QUALITY MANAGEMENT

Application Report

Management of outlier bobbins in ring spinning mills

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Contents

1 Introduction

With the introduction of electronic textile laboratory systems a few decades ago most of the spinning mills have started to systematically take samples in the production area (Fig. 1). With this method quality managers could establish a quality management system with which the influence of the raw material, the spinning machinery, the environmental conditions, etc., could be analyzed.

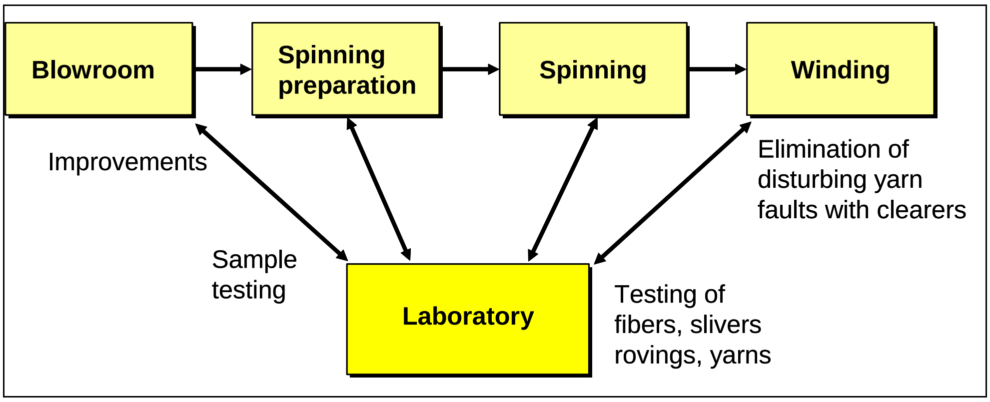

Fig. 1
Testing system found in most of the spinning mills

With such quality improvement methods it is also possible to establish quality statistics for each article or each machine and to compare the quality level of the mill with competitors by means of international benchmarks, e.g. the USTER® *STATISTICS*.

It has to be taken into consideration, however that spinning mills mostly have more than 20’000 production positions. Therefore, a mill has to expect many outlier bobbins every day. An outlier bobbin can be characterized as a bobbin which, when processed into a woven or knitted fabric, can be recognized by the human eye as a defect either in grey fabric or after dyeing. The quality characteristics of such bobbins deviate from the tolerance band throughout the bobbin and may also lead to manufacturing problems in subsequent processes.

This paper deals with proven methods how outlier bobbins can be conquered in a ring spinning mill.

2 Where do outlier bobbins come from?

A ring spinning mill differs from many other industries by the high number of production positions. In order to produce 5 to 20 tons of yarn per day it is required to install 20’000 to 30’000 ring spinning positions which are operated 24 hours per day, 7 days per week. The daily production very much depends on the yarn count.

Therefore, the risk of having worn out or defective machine parts such as card wires, rollers of drawboxes, ring travelers, spindles, etc., which produce outlier bobbins every day, is very high.

One single yarn in a woven or knitted fabric which is beyond the tolerance limits can deteriorate the entire fabric.

Therefore, there is a considerable interest in all spinning mills to detect such bobbins and to eliminate them from the spinning process.

3 Tools for the detection of outlier bobbins

3.1 Description of the detection principles

In order to speed up the recognition of outlier bobbins the capabilities of on-line and off-line systems have to be combined. Table 1 shows the properties of off-line and on-line systems.

Off-line:	On-line:
• Sample testing	• 100% monitoring
• High reproducibility	• Detection and elimination of seldom-occurring events
• High accuracy	• Enormous amount of data
• Interlaboratory comparison	• Sound statistical platform
• Comparison with benchmarks	• Trend analysis

Table 1
Capabilities of off-line and on-line systems

Table 1 underlines that on-line systems have one particular characteristic: 100% of all yarns are tested. In an average size spinning mill about 1 million km of yarn is produced per day.

3.2 Seldom-occurring yarn faults and inferior quality characteristics

When using on-line systems for the measurement of 100% of all bobbins we have to distinguish the following:

- There are some seldom-occurring yarn faults which are disturbing in a fabric and which have to be eliminated with a yarn clearer on the winding machine (Fig. 2).
- There are some deteriorations of quality characteristics of a bobbin which can considerably downgrade a fabric and which concerns the entire bobbin (Fig. 3).

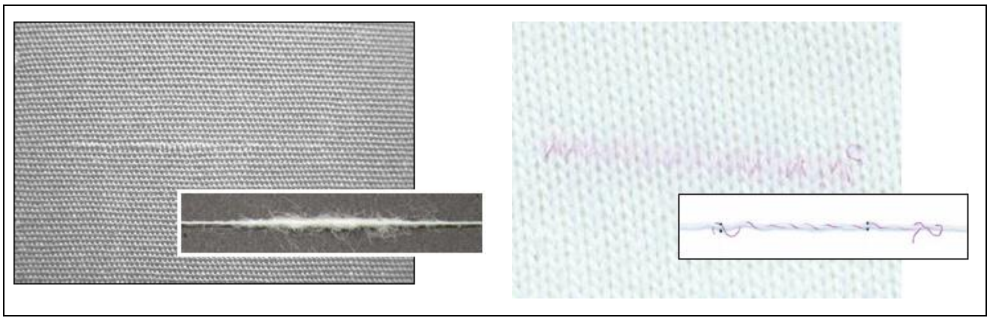

Fig. 2
Seldom-occurring faults / Thick place on the left, foreign fiber on the right

Disturbing faults must be eliminated on the winding machine. However, every cut has to be replaced by a splice. The number of cuts per 100 km varies in the textile industry between 10 and 70 for each of the above mentioned yarn faults.

Bobbins which have quality problems such as high unevenness, high number of imperfections, excessive hairiness, periodic faults, high cut rates, have to be ejected at the winding machine, because these inferior quality characteristics are not seldom-occurring events, but available throughout the bobbin.

Fig. 3 shows 2 different types of quality problems (knitted fabric on the left, woven fabric on the right).

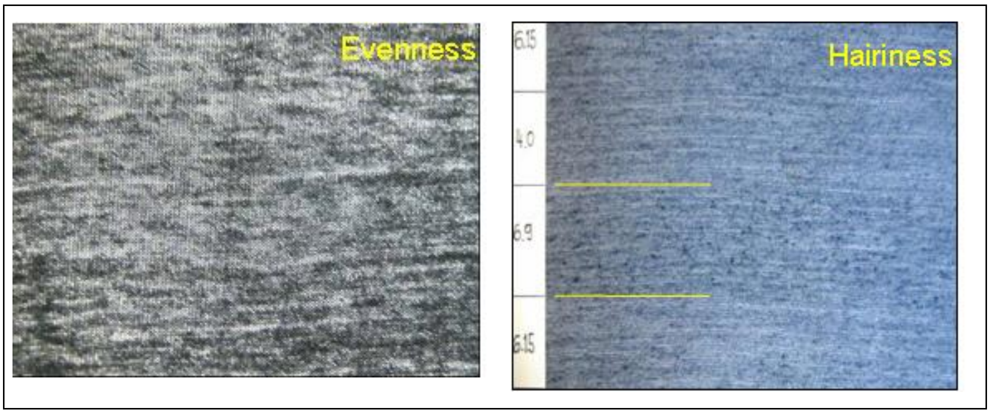

Fig. 3
High unevenness on the left and high hairiness variation on the right

The clearer has the capability to measure unevenness, imperfections, hairiness, etc., and, therefore, can separate the bobbins with excessive quality characteristics.

Fig. 4 represents on a historical overview what kind of disturbing faults can be corrected directly on the winding machine because they are seldom-occurring events.

Bobbins of inferior quality characteristics throughout the bobbin can be recognized and, afterwards, the bobbins can be ejected at the winding machine.

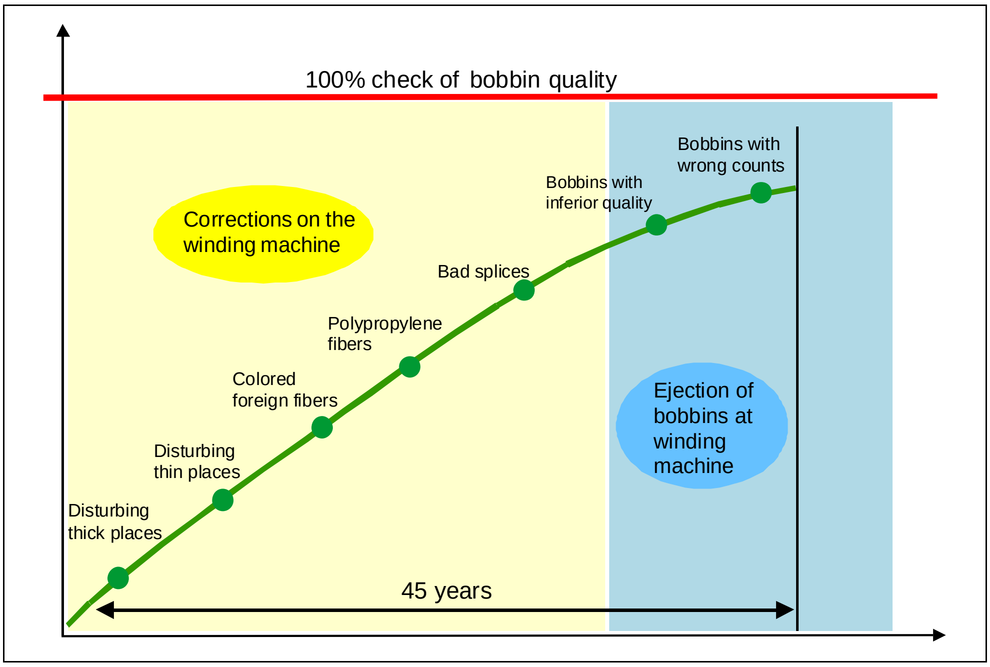

Fig. 4
Quality problems which could be conquered in the past 45 years

In Fig. 4 it is also demonstrated that a significant part of the existing quality problems in yarn manufacturing can be detected with modern yarn clearers and that we are approaching the 100% line. This line is the reference and the long-term objective to get rid of all disturbing faults which may occur within a specific spinning process. Fig. 4 also explains that spinning mills have a tool available today with which they can handle many quality challenges in spinning mills today.

3.3 Limitations of online systems

As already mentioned, a yarn clearer has the capability to separate outlier bobbins from the production line. However, the clearer is not an ideal tool to analyze outlier bobbins in order to find the sources of inferior quality. For this purpose the laboratory systems offer much more options.

3.4 Criteria to select the limits for quality characteristics

Bobbins which exceed the selected limits of quality characteristics have to be ejected at the winding machine. For this purpose we first have to discuss the characteristics which can be detected with a modern yarn clearer:

- Unevenness
- Frequent thin places
- Frequent thick places
- Frequent neps
- Hairiness
- Periodic faults
- Excessive cuts
- Clusters of faults

For establishing a real quality management system it is of utmost importance that selections made by the yarn clearer with respect to quality characteristics can be verified in the laboratory.

The following are a few examples to explain what this means.

Fig. 5 represents the monitoring of a yarn unevenness on the winding machine (USTER® *QUANTUM*) and in the laboratory (USTER® *TESTER 5*) over a period of 84 week. It can be noticed that the unevenness is increasing in the first year from 12,8 to 13,0%. After the 55th week the unevenness is increasing considerably. This increase is shown by the yarn clearer and also by the evenness tester in the laboratory.

This indicates that we can analyze the ejected bobbins in the laboratory and find the origin with all the evaluation options which a laboratory system can offer.

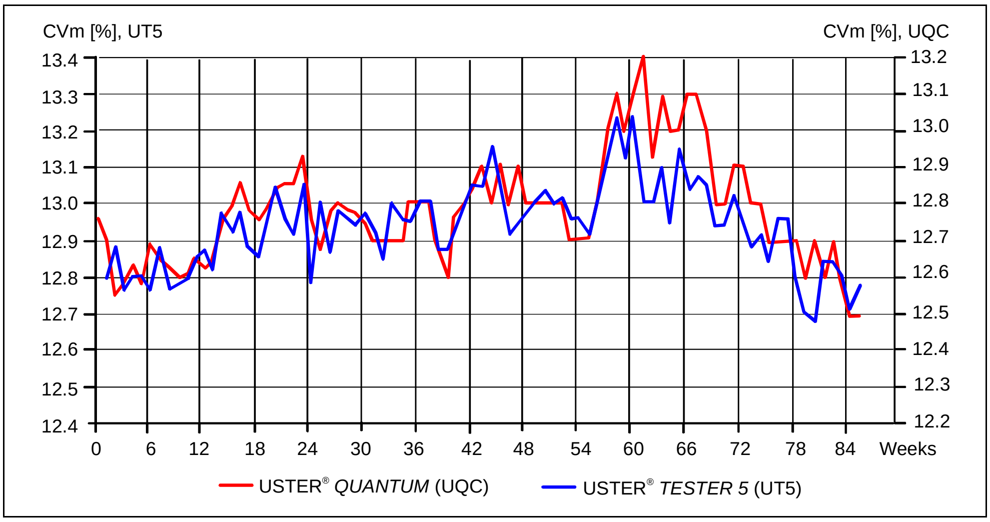

Fig. 5
Evenness CVm, Count: Nec 30, ring-spun yarn, cotton, combed

Fig. 6 shows an example of a comparison of thick places on the machine and in the laboratory over a period of 48 weeks.

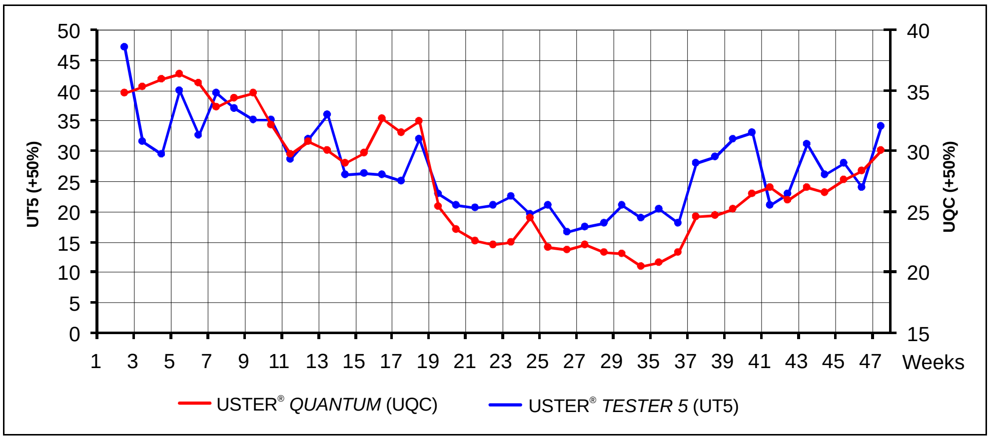

Fig. 6
On-line monitoring of thick places / Count: Nec 30, ring-spun yarn, cotton, combed

Fig. 7 shows the determination of hairiness on the machine over a period of 34 weeks.

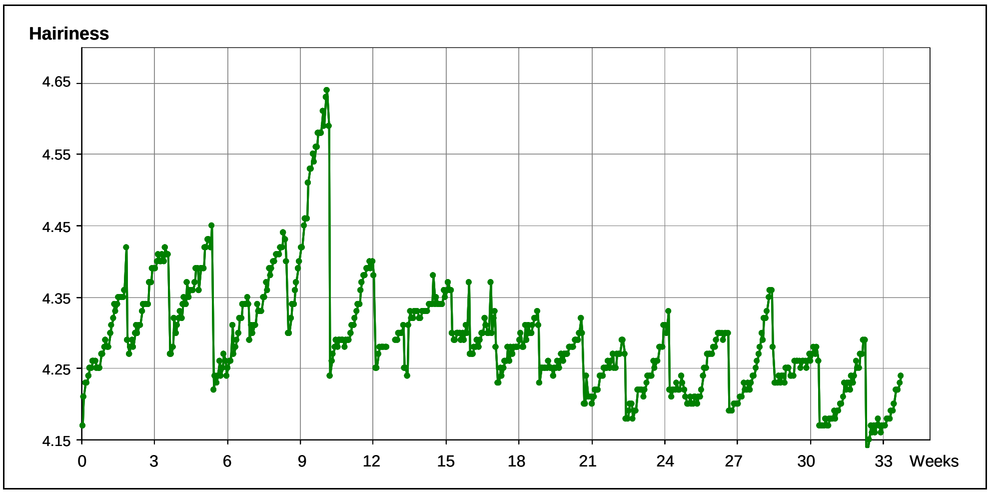

Fig. 7
On-line monitoring of hairiness / Count: Nec 30, ring-spun yarn, cotton, combed

In week 10 a massive increase of the hairiness can be noticed.

Fig. 8 shows the distribution of the hairiness of another yarn batch on the winding machine. A threshold was selected to separate the bobbins which exceed the warning limit. Yarns with hairiness values beyond the warning limit can be recognized in a woven or knitted fabric.

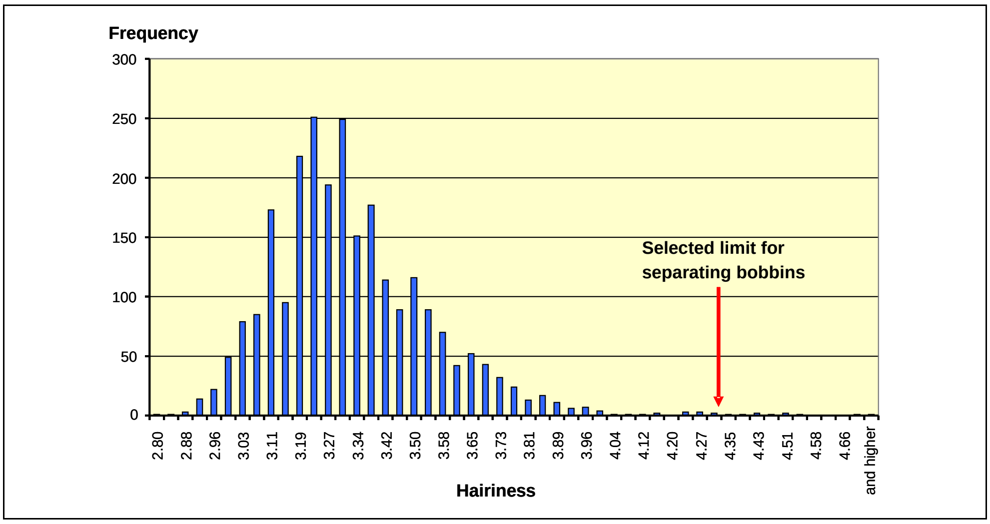

Fig. 8
On-line hairiness measurement / Count: Nec 40, ring-spun yarn, cotton, combed

Fig. 8 shows the distribution of the hairiness measured on a winding machine on 2500 bobbins.

3.5 Installation of a quality management system to eliminate outliers

In the previous chapters it was explained in detail how modern quality management tools can contribute to the improvement of the performance of a spinning mill. However, we identified some areas where the mill managers and the quality managers still suffer. One significant quality problem are outlier bobbins. Since one single thread in the warp on a weaving machine can downgrade the entire woven fabric, it is of utmost interest to get rid of outliers.

Therefore, a well organized spinning mill has a maintenance and repair crew which permanently improves outliers among the production positions. The repair crew, however, needs input from the laboratory where systematic quality analyses are made.

Fig. 9 shows the principles of operation in a modern spinning mill.

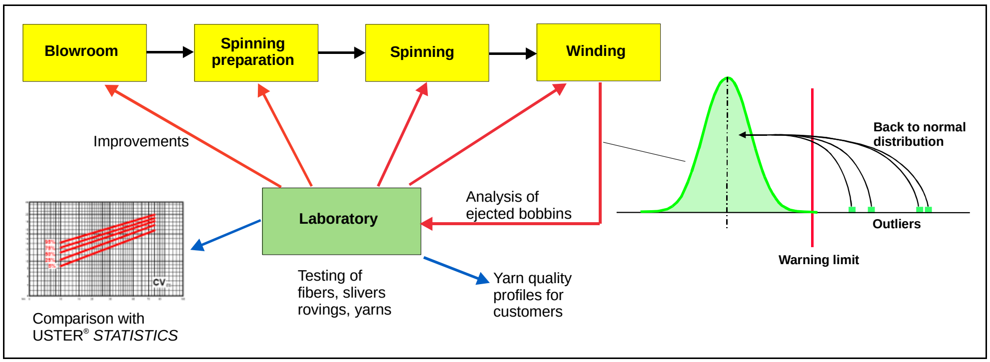

Fig. 9
The bobbins which are ejected by the winding machine are analyzed in the laboratory. Outliers are brought back to the normal distribution.

The bobbins of individual spinning machines are marked to identify the production positions where the ejected bobbins came from.

The ejected bobbins are brought to the textile laboratory where the quality problems are evaluated. The findings are listed on an instruction sheet for the repair crew. It is the intention to bring back the outliers to the normal distribution (Fig. 9).

The maintenance and repair crew has to undertake the repair works at the machines (Fig. 10). Successful repairs are reported back to the laboratory.

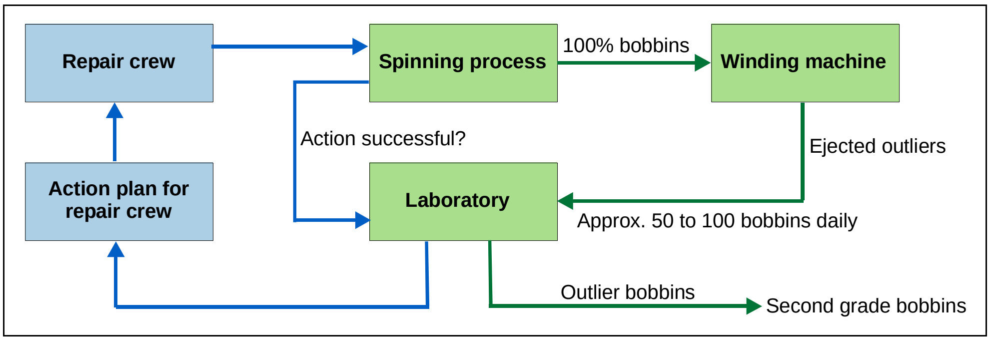

Fig. 10
Recommendations for a systematic quality management

Bobbins which are recognized as having tolerated quality characteristics will go back to the yarn batch. The outlier bobbins will be handled as second grade bobbins and eliminated from the production.

3.6 Tracing back outliers bobbins to the source

Bobbin identification method

The easiest way to trace back outlier bobbins is the designation of each bobbin with the number of the spinning position. This identification can be realized for one ring spinning machine within 20 minutes.

Fig. 11 shows the identification of the bobbins.

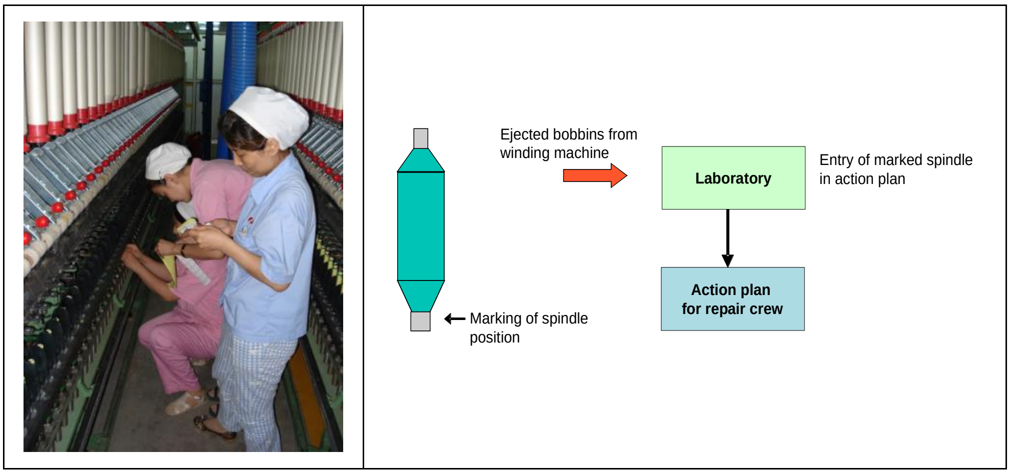

Fig. 11
Identification of spinning positions for one doff

If the winding machine ejects a bobbin from this ring spinning machine, it is easy to find the spinning position where the bobbin was produced.

Therefore, it is recommended, particularly in low cost countries, to designate the bobbins of one doff and one machine every day. In a medium size spinning mill of 20’000 to 30’000 spindles it will last approximately 20 to 30 day to check and trace back all the outlier bobbins in a mill.

Identification process:

- The spinning mill establishes a test plan which ring spinning machine has to be tested at what day.
- All the bobbins of this machine are identified for one doff so that the laboratory operators know where the ejected bobbin came from.
- The production position which produced the ejected bobbin is entered into the action plan for the maintenance and repair crew.
- The maintenance and repair crew receives an action plan from the laboratory.

Fig. 12 shows part of an action plan for the maintenance and repair crew. The yellow part is filled in by the laboratory staff. This part also has a column where the laboratory operators insert the expected source of the fault.

The green part of the action plan is filled in by the repair crew. They also confirm if the expected source proposed by the laboratory staff was correct. If the crew finds another fault, the technical problem is described in detail.

The action plan goes back to the laboratory the same day when all the actions are finished.

Machine	Spinning position	Detection in laboratory	Expected source	Source found by repair crew	Action taken	Time for repair	Signature	Date
14 RSM	231	Peak in spectrogram at 8 cm	Damage on front roller, ring spinning	Contamination of front roller due to honeydew	Cleaned front roller	10 min		June 25, 2007
14 RSM	284	High periodic hairiness	Ring traveller	Ring traveller worn out	Replaced ring travellers	5 min		June 25, 2007
3 Finisher drawframe		Periodicity at 28 m	Contamination of drawbox of finisher drawframe	Same	Cleaned drawbox of finisher drawframe	10 min		June 25, 2007

Fig. 12
Systematic repair of defective production positions

Lessons learned with the first systems in mills:

- The yarn monitoring system on the last machine in the spinning process also has to check the quality characteristics.
- The monitoring of the quality characteristics on the winding machines offers new opportunities to considerably lower the daily outlier bobbins.
- Modern on-line systems support spinners to keep the quality of every yarn package within pre-set limits.

Outlier bobbins produced by non-identified spinning positions

As has been mentioned above, the bobbins of all spinning positions are identified once in 20 to 30 days. This method allows a precise tracing back of outlier bobbins to the source of the problem.

However, in a spinning mill with 25 ring spinning machines there are 24 machines which deliver non-identified outlier bobbins to the laboratory via the winder at a certain date. If there is a clear assignment in the mill what kind of bobbins were processed on what winding machines, it also allows the assignment of the type of problems at least to a specific spinning machine.

If a spinning mill uses link systems, the back tracing of the bobbins to the ring spinning machine is easy. In spinning mills with stand alone winders it depends on the organization of the mill.

Example: If more and more non-marked bobbins exceed the hairiness thresholds, it may be time to replace the ring travelers.

3.7 Examples from the industry

The closed loop system was tested in the industry with considerable success. If the clearer really can detect quality deviations from established benchmarks, it will also be possible for the quality specialists to trace back the yarn faults to the origin. The following are a few examples where faults could be traced back to the ring spinning machine.

Examples 1 and 2

A bobbin was ejected by the automatic winding machine as an outlier, because the evenness (CV_m) was too high. In the laboratory the high evenness could be confirmed. Since the bobbin was identified with the spinning position at which the yarn was produced, the repair crew found that the top roller of the respective drawbox was contaminated with honeydew (Fig. 13).

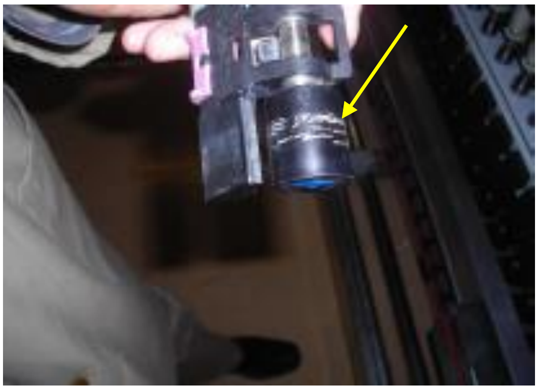

Fig. 13 Honeydew on front roller

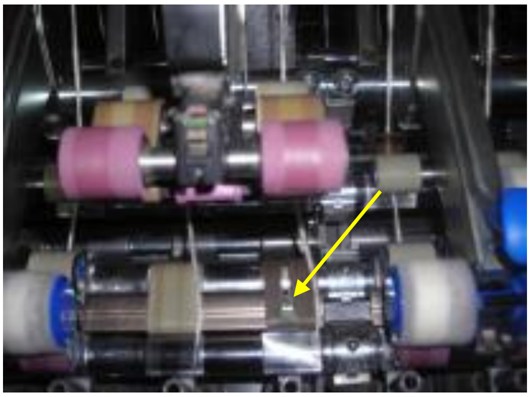

Fig. 14 Defective apron

Another outlier bobbin was ejected at the winding machine because the number of S-faults was too high. A check at the spinning machine could clarify that a defective apron with a hole has caused this alarm at the yarn clearer (Fig. 14).

Examples 3 and 4

Another outlier bobbin was ejected because of a high number of S-faults. After having confirmed this in the laboratoary as well, the check at the respective spindle at the ring spinning machine has shown that the apron of the drawbox moved in the wrong direction, and, therefore, the joint was defective (Fig. 15).

Fig. 15 Wrong direction of apron, bad joint

Fig. 16 Intensive contamination at output of drawbox

A bobbin was identified as outlier by the yarn clearer because the number of imperfections was too high. The check at the ring spinning machine has shown an accumulation of fiber fragments at the locations indicated by yellow arrows in Fig. 16.

3.8 Recommendations for a sampling plan

There are some limitations on the winding machine to reach the same accuracy as spinners reach in the laboratory. The reasons for these limitations are:

- Long maintenance cycles for clearers
- Contamination of the measuring zones of on-line systems as a result of a permanent monitoring, 24 hours a day, 7 days per week
- The yarn speed is not constant on a winding machine. Therefore, periodic mass variations cannot be measured directly on the winding machine. Periodic events have to be measured by indirect measurements such as the higher evenness or the frequent occurrence of thick and thin places. However, in the laboratory the operator can measure the yarns at constant speed and, consequently, an accurate spectrogram can be determined. With this precise information of specific periodicities the textile laboratory can elaborate a detailed action plan.
- The microclimate on the winding machine near the yarn clearer is given by various variables such as the environmental conditions in the winding room, the heat produced by the winder, etc. In the laboratory the environmental conditions are defined by international standards.

As a result of this it is strongly recommended to check the bobbins in the laboratory which are ejected at the winding machine due to quality problems.

Table 2 is a recommended test procedure for a textile laboratory in a mill with 27'000 spindles, cotton 100%, count range Ne 40 to Ne 80.

Machine	No. of machines or positions	Quality characteristics	Test intervals	Test speed	Test length	Required test time per day *
Card	12	Evenness Diagram Spectrogram Variance-length curve	2 per day	100 m/min	250 m	8 min
First draw-frame	2	Evenness Diagram Spectrogram Variance-length curve	2 per day	100 m/min	250 m	8 min
Comber	12	Evenness Diagram Spectrogram Variance-length curve	2 per day	50 m/min	250 m	16 min
Finisher draw-frame	4	Evenness Diagram Spectrogram Variance-length curve	4 per day	50 m/min	250 m	32 min
Roving frame	600	Evenness Diagram Spectrogram Variance-length curve	5 roving bobbins per day	100 m/min	250 m	16 min
Ring frame	27'000	Evenness Diagram Spectrogram Imperfections Hairiness Yarn diameter Density Trash	10 bobbins per machine every third day (90 bobbins daily)	800 m/min	1000 m	169 min
Winder	600	Evenness Diagram Spectrogram Imperfections Hairiness Yarn diameter Density Trash	60 ejected bobbins from winding machine daily 20 cones per day	800 m/min 800 m/min	1000 m 1000 m	113 min 39 min
Total						**401 min**

Table 2 Total test time required in the laboratory per day for this example

* Time required also includes setting of instrument and sample preparation

The total test time per day is equivalent to 401 minutes or 6 hours and 41 minutes. This indicates that the tests can be managed in one shift.

The total test time is based on an average work load in the laboratory. However, the slivers of the cards, drawframe, combers, etc., can also be measured at the same day.

As a measure for corrections at machines with non-identified bobbins we recommend to study the action plan once per day, to check the analysis of the outlier bobbins, to walk along each machine and to check the spinning positions.

4 Role of the laboratory in a modern spinning mill

4.1 Tasks of a modern laboratory

The textile laboratory in a modern spinning mill has to fulfill four tasks (Fig. 17):

- Systematic or random sample testing of the current production for statistical reasons.
  - Elaboration of a statistical platform for raw material, slivers, rovings and yarns. For yarns the mill statistics can be based on machines or articles Comparison with international benchmarks (green arrows, Fig. 17). The production statistics are based on bobbins.
  - Set up of new machines. Check of slivers, rovings or yarns and comparison with known benchmarks or agreements.
  - Changing of articles. Comparing quality characteristics with internal statistics, if already available. Modification of machine settings if quality characteristics are not within given limits, agreed with customer yarn quality profile.
- Production of yarn quality profiles for customers (blue arrows, Fig. 17). These quality profiles are frequently based on cones.
- Analysis of bobbins which were separated by the yarn clearer as outliers (red arrows, Fig. 17). Listing of an action plan based on outlier bobbins as an instruction for the maintenance and repair crew.
- Development of new yarns (orange arrows, Fig. 17).

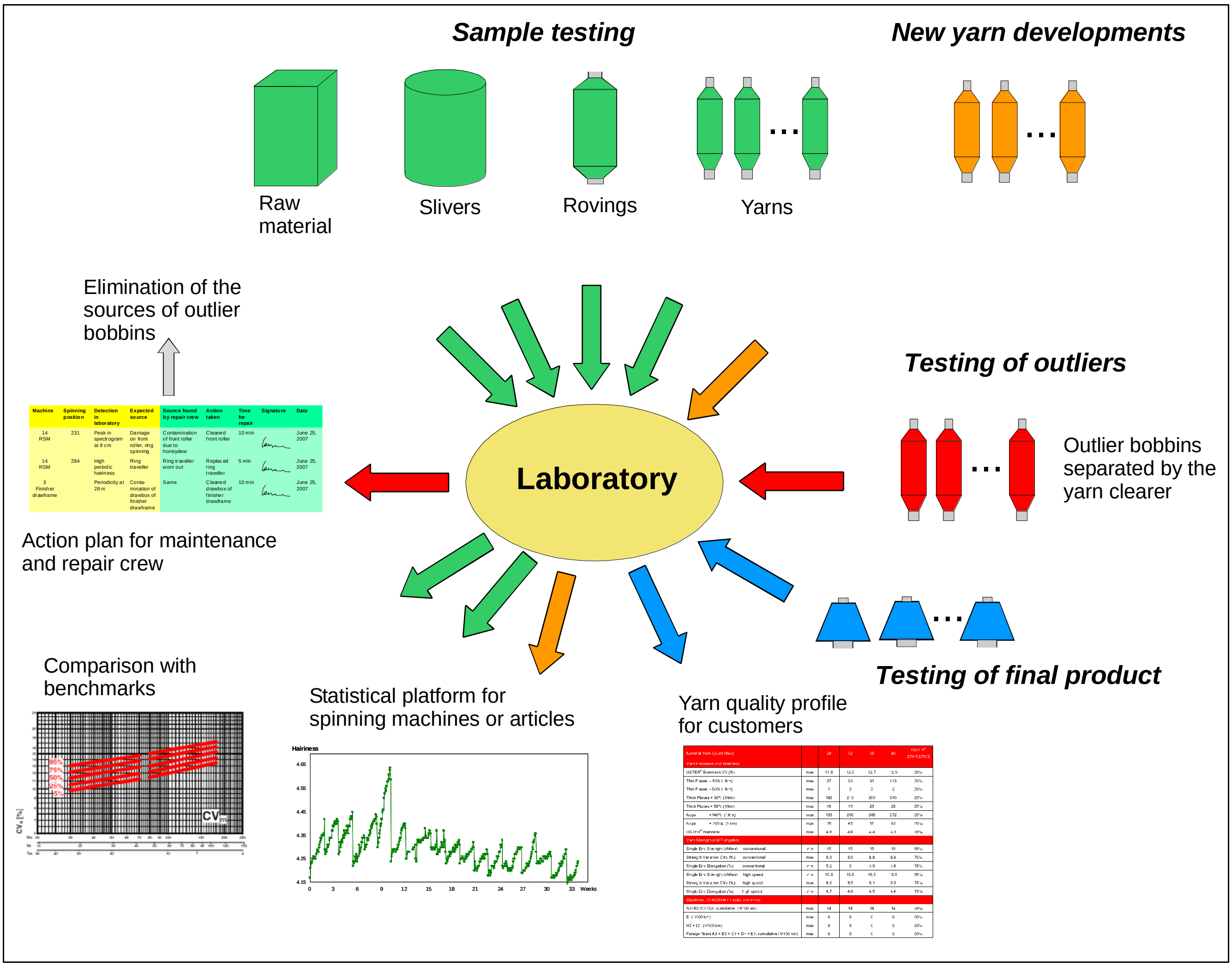

Fig. 17 Tasks in a modern laboratory

4.2 Sample testing

The sample testing in the laboratory includes the measurement of raw material in all stages of the spinning process. This includes also the measurement of sliver and rovings.

The systematic or random sample testing of the current production serves for an establishment of a sound statistical platform for the mill.

Raw material testing:

The bale lay-down is carried out with the USTER® *HVI* System whereas the process control is executed with the USTER® *AFIS* System. Process control means the monitoring of the raw material from the bale to roving.

It concerns the change of the fiber length, the short fiber content, the formation and elimination of neps, the reduction of dust and trash particles, etc., along the spinning process.

Evenness testing of slivers:

This test is used as a standard test to detect changes of the performance of cards and drawframes.

Evenness testing of rovings:

This test is used as a standard test as well to detect changes of the performance of the roving frame.

Testing of yarns:

Depending on the requirements the sample testing can be based on the yarns produced in the mill, i.e. for every batch which is produced for specific customers the mill has to define the quality characteristics for the mill statistics.

The samples are taken randomly from the machines where the yarn batch is produced. The size of the sample depends on the accuracy of the statistics which has to be established (see also Table 3).

Example: A spinning mill produces a combed cotton yarn for a specific customer, Ne 40, on 6 machines, 1008 spindles each, for 10 days. At these 6 machines 10 bobbins are taken randomly every third day during the day shift and measured in the laboratory. This production lot is equivalent to approximately 23 metric tons of yarn. The sample size after 10 days was 180 bobbins in total, which is sufficient for as a statistical basis for this lot.

A second option is a systematic check of all the machines to compare the result with benchmarks which already exist in the mill or with the USTER® *STATISTICS*.

For both mentioned options the mill uses the results for long-term statistics for various quality characteristics such as the fiber parameters, the evenness, the imperfections, the periodic faults, the strength, the elongation, the remaining disturbing thick and thin places and foreign fibers, etc. (see also Table 3).

Installation of new machines or maintenance:

After the installation of new machines or after the maintenance of machines the slivers, rovings and yarns have to be tested in the laboratory to be sure that the machines have the expected performance.

4.3 Elaboration of yarn quality profiles for customers

In a modern industrial environment the supplier determines the quality level of his products. This is a basic quality concept which is also supported by industrial standards such as ISO 9000. Consequently, if the yarn buyer asks for the quality characteristics of the yarn batch, the supplier will deliver these figures.
The figures are mostly based on the values of the cones because the cones are the final product of the spinning mill. If the yarn buyer is not satisfied with the quality of the yarn, the claims have to be based on the quality characteristics of the cones because the bobbins are not available anymore.
The yarn producer and the yarn buyer together have to define the yarn quality profile together. An example of yarn quality profile is shown in Table 3.

4.4 Development of new yarns

In most of the spinning mills it is not possible anymore to produce the same yarn counts with the same raw material for decades due to the high cost pressure for commodities. Therefore, mills have to be creative and have to penetrate into new areas such as slub yarns, microfiber yarns, mélange yarns, etc. The start-up of such developments consumes a considerable amount of the time in the laboratory.

An example of a yarn quality profile is shown in Table 3.

Nominal Yarn Count (Nec)		**28**	**32**	**36**	**40**	**USTER® *STATISTICS***
Fiber Quality						
AFIS: Number of neps, bale (1/g)	max	250	240	230	220	50%
HVI: Micronaire, bale	Range	3.8 – 4.5	3.8 – 4.5	3.8 – 4.5	3.8 – 4.5	
HVI: Fiber Length UHML (mm)	min	28	28	28	28	50%
AFIS: Fiber Length UQL(w), bale (mm)	min	30	30	30	30	50%
AFIS: Short Fiber Content SFC(n), finisher drawframe (%)	max	13	12	11	10	50%
Yarn Count and Twist						
Deviation of Count (%)	max	± 2.5	± 2.5	± 2.5	± 2.5	
Count Variation CVb (%)	max	1.5	1.5	1.5	1.5	
Twist Multiplier alpha e	max	3.6	3.6	3.6	3.6	
Variation of Twist CVt (%)	max	3	3	3	3	
Direction of Twist		Z	Z	Z	Z	
Yarn Evenness and Hairiness						
USTER® Evenness CV (%)	max	11.8	12.5	12.7	12.9	20%
Thin Places - 40% (1/km)	max	37	60	91	113	20%
Thin Places - 50% (1/km)	max	1	2	2	2	20%
Thick Places + 35% (1/km)	max	182	240	300	340	20%
Thick Places + 50% (1/km)	max	16	19	23	25	20%
Neps +140% (1/km)	max	153	200	245	272	20%
Neps + 200% (1/km)	max	35	45	57	63	20%
USTER® Hairiness	max	4.8	4.6	4.4	4.3	50%
Yarn Strength and Elongation						
Single End Strength (cN/tex) conventional	min	15	15	15	15	95%
Strength Variation CVb (%) conventional	max	8.3	8.6	8.8	8.9	75%
Single End Elongation (%) conventional	min	5.2	5	4.9	4.8	75%
Single End Strength (cN/tex) high speed	min	16.5	16.5	16.5	16.5	95%
Strength Variation CVb (%) high speed	max	8.6	8.9	9.1	9.3	75%
Single End Elongation (%) high speed	min	4.7	4.6	4.5	4.4	75%
Significant *CLASSIMAT* Faults, remaining						
A3+B3+C2+D2, cumulative (1/100 km)	max	14	14	14	14	50%
E (1/100 km)	max	0	0	0	0	50%
H2 + I2 (1/100 km)	max	0	0	0	0	50%
Foreign fibers A3 + B2 + C1 + D1 + E1, cumulative (1/100 km)	max	0	0	0	0	50%

Table 3 Yarn quality profile

4.5 Analysis of outliers

A permanent headache in a spinning mill is the production of outlier bobbins. An outlier bobbin is a bobbin where one or more quality characteristics exceed preselected thresholds.

The thresholds are set on a level where faults may be recognized in woven or knitted fabrics, particularly after bleaching or dyeing.

A modern yarn clearer such as the USTER® *QUANTUM* clearer can separate the outlier bobbins.

The clearer, however, does not analyze the bobbins in detail. On the display of the winding machine the type of alarm is indicated, but no analysis is made about the source of the fault. For this purpose there are better tools available in the laboratory.

This can be underlined with 2 examples:

- A periodic mass variation due to a front roller defect on one position of the ring spinning machine will increase the coefficient of variation of evenness CVm of the yarn. It may also trigger the “pearl chain channel” which indicates that there are numerous faults in the same fault length and mass increase area. However, since the yarn speed on the winding machine is not constant, the clearer cannot analyze that there is a specific periodicity with a wavelength of 8 cm by means of a spectrogram. Therefore, an analysis has to be made in the laboratory.
- A bobbin was rejected on the winding machine because the hairiness has exceeded the predetermined threshold. The diagram of the laboratory system has shown that a defective ring traveller of this particular ring spinning position has caused this fault.

5 Conclusion

Most of the spinning mills have an established quality management system based on sample testing. With such a quality system, however, it may take one year or more to get rid of outliers.

This paper describes a method with which outlier bobbins can permanently be separated on the winding machine with the help of yarn clearers and traced back to the faulty spinning position.

The method which is described in this paper also allows the daily elimination of outlier bobbins.

The described system is used by various mills with considerable success.

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