IMPROVED RAW MATERIAL UTILIZATION WITH NEW CONCEPTS IN CLEANING AND CARDING

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Abstract

Optimizing raw material utilization, while at the same time increasing quality and productivity of yarn manufacturing, represents the top challenge for spinning mills that are participating in the global competition. This presentation will show developments in spinning preparation and carding, which take these trends into consideration. While the actual cleaning of cotton with simultaneous waste reduction as well as foreign matter removal in spinning preparation can be mentioned in this connection, the main focus in regard to cards needs to be turned to improving the setting processes and the application of on-line sensor technology. Examples in actual operation prove that these measures allow optimized machine functioning, while at the same time lowering raw material costs. This considerably increases the efficiency of the spinning mill and helps to justify new machinery investments.

Introduction

The growing global competition forces the cotton spinning mills to produce yarns in ever-increasing quality at internationally competitive prices. When comparing the cost structures in different locations it can be clearly seen – under consideration of all the regional dissimilarities – that the raw material price now as before represents the dominating factor in yarn manufacturing costs. This means that the key to survival in the international market is to best possibly utilize the raw material, despite all influences of labor costs and capital costs. This not at all new realization, however, must be put into successful action at an ever-increasing pace in view of constantly changing production requirements, which, for instance, are caused by raw material deviations and smaller lot sizes.

To accomplish this, appropriate equipment and tools are necessary to adjust the machinery in a quick, flexible, controlled and reproducible way to the requirements of the item to be produced. Particularly the machines, on which the attainable quality can greatly be improved, deserve special attention here. Regarding further development it is therefore understandable and logical to turn the main focus in spinning preparation to the cleaners and card. To get as close as possible to reaching the above goals it is necessary to initiate improvements mainly on the

- Setting elements and the
- Quality sensors

in order to provide the spinning mill with the correct tools to attain best possible efficiency.

Blowroom

Cleaning

The importance in spinning preparation is that interfering particles are removed from the cotton in a particularly gentle and waste-saving manner. Nevertheless, to merely attain a high degree of cleaning is not practical as long as the waste quality is not optimized in correspondence to the raw material as well. An adjustment to the lowest usable lint content in the waste is just as impractical, if this results in a low degree of cleaning.

This complexity can best and most effectively be observed in the Cleanogram, which displays waste quantity and degree of cleaning under the influence of raw material and its cleanability, as well as total trash content (**Fig. 1**). If a cotton containing 2% trash could be freed of all foreign matter by extracting 2% waste, then the theoretical ideal line for the degree of cleaning as shown in the Cleanogram as a straight line would be achieved. However, in a practical example, cleaner waste of 1.6% results in a combination of 1.2% trash and 0.4% lint content. The intersecting point of the waste quantity and the separated impurities of 1.2% establishes the operating point, which should be as near to the ideal line as possible, at a very high separation level to attain a reasonable degree of cleaning.

Thus, modern cleaners, which were developed with the aid of such methods, provide the spinner with tools that help him realize a high cleaning efficiency as well as a high degree of cleaning. As examples for such a machine serve the cleaners of the "Cleanomat" series **(Fig. 2)**, whose worldwide success as best-selling cleaning product line is not least due to this capability.

Foreign Matter Removal

Contamination is a serious problem to the cotton, textile, and apparel industry (**Fig. 3**). A solution to the foreign matter dilemma in spinning was initially provided by electronic yarn monitoring systems with foreign fiber detection installed on spinning or winding frames. Despite the many advantages of this technology, it was soon recognized that removing contaminants in yarn state was a costly and awkward undertaking. In 1995, systems were introduced to the market that would intercept foreign matter in the opening and cleaning line, i.e. at the very beginning of the spinning process in order to prevent fibrous contaminants from becoming fibrillated and dispersed. These systems are based on CCD camera or electro-optical sensor technology. Cotton tufts are scanned while being conveyed by airflow and contaminated lint is separated via diverters or compressed air nozzles. Experience with this particular technology has revealed some limitations as well, because large and compact fiber tufts fully enclose and conceal many of the contaminants.

In contrast to the common belief, it was also discovered that the vast majority of fibrous contaminants remains essentially intact even after the cleaning process and that only at the card, i.e. at the revolving flats in particular, the integrity of the contaminants is severely damaged, leaving numerous individualized fibers. Truetzschler's Securomat SCFO (**Fig. 4**), a novelty introduced during 1999's International Textile Machinery Exhibition (ITMA) in Paris, has therefore been placed at the end of the opening and cleaning line, right before the cards. At that position, tuft size is minimal and to further enhance system resolution, a CCD color line scan camera monitors the surface of a rotating spiked cylinder (**Fig. 5**). Among the tiny tufts and individualized fibers present on the cylinder surface, even the smallest contaminants are exposed and distinctly presented to the camera system (**Fig. 6**). Upon exceeding certain camera signal limits, pneumatic valves and compressed air nozzles are activated and the foreign object is ejected into the waste duct. A total of 32 nozzles are installed across the width of the machine but the compressed air impulse is confined to one or two nozzles covering the actual position of the foreign object (**Fig. 7**). As a result, the loss of usable lint is kept to an absolute minimum and very sensitive settings can be realized.

Since 1995, an amazing 660 foreign matter systems from different manufacturers have been installed worldwide. What does this mean for cotton? It means that some 660 spinners worldwide are becoming increasingly aware of the contamination problem and also increasingly skeptical regarding the attitude and capability of their raw materials suppliers. I anticipate that we are not far from the day that many spinners will unanimously and vigorously demand a solution to the contamination problem to be realized on the cotton production end of the business.

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Growing regions known for excessive contamination may soon face severe difficulties.

Cards

Now as before, the card (**Fig. 8**) is the one machine in the spinning mill which does have the greatest effect on the quality of the end product. However, to accomplish this as effectively as possible under the above-mentioned conditions, special emphasis was placed on the redevelopment of the setting elements and the advancement of on-line sensor technology on our latest innovations.

Setting

Among the multitude of possible setting points which have an influence on quality and productivity, it is known that the setting of the carding gap between main cylinder and revolving flats is the most effective and important one. Hence, the tiniest changes of even a few thousandths of an inch influence the card sliver quality. When considering, however, that this important setting is usually still carried out by subjective sensing of the distance via feeler gauges, it becomes clear that this is the most effective place to simplify the setting and improve the reproducibility of the carding quality.

For the new high production card DK 903, the interaction of all elements of the revolving flats system was newly designed to meet these requirements [1]. With

- flat bars made of high-precision aluminum extruded profiles **(Fig. 9)**
- flexible bend, now with 6 instead of 4 adjusting spindles (**Fig. 10)**
- flat drive with a separate variable speed drive
- non-contact flat distance measuring system FLATCONTROL FCT **(Fig. 11)**
- newly developed precision setting device PRECISE FLAT SETTING PFS **(Fig. 12)**

the flat adjustment can be carried out in seconds without tools, reaching a new optimal level and up to now unknown precision. **Fig. 13** documents, with the help of the FLATCONTROL print-outs, how such an adjustment can be accurately carried out, for instance in two steps by 4/1000" each.

Sensor Technology

In the field of quality sensor technology, sensors to control and regulate the sliver evenness on the card are part of the standard equipment today. With help of these sensors and sophisticated closed-loop feedback control techniques – into which all drives that determine the material flow are gradually incorporated – it is possible today to produce card slivers at an excellent level of evenness and to continuously monitor their quality. Of same, if not even more importance, is the removal of trash, neps and other interfering particles from the material by the card. A control of this important function, however, is still carried out by very expensive random tests in the laboratory within the scope of gravimetrical trash measurement and nep counting. The realization of online-control for the interfering particles is therefore rightfully an item of top priority for the spinning mills.

The development of the on-line nep sensor NEPCONTROL provides a device which ensures that these requirements placed on high production cards are met. In this connection, a camera located below the stripper roll **(Fig. 14)** traverses in a hollow profile and detects the size and number of interfering particles by constantly providing sample images over the width and length of the web produced. A computer installed at the profile classifies the type of interfering elements as neps, seed-coat fragments and trash, and transmits the result to the card control. Afterwards the particle counts per gram can be shown on the card display. In addition to plotting neps over time, the nep distribution can also be established over the working width and automatically monitored for limiting values.

By utilizing the NCT, the setting of the card to a constant nep level can for the first time be carried out in a quick and accurate way.

Practical Results

Technical innovations must first prove themselves to the machine user during every-day operation [2]. Only then it can be seen if the advantages, based on theory and later confirmed in the research laboratory, also hold true in actual operation.

At this time, I would like to limit myself to some typical examples made in cotton spinning mills to document the different objectives of an optimization in the plant. Experience has confirmed that the following applications open up potentials in the technical as well as economical area:

- Increase of production while maintaining at least the same quality
- Increase of quality while maintaining at least the same production
- Reduction of raw material costs while maintaining same quality and production
- Optimization of quality by using on-line sensor technology

Increase of Production while Maintaining same Quality

Here an example from a rotor-spinning mill can be used, in which an Ne 20 cotton yarn is spun. The customer already had some high production cards type DK 803, operating at a quite high production rate of 175 lb./h. During an expansion, a DK 903 was also used for the same raw material, which resulted in slightly improved quality values. Then the production was gradually increased until the same quality values were achieved with the new card. As can be seen on **Fig. 15**, the same quality is only reached at the significantly higher production rate of 265 lb./h, at which the card has now been operating for several months. Wear and tear on clothing and strain on components show normal behavior, so that even with this extremely high output carding under production conditions is possible.

Increase of Quality while Maintaining same Production Rate

We were able to find an impressive example for this application in a spinning mill for combed cotton yarns. The spinning mill produces a yarn for shirting with a count of Ne 50 from combed cotton. Here a comparison with a modern high production card type DK 803 was made as well, which produced at 90 lb./h slivers for a top-quality yarn in the range of 5% Uster line. With the DK 903 it was possible to prove that by a reproducible and precise setting of the card this quality could still clearly be increased, all the way up to the yarn state (**Fig. 16**). Worth mentioning are especially the improvements of the IPI values and the reduction of short Classimat defects.

Reduction of Raw Material Costs while Maintaining same Quality and Production

It is well known that quite the largest part of yarn manufacturing costs is the expense for raw material, which usually amounts to more than 50% of the spinning costs. Consequently – aside quality and production optimization – it is often far more rewarding to target a reduction of raw material costs. However, the selection of a cheaper raw material requires a very precise adjustment of the machine if this goal is to be achieved; for this a sensitive and accurate coordination of settings on the complete card is required. Even very experienced card technicians often found their limits in this area. With the new setting possibilities in the flat area and the targeted adaptation of the carding zones by the Twin-Top-System, a fine-tuning of the card can be carried out with less effort and higher setting precision. This is clearly a progress, even when the cost of raw material is targeted.

A ring spinning mill, which produces Ne 14, 100% cotton yarn, served as first example for this approach. By using the new cards the quality as well as the production rate were successfully increased. Consequently, a search was made to find a more reasonably priced raw material. Thus, the raw material costs could be reduced by 5 cents/lb., without lowering the quality for this item below the required level. We are pleased to say that in this case it was even possible to maintain a production advantage of 60% while simultaneously improving the yarn imperfections. (Raw material specification and costs see **table 1**). An economics study, which considered all other types of costs aside from raw material savings (investments, space requirements, air conditioning, energy, labor), showed that annual raw material savings of US$ 365,000.00 were achieved with an average utilization of 5 cards **(Fig. 17**). This is an impressive example about the great changes that are possible in economic efficiency when savings in raw material costs can be influenced by technical innovations.

For the second example a spinning mill was selected which produces an Ne 41 yarn from a blend consisting of 67% polyester and 33% combed cotton. Here the investment in new carding was to be additionally protected by trials with lower raw material costs as before. In comparison with the existing card room, consisting of at least 20-year-old cards, a distinct production increase and improved quality could be achieved again. The raw material costs were reduced by 5 cents/lb. using a cheaper material, with which the quality – at almost double the production rate – could be maintained **(Fig. 18)**. An economic study that was carried out here as well established, that the savings related to raw material were very high. This not only justified the investment in new cards, rather there remained an additional savings, which amounted to US$ 51,000.00 annually with an average utilization of 4 cards. This is even more remarkable when considering that the cotton share was only 33%, and was combed.

Optimization of Quality by using On-Line Sensor Technology

Many applications of the on-line nep count on the card meanwhile show the excellent agreement with the measuring results made on conventional laboratory devices. This is demonstrated in an exemplary manner in **Fig. 19** for the correlation of nep values between the NCT and the AFIS measurement in the laboratory. In this connection, however, I find it important to mention that it is not as much the perfect match between the absolute values of the two measuring methods. Rather, the recording of changes in the nep level caused by raw material or machines is significant. The value of an on-line measurement lies mainly in the greatly improved statistical significance of evaluation, since actual operation in the spinning mill proves that even in case of very quality-conscious companies the scope of random laboratory samples is usually smaller by a factor of at least 2000, as compared to on-line monitoring. Above all, trends in the development of interfering particles can be quickly and accurately detected in a much faster way without the need for additional personnel. This can be seen in the following diagrams where the nep time series of cards were recorded in a major US-spinning mill with the help of the NCT.

Fig. 20 shows the nep monitoring for one of the cotton cards over a period of 25 days. A new developed wire combination was tested on this machine and the success of this measure could be seen automatically in the nep readings of the NCT within a very short period of time. Another type of detecting malfunction of the machine can be seen in the small peak of the nep readings in the right half of the diagram. A not proper suction situation originating from the filter house of the spinning mill, which was not detected by the pressure sensor was the reason for an unacceptable level of nep readings. This malfunction of the machine would probably have remained unnoticed for several days till the next laboratory check of neps without the on-line measurement capability of the NCT.

Fig. 21 shows, how changes of material specifications due to new bale lay-downs effect particle counts in the card. By using the NCT unacceptable deviation of particle levels can be avoided and the utilization of raw material can be optimized with the help of this new on-line method. An equivalent account using random-type tests could never be attained even in theory.

References

[1] Schlichter, S. Precise Flat Setting – A new way of adjusting high production cards Melliand Textilberichte 80 (1999) 591 – 593.

[2] Schlichter,S. ; Färber, C. New methods for achieving controlled and reproducible card sliver quality Melliand Textilberichte 81 (2000) 587 – 592.

Raw Material Data		DK 740 (50 kg/h) Standard Mix	DK 903 (80 kg/h) Low-Cost Mix
Grade		strict middling	strict low middling
Staple	inch	$1\,^{1}/_{8}$	$1\,^{3}/_{16}$
Micronaire		4.1	3.7
Maturity	%	74	64
Trash Content	%	2.2	4.3
2.5% Span Length	mm	29.2	30.4
Uniformity Ratio	%	49.3	47.0
Short Fiber Content	%	8.6	10.6
Strength	cN/tex	22.8	22.8
Price	US cts/lb	50.40	45.36

Table 1. Raw material data.

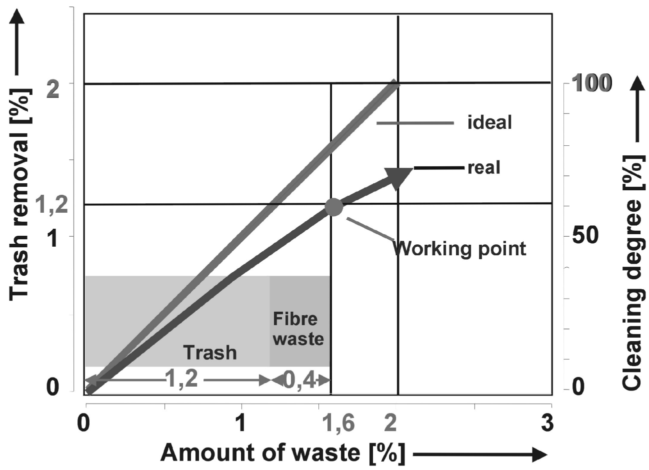

Figure 1. Cleanogram.

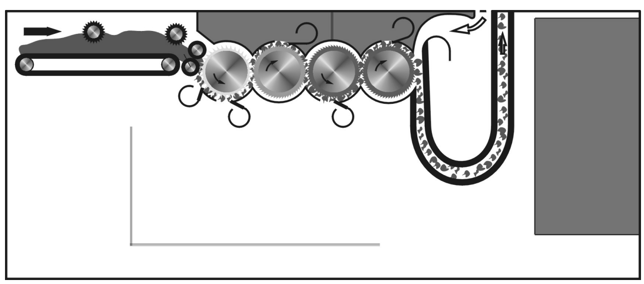

Figure 2. Cleanomat CXL 4.

Figure 3. Contamination in cotton.

Figure 4. SECUROMAT SCFO.

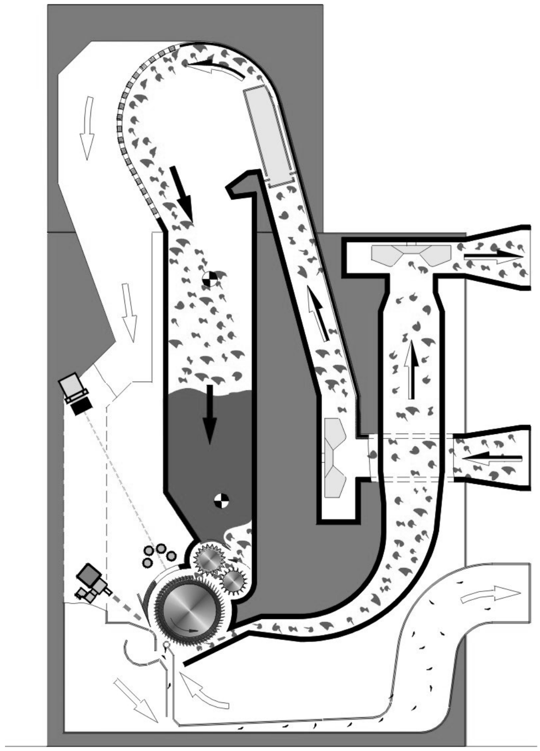

Figure 5. Schematic view of SECUROMAT SCFO.

Figure 6. CCD color line scan camera.

Figure 7. Compressed air ejection nozzles.

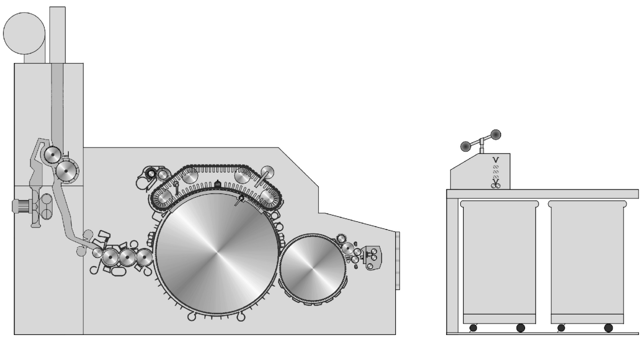

Figure 8. High production card DK 903.

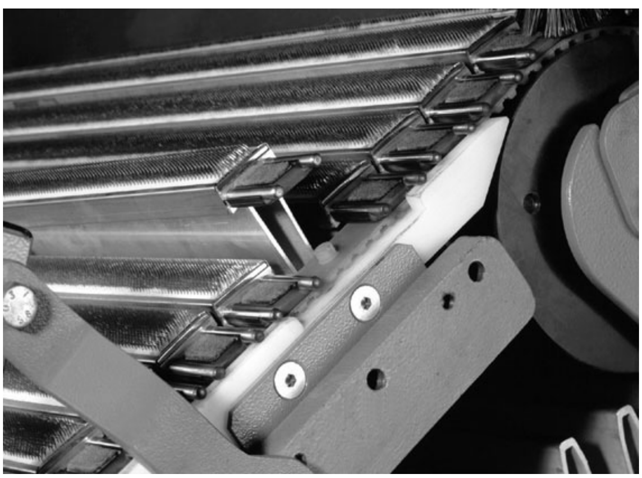

Figure 9. Aluminum flats.

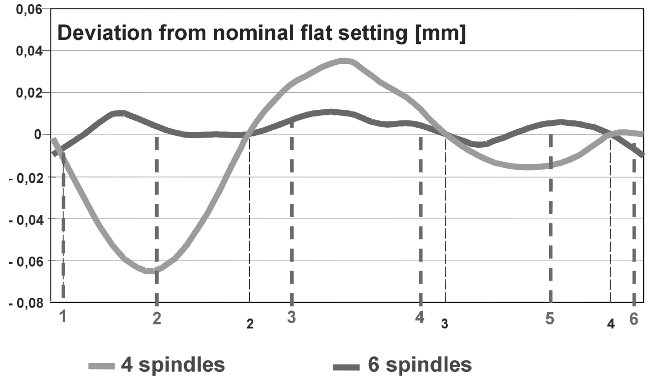

Figure 10. Adjustment of the flexible bend with 4 and 6 adjusting spindles.

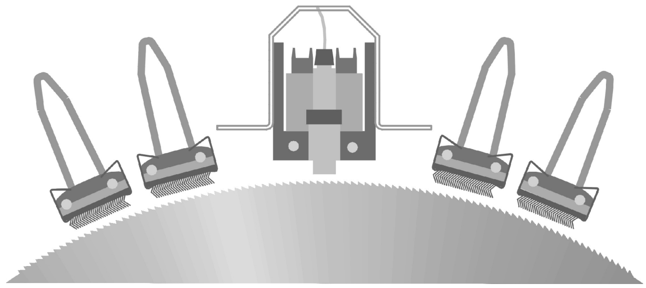

Figure 11. FLATCONTROL FCT.

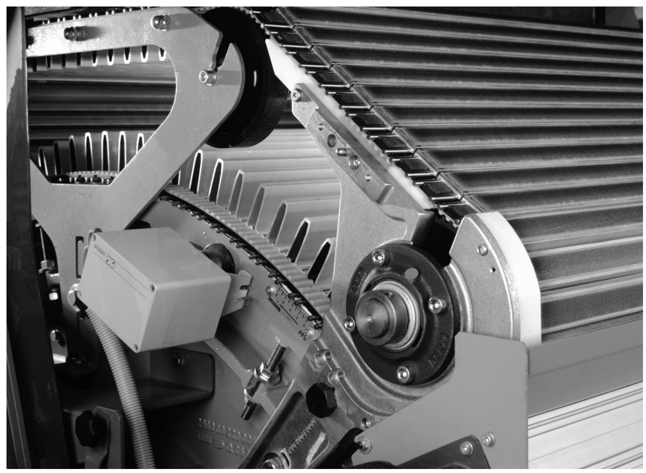

Figure 12. PRECISE FLAT SETTING PFS.

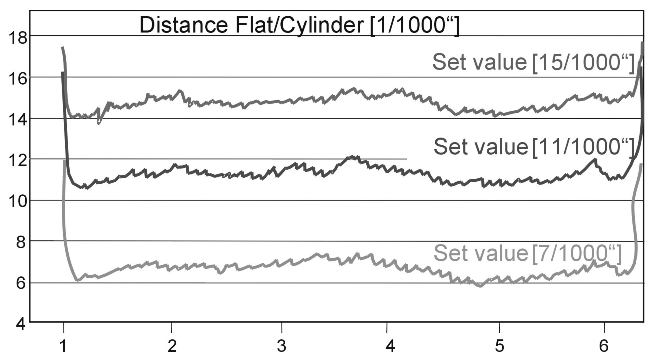

Figure 13. Flat adjustment with PFS.

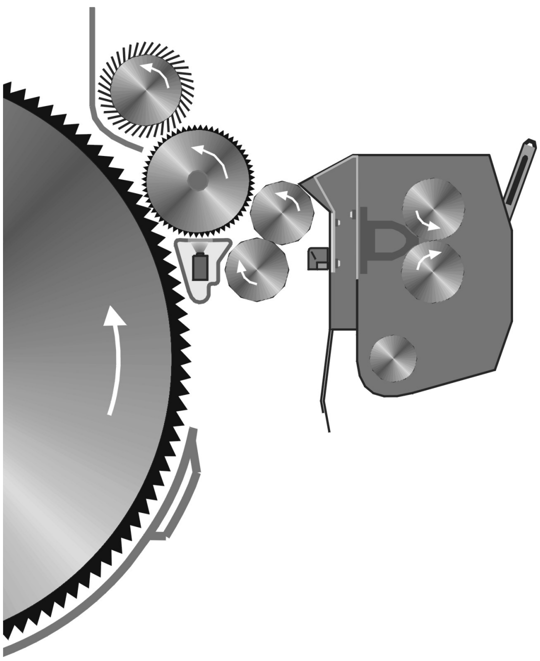

Figure 14. NEPCONTROL NCT.

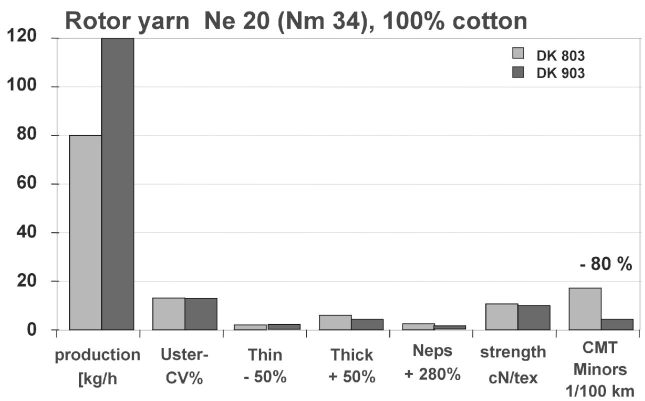

Figure 15. Increase of production while maintaining quality.

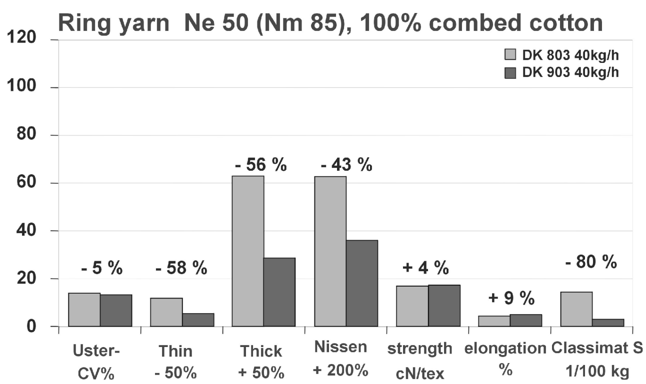

Figure 16. Increase of quality while maintaining production.

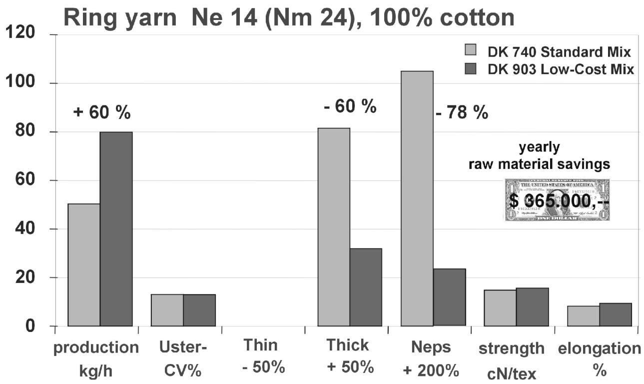

Figure 17. Reduction of raw material cost while maintaining production and quality (rotor yarn).

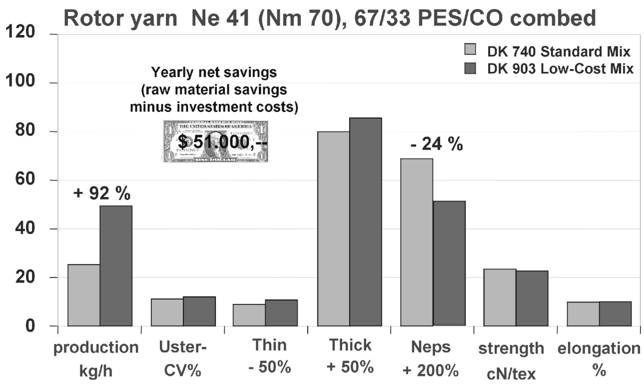

Figure 18. Reduction of raw material cost while maintaining production and quality (ring yarn).

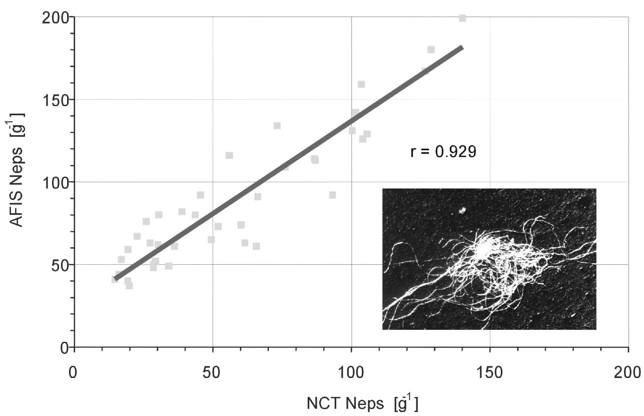

Figure 19. Correlation between NCT and AFIS measurement.

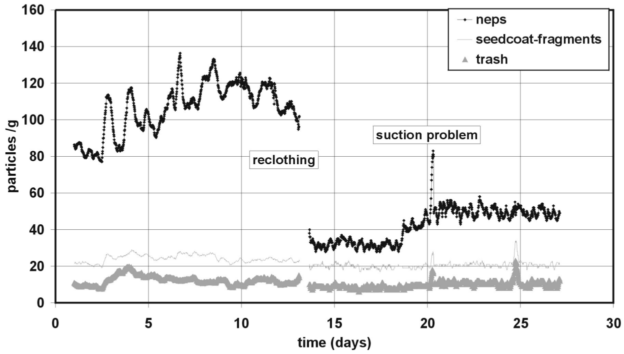

Figure 20. Nep monitoring in a US spinning mill.

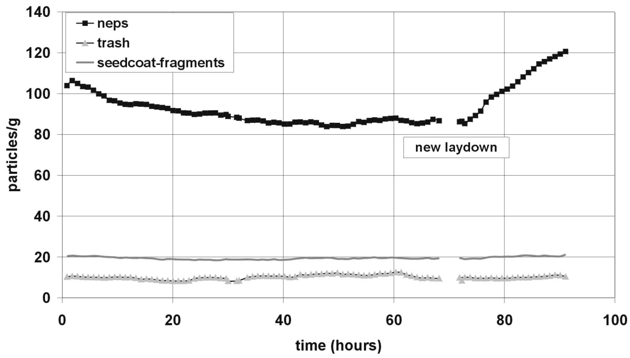

Figure 21. Nep monitoring in a US spinning mill.