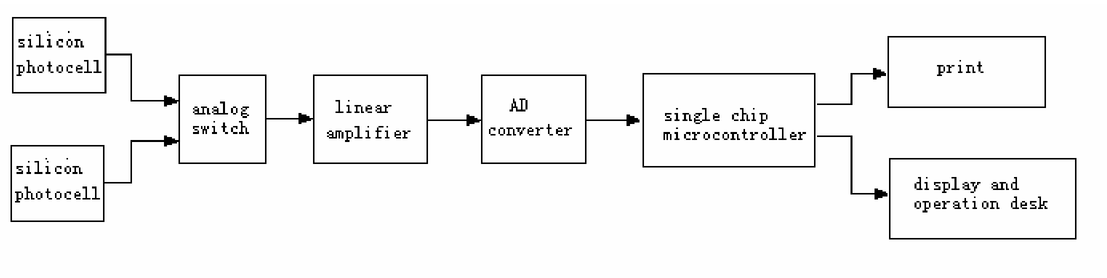

Fig2. The principle frame of the computer control circuit

The two silicon photocells in Figure2 are Components 7 and 8 in Figure 1, and Component 9 in the dashed frame is the microcomputer set for test, display and print. After getting through the cotton fibres, the laser produced by laser generator is separated into two lasers, which representing the number of the cotton fibre and the transmitted optical intension of the fibre respectively, after the processing of an analog switch, the currents generated by the two silicon photocells are time-divided transferred to the linear amplifier. Then the amplified photocurrent signal is transformed to digital signal via Analogy-Digital converter. The maturity ratio of the cotton fibre sample can be obtained after calculating the digital signal by the single-chip microcontroller.

The flow chart shows as follows:

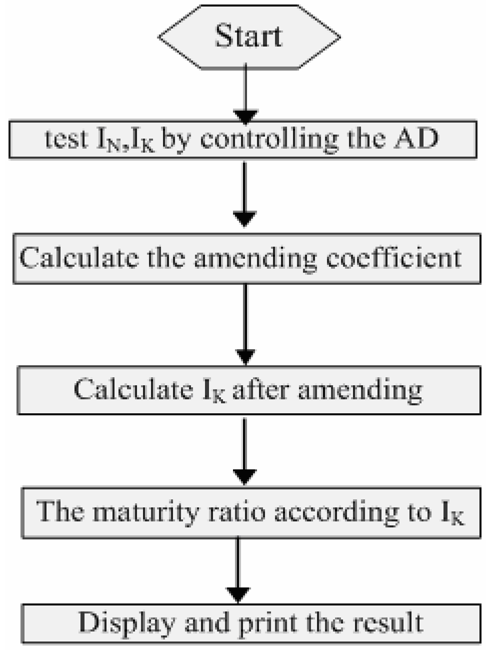

Fig 3. The flow chart of the software process

CONCLUSION

1. Testing precision: the difference from the calibration cotton value ≤ 0.02;
   For upland cotton (from Shandong province, China), the correlation coefficient beween polarized light method and lumen-and-wall thickness constract method is above 0.97, which the average result is 0.978.
   For sea-island cotton (from Xinjiang province, China), the correlation coefficient beween polarized light method and lumen-and-wall thickness constract method is above 0.97,which the average result is 0.973.
2. High efficiency; test in high speed;
   After preparing the cotton specimen, the result will be showed in the screen in less than 1 second. However, it will take one or two minutes to get the cotton specimen prepared.
3. The sample is representative and it can be tested about 1000 cottons from each sample (the fibre on the object carriers), which tests 15mm for each cotton fibre.

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ON-LINE MEASUREMENT OF FIBER LENGTH IN THE GIN

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The measurement of fiber qualities by instruments in the laboratories, for cotton classing or other applications, is well established and the benefits are known.
However, the laboratory is not the last frontier to test cotton and it is quite conceivable that it is also does not offer the most efficient and economical logistics for all applications. In past years the efforts have been focused on how to take these measurements further up the cotton chain and into the gin.

BACKGROUND

The critical fiber qualities used today in classing, procurement, quality control and trade are:

- length, uniformity, short fiber content
- strength, elongation
- micronaire,
- color (Rd, +b and grade)
- trash (percent area, count and grade)
- moisture

Measurements of some of these qualities are already being performed in the gin.

This paper will briefly review the existing on-line measurements and report on the most recent progress on the incorporation of additional measurements.

CURRENT MEASUREMENTS PERFORMED ON-LINE IN THE GIN

Uster's Intelligin system has been introduced previously in this conference. Intelligin uses the proven HVI sensors for moisture, color and trash measurements. Intelligin components are installed in the gin's ducts and they measure cotton qualities in real time as the bale is produced. The system uses the following information to advise the ginner of the most optimum settings in order to improve the efficiency of the ginning process and to preserve fiber qualities:

- Measures the moisture, color and trash content at key points in the ginning process,
- Recommends the optimum temperature for the dryer based on the condition of the incoming cotton,
- Recommends the optimal trash removal at the pre-cleaners and the lint cleaners,
- Measures the final bale moisture and recommends necessary actions such as dryer control or addition of moisture to the cotton in the process.

The Intelligin system can be configured such that optimum control can be made automatically by the system or manually by the ginner. The system is illustrated in Figures 1 through 4. However, this system does not provide the remainder of HVI measurements such as length, strength and micronaire for cotton classing and other applications.

IMPLEMENTATION OF FIBER LENGTH MEASUREMENT

The first prototype of on-line length research for gin applications was designed in 2005. This instrument was based on the length/strength measurement module of the Automated Classing System (ACS) that was introduced to USDA in 2002. (Figure 5). The sampling process consisted of two stages. First, a sample was extracted from the air stream and transferred via a by-pass duct to a paddle sampler which was subsequently compressed against a sample plate. Second, the length unit extracted a sub sample using the ACS comb from the collected sample. Several challenges were faced and lessons learned from this first prototype, some of which are listed below:

1. The interaction of air flow from the gin's ducts across the sample plate was very disruptive to the operation and had to be carefully controlled.
2. Software and hardware limits were developed and applied to improve sampling accuracy.
3. Reduced complexity was a must for the final product.
4. The next prototype would emulate a typical Intelligin station, eliminating the need for sample extraction and return to the air stream.

Of the above points, the largest problems to overcome were the interaction of the gin's air flow with the instrument and introduction of contaminates such as trash and loose lint. To better understand these phenomena a review of sample preparation and presentation within the HVI can prove helpful. This operation in HVI falls in 2 categories. In the first category, the samples in bulk are presented to the HVI sensors for measurements such as color, trash and moisture. This approach is duplicated in Intelligin using the paddle sampler as the means to present the cotton sample to these sensors. The second category of sampling requires the preparation of a sub sample for length, strength and micronaire. The major difference between these two sampling processes is that in the first category sensors are sealed, whereas the second category due to the sub-sampling process, requires the exposure of the sensors and the internal mechanisms to contamination and air flow turbulences of the gin's ducts.

Several hardware and software safeguards had to be developed to reduce the impact of air flows and contaminations ensuring proper sample presentation to the length module.
The implementation of these changes created complexity for this prototype that had to be addressed in prototype II.

The results from the performance of the first prototype were encouraging enough to initiate the design of the second unit in 2006. This new prototype, which was based on the HVI 1000 length module, was installed at a gin during the 2006 gin season. More specifically this integrated system is comprised of an Intelligin paddle sampler in the duct, automated comb transport, automated carding and brushing of the fiber comb, the HVI 1000 length module, new sample plate, and automated cleaning of the fiber comb. This integrated system was incorporated into the duct at the lint flue of the gin between the lint cleaner and the battery condenser as illustrated in Figure 6.

Figure 7 shows the transport mechanism and the installation in the duct. Figure 8 shows the special designed sample plate with the associated sampler hardware. Figure 9 shows the total system. The cabinet's internal design was such that it uses the gin's air flow to create negative pressure within this cavity in order to minimize contamination.

A video of the operation of this system will be viewed with the presentation of this paper at the conference.

Real-time data was taken with 5-6 samples per bale for approximately 1000 bales and compared to the USDA classing data for the same bales before the ginning season ended at this gin. Because this gin was using module averaging, the Upper Half Mean Length (UHML) was compared to the USDA module averaged data. Figure 10 indicates that the length data compared well to the module averaged data for the same bales using the applied USDA sustainment tolerances of +/- 0.3 mm.

The conclusion of the trial with the prototype II in 2006 was:

1. The sampling issues of the first prototype were resolved.
2. The complexity of the instrument was reduced.
3. Proof that length can be measured in real-time and on-line at the gin was obtained.
4. Proof that this data compares well with off-line HVI data was obtained.
5. Further simplification of the architecture, if possible, to make it a candidate as another module for Intelligin.
6. No mechanical failures were experienced during this trial.

CONCLUSIONS AND REMARKS

Future plans for development of on-line measurement of fiber length in the gin will focus on further simplification of product. We will also investigate various calibration methods, self cleaning and ease of maintenance.

This development increases the value to on-line process control in the gin by adding yet another real-time quality measurement and allows the ginner to further optimize the processes such as drying and cleaning to preserve fiber length, uniformity and to reduce or optimize the amount of short fiber content. Finally, and even more significantly, this product will also bring us one step closer to the ultimate goal of cotton classing in the gin.

Gin Process Control System
USTER® Intelligin System

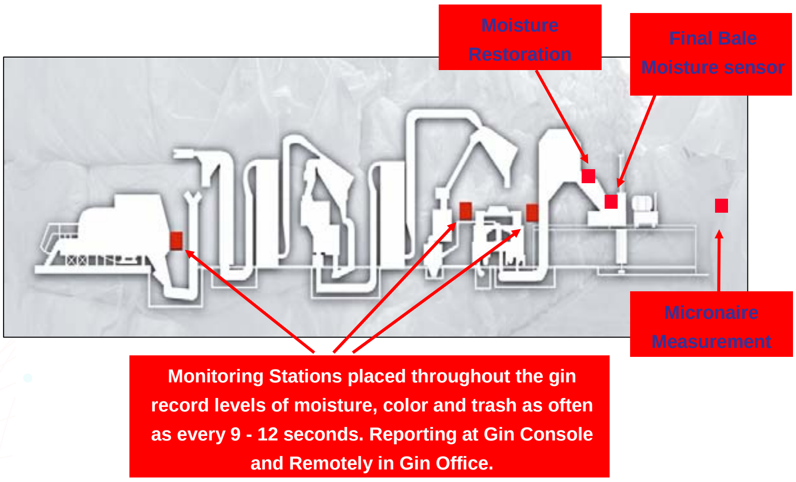

Figure 1.

USTER® Think quality

Intelligin
Sampling Station

Positioned just past the lint cleaners, this station gives a final reading of fiber moisture, trash and color to ensure the accuracy of the decisions made before cotton enters the bale press. This information is used as feedback to make adjustments to the process and assign color, trash and moisture properties in the bale.

Figure 2.

USTER® Think quality

Intelligin Sampling Station

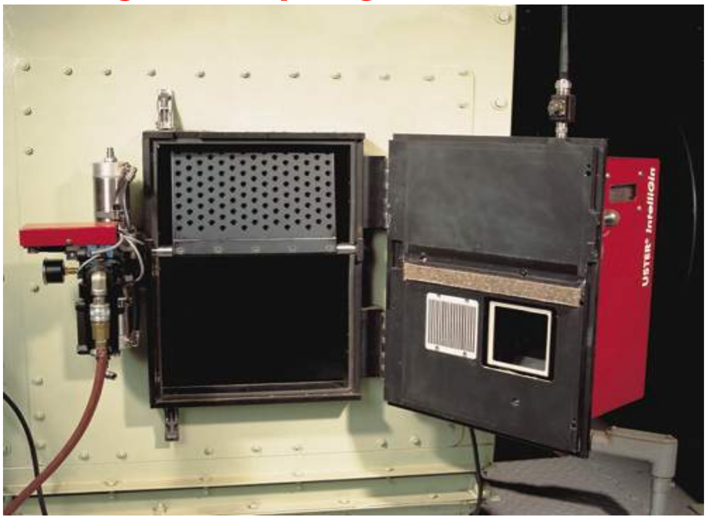

Figure 3.

Intelligin Control Console

Figure 4.

2005 On-Line Length Prototype I

Figure 5.

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2006 On-Line Length Prototype II Sampling Schematic

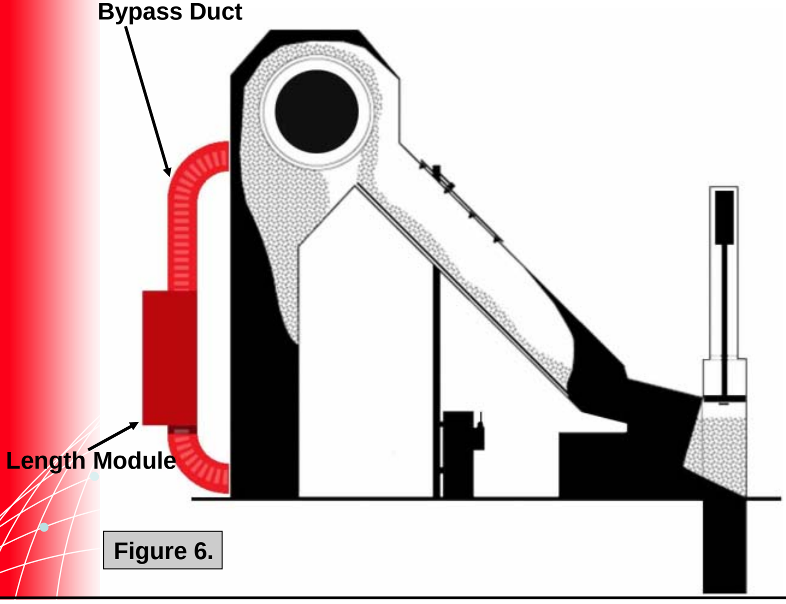

Figure 6.

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2006 On-Line Length Prototype II Transport Mechanics

Figure 7.

2006 On-Line Length Prototype II Sampler

Figure 8.

2006 On-Line Length Prototype II

Figure 9.

Comparison of On-Line Length Data to USDA Module Avg. Data with USDA Sustainment Tolerances of +/-0.3mm

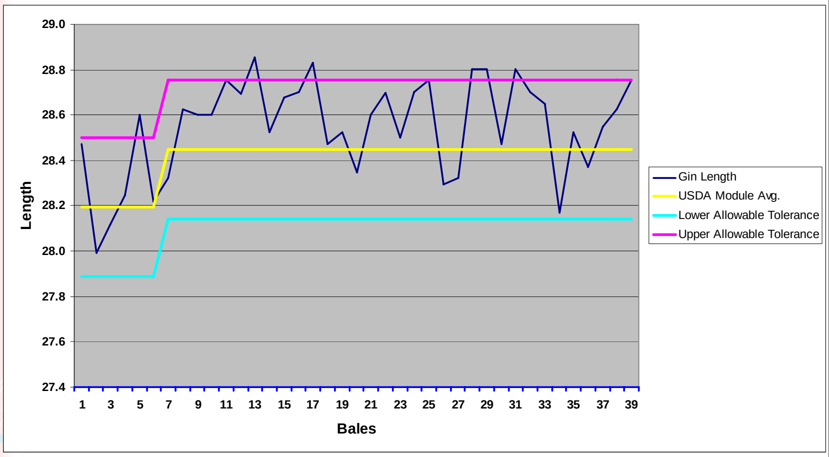

Figure 10.

COTTON FIBRE LINEAR DENSITY AND MATURITY MEASUREMENT AND APPLICATION

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ABSTRACT

A major problem associated with cotton fibre quality is related to the control and management of cotton fibre maturity and linear density (fineness) from growing through to spinning. At the centre of the problem is the absence of rapid and accurate measures for cotton fibre linear density and maturity. The problem exists despite the very significant impact that fibre maturity and linear density can have in the spinning mill and on the quality of fabric. Confounding control of fibre maturity and linear density is the widely accepted and used Micronaire test method, an airflow technique that measures a combination of fibre linear density and maturity. A consequence of using the Micronaire is that cotton can be classified inappropriately. For example, fine mature cotton can have the same Micronaire value as coarse immature cotton. Thus, there is a need for a new measurement technique to separate these. Recognition of fibre quality is of particular importance to the Australian cotton industry where varieties of fine, mature cotton have been wrongfully discounted because low Micronaire values were taken as indicating immature cotton, or high micronaire cotton may be discounted where in some cases the cotton may be fine and mature and appropriate for producing fine count yarns. In this paper progress of two instruments developed by CSIRO Textile and Fibre Technology (CTFT) in conjunction with the Australian Cotton Industry, which measure cotton fibre linear density and maturity directly and rapidly, is discussed.

INTRODUCTION

Cotton fibre linear density (sometimes referred to as fibre fineness) and maturity are two important fibre quality parameters that are currently not routinely evaluated or used by the industry. This paper will review research being undertaken at CSIRO in Australia (a) to develop suitable instrumentation to measure these parameters and (b) to explore the application and significance of these parameters. Preliminary work in this area was presented at an earlier Bremen conference (Gordon et al, 2004).

BACKGROUND

Definitions

During growth the cotton fibre, the longest single cell in nature, initially elongates with an approximately circular cross-section until it achieves its final fibre length of 22 to 35 mm. The elongation period lasts for between 16 and 20 days after flowering. At this point the cell wall (referred to as the primary cell wall) is very thin (< 0.4 μm) and extensible. Secondary wall synthesis starts during the final elongation phase and continues for another 15 to 22 days. During this phase successive concentric layers of cellulose are deposited on the inside surface of the cell wall. Maturation is evident when the fibre dries and the cylindrical cell collapses into a flattened, twisted ribbon with the characteristic irregular kidney shaped cross-section illustrated in Figure 1.

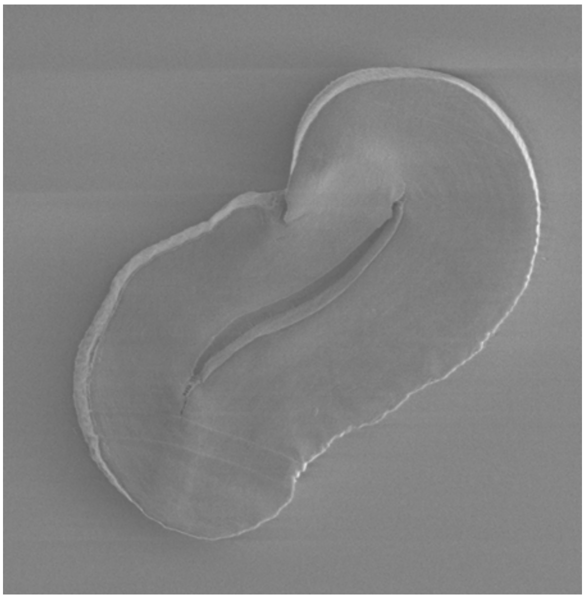


Figure 1: SEM of a cotton fibre cross-section.

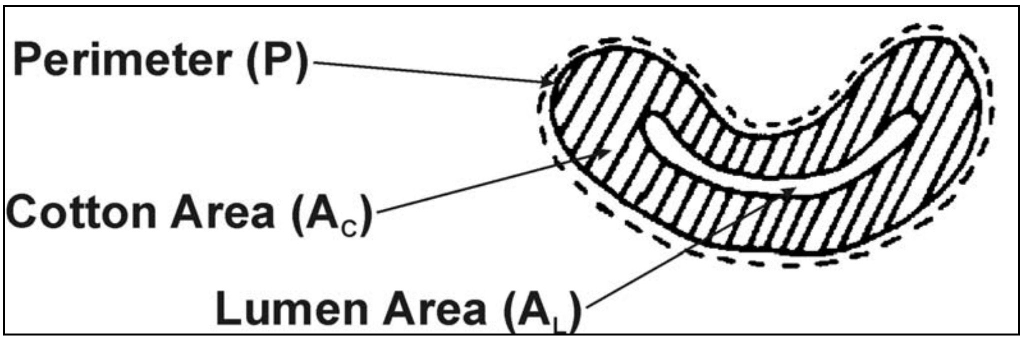


Figure 2: Schematic of a cotton fibre cross-section (modified from Boylston et al, 1990).

Figure 2 illustrates schematically this cross-sectional shape defining the fibre perimeter P, and the cell wall area A_c. Following the approach developed by Pierce and Lord (1939) and adopted by others (Thibodeaux et al, 2000; Hequet et al, 2006; and Montalvo et al, 2007) the degree of wall thickening theta (θ) is defined as the ratio of the cell wall area (A_c) to that of a circle having the same perimeter as the fibre cross-section, i.e.

$$\theta = 4\pi A_C/P^2 \qquad (1).$$

This term is converted, for convenience, to give fibre maturity ratio (M) as follows:

$$M = \theta/0.577 = 4\pi A_C/(0.577P^2) \qquad (2).$$

Further the fibre linear density (H) is given by:

$$H = \rho A_C \qquad (3),$$

where ρ, the cellulose cell wall density, is generally assumed to be constant at 1.52 g/cm^3.

Fibre linear density has sometimes been referred to as fibre fineness. However due to the irregular shape of the fibre cross-section, fibre linear density is not a direct measure of any actual geometric dimensions of the fibre *per se* and cannot be interpreted in that physical sense. Thus the term 'fibre fineness' is perhaps a little misleading and so it will not be used further in this paper. It is noted that the synthetic fibre industry have readily adopted the concept of fibre linear density with the units millitex (mg/km) or denier (g/9000 m) and it is in common usage commercially.

Micronaire and its limitations

To date it has not been possible to routinely, at commercial speeds, measure fibre linear density or fibre maturity directly so instead the industry has had to rely on the Micronaire test and value. This test is both rapid and relatively robust, which has aided its widespread adoption; however the interpretation of the Micronaire value is complex. Lord (1956) demonstrated that the Micronaire value is rather complex being a function of the product of both fibre linear density (H) and fibre maturity (M). The empirical relationship developed by Lord is:

$$H*M = 3.86*Mic^2 + 18.16*Mic + 13 \qquad (4).$$

Whilst recent work by Hequet et al (2006) has suggested that some minor adjustment to this relationship might be appropriate, it is well established that the Micronaire value is certainly a function of the product of fibre linear density and maturity. The consequence is that it is not possible to accurately determine fibre linear density or maturity value from the Micronaire value as illustrated in Figure 3. As an example, the vertical line on this graph demonstrates that a particular Micronaire value (4.1 in this example) can be obtained from cottons with a range of different fibre linear density and maturity combinations. As demonstrated later in the paper these different cottons can exhibit quite different behaviours in the spinning mill.

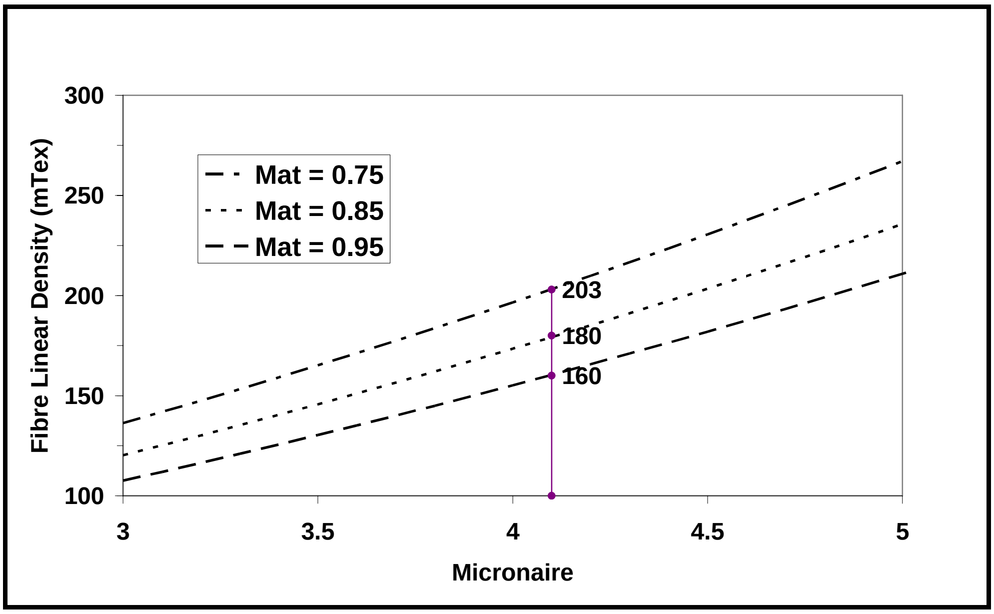


Figure 3: The relationship between fibre linear density and Micronaire. Each dotted line represents a different fibre maturity (Mat) value covering the common commercial range. The vertical line highlights that a particular Micronaire value (in this case 4.1) can represent cottons with a range of different fibre linear density values depending on fibre maturity.

The Australian Context

The Australian cotton industry is one of the most modern and technically advanced agricultural industries in the world. Nearly all Australia's cotton is exported to mills in Asia, with China, Indonesia, Thailand, South Korea and Japan being the main destinations (Australian Cotton Shippers Association, 2007). Whilst Australia produces only a small amount of the world's traded cotton, most of it is used by spinning mills for high quality fine count combed yarns and from this perspective Australia is a significant producer of world high-medium grade cotton.

The cotton Australia has grown over the last decade has earned a very good reputation amongst spinners for its spinning ability and for producing high quality yarns. Surveys of mills that use Australian cotton to obtain more accurate information on the quality of Australian cotton (Gordon et al, 2004) indicate that a move to Micronaire values within the 'premium' range of 3.8 to 4.2 would be beneficial, on the basis that this cotton is both fine (has a low linear density) and mature.

We believe that measuring and controlling fibre linear density and maturity and understanding their respective impacts during textile processing will be beneficial in achieving these desired industry aims. Hence CSIRO have, in conjunction with the Australian Cotton Industry, developed two new technologies for measuring fibre linear density (Cottonscan™) and maturity (SiroMat™) quickly, directly and accurately. Each technology is based around an existing standard technique. In the case of fibre linear density (the Cottonscan™ instrument) the standard method for linear density by the cut and weigh method is automated and for fibre maturity (the SiroMat™ Instrument) the standard method for maturity by polarized light microscopy is automated.

Following sections describe in more detail CSIRO's understanding and progress in this area.

FIBRE LINEAR DENSITY

The importance of the number of fibres in the yarn cross-section

For a given yarn count, if the fibre linear density is known it is straight forward for the spinner to accurately determine the average number of fibres in the yarn cross-section. This is extremely useful information as it is well known that the average number of fibres in a yarn cross-section can be a key determinant of both spinning efficiency and yarn evenness/quality due to the statistics of random processes associated with the positioning of individual fibres along a yarn (Martindale, 1945). There is no ability to sense the number of fibres on the spinning system at any particular point that would enable this random limit to be overcome. Spinners are well aware of the spinning limit or 'wall' whereby it is practically impossibly to spin a fine count yarn if the fibre is too coarse (this is the basis of the discounts for high Micronaire cotton.)

In ring spinning of fine wool yarns where fibre diameter is well characterized the average number of fibres in the yarn cross-section can be readily calculated. In this case workers at CSIRO have been quite successful in developing a software package based on a mechanistic understanding of the spinning process and the random statistics associated with the number of fibres in the yarn cross-section (Lamb and Yang, 1996). Figure 4 reproduced from Lamb and Yang (1996) illustrates both the success of this software to accurately model practical wool spinning and also demonstrates that the number of thin places in the yarn increases exponentially as the number of fibres in the yarn cross-section decrease, i.e. the wall defining the spinning limit is indeed very steep.

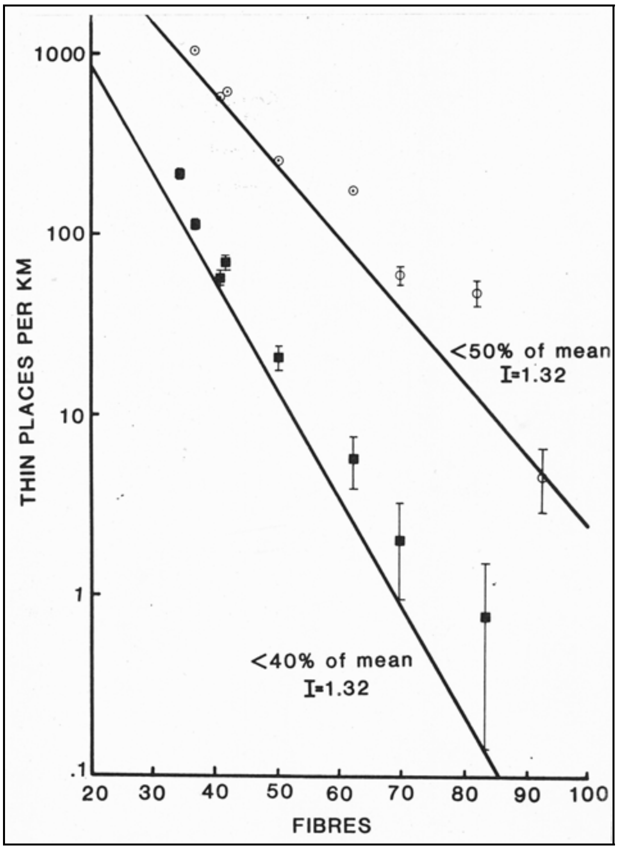


Figure 4: Predicted and measured thin places in ring spun worsted wool yarns plotted against the number of fibres in the yarn cross section (reproduced from Lamb and Yang, 1996)

Theoretical Application to Cotton Spinning

The basic principles and understanding of ring spinning apply to all fibre types including cotton. Qualitatively cotton spinners are very familiar with these effects and in particular spinners of fine yarns do indeed choose their input fibre carefully.

Figure 5 illustrates the results of some simple modelling of the number of fibres in the cross-section of a 15 tex cotton yarn for three different fibre qualities. Using random/Poisson statisitics, Figure 5a shows the distribution of the number of fibres in the cross-section and Figure 5b highlights how the relative number of thin places in the yarn (in this case less than forty fibres in the yarn cross-section) rapidly increases with a relatively small increase in fibre linear density: in this example a 10% increase in fibre linear density, i.e. from 160 to 180 mtex, leads to a 300% increase in the number of thin spots in the yarn. So the 160 mtex fibre might easily spin and produce a commercially acceptable yarn whereas the spinner might not be able to successfully spin a commercially acceptable yarn from the 180 mtex fibre.

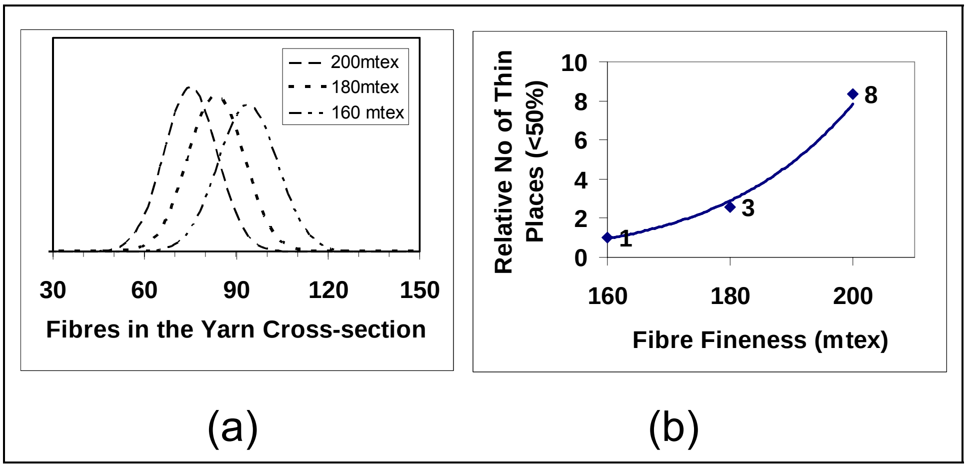


Figure 5: Illustration of the effect of fibre linear density on (a) the number of fibres in the yarn cross-section and (b) the number of thin places in the yarn

It is interesting to note that the range of fibre linear density values used in the example above, i.e. Figure 5, is similar to the range of fibre linear density values shown in Figure 3 that have the same Micronaire value. That is, Figure 5 illustrates that different cottons with the same Micronaire value, within the expected practical/commercial range of fibre linear density and maturity combinations, can deliver extremes of performance in spinning!

Measuring Cotton Fibre Linear Density: The Cottonscan™ Instrument

Figure 6 shows the Cottonscan™ instrument that has been under development at CSIRO (Naylor and Sambell, 1999; Naylor, 2001; Gordon and Naylor, 2004; Gordon et al, 2004; and Naylor and Purmalis, 2005). The approach to measuring fibre linear density is based on the direct method of measuring the total length of a known mass of the fibre snippets to calculate directly mass per unit length.

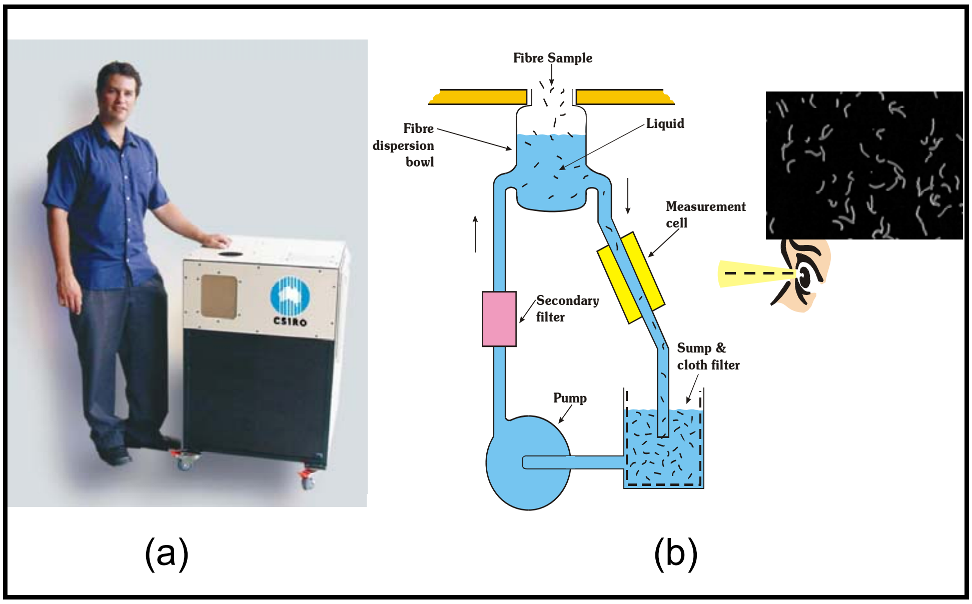


Figure 6: (a) Photo of the Cottonscan™ Instrument and (b) schematic of operation

As shown schematically in Figure 6(b), prepared and weighed fibre snippets are suspended in an aqueous medium within the instrument prior to the measurement cell. The suspended snippets are then imaged as shown in the measurement cell and image analysis is used to determine the total snippet length within the image. To improve the cycle time of the instrument, a premise of the instrument is that a suspension of fibre snippets can be formed so that it is reliable to sub-sample the suspension rather than measuring the total volume in order to determine the length of fibre snippets within the sample. Thus the calculation of the average fibre linear density H of a sample is as follows:

$$H = \boldsymbol{M}^{*}(v/V)/l \qquad (5),$$

where ***M*** is the total mass of the snippets, V the total volume of the suspension and l is the measured length of fibre snippets in the sub-sampled volume v.

Hence a technical requirement for the snippet preparation device is its ability to deliver snippets that can be readily mixed into a uniform suspension within the Cottonscan™ instrument. From an operator perspective it is also important that all aspects of the Cottonscan™ instrument including the snippet preparation device be both easy to operate and generally ‘user-friendly’.

Naylor and Purmalis (2005) reported comparative trials of three Cottonscan™ Version 2 instruments. Using well blended sliver samples, good agreement between instruments was observed (average between instrument difference were less than 4 mtex) and the observed 95% confidence limits for replicate measurement of average fibre linear density on a single instrument was ± 6.5 mtex, (i.e. ± 3% for a typical 200 mtex sample).

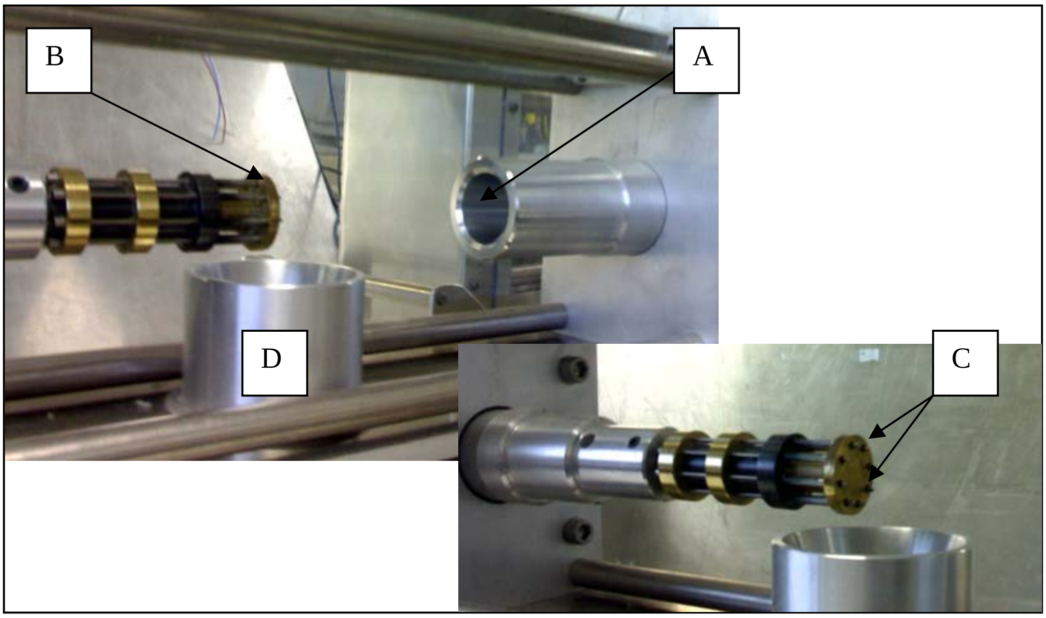


Figure 7: The new automatic snippet preparation module highlighting **A** the sample chamber, **B** the piston, **C** the cylindrical punches and **D** the sample collection cup

A significant breakthrough with the technology was the development of an easy to operate module for preparing snippets from lint samples, (Higgerson et al, 2007). The module is illustrated in Figure 7. A sample (approximately 10 g) of lint is manually inserted into chamber A. Movement of Piston B to a fixed pressure compresses the lint sample and then in a second action cylindrical cutters each approximately 2 mm in diameter extend from the face of the piston to collect a core of snippets from the cotton lint sample. In the current design a set of 8 cylindrical cutters are arranged in the piston assembly so that the total mass of snippets collected from one cycle of the preparer is approximately 80-100 mg, i.e. adequate for the Cottonscan™ instrument. The piston head assembly including the cylindrical corers/cutters has been used routinely for many years to prepare wool snippets for commercial testing in the Sirolan-Laserscan™ instrument. In the wool application, this engineering design has proved to be both robust and easy to operate. The snippet preparation module is driven by an external compressed air supply and appropriate safety interlocks are standard features.

In preparation for an inter-laboratory trial using the new snippet preparation device three instruments each with individual automatic snippet preparation modules were assembled and tested at CTFT. In Equation 5, in principle, all the parameters to calculate the average fibre linear density are known and fixed. However, in practice, prior to instrument calibration/harmonisation, small differences (typically less than 15%) in the resultant fibre linear density values between instruments can occur due to difficulties in accurately determining the two volumes v and V and the effect of between instrument variations in the lighting systems affecting the observed length of snippets, *l*. Calibration cotton with an assigned average linear density value (157 mtex) was used to harmonise the results of each instrument for this particular cotton via the introduction of a small machine specific linear correction factor β. Equation 5 is thus modified as follows:

$$F= \beta \boldsymbol{M}^*(v/V)/l \qquad (6).$$

Following this calibration procedure, two Cottonscan™ systems were shipped in preparation for an inter-laboratory trial to compare the operation of three different Cottonscan™ systems at three different locations within Australia (a commercial cotton classing house, the test laboratory at CSIRO's major Australian on-farm cotton R&D research station, and CTFT). It is noted that on arrival at their destination, the instruments were installed and no further recalibration was undertaken prior to conducting the inter-laboratory trial. Thus the trial was designed to test the robustness of the instrument to both (a) the rigour of transport and also (b) their performance in different environments with different untrained operators.

For this trial 5 different cottons were chosen covering a range of linear density values from 160 mtex to 250 mtex. These comprised the three well blended cottons samples used previously (Naylor and Purmalis, 2006), a one bale sample of a commercial Australian upland cotton that was blended and processed to sliver and then broken to form a loose fibre sample (Sample Ref No: SRL6000) and finally an unblended fibre sample of Australian Pima cotton, (i.e. sampled directly from a commercial bale without any further blending). Nine replicate samples of each cotton (each approximately 10 g) were prepared centrally and supplied to each laboratory for the trial.

The results of the measured average linear density values from this trial are summarised in Figure 8. Figure 9 shows the partial residuals from an ANOVA of this data after removing the average between sample differences. Statistically significant but relatively small global differences between laboratories were observed as listed in Table I. From this analysis the 95% confidence interval for a single measurement is ± 10.4 mtex (note this confidence limit includes the between laboratory/instrument component).

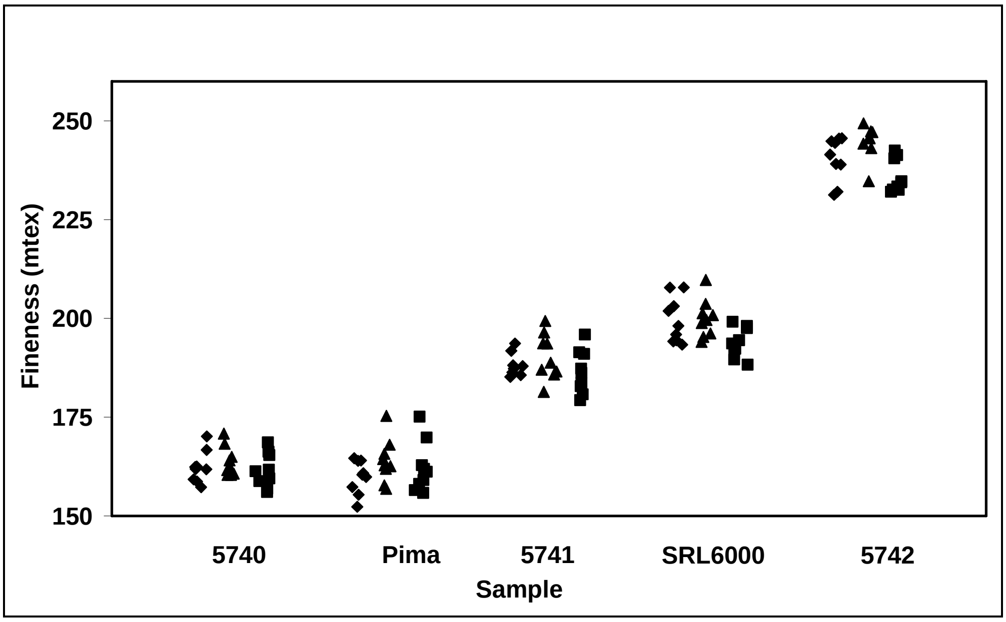


Figure 8: Results of the inter-laboratory trial comparing three Cottonscan™ systems (the different symbols represent the three different laboratories)

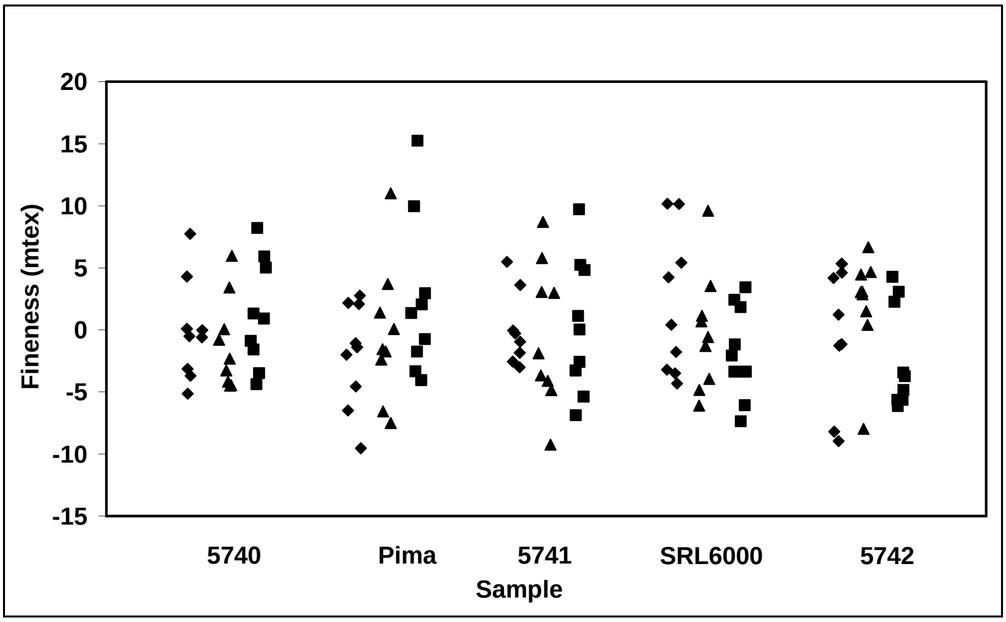


Figure 9: Partial residuals from an ANOVA of the data in Figure 8 taking account of the between sample variation (the different symbols represent the three different laboratories)

Table I: Summary of the overall differences between laboratories in average linear density values.

Laboratories	Global Difference (mtex)	Stat. Significance
Lab 1 – Lab 2	-2.47	*
Lab 1 – Lab 3	2.02	NS
Lab 2 – Lab 3	4.49	*

* Significant at the 95% level.

Analyses of variance were performed with each cotton and the results are summarised in Table II. It demonstrates that for each particular cotton, the within sample variation dominates, i.e. it is much larger than the between laboratory effect. Further the between laboratory effects are not statistically significant for the finer cottons and the small statistically significant differences only appear for the coarser cottons, i.e. small inter-instrument differences only appear as one moves 50 mtex or further away from where the instruments have been harmonised using the calibration cotton (157 mtex).

Table II: Summary of ANOVA's for individual cotton average linear density values.

Cotton	Mean Linear density (mtex)			Variance			[1]Between Labs Significance
	Lab 1	Lab 2	Lab 3	Within Cotton	Between Laboratory	Total	
5740	162.30	163.76	161.61	16.19	-0.60	16.19	NS
Pima	159.86	163.92	162.26	29.63	0.89	30.52	NS
5741	188.23	190.31	186.49	24.88	0.90	25.78	NS
SRL6000	199.64	199.97	193.92	23.38	8.97	32.35	*
5742	240.39	244.80	236.03	21.99	16.77	38.76	**

[1]NS = Not Significant; * = Significant at 95% level; ** = Significant at 99% level

One additional feature of the Cottonscan™ instrument is that if the Micronaire value of a cotton sample is independently measured and input into the instrument with the sample details, the software automatically calculates the maturity of the sample based on the measured fibre linear density and Micronaire values (using the relationship developed by Lord, i.e. Equation 4). In the present inter-laboratory trial the Micronaire values were available and the 95% confidence limits calculated from the ANOVA of the complete set of maturity values was ± 0.047 units. Overall results and analysis indicate that the Cottonscan™ system can indeed be used to reliably determine the average fibre linear density of a lint sample.

Practical Applications of Cotton Fibre Linear Density measurements from Cottonscan™ to Spinning Data

A wide range of studies into the role of variety and agronomic factors on textile processing parameters is currently being undertaken at CSIRO and the results from this study will be published elsewhere in due course. A subset of this trial, involving one bale samples of a range of upland varieties grown in controlled large scale field trials has been processed at the CSIRO textile mill into 20 tex ring spun yarn. Cottonscan™ measurements were made on seven lots forming this trial and Figure 10 demonstrates the relationship between the measured yarn tenacity values and (a) the Micronaire value and (b) the average fibre linear density values. It is clear from the mill's perspective that the average cotton linear density values are a much better predictor of yarn tenacity than the Micronaire value. A specific example relates to the two cottons circled in each graph. Both these cottons have the same measured Micronaire value but are quite different in terms of yarn properties, i.e. based only on Micronaire values, a mill would be unable to identify the different potential of these two different cottons. Cottonscan™ average fibre linear density results are however able to clearly distinguish these two cottons and correctly predict the difference in yarn properties. Note that the observed correlation with average fibre linear density is indeed in line with the established understanding of the spinning process where the use of finer fibres, increases the number of fibres in the cross section for a given yarn count leading to improved yarn evenness, and hence higher yarn tenacity values.

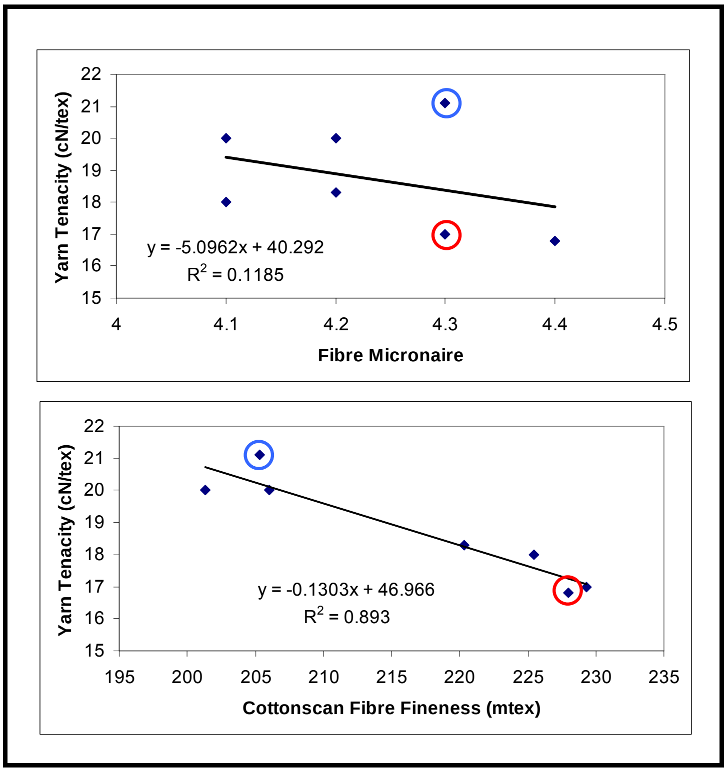


Figure 10: The Relationship between yarn tenacity values and (a) the Micronaire value and (b) the average fibre linear density values, from spinning trials comparing a range of Australian Upland cotton varieties

FIBRE MATURITY

Cotton fibre maturity is equally an important property to spinners and fabric manufacturers. Whilst many textile processing stages in the transformation of fibre through to fabric are sensitive to fibre properties that are contiguous with fibre maturity, the property of fibre maturity *per se* is more often not the dominant factor (Smith, B., 1991) in the same way that linear density, staple length and bundle strength dominate yarn quality parameters. The exception is perhaps the non-uniform dyeing of fabric; manifest as shade bands and repeats along fabric lengths, colour yield, barré and under-dyed or undyed neps, which is directly related to fibre maturity variations in the cotton being processed.

Measuring Cotton Fibre Maturity: The SiroMat™ Instrument

Figure 11 shows the SiroMat™ instrument developed at CSIRO (Gordon and Naylor 2004, Gordon, Lucas and Phair 2005). The method determines fibre maturity based on the colours that fibres assume when viewed under a polarized light microscope. The relationship between the interference colours assumed by fibres under crossed polars and fibre maturity is based upon the orientation of cellulose chains in the fibre wall, which affect the path length of light through the wall. The method has previously been overlooked because classing the fibres on the basis of colour was subjective and the manual counting of fibres was too slow. The Standard Method (ASTM D1442, 2000) in fact warns against using the method for acceptance testing because "laboratory precision can be poor." However, the advent of colour digital cameras and the increased power of today's personal computers have made this approach viable.

In addition it has been thought that the method was biased by fibre linear density (Lord and Heap, 1988) or, by implication the path length of light through the fibre. A survey of the interference colours assumed by different cottons by Gordon and Phair (2005) showed that there was no difference in colour on the basis of genetic origin or intrinsic fineness. Three different cotton species were included in the survey and thus a wide range of cross-sectional parameters (cross-sectional wall area and perimeter) were represented. The survey demonstrated that the interference colours transmitted by a fibre related directly to a prescribed range of values for fibre maturity, and were not co-dependent upon fibre perimeter or cross-sectional area as previously thought.

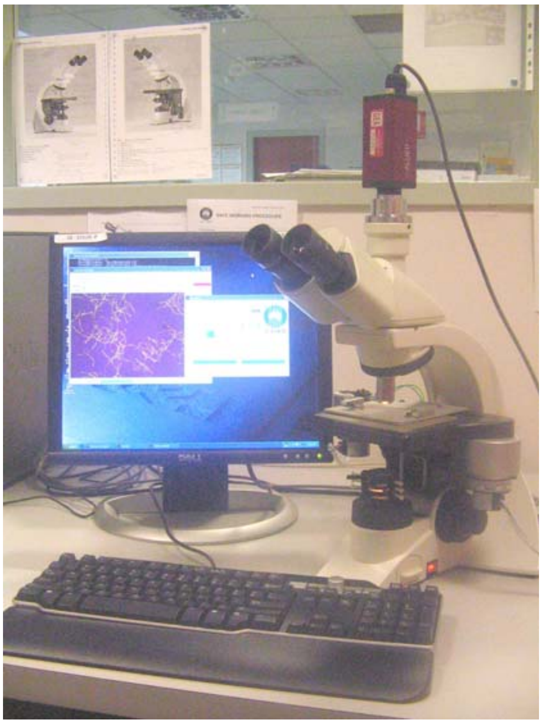
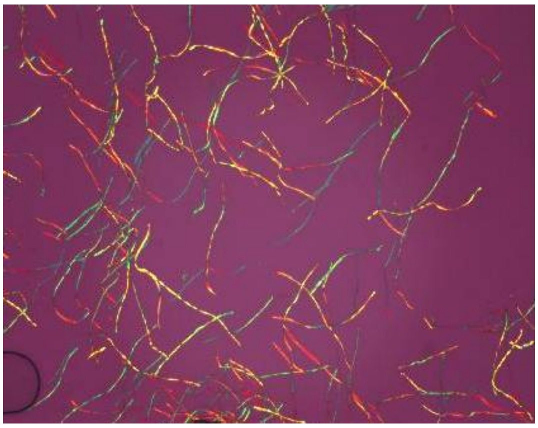


Figure 11: Photo of one the SiroMat™ instruments at CSIRO.

Colour digital cameras, image analysis software and higher powered computers have made automation of the polarized microscopy test viable and allow test times of less than two minutes per sample to be achieved. Moreover, the sample, which can be derived from raw or processed cotton fibres, does not require conditioning before testing. The SiroMat™ method determines fibre maturity based on the colours fibres assume when viewed under a polarized light microscope set up according to the ASTM standard. Cotton fibres are automatically scanned and analyzed so that selection of fibres or fibre sections and interpretation of their colour is no longer subject to operator interpretation. Figure 12 shows one of 36 fields-of-view (FoV), the area of which measures 9 mm^2, analysed by the SiroMat™.

As well as measuring average fibre maturity the method is also able to measure the distribution of mature and immature fibres in a sample. Figure 13 shows an image of cotton fibre segments analyzed by the SiroMat™ test. Notable in this example is the negative skew of the fibre maturity distribution, which is seen in mature cottons, i.e. those with average maturity ratios in excess of 0.85. The SiroMat™ maturity distribution tends towards a more standard normal distribution with increasing immaturity in the cotton sample.



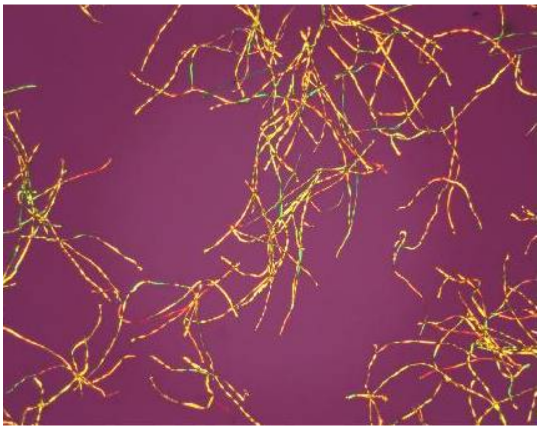


Figure 12: (a) Immature fibres in SiroMat™ FoV and (b) mature fibres.

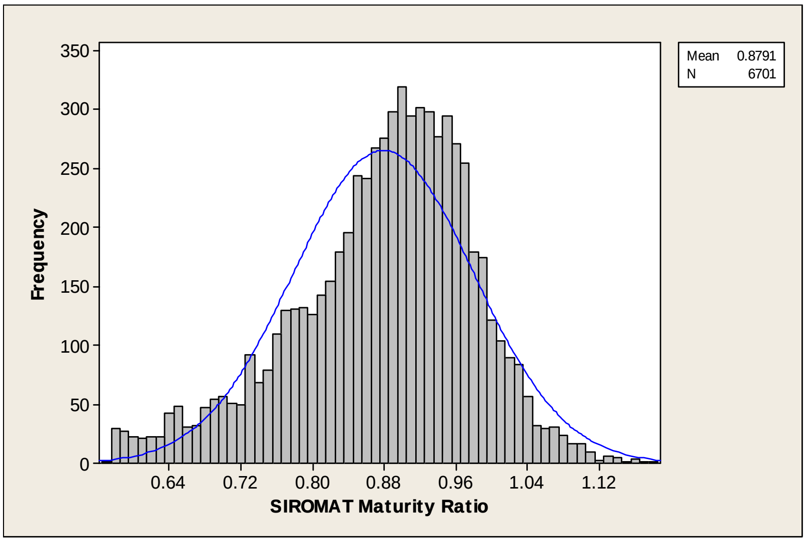


Figure 13: Typical SiroMat™ maturity ratio distribution obtained for 'mature' cotton. Note negative skew with long immature tail for the average maturity ratio value of 0.88.

The SiroMat™ is calibrated in terms of maturity ratio according to the conventions described earlier in this paper (see Equation 2). The current calibration equation is a two term multiple linear regression with the independent variables being the area of yellow and green colour measured in the fibre snippet images as per Figure 12. These percent colour areas are correlated with maturity ratio data measured currently using a 'Shirley' Fineness and Maturity Tester (FMT) on a calibration set of predominantly Australian Upland cottons. Figures 14 and 15 show the prediction ability of the current SiroMat™ calibration on a validation set of these cottons. The correlation co-efficient (r^2) for the relationship is in excess of 0.75 with a 95% confidence interval for averages in the set illustrated of ±0.074.

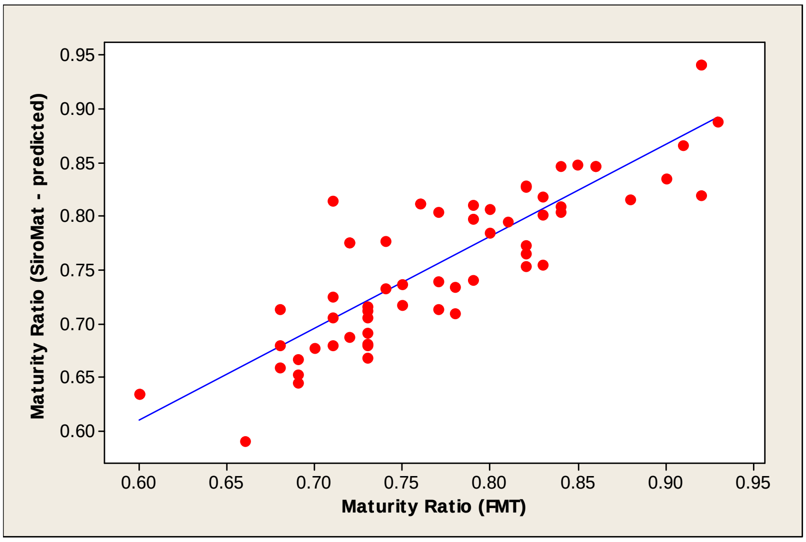


Figure 14: Relationship between SiroMat predicted results and reference results (as measured by the 'Shirley' FMT); $y = 0.874x + 0.115$; $r^2 = 0.754$.

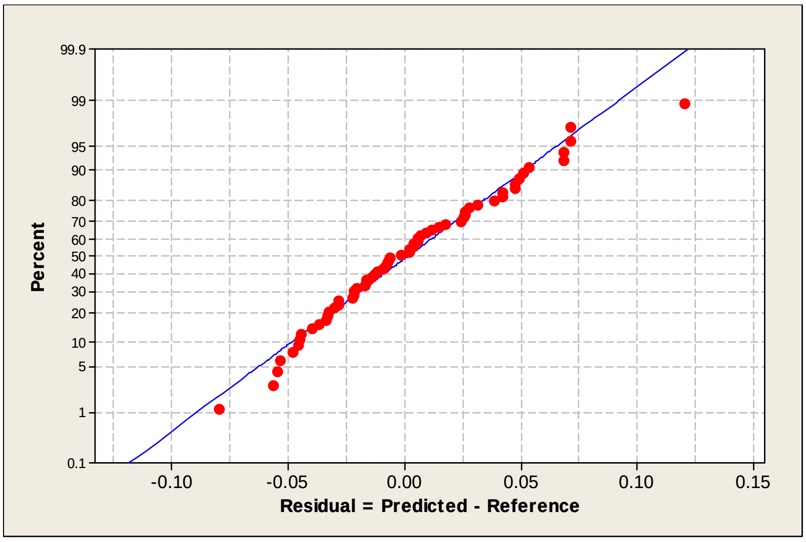


Figure 15: Normal probability plot of residuals from Figure 14.

Specimens of SiroMat™ testing are typically prepared by blending them through one passage of a 'Shirley' Analyser. Although this action is not necessary, we note blending fibre samples as part of specimen preparation improves the precision of the results and consequent correlations with reference and other data - see Figure 16 as an example of this effect. After blending specimen preparation then involves guillotining a fibre beard prepared using a 'Fibrosampler' to obtain between 2 to 3 mg of 1 mm snippets from two cuts near the aligned end of the beard. The snippets are collected and then spread in an annular pattern on a 5 cm x 7 cm glass slide using an OFDA™ fibre spreader. A clean 5 cm x 7 cm slide is used to cover the specimen. Castor oil (refractive index = 1.477 - 1.481) is used as the mounting medium to enhance the contrast of the fibre snippets to their background.

Preparing the SiroMat™ instrument involves adjusting the digital camera settings (U balance, V balance and shutter speed) and the microscope lamp intensity to match a prescribed FoV background colour in terms of red, green and blue ratios. Background colours are checked at regular intervals during testing to minimize drift in instrument readings. Each sample measured in Figure 14 represents an average of four replicates obtained from blended raw (bale) fibre samples.

Recent work with the SiroMat™ has focussed on demonstrating the value of SiroMat™ data with respect to predicting harvest (agronomic) and mill quality. Following are examples of SiroMat™'s ability to measure fibre maturity in samples of cotton contrived to represent early and late defoliated cotton, and to predict dye uptake in fabrics processed from cottons of the same Micronaire but different average maturity. The ability to use SiroMat™ maturity ratio to calculate fibre linear density was also examined.

Effects of defoliation timing

In one study (Gordon et al, 2007) seed-cotton samples from immature and mature plants of the same variety were manually combined into 11 blends containing different proportions of immature and mature fibre based on weight; i.e. 100% mature: 0% immature down to 0% mature: 100% immature, in 10% increments. Blended samples were saw ginned, cleaned and then tested using SiroMat™ to demonstrate the ability of the SiroMat™ instrument to differentiate samples on the basis of their mean maturity and dispersion statistics and to demonstrate the potential value of SiroMat™ data in predicting nep generation. Figure 16 shows the strong relationship between the percent of blended mature and immature cotton and SiroMat™ measurements of maturity ratio and demonstrates the ability of SiroMat™ to measure the percent of immature fibres in a sample.

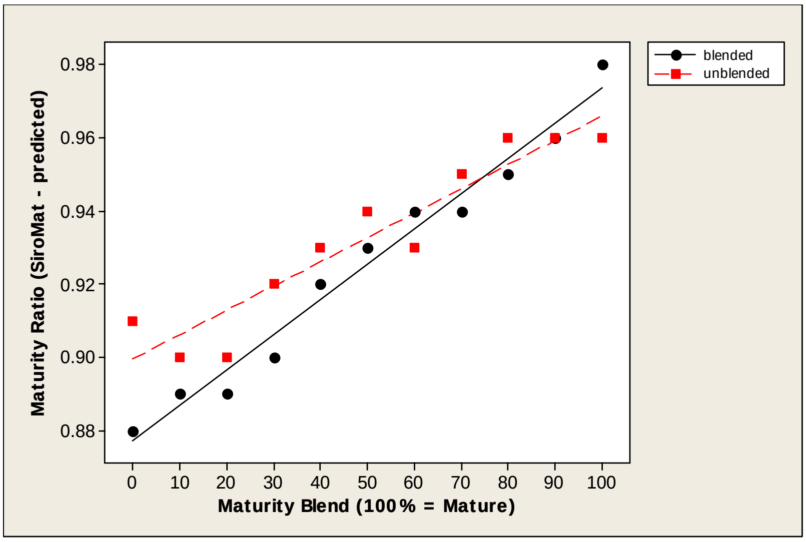


Figure 16: SiroMat™ maturity ratio results for blended (r^2 = 0.976) and unblended (r^2 = 0.873) maturity blend samples. The standard error of prediction for the percent of mature (blended) fibres in each blend is ±5.49(%).

Predicting product quality in mills

In another study (Gordon et al, 2008) the sensitivity of SiroMat™ average maturity and distribution values (standard deviation and skewness values) to differences in griege yarn and dyed fabric quality were examined. Two sub-sets of cotton each with the same average Micronaire as measured by HVI but with different fibre maturity values as measured by SiroMat™ were processed from raw fibre through to dyed finished knit fabric. Table III shows the correlation matrix between the fibre test results and finished product properties, i.e. yarn properties and dye uptake in fabric. The correlations show that Micronaire, or linear density, calculated using SiroMat™ maturity ratio and Micronaire according to Lord's Equation (Eq. 4) have, along with staple length and bundle strength, a strong influence on basic (20 tex ring spun) yarn quality parameters such as evenness (CVm), imperfections (thin places and neps) and tenacity. In this set of yarns both Micronaire, measured by HVI, and the calculated linear density had a lesser affect on yarn tenacity than the set of yarns used in Figure 10 due to the wider range of staple strength and length between cottons in this set having a more dominant effect on yarn tenacity (see Table III). However, it is interesting to look at plots of these properties with yarn tenacity. Figure 17 shows yarn tenacity against linear density calculated from SiroMat™ and Micronaire results, and against only Micronaire results. Although not borne out by the correlation statistics, there is evidence in these plots of linear density better describing a yarn tenacity affect, particularly with regards to the 'finer' sub-set (Micronaire 4.4) of cottons. Fibre maturity by itself had little influence on yarn properties, although it had a very significant influence on dye uptake, measured in this study as the level of reflectance (*L**) – see Figure 18.

Table III: Correlation coefficients and probabilities of a linear relationship between SiroMat™ results and yarn and fabric properties

Fibre property	**Yarn properties**				**Dye uptake measured as colour according to the CIELab model**		
	CVm	**Thin**	**Neps**	**Ten**	***L****	***a****	***b****
LEN (HVI)	**-0.870** ***0.005***	**-0.848** ***0.008***	-0.181 *0.667*	**0.746** ***0.033***	0.051 *0.905*	-0.260 *0.533*	0.185 *0.661*
STR (HVI)	**-0.748** ***0.033***	-0.690 *0.058*	-0.145 *0.733*	**0.880** ***0.004***	-0.123 *0.772*	-0.348 *0.399*	0.367 *0.372*
MIC (HVI)	**0.943** ***0.000***	**0.876** ***0.004***	0.481 *0.227*	-0.587 *0.126*	-0.443 *0.272*	0.403 *0.322*	-0.093 *0.826*
MR (SiroMat)	0.036 *0.933*	0.018 *0.967*	-0.145 *0.733*	0.137 *0.747*	**-0.799** ***0.017***	0.538 *0.169*	-0.592 *0.122*
FIN (SiroMat)	**0.898** ***0.002***	**0.833** ***0.010***	0.539 *0.168*	-0.588 *0.126*	-0.146 *0.731*	0.179 *0.672*	0.150 *0.724*
Std. Dev. (SiroMat)	-0.077 *0.856*	-0.004 *0.992*	-0.018 *0.966*	-0.098 *0.817*	**0.713** ***0.047***	-0.433 *0.284*	0.456 *0.256*
Skewness (SiroMat)	-0.063 *0.882*	-0.080 *0.851*	0.220 *0.600*	0.193 *0.647*	**0.864** ***0.006***	-0.579 *0.132*	0.557 *0.152*

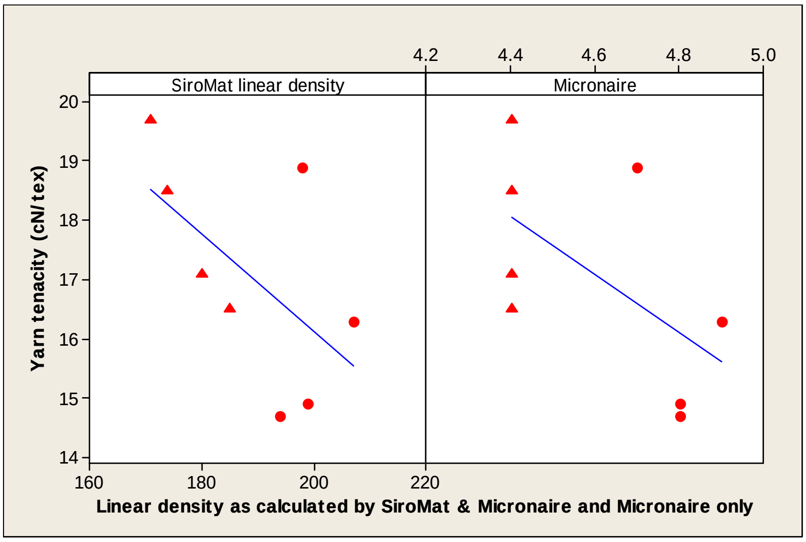


Figure 17: Fibre linear density as calculated from SiroMat™ and Micronaire, and Micronaire with yarn tenacity; ▲ = sub-set of samples with average Micronaire of 4.4, ● = sub-set of samples with average Micronaire of 4.8.

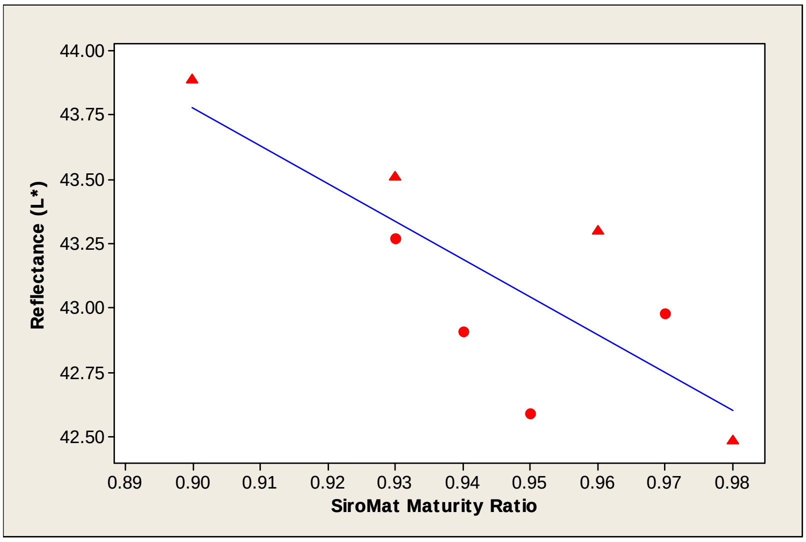


Figure 18: SiroMat™ maturity ratio vs. reflectance results from cottons with same Micronaire but different maturity:linear density combinations; ▲ = sub-set of samples with average Micronaire of 4.4, ● = sub-set of samples with average Micronaire of 4.8.

CONCLUSION

New instrumentation for measuring fibre linear density and fibre maturity under development at CSIRO, namely the Cottonscan™ and the SiroMat™ are proving to be both reliable and capable of providing valuable additional information to the textile processor and on-farm sectors of the cotton industry. For crop and fibre researchers and growers it is hoped the instruments can be used:

- As a selection tool for linear density and maturity in new experimental varieties.
- To measure the effects of plant physiology, i.e. carbohydrate and nutrient flow and genetic coding, on the linear density and maturity of varieties.
- To measure effects of production variables, i.e. water, nutrient and harvest preparation, on linear density and maturity of varieties.

For the market, i.e. merchants and spinners, it is hoped the new measurements will bring:

- Better informed selection of varieties and growing conditions to produce fine and mature, i.e. premium, fibre.
- Elimination of ambiguities in Micronaire discounts.
- Consistent production and supply of fibre within current Micronaire/linear density premiums to address market concerns.
- Additional information to processors (spinners and dyers) on the potential quality of yarn and fabric production.

ACKNOWLEDGEMENTS

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FASERINSTITUT FIBRE BREMEN

29th International Cotton Conference BREMEN

April 2 - 5, 2008

Session VI: Cotton Testing and Testing Harmonisation

ITMF International Committee on Cotton Testing Methods

Chairmans report
ITMF committee on cotton testing methodes
Anton Schenek

Task Force on HVI - Mona Qaud
Task Force on Length - Axel Drieling
Task Force on Stickiness - Jean-Paul Gourlot
Task Force on Neps and Trash - Jonn Foulk
Task Force on Fineness and Maturity - Gary Gamble
Task Force on Colour - Malgorzata Matusiak

Editor's Note

The minutes will be published in a
PROGRESS REPORT in due time.

- ***International activities in cotton classification standards***
  James Knowlton
- ***Results of the first year of implementation of the CSITC Round Trial***
  Axel Drieling
- ***Cotton classing reform in China***
  Xiaoxin Yu, Naihua Wang
- ***Analysis of chemical residues on cotton and cotton products***
  Rainer Weckmann

INTERNATIONAL ACTIVITIES IN COTTON CLASSIFICATION STANDARDS

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ABSTRACT

The United States Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Cotton Program is promoting international standardisation in cotton classification through activities in the Universal Cotton Standards Agreement and American Society for Testing and Materials (ASTM) International. Being the largest supplier of physical cotton fibre classification standards in the world, the AMS Cotton Program strives to insure that its standards meet the needs of the international cotton industry.

The AMS Cotton Program is active in assisting the standardisation initiatives of the International Cotton Advisory Committee’s (ICAC) Commercial Standardisation of Instrument Testing of Cotton (CSITC) Task Force. The AMS Cotton Program also conducts the USDA HVI Check Test Program for over 50 international participants and is also active in providing cotton classification training and seminar programs to various international organisations.

INTRODUCTION

The USDA, AMS, Cotton Program has many years of experience in developing and using cotton fibre classification standards. Since 1923, the AMS Cotton Program has been producing the Universal Cotton Standards under the auspices of the Universal Cotton Standards Agreement. Since 1991, the AMS Cotton Program has High Volume Instrument (HVI) tested practically every cotton bale produced in the United States totaling approximately 300 million bales of cotton. This vast amount of experience in producing cotton fibre standards and providing large scale HVI cotton classification testing has equipped the AMS Cotton Program to play a significant role in facilitating the worldwide transformation from manual to instrument based cotton classification.

UNIVERSAL COTTON STANDARDS AGREEMENT

In 1923, the Universal Cotton Standards Agreement was established and provided the mechanism for developing internationally accepted cotton classification standards. The current Agreement is between the USDA, the U.S. cotton industry and 23 international cotton associations representing 21 countries. The Agreement provides the AMS Cotton Program with the guidance needed to produce the Universal Colour/Leaf Grade Standards and the Universal HVI Standards for measurements of micronaire, strength, length, length uniformity index, colour Rd and colour +b. Every three years, the delegates of the Universal Cotton Standards Agreement meet in Memphis, Tennessee, USA to consider changes to the Agreement.

Historically, the purpose of the Universal Cotton Standards Agreement has been to provide a universally accepted classification standard for trading of U.S. cotton. However, over time the scope of the Universal Cotton Standards has expanded as a basis of cotton trading for many non-U.S. cottons. Furthering this international expansion of the use of Universal Cotton Standards has been the growing adoption of HVI testing outside of the U.S. The Universal Cotton Standards serve as the primary calibration reference standard for HVI testing and as a result, the expansion of HVI systems around the world has resulted in expansion of the Universal Standards.

Given that the Universal Cotton Standards are now internationally utilised and accepted to such a great extent, it is important that delegates of the Universal Cotton Standards Agreement be broadly representative of the users. The current bylaws of the Universal Cotton Standards Agreement allow only spinners and merchant associations involved in the trade and/or consumption of U.S. cotton to be delegates to the Agreement. This structure is based on the historic purpose of the Agreement which was focused only on trading of U.S. cotton. USDA is now preparing a proposal that representation of the Agreement be expanded to cotton associations that may not deal with trading or consumption of U.S. cotton but that use Universal Cotton Standards as their primary reference standard for other cotton growths. This proposal will be considered at the next Triennial Universal Cotton Standards Conference scheduled for 11-13 June 2008.

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM) INITIATIVES

The AMS Cotton Program is currently leading the development of two new cotton fibre classification standards in ASTM International. These standards are “The Qualification of Cotton Classification Instruments” and “The Value Establishment of Calibration Cottons”.

The purpose of “The Qualification of Cotton Classification Instruments” standard is to provide a standard practice for determining the performance of an instrument being considered for use in cotton classification. The development of this standard is based on the AMS Cotton Program’s own cotton classing performance specifications which were developed over many years of instrument developing, testing and procurement experiences. Included in the standard are standardised measurement tolerances for determining whether or not an instrument is producing sufficient accuracy for cotton fibre classification.

The instrument qualification standard has been approved by all necessary ASTM committees and sub-committees and will be released as an official ASTM International standard by June of 2008. The standards will provide performance specifications for micronaire, strength, length, length uniformity index, colour Rd, colour +b, trash percent area and trash particle count.

“The Value Establishment of Calibration Cottons” standard is in the early stages of development within ASTM International with promulgation not expected until 2009. The overall objective of this standard is to deter the development of different calibration cottons that would lead to global cotton marketing confusion. More specifically, the purpose of this standard is to take and develop the calibration cotton value setting procedures utilised by the AMS Cotton Program into an official standard test practice. Establishment of the Universal Calibration Cotton Standards is a very detailed and complex process that requires a great deal of planning and testing. This standard will cover details of the value establishment process for the purpose of providing the necessary procedures for any organisation considering production of HVI calibration cottons. The hope is that this standard will prevent the establishment of any standard that is different from the Universal Standards by providing sanctioned means for an organisation to produce calibration cottons that are compatible with the Universal HVI Cotton Calibration Standards.

INTERNATIONAL ROUND TESTING PROGRAMS

An essential ingredient to the success of standardisation in instrument based cotton classification is the availability of and strong participation in international round testing programs. The AMS Cotton Program is actively involved in three internationally recognised round testing programs that each offer unique and valuable aspects of assessing instrument performance. The three round testing programs are:

1) CSITC Round Test
2) Bremen Round Trial
3) USDA HVI Check Test

The CSITC Round Test is organised by the International Cotton Advisory Committee's (ICAC) Commercial Standardisation of Instrument Testing of Cotton (CSITC) Task Force. The Bremen Round Trial is organised by the Bremen Fibre Institute and the USDA HVI Check Test Program is organised by the AMS Cotton Program.

Successful performance in these round tests requires adherence to the accepted international standards which include the Universal HVI Calibration Standards. In addition, participants must follow standardised testing, calibration and moisture conditioning procedures as provided by the International Textile Manufacturers Federation (ITMF) HVI User Guide and/or the USDA's "Guidelines for HVI Testing".

CLASSIFICATION TRAINING SEMINARS AND INFORMATION EXCHANGES

The AMS Cotton Program is promoting standardisation of cotton fibre classification through training seminars and information exchange initiatives. In February of 2007, a training seminar was conducted at the AMS Cotton Program's facility in Memphis, Tennessee, USA to a group of HVI technicians from China. The specialised training included HVI repair and maintenance in addition to setting up and managing a technician program for maintaining multiple HVI systems. In December of 2007, the AMS Cotton Program participated in training seminars in Indonesia, Vietnam and Thailand. These seminars provided textile mill managers with valuable information regarding accessing and using USDA HVI classing data and standards to optimise cotton utilisation in the mill. Training seminars are already being planned by USDA for various groups in 2008.

Information exchange initiatives have proven to be a valuable means for the AMS Cotton Program to share its wealth of experience and to thereby assist organisations implementing large scale HVI cotton classification operations. By addressing specific problems and issues of organisations in their development efforts, the AMS Cotton Program has been able to assist in accelerating implementation of instrument based cotton classification programs.

CONCLUSION

Additional information on subject matter presented in this report can be obtained by emailing inquiries to cotton.standards@usda.gov . The Standardisation and Engineering Branch of the USDA, AMS, Cotton Program is located in Memphis, Tennessee, USA and is responsible for all USDA cotton standards activities including development, production and world-wide distribution. Please feel free to contact the AMS Cotton Program for any information or questions regarding procurement of calibration standards, round testing information, standardised HVI testing procedures and/or general standardisation information.

RESULTS OF THE FIRST YEAR OF IMPLEMENTATION OF THE CSITC ROUND TRIAL

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ABSTRACT

The ICAC Task Force on Commercial Standardization of Instrument Testing of Cotton (CSITC) was created to achieve reliable instrument test results for the global cotton trade. One of the main topics is a dependable evaluation of the capability of cotton testing facilities to produce reliable test results for micronaire, strength, length, uniformity and color. The output of the specifically developed CSITC Round Trial system is a single, aggregated rating number as well as detailed information regarding accuracy and precision to improve laboratory performance. The results of the first year of Round Trials with 68 testing facilities and 119 instruments are presented.

INTRODUCTION

For the purpose of achieving reliable instrumental test results for the global cotton trade, the ICAC Task Force on Commercial Standardization of Instrument Testing of Cotton (CSITC) brought together 15 international representatives of spinning mills, traders, cotton producers and research. This group has made several recommendations to build a worldwide system for classifying cotton productions and encourages the use of High Volume Testing devices as they can provide reliable results that can be used in trade.

One of the most important missions of the CSITC Task Force is to check the reliability of cotton testing laboratories and the test results provided by the laboratories. A specifically developed CSITC Round Trial system allows the laboratories to demonstrate their capability to meet recommended standards, although certification cannot guarantee the accuracy of individual results. Additionally, CSITC Round Trials will help them to achieve more accurate results.

The defined aims of the CSITC Round Trial are:

- Evaluation of the test methods / test result variation
    - inter-laboratory variation
    - in-laboratory variation
    - possible additions as the variations between instrument types etc.
- Rating of the participating laboratories, based on the trueness of the results
- Detailed analysis of laboratory results to achieve more accurate results, based on trueness and precision

The CSITC Round Trial system has been created and is now conducted in co-operation between the Bremen Fibre Institute (FIBRE) and the USDA-AMS. It is headed by the International Cotton Advisory Committee (ICAC).

CSITC ROUND TRIAL CONFIGURATION

The participation in CSITC Round Trials is anonymous and individual results will only be given to the individual participants. Laboratories will participate with typical high volume test devices or adequate instruments that conform to Universal Standard Material results for the chosen parameters and that do not show any systematic deviation nor extended result variability. Participation in a CSITC Round Trial is not limited to test centres using Uster HVI equipment. CSITC evaluations are based on test results and are not dependent on the manufacturer, model or kind of testing instruments used.

The tested parameters were chosen by the CSITC Task Force according to the reliability of the parameters: Micronaire, Strength (grams/tex), Length (Upper Half Mean Length - expressed in inches and decimals, or in mms), Length Uniformity Index, Color Rd, Color +b. All measurements have to be done in compliance with the Universal Calibration Standards. Each test consists of 1 measurement for micronaire, 2 measurements for length/strength and 2 measurements for color.

The CSITC Round Trials are conducted 4 times per year and each single Round Trial includes 5 cottons. 4 cottons are Upland type or have similar properties and are well pre-tested for homogeneity. Additionally a 5th cotton is included, e.g. from a different origin or with different processing or different behaviour. This cotton is not taken for the evaluation of laboratories, but for the overall evaluation of laboratory performance on different kinds of cotton samples. All interested people / organisations are invited to provide cotton for this purpose.

Round Trial testing has to be done on 5 days to enable reliable evaluation of trueness and precision (see figure 1). 6 tests have to be done on each day and for each cotton. So there are 30 tests on each cotton sample.

	Cotton 1	Cotton 2	Cotton 3	Cotton 4		*Cotton 5*
day 1	6 tests	6 tests	6 tests	6 tests		*6 tests*
day 2	6 tests	6 tests	6 tests	6 tests		*6 tests*
day 3	6 tests	6 tests	6 tests	6 tests		*6 tests*
day 4	6 tests	6 tests	6 tests	6 tests		*6 tests*
day 5	6 tests	6 tests	6 tests	6 tests		*6 tests*
Sub Total	30 tests	30 tests	30 tests	30 tests		*30 tests*
Total	150 tests for each Round Trial					

Figure 1: Test scheme for each CSITC Round Trial; cotton 5 is not taken for evaluating the instruments, but for information purposes

The CSITC Round Trials was established in addition to existing round trials like the USDA HVI Check-Test or the Bremen Cotton Round Trial, as these are not suitable to fulfil the requirements given by the CSITC Task Force. The differences between the CSITC Round Trials and the existing round trials are mainly

- the multiple day testing,
- the evaluation of single test data instead of average results
- the evaluation of trueness and precision
- the awarding of an official laboratory evaluation result based on trueness
- the detailed analysis of the laboratory results to help achieving more accurate results

Nevertheless, the existing round trials will remain important, as e.g.

- the USDA HVI Check-Test allows comparisons on every month,
- the Bremen Round Trial includes all instruments and parameters which are not covered by the CSITC Round Trial or the USDA HVI Check-Test,
- the Bremen Round Trial is free of costs, so that all laboratories can p

Calculation details:

- For the evaluation of each laboratory all test results of this lab are taken except when they are exceeding broad limits (as e.g. micronaire 1.5 to 8) - these results are totally deleted from the following calculation. Typical mistakes for this are typing errors.
- For acquiring reference results for evaluation, the inter-laboratory averages of all laboratories are taken excluding outlying laboratories for the specific parameter according to Grubbs' algorithm [ISO 5725], significance level 0.05.
- For calculating all averages and standard deviations, outliers are excluded in the particular data set according to Grubbs' algorithm.
- For calculating median results, no outliers are excluded.

All evaluation is done for each single instrument. As soon as one testing facility is participating with more than one instrument, each instrument is evaluated separately. The results of all instruments from one testing facility are only combined in the certificate issued by the ICAC.

ROUND TRIALS AND PARTICIPANTS IN 2007

The Round Trial was conducted 4 times in 2007. In sum, 68 different testing facilities participated with 119 different instruments. The participating testing facilities came from the following continents:

- Europe 16 labs
- South America 16 labs
- North America 13 labs
- Asia 9 labs
- Africa 8 labs
- Australia 4 labs

As not all testing facilities participated in all 4 Round Trials; and as some testing facilities participate with their instruments in a rotation principle, there were e.g. in Round Trial 2007-4 59 testing facilities with 79 instruments.

The consensus of the CSITC Task Force is that the stage has been reached where greater participation is possible and where greater participation is essential to bring the CSITC aim to a success. Again with this presentation, all testing facilities are invited to participate. Registration is to be done via csitcsecretariat@icac.org.

ROUND TRIAL RESULTS: DATA VARIABILITY

For all users of instrument test results, it is essential to know about the variability of the utilized instruments and methods:

- Trading has to base on test methods ,so the possible deviation between test results from one laboratory and between different laboratories has to be known.
- Instrument manufacturers can base on the data of the Round Trial to improve the test method
- Laboratories can evaluate the reproducibility of the instruments and the measurement uncertainty.

For this purpose the variability information given in this Round Trial is very valuable information. The broad basis of the results (approx. 80 laboratories, 20 cottons evaluated per year, 30 tests for each cotton) is resulting in statistically highly assured data. All results of each Round Trial can be downloaded from www.icac.org.

As in 2007 20 cottons were evaluated, each for 6 properties, and each property with different variability information, it is not useful to give all frequency distributions in this presentation. An exemplary frequency distribution is given in figure 2.

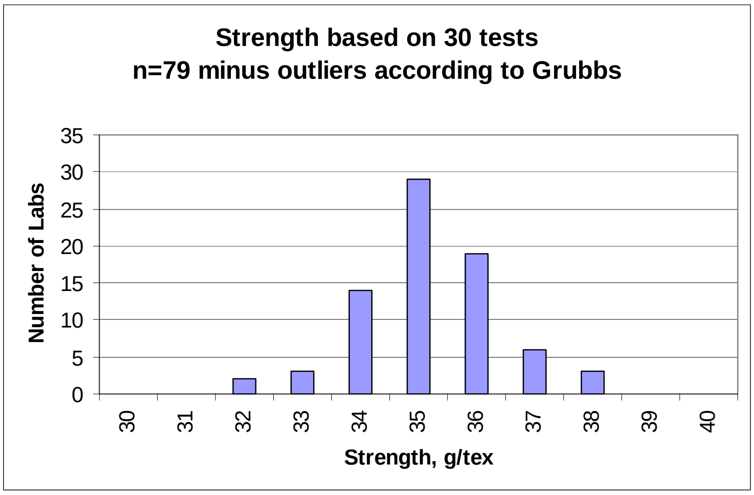

Figure 2: Exemplary strength frequency distribution between instruments, based on 30 tests, for RT 2007-4, Cotton2, Average = 35.25 g/tex, SD = 1.133 g/tex, CV = 3.2%

As soon as standard deviations are used for describing a distribution, it is not necessary anymore to show each distribution. The relation between standard deviations and percentages of included results is therefore given in figure 3.

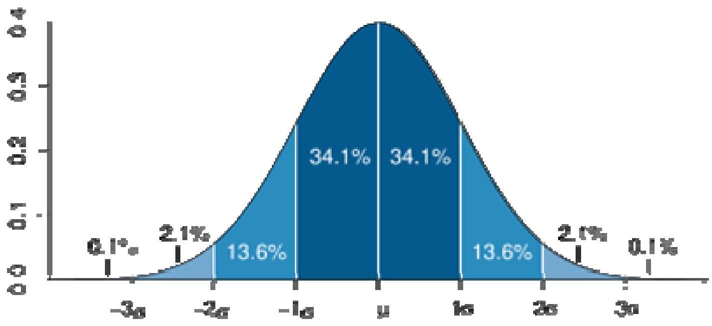

Figure 3: Standard Deviations and percentages for a Normal Distribution [Wikipedia]:
+/- 1 SD ≈ 68.3 % +/- 2 SD ≈ 95.4 % +/- 3 SD ≈ 99.7 %

Table 1 gives a complete overview about all variability data in the 4 Round Trials from 2007:

- Inter-laboratory variation based on 30 tests is the reflecting the systematic variation between the laboratories/instruments with minor influence of the material variability
- Inter-laboratory variation based on 6 tests on 1 day is additionally including influences between different days
- Inter-laboratory variation based on single tests is reflecting the variation that has to be regarded for commercial / trading purposes, because usually only one test is done on each bale as basis for trading the cotton. A different result in another laboratory might cause claims.

<u>Summary:</u>
The variation data is very valuable information for everyone. Based on 4 Round Trials with each 4 cottons and each 66 to 79 participating instruments from 6 continents, it is statistically highly assured data, which will be difficult to achieve with any other source. Comparing the results from Round Trial 2007-1 to 2007-4, it can be seen that the results are very consistent. This is demonstrating the usability of the Round Trial variability data.

A trend in the results, which can certainly not be expected for one year, would show improvements in the overall laboratories' performance and/or the instrument reliability. The CSITC Task Force will track the trend over the years.

Besides the inter-laboratory variation it is possible to get reliable information about typical in-laboratory variation, too:

- in-laboratory variation between single tests
- in-laboratory variation between different days with each 6 tests

The results for in-laboratory variation are given on the ICAC website, but not presented here. This data is useful for testing facilities to compare their variation to the typical variation.

Table 1: Inter-laboratory variation data from the 4 Round Trials

Micronaire			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**70**	**74**	**69**	**79**	
Interlab. Variation	based on 30 tests	SD	**0,077**	**0,087**	**0,075**	**0,078**	
		CV %	**1,8**	**2,4**	**1,8**	**1,9**	
	based on 6 tests	SD	**0,083**	**0,094**	**0,081**	**0,087**	
		CV %	**1,9**	**2,6**	**2,0**	**2,1**	
	based on single tests	SD	**0,093**	**0,101**	**0,094**	**0,097**	
		CV %	**2,1**	**2,7**	**2,3**	**2,3**	

Strength			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**70**	**74**	**69**	**79**	
Interlab. Variation	based on 30 tests	SD	**1,338**	**1,086**	**1,181**	**1,024**	
		CV %	**4,8**	**4,1**	**4,2**	**3,8**	
	based on 6 tests	SD	**1,408**	**1,202**	**1,214**	**1,166**	
		CV %	**5,0**	**4,5**	**4,3**	**4,3**	
	based on single tests	SD	**1,547**	**1,335**	**1,439**	**1,346**	
		CV %	**5,5**	**5,0**	**5,0**	**5,0**	

Length			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**70**	**74**	**69**	**79**	
Interlab. Variation	based on 30 tests	SD	**0,0118**	**0,0120**	**0,0112**	**0,0101**	
		CV %	**1,1**	**1,1**	**1,0**	**1,0**	
	based on 6 tests	SD	**0,0135**	**0,0131**	**0,0130**	**0,0126**	
		CV %	**1,2**	**1,2**	**1,2**	**1,2**	
	based on single tests	SD	**0,0173**	**0,0165**	**0,0166**	**0,0167**	
		CV %	**1,6**	**1,5**	**1,5**	**1,6**	

Uniformity			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**70**	**74**	**69**	**79**	
Interlab. Variation	based on 30 tests	SD	**0,516**	**0,476**	**0,476**	**0,514**	
		CV %	**0,6**	**0,6**	**0,6**	**0,6**	
	based on 6 tests	SD	**0,605**	**0,569**	**0,577**	**0,608**	
		CV %	**0,7**	**0,7**	**0,7**	**0,8**	
	based on single tests	SD	**0,832**	**0,782**	**0,792**	**0,815**	
		CV %	**1,0**	**1,0**	**1,0**	**1,0**	

Color Rd			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**67**	**71**	**66**	**77**	
Interlab. Variation	based on 30 tests	SD	**0,738**	**0,924**	**1,050**	**1,041**	
		CV %	**1,0**	**1,2**	**1,4**	**1,4**	
	based on 6 tests	SD	**0,860**	**1,004**	**1,067**	**1,019**	
		CV %	**1,1**	**1,3**	**1,4**	**1,3**	
	based on single tests	SD	**0,963**	**1,043**	**1,138**	**1,069**	
		CV %	**1,2**	**1,4**	**1,5**	**1,4**	

Color +b			RT 2007-1 Average Cotton 1-4	RT 2007-2 Average Cotton 1-4	RT 2007-3 Average Cotton 1-4	RT 2007-4 Average Cotton 1-4	Consistent? Trend?
Number Of Instruments			**67**	**71**	**66**	**77**	
Interlab. Variation	based on 30 tests	SD	**0,290**	**0,356**	**0,364**	**0,343**	
		CV %	**3,0**	**2,9**	**3,6**	**2,9**	
	based on 6 tests	SD	**0,317**	**0,381**	**0,367**	**0,381**	
		CV %	**3,3**	**3,1**	**3,7**	**3,3**	
	based on single tests	SD	**0,353**	**0,411**	**0,403**	**0,404**	
		CV %	**3,6**	**3,4**	**4,0**	**3,5**	

SUMMARY EVALUATION OF THE LABORATORY PERFORMANCE

For all users of instrument test results, it is helpful to know about the reliability of cotton testing laboratories and their test results.

The evaluation results for the instruments in a testing facility is very beneficial

- for the testing facility, as it can prove its good performance
- for the customers of the testing facilities and for users of the instrument test results, as they can get an objective information about the reliability of the testing facility and its results
- for cotton associations to choose their arbitration laboratory based on the quality of the laboratory.

This information is the leading aim of the CSITC Task Force activities. With the information about the reliability of the test results of a testing facility, results can be used for commercial purposes.

	Performance of Laboratory 115							
			Micronaire	**Strength**	**Length**	**Uniformity**	**Color Rd**	**Color +b**
Step 1	**Reference Values**	Cotton 1	3,83	32,82	1,207	82,42	76,31	12,14
		Cotton 2	5,17	28,22	1,136	81,90	78,06	11,53
		Cotton 3	4,40	25,54	0,948	78,53	74,86	10,86
		Cotton 4	3,81	32,89	1,177	83,65	76,08	10,98
Step 2	**Laboratory Average of All Days**	Cotton 1	3,80	33,62	1,207	82,71	75,37	11,38
		Cotton 2	5,23	28,50	1,134	81,44	76,05	10,82
		Cotton 3	4,36	26,11	0,969	76,13	73,62	10,41
		Cotton 4	3,79	32,72	1,182	83,83	75,29	10,17
Step 3	**Rel. Distance to Reference**	Cotton 1	-0,03	0,80	0,000	0,29	-0,94	-0,76
		Cotton 2	0,06	0,28	-0,003	-0,46	-2,00	-0,71
		Cotton 3	-0,04	0,57	0,021	-2,40	-1,24	-0,45
		Cotton 4	-0,02	-0,18	0,005	0,18	-0,79	-0,81
Step 4	**Mean Absolute Distance to Reference**		0,04	0,46	0,007	0,83	1,24	0,68
Step 5	**Scale Factor** (Based on USDA Reproducibility Limits except Rd)		0,10	1,50	0,02	1,00	1,50	0,50
	Summary Evaluation for Each Property (=Mean Abs. Distance divided by Scale Factor)		**0,38**	**0,31**	**0,36**	**0,83**	**0,83**	**1,37**
Step 6	**Relevance of Property**		1,00	1,00	1,00	1,00	1,00	1,00
	Summary Evaluation of All Properties (=Average of all properties)		**0,68**					

Figure 4: Example for the steps of evaluation for a single instrument

The evaluation of the participating laboratories/instruments is solely done regarding the trueness of the instrument test results; precision is not taken into account. The procedure for the analysis is easy to follow, and it is useful to understand the evaluation process. Therefore the steps of evaluation are shown in figure 4. The steps are:

- Step 1: The evaluation is done in comparison to the reference results, which were calculated from the inter-laboratory averages.
- Step 2: For each cotton and each parameter, the average result of all tests for all days is calculated (average of 30 test results).
- Step 3: For each cotton and each parameter, the distance between the laboratory result and the reference result is calculated.
- Step 4: For each parameter, the average absolute distance of all cottons is calculated.
- Step 5: For each parameter, the mean absolute distance is divided by a "Scale Factor". This step allows a comparison between the parameters. The scale

factors are based on the USDA Reproducibility Limits. For Rd this result was slightly enlarged regarding the decision of the CSITC Task Force due to the increased variability of these results. The result of this step is a Summary Evaluation for Each Property.

- Step 6: Based on the evaluations for each property, the Combined Summary Evaluation of All Properties is calculated by averaging the results of each property. (Additionally it is possible to apply different relevance factors for each property, but at this stage this is not done.)

A) COMBINED EVALUATION RESULT

The Combined Summary Evaluation Result of All Properties is a parameter that allows a comparison between different laboratories. The lower the Evaluation Result, the better the performance of the instrument/laboratory.

Figure 5 is showing the typical distribution of the evaluation with combined properties. This example is for Round Trial 2007-4. The best instruments usually have an evaluation result of 0.2 to 0.25. Typically about 50% of the instruments show an Evaluation Result below 0.5. The major part of all instruments is below or up to 0.9. And there are always some outliers showing an evaluation result far higher than 1.

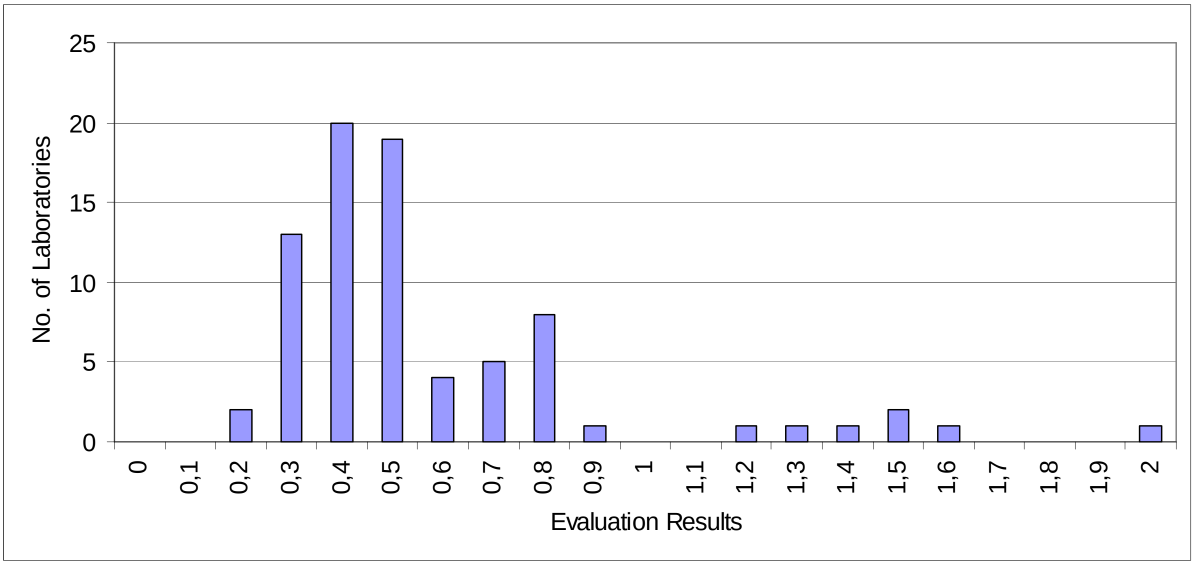

Figure 5: Distribution of the Evaluation with combined properties for Round Trial 2007-4

The laboratory evaluation in comparison between the 4 Round Trials in 2007 is listed in table 2. It can be seen that the overall evaluation is quite consistent during the Round Trials. This leads to the following conclusions:

- The principle of the evaluation allows to get repeatable information about the instrument performance
- For the average of instruments, no improvement in performance is detectable up to now.

For looking at trends, it will be difficult to base on the average of all instruments, as all participating instruments may improve and new instruments with less reproducible results add.

Table 2: Laboratory/Instrument Evaluation with combined properties
– statistics for the 4 Round Trials –

Laboratory Evaluation Combined Properties	2007-1	2007-2	2007-3	2007-4	Consistent? Trend?
Median	0,50	0,51	0,47	0,49	
Best Evaluation	0,22	0,24	0,25	0,21	
Worst Evaluation	3,02	2,15	2,28	1,99	

A second view has to be taken on the summary evaluation results, regarding the consistency of the results for single instruments. It is difficult to name objective parameters for this. For this, a selection of instruments is shown in figure 6. Different numbers are different testing facilities, a different character behind a similar number means two different instruments in one testing facility. It can typically be seen that

- for instruments with a “good” evaluation result, the results are quite constant for all the 4 Round Trials (example 04a, 18a, 18b, 25a, 25b)
- for instruments with less good evaluation results, the results are varying between the 4 Round Trials (example 44b, 44d, 60a)
- Results from different instruments in the same testing facility show at least comparable results, although there might be residual differences (4a and 4b, 18a and 18b, 60a and 60b)

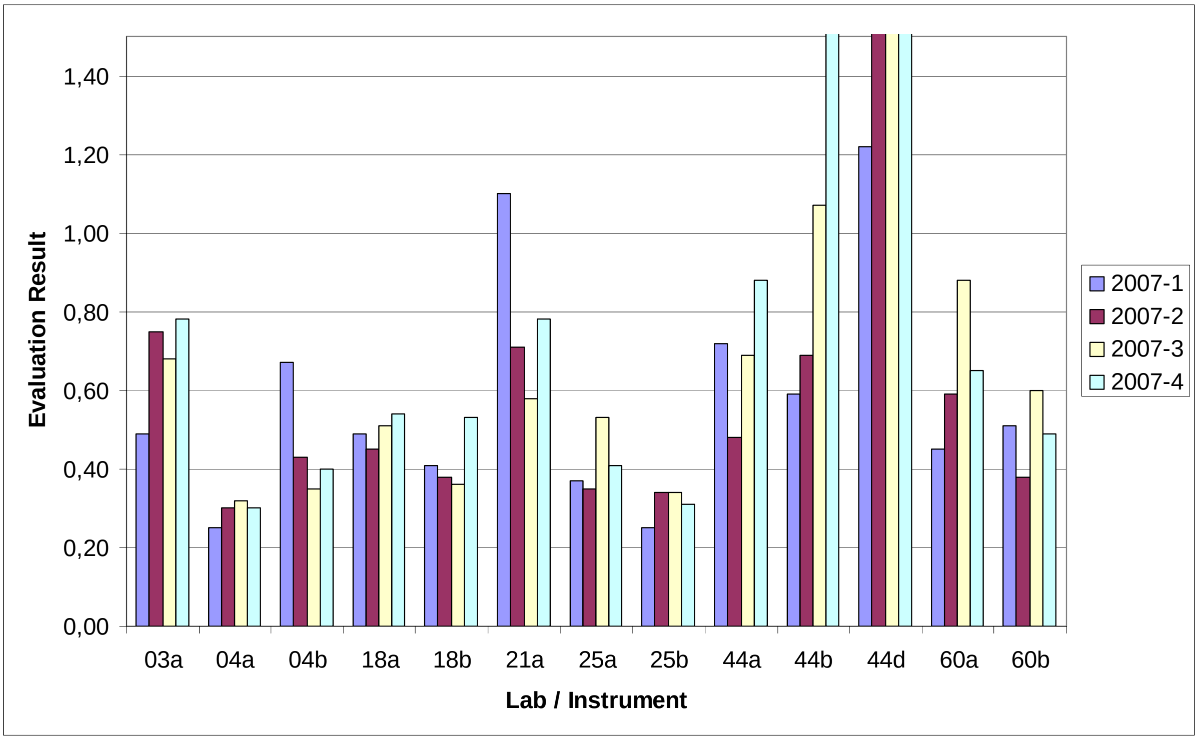

Figure 6: Evaluation with combined properties for some instruments for Round Trials 2007-1 to 2007-4

The evaluation with combined properties, that is <u>one</u> result for each instrument, is given in a certificate issued by the ICAC. Testing facilities with more than one instrument get one certificate including the evaluations for each instrument. Additionally each testing facility is getting a certificate just stating their participation without results.

The certificates can be used by the testing facilities to prove their performance or at least their efforts to come to reliable test results.

B) EVALUATION RESULTS FOR EACH PROPERTY

Besides the combined evaluation it is useful to get an impression about the performance for each property. The calculation for each instrument is included in the description given for figure 4. With this information it can easily be seen for the testing facilities, which parameters can be offered, and where improvements have to be made.

The comparison of the evaluation statistics for each property are given in table 3.

- The results are less consistent than the combined evaluation, but still in a narrow range
- No trend is detectable for any property
- The best evaluation result for each property is usually better than for the combined evaluation
- Comparing the median results of the different properties, Length and Uniformity show the lowest/best results.

Table 3: Laboratory Evaluation for each property
– statistics for the 4 Round Trials –

2007-1	**Evaluation Micronaire**	**Evaluation Strength**	**Evaluation Length**	**Evaluation Uniformity**	**Evaluation Color Rd**	**Evaluation Color +b**
Median	0,51	0,64	0,42	0,35	0,40	0,42
Best Eval.	0,09	0,16	0,07	0,10	0,06	0,07
Worst Eval.	1,64	3,72	9,97	1,62	3,00	4,24

2007-2	**Evaluation Micronaire**	**Evaluation Strength**	**Evaluation Length**	**Evaluation Uniformity**	**Evaluation Color Rd**	**Evaluation Color +b**
Median	0,56	0,49	0,38	0,30	0,39	0,43
Best Eval.	0,12	0,14	0,11	0,10	0,10	0,12
Worst Eval.	4,92	2,90	1,94	1,75	2,62	3,02

2007-3	**Evaluation Micronaire**	**Evaluation Strength**	**Evaluation Length**	**Evaluation Uniformity**	**Evaluation Color Rd**	**Evaluation Color +b**
Median	0,49	0,45	0,41	0,36	0,50	0,42
Best Eval.	0,09	0,11	0,11	0,07	0,07	0,07
Worst Eval.	2,01	3,03	3,32	1,56	2,61	4,00

2007-4	**Evaluation Micronaire**	**Evaluation Strength**	**Evaluation Length**	**Evaluation Uniformity**	**Evaluation Color Rd**	**Evaluation Color +b**
Median	0,50	0,48	0,32	0,36	0,52	0,41
Best Eval.	0,14	0,15	0,08	0,06	0,08	0,08
Worst Eval.	2,12	2,66	2,89	2,53	2,93	8,06

DETAILED LABORATORY ANALYSIS

Besides the overall evaluation results of each instrument, a detailed analysis of the test results is helpful for the participating testing facilities to achieve more reliable results. This detailed evaluation does regard the trueness and the precision of the data. This can be achieved, as all individual data of the laboratories/instruments is evaluated in the CSITC Round Trial.

The detailed analysis is carried out for every instrument and given to the testing facilities as a basis to find out possible measures to improve their performance.

An evaluation that is calculated for every instrument and given to the testing facilities is the detailed trueness evaluation. The graphs are useful in order to find systematic deviations or biases. In figure 7, the deviations of four instruments in Round Trial 2007-4 are shown (x-axis: reference result for the 5 cottons; y-axis: Deviation between actual result and reference result for this instrument). In this example it can be seen that

- figure 7 left/above
    - the trueness of all cotton results is good
    - the results of the single days are sufficiently consistent
    - no actions necessary to improve
- figure 7 left/below
    - for short cottons, the deviation from the reference result is too high
    - for the long cotton, the deviation is smaller / in the usual range
    - the results of the single days for the cottons are extremely consistent
- figure 7 right/above
    - the results of the single days are sufficiently consistent
    - 2 cottons exhibit totally wrong results
    - obviously this testing facility mixed up between two cottons
- figure 7 right/below
    - the trueness of the results is in a tolerable range
    - the results between the single days are totally deviating from each other

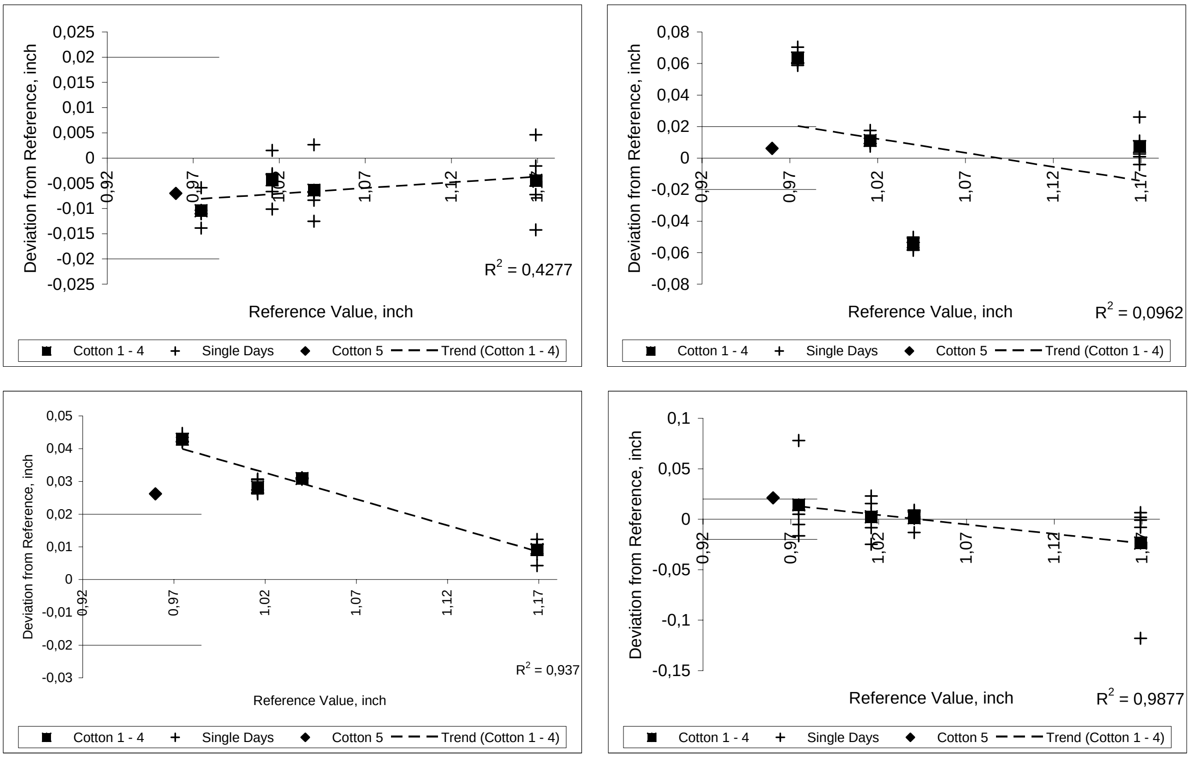

Figure 7: Graphical analysis of the deviations of 4 instruments in comparison (length, RT 2007-4)

Another valuable evaluation is the comparison of the result variation for each specific instrument compared to the typical variation (given as the median SD of all instruments). The in-laboratory variation has to be divided into:

- in-laboratory variation between different days (with each day having 6 tests)
  - o not including the typical variation between the single subsamples
- in-laboratory variation between single tests on one day
  - o not including influences between different days
- in-laboratory variation between all test results (30 tests for each cotton)
  - o this variation is including both kinds of variations above

In table 4, the exemplary instrument (see additionally figure 7 right/below)

- shows variations between single tests on one day, which are nearly 3 times higher than usual – the reasons for this have to be found out
- shows variations between different days, which are nearly 5 times higher than usual – the reasons for this may be different and have to be found out, too.

Table 4: Example for the analysis of the in-laboratory variation (length, RT 2007-4, instrument 74013-1)

Length - In-laboratory Variation		**Typical**	**Example laboratory/ instrument**	**Comment**
between different days with each 6 tests	SD	0,0066	0,0295	exremely higher
between single tests on one day	SD	0,0103	0,0293	higher
between all tests on different days	SD	0,0122	0,0496	exremely higher

The analyses shown here are already distributed to the testing facilities, so that every participant can use them for improvements.

Besides the analyses given here, there are many possibilities to find out reasons for result deviations, as

- the information from the laboratories about the temperature / humidity
- the information from the laboratories about the used calibration material
- the information from the laboratories about the used hard- and software
- the single test results, which are suitable for extra evaluations.

With the CFC/ICAC/33 project, which is co-funded by the European Union and the Common Fund for Commodities, and which started in December 2007, it will be possible to find sufficient time to have a detailed diagnosis of the information included in the Round Trials and to contact the testing facilities with the findings. Typical examples that were already found out now are:

- Use of calibration material that is not fitting to the usual testing, including Pima calibration cotton
- Insufficient comparison of test results between different days
- Insufficient comparison of test results between different instruments in one testing facility
- Mixing up of the samples for testing
- Mixing up of results for the different properties

This specific support, based on the detailed analyses and their explanation to the testing facilities, based on specific diagnosis, and based on a subsequent assistance, will create at least the chance for every testing facility to improve the reliability of its data.

COMPARISON OF THE INTER-LABORATORY AVERAGES TO THE USDA ESTABLISHED RESULTS

The evaluations are by consensus of the CSITC Task Force carried out for each instrument in comparison to the inter-laboratory average. Nonetheless all CSITC Round Trial inter-laboratory averages are compared to USDA Established Results, so that any inconsistencies can be found and traced.

Table 5 is showing the differences, each Round Trial based on 4 cottons. Small, but systematic differences seem to occur for Micronaire and Length. For Micronaire a possible reason is the use of older reference material, which is not fully fitting to the latest calibration material. For length, no suitable explanation was found up to now. The differences will be traced in the future Round Trials.

Table 5: Differences between CSITC inter-laboratory averages and USDA Established Results based on 4 times 4 cottons

	Difference between inter-laboratory averages and USDA Established Results			
	Average of cotton 1 to 4 for each Round Trial			
Property	**2007-1**	**2007-2**	**2007-3**	**2007-4**
Mic	-0,07	-0,08	-0,07	-0,06
Str	0,01	0,33	-0,10	0,08
Len	0,004	0,004	0,006	0,003
UI	0,21	-0,05	0,16	0,04

COMPARISON BETWEEN DIFFERENT INSTRUMENT MANUFACTURERS AND TYPES

The CSITC Round Trials allow, based on the statistically highly assured data (4 Round Trials per year, each 4 cottons, and each 66 to79 participating instruments up to now) to compare the results from different types of instruments. The CSITC Task Force agreed to publish the data as soon as the data is sufficiently reliable. For this, a minimum number of approx. 10 instruments will be suitable.

The number of instruments per type is:

- Uster HVI 1000 types: 11 to 19
- Uster HVI 900 types: 28 to 31
- Uster HVI Spectrum types: 14 to 18
- Premier types: 7 to 9
- Lintronics types: 1 to 3

For this reason, only the Uster types are compared to each other up to now.

In table 6, the summarized differences between the instrument types are reflected for all 4 Round Trials.

- For micronaire, HVI 1000 seems to give slightly higher results than the average
- For colour Rd, HVI 1000 seems to give slightly higher results than the average.

Possible reasons are discussed in the CSITC Task Force, and one possible reason is again given with the age or condition of the calibration material.

Table 6: Differences between the results of different instrument types based on 4 times 4 cottons

		Difference between specific-instrument-average and all-instrument-average			
		Average of cotton 1 to 4 for each Round Trial			
Property	**Instrument**	**2007-1**	**2007-2**	**2007-3**	**2007-4**
Mic	All instruments				
	HVI 1000	0,07	0,01	0,04	0,04
	HVI 900	-0,01	0,00	0,00	-0,02
	HVI Spectrum	-0,01	-0,01	-0,01	-0,02
Str	All instruments				
	HVI 1000	0,14	-0,12	0,05	0,04
	HVI 900	0,03	0,37	0,21	0,16
	HVI Spectrum	0,14	0,06	-0,20	-0,11
Len	All instruments				
	HVI 1000	0,001	0,001	0,000	-0,002
	HVI 900	0,003	0,004	0,002	0,004
	HVI Spectrum	-0,004	-0,006	0,006	-0,002
UI	All instruments				
	HVI 1000	-0,05	0,01	-0,11	-0,12
	HVI 900	0,00	0,08	0,00	0,11
	HVI Spectrum	-0,07	-0,17	0,07	-0,09
Rd	All instruments				
	HVI 1000	0,23	0,70	0,81	0,66
	HVI 900	-0,33	-0,34	-0,12	-0,44
	HVI Spectrum	0,19	-0,30	-0,68	-0,42
+b	All instruments				
	HVI 1000	0,08	0,08	0,03	0,03
	HVI 900	-0,02	-0,08	-0,13	-0,09
	HVI Spectrum	-0,08	-0,01	0,03	-0,04

NEW DEVELOPMENTS

The CSITC Round Trial data is anonymous. Up to now only the overall evaluation results and the variability information are published. The testing facilities and their instruments are coded with anonymous and changing numbers. No specific results of any testing facility will be published. Each testing facility is deciding for itself whether to publish its results or keep it secret.

In a discussion in the CSITC Task Force in October 2007, it was seen as a positive step to publish a list of the participating testing facilities, as the CSITC effort is generally recognized as positive for the international industry. And the list will be positive for each participating testing facility.

Based on this the Task Force supported a proposal to publish the list of participating testing centres, with the proviso that those not wishing their names to be included could choose not to be listed. It was emphasized that only the names of participating testing centres, and not confidential information about performance, would be made public.

As expected, most testing facilities agreed to be listed, so the list will be published from 2008 on.

SUMMARY

The CSITC Round Trial is one major step towards the internationally aspired commercial standardization of instrument testing of cotton.

In its first year of implementation the CSITC Round Trials proved to give:

- Consistent and valuable information for the data variability of High Volume Testing instruments for inter-laboratory and in-laboratory variation.
- Significant and consistent summary evaluation results for rating the test instrument performance in the participating testing facilities.
- Suitable detailed analyses according to accuracy and precision to improve the data reliability in the participating testing facilities.
- Suitable information comparing the results of different instrument types.

The stage has been reached where greater participation is possible, and all testing facilities are invited to participate at and benefit from this activity. Registration is to be done via csitcsecretariat@icac.org.

ACKNOWLEDGMENT

The work for the CSITC Round Trials is part of the CFC/ICAC/33 project “Commercial Standardization of Instrument Testing of Cotton for the Cotton Producing Developing Countries in Africa”. This project is co-funded by the European Union and the Common Fund for Commodities (CFC). We would like to thank the European Union and the Cotton Fund for Commodities for this support.

COTTON CLASSING REFORM IN CHINA

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ABSTRACT

In 2003, Chinese government established cotton classing reform project to rebuild gins and China Fiber Inspection Bureau performed official classing for each Chinese cotton bale. Until now, 701 gins have been rebuilt and 89 HVI laboratories have been constructed. To improve repeatability, CFIB adopted some strict methods to control test process and environment.

BACKGROUND

China is the biggest cotton producer, consumer and cotton textile exporter in the world now. But in the past long time, Chinese cotton classification and test technology were not advanced. During the times of planned economy, cotton trade was based on gin's manual classing. Along with the Chinese economy reform, old classing system was not able to satisfy the market, so in 2001, Chinese government constituted a new act to establish authoritative official cotton classification system. CFIB, an organization independent of cotton trade, performed official classing, but the test method still was manual classing based on 10 percentage sample.

Although Chinese government had established a new cotton classification system at the beginning of 21 century, but manual classing still brings on the dissension, percentage sample and manual test data can not fit the demand of mill's modern production. In 2003, Chinese government established a cotton classing reform project, all the gins would be rebuilt in five years to produce 227Kg bale-type lint cotton to decrease gins amount from current over 8,000 to 3000, about 100 laboratories with over 300 HVIs would be constructed by CFIB. Each cotton bale would be sampled with a unique label and brought to CFIB laboratories for classing. Official classing properties currently include Manual Grade and HVI's Rd, +b, Length, Length Uniformity, Micronaire, Strength.

PROGRESS OF CHINESE COTTON CLASSING REFORM

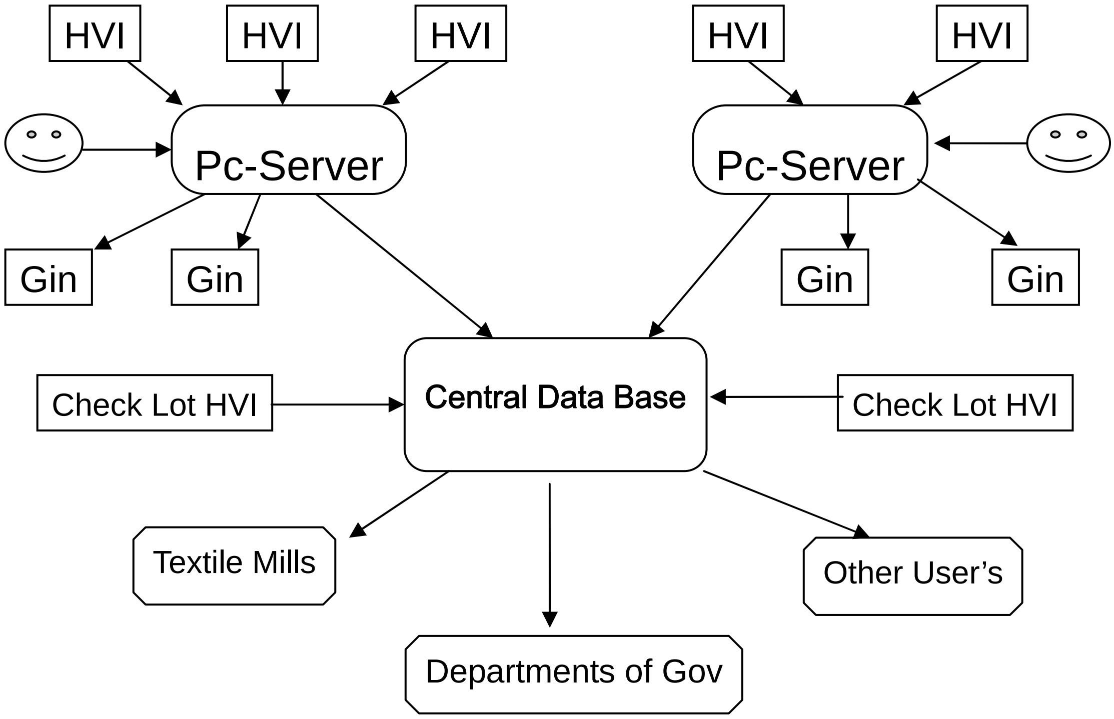
In the past four years, reform project was almost running well. Table.1 is the increase of classing bales, rebuild gins, labs and HVIs

Table 1. Increase of Reform

Crop Year	Classing Bales	Gins	Labs	HVIs
2004	130,000	19	8	22
2005	380,000	99	28	83
2006	3,400,000	427	54	149
Until Jan. 20, 2008	6,300,000	701	87	213

HVI DATA NETWORK

CFIB constructed a network for HVI data. One Central Data Base is installed in CFIB headquarters, and Pc-Servers are installed in each local laboratory, Central Data Base and local Pc-Servers are connected through internet under VPN method. In local labs, several HVIs and manual classing input terminals are connected with Pc-Server for classing data transmitting automatically, all classing data would be sent to Central Data Base everyday. Gins can dial to local Pc-Servers to download their classing data. In CFIB headquarters, several HVIs and manual classing input terminals are connected with Central Data Base for check lot, all check lot compared results will be sent to local labs automatically. CFIB established a website based on Central Data Base to release quality report, users can browse, check or download quality information. Figure 1 is the frame figure of HVI Data Network.



Website: www.ccqsc.gov.cn

Figure 1.

Quality Assurance In CFIB

For one of the worldwide biggest cotton classing systems, repeatability is the most important point to CFIB. Many factors could influence accuracy and precision of HVI, including calibration material, sample conditioning, process of calibration and check, acceptance of HVI, HVI operation, training for operator, HVI maintenance, check lot test, etc.

Calibration Material

Until now, all calibration material - including in-house cotton for Chinese HVIs are purchased from USDA. Considering the bigger variety range in Chinese cotton, CFIB is researching our own calibration cotton and will cooperate with USDA for value giving in the future.

Training

All HVI operator and repairman were trained by CFIB and USTER.

Acceptance of HVI

All HVIs installed in CFIB were passed the strict 8×8, 6×8, etc. test.

Quality Assurance System

To improve repeatability of HVI classing, CFIB developed Quality Assurance System running on the hardware environment of HVI Data network. Temperature and humidity sensors are set in sample conditioning room and HVI test room, they connected with local Pc-server. All samples would be set in a environment (20±1℃,65±3%) for 24hours sample conditioning. If the environment is over required range for a ruled time, Pc-Server will reject classing data and warn operator. HVI and Pc-Server communicate under TCP/IP and Pc-Server make lots of judgement automatically to ensure every operation matching regulation, if not, Pc-Server would reject classing data and give relevant warning information. For example, operators must check HVI using in-house cotton according to required frequency, If not, he could not continue test, if check is not passed, HVI must be recalibrated, otherwise, he still can not continue test. All quality assurance data will be sent to Central Data Base for analysis and statistics.

HVI Remote Diagnose system

CIFB is now cooperating with Uster to develop the remote diagnose system to improve the efficiency of HVI maintenance and repair. Basic method of this project is Pc-Sever collect all relevant HVI running parameters and make judgement so that HVI normal status can be maintained and the instruction can be given rapidly to local repairman.

Check Lot Test

One percent of All samples will be retest by CFIB central laboratory. Each sample will be test by two HVIs and the average result will be compared with original result.

International Round test

As one of the biggest HVI countries, same HVI test level is very important to CFIB. CFIB has joined USDA’s and Bremen’s round test projects and consider to join CSITC’s round test in the future.

CONCLUSIONS

Cotton classing reform is to promote the orderly and efficient marketing of cotton, HVI test will meet more needs of Chinese cotton and textile industry. CFIB appreciates the strong support from USDA, Bremen and Uster, and will enhance international cooperation in cotton test field to meet needs and expectations of world cotton industry.

ANALYSIS OF CHEMICAL RESIDUES ON COTTON AND COTTON PRODUCTS

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www.hohenstein.de

The aim of this lecture is to report on many years of experience in testing for harmful substances in raw cotton and cotton textiles.
In particular it will deal with the subject of contamination with pesticide residues, which is frequently a topic of public discussion.

Pesticides in textiles are currently once again extremely topical and an explosive subject. We should look for the reasons in increasing development of ecological cotton collections by renowned textile companies.

Since the late 1980s, the Hohenstein Research Institute has been concerned with testing textiles for harmful substances.
The pinnacle of this work was creation of the Oeko-Tex Standard 100 in 1992.
This standard, with the motto:

> "Textiles Vertrauen - Schadstoffgeprüfte Textilien"
> "Confidence in Textiles – Tested for harmful substances".

relates exclusively to human ecology, in other words to the interaction between textiles, their content and the wearer.

At the time there was robust discussion in the media about the toxicity of textiles, with the result for the consumer being a state of absolute uncertainty.
The Oeko-Tex Standard 100 – which other European textile testing institutions have adhered to in the intervening years – has had an effect and has in the meantime established itself worldwide as the most used label denoting the absence of harmful substances in textiles.

From the start, testing cotton and cotton textiles for pesticide contamination was an important criterion. It is predominantly pesticides that consumers and the media discuss and fear as a harmful contaminant in cotton.
Is this accusation justified? What is the real pesticide contamination situation?
What were the results of the many tests carried out over the years?

Since 1991 the Bremen Cotton Exchange has regularly had raw cotton from the widest possible range of provenances checked at Hohenstein for harmful substances, especially pesticide residues.

Table I: List of tested pesticides 1992 - 2008

<u>1992:</u>

Aldrine	Heptachloroepoxide	Malathion
DDD	Hexachlorcyclohexane, α-	Mirex
DDE	Hexachlorcyclohexane, β-	Methoxychlor
DDT	Hexachlorcyclohexane, δ-	Parathion
Dieldrine	Lindane	PCP
Heptachlor		Sevin

<u>1997:</u>

2,4,5-T	Dieldrine	Hexachlorcyclohexane, β-
2,4-D	Endosulfan, α-	Hexachlorcyclohexane, δ-
Aldrine	Endosulfan, β-	Lindane
Carbaryl	Endrine	Methoxychlor
DDD	Heptachlor	Mirex
DDE	Heptachloroepoxide	Toxaphen
DDT	Heptachlorobenzene	Trifluralin
	Hexachlorcyclohexane, α-	

<u>2008:</u>

2,4,5-T	Diazinon	Lindane
2,4-D	Dichlorprop	Malathion
Azinophosmethyl	Dicrotophos	MCPA
Azinophosethyl	Dieldrine	MCPB
Aldrin	Dimethoate	MCPP / Mecoprop
Bromophos-ethyl	Dinoseb and salts	Metamidophos
Captafol	Endosulfan, α-	Methoxychlor
Carbaryl / Sevin	Endosulfan, β-	Mirex
Chlordane	Endrine	Monocrotophos
Chlordimeform	Esfenvalerate	Parathion
Chlorfenvinphos	Fenvalerate	Parathion-methyl
Coumaphos	Heptachlor	Perthane
Cyfluthrin	Heptachloroepoxide	Phosdrin / Mevinphos
Cyhalothrin	Hexachlorobenzene	Propethamphos
Cypermethrin	Hexachlorcyclohexane, α-	Profenophos
DEF	Hexachlorcyclohexane, β-	Quinalphos
Deltamethrin	Hexachlorcyclohexane, δ-	Strobane
DDD	Isodrine	Telodrine
DDE	Kelvane	Toxaphene /
DDT	Kepone	Camphechlor
		Trifluralin

Most recently, 15 types of raw cotton were tested in June 2007.
In each case the tests were conducted according to current Oeko-Tex Standard 100 criteria.
In each case the analysis referred to the threshold values for the extra-strict baby standard.

Cotton experts will certainly not be surprised by the results:

Table II: Results of pesticide tests on raw cotton for Bremen Cotton Exchange

2007 test	Raw cotton from 15 provenances	No pesticide traces
2005 test	Raw cotton from 15 provenances	No pesticide traces
2004 test	Raw cotton from 15 provenances	No pesticide traces
2002 test	Raw cotton from 15 provenances	One sample with 0.3 ppm pesticide content
2000 test	Raw cotton from 15 provenances	2 samples with 0.03 and 0.08 ppm pesticide content
1998 test	Raw cotton from 13 provenances	3 samples with 0.001, 0.006 and 0.35 ppm pesticide content
1996 test	Raw cotton from 11 provenances	3 samples with 0.005, 0.005 and 0.02 ppm pesticide content
1991-1994 test	Raw cotton from 33 provenances	5 samples without pesticide contamination 28 samples with pesticide contents of 0.001 to 0.077 ppm (DDT, Lindane)

These results give rise to the conclusion that there is no significant contamination of raw cotton with pesticides. Nowadays no pesticide contamination is to be found in raw cotton.
The pesticide contamination feared by the public is practically non-existent.
The test chronology shows that the pesticide contamination that was already insignificant in the early 1990s is practically non-existent, with the development of improved biodegradable products by the chemical industry and constantly reducing application quantities.

By the same token, the tests carried out on the samples of raw cotton from the Bremen Cotton Exchange exhibited no harmful substance contamination from formaldehyde, pentachlorophenol and heavy metals.

I would further like to report on years of experience testing cotton textiles across the board:

As a founding member of the OEKO-TEX STANDARD 100 and a member of the International Association for Research and Testing in the Field of Textile Ecology, the Hohenstein Research Institute has over 16 years' experience of testing cotton textiles for harmful substances such as pesticides. To date the OEKO-TEX Association has issued more than 60,000 OEKO-TEX STANDARD 100 certificates, the majority of the certified products being cotton textiles. Our own experience and knowledge from investigations by other members of the OEKO-TEX Association encompasses tens of thousands of harmful substance tests on cotton textile goods. The scope of the tests covers a comprehensive range of products, from testing cotton yarns (i.e. products that are very close to raw cotton!), via underwear, babywear, T-shirts, sweatshirts, and shirts, to bed linen and other domestic textiles.

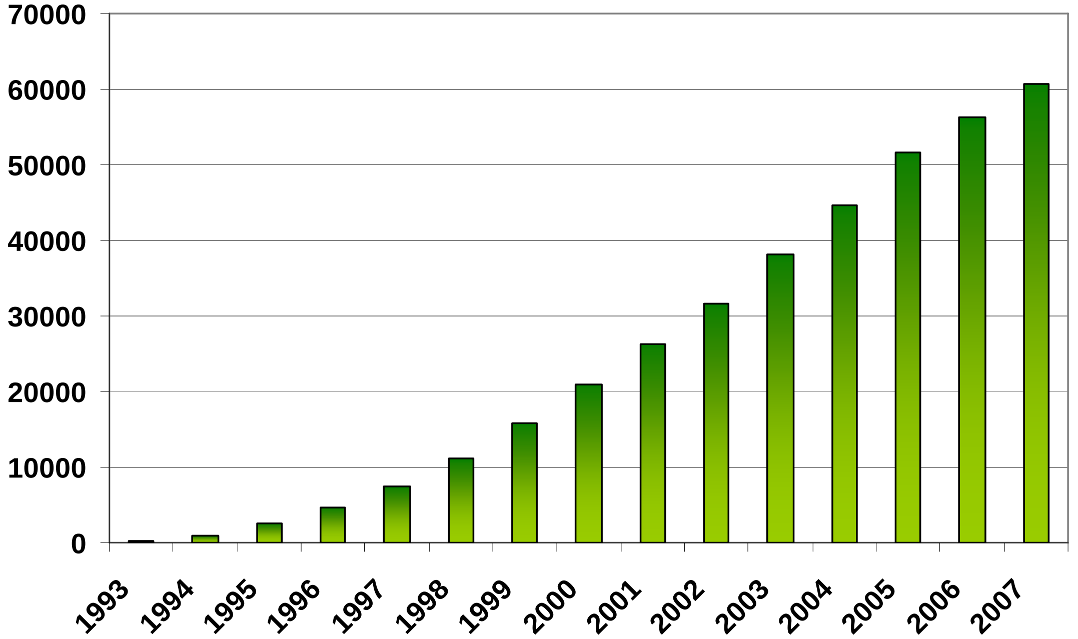

Figure 1: Number of Oeko-Tex Standard 100 certificates issued 1993 - 2007

With a couple of minor exceptions, no contamination with pesticides or heavy metals has been determined, so that it has been possible to issue a certificate.
Experience, based on this volume of test results, allows us to say that there is no relevant contamination of cotton textiles with pesticides or other harmful substances.

FASERINSTITUT FIBRE BREMEN

29th International Cotton Conference BREMEN

April 2 - 5, 2008

Session VII: Cotton Processing

- ***New method for the detection and separation of foreign parts including polypropylene***
  Armin Leder
- ***The way to optimal yarn quality***
  Iris Biermann
- ***Modern combing systems - economy and quality***
  Albert Rusch
- ***True Neps: Measurement and correlation to results in ring-spinning***
  Varadarajan Srinivasan
- ***Five year spinning study***
  Jonn Foulk

NEW METHOD FOR THE DETECTION AND SEPARATION OF FOREIGN PARTS, INCLUDING POLYPROPYLENE

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Truetzschler, Moenchengladbach, Germany

ABSTRACT

Foreign fibres made of white or colourless polypropylene present still a massive problem for the cotton-processing industry. To compensate for the subsequent damages of a contamination with polypropylene, enormous sums are spent annually on all levels of the value-added chain, though mainly by spinning, weaving, knitting and finishing operations.

The conventional technical solutions to combat the foreign fibre problem in the spinning mill possess system-related advantages, but also disadvantages. This applies to foreign part separation systems in spinning preparation, as well as to electronic yarn cleaners with foreign fiber detection. As a result of intensive development efforts, Trützschler introduced the new SECUROPROP SP-FP for the first time at ITMA 2007.

In addition to the already known, and now optimised detection and separation of coloured foreign parts, this machine offers newly developed sensors for translucent foreign parts, to fight the dreaded contamination of cotton products with polypropylene fibres. In doing so, use is made of the physical principle of illumination with polarised light, which is already known, though has not been realised in this field. This method, for instance, is known from the stress-optical examination of components in mechanical engineering. The actual sensor of the SP-FP consists of a CCD colour line camera that detects the generated luminous effect, or colour effect, which is created by depolarisation during object illumination. Image analytical algorithms are subsequently consulted to differentiate between foreign parts to be separated, and normal cotton tufts.

The details and main advantages of this technology are explained in this field report.

SECUROPROP SP-FP - Efficient detection and separation of foreign parts, including colourless polypropylene

Foreign fibres made of polypropylene

Foreign fibres made of white or colourless polypropylene present still a massive problem for the cotton-processing industry (**figure 1a and b**). Enormous sums are spent annually at all levels of spinning, weaving, knitting and finishing, compensating for damages caused by polypropylene contamination.

Figure 1a

Figure 1b

Solution by using polarised light

At this year's ITMA, a groundbreaking development in the field of foreign fibre detection has been introduced: The Trützschler SECUROPROP SP-FP (**figure 2**).

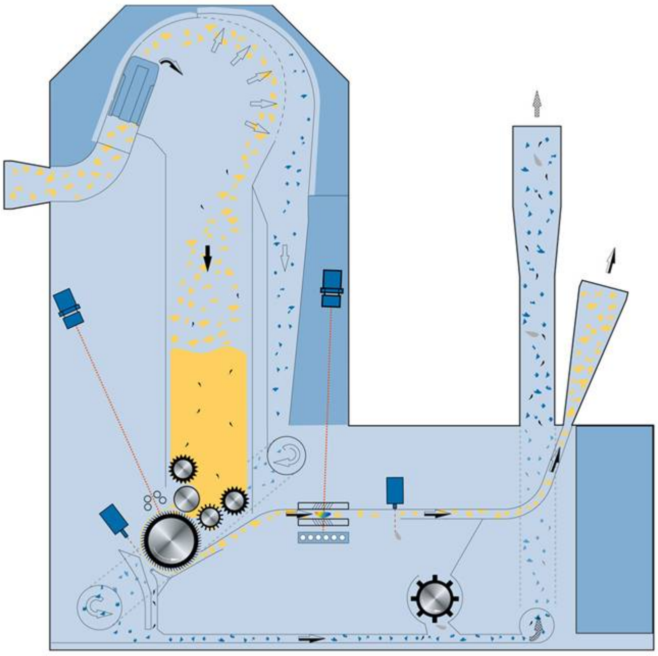

Figure 2

The tried and tested technology and the excellent performance of SECUROMAT SP-F have been consistently enhanced, resulting in the SECUROPROP SP-FP, which - besides coloured foreign parts - can detect and separate also white, colourless and transparent polypropylene in the blow room - and all this at absolutely minimum loss of good fibres. In this connection, Trützschler is using a completely new, patented technology. For the detection of these foreign parts, polarised light and CCD colour line cameras are applied. Over and above, the practically applicable detection resolution has been clearly increased once more. Thus, it is possible to detect parts starting at 0,4 mm. This means that even PP threads will be safely separated.

Fibre tufts and foreign parts located in a rectangular duct are illuminated with fluorescent tubes. The light emitted from the fluorescent tubes is first channelled through a polarisation filter. A second polarisation filter is located in front of the lens of the colour line camera. When using polarised light, all translucent foreign parts - that is to say all parts with a certain degree of transparency - appear as multi-coloured objects (**figure 3a and figure 3b**), while the cotton tufts remain inconspicuous (**figure 4**). Next, the foreign parts made of polypropylene or polyethylene are selectively separated by one or several of a total of 64 compressed air nozzle groups, arranged over the working width. With this method, the loss of good fibres is reduced to a minimum.

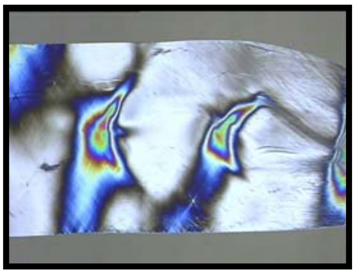

Figure 3a

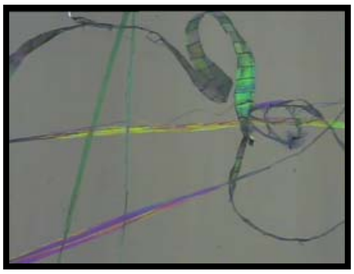

Figure 3b

Figure 4

What are the customer benefits?

The SECUROPROP is a multifunctional machine, combining the functions of numerous single machines:

- Separation of fibres and transport air current, and complete dust extraction
- Material storage and continuous feeding of carding (CONTIFEED), with speed controlled feed roll drive.
- Gentle fine opening through needle roll
- Detection and separation of coloured foreign parts
- Detection and separation of white and colourless foreign parts made of polypropylene/polyethylene

The detection unit for polypropylene is the most effective one currently available on the market. SECUROPROP

- eliminates manual separation of foreign parts
- lowers the number of yarn cleaning cuts on rotor spinners or winders, and prevents catastrophic efficiency collapses on spinning machines or winders due to acute and massive contamination.
- Enables production of yarns that are almost free of foreign fibres at clearly improved quality
- Prevents expensive claims, since a reduction of defective material due to reduced wastage, less second quality, and less reworking occurs.

Some of the new and improved machine characteristics shall also be mentioned at this occasion:

- Maximum production performance up to 1000 kg/h
- Coloured touch screen for simple and intuitive operation, second TFT monitor for calibration of the system
- Optional service platform
- Constructive details and overall solutions that specifically emphasise the need for simple and quick maintenance

How is the practical advantage noticeable in the spinning mill?

In **Figure 5,** a SECUROPROP has been placed in a blow room that is already equipped with foreign part detection (SECUROMAT). The efficiency of a rotor spinning machine is applied, measured in layers over running time. The rotor spinning machine is not equipped with a yarn cleaner for PP.

Up to now, this customer has only assumed that foreign polypropylene parts cause yarn breaks in the winding process due to their fibre properties, thus lowering the machine's efficiency. PP is significantly coarser than cotton and creates a weak spot in the yarn. The consequence in many cases: Yarn breakage!

This is even referred to as PP clusters, which are responsible for actual efficiency collapses. Fact is: Since the application of efficient PP-separation in the blow room, a continuously high efficiency is being achieved.

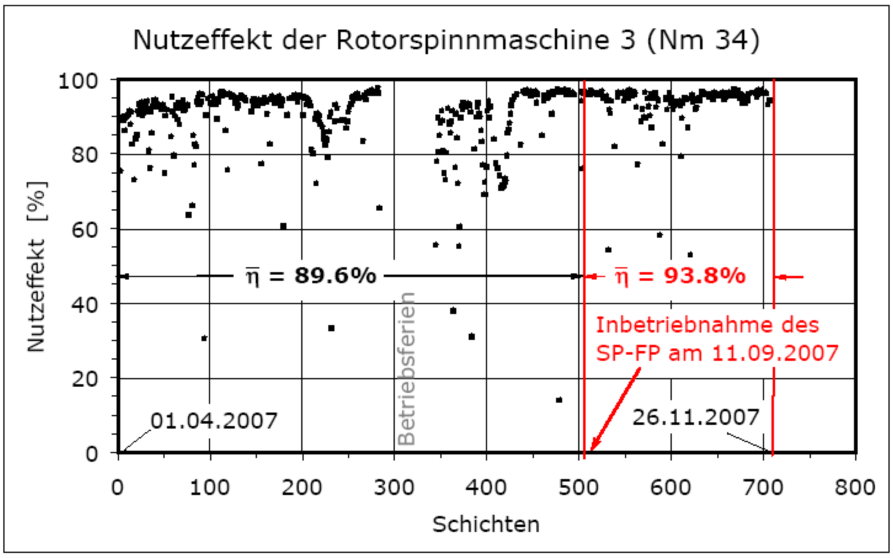

Figure 5

The SECUROPROP solves a key problem that every spinner is aware of, and strives to eliminate. Our customers and our marketing have often pointed out that a solution to this problem has been long overdue. The coming years will show how well this particular solution covers our customers' requirements.

THE WAY TO OPTIMAL YARN QUALITY

I. Biermann
Oerlikon Schlafhorst, Mönchengladbach, Germany

1 Introduction

Oerlikon Schlafhorst, the market and technology leader for ring spinning, winding and rotor spinning, sets the benchmark for engineering and technology in the area of yarn production from staple fibres. The performance packages for all machines, from Autocoro and BD line, Autoconer, all the way to Zinser machines, is evidence of the textile-technological core competence for high-quality packages, yarns and yarn joints and provide the customer with clever solutions for actual spinning operation.

Figure 1: Oerlikon Schlafhorst product portfolio

The success of a spinning mill depends on how well its end product "yarn package" performs in downstream processing. Regardless of whether it is a sales spinning mill or full liner, success factors in the textile process chain are the characteristics.
From the viewpoint of the sales spinning mill, this has an influence on

- the measure for price/performance ratio,
- the rate of complaint, i.e. part of the quality costs
- and customer loyalty

From the viewpoint of the full liner, this is even simpler. He detects the advantages of good unwinding properties directly during processing.

- Productivity increase during downstream processing, which can be achieved by him thanks to improved or faster unwinding properties.
- Quality cost reduction in downstream processing
- But there is also a reduced risk of producing "second-rate fabrics".

The production of defective goods when processing the fabric is significantly more expensive than at an earlier stage in the textile processing chain. Thus, it is essential to embark on the way to an optimal yarn package already at the time of package build.

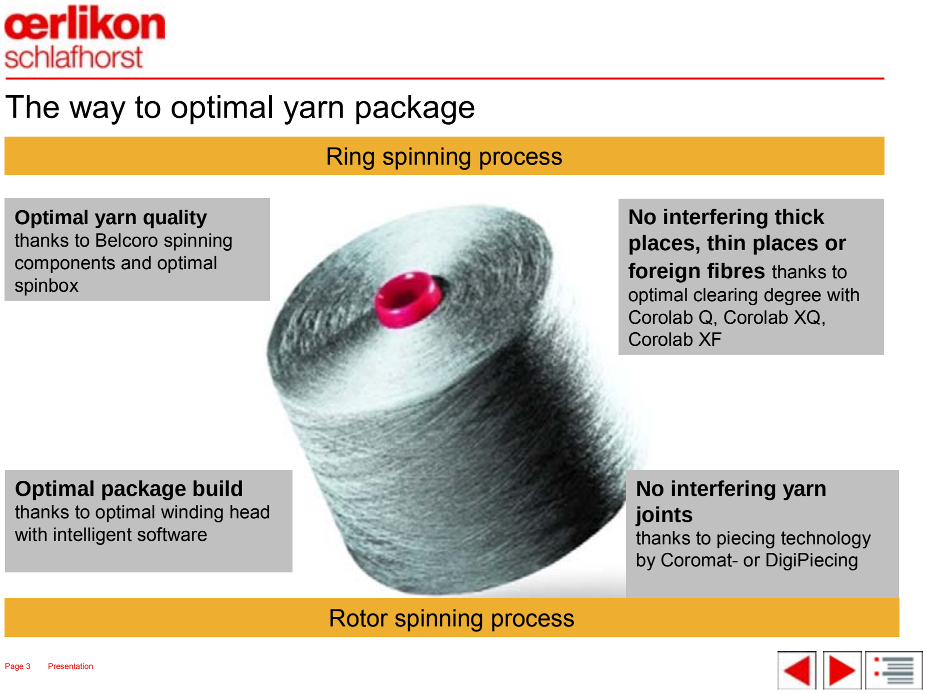

Figure 2: Four main factors of the optimal yarn package

Though what exactly influences the statement “This is a good or bad yarn package in knitting or weaving"?
Being the four central factors, the following points must be mentioned:

- Yarn quality according to textile application
- Quality of yarn joints
- Actual package build and
- Yarn clearing.

These four factors are the way to an optimal yarn package.

For years, Oerlikon Schlafhorst has been focusing on these factors. Regardless whether ring-spun or rotor-spun yarn, the modern machine equipment from Oerlikon Schlafhorst enables the balance of these four parameters, thus allowing for a trouble-free and economic downstream processing.

2 Yarn quality according to textile application

The influencing factors affecting yarn quality differ between rotor spinning and ring spinning.

Optimal yarn quality

Factors influencing yarn quality

	Ring spinning process	Rotor spinning process
Applied raw material	Fibre length Fibre tensile strength / elongation Fibre fineness / maturity Fibre purity/cleanliness	Fibre tensile strength / elongation Fibre fineness / maturity Fibre purity/cleanliness Fibre length
Sliver / roving quality	Roving irregularity	Sliver irregularity
Applied spinning components	Ring and ring traveller Drafting system Spindle	Rotor Opening roller Navel Torque stop
Spinning settings	Settings of drafting system Spindle speeds	Rotor speed Opening roller speed

Page 4 Presentation

Figure 3: Influencing factors on yarn quality

The yarn quality is influenced by the applied raw material, the quality of preparation, all the way to spinning settings and utilised spinning components.

Figure 3 shows the ranking of influencing factors.

2.1 In the rotor spinning process

2.1.1 "Recommendation of spinning settings"

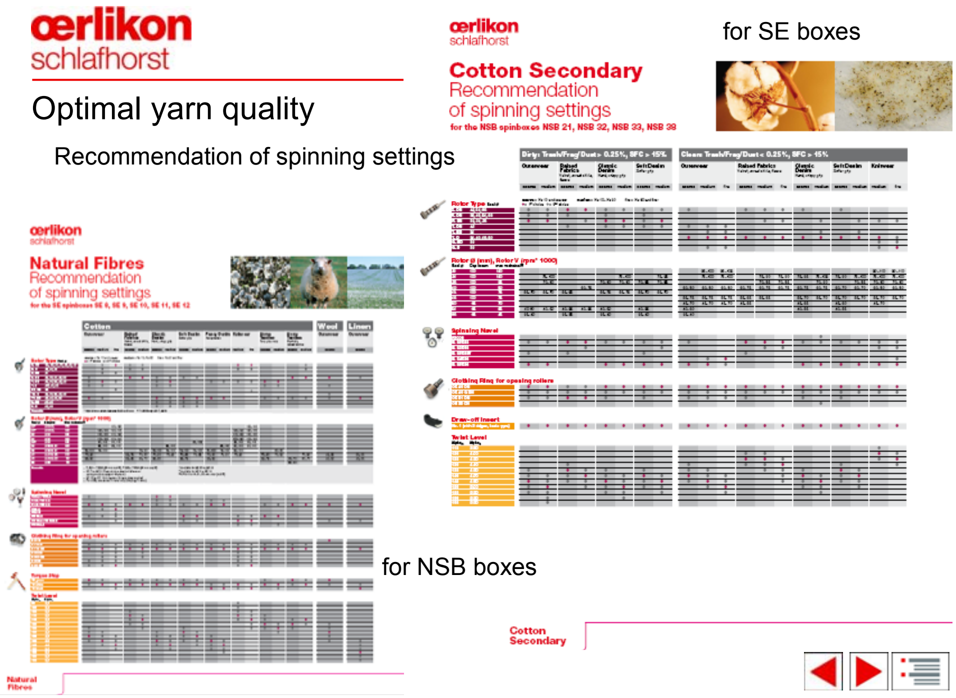

Figure 4: Recommendation of spinning settings

Since the selection of correct spinning settings has such a great impact on the later textile application, Oerlikon Schlafhorst issued the new "Recommendation of Spinning Settings" Figure 4 for rotor spinning for the SE spinbox types of the Autocoro line and the NSB spinboxes of the BD line already at the occasion of ITMA 2007.

The user can choose between different fibre categories as follows:

- Natural fibres
- Cotton Secondary
- Synthetics
- Cellulosics
- Blends

The areas of textile application quoted in the recommendation are as follows:

- Outerwear
- Raised fabrics
- Classic denim
- Soft denim
- Fancy denim
- Knitwear
- Home textiles
- Technical textiles
- Workwear

The likelihood of finding the qualitative and economic optimum is greatest when a yarn is designed in accordance with later use, e.g. an open voluminous yarn for raised fabrics or slender yarns with less hairiness for shirt fabrics.

Yarns can be actively designed by means of spinning components. Spinning components are mainly:

- Rotors
- Opening rollers
- Navels

Additional elements - though not actually referred to as spinning components – that also have an influence on yarn quality and running behaviour are:

- Torque Stop
- Channel plate or adapter

Depending on fibre material and textile use, the application recommendations indicate a recommendation for the

- Choice of rotor
- Choice of adapter
- Choice of opening roller
- Choice of navel
- Choice of Torque Stop
- Yarn twist

2.1.2 Choice of rotor

The fibres supplied by the opening roller via the feed channel are collected again in the rotor, i.e. the fibres are redoubled in the rotor groove. The rotor also gives the twist to the initially untwisted fibres, thus producing the rotor yarn.

Figure 5: Belcoro rotors

Belcoro rotors Figure 5 have a visible rotor designation when SE spinbox is open. All rotor types are available as Schlafhorst Belcoro rotors for all SE spinbox generations, from SE 7 to SE 12.

Schlafhorst provides rotors for hybrid bearings or magnetic bearings (MRPS magnetic rotor positioning system). The hybrid bearing is the long-known system with oil wick lubrication. Over the years, service life has been significantly improved by a ceramic pin in the rotor shaft. However, compared with the magnetic bearing, the hybrid bearing is still high-maintenance. The magnet provides non-contact positioning of the rotor base and offers:

- 100 % precise rotor position
- No soiling caused by oil, i.e. it is low-maintenance.
- Reduced cleaning effort.

Practical experience proves that the cleaning intervals of the entire rotor bearing can be extended two to three times.

Depending on yarn application and production conditions, four parameters must be considered:

- Rotor type
- Rotor coating
- Rotor diameter
- Rotor speed

2.1.2.1 Rotor type

Basically, the rotor type is characterised by the shape of the rotor groove and the rotor coating. Yarn parameters and yarn properties such as volume, lustre and handling, as well as the most diversified applications can be influenced by the choice of rotor groove.

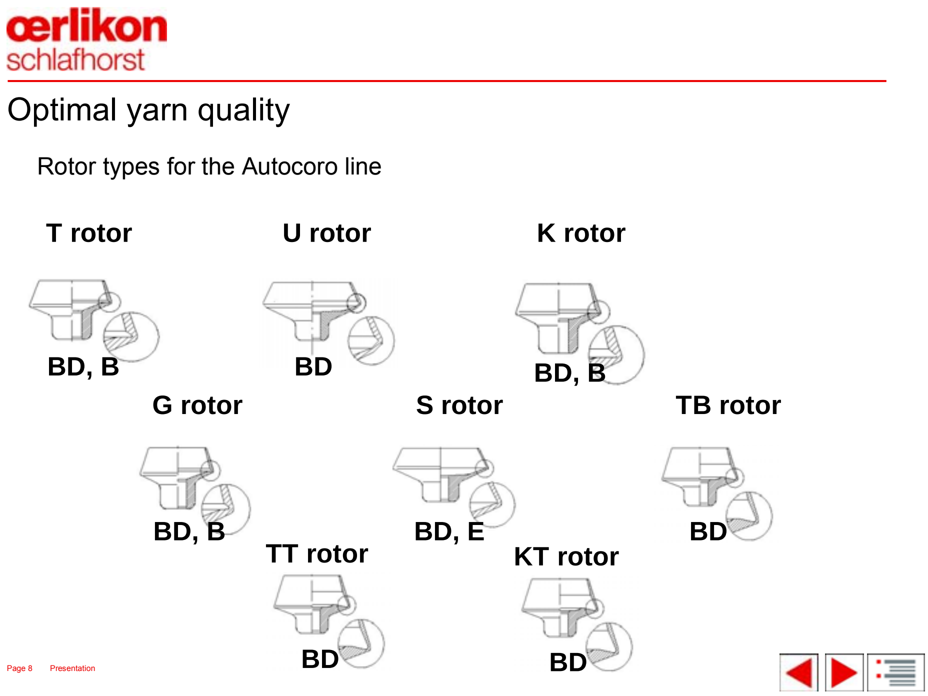

Figure 6: Rotor types for Autocoro line

To assess the entire rotor configuration, the design of both the fibre sliding surface and the rotor base must not be disregarded. The rotor configurations have established themselves over a long period of development and are based on many practical experiences.

The "Recommendation of Spinning settings" indicates clearly when to apply what rotor type.

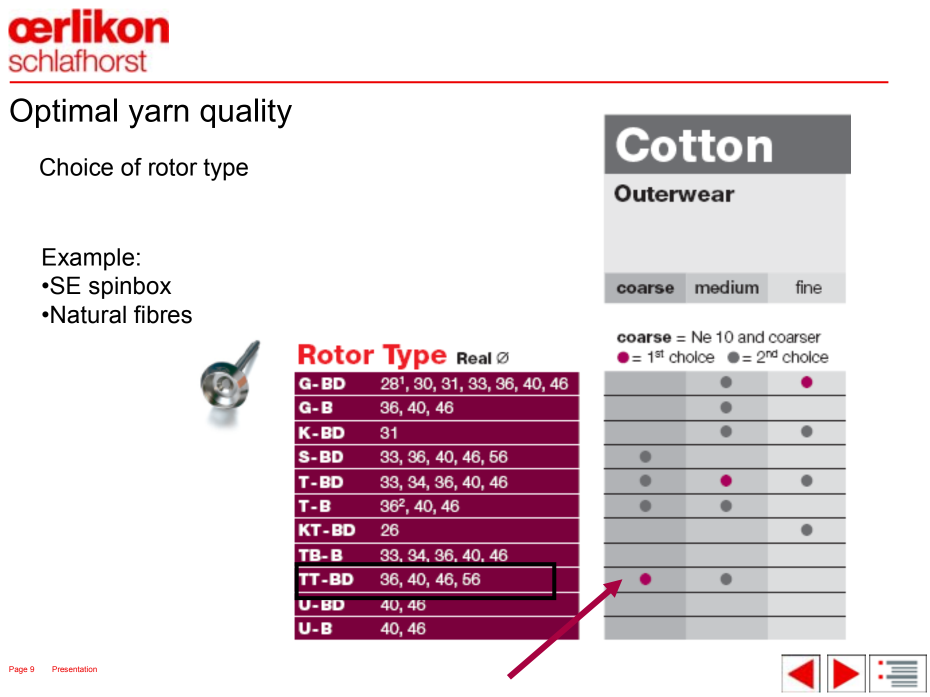

Figure 7: Rotor types in the application recommendations

> Figure 7:
>
> Depending on textile application, fibre material and yarn count, the user finds the 1st choice and 2nd choice of rotor type in this table. 1st choice indicated by red dot. The grey fields represent 2nd choice. At the same time, the available rotor diameters are indicated.
>
> Example:
>
> - Outerwear
> - 100 % cotton
> - Coarse yarn counts, NE 10 and coarser
>
> 1st choice of **rotor type TT**. The TT rotor is currently only available in **BD coating**. This rotor is available in the following rotor diameters:
>
> - 36 mm
> - 40 mm
> - 46 mm
> - 56 mm

2.1.2.2 Rotor diameter

The chosen rotor diameter is dictated in the first instance by the fibre length being processed. This fibre length should not significantly exceed 1.25-fold of the rotor diameter.

The rotor diameter must be matched to the yarn count. Coarser yarns should always be produced with larger-diameter rotors on account of the higher fibrous masses and the lower absolute yarn twist.

Choosing the correct rotor diameter can greatly influence important yarn properties and yarn parameters, like for instance volume, lustre and handling. In addition, the rotor diameter has also a decisive influence on the choice of twist factor, since it is in direct relation to yarn count and yarn twist multiplier.

The “Recommendation of Spinning Settings” clearly shows the importance of combining all parameters in relation to textile application.

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Optimal yarn quality

Rotor diameter

Rotor Ø (mm), Rotor V (rpm* 1000)

Real Ø	Adapter	Max technical V			
26[1]	A 26 SL	170			130–150
28[2]	A 28 SL	150		120–145	120–145
30	A 31	135		110–130	110–130
31	A 31	130		100–125	100–120
33[3]	A 31	125		90–115	90–115
34	A 36/A 31	120		85–110	85–110
36	A 36/A 31	110	75–100	75–100	
40	A 40/A 36	100	70–90		
46	A 46/A 40	80	55–80		
56	A 56	70			

Figure 8: Choice of rotor diameter from the application recommendation

Figure 8

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

we recommend **TT 536 BD, TT 540 BD or TT 546 BD**

The disruptive influence of foreign fibres, a dust and trash particle manifests itself to a greater degree for smaller-diameter rotors than larger-diameter rotors. This means an increase in yarn breaks and decrease in spinning stability. Thus, the application recommendations contain always only one diameter range.

2.1.2.3 Rotor speed

The interaction of rotor speed and rotor diameter determines the centrifugal force with which the fibres are pressed into the rotor groove, as well as the spinning tension, i.e. the yarn tensile force at the yarn detachment point.

The centrifugal force increases in proportion to the speed, causing the fibres to be pressed stronger into the rotor groove, and thus increases the torque required to introduce the twist. This has an influence on yarn values, especially on elongation and strength, and on spinning stability. The spinning tension has a decisive influence on running behaviour and indirectly on winding hardness of the packages.

Rotor speed, rotor diameter and yarn count cannot be considered separately in terms of stability of the spinning process and the yarn quality attainable. Therefore, the “Recommendation of spinning settings” features the combination of choices.

Performance limits due to fibre strength and elongation have to be taken into account when selecting the rotor speed. When exceeding these limits, the yarn values decrease, in particular elongation drops and the number of yarn breaks increases, see Figure 9.

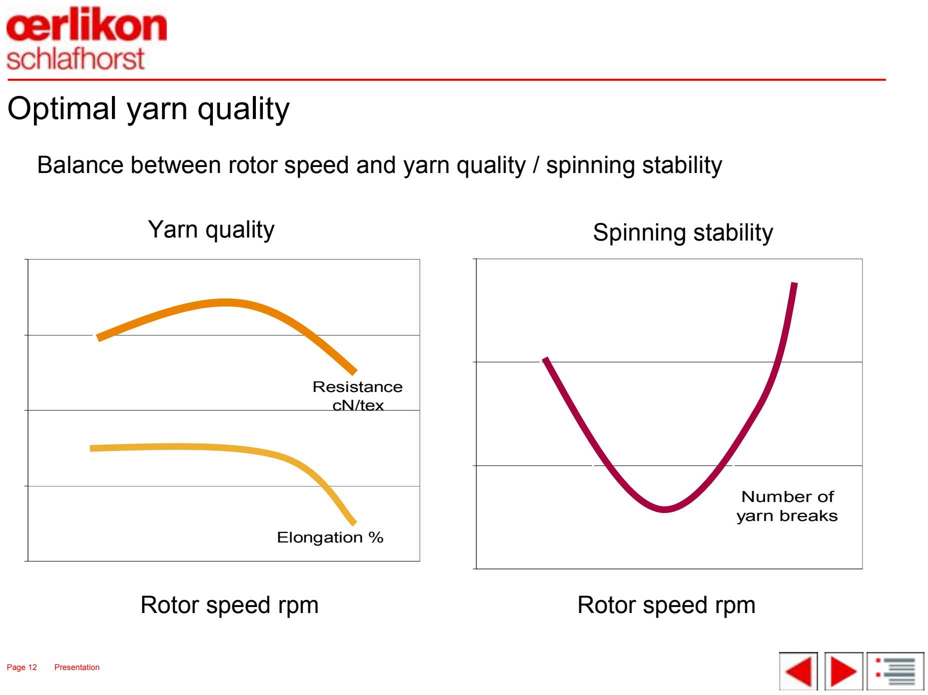

Figure 9: Balance between rotor speed and yarn quality / spinning stability

Falling below the minimum speed for spinning stability also results in increased yarn breaks and generally also decreasing yarn values. However, in addition to minimum speeds, there are also technical maximum rotor speeds. They depend on physics and metallic material properties.

Optimal yarn quality

Rotor diameter

Rotor Ø (mm), Rotor V (rpm* 1000)

Real Ø	Adapter	Max technical V			
26[1]	A 26 SL	170			130–150
28[2]	A 28 SL	150		120–145	120–145
30	A 31	135		110–130	110–130
31	A 31	130		100–125	100–120
33[3]	A 31	125		90–115	90–115
34	A 36/A 31	120		85–110	85–110
36	A 36/A 31	110	75–100	75–100	
40	A 40/A 36	100	70–90		
46	A 46/A 40	80	55–80		
56	A 56	70			

Figure 10: Choice of rotor diameter, part 2 of application recommendations

Figure 10

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

we recommend **TT536 BD** – i.e. 36 mm actual diameter – in combination with a rotor speed of **75.000 to 100.000** rpm.

The technical maximum speed of the according rotor is also contained in the table.

2.1.3 Choice of adapter

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Optimal yarn quality

Choice of adapter

Page 14 Presentation

Figure 11: Choice of correct adapter

The adapter for spinbox types SE 10 to SE 12, and the channel plate for spinbox types SE 7 to SE 9 cannot be considered spinning components in the usual sense. However, they ensure correct positioning of the navel in relation to the rotor groove, and targeted feed of fibres onto the rotor wall. Thus, the choice of the correct adapter or correct channel plate is very important.

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Optimal yarn quality

Rotor diameter

Rotor ∅ (mm), Rotor V (rpm* 1000)

Real ∅	Adapter	Max technical V			
26[1]	A 26 SL	170			130–150
28[2]	A 28 SL	150		120–145	120–145
30	A 31	135		110–130	110–130
31	A 31	130		100–125	100–120
33[3]	A 31	125		90–115	90–115
34	A 36/A 31	120		85–110	85–110
36	A 36/A 31	110	75–100	75–100	
40	A 40/A 36	100	70–90		
46	A 46/A 40	80	55–80		
56	A 56	70			

Page 15 Presentation

Figure 12: Choice of adapter from the application recommendation

Figure 12

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

we recommend TT536 with the **36 adapter** as 1st choice or **31 adapter** as 2nd choice.

2.1.4 Choice of navel

In addition to the already described technical and technological explanations concerning the rotor, the configuration of the navel has also a decisive influence on spinning result and structure of textile products. Schlafhorst uses mainly navels made of ceramic material.

Figure 13: Choice of navel

Notches in the navel generate oscillations in the yarn. Since the already integrated piece of yarn briefly lifts off the rotor groove, the friction between yarn and groove is reduced. Thus, the twist enters the fibre bundle with less effort. The navel with four notches K-4 or KN-4 has established itself as universal navel. See Figure 14.
Navels with outer knurling increase the friction between the navel and the yarn. The false twist is increased and displaced in the direction of the rotor groove as far as the binding-in zone.

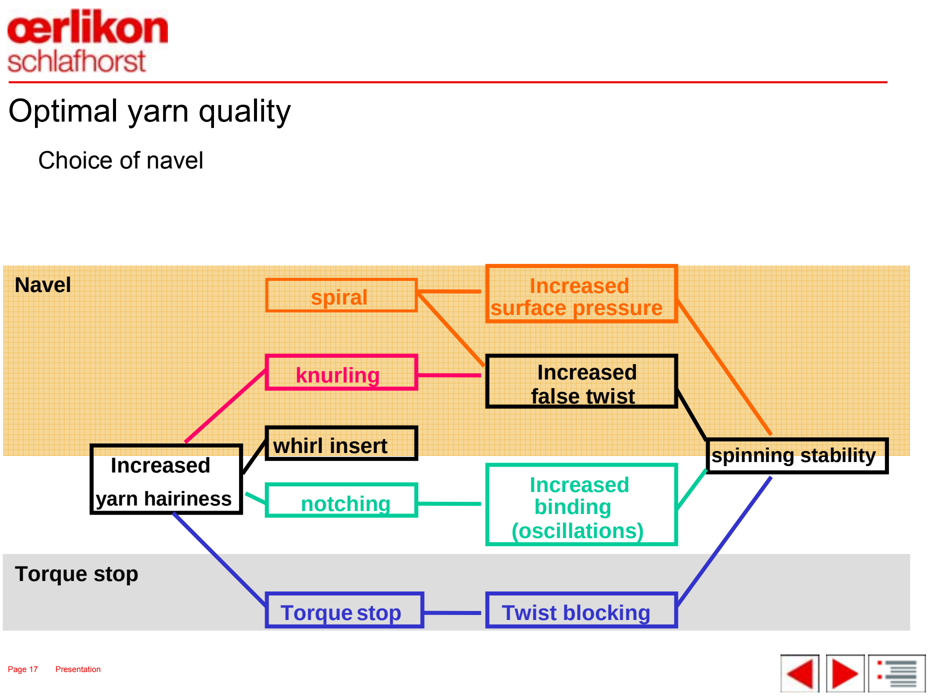

Figure 14: What type of navel is chosen when?

The spiral of the KS navel reduces the contact surface of the yarn, thus increasing the surface pressure between yarn and navel. Compared with a smooth navel, this results in increased false twist and improved spinning stability. Yarn evenness, imperfections and hairiness are not influenced by this. The KS navel has gained popularity above all for smooth weaving yarns in the medium and fine count range. It is not suitable for pure man-made yarns.

Both notching and milling and the use of intermingling influence the visual appearance of the yarn. Compared with the smooth KG navel, the yarn appears coarser and has increased hairiness. However, spinning stability and consequently yarn break ratio are noticeably improved.

By choosing the correct navel, the character of the yarn can thus be optimally matched to fit the corresponding application.

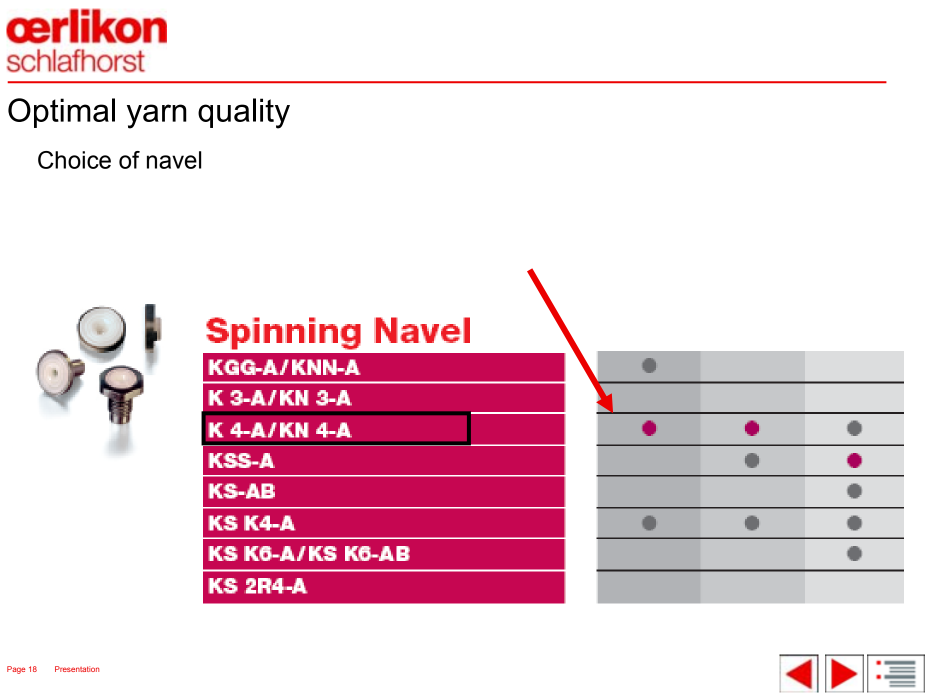

Figure 15: Choice of navel from the application recommendation

Figure 15

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

we recommend **K4-A** or **KN4-A**

2.1.5 Choice of opening roller

The opening roller is assigned to clean the sliver and open it all the way to the individual fibres, for transporting them into the rotor via the fibre guide channel. Such a degree of opening to the individual fibre is essential for trash separation as well as for a good yarn quality and good running behaviour during rotor spinning. This process should take place with as little damage to the fibres as possible. It is influenced by tooth configuration, surface finish, assignment, material throughput and opening roller speed.

Figure 16: Choice of opening roller

Schlafhorst offers Belcoro opening rollers for natural fibres like cotton, cotton waste, regenerated cotton fibres as well as manmade fibres up to a staple length of 60 mm. All clothing rings are made of solid steel and not of wire clothing.

In addition to the nickel coated surface of the solid rings with the N marking, Schlafhorst offers opening rollers with 3d coating, a diamond coating with nickel plating (DN) for high service life and a good degree of fibre opening. As an alternative and depending on application, diamond coated opening rollers can be used exclusively.

During many years of development and experience, Oerlikon Schlafhorst developed various tooth configurations for all applications. In the process, consideration must be given to raw material facts such as fibre length, distribution of fibre length, short fibre content and surface structure of fibre and its friction value.

To cover an extremely broad range of applications, the most diversified configurations have been developed for cotton processing over the years. According to relevance, these are the types B 174, B 300 and B 20. For processing of man-made fibres and their blends, type S 21 is used with few exceptions.

2.1.5.1 Opening roller speed

In addition to choosing the opening roller type, the opening roller speed is also a decisive criterion for fibre opening and yarn quality, depending on raw material.

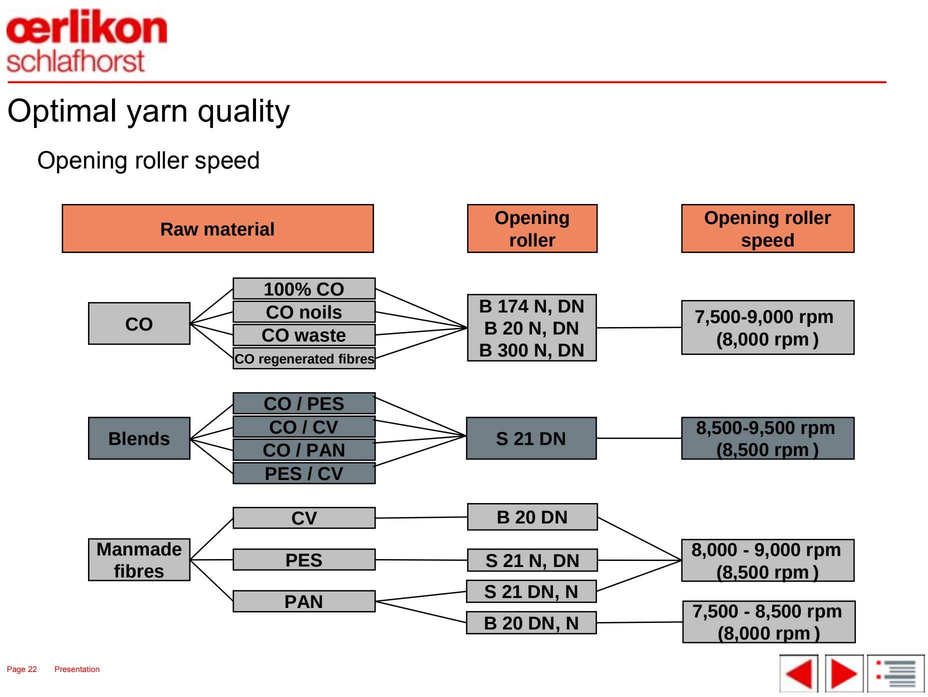

Figure 17: Choice of opening roller speed

Figure 17 shows the application of the opening roller in relation to raw material. Reference is made to a recommendation for the opening roller speeds to be chosen. In this connection, contrary to the often quoted theory of using high opening roller speeds with coarse yarns and low opening roller speeds with fine yarns, the exact opposite applies. Practical experience shows that to achieve good evenness, low degree of imperfections and good running behaviour, finer yarns should always be spun with higher opening roller speeds than coarse yarns.
Approx. 95% of all applications are covered by the recommendations provided.

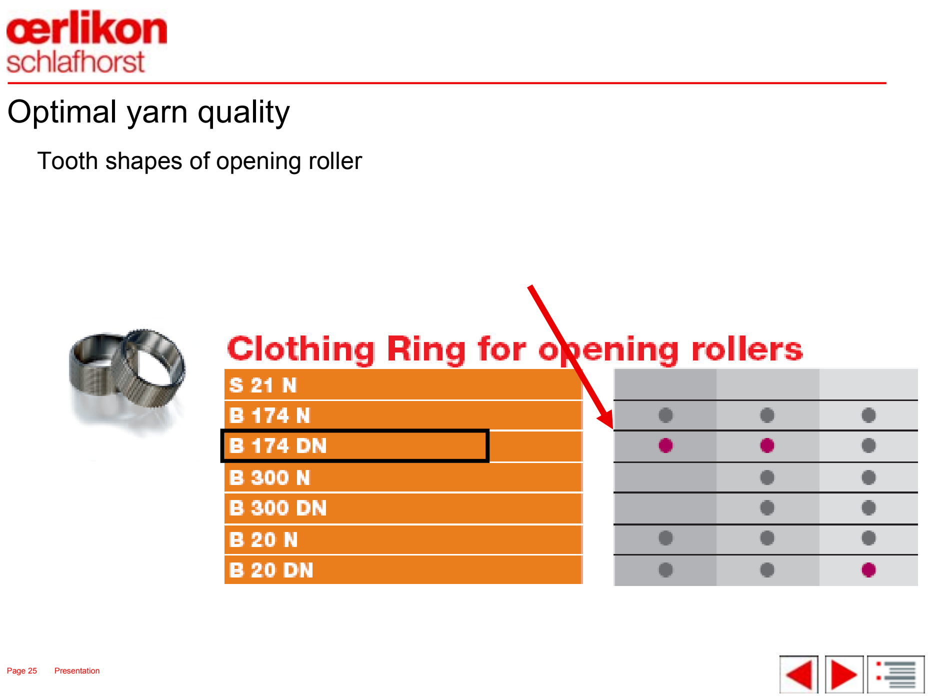

Figure 18: Choice of opening roller type from the application recommendation

Figure 18

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

B 174 DN is recommended.

2.1.6 Choice of Torque Stop

While the navel generates a false twist, the Torque Stop causes blocking of the real twist.

The ribs of the Torque Stop produce a twist blocking between the Torque Stop and the binding-in zone of the yarn in the rotor. The false twist is supported and briefly maintained. This results in an extension of the binding-in zone. The yarn strength in this area is increased. Thus, spinning stability is improved. Due to this, it is possible to spin with a lower yarn twist at the same running behaviour or to reduce the yarn break rate when yarn twist is constant.

Figure 19: Choice of Torque Stop

Using the Torque Stop usually results in a slight increase in yarn hairiness. This is quite desirable for a voluminous yarn and the resulting soft handling. The application is particularly recommended for small rotor diameters.

As TS 30, the Torque Stop is equipped with the following clip (yarn knee), see Figure 19.

- Colour green — Application without ridges, i.e. very low blocking effect
- Colour white — Application with three pronounced ridges
- Colour black — Application with three very pronounced ridges

The TS 30 navel tube for spinbox types SE 10, SE 11 and SE 12 is made of plastic. The difference to earlier spinbox generations (SE 7 to SE 9) lies in the navel tube fastening and the yarn knee holder. The ceramic insert of the clip is the same in both executions.

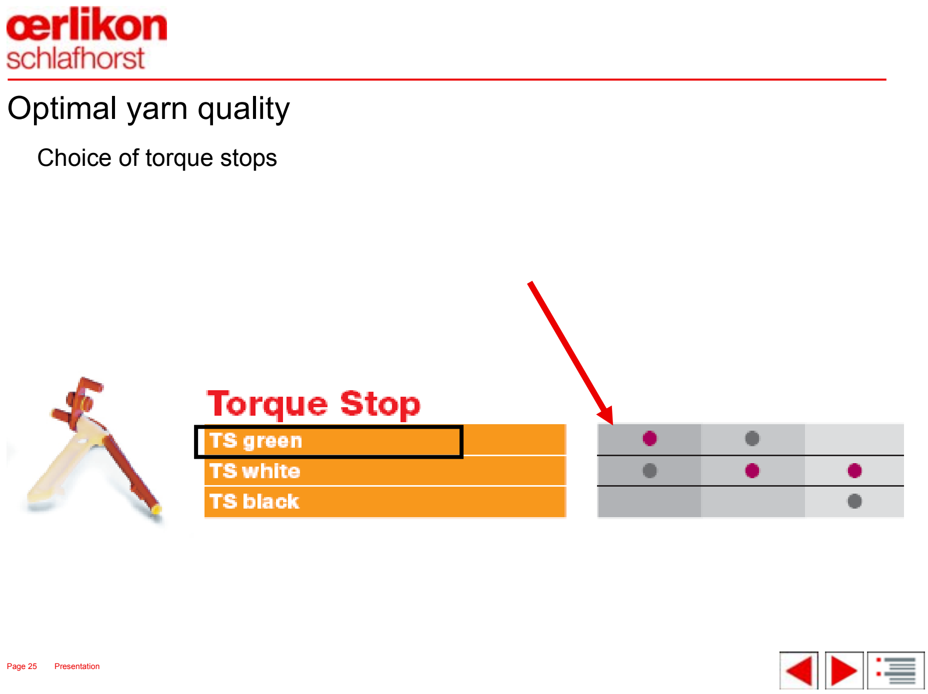

Figure 20: Choice of Torque Stop from the application recommendations

> Figure 20
>
> In our accompanying example
>
> - Outerwear
> - 100 % cotton
> - Ne 10 and coarser
>
> we recommend **Torque Stop green**.

2.1.7 Choice of yarn twist according to textile application

The yarn twist has a large influence on yarn strength, but also on the basic yarn character. In the cotton sector, the yarn twist varies by the basic strength of the applied fibre material. Thus, it is very difficult to recommend the applicable yarn twist. However, if the twist is also considered as starting point of the according application, it is of much help when creating a new fabric.

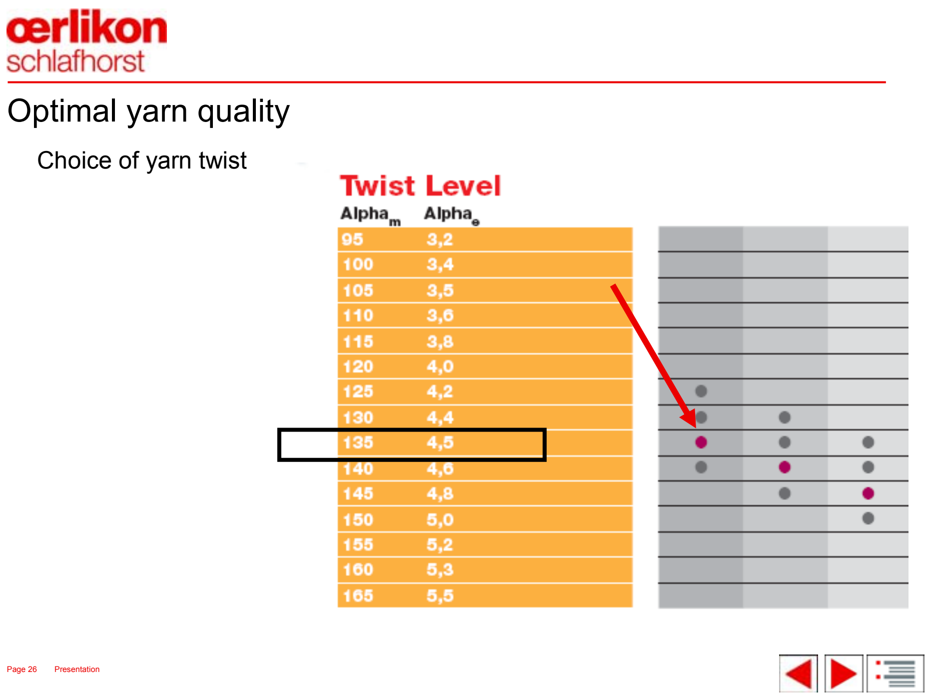

Figure 21: Choice of yarn twist from the application recommendations

Figure 21

In our accompanying example

- Outerwear
- 100 % cotton
- Ne 10 and coarser

we recommend the twist factor **Alpha engl. 4.5**.

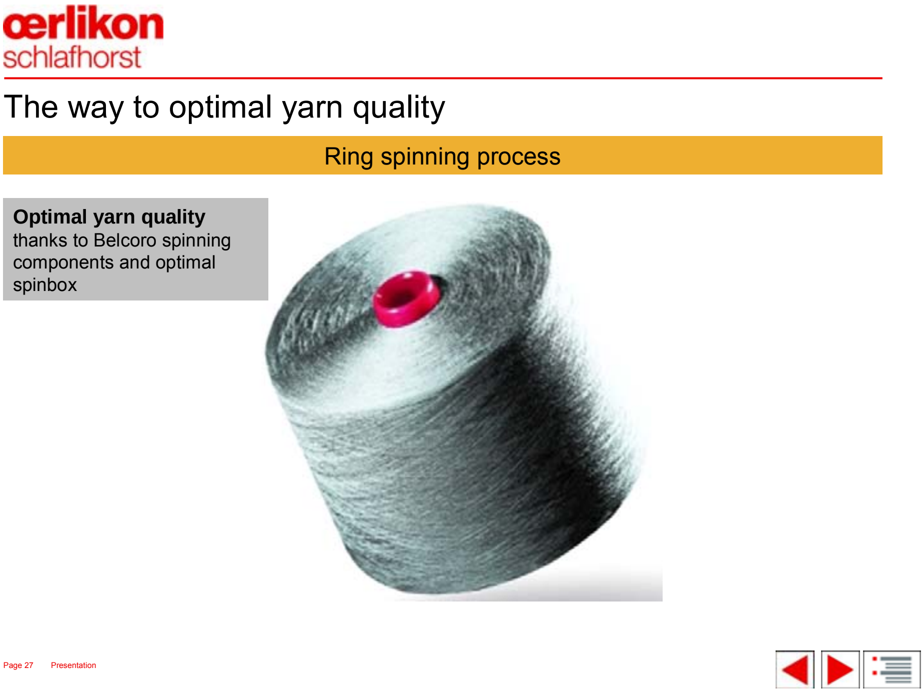

Figure 22: Ring spinning process

2.1.8 Choice of raw material

The ring spinning process requires a number of production stages, particularly in comparison with the rotor spinning process. Each process stage has an influence on the later yarn quality. During planning, the main focus is on roving and conventional ring spinning as well as CompACT³.

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Comparison of yarn counts

Ring spinning	Yarn counts	Rotor spinning
coarse yarn counts	< Ne 10	coarse yarn counts
coarse yarn counts	up to Ne 20	medium yarn counts
medium yarn counts	up to Ne 40	fine yarn counts
fine yarn counts	up to Ne 100	-
finest yarn counts	from Ne 100	-

Page 29 Presentation

Figure 23: Comparison of yarn count ranges

This multitude of process stages might sound negative, but it also results in a high universality for ring spinning in regard to spinning of an extremely large yarn count palette. While in rotor spinning the processing of NE 40 cotton yarn already reaches the limit of economic feasibility, ring spinning can still produce Ne 100 or finest cotton yarns over Ne 100. Naturally, the basic requirement for finest yarn counts is an appropriate raw material.

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Optimal yarn quality

Selection of raw material and output fineness

Fibre fineness Fibre length (HVI)	Mic 4.8 1 1/32" (27.8 mm)	Mic 4.0 1 1/8" (28.6 mm)	Mic 3.4 1 3/8" (33 mm)
Card Output fineness	Ne 0.11	Ne 0.12	Ne 0.15
Draw frame Output fineness	Ne 0.11	Ne 0.12	Ne 0.15
Roving frame Output fineness	Ne 0.41	Ne 0.74	Ne 1.65
Spinning machine Output fineness	Ne 12	Ne 30	Ne 80

Page 30 Presentation

Figure 24: Selection of raw material and output fineness

In ring spinning and in rotor spinning as well the yarn quality depends of course also strongly on the quality of the applied raw material. The illustration shows clearly the yarn count range that can be spun with which cotton, based on fibre fineness and staple length.

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Fibres in yarn cross-section - irregularity

Fibre fineness (MIC) Staple length ["] HVI fibre length [mm] Yarn count [Ne]	4,8 1 1/32 27.8 12	4,0 1 1/8 28.6 30	3,4 1 3/8 33 80
Card Fibres in sliver cross-section Evenness [%]	 28,400 1.75	 31,250 3.2	 29,400 3.4
Draw frame Fibres in sliver cross-section Evenness [%]	 28,400 1,75	 31,250 1.85	 29,400 2.0
Roving frame Fibres in roving cross-section Evenness [%]	 7,620 3.7	 5,070 3.9	 2,675 4.2
Ring Spinning Machine Fibres in yarn cross-section Evenness [%]	 260 9.0	 125 12.2	 55 14.7

Page 32 Presentation

Figure 25: Fibres in yarn cross-section

Fibre fineness determines number of fibres in the cross-section in the according process stage. Looking at cotton with 3.4 micronaire at Ne 80 shows that on average only 55 fibres remain still in the yarn cross-section. At the same time, it becomes clear that yarn evenness decreases in relation to number of fibres contained in the yarn cross-section. Here the rule of thumb - the finer the spinning, the finer the required fibres – becomes apparent. Though this is not all; considering that with higher yarn count the processing interval increases, i.e. the roving bobbin change can increase by more than one month, the question arises whether the blend feed in spinning preparation is the same after this time span. Thus, to even be in a position to ensure constant quality, the raw material must be held ready for several months.

Hence, there exists a so-called marginal irregularity.

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Marginal unevenness

Fibre fineness [MIN] Staple length ["] HVI fibre length (mm)	4.8 1 1/32 27.8	4.0 1 1/8 28.6	3.4 1 3/8 33
Yarn count Ne 12 Fibres in yarn cross-section Marginal unevenness [%]	260 6.19	313 5.65	368 5.21
Yarn count Ne 30 Fibres in yarn cross-section Marginal unevenness [%]	104 9.80	125 8.94	147 8.25
Yarn count Ne 80 Fibres in yarn cross-section Marginal unevenness [%]	39 16.0	47 14.6	55 13.5

Page 32 Presentation

Figure 26: Marginal irregularities

Figure 26 shows the maximum possible evenness, depending on micronaire. The example given here points out that a fineness of 4.8 Mic and yarn count of Ne 30 cannot reach a yarn evenness below 9.8% under theoretically optimal conditions – regardless whether this cotton is even run-capable.

2.1.9 Roving

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Zinser roving frames and their levels of automation

Roving Frame Concept

- Zinser 668
- Zinser 670 RoWeMat
  - Zinser 670 BigPac

Page 33 Presentation

Figure 27: Zinser roving frames and their degrees of automation

After discussing the applied raw material and its influence on yarn quality parameters, now to more concrete influencing factors in the process stage of roving. The types of Zinser roving frames are available at different degrees of automation:

- Roving frame with manual package change Zinser 668
- Roving frame with integrated doffer Zinser 670 RoWeMat
- Roving frame with integrated doffer, designed for production of coarse yarns Zinser 670 BigPac

Figure 28: Zinser roving frame 670 RoWeMat.

A high degree of automation in roving makes sense not only in terms of economy and handling. It also actively influences yarn quality. A relatively bulky roving bobbin is difficult to place into the creel of the ring spinning machine by one person without touching it. Possible damage to the bobbins is therefore eliminated.

Naturally - in addition to handling - the roving frame setting also influences the yarn quality.

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Basic setting of roving frame

	Carded cotton Combed cotton	100 % synthetics
Flyer speed [1/min]	1,100 – 1,450	1,200 – 1,500
Lowering flyer-nspi	100	50
Twist multiplier [αm]	36 - 41	22 - 26
Delivery [m/min]	34	42
Break drafting zone UW [mm]	65	65 fibres up to 45 mm 75 fibres up to 54 mm 85 fibres up to 63 mm
Main drafting zone UW [mm]	46	49 fibres up to 45 mm 60 fibres up to 54 mm 76 fibres up to 63 mm

Page 35 Presentation

Figure 29: Basic roving frame setting, part 1

When processing cotton, the flyer speeds are generally always somewhat lower. The main reason for this is the reduced length and substance strength as compared to synthetic fibres such as polyester, polyacrylic or viscose.

The twist multiplier is generally also higher for cotton. The fibre/fibre friction is naturally lower for cotton. When processing synthetics, it can be influenced via the finishing agent.

The break drafting zone and main drafting zone of the drafting system are determined by the fibre length.

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Basic setting of roving frame

	Carded cotton Combed cotton	100 % synthetics
Break draft [fold]	1.19	1.25 to 1.31
PK loading	green / green / green	red / red / red
Piler head	GRA	G2
Pressure finger deflection [fold]	2 ½	1 ½
Creel roll drive [fold]	1.09 to 1.12	1.03

Page 36 Presentation

Figure 30: Basic roving frame setting, part 2

The break draft is dependent on fibre curling, especially when processing synthetics.

For synthetics, the load of the drafting system is accordingly increased due to the higher draft forces. Generally, though, this should be limited to what is absolutely necessary to keep wear of the drafting system (among other things grinding intervals, bearing lubrication, etc.) low. The colour code applied here stands for:

- Green – low load
- Red - high load

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Piler heads

Types of piler heads	Application	Form of head
GRA	carded and combed cotton yarns, coarse to medium	sharp-edged
G2	coarse, carded short staple cotton yarns	round
GR	fine yarns, cotton and cotton blends	round form, slightly notched

Page 37 Presentation

Figure 31: Piler heads

The piler heads are comparable with the navels when rotor spinning. They influence the running behaviour in regard to standstills, twist insertion and hairiness of the roveing. The letter combinations describe the shape of the piler heads.

There are additional piler heads. However, practical experience has shown that 95 % of applications are covered by the heads listed in figure 31.

Synthetic fibres require calender roll drives in the creel to ensure a safe sliver transport. Slight tension in front of the drafting system can possibly provide better drafting properties.

In case of pure cotton, the operation is usually tension-free without calender rolls, though due to better synchronisation with octagonal creel rolls. Combed material should have a feed sliver that is as coarse as possible, to prevent false drafting. In this regard, the draw frame slivers are very sensitive due to low cohesion.

2.1.10 Ring spinning

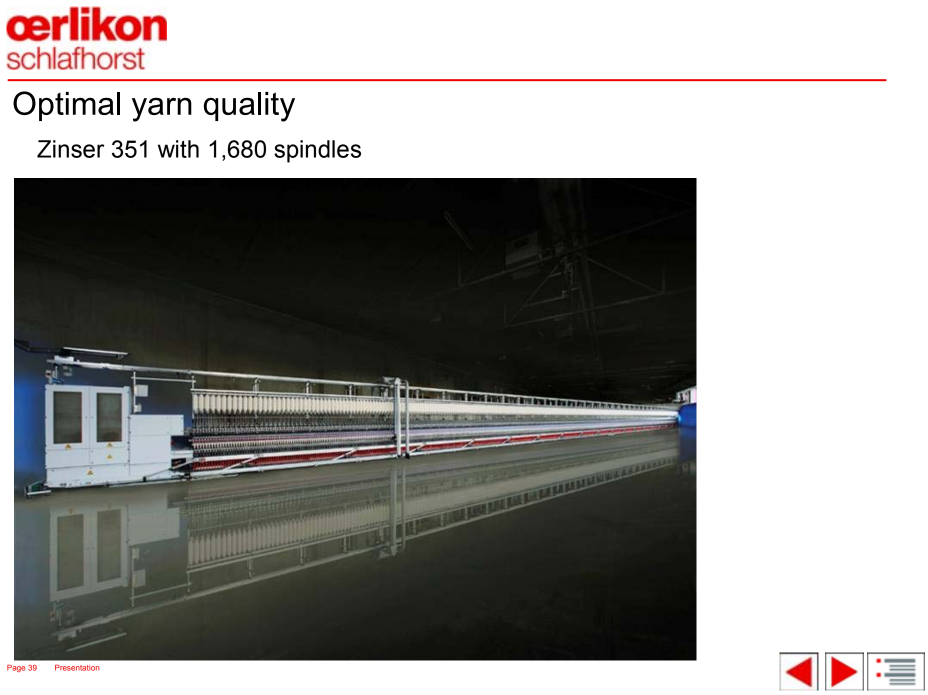

Figure 32: Zinser 351 with 1,680 spindles

Similar to the rotor spinning machine, the ring spinning machine has some machine components that have an active influence on yarn quality.

First of all, the yarn path within the ring spinning machine and its elements are viewed:

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Machine components

Creel
Suspended holder
Drafting system • Roving guide
Pendulum weighting arm • Bottom apron • Top apron • Cage with top apron holder • Distance clip

Page 40 Presentation

Figure 33: Machine components, part 1

Figure 33 shows the following stations, from top to bottom:

- Creel
- Suspended holder
- Drafting system
- Pendulum weighting arm

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Machine components

Travelling yarn guide (WF)
Anti-ballooning ring
Spinning ring / traveller / ring rail
Spindle / tube
Spindle rail
Spindle brake
Spindle bottom

Page 41 Presentation

Figure 34: Machine components, part 2

As well as in Figure 34

- Reversible yarn guide
- Anti-ballooning ring
- Spinning ring, traveller, ring rail
- Spindle and tube
- Spindle rail
- Spindle brake and
- Spindle bottom

Creel and suspended holder
When observing the yarn path in the ring spinning machine, the start has to be made at the creel with its suspended holder for creeling of roving bobbins.

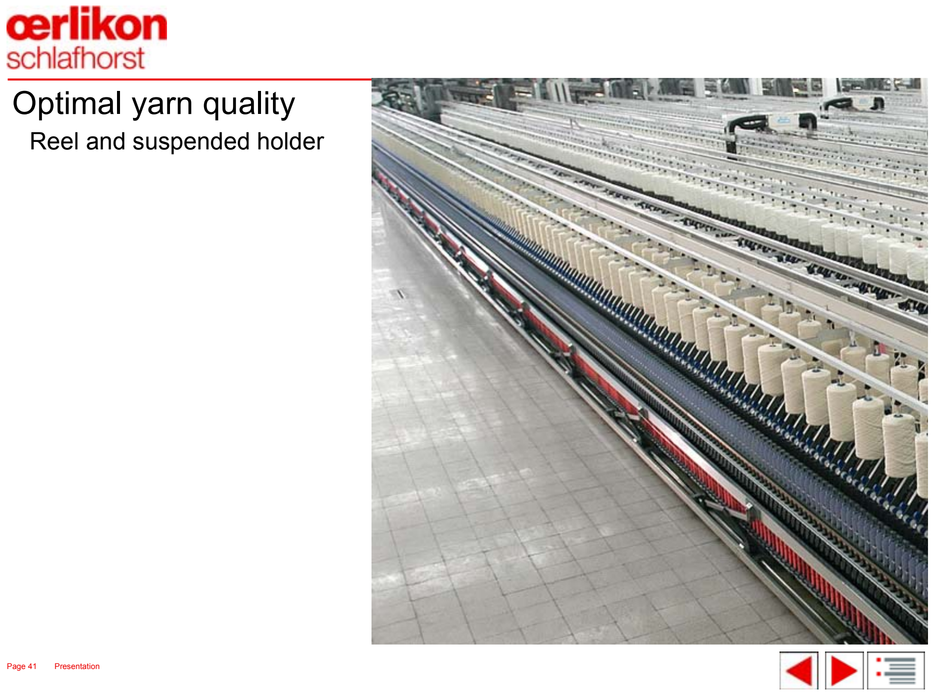

Figure 35: Yarn path from creel to ring

Correct positioning, correct roving path and guide are important factors to ensure a good yarn quality.

Correct roving twist and friction on the deflection bar in the creel are factors that can influence yarn regularity and running behaviour.
If, for instance, the roving twist is too high, so-called slippage can occur in the drafting system. Slippage results in yarn breaks. A twist that is too low causes a high degree of irregularity and imperfections (thin places).

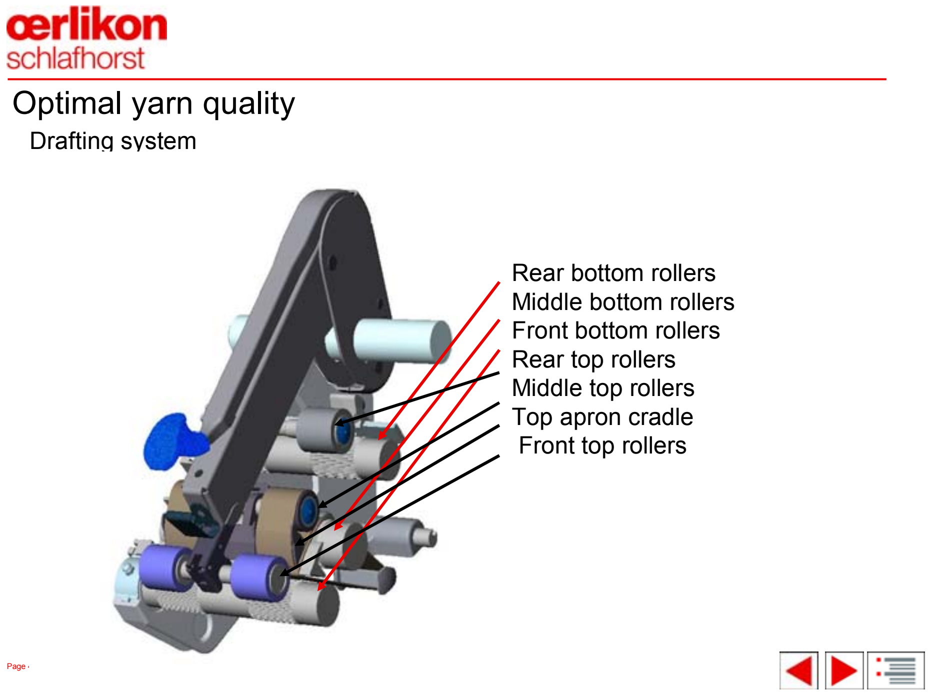

Figure 36: Drafting system

Drafting system

A drafting system consists of steel and rubber rollers, guiding the roving at different speeds, and drafting it to the required yarn count according to the different speeds.

The individual rollers are identified as follows:

- Rear bottom rollers
- Middle bottom rollers
- Front bottom rollers
- Rear top rollers
- Middle top rollers
- Front top rollers
- Top apron cradle

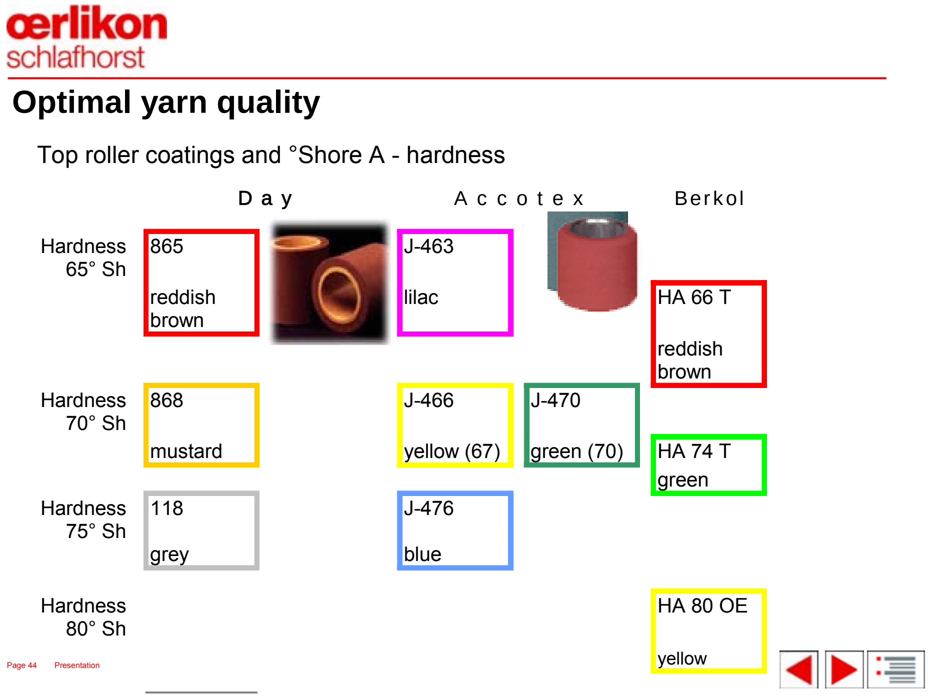

Figure 37: Top roller coatings

With the choice of top roller coatings and their various coating hardness (Figure 37), it is possible to influence the different fibre properties and drafting results.

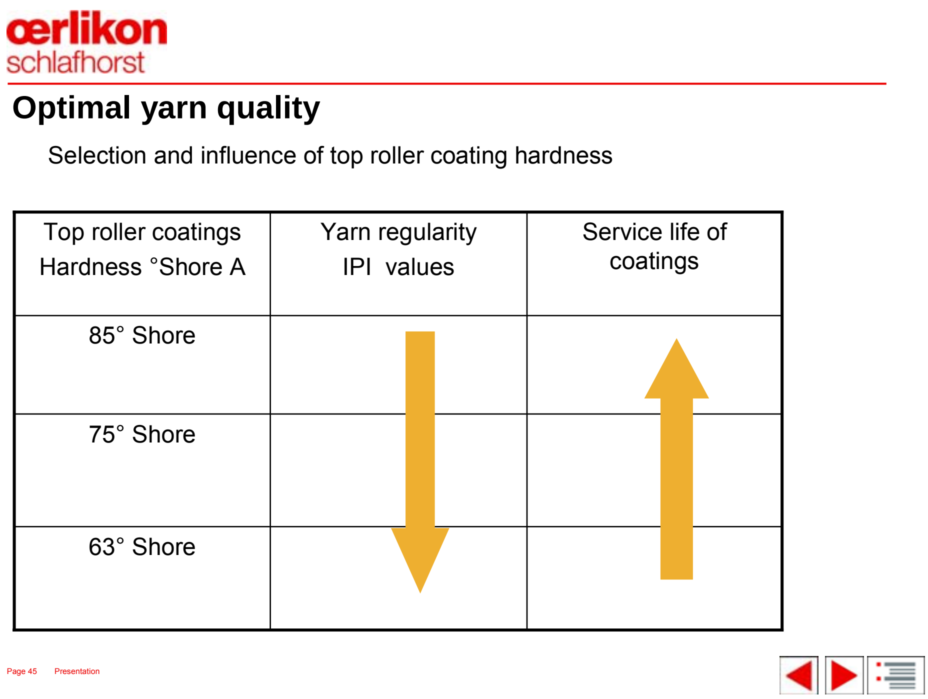

Figure 38: Influence of top roller hardness

In this case, the following rule of thumb applies:

- The softer the coating, the better the IPI value, but the shorter the service life.
- Fine yarns run with coatings as soft as possible.
- Synthetics, especially polyester, prefer hard coatings due to higher draft forces.

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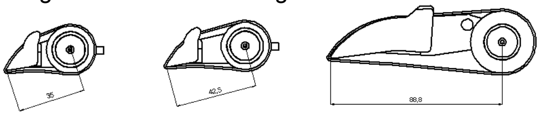
Setting width of main drafting zone on bottom roller and top roller



Types of top apron cradles	Fibre length	Length classes
OH 62, OH 2022	up to 40 mm	Cotton - short staple
OH 132, OH 2042	up to 51 mm	Cotton - medium staple
OH 122	up to 60 mm	Cotton - long staple
OH 6022	up to 200 mm	Wool - worsted yarn

Page 46 Presentation

Figure 39: Types of top apron cradles

There are various types of top apron cradles – also called cage (Figure 39). Depending on fibre length, different apron shapes and sizes are required. The cradle, together with the deflection bar, influences the main draft and thus largely yarn quality. The optimal setting is considered as one of the biggest influencing factor on yarn quality.

Roving guide

The roving guide has the assignment to position the rove and simultaneously minimise wear on roller coatings through traversing. Traversing of + / - 5 mm is common. According to roving count, different roving guides are available. When spinning core yarns, there is principally no traversing. Traversing causes the core position to vary. This results in different optical refractions of the yarn in the fabric. The textile surface does not have a uniform appearance.

Pendulum weighting arm

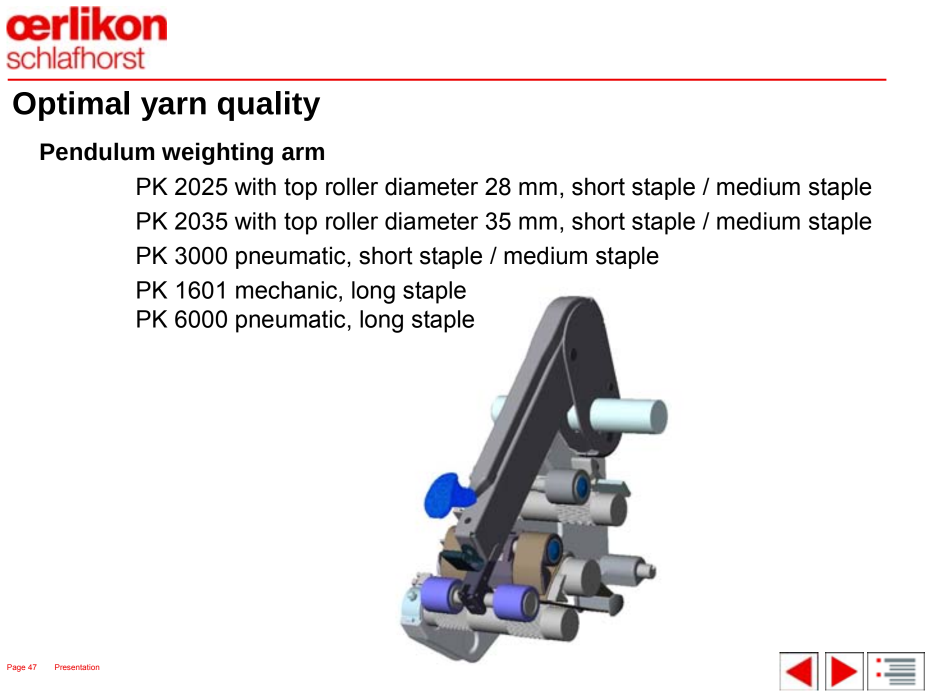


Figure 40: Types of pendulum weighting arms

The pendulum weighting arms, in short PK, have the assignment to press the roller pairs together with defined pressure ratio. This is the only way to ensure a defined roving guidance and drafting.

Distance clip:

With the distance clip, in short clip, the user can actively influence the running behaviour and yarn quality. Regrettable, this also has a downside: spinning stability increases, however yarn evenness, number of imperfections and hairiness can decrease.

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Selection and influence of height of distance plate

Height	Evenness Imperfections Hairiness	Yarn strength Yarn elongation	Spinning stability
very high			
higher			
lower			
very low			

Page 48 Presentation

Figure 41: Influence of clip height on yarn quality

The distance clips are of different heights. The roving path changes accordingly. The higher the distance clip, the higher the strength, though the worse yarn regularity and spinning stability during production.

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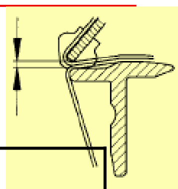
Optimal yarn quality

Selection of distance clips



Colour	Yarn count		
	OH 2022	OH 2042	OH 122
red		Ne 80 and finer	Ne 60 and finer
yellow		Ne 50 and finer	Ne 40 -100
purple	Ne 60 and finer	Nee 40 -100	Ne 40 -100
white	Ne 40 -70	Ne 30 -85	Ne 30 -85
grey	Ne 30 - 54	Ne 20 - 60	Ne 20 - 60
black	Ne 20 - 44	Ne 12 - 40	Nee 12 - 40
beige	Ne 30 and coarser	Nee 30 and coarser	Ne 30 and coarser
green	Ne 20 and coarser	Ne 20 and coarser	Ne 20 and coarser

Page 49 Presentation

Figure 42: Distance clips, subject to yarn counts

In Figure 42 you will find the according distance clips per top apron cradle and yarn count.

Revolving yarn guide

Together with the traveller and the anti-ballooning ring, the revolving yarn guide, also referred to as pigtail, forms the yarn balloon.

Anti-ballooning ring

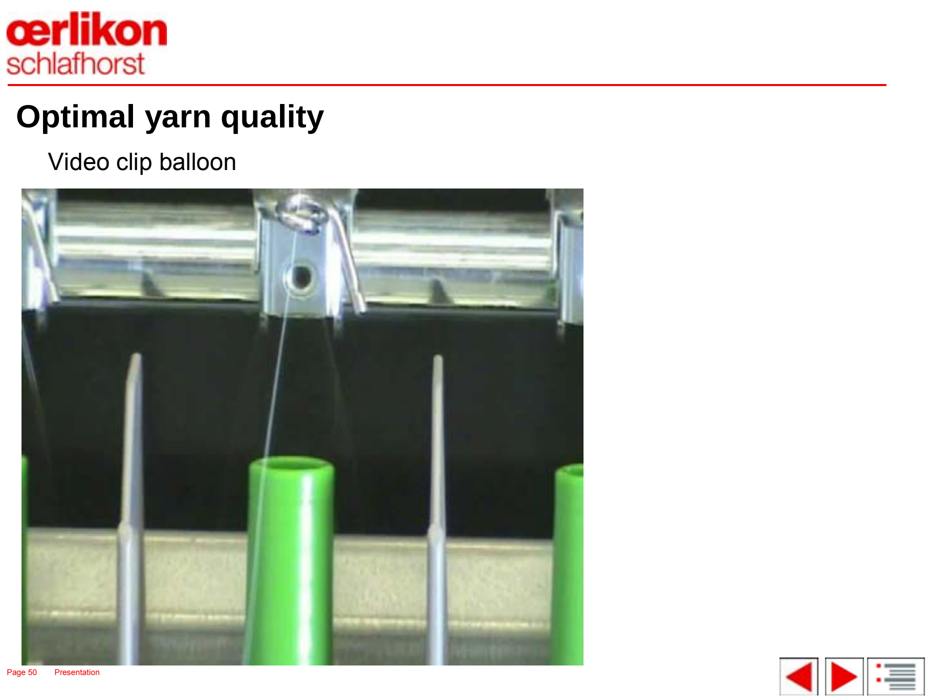


Figure 43: Yarn balloon

As the name implies, the anti-ballooning ring has the assignment to limit the balloon. To minimise yarn tension, the balloon must be limited. In case of excessive tension, yarn strength and elongation could already be removed, or yarn breaks could occur.

In long-staple spinning with its relatively low yarn strengths, a so-called spin finger can be applied in the ring spinning process to minimise yarn tension. It allows a slight increase of the spindle speeds without causing too many yarn breaks or yarn damage.

Spinning ring, traveller, ring rail

The ring diameter depends on the tube format. In turn, the tube format is dictated by the textile application and the optimal spinning geometry.

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Optimal yarn quality

Bobbin build-up

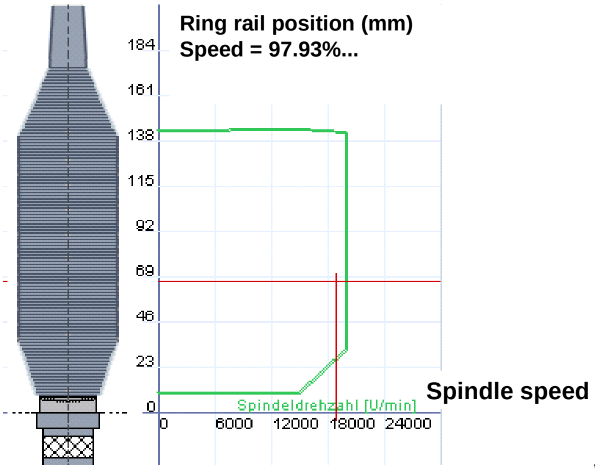

Figure 44: Bobbin build-up

Concerning tube height, generally the rule applies to select a ratio of 1 to 5. This means that a 38 mm ring would require a tube length of 200 to 210 mm, a 45 mm ring a tube length of 230 to 240 mm.

The spindle form must be matched to the inside diameter of the tube. The tubes have standard sizes. Standard 3, for instance, is for denim. Standard 3 has a small tube diameter. When processing denim, this is important due to the coarser yarn counts and the required capacity on the bobbins.

The relation between tube outside diameter and ring inside diameter is an important dimension for the bobbin build-up.
The smaller the ratio, the smaller the tension differences that affect the yarn during the bobbin build-up.

The coiling length of the bobbin specifies the yarn path that is deposited onto the bobbin during one up and down travel of the ring rail. In practice, a coiling length of 5.5 m is common to ensure a good unwinding behaviour in winding. The range of coiling length fluctuates between 3.5 and 8 m, depending on application.

Due to economic reasons, the objective is always to place a maximum amount of material onto the bobbin, however, without impairing the later unwinding behaviour.

During the bobbin travel, the speed is reduced at the beginning and end. This is important, since it allows for optimal tension conditions and thus lower yarn break ratio.

The more uncritical the material, the steeper is the speed's acceleration and deceleration ramp. When dealing with compact yarn and fine yarn counts, a flatter speed ramp is applied. In this case the lubricating film generated by the hairiness must always be slowly built up again before resuming top speed - Figure 44.

In addition to ring diameter, the rings are defined by their profiles. Rings and ring rails form a symbiosis. Objective is to keep the friction between ring and ring rail at a minimum. In Figure 45 you can find the profiles with their standard applications.

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Ring profiles and their applications

Profile form	Application
Standard profile (C)	coarse to medium yarn count range
Elliptical profile (EI)	high speeds fine yarn counts
J rings	wool long staple
Flange 1	medium to fine yarn counts
Flange 2	coarse to medium yarn count range

Page 52 Presentation

Figure 45: Ring profiles and their applications (Examples)

Spinning rings consist of different coatings. The manufacturers pursue various philosophies. While Reiners & Fürst is known for Cera-Dur / Turbo rings, Bräcker banks on titanium rings.

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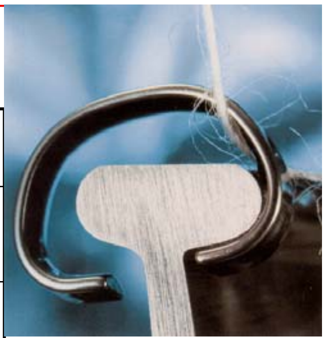
Types of spinning rings

Type of coating	Application	Max. speed of traveller
Champion	Standard applications, second-hand machines	35 m/s
Nitro-Poli-Dur	High performance ring	38 m/s
Turbo	High performance ring	40 m/s
Cera-Dur	Highest performances and compact spinning	42 m/s
Titanium	Highest performances and compact spinning	42 m/s



Page 53 Presentation

Figure 46: Types of spinning rings

In Figure 46, you will find a listing of various ring spinning rings made by Reiners / Fürst and Bräckert, from old Champion rings to latest Cera-Dur ring. The coatings, together with the ring profiles, influence the speeds of the ring travellers.

Considering that the ring traveller speeds not only depend on the material of the actual traveller, but that fibre material and many other boundary conditions limit the possible speeds, the following rule of thumb can be applied:

- Conventionally max. 38 to 42 m/min under optimal conditions
- CompACT³ max. 36 to 40 m/min under optimal conditions

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Allocation of ring traveller weights

Yarn product	Traveller number	Traveller weight [mg]
100% CO carded Ne 5	20	325
100% CO carded Ne 12	7	112
100% CO combed Ne 30	4/0	35.5
100% CO combed Ne 80	15/0	14.0
100% CO combed Ne 120	20/0	9.0

Page 54 Presentation

Figure 47: Allocation of ring traveller weights

Depending on spun yarn count, the according traveller weights are chosen. The finer the yarn, the lighter is the ring traveller.

The traveller weight is always chosen in such a way that operation can take place at highest-possible speeds via the displacement range. This means an optimal development of the yarn balloon. A traveller that is too heavy, or excessive speed, results in tension peaks, and thus yarn breaks.

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Optimal yarn quality

Types of ring travellers

Coating	Application
Super polished	Ring inlet, standard application
Black speed	Standard applications, man-made fibres
Econ	High performance all materials
Super speed	High performance all materials
Cera-Nit	High service life
Dia-Dur	Highest speeds and service life
Cera-Dur	Highest speeds, extremely high service life, compact spinning

Page 55 Presentation

Figure 48: Types of ring travellers - coatings

In addition to ring traveller weights, the choice of coating in relation to textile application is also of importance.

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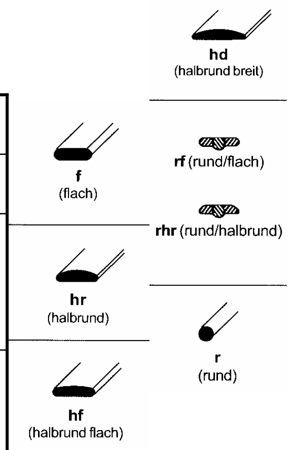
Optimal yarn quality

Types of ring travellers

Traveller profile	Application	Comments
hr	Carded cotton Nm 10 - 30	Good traveller lubrication
hd	Combed cotton Nm 20 -50	Also for blends and synthetics In addition to speed, can influence hairiness.
hf	Combed cotton Nm 70 -250	For CompACT³ In addition to speed, can influence hairiness.
f **rf** **r**	Core yarns Acrylic	For sensitive items For temperature sensi-tivity



Page 56 Presentation

Figure 49: Types of ring travellers - shapes

Besides weight and coating, the third component of ring traveller variations is the shape of the ring.

Standard is the hr-shape in the coarse carded yarn count range. The hd shape is applied on combed qualities up to Nm 50, but also for blends. The shape can positively influence speeds and hairiness.
The hf-shape is usually applied for very fine cotton qualities, particularly on CompACT³ yarns.
All sensitive qualities, like for instance the temperature-sensitive fibres polyacrylic, polyester, etc., as well as core yarns, require flat or round shapes such as f, rf or r.

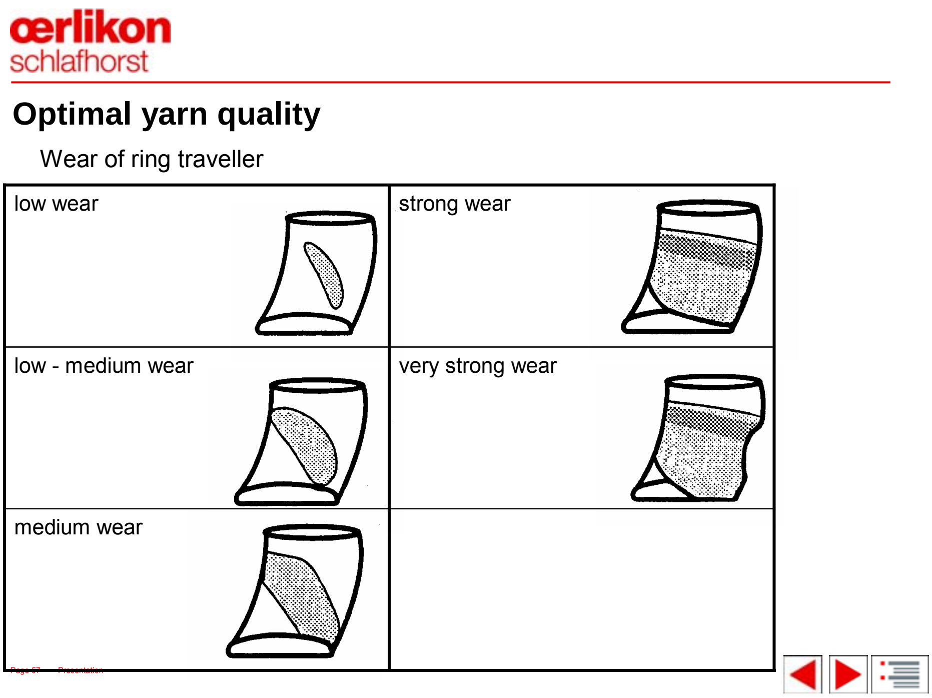


Figure 50: Ring traveller wear

The spinning technician should observe whether there are increasing yarn breaks. This can be a sign of severely worn ring travellers. A replacement should be made. Normally, the ring travellers are replaced every 10 to 30 working days.

2.1.11 Basic settings on the ring spinning machine

As guidelines for a basic ring spinning machine setting the values displayed in Figure 51 to 53 apply.

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Optimal yarn quality

Basic setting of ring spinning machine

		Carded/combed cotton	100% synthetics
Spindle speed [1/min]		12,000 – 20,000	12,000 – 20,000
		restricted by yarn break rate	restricted by yarn break rate and raw material damage (thermal)
Width of break-drafting zone [mm]	up to 40 mm fibres	60 - 65	65
	up to 51 mm fibres		70
	up to 60 mm fibres		73

Figure 51: Basic settings, part 1

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Optimal yarn quality

Basic setting of ring spinning machine

		Carded/combed cotton	100% synthetics
Width of main drafting zone [mm]	up to 40 mm fibres	44.5	44.5 / 46.5
	up to 51 mm fibres		54 / 56
	up to 60 mm fibres		68 / 71.5
Break draft [fold]		1.14 - 1.18	1.16 – 1.25
Type of pendulum weighting arm	up to 40/51 mm fibres	2025	2025
	51/60 mm fibres		2035

Figure 52: Basic settings, part 2

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Optimal yarn quality

Basic setting of ring spinning machine

		Carded/combed cotton	100% synthetics
Loading (R/M/F) daN		12/10/14	16/14/18
Ring / traveller system		Turbo / Titanium	Turbo / Titanium / CeraDur
Application options		EFW / LS Spindle brake Spindle HF3C for coarse yarns Bottom rollers 32 mm for coarse yarns	

Page 60 Presentation

Figure 53: Basic settings, part 3

2.1.12 Compact spinning

Compact spinning is a type of ring yarn “finishing”. The objective of every compact spinner is:

- Improvement of yarn quality in regard to irregularities, IPI value, hairiness and strength.
- Increase of spinning stability.
- Achieving a new yarn structure.
- Improvement of fibre substance utilisation and
- An increase of productivity in downstream processing.

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Optimal yarn quality

Yarn structure ring yarn 100% combed cotton

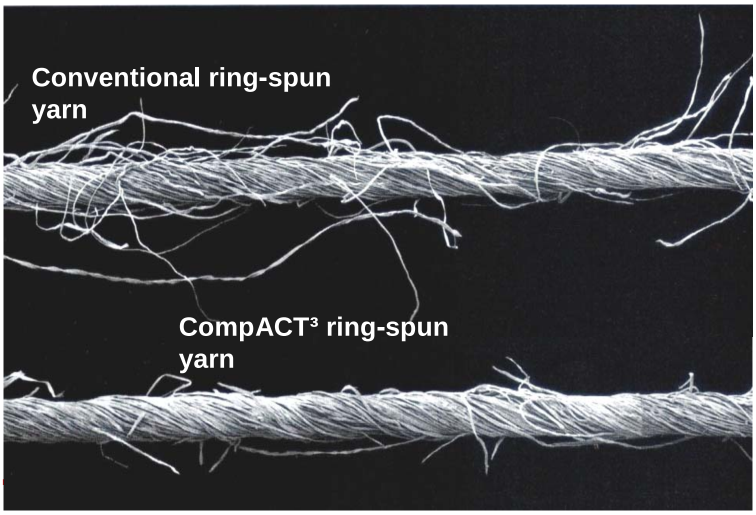

Figure 54: Yarn structure differences between conventional and compact

Already the scanning electron microscope reveals (Figure 54) the difference of yarn character between conventional and compact spun yarns. A CompACT³ yarn is significantly more even and features less hairiness. Due to the good fibre parallelisation, it is also possible to achieve a better material yield, which results in increased yarn strength.

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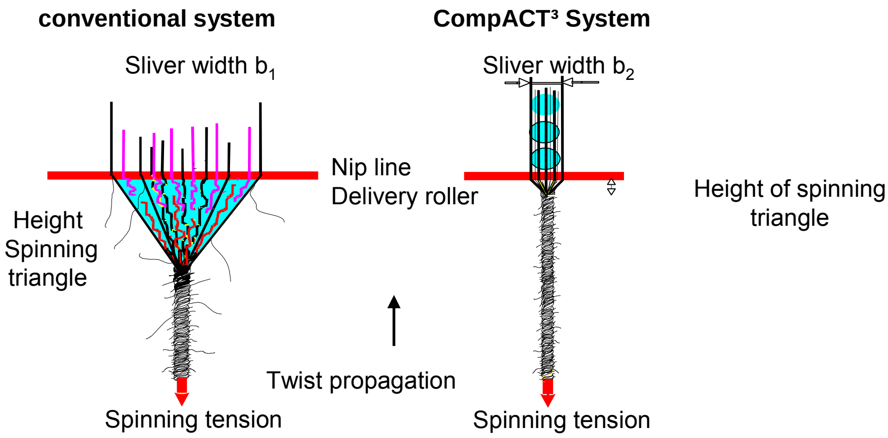
Optimal yarn quality

Basic principle of Zinser CompACT³ technology



Page 62 Presentation

Figure 55: Illustration of spinning triangle, conventional and CompACT³.

The essential difference between compact spinning and conventional ring spinning is the reduction of the spinning triangle. During conventional ring spinning, the peripheral fibres in the spinning triangle are uncontrollably exposed for a brief moment, while during compact spinning the fibres are continuously under control. This results in an improved fibre orientation in the yarn bundle.

The objective of CompACT³-Sytems is therefore:

- Minimising width and height of spinning triangle.
- Integration of protruding and non-parallel fibre ends.
- Peripheral fibres are integrated without overstretching.
- Fibre relaxation on the compacting apron.

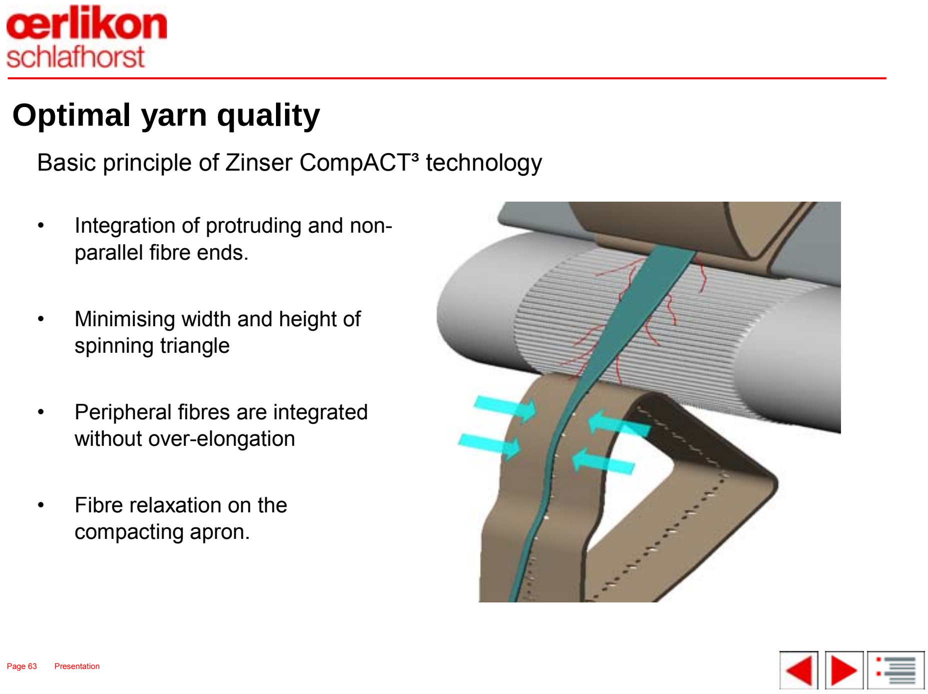


Figure 56: Basic principle of CompACT³ spinning

To assess the quality of a CompACT³ yarn, it is always important to see which input has been placed into the system. With a CompACT³ system, for instance, a coarse conventionally spun yarn with an Uster hairiness of 10 and more can be reduced in excess of 40 % to an Uster hairiness of 6. The finer the count, the lower is the hairiness. In the Ne 80 CompACT³ range, it is quite possible to reach Uster values of about 2.0. However, this can only be achieved with according feed quality and settings.

When discussing hairiness values, it is always important to consider the test method. If the Zweigle S3 value is discussed, larger reductions are possible.

What are the parameters that influence quality during production of conventional ring yarns and CompACT³ yarns:

- Choice of raw material according to textile application.
- Production automation from tuft to package.
- Optimal basic machine settings.
- Targeted selection of technology-relevant components and settings.

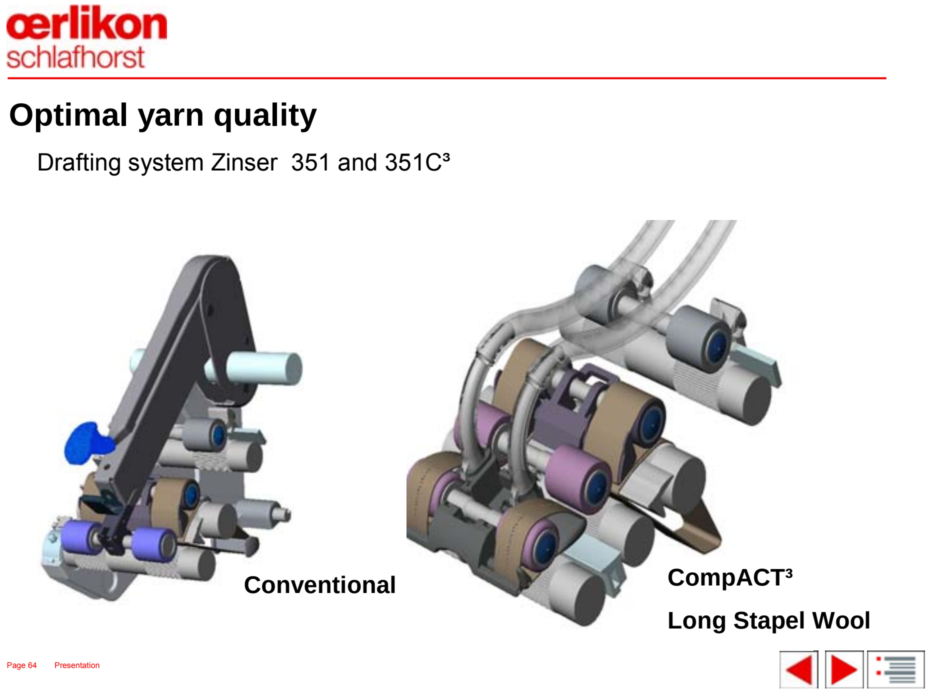


Figure 57: Drafting systems Zinser 351 and Zinser 351 C³

However, compacting quality is not only decided by actual hairiness reduction and strength increase. Much more important is the stability of these parameters. The system must be planned in such a way that each metre of yarn is compacted. The self-cleaning mechanism of the CompACT³ system Zinser 351C³ ensures that the compacting process is not impaired by any apron contamination and thus varying pressure ratios. The user of this system can be sure that actually every metre of compact yarn is being compacted. Other systems without this benefit produce compact yarns that have uncompressed phases that are not noticed by the operator. In the finished textile goods, this becomes evident in form of streaks in the fabric or knit, making them second choice.

Comparison studies substantiate the quality increases.

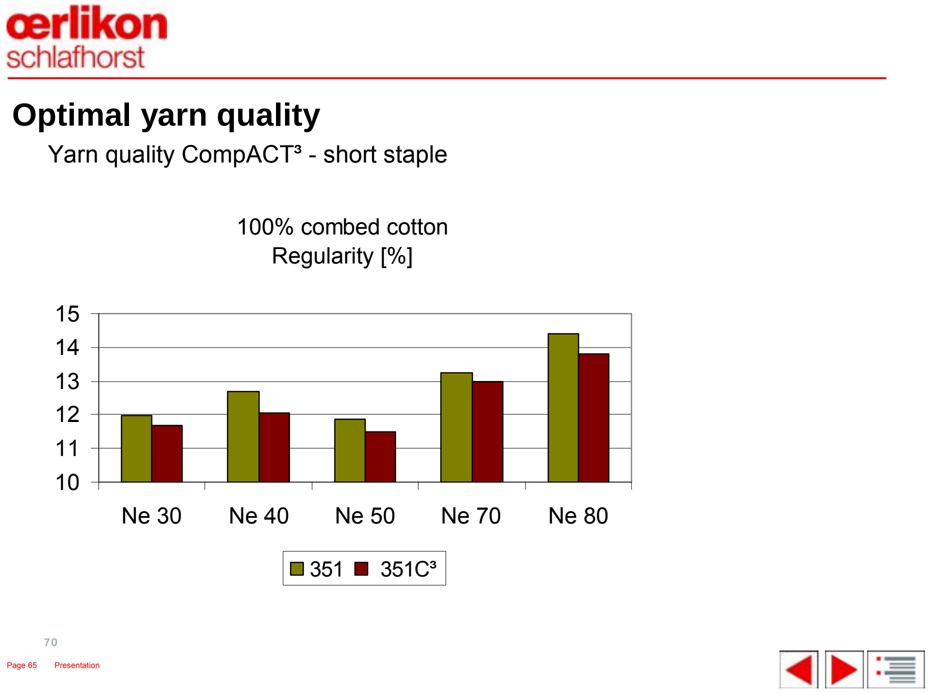


Figure 58: Comparison of yarn unevenness

As can be seen in Figure 58, yarn quality has been improved by 0.2 to 0.7 percentage points, regardless in which yarn count range the yarn was compacted.

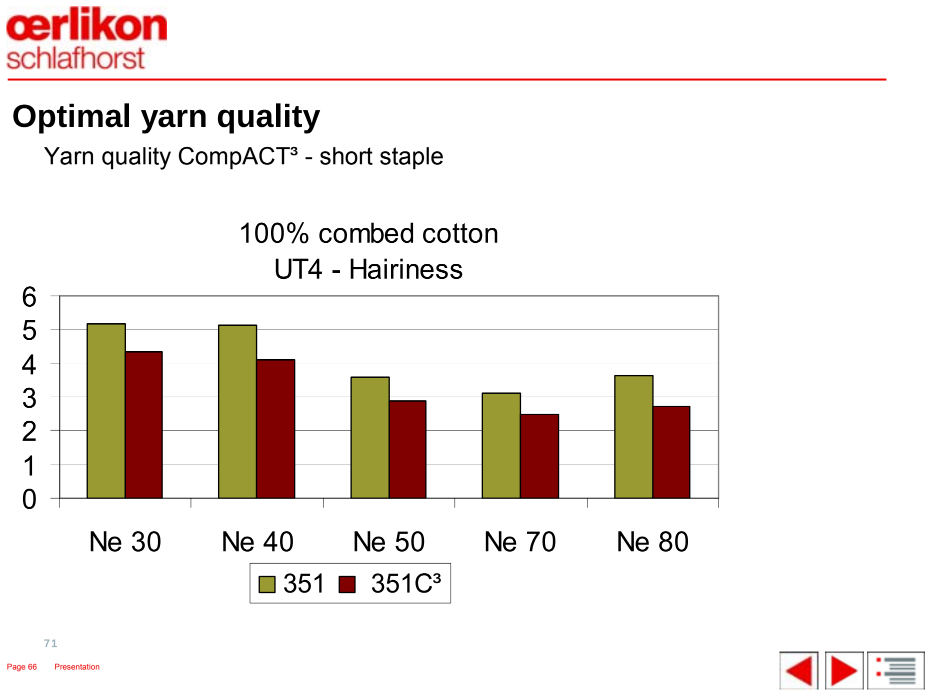


Figure 59: Comparison of significantly reduced Uster hairiness

In case of yarn hairiness according to Uster, the quality reduction is similar. Overall, when comparing conventional to CompACT³, a difference of the hairiness index of 0.7 to 1 is registered, regardless of yarn count.

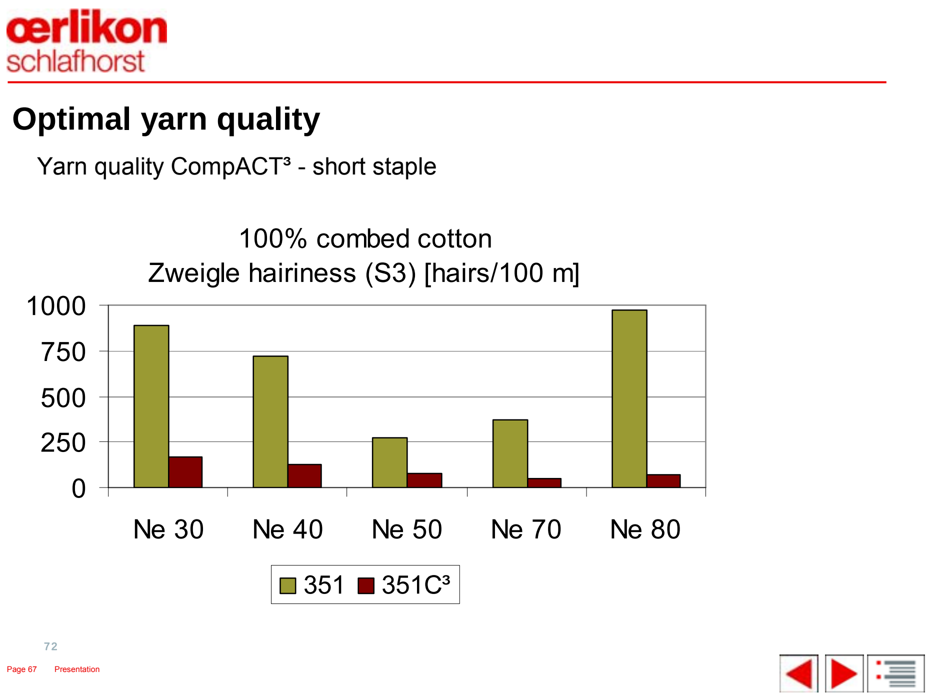


Figure 60: Comparison of Zweigle hairiness

As mentioned above, the influence of hairiness reduction is largest by the CompACT³ system. In the existing example, it has been possible to substantiate a 72 to 92 % reduction of the Zweigle S3 value.

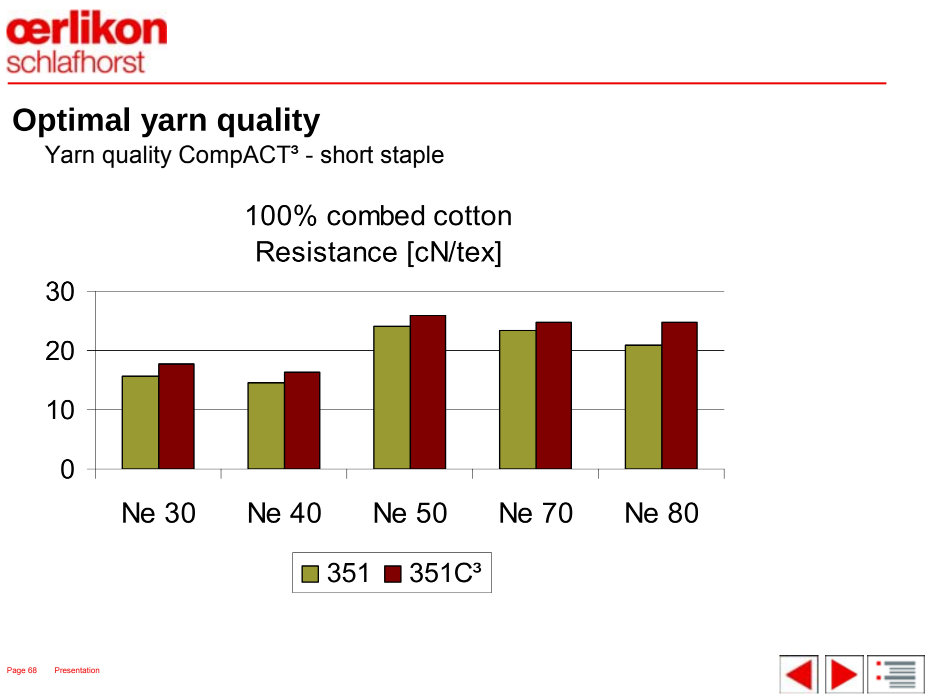


Figure 61: Strength comparison

In the case on hand, a strength growth of 1 to 4 cN/tex was verified. This is a large improvement, particularly in the fine yarn count range.

However, the CompACT³ system can also be used to reduce raw material costs. More than half of the yarn production costs must already be calculated for the raw material. Is it possible to purchase lower-priced cotton and bring the yarn to the same level by compacting, and can the yarn be spun at same production rates at reduced manufacturing costs?

This simple example shows that the CompACT³ system cannot only be applied to hunt down the lowest hairiness or highest strength, especially when considering the requirements for later application of the yarns – the yarn properties in view of later utilisation normally exceed requirements. Here lies a lot of potential for good ring spinning mills.

3 Quality standards in the spinning industry

3.1 What does the spinning industry really need?

Figure 62: Quality standards

In the spinning industry a lot centres on quality. When talking about 'quality', yarn quality is meant. The retail trade also specifies a number of parameters. One widespread rule of thumb is that if the yarn quality according to Uster Statistics is on the 25 % line, then it is good. If it lies on the 5 to 10 % line, it is even very good. The trade is particularly pleased if a grade achieves the highest level in the statistics, as then it is always on the safe side. The spinning mill is likewise proud of the quality and uses the result for advertising purposes. Spinning mills grudgingly accept the higher production costs incurred to attain this quality, for example due to the use of expensive raw materials and a lower level of productivity. On the other hand, there are spinning mills - whose yarns according to Uster Statistics rather belong to the lower third - that are also very successful and advertise a higher yarn quality. Which spinning mills are right? And if ‘quality’ is such a flexible concept, what should be considered ‘good quality’?

It is obvious that this discussion only focuses on yarn quality, and other decisive parameters that determine the possibility of trouble-free downstream processing are not taken into consideration.

Another type of spinning mill, for example, is geared to the requirements that the yarn has to satisfy. In dialogue with downstream processors, this spinning mill determines what quality parameters are required for the applications and to what extent. The mill gears its entire process to this, from the raw material to the spinning setting. The main thing is that the yarn is convincing in the textile process, with extensive dialogue and know-how transfer contributing to a made-to-measure yarn.

However, for the classic sales yarn spinner, this procedure can initially be very laborious. Often a sales yarn spinner does not even know the downstream processing companies, let alone their profile of requirements in respect of the yarns. In this analysis phase, Oerlikon Schlafhorst supports its customers in a globally unique manner with the Belcoro Quality Standards. The yarn parameters listed there have been established by Oerlikon Schlafhorst technologists, jointly with customers of Oerlikon Schlafhorst, weaving mills and knitting mills, by taking practical aspects into account. They are thus a valuable orientation guide when it comes to the question: What quality do customers of spinning mills require?

The Belcoro Quality Standards are accessible to Oerlikon Schlafhorst customers and list for the most common yarn counts and raw materials exactly which criteria weaving or knitting yarns have to satisfy if they are to excel in downstream processing.
In addition, Oerlikon Schlafhorst specialists offer customers support in the worldwide Technology Centres and also locally in implementing their quality targets, whether by assisting in the selection of fibres or finding an optimum spinning setting.

3.2 What distinguishes the Belcoro standards from the Uster Statistics?

The Belcoro standards have been developed on the basis of practical experience and are logically oriented to the application. This application reference in particular is frequently ignored when spinning mills take the Uster Statistics as their evaluation standard. Assessing the yarn quality is not even in correspondence with the original intention of the Uster statistics; they primarily constitute a global statistical survey of yarn quality. They simply state what the globally produced yarn quality is, no more and no less. Using the Uster Statistics, any spinning mill can estimate where it is positioned in the global market, a factor that is surely valuable when making strategic corporate decisions. However, the spinning mill can scarcely assess on this basis whether its yarns meet the requirements and it is even less able to draw conclusions regarding the efficiency of its production process.

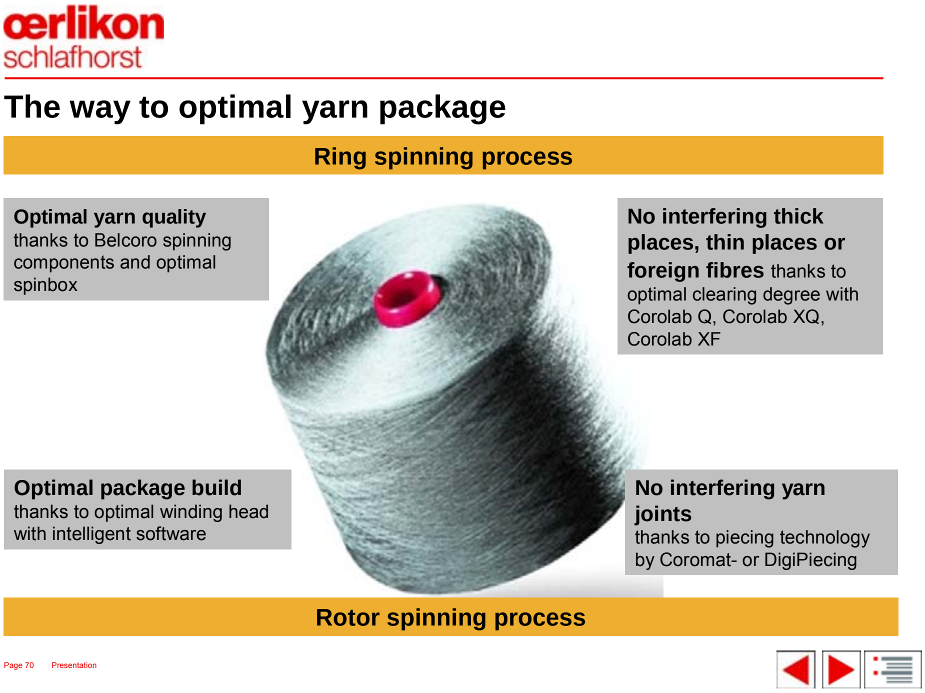


Figure 63: The way to optimal yarn package

Everything that proves to be of value has its imitators. In addition to the classics, Uster Statistics and the Belcoro Quality Standards, the brands 'ComfoRo®' and 'Usterized®', for example, have also been appearing in the market for some time now. Both brands suggest a high yarn quality. ComfoRo® has been developed by Rieter for open-end yarns spun on Rieter rotor spinning machines and for textiles manufactured from these. The mark does not embody any guarantee of quality. Nor are there any such guarantees for yarns identified by the 'Usterized®' brand. This mark developed by Uster simply points to the fact that the yarns were tested in the standard climate using well maintained laboratory equipment by Uster. Neither brand is comparable with Belcoro. Belcoro is the only system that both defines and assesses quality, thus guaranteeing maximum quality assurance.

The question concerning groundbreaking trends in staple fibre spinning can clearly be answered with "more quality". This has been confirmed by the market for many years; in all processes and technologies the topic of quality has been raised to a higher level. Oerlikon Schlafhorst, the specialist for machines for production of staple fibre yarns, has always been a centre of competency, focusing on converting this demand into practical implementation. The result is maximum quality of yarn, package, as well as yarn joints for utmost efficiency of all processes.

MODERN COMBING SYSTEMS - ECONOMY AND QUALITY

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High potential in raw material saving is located in cotton spinning. Since combing accounts for 20% of the total ringspinning conversion cost this paper focuses on the potential of raw material saving and cost reduction in the cotton combing process. Modern combing systems are predestined for sliver preparation for finest quality yarns - but not only. New requirements such as up-grading, efficient combing for cotton-rich blends or combing for coarse denim yarns of highest standards are also common today.

Reduced cotton subsidies, agricultural restrictions due to water shortage, ecological concerns and rising transport costs on the cost side and falling yarn prices on the income side - Ne 30, 100% CO, carded dropped 14 % within 12 months -, would be reasons enough to drive us all out of the cotton spinning business.

However, man made fibres dependent on non renewable resources, short-comings in yarn characteristics and fabric appearance - let alone pilling tendencies and wearing comfort obviously are no valid options to cotton.

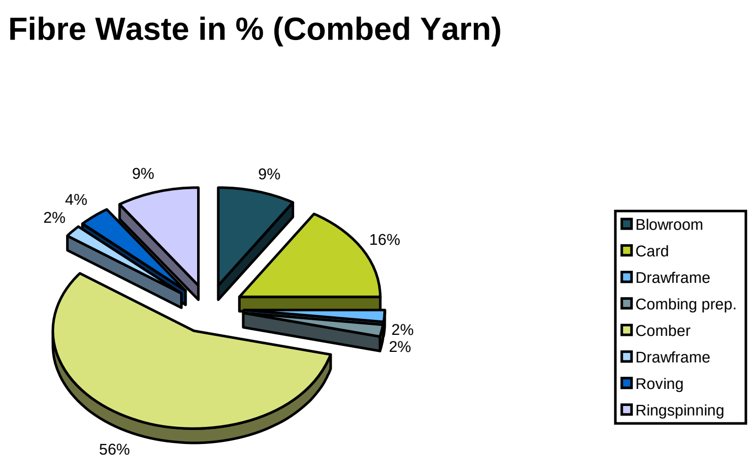
Raw Material Management in Ringspinning

Raw material exploitation has been a prevailing issue in cotton processing from bale to yarn and to a lesser degree in the consecutive processes of weaving, knitting and finishing. Rieter, a supplier of rotor- and ringspinning Systems from bale to yarn, has complete command of the entire spinning process and is, thus, in the best position to monitor and optimise the percentage of waste in relation to yarn quality in each individual process step.

Combing

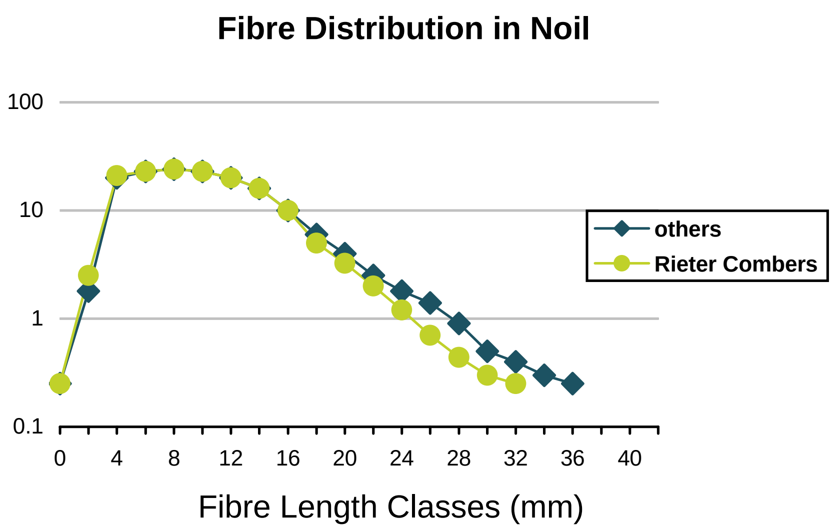
Savings in Raw Material

In this paper, we shed some light on the combing process because combing accounts for 50 - 60% of the total raw material extraction by weight in the ring spinning process, Graph 1.



Graph 1: Process Related Waste in Combed Ring Yarn

The key issue in combing economy is *fibre selection*. Rieter combers are recognised for 2 - 3 % lower noil extraction compared to other makes. The comparison of fibre distribution reveals considerably more long fibres, fibre length classes from 22 to 36mm, in the noil of other combers. (see upper line in graph 2)



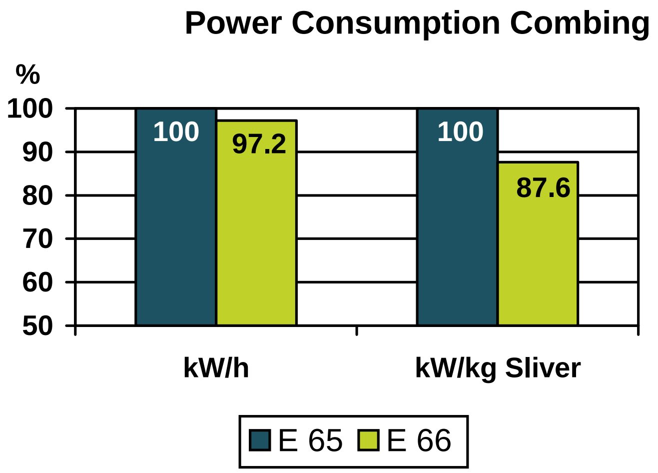
Graph 2: Fibre Distribution in Comber Noil

The comparison implies the same raw material specifications and identical yarn qualities and yarn properties.

Let’s base the calculation of the raw material savings in combing on an hourly production of 300 kg combed yarn spun from 1 3/32” cotton:
300kg/h, 8400 production hours, cotton 1 3/32” € 1.04/kg, 2% savings, 50% reselling value of noil = total raw material saving per combing set: € 25’200/year. For fine yarn counts with Giza 88 the savings amount to € 43’600.--/year.

Savings in Power Consumption

The latest generation of Rieter combers is designed for nip rates of 500 min^{-1}. The engineering target was to reduce the inertia forces of the combing elements and to



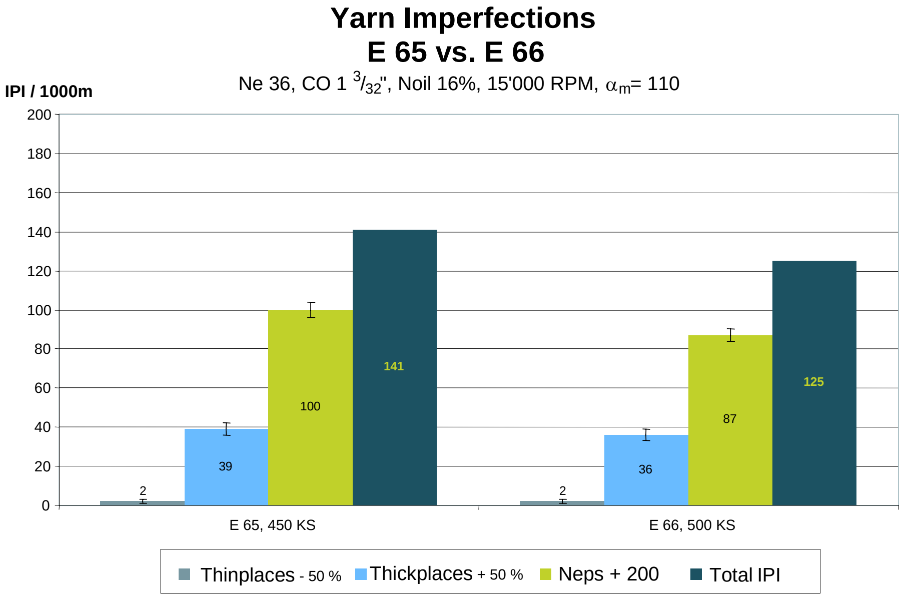
Graph 3: Comparison of Power Consumption on modern Combers

tune the detaching motion to cope with the designated speed. Calculating inertia-forces is engineering basics but when it comes to find out the truth about power consumption, measurements and comparisons in the field are the only reliable methods. Field measurement on the E 66 confirmed the expectations. Compared to the former model E 65 producing 65.3 kg/h with a power consumption of 3.6 kW/h the new E 66 consumes 3.5 kW/h at a production of 72 kg/h, which results in real power saving of 12.4 %, see Graph 3.

Predefined Quality

Nobody, profitably running a spinning mill, can afford to produce quality *as good as possible* any longer. The key to success is the production of the very quality which the yarn buyer, or in vertical mills the weaver, asks – and pays for. Systematic control of the process is not only a prerequisite for attaining the predefined quality but also for the constancy of the required quality.

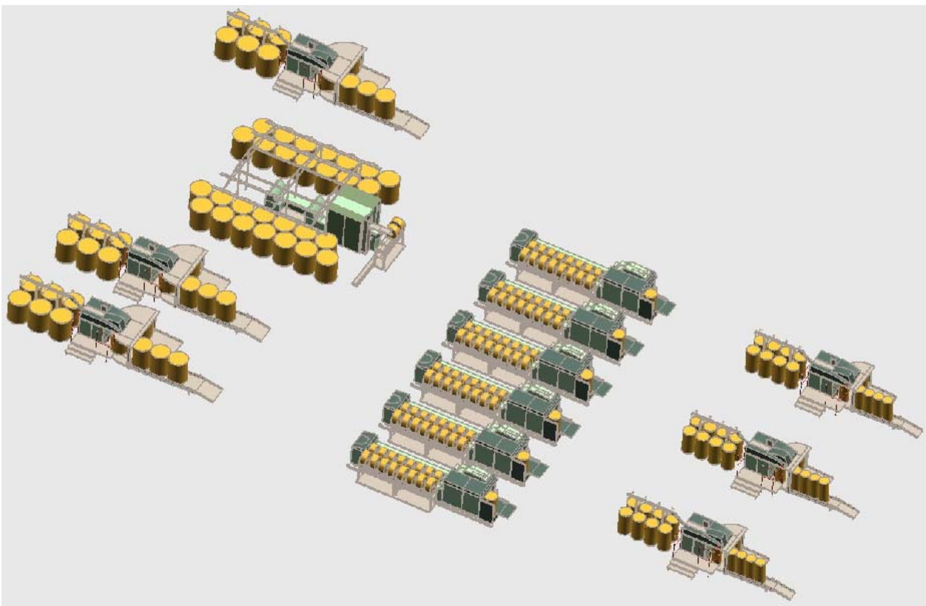
Modern combers are engineered to compensate variations of raw material as well as changes in short fibre content, e.g. more short fibres in the lap lead to higher noil extraction. Thus, the short fibre content in the combed sliver remains constant. Constancy is also compelling for the quality over the entire production range of the comber, irrespective of the nip rate (see Graph 4) and also from head to head within the comber and from comber to comber within the combing department.



Graph 4: Higher Production and lower IPIs with the new Rieter Comber Type E 66

Economy and Quality in High Production Combing Sets

To cope with the increasing comber productions, Rieter developed a new winding technology for higher speeds in the lap formation. The technology was introduced in a new model combing preparation type OMEGAlap E 35 which provides



Picture 1: Rieter Combing Set with 1 Combing Preparation feeding 6 Combers

sufficient capacity to feed 6 fully automatic, high performance combers type E 76. This brings the sliver production of one combing set consisting of 1 combing preparation and 6 combers to a new level of 420 kg/h combed sliver.

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TRUE NEPS: MEASUREMENT AND CORRELATION TO RESULTS IN RING-SPINNING

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Premier aQura provides the most reliable and accurate Nep measurement with a very low variability in the results by testing a statistically significant sample size of 5 to 10 g within a short span of three minutes. ***Premier aQura*** is capable of measuring Neps from 100 microns onwards with a measurement accuracy of 10 microns. Taking advantage of this technological capability, ***Premier*** has now come out with a parameter called ***True Neps***. It is a prediction of Neps in the yarn at various sensitivity levels like +140% and +200% provided by the Yarn Evenness Testers. This is achieved by testing the Finisher Draw Frame slivers in ***Premier aQura***.

Theory behind *True Neps*

Not all the Neps of various sizes available in the fibre stage get translated into yarn Neps. A Nep become significant or insignificant based on the count spun out of that fiber material. The following figure explains the same.

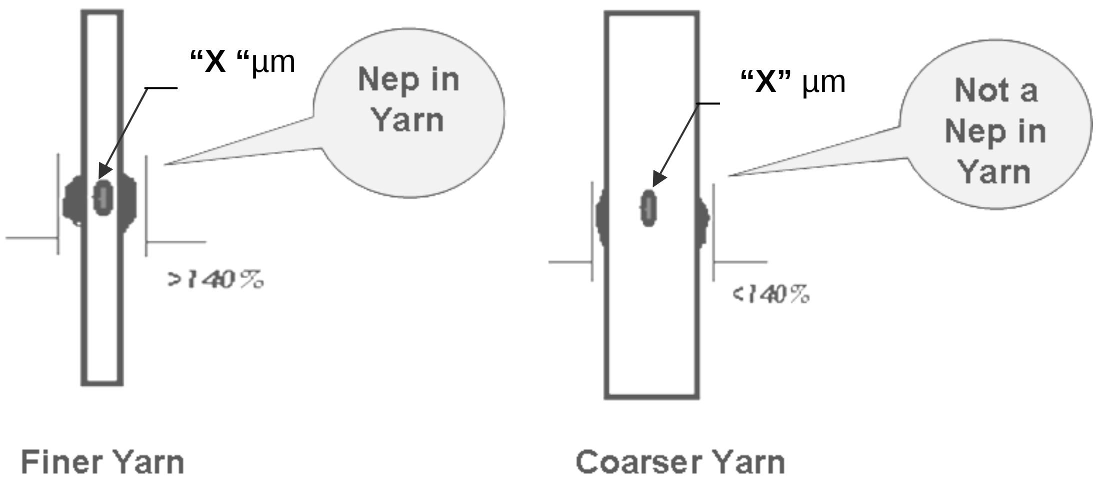

Figure 1: Illustration of a Nep in a finer and coarser yarn

Figure 1 shown above is self explanatory. For example, a Nep with size of "**X"** µm at fibre stage become significant when form part of the finer yarn count. The same Nep become insignificant when spun into a coarser count since it gets embedded into the yarn structure.

True Neps by ***Premier aQura*** are the Neps which are significant and measured by the evenness tester as yarn Neps.

Materials and Methods

A wide range of Ring spinning yarn counts and the corresponding Finisher Draw Frame slivers were selected for validating the True Nep predictions by ***Premier aQura***. The ***True Nep*** measurement is done at Finisher Draw Frame sliver so that the prediction will be more accurate. Note, the down stream processes like Speed Frame and Ring Frame has less impact on Nep. However the conditions of the machineries may vary the degree of influence.

The ***Premier aQura*** was used for testing the Neps in the Finisher Draw Frame slivers and ***PREMIER iQ*** for Yarn Ring cops. The test details are as given below.

Table I: Test details

S.No.	Instrument	Sample Size	Test Conditions
1	*PREMIER iQ™*	20 Cops/sample	400 m/min, 1min
2	*PREMIER aQura™*	4 tests/sample	--

Relationship between yarn count and *True Nep Size*

Tests were conducted in ***Premier aQura*** and ***PREMIER iQ*** for both the sliver and yarn materials respectively. Based on the Nep distribution of the Draw Frame sliver and the actual yarn Neps, with an optical correction factor applied, the relationship between the various counts and the ***True Nep size*** for 140% and 200% Nep sensitivity levels are as follows.

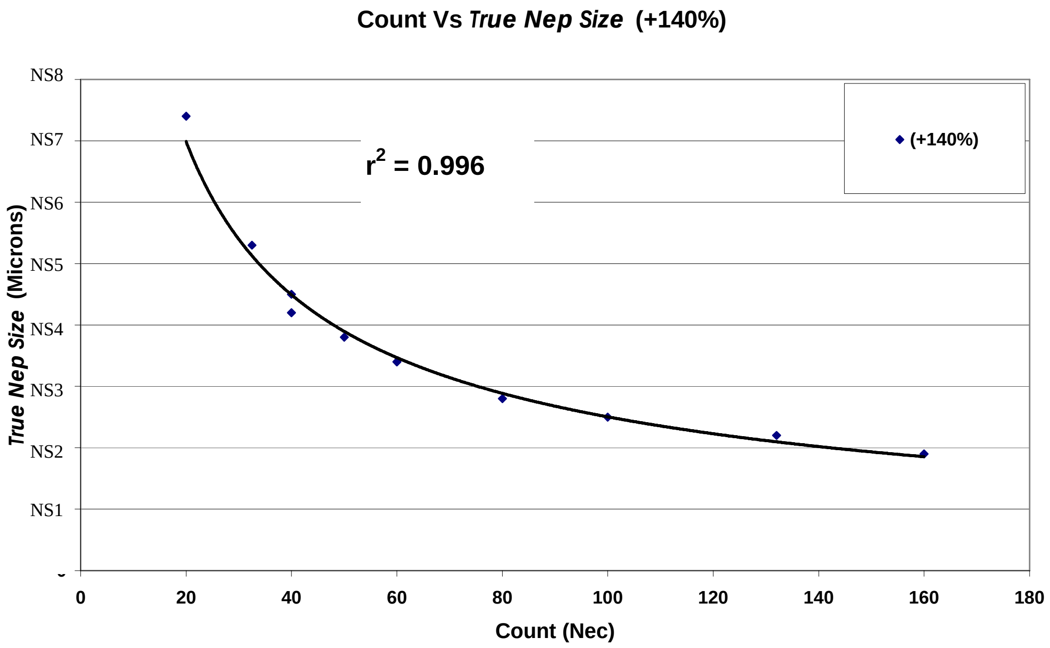

Figure 2: Count Vs. *True Nep size* for +140% Nep sensitivity level

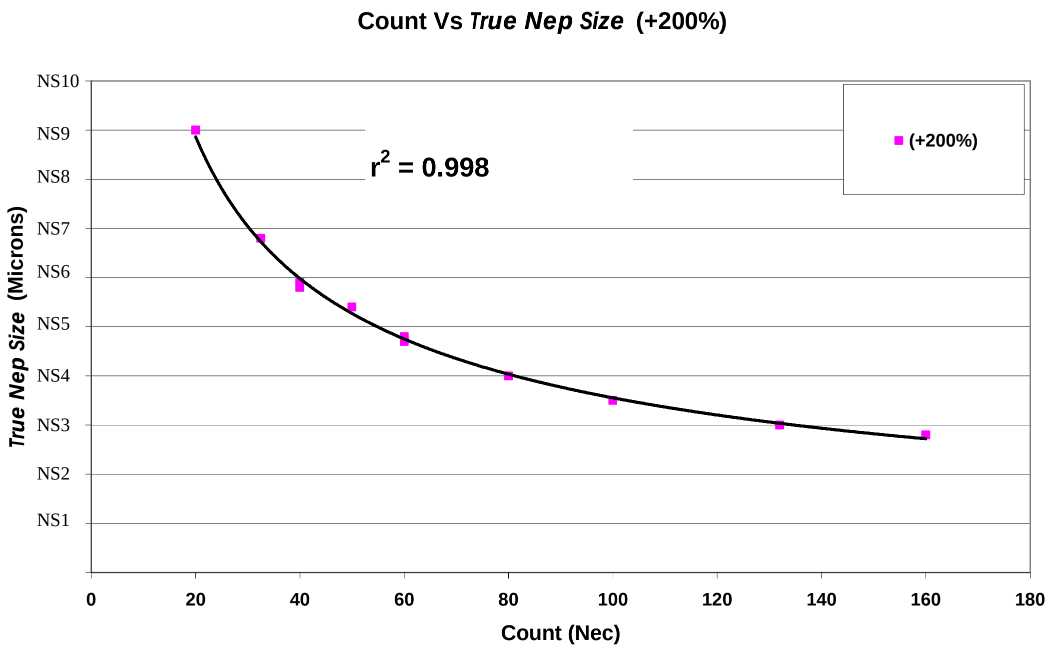

Figure 3: Count Vs. *True Nep size* for +200% Nep sensitivity level

It can be observed from the above that, a very good correlation exists between the Yarn count and the ***True Nep size***. This has been taken as a basis for conducting and validating the ***True Neps***.

The following section deals with the results of the ***True Neps*** as measured by ***Premier aQura*** in the Draw Frame sliver and co-relation of those Neps with yarn Neps measured by ***Premier iQ***.

Results and discussions for controlled study

A controlled process was carried out from Finisher Draw Frame to Ring Frame. The results of the studies are as follows.

Table II: *True Neps* Vs Actual Yarn Neps – Controlled Trials – Combed Counts

Count	Neps / Km (140% Level)		Neps / Km (200% Level)	
	True Neps (Premier aQura)	**Yarn Neps measured by Evenness Tester**	***True Neps (Premier aQura)***	**Yarn Neps measured by Evenness Tester**
20s CH	118	102	30	27
34s CH	127	126	36	29
40s CH	249	256	59	60
40s CH	162	151	44	25
50s CH	213	228	35	34
60s CH	305	309	59	54
60s CH	480	452	60	71
40s CW	295	369	89	92
60s CW	470	405	59	65
80s CW	502	448	111	101
100s CW	472	414	106	100
132s CW	470	474	116	97
160s CW	849	805	210	183
Correlation (r^2)	**0.970**		**0.962**	

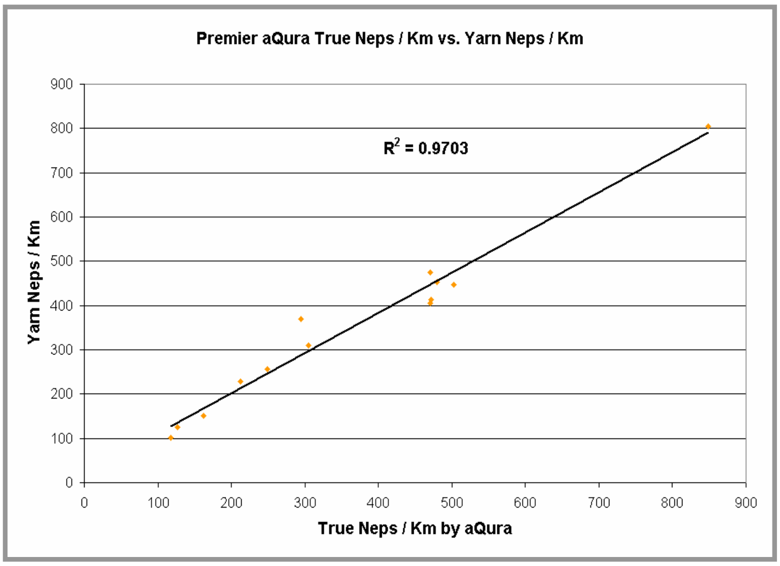

Figure 6: *True Neps* Vs Actual Yarn Neps (+140%) – Controlled Trials – Combed Counts

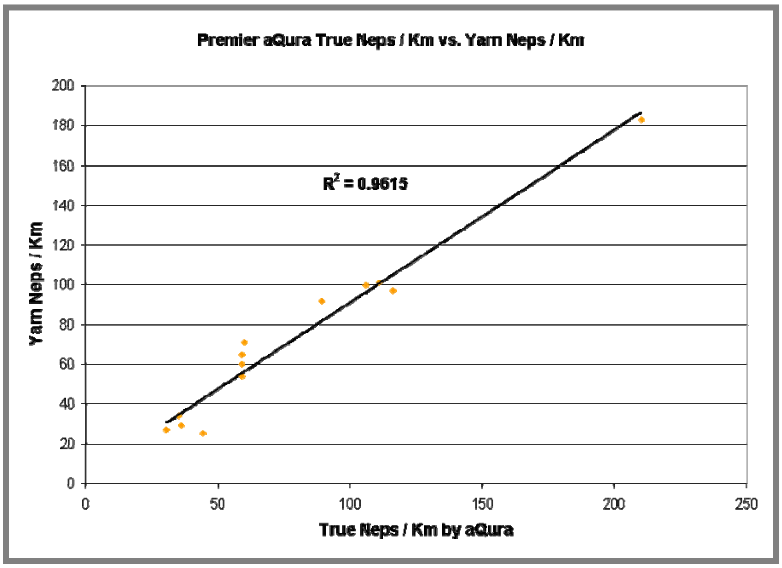

Figure 7: *True Neps* Vs Actual Yarn Neps (+200%) – Controlled Trials – Combed Counts

It can be observed that there exists a good correlation (r^2) between the ***True Neps*** measured in the ***Premier aQura*** and the actual yarn Neps measured by the evenness tester.

Nevertheless, it is important to verify the above scenario in an uncontrolled environment also since mills test their regular samples in random and uncontrolled environment only.

Hence, uncontrolled samples of Draw Frame sliver and the Ring yarns were collected and tested in ***Premier aQura*** and ***PREMIER iQ*** respectively. The results are as follows.

Results and discussions for uncontrolled study

Table III: *True Neps* Vs Actual Yarn Neps – Uncontrolled Trials – Combed Counts

Count	Neps / Km (140% Level)		Neps / Km (200% Level)	
	***True Neps* (Premier aQura)**	**Yarn Neps measured by Evenness Tester**	***True Neps* (Premier aQura)**	**Yarn Neps measured by Evenness Tester**
20s CH	89	83	30	22
30s CH	81	67	20	19
30s CH	175	112	66	42
30s CH	127	151	42	39
30s CH	256	153	79	56
40s CH	369	294	118	89
80s CW	465	392	111	81
100s CW	502	544	112	113
132s CW	510	611	134	116
160s CW	790	980	185	163
Correlation (r^2)	**0.942**		**0.953**	

The graphical representations of the same are also given below.

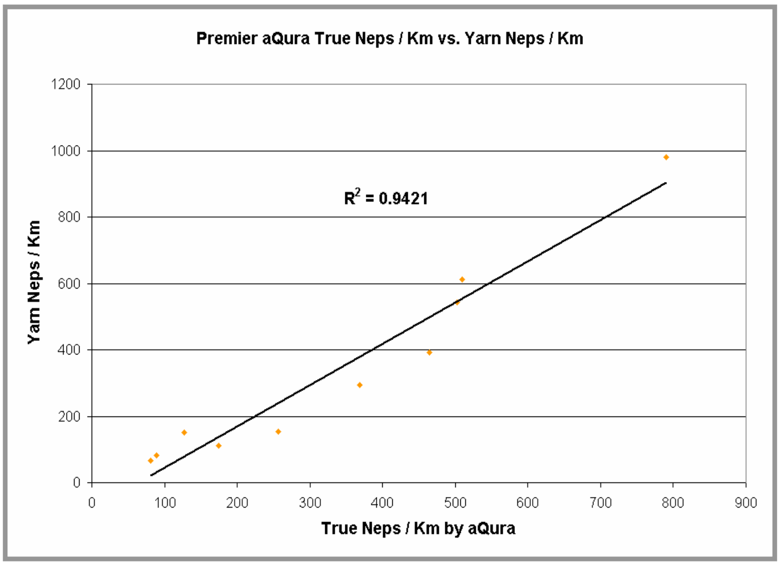

Figure 8: *True Neps* Vs Actual Yarn Neps (+140%) – Uncontrolled Trials – Combed Counts

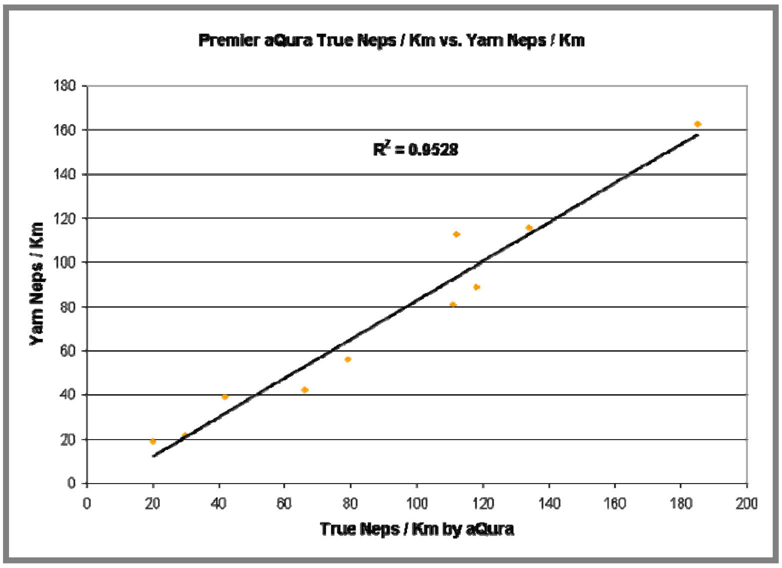

Figure 9: *True Neps* Vs Actual Yarn Neps (+200%) – Uncontrolled Trials – Combed Counts

It is clearly observed from the above tables and figures that, correlation for ***True Neps*** and the actual yarn Neps is as good as controlled environment.

The spinners can benefit using the ***True Neps*** values for predicting the final Yarn Neps and take corrective and preventive actions in the process to avoid time and material wastages.

The same type of trials have been carried out for carded counts also. The Finisher Draw Frame sliver of the carded count material and the Ring yarns are tested in ***Premier aQura*** and ***PREMIER iQ*** respectively. The results are as follows.

Table IV: *True Neps* Vs Actual Yarn Neps – Uncontrolled Trials – Carded Counts

Count	Neps / Km (140% Level)		Neps / Km (200% Level)	
	True Neps	Yarn Neps measured by evenness tester	True Neps	Yarn Neps measured by evenness tester
20s KHY	185	225	62	39
30s KHY	1575	1540	290	290
34s KHY	2417	2443	563	530
40s KHY	2883	2784	675	630
40s KW	1394	1514	363	327
Correlation (r^2)	**0.995**		**0.994**	

The graphical representations of the same are also given below.

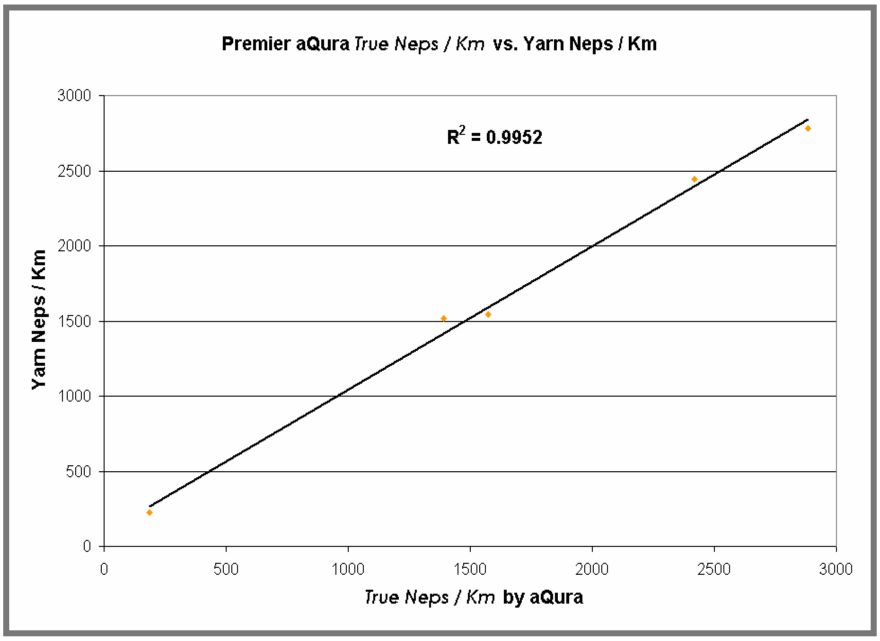

Figure 10: *True Neps* Vs Actual Yarn Neps (+140%) – Uncontrolled Trials – Carded Counts

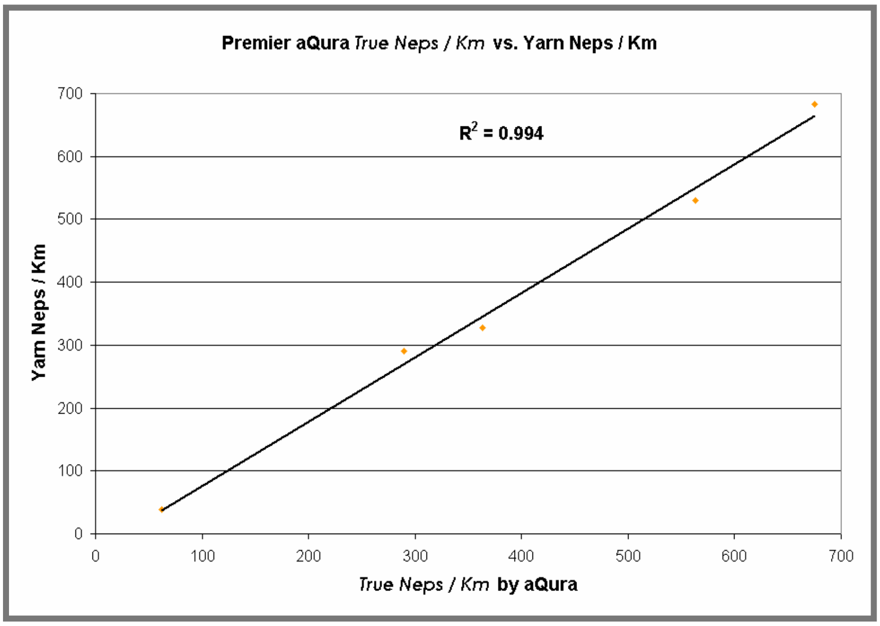

Figure 11: *True Neps* Vs Actual Yarn Neps (+200%) – Uncontrolled Trials – Carded Counts

It shows that, in the case of carded counts also there exists a good correlation between the ***True Neps*** of Finisher Draw Frame sliver and the Ring yarn.

Application of *True Neps* at card sliver stage

The application of ***True Neps*** also can be extended to Carding Slivers. The ***True nep*** absolute values will be different from actual yarn neps due to in between processes. However it has a very good correlation with Yarn neps.

An application study was conducted for 18 Carding Machines using ***True Neps***. The Normal neps and ***True Neps*** per gram were measured. The following graph shows the advantage of looking at ***True Neps*** at card sliver instead of looking at the normal Neps.

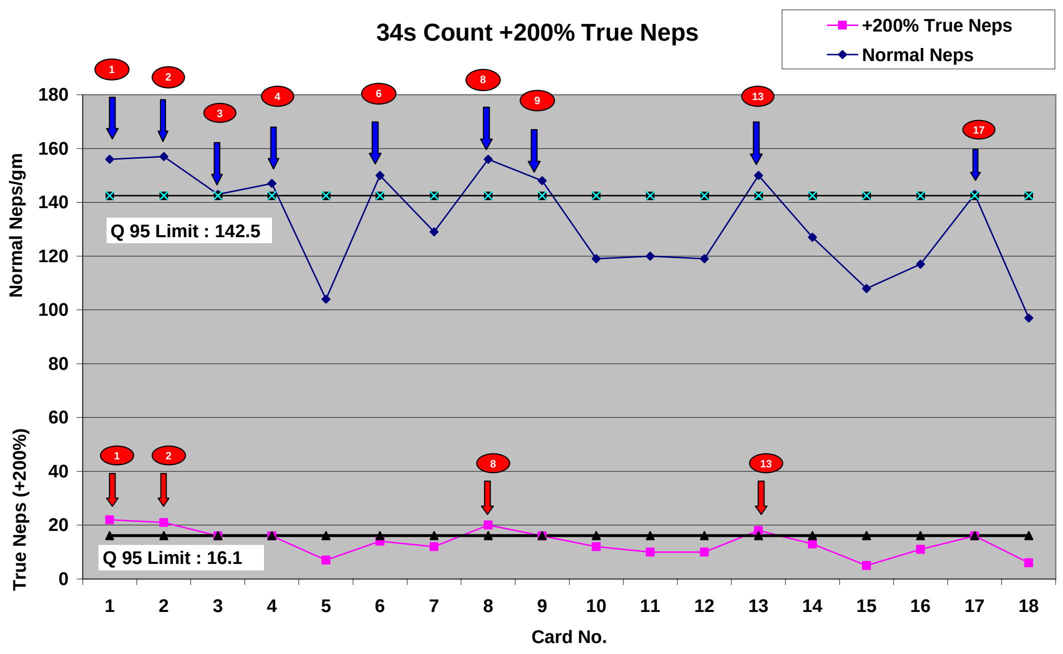

Figure 12: *True Neps* (+200%) at card sliver compared to Normal Neps

From the above graph it is clear that, more number of cards are above the control limit if normal neps alone considered. In the case of ***True Neps*** (the disturbing neps based on the yarn count spun) only few cards are above the control limit. This helps in taking appropriate decisions on corrective actions.

Application and Recommendations for *True Neps*

Recommended count range	:	20s – 160s Nec (29.52 – 3.69 Tex)
Applicable sensitivity Levels	:	+140% and +200%
Prediction done at	:	Finisher Draw Frame Sliver (But ***True Neps*** can be extended to other back processes also).
Applicable yarn materials	:	Ring Cops only (Both carded and combed).

CONCLUSIONS

With the advancement in the measurement technology, ***Premier aQura*** *is* able to measure from minimum of 100 microns with 10 microns accuracy.

Results of controlled and uncontrolled studies show a very good correlation between ***True Neps*** and actual yarn neps at different sensitivity levels in both carded and combed counts. Also the benefits of ***True Neps*** can be extended to back processes such as card slivers to identify and enhance the performance.

FIVE YEAR SPINNING STUDY

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The USDA-ARS Cotton Quality Research Station (CQRS) has completed a comprehensive study of the relationship of cotton fiber properties to the quality of ring spun yarn. Cottons in this study demonstrated fiber quality traits that allow them to operate at high speeds on the latest generation of ring spinning equipment. Fiber quality measurements supplied by the High Volume Instrumentation and Advanced Fiber Information System are not sufficient as processing speeds increase. Additional fiber quality measurements are crucial to improving plant varieties, production practices, machinery design, and processing efficiency. Cotton was grown and harvested in 2001-2005 from three of the largest producing growing regions (Georgia, Mississippi, and Texas) in the US and subsequently ginned at their respective locations. Cotton was spun into ring yarn at the CQRS laboratory. This manuscript explores the common fiber quality measurements obtained from the HVI™ and AFIS™ along with supplementary fiber quality measurements such as frictional properties, metal content, waxes, pectins, glucose levels, and other classical and slower fiber measurements including Stelometer, Suter-Webb arrays, Shirley Analyzer, and Peyer. This manuscript explores fiber quality measurements and how they predict yarn quality and processing efficiencies.

HVI™ properties (micronaire, length, length uniformity, strength, elongation, color, and trash) have been considered the most important and most readily acceptable factors in predicting cotton quality for subsequent textile processing and spinning. Spinning quality of cotton is dependent upon a combination of fiber physical properties and unknown measurements. Physical fiber properties (length, strength, and fineness) are genetically controlled; nevertheless, these properties are affected by environmental conditions. Yarn properties typically considered include strength, uniformity (evenness and defects), appearance, and processing efficiency (ends down). An important yarn quality measurement is strength that is determined by fiber strength and fiber interactions (some fibers break during testing while others slip). Correlations of yarn strength to fiber cohesion were first presented by F. T. Peirce in 1946 (Bogdan, 1956; Bogdan 1967). These fiber-to-fiber frictional properties are important but without a convenient way to measure them they are typically ignored. In addition to these fiber-to-fiber properties there are also interactions between fibers and processing equipment. Research relating to yarn typically involves HVI™ fiber properties; nevertheless, time-consuming or unidentified measurements may provide additional insight.

Fiber processing and spinning are affected by surface chemical and physical characteristics and contaminants found on cotton. Fiber cohesion is what holds fibers together for processing and is dependent upon surface properties (e.g. metal content, wax, pectin), insect contamination, crimp, surface roughness, fiber-to-fiber friction, electrostatic potential, fiber length, and linear density. Mature cotton contains 93 to 96% cellulose on dry weight basis with the noncellulosics portion containing 1.3% protein, 0.9% pectic substances, 1.2% ash, 0.6% wax, 0.8% organic acids, 0.3% sugars, and 0.9% other components (Perkins, 1971). It has been demonstrated that the surface of cotton contains few amino acids (Gamble, 2002). Compared to cellulose, sugars hydrolyze relatively easily while thermal degradation of sugar on cotton is largely due to dehydration reactions occurring at temperatures above their melting point (Gamble, 2002). Normal ginning processes expose cotton to temperatures that degrade sugar and pectin and could affect fiber processing since indirectly pectin is negatively correlated with fiber friction (Gamble, 2003). Wax on cotton fibers is well known to lubricate and improve spinning (Varadarajan, Iyer, and Saxena, 1990) and upon exposure to high temperatures undergo complex chemical reactions. Other constituents found on cotton fibers may interact in these chemical reactions depending upon variables such as temperature, pH, moisture content, presence or absence of metal ions, amino acids, and sugars.

Contributions of fiber properties to yarn strength are typically higher for one year than subsequent years due to changing environmental conditions. Tharp (1960) states that higher mean temperatures cause the lint to be shorter, stronger, and coarser. It has also been stated by Tharp (1960) that water stress in late stages of development produces stronger fibers; however, these fibers are often thin walled and produce neps throughout processing. According to Perkins and Brushwood (1997), cotton fiber is typically slightly acidic or neutral (pH range from 6.3 to 7.0), however, rainfall and microbiological activity in one year may increase the pH to above 9.0. Perkins and Brushwood (1997) further indicate that light to moderate rain or excess microbiological activity typically causes the loss of organic compounds (e.g. malic and citric acid) that increases the presence of residual alkaline earth metals (e.g. potassium, magnesium, sodium). Cotton properties such as color are likely influenced by thermal or microbiological degradation of components (wax, pectin, protein, and sugar) found on fibers. Many individuals believe that as the color of cotton changes the processability of the fibers decreases, with Brushwood (1989) stating that overheating and over drying both cause discoloration and a reduction in fiber quality. Cheng and Cheng (2003) state that the color of cotton is affected by contamination during harvesting and ginning as well as environmental conditions such as fungi, insects, soil, plant diseases, frost, or drought and cotton that contains more trash.

Classic/supplementary measurements in this study are as follows: Stelometer using the flat bundle method; mean fiber length, coefficient of variation, upper quartile length, and short fiber content by weight via the Suter-Webb Array method (ASTM, 1997e); fiber mean length, length coefficient of variation by weight, percentage of fibers by weight that are less than 0.5 inches (short fiber), the length that is exceeded by 25 % of the fibers by weight in a test specimen (Upper quartile length, Peyer L25), and percentage of fibers by weight that are less than 0.25 inches were measured using a Peyer AL-101 (Siegfried Peyer Ltd., Wollerau, Switzerland) (ASTM, 1993);

Shirley Analyzer was used to separate the cotton sample into lint, visible and invisible trash results (ASTM, 2004a); fiber friction was evaluated using the Rotorring 580 (Spinlab; Knoxville, TN); conductivity, pH, and glucose measurements were performed on extract from 20 ml of deionized water per gram of cotton; moisture content determinations were conducted (ASTM, 2004b); wax and alcohol extractions were performed; and metal analysis measurements were obtained for all cotton varieties in the first three years.

With advances in instrumentation, more fiber properties can be measured in more ways. At the same time, technological advances in spinning have led to new methods of yarn production. The Cotton Quality Research Station of the USDA-ARS has completed a comprehensive study of the relationship of cotton fiber properties to the quality of spun yarn. Previous work described the commercial variety spinning study design, the measurements and testing procedures, the spinning processes, the fiber property distributions, yarn characteristics, and spinning performance described by summary statistics and histograms. This manuscript will explore common and traditional fiber measurements (HVI™ and AFIS™) alongside classic fiber quality measurements (such as frictional properties, metal content, waxes, pectins, glucose levels, and other supplementary and slower fiber measurements including Stelometer, Suter-Webb arrays, Shirley Analyzer, and Peyer) to better understand these measurements in predicting yarn quality and processing efficiency using modern, high speed processing equipment.

MODEL

Model building began with fiber measurements derived from the HVI™ and AFIS™ instruments. A total of 7 HVI™ fiber measurements (fiber length {Length}, length uniformity {Uniform}, strength {Strength}, micronaire {Mic}, trash {Trash}, Rd {Rd}, and +b {+b}) were measured for each of the 154 blended lots. HVI™ classification was performed on bale samples prior to bale blending. For the first three years of the study, 32 HVI™ measurements were taken for each cotton lot with years 4 and 5 utilizing 24 HVI™ measurements for each lot. To better utilize all collected data standard deviations were calculated for variables where replicate measurements were taken. For each spinning lot, the distribution of values were summarized for each measurement and cotton variety by two variables, the sample mean and the sample standard deviation.

A total of 6 AFIS™ fiber measurements (fineness {Fineness}, upper quartile length {UQL}, short fiber content {AFISSFC}, Maturity Ratio {Maturity}, Neps (count/gram) {Nep}, and visible foreign matter {VFM}) were measured for each of the 154 blended lots. The Advanced Fiber Information System (AFIS™) (Uster Technologies Inc., Knoxville, TN) is a destructive method that aeromechanically opens fibers and separates fiber, trash, and dust for electro-optical measurements thus producing various distributions. These blended stock AFIS™ measurements were obtained for all cotton spinning lots with three tests of 3,000 fibers each performed by one technician on a sample and the results averaged to obtain an observation. For each spinning lot, the distribution of AFIS™ values were summarized for each measurement by two variables, the sample mean and the sample standard deviation.

Model building in this study also consisted of classic/supplementary fiber measurements of the 154 lots of blended stock that are described by Foulk et al. (2007). A total of 26 supplementary/classic measurements (Stelometer strength {Stelstr} and elongation {Stelong}, Suter-Webb array upper quartile length {SWUQL}, mean length {SWML}, coefficient of variation {SWCV}, short fiber content {SWSFC}, Peyer mean length {PML}, coefficient of variation {PCV}, short fiber content {PSFC}, upper quartile length {PUQL}, fibers <0.25 in. {PL25}, Shirley Analyzer visible {SAvis} and invisible waste {SAInvis}, Rotoring friction {Friction}, conductivity {Conduct}, water fraction {Water}, pH {pH}, glucose fraction {Glucose}, wax extractable {Wax}, alcohol extractable {Alcohol}, potassium {K}, calcium {Ca}, magnesium {Mg}, sodium {Na}, heat units {Temp}, and rainfall {Rain}) were measured for each of the 154 blended lots.

Two measures of environmental conditions (cumulative heat units and total rainfall levels) were approximated for cotton grown in the various locations. Fiber bundle strength and elongation values were determined using a Stelometer and for each spinning lot a total of six breaks were performed with three tests per technician. Mean fiber length, coefficient of variation, upper quartile length, and short fiber content by weight were gently measured via the Suter-Webb Array method. These Suter-Webb array length measurements were obtained for all cotton spinning lots with two tests performed by two technicians on a sample and the results averaged to obtain an observation. Fiber mean length, length coefficient of variation by weight, percentage of fibers by weight that are less than 0.5 inches (short fiber), the length that is exceeded by 25 % of the fibers by weight in a test specimen (Upper quartile length, Peyer L25), and percentage of fibers by weight that are less than 0.25 inches were measured using a Peyer AL-101. One test was performed by each of two technicians on a sample and the results were automatically averaged to obtain an observation. Results were generated using a Shirley Analyzer to separate the cotton sample into lint, visible and invisible trash results with two tests performed by one technician on a sample and the results averaged to obtain an observation. Cotton samples were evaluated for fiber friction using the Rotorring with 3 tests performed by one technician on a sample and results averaged to obtain an observation.

Several of these classic/supplementary properties used in model building were derived from chemical tests. Moisture measurements were obtained for all cotton samples with three tests performed by one technician on a sample and the results averaged to obtain an observation. Cotton samples were extracted using 20 ml of deionized water per gram of cotton, with three replicates performed for each of the treated cotton samples. The resulting extract was then subjected to conductivity, pH, and glucose measurements. The conductivity measurements were obtained for all cotton samples with three tests performed by one technician on a sample and the results averaged to obtain an observation. Triplicate glucose determinations of unprocessed fiber were performed. Immediately after the measurement of fiber moisture, wax extractions were completed. Alcohol extractables were performed with corrections for individual fiber moisture contents. These alcohol and wax extractable measurements were obtained for all cotton samples with three tests performed by one technician on a sample and the results averaged to obtain an observation. Cotton fiber metal analysis were performed for all lots with a minimum of duplicate measurements of triplicate samples for a specific metal were performed for each sample.

The 154 lots of blended stock were ring spun into yarn. Details of testing and processing conditions along with a summary of spinning results are discussed by Foulk et al. (2007). This report examines the relationship of HVI™, AFIS™, and classic/supplementary fiber properties to the 12 spinning performance variables. The models were used to predict 12 yarn characteristics. A modeling strategy was developed using SAS regression models limited to no more than 10 different variables. For each spinning method and spinning performance outcome, multiple linear regression models are fit using as predictors: (1.) HVI™ fiber properties; (2.) AFIS™ fiber properties; (3.) classic/supplementary fiber properties; and, (4.) classic/supplementary, HVI™, and AFIS™ properties combined together. The models were fit to data from the 154 blended lots using SAS procedure STEPWISE with a significance level of 20% as the criterion for variables to enter and stay in the model. This technique is a method of analyzing the variability of a dependent variable by using information available on independent variables. A forward variable selection method enters variables into a model one at a time based on a pre-set significance level to search for an acceptable model. Significance level entry (SLE=0.20) for significance criterion for entry of a variable into the model and significance level stay (SLS=0.20) were the criterion for removal from the model.

DISCUSSION

Before assessing fiber properties it is advantageous if one graphically evaluates relationships to better comprehend the cotton fiber chemistry prior to modeling. Figure 1 demonstrates the year to year variability and the relationship between conductivity and friction. Figure 2 reveals the year to year variability and the relationship of conductivity to glucose fraction. Figures 3 and 4 demonstrate the year to year variability and relationship of friction to wax and alcohol extractable. Figures 5 and 6 demonstrate the year to year variability and relationship of friction to calcium and potassium. Figures 7, 8, and 9 demonstrate the year to year variability and relationship between ring yarn strength and HVI™ length, micronaire, and strength with longer fibers, finer fibers, and stronger fibers producing stronger yarn. These figures demonstrate variability and grouping from year to year.

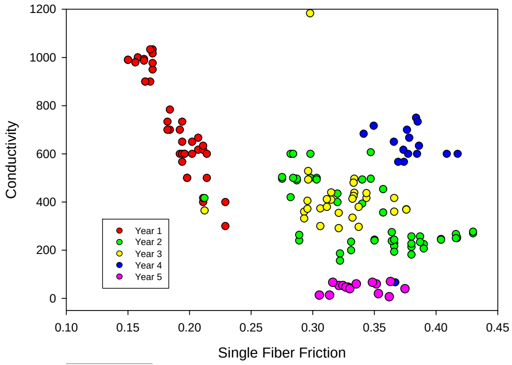

Figure 1. Fiber conductivity relationship to single fiber friction.

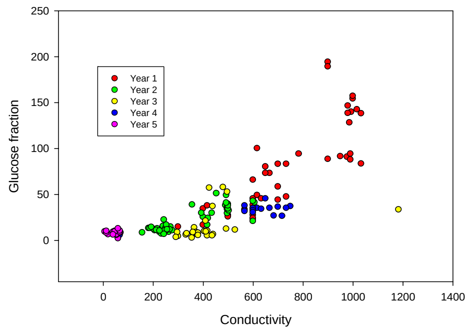

Figure 2. Fiber glucose fraction relationship to cotton fiber conductivity.

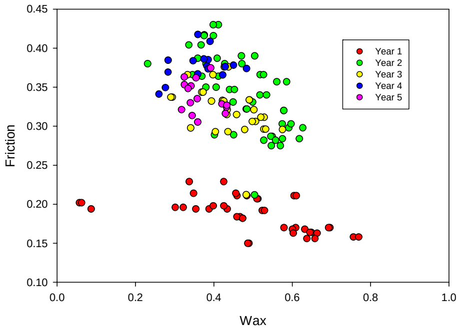

Figure 3. Fiber friction relationship to cotton fiber wax content.

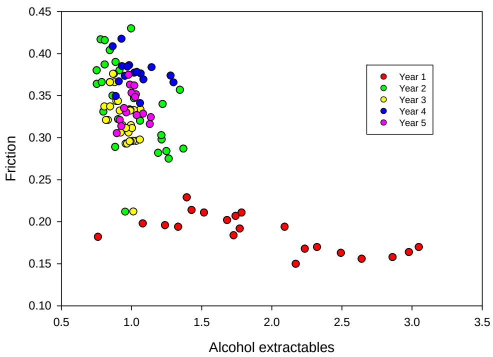

Figure 4. Fiber friction relationship to cotton fiber alcohol extractable.

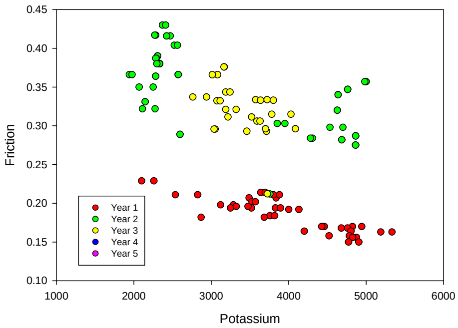

Figure 5. Fiber friction relationship to cotton fiber potassium.

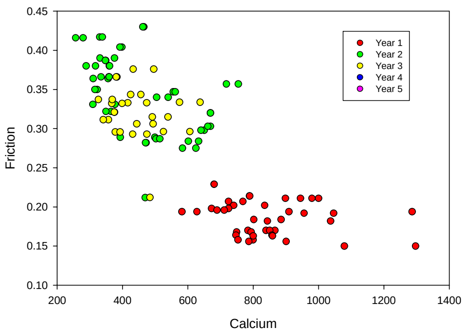

Figure 6. Fiber friction relationship to cotton fiber calcium.

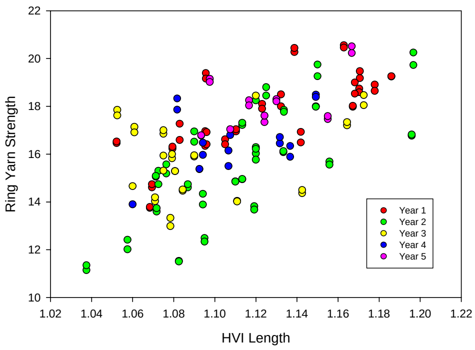

Figure 7. Fiber length relationship to ring yarn strength.

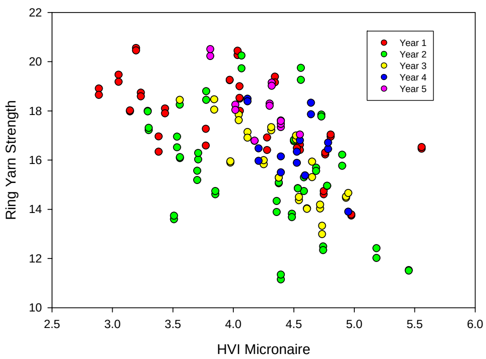

Figure 8. Fiber fineness relationship to ring yarn strength.

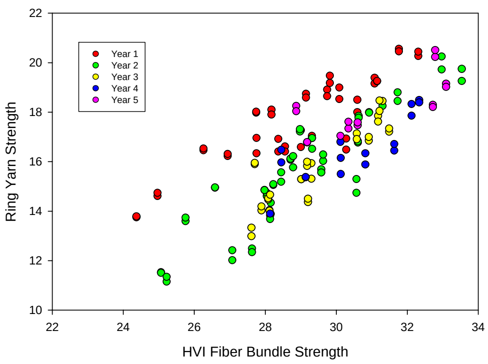

Figure 9. Fiber bundle strength relationship to ring yarn strength.

Models were first fit for ring (Table 1) spinning using typical HVI™ properties as predictors using regression models limited to no more than 10 different variables. These are the properties upon which cotton is sold and these models provide a baseline for judging how much improvement in prediction (R^2) is gained by using different predictor variables. Table 1 lists Y-variables, coefficient of determination (R^2) and variables used in decreasing order of significance.

Table 1. Predicting ring yarn properties via HVI™ properties.

Y variable	R^2	Predictor Variables					
Ends down	0.026	Trash					
Strength	0.887	Mic	Uniform	Strength	Trash	Rd	+b
Elongation	0.586	Length	Mic	Uniform	Strength	Trash	
Neps	0.682	Length	Mic	+b	Trash	Rd	Strength
Thick place	0.73	Length	Uniform	Mic	+b	Strength	Rd
Low place	0.651	Uniform	+b	Mic	Strength	Trash	Rd
CV	0.708	Uniform	Mic	+b	Strength	Trash	Rd
Major	0.206	Mic	+b	Trash	Strength		
Minor	0.397	Uniform	+b	Strength	Rd	Trash	
Long thick	0.053	Trash	Rd				
Long thin	0.546	Uniform	+b	Strength	Trash	Rd	
Yarn board	0.713	Mic	+b	Uniform	Strength	Rd	Trash

Models were then fit for ring (Table 2) spinning using typical AFIS™ properties as predictors using regression models limited to no more than 10 different variables. These are the properties upon which textile mills may make use of and these models demonstrate the coefficient of determination values (R^2) using AFIS™ predictor variables. Table 2 lists Y-variables, coefficient of determination (R^2) and variables used in decreasing order of significance.

Table 2. Predicting ring yarn properties via AFIS™ properties.

Y variable	R^2	Predictor Variables				
Ends down	0.0533	Fineness	Nep			
Strength	0.584	Maturity	SFC	Fineness	Nep	
Elongation	0.568	Maturity	SFC	Fineness		
Neps	0.291	UQL	VFM	Fineness	Nep	
Thick place	0.28	SFC	Fineness	Nep		
Low place	0.225	Maturity	UQL	SFC	Fineness	
CV	0.239	UQL	VFM	SFC	Fineness	Nep
Major	0.0867	VFM	SFC	Fineness	Nep	
Minor	0.151	SFC	Fineness			
Long thick	0.0169	Fineness				
Long thin	0.173	UQL	SFC	Nep		
Yarn board	0.552	VFM	SFC	Fineness	Nep	

Models were fit for ring (Tables 3) spinning using classic/supplementary properties as predictors using regression models limited to no more than 10 different variables. These properties are seldom measured and demonstrate the utility of these measurement predictors and respective coefficient of determination values (R^2). Table 3 lists Y-variables, coefficient of determination (R^2) and variables used in decreasing order of significance.

Table 3. Predicting ring yarn properties via classic/supplementary properties.

Y variable	R^2					Predictor Variables					
Ends down	0.503	SWML	PML	SWSFC	PCV	Temp	Ca				
Strength	0.915	SWML	PML	SWUQL	Friction	Stelstr	SAvis	Stelong	K	Na	
Elongation	0.788	Stelong	Alcohol	SAvis	SWCV	Mg	K				
Neps	0.735	SWUQL	Friction	SAInvis	SWSFC	pH	SWCV	Stelstr	Rain	Na	Temp
Thick place	0.863	SWUQL	Wax	Stelstr	pH	Stelong	SWSFC	PSFC	Rain	Temp	K
Low place	0.865	PL25	SWML	Friction	Wax	Alcohol	SWSFC	Stelong	Stelstr	Rain	Temp
CV	0.888	SWUQL	Friction	Alcohol	PCV	PSFC	Stelstr	SWCV	Stelong	Rain	Temp
Major	0.299	SWML	PL25	PF25	SWSFC	Wax	alcohol	Temp			
Minor	0.619	SWML	PML	Wax	SWSFC	SWCV	pH	StelStr	Rain		
Long thick	0.387	Wax	Alcohol	SAInvis	pH	SAvis	Rain	Glucose	Conduct		
Long thin	0.830	PBSL25	SWML	Wax	SWASFC	Stelstr	Stelong	Rain	Temp		
Yarn board	0.771	SAInvis	PF25	SWCV	PSFC	Glucose	Temp	Mg	K		

Models were finally fit for ring (Table 5) spinning using classic/supplementary, HVI™, and AFIS™ properties as predictors using regression models limited to no more than 10 different variables. These seldom measured classic/supplementary properties combined with HVI™, and AFIS™ demonstrate the utility of measurement predictors and respective coefficient of determination values (R^2). Table 5 lists Y-variables, coefficient of determination (R^2) and variables used in decreasing order of significance.

Table 5. Predicting ring yarn properties via AFIS, HVI, and Classic/supplementary properties.

Y variable	R^2					Predictor Variables					
Ends down	0.594	SWML	PL25	Mic	Uniform	+b	SWSFC	PCV	Mg	Ca	Temp
Strength	0.946	Friction	PML	SAInvis	Alcohol	Strength	Stelstr	SWCV	AFISSFC	Fineness	Temp
Elongation	0.850	Maturity	Wax	Mic	Stelong	SAVis	+b	SWCV	Trash	Rain	Na
Neps	0.773	SWUQL	SAInvis	SAVis	pH	Trash	Uniform	Stelstr	Na	Nep	Temp
Thick place	0.898	Friction	Uniform	SAVis	PSFC	Rd	Stelstr	PCV	SWSFC	Rain	Temp
Low place	0.876	PL25	SWML	Friction	Wax	Alcohol	Uniform	SWSFC	Stelstr	Rain	Temp
CV	0.908	PL25	SWUQL	Friction	Alcohol	Uniform	SWSFC	Stelstr	Rain	Fineness	Temp
Major	0.347	SWML	PL25	UQL	Maturity	PSF25	Uniform	SWSFC	+b	Temp	
Minor	0.691	SWML	Wax	SWSFC	SWCV	Uniform	AFISSFC	Stelstr	Rain	Temp	K
Long thick	0.387	Alcohol	Wax	SAInvis	pH	SAVis	Rain	Glucose	Conduct	Mg	K
Long thin	0.861	Friction	Wax	SWML	PCV	PSFC	Uniform	SWSFC	Trash	Rain	Temp
Yarn board	0.796	Uniform	PL25	SAVis	AFISSFC	PSFC	Stelstr	SWCV	Strength	Fineness	K

Evaluating the coefficient of determination values in Tables 6 demonstrates generally how the Statimat yarn strength, Statimat yarn elongation, yarn thick places, yarn low places, yarn coefficient of variation, and yarn appearance can be better predicted than yarn neps, yarn low places, yarn major places, yarn minor places, yarn long thick places, and yarn long thin places. Compared to the HVI™ properties, AFIS™ properties do an inferior job of predicting ring spun yarn properties. Classic/supplementary fiber measurements are improved beyond HVI™ or AFIS™ fiber properties. Using the HVI™ properties alone as predictors, some yarn characteristics such as strength can be relatively well predicted for ring spinning methods (R^2 = 0.887) while other properties such as Long Thick Places are still poorly predicted (R^2 = 0.053). Using the classic/supplementary properties alone as predictors, some yarn characteristics such as strength can be relatively well predicted for ring spinning (R^2 = 0.9152) while other properties such as Long Thick Places are still poorly predicted (R^2 = 0.387). Combining HVI™, AFIS™, and classic measurement properties subsequently improves the coefficient of determination. This increase in coefficient of determination values likely demonstrates the classic/supplementary properties contain additional properties not measured by the HVI™ or AFIS™. Table 6 include a summary of the 12 models in terms of R^2 values that includes a "mean" which is the average R^2 value for ring spinning.

Table 6. Coefficient of Determination (R^2) for various classic, HVI™, and AFIS™ variables

Response prediction (y variable)	AFIS™ without stdev	HVI™ without stdev	Classic without stdev	Classic, HVI™, & AFIS™ without stdev
Ends down	0.0533	0.026	0.503	0.594
Strength	0.584	0.887	0.915	0.946
Elongation	0.568	0.586	0.788	0.850
Neps	0.291	0.682	0.735	0.773
Thick place	0.28	0.73	0.863	0.898
Low place	0.225	0.651	0.865	0.876
CV	0.239	0.708	0.888	0.908
Major	0.0867	0.206	0.299	0.347
Minor	0.151	0.397	0.619	0.691
Long thick	0.0169	0.053	0.387	0.387
Long thin	0.173	0.546	0.830	0.861
Yarn board	0.552	0.713	0.771	0.796
Mean	**0.268**	**0.515**	**0.705**	**0.744**

Yarn strength can be predicted relatively well as indicated by the high R^2 values for that variable. The Statimat ring yarn strength has an R^2 value of 0.887 when using HVI™ properties, an R^2 value of 0.584 when using AFIS™ properties, an R^2 value of 0.915 when using classic properties, and an R^2 value of 0.946 when using HVI™, AFIS™, and classic properties. For ring spun yarn and HVI™ properties, strength trash, micronaire, and uniformity are the most important properties. For ring spun yarn and AFIS™ properties, fineness, short fiber content, maturity, and neps are the most important properties. For ring spun yarn and classic/supplementary properties, Stelometer strength, Suter-Webb array mean length, potassium, Peyer mean length, and friction are the most important property. These results are generally in agreement with Deussen (1993) who stated that key properties for ring spinning are as follows: length, strength, fineness, and friction. Friction is not an HVI™ or AFIS™ measurement but is associated with surface contaminants found on cotton (Gamble, 2006). Friction has been linked to cotton fiber crimps in cottons fibers with longer lengths and maturity (Clegg and Harland, 1924; Morton and Hearle, 1993; Patil, 1992; Foulk and McAlister., 2002). These results also agree with F.T. Pierce who in 1946 stated that correlations of yarn strength to fiber strength, fiber cohesion, and fiber regularity were important.

SUMMARY

Results from this study agree with other studies in that stronger and longer fibers produce stronger ring yarn. Cottons studied in this project indicate that the Statimat yarn strength, Statimat yarn elongation, yarn thick places, yarn low places, yarn coefficient of variation, and yarn appearance can better predicted than yarn neps, yarn major places, yarn minor places, yarn long thick places, and yarn long thin places. For ring spinning, it demonstrates how classic/supplementary properties are outstanding predictor properties. It further demonstrates how HVI™ properties are better predictor properties than AFIS™ properties. Combining classic/supplementary, HVI™, and AFIS™ properties subsequently improves the coefficient of determination for ring spinning. These results are generally in agreement with prior studies who state that key properties for the ring spinning are as follows: length, strength, fineness, and friction.

DISCLAIMER

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture, information is for information purposes only, and does not imply approval of a product to the exclusion of others that may be suitable.

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