COTTON CARDING TECHNOLOGY IN 2012: A STATUS REPORT ON THE LATEST MACHINE DEVELOPMENTS

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ABSTRACT

In September 2011, Truetzschler introduced the TC 11 card to the world's textile community. This new generation of machines provides better quality, 30% to 40% higher productivity and reduced carding cost. An introduction of the analytical process that led to a precise definition of the development targets is followed by a detailed description of some of the pertinent technical features of that machine. A subject of concern to many cotton yarn manufacturers today is energy cost and supply. This key component of the total operating cost associated with carding was under special focus during the development phase of the TC 11 and the encouraging results of these efforts are discussed.

INTRODUCTION

It is commonly accepted that carding is one of the most important processing stages in cotton yarn manufacturing. Apart from the comber, the card is the only machine in a spinning mill that not only performs a conversion but actually adds value to cotton as a textile raw material by removing trash, neps, seed-coat fragments and short fibres. All cotton yarns are carded but not all cotton yarns are combed. Therefore, in the context of all efforts to improve cotton fibre quality, advances in carding technology can make a significant contribution, eventually making cotton a more desirable fibre. However, as productivity rises, which is an irreversible trend that is observed with all spinning machinery, the card becomes less efficient at removing these unwelcome constituents unless appropriate measures are taken to increase carding intensity along with production rate. The Truetzschler TC 11 card, which was introduced to the global textile public only a few months ago, is presently in the early phase of worldwide market introduction and represents a new generation of cards with unprecedented performance in terms of quality, productivity and cost. The machine stands out by effectively reducing operating cost, i.e. energy cost, in particular. In addition, through minimising overall specific capital expenditure, the TC 11 is the most economical solution available on the market. The impact that this new generation of cards will have on cotton yarn manufacturing is discussed in this paper.

ANALYTICAL DETERMINATION OF THE DEVELOPMENT TARGETS

An effective method to raise the productivity of many machines, not only in textiles, is to increase the working width, i.e. the total area that is employed to accommodate active machine elements that take effect on the raw material processed. In cotton carding, this is labelled the 'carding area' or the total area that the fibres are spread out over in order to be freed from objectionable particles, individualised and longitudinally oriented. If that can be accomplished while maintaining or even improving quality, this is a sure-fire route to a superior product.

Prior to embarking on a specific development project, an abstract question was phrased that required an in-depth analysis of carding and the spinning mill environment. The question was: What is the optimum working width of a card with the technology available to us, today? This is not a simple question but a complex and multi-dimensional optimisation problem. Issues that were investigated included aspects such as production rate, mechanical precision, manufacturing cost, sliver quality, energy consumption, functionality of suction systems and the interrelation between delivery speed, sliver weight and production rate. In a spinning mill context, the key factors including efficiencies, total energy consumption, floor space requirement, filter capacity and maintenance were analysed. All this was also done for different total mill processing capacities, spinning systems and yarn counts. The tools that were used comprised complex calculations, computer simulations and experimental procedures. One thing was crystal-clear from the very beginning: The main cylinder diameter was not to be varied but maintained at 1,287 mm for optimum carding performance as proven by approximately 43,000 Truetzschler cards built to date and placed in the world's markets. It was also intended not to change any of the other roll diameters as well as their relative positioning to each other. The overall result of this analytical exercise is summarised in Figure 1 where the performance/price ratio is plotted over machine working width.

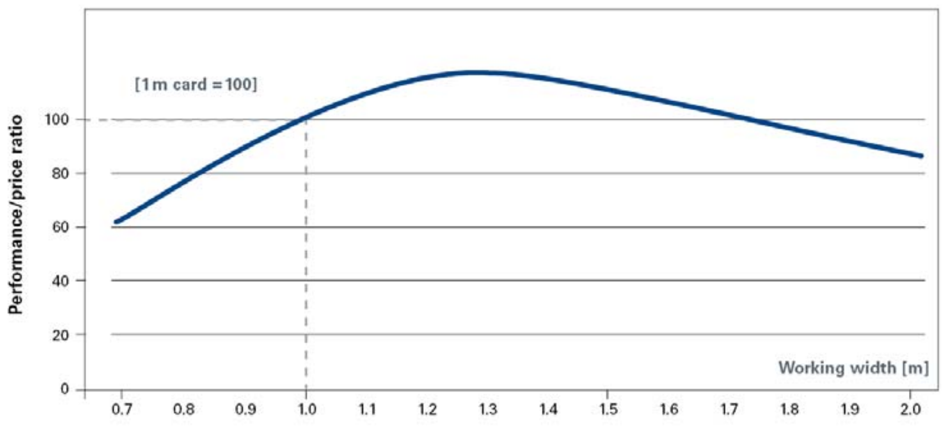


Figure 1: Performance/price ratio as a function of working width

It becomes apparent from this graph that the highest productivity at minimum cost is obtained in a range of working widths between 1.25 m and 1.30 m. The optimum is at exactly 1.28 m (50"). This translates into a total carding area of roughly 5.3 m² (Figure 2) that no other card can provide.

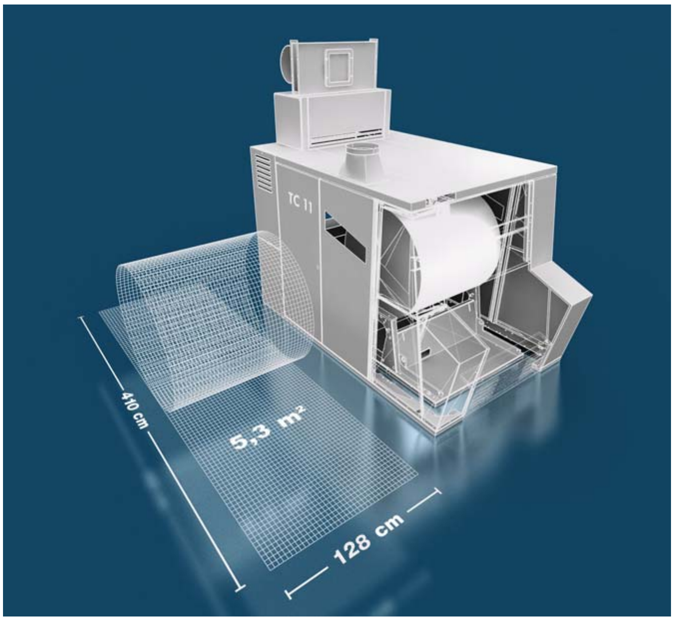


Figure 2: Total carding area

When broken down into the pre and post-carding area as well as the area covered by the revolving flats, numbers as represented in Figure 3 will emerge.

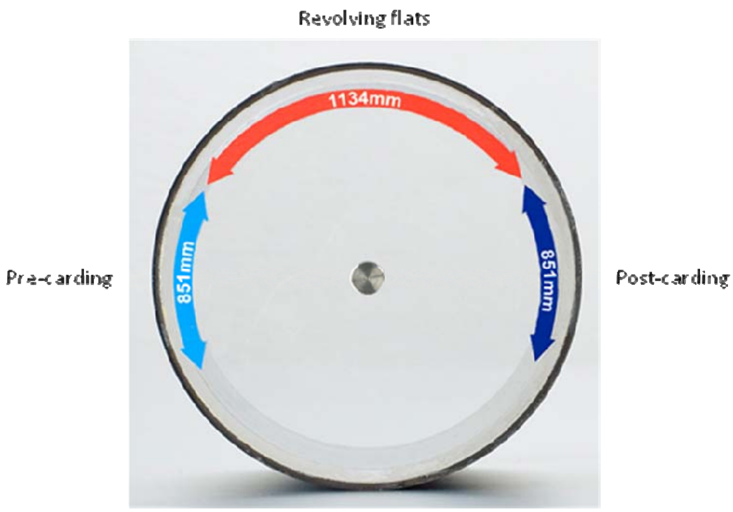
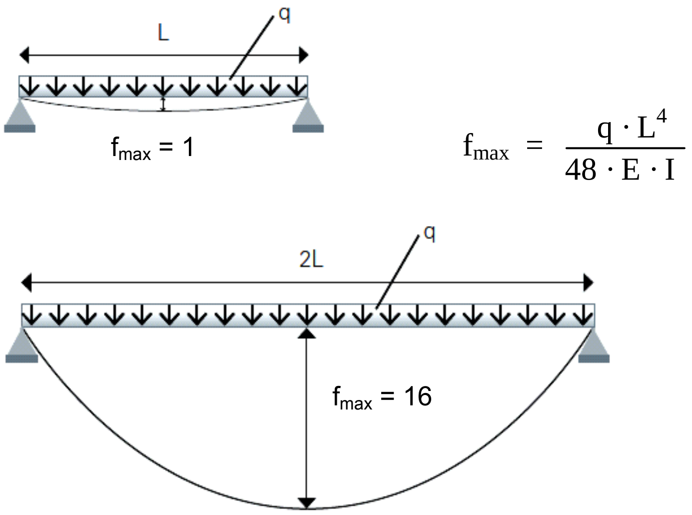


Figure 3: Length of carding zones

Needless to say that increasing the total carding area by some 30% while maintaining the basic geometry and arrangement of machine components, will result in a 30% rise in productivity with identical sliver quality, given that mechanical precision is maintained at the former level.

For that reason, mechanical precision was one of our biggest concerns and became a central subject during the initial analysis phase. When it comes to increasing the width or length of an object, engineers immediately think of the formula describing the elastic behaviour, the deflection of a beam under its own weight or under a uniform load across the beam. To keep it simple, let us assume we would double the width of a beam type structure (Figure 4):



$$f_{max} = \frac{q \cdot L^4}{48 \cdot E \cdot I}$$

Figure 4: Deflection of a beam type structure under uniform load

With the same cross-section of the beam, the same material and the same load, doubling the width would entail 16 times higher deflection! This is hard to handle and anything that would be done to overcome this law of physics would result in sky-high cost. Therefore, precision was one of the crucial factors in limiting the working width, since our paradigm was: No compromises in precision, whatsoever, because carding is all about precision.

As a result of these analyses, we selected the MAGNOTOP system for the revolving flats, which is clearly more precise and more rigid due to its larger cross-section. Moreover, it is simply the superior system when it comes to maintenance (Figure 5).

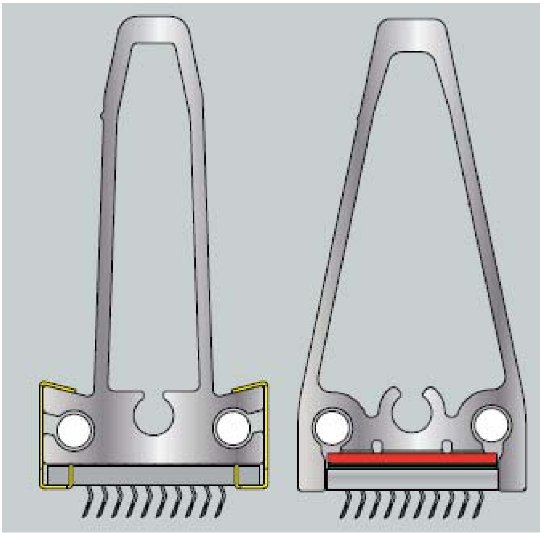


Figure 5: Comparison of a conventional flat bar (left) and MAGNOTOP (right)

MAGNOTOP was developed several years ago. It is a system that does not require clipping to attach the clothing strip to the extruded aluminium flat bar. Alternatively, ultra-strong neodymium magnets hold the clothing strip in place and greatly facilitate the process of exchanging clothing strips once they are worn or have to be exchanged due to lot change requirements. MAGNOTOP achieves higher precision at a working width of 1.28 m than our classic aluminium flat bar does at a working width of 1.0 m.

The stationary flats and the mote knives/suction hoods also had to be modified, strictly for mechanical precision reasons. We worked with our suppliers of extruded aluminium profiles to at least preserve precision at a greater working width. When rethinking the established manufacturing process, our suppliers found ways and means to not only maintain but even increase mechanical precision. The design of both the stationary flats and mote knives/suction hoods was slightly modified, as can be seen in Figure 6.

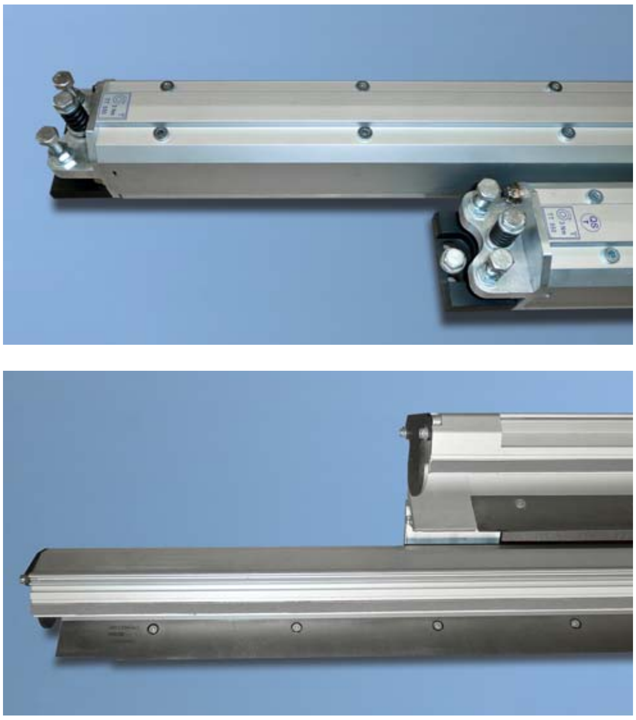


Figure 6: Stationary flat bar (top) and
mote knife/suction hood (bottom)

In essence, the card was made wider and precision was improved at the same time – a win-win-situation, achieved by carefully determining the true optimum working width of a card. Since sliver and yarn quality parameters improve to a noticeable extent through the effect of greater mechanical precision, the productivity gain obtained with the TC 11 is actually greater than 30%, i.e. up to 40%.

Several prototypes of a 1.28 m wide card were built on the basis of our predecessor card model TC 7 in order to verify the theoretical analyses under practical conditions. All assumptions were found to be correct and the actual development process was initiated.

SOME NEW FEATURES OF THE TC 11 CARD – A DETAILED VIEW

Figure 7 is a picture of the new TC 11 card. Although the card has a larger working width of some 30%, the floor space requirement or the footprint of the machine was maintained at a level identical to previous machines with 1.0 m working width. Actually, there is a small difference of 1% to the disadvantage of the TC 11, but that can be neglected.

Figure 7: TC 11 card

Basically, this means 30% to 40% higher productivity than older card models with the same floor space, or, conversely, the same productivity level with lower floor space requirement. Floor space savings translate directly into lower capital cost for real estate and buildings as well as lower operating cost due to reduced air conditioning requirements, lighting, building maintenance, etc.

The chute feed of the TC 11 had to be adapted to the higher productivity level by increasing the storage capacity of the upper chute. Figure 8 is a direct comparison between the chute feed design of the TC 11 and its predecessor, the TC 7.

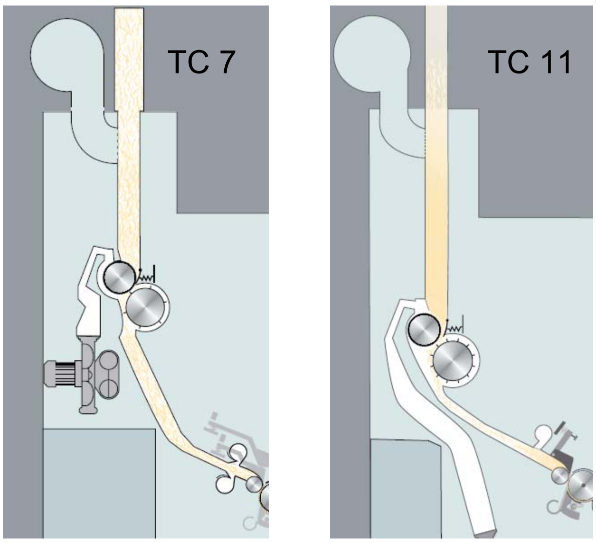


Figure 8: Comparison of TC 7 and TC 11 chute feed designs

The greater material reserve in the upper chute guarantees longer uninterrupted production phases.

The TC 11 is available with single or triple licker-in arrangement, depending on the application (Figure 9). For 100% virgin cotton, the recommendation is to apply the triple licker-in, which is also true for extra-long staple cottons for fine-count spinning. Triple licker-in is mandatory for all types of reprocessed cotton waste or high proportions of waste/reprocessed waste added to virgin cotton. Single licker-in is suggested for man-made fibre applications.

Figure 9: Triple licker-in unit

The feed table and licker-in unit used to be separate entities but have now been merged into a single component, facilitating all maintenance procedures in this area. Contrary to our initial intentions, the relative positioning of the three rolls had to be altered due to space restrictions. It is interesting to note that the feed table/licker-in no longer rests on a rigid machine frame but is attached to the main cylinder support structure via a pivot joint. The same can be said about the web delivery unit: pivot point mounting with no machine frame extending into the web delivery zone (Figure 10). The main cylinder support structure is currently all that is left from the conventional machine frame.

Figure 10: Side view showing the main cylinder support structure

The design of the main cylinder support structure with the licker-in and web delivery unit attached via pivot points, is the result of optimising the thermal expansion/contraction behaviour of the machine. This was accomplished with a relatively new feature that is marketed under the name of T-CON. On the basis of temperature measurements of the main cylinder, lateral shield and ambient air, the thermal behaviour of the card is modelled in the machine control software. As a result, the change of card settings while the machine is heating up or cooling down can be monitored closely online. More importantly, the actual settings of all elements around the main cylinder under steady-state production conditions can be viewed on the machine control display. Once the actual settings are known, the card technician can optimise those settings in order to improve the performance of the machine. To facilitate the optimisation process further, the machine's computer control continuously establishes the optimum settings based on the actual readings and a recommended scenario is displayed (Figure 11).

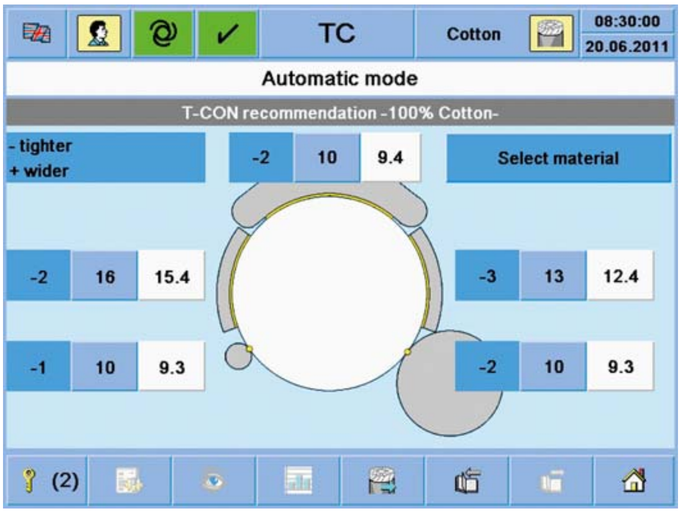


Figure 11: T-CON recommendation of card settings on the display

If the card is set excessively tight, however, some peripheral elements may touch the main cylinder and cause severe damage to both the card wire and the machine itself. T-CON therefore displays a warning once a certain minimum threshold is exceeded. A sophisticated electrical switch feature shuts the machine off instantaneously, once a first physical contact in the millisecond range between the main cylinder and any peripheral element has occurred. This measure will effectively prevent any wire or machine damage if the card technician is overly ambitious in optimising the settings. T-CON was an indispensable tool during the development process, providing guidance in realising, understanding and appropriately addressing the numerous and rather complex phenomena associated with thermal behaviour. With 100% cotton, the key parameter that affects temperature levels is main cylinder speed, but T-CON has also helped to reveal the interesting fact that different cottons with similar physical characteristics generate different temperature levels. It is not known to us, however, which fibre properties account for that effect.

FOCUS ON REDUCING ENERGY CONSUMPTION

Reduction of energy consumption as a major component of operating cost is a key attribute of the new TC 11. The urgent need to conserve energy and thus reduce greenhouse gas emissions on a global scale has been on the agenda of international policy makers ever since the Kyoto Protocol in 1997. But apart from environmental concerns, energy has become a critical cost factor in the spinning sector, with some parts of the world even suffering from an unstable or insufficient energy supply. In a recent survey conducted during the International Textile Machinery Exhibition (ITMA) in Barcelona, Spain, in September 2011, 94% of a total of 135 textile executives from 39 countries responded by saying that low energy consumption was a very important or at least an important consideration when making an investment decision. Low energy consumption ranked second on the list of vital features. High quality of the textile product was the number one priority, with 96% of all participants confirming this as important or very important.

Specific energy consumption in kWh kg^{-1} is the amount of energy required to produce one kg of material. With cards, the electrical power requirement of the drives accounts for the largest share, followed by exhaust air removal and the use of compressed air. In a mill context, energy savings result from operating fewer machines at higher production rates and the collateral savings in filtration and air conditioning. However, through the utilisation of energy-efficient motors that conform to the international IE2 standard and suction systems that are optimised with respect to their fluid mechanics, the card itself has made a significant contribution. Compared to the TC 7 predecessor model card, the new TC 11 reduces overall energy cost by up to 20%, depending on the size of the installation – and the TC 7 is by no means an energy waster. Apart from energy cost as a component of operating cost, it goes without saying that fewer machines operated in a spinning mill may also go along with a reduction of labour cost, wherever that represents a significant item.

From a historical point of view, Figure 12 illustrates the development of production rate and specific electrical power consumption over time and the different card models produced in those periods.

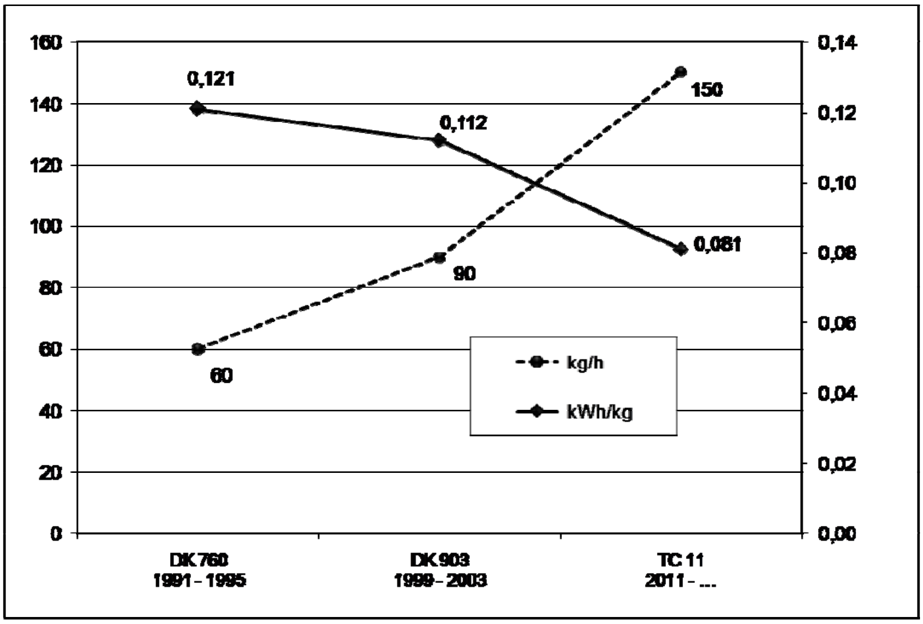


Figure 12: Production rate and specific electrical power consumption

The data is based on 100% cotton for rotor spinning. With a higher production rate and more efficient energy-saving technology applied in these machines, electrical power consumption has declined steadily. Today, the TC 11 can go well below the 0.1 kWh · kg^{-1} mark.

Likewise, the specific airflow in m³ · kg^{-1} as a direct measure of energy consumption due to exhaust air handling, shows a similar relationship (Figure 13).

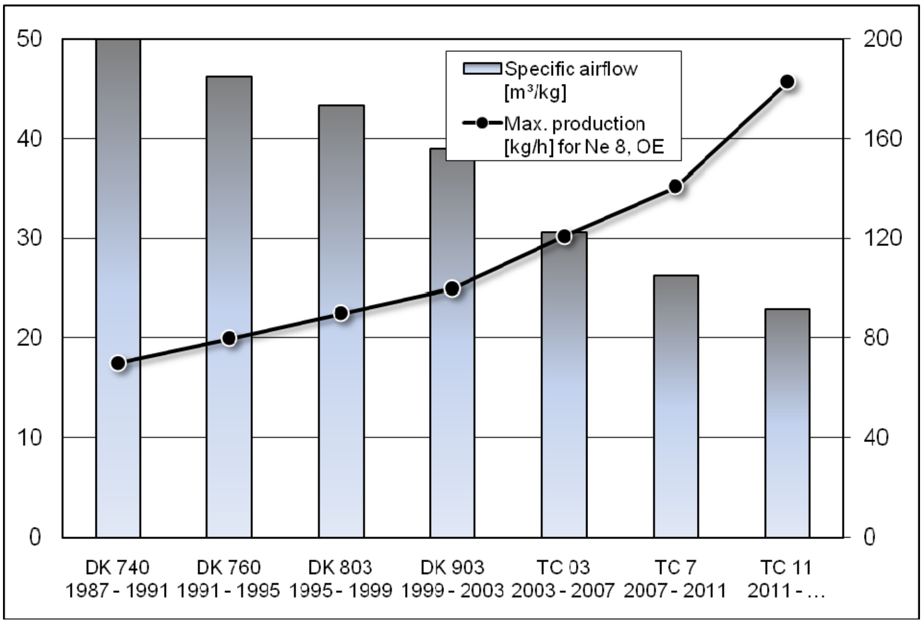


Figure 13: Production rate and specific airflow

This is a result of the continuous geometrical optimisation of the suction systems, with reduced air flow, vacuum and pressure drop.

CONCLUSIONS

Truetzschler's new TC 11 card represents the substantial progress that has been made in cotton carding technology during the recent years. Quality, productivity and cost of carding have been appropriately addressed. All manufacturing cost components, i.e. capital, operating and labour costs, have been positively affected, with energy cost under special focus. In an otherwise difficult business environment, that machine will certainly make a positive contribution by optimising the overall cost of the cotton yarn manufacturing process, which in turn should provide cotton with some additional attractiveness for the spinning industry. It is not only the economic advantage or the overall economic feasibility of a new generation of machines that triggers the willingness to invest into new business, expansion or the replacement of older machines. Progressive technology, for which T-CON, the online system for monitoring and optimising the card settings is an excellent example, is also regarded as an asset to potentially rationalise the cotton yarn manufacturing process.