INCREASED OUTPUT OF RAW MATERIAL THROUGH FIBRE RECYCLING FROM DROPPINGS

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Abstract

By-products occurring in cotton preparation are often incorrectly classified as waste. In the past, fall-out fibres were separately vigogne spun and condenser spun to coarse low efficiency yarns. The profit obtainable per kg of yarn, however, is only marginal. The cost-intensive handling of by-products like sorting, pressing, opening, cleaning, and transporting reduce the profit of processing fall-out fibre in vigogne spinning to an extent to make this process uneconomical.

Introduction

New spinning methods and a high degree of automation have totally changed the cost structure of a spinning mill. The share of total expenditure represented by wages has nearly become of secondary importance. Dominating cost factors are raw material, capital expenditure and energy costs (fig. 1).

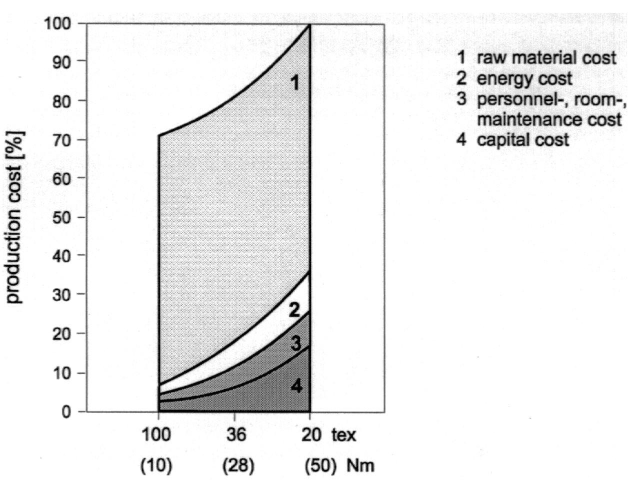

Figure. 1. Cost Distribution

Raw material costs represent the largest potential of further economy in yarn production. With the gradually increasing use of mechanical harvesting equipment the quality of by-products occurring changed considerably. Formerly, by-products were considered to be mainly immature short fibres of reduced strength. Modern harvesting processes changed this. On the basis of these developments the "Institut für Textil- und Verfahrenstechnik Denkendorf" carried out comprehensive research work in the view of settling the following questions:

1. What percentage of raw material fibres will fall out during cotton cleaning up to and including the card?
2. What would an economical concept of upgrading by-products look like?
3. What risks will rise with regard to yarn quality when recycling recovered fibres? And, how to determine the maximum percentages of fall-out fibre admixtures?

The answers to these questions presented solutions which could then be realized in industrial practice.

Discussion

Our Institute analysed the by-products of a great number of spinning mills. It can be said that the quality of the by-products is a function of the quality of the original cotton. A high-grade cotton yields by-products of a fibre quality which is superior to that of low-grade original cotton.

It is a fundamental fact that a cleaning process always entails the separation of good fibre material as well as "trash". Spinning mill managers usually are of the opinion that droppings should be "black". However, black droppings mean that there has not been achieved an optimum degree of cleaning as shown with fig. 2 as an example for new cleaning machines.

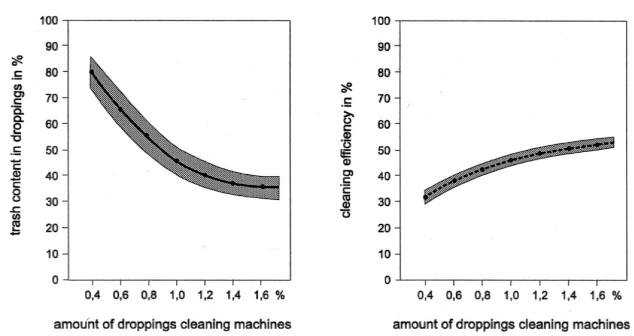

Figure 2. Cleaning Efficiency

The maximum degree of contaminant separation and, thus, the highest possible cleaning effect is achieved with the highest percentage of droppings. In this position of the cleaning machine, you will also separate the highest proportion of good-fibre material. This illustrates that an increased percentage of good-fibre separation results in better cleaning of the grey cotton, a fact that applies to all cleaning machines we examined. Such a method of processing is not economical unless it will be possible to ensure optimum recovery of the good fibres from the fall-

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out material. Our analysis showed that the droppings from cleaning machines in use contain an average of about 50 % of good-fibres up to and including the card. There is a wide range of variations, dependent on raw materials, cleaning efficiency, productions rates, number of licker-ins per card, etc. (fig. 3.).

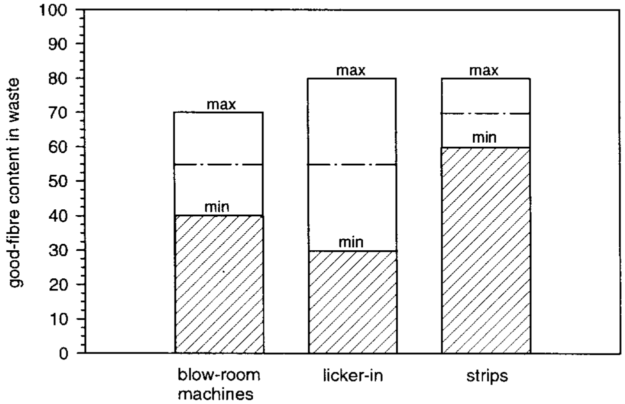


Figure 3. Good-Fibre Content in Waste

For the purpose of further developments, 3 spinning mills of a very different production program and different raw material use were examined.

Spinning mill A:	for OE-yarn up to Nm 50 (Ne_c 30)
Spinning mill B:	ring-spun yarn, carded and combed up to Nm 70 . (Ne_c 40)
Spinning mill C:	ring-spun yarn, combed up to Nm 100 (Ne_c 60)

An analysis of fibre thickness showed that in all 3 spinning mills the thickness of the recovered fall-out fibres differed from that of the original cotton fibre to only a minor extent (fig. 4).

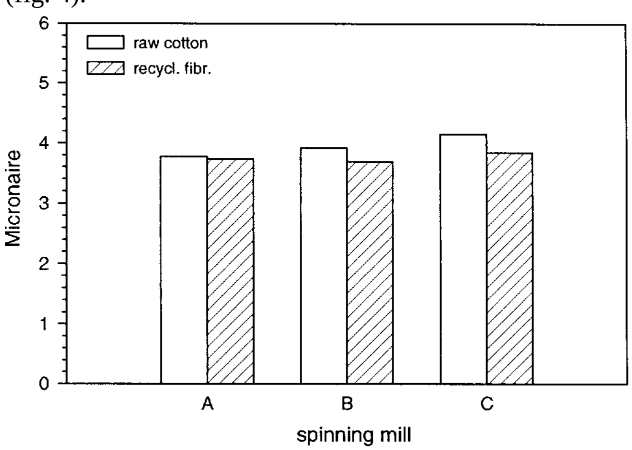


Figure 4. Micronaire - Original - vs. Recovered Fibres - Spinning Mill A/B/C

Essentially the same applies to the degree of maturity as determined by the Causticaire method. The recovered fall-out fibres, of course, cannot be riper than the fibres of the original grey cotton. Fig. 5 illustrates very clearly that the degree of ripeness of the recovered fibres tends to be nearly equal to that of the grey cotton.

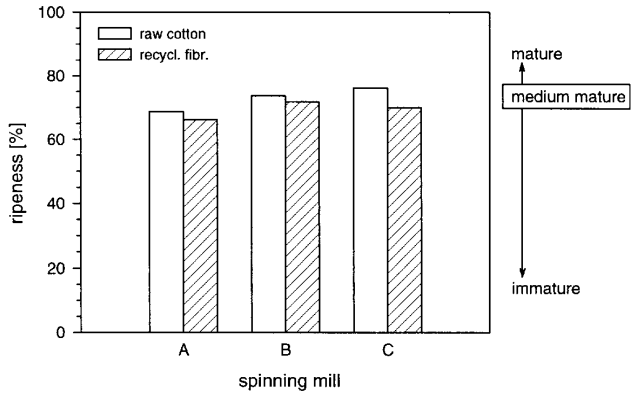


Figure 5. Fibre Maturity - Original - vs. Recovedred Fibres - Spinning Mill A/B/C

Therefore, it is no longer correct to say that droppings exclusively consist of unripe fibres. The effect of reprocessing can especially be seen regarding fibre-length distribution. The 50 %-spanlength values for recovered fibres are according to fig. 6 always below the values of the original material.

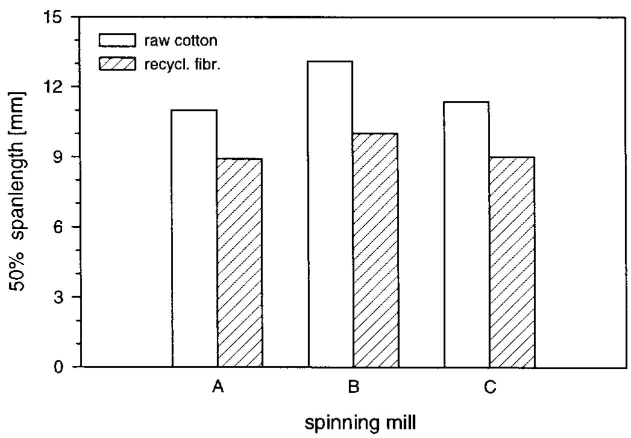


Figure 6. HVI-Spanlength (50% SL) - Spinning Mill A/B/C

No doubt, this shortening is influenced by the recovery process. Taking these facts into consideration, a direct comparison between grey cotton and recovered fibres is not quite correct. On the other hand, the recovered fibres are to be admixed to the blend as original raw material and for this purpose the quality of the admixed fibres is to be exactly known.

In this context, it is frequently questioned whether it is of use to recover fall-out fibres for the purpose of spinning combed and carded yarn. The main argument against this procedure says that the greatest part of the added recovered fibres will be combed out again. This matter will be further analysed on the basis of fibre-length distribution (fig. 7) as encountered at spinning mill B.

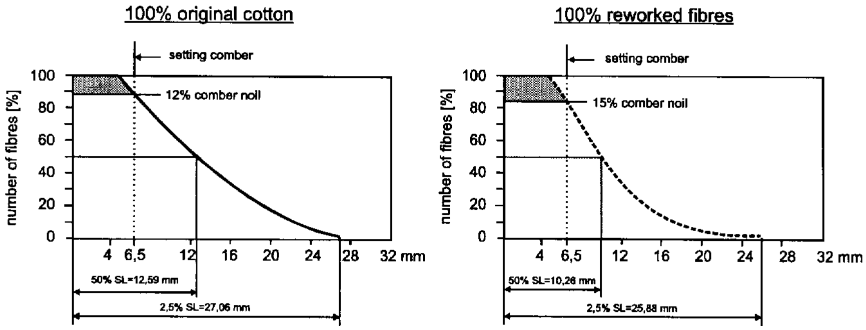


Figure 7. Fibre-Length Distribtuion - Spinning Mill B

There, the combing machines are adjusted to an average comb-out rate of 12 %. In accordance with the fibre length diagram, all fibres shorter than 6,5 mm would theoretically be combed out from the original raw material. With the same setting, the combing machines comb out about 15 % of fibres of recovered fibre material. If a sliver of 100 % fall-out fibres was to be produced the combing rate would be of the order of 15 %. However, being given that the recovered fibres are to be admixed at small percentage rates, a noticeable percentage increase of comber waste cannot be ascertained in most cases.

This fact furnishes the proof that the upgrading of droppings represents an important instrument for raw material savings and cost reduction in the spinning of combed- and carded yarn, as well.

From the more economic point of view, a 3 %-saving on raw material in the production of a 20-tex yarn would require a saving on wages of about 35 % in order to achieve an equal effect of economy.

The analysis of the composition of the droppings revealed that they contain 40 to 45 % trash and dust on average, the rate of extractable fibres thus being of the order of 50 to 60 %. There rises the technological task to gently and efficiently clean a material containing about 50 % of foreign matter. Generally, the medium rate of contamination of grey cotton used in spinning mills does not exceed an average value of between 3 and 4 %. This means that droppings contain about 10 times more trash and approximately 100 times more dust than grey cotton does. Attempts to clean these droppings by means of traditional blow-room equipment failed because of the high percentage of contaminants contained in the input material. Very soon it became obvious that a special machine would have to be developed in order to cope with this substantial level of contamination. In practice, this means that, by weight and per unit of time, such a machine would discharge just as much waste as recovered fibres, a fact which is of importance with regard to waste discharge. A blow-room machine designed for the discharge of 40 to 50 kgs of contaminants per hour does not exist.

The following requirements had to be met by the new machine concept:

1. Early-stage separation of heavy parts in order to keep these off from the actual cleaning machine. There would also be a risk that the heavy parts are broken up to small fragments which would merely aggravate the problem.
2. Homogeneous presentation of well pre-opened input material.
3. Efficient trash separation through high-centrifugal forces with maximum opening of the fibre material.
4. Substantial dedusting achievable by no other means than by an efficient air-flow.

All these requirements led to a machine concept as it has been realized with the Clean-Star System (Temafa GmbH). The Clean-Star System does not only comprise the actual cleaning machine but is a system of machines - as the name itself says - where the individual machines are combined with each other. One component of the system is a Heavy Parts Separator (fig. 8) preceding the cleaning machine.

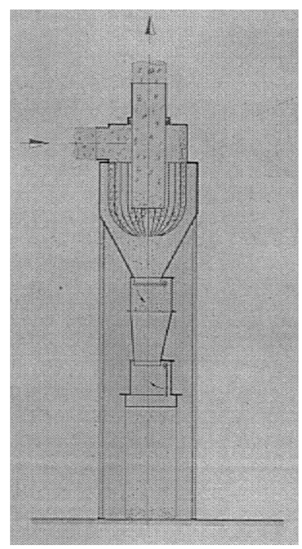


Figure 8. Schematic View of Pneumatic Cleaner (Heavy Parts Separator)

A suitably designed air-flow arrangement allows heavy particles like trash, wood and seeds to fall off downwards and out of the sphere of the air-flow. About 15 % of the contaminants are separated in this way, i.e. without any mechanical strain being applied. These particles will not encumber the cleaning machine itself and the risk of larger particles being broken up, thus, gets considerably reduced. The Heavy Parts Separator works with underpressure according to a patented principle preventing dust from being liberated to the outside.

The actual cleaning machine is the Clean-Star.

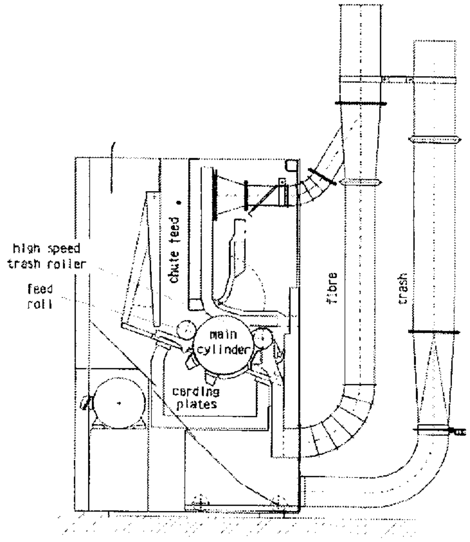


Figure 9. Schematic View of Clean-Star

The principal component of this machine and an absolutely new element in cotton cleaning is a high-speed trash roller, working width 1 m, working according to the principle of contaminant separation on the OE-machine . It is of advantage that small trash particles and even neps are separated, as well. The high speed of 6000 1/min generates centrifugal forces of an extent that has been unknown up to now in the area of cotton blow-room machinery. The cleaning effect,thus, achieved with the Clean-Star System is far superior to the degree of cleaning obtainable with blow-room equipment only. If we assume an average trash content of 55 % in the input material and an output material containing 2,5 % residual trash, the cleaning effect with the Clean-Star System is of the order of 90 to 95 %. Traditional blow-room machines achieve a cleaning effect of only 30 to 50 % depending on the rate of material throughput.

Summing up, we have reached the following findings concerning the quality of recovered fibres:

1. The grade of maturity and fibre thickness of reprocessed fibres is quite similar to the corresponding properties of the original raw material.
2. The recovered recycled fibres are classified as being only slightly inferior with regard to fibre length and tensile strength. Notwithstanding this fact, the application of recovered fibres in combed assortments does not seem to be excluded.
3. The percent-contamination of recovered fibres mostly appears to be lower compared to the contamination of the original grey cotton.

With these premises there rises the interesting question if a risk of impairing yarn quality is a function of the percentage rate at which admixed fibres are added.

For test purposes a determined quantity of droppings up to and including card strips, was taken from each spinning mill in proportion to their occurrence in order to be blended and then processed through the Clean-Star System. In spinning, the percentage of recycled fibres was continuously increased whilst checking the yarn quality and processability (thread breakage).

The following criteria appear to be important with regard to yarn quality:

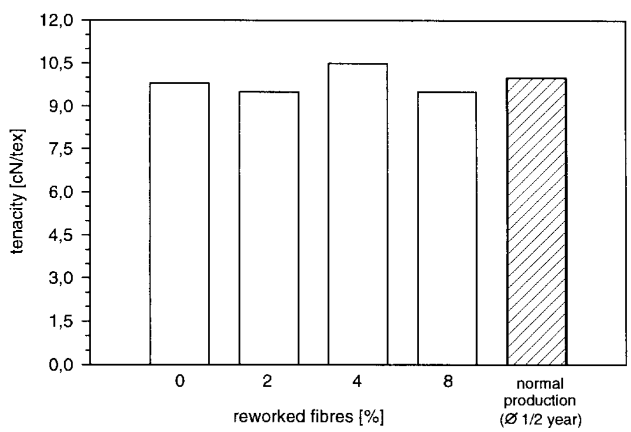
tensile strength, irregularity, thin sections,
thick sections, neps, hairiness, Classimat faults.

Each quality of yarn resulting from the different percentages of admixtures was compared with the standard running production not using admixtures of recycled fibres.

Furthermore, the average value of the corresponding quality over the last six months was ascertained in order to find out the variation of quality fluctuations due to the differing inputs of raw material. This is called 'average production'.

In the following, only the outstanding yarn properties will be illustrated:

Fig. 10 and 11 show the values for OE-yarn 25 tex (Ne_c 24) with regard to tensile strength and elongation whilst increasing the percentage of admixtures.



Yarn - Figure 10. Tenacity of Rotor Spinning Mill A

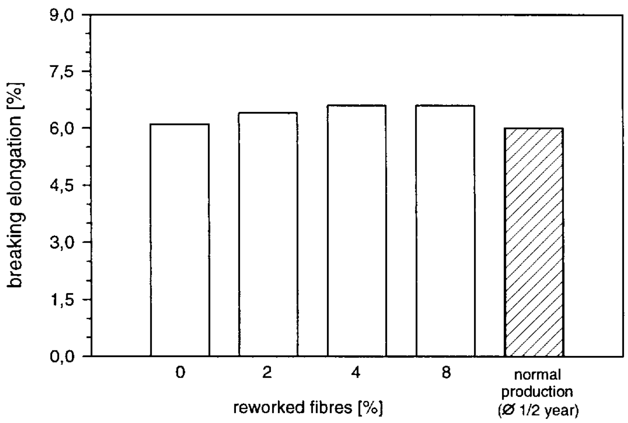


Figure 11. Breaking Elongation of Rotor Yarn - Spinning Mill A

As you can see, the data don't show any tendency to depend on the percentage of admixtures. In spite of the addition of recycled fibres the values correspond to a 0 %-admixture.

The yarn evenness according to Uster CV % equals in the case of the various admixtures the evenness of yarns produced without adding recycling fibres (fig. 12).

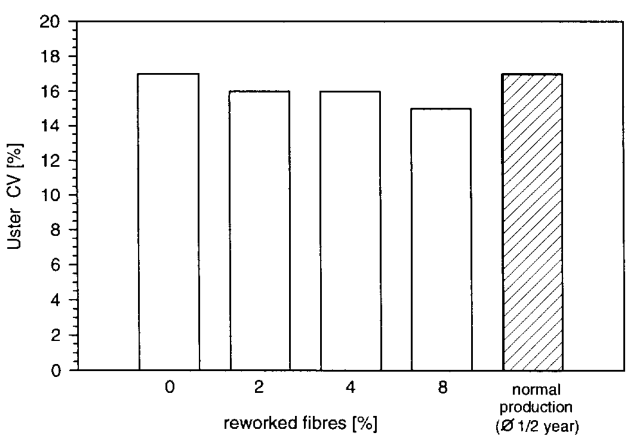


Figure 12. Uster-CV of Rotor Yarn - Spinning Mill A

Every experienced spinner knows to which extent the occurrence of neps is subject to variations. A systematic relation between percentage of admixture and nep occurrence has not been observed (fig. 13).

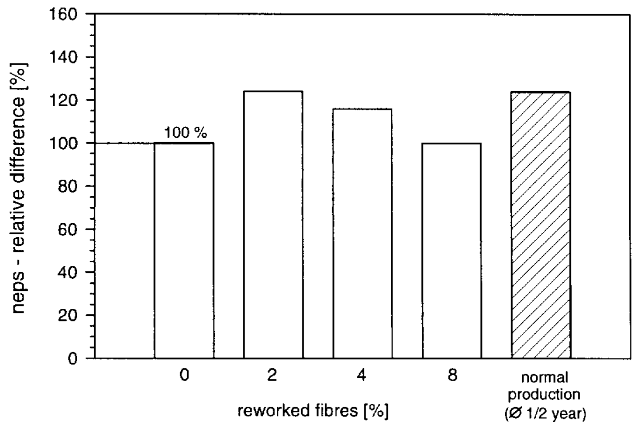


Figure 13. Number of Neps of Rotor Yarn - Spinning Mill A

The processing efficiency was checked by measuring the rate of thread breakages occurring (fig. 14).

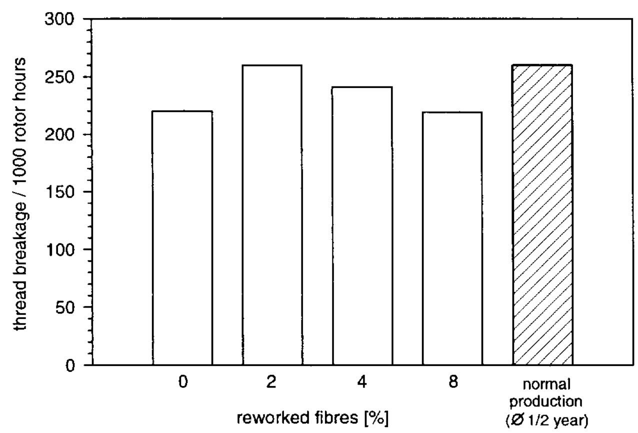


Figure 14. Running Properties of Rotor Yarn - Spinning Mill A

Processability features could be checked by means of a data display arranged at the OE-machines. Furthermore, the deposits on the rotor were examined. No influence due to recycling-fibre admixture was noted with regard to processing efficiency or deposits in the rotor. And, neither were any Moiré effects visible during the subsequent weaving tests (fig. 16). The frequency of thread breakages varies as does the number of neps occurring. During these tests all values registered were lower than the average value of the last 6 months.

Results in Spinning of Combed Yarn up to Ne 60

The results achieved at mill C spinning combed yarn up to Ne 60 should be of special interest. In this spinning mill, the average percentage of comber waste is of the order of 18 % when producing a yarn of Ne 60. Besides, this mill incorporates new blow-room installations as well. In this case, everything had been tried to reduce the rate of droppings to a minimum whilst obtaining an optimum cleaning result.

At this spinning mill there results a slight percentage increase in comber waste occurrence as a function of the percentage of admixtures applied (fig. 15).

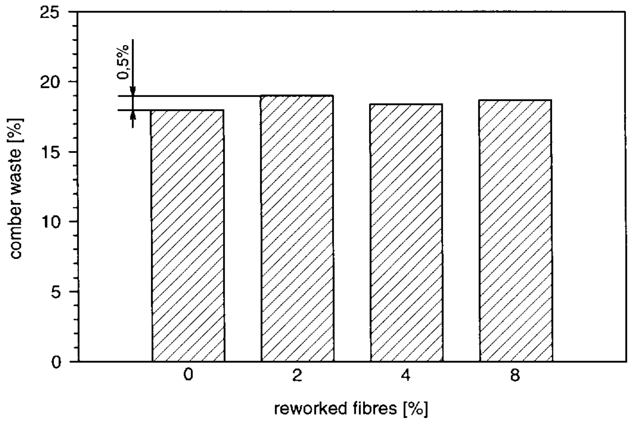


Figure 15. Influence of Admixed Fibres [%] on comber Waste in [%] - Spinning Mill C

Even under these circumstances, the use of recycled material in the combed yarn sector is economical when operating the latest state-of- the-art equipment in blow- and card-room.

Of greater interest in this context are the data obtained with regard to yarn evenness. With this high-count yarn evenness is not a function of the percentage rate of recycled fibre admixtures (fig. 16).

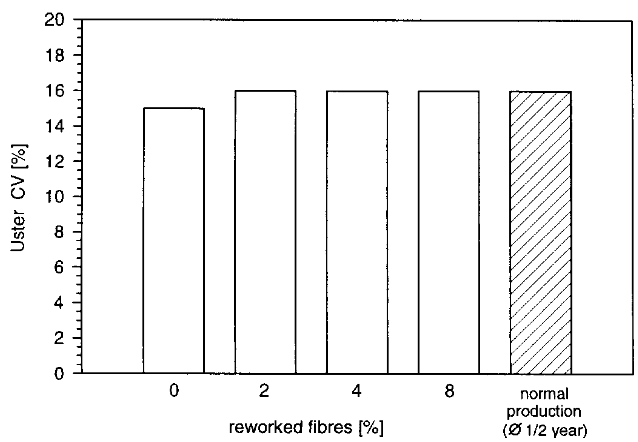


Figure 16. Influence of Admixed Fibres [%] on Uster-CV [%] - Spinning Mill C

As far as the occurrence of neps (fig. 17) is concerned, the rate encountered during the tests at spinning mill C was even below the average level registered during the previous six months. This must be ascribed to the raw material processed at the period of testing.

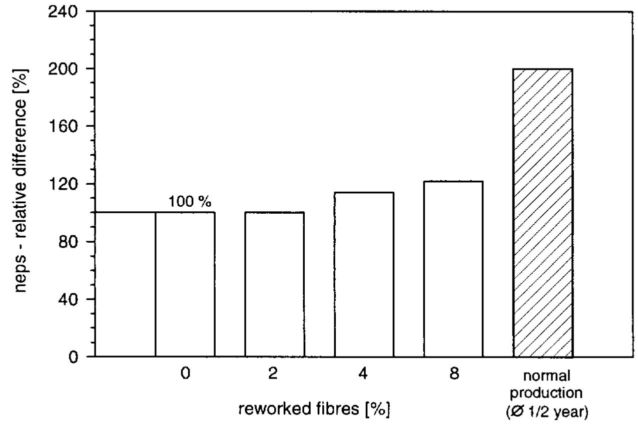


Figure 17. Influence of Admixed fibres on Neps - Spinning Mill C

These findings show that there is no systematic variation in the quality of combed yarns as a function of the percentage of recycled fibres admixed.

Here, too, an analysis of yarn breakages reveals interesting facts. During all test procedures, end-downs counted at the ring-spinning frame ranged around the normal level of spin-stability. We, thus, confirmed that even with combed yarns of yarn count Ne 60 the processability is not affected when adding recycled fibres to the original material.

Summary

In addition, I would like to give you some information about a Swiss mill which was operated with the Clean-Star System for several years. The percentage of cotton waste regarding an US-cotton blend which they process is normally between 5 and 6 %. Experiences show that about half of this percentage can be recovered without risk to quality.

Finally, I'd like to add some basic information concerning fibre preparation.
Each machine for fibre cleaning, opening and dust removal has its typical characteristics concerning cleaning efficiency and capacity. As far as cleaning machines and cards are concerned, cleaning efficiency decreases as soon as production is increased. This means that there will be a higher trash content. The same applies to recycling machines. The differences between good and bad machines are illustrated by the following figure (fig. 17). If production is raised, cleaning efficiency will decrease.

You will note, that the output of machines increases in relation to the input because of worse cleaning and reduced short-fibre elimination.

Here, we must remember that this only appears to be profitable. Due to a qualitative aggravation of the input material short fibres and neps will increase.

In our opinion, fibre recycling makes sense with this critical material only, if the best quality possible is achieved. Also with lower throughput (production), recycling is economical. Production should not take precedence.

In Europe, recycling at 120 lbs/hr is profitable.