Improved analysis of yarns in the laboratory
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1 Introduction

According to the Uster Statistics the evenness of yarns has permanently improved in the past 50 years. This was the result of better tools to monitor and analyze yarns on OE rotor spinning and winding machines and in the laboratory. As a result, a significant increase of the productivity was possible over a long period.

However, when discussing quality items with weavers, knitters, traders and retailers, there are still substantial quality problems available which have its origin in yarn manufacturing. Such problems still deteriorate the margin in the textile industry.

Uster Technologies has contributed considerably in the past 60 years to improve the testing and monitoring systems to avoid second grade yarns. A new approach to define yarn quality was made with the development of the Uster Tester 5.

Fig. 1 shows the USTER® TESTER 5. This multi-purpose laboratory system has six sensors for the analysis of all kinds of yarn quality characteristics.

2 Yarn faults which affect the appearance of fabrics

The following are the four fundamental areas which affect the appearance of fabrics.

Below standard appearance of fabrics which are caused by evenness variations in yarns

• Short-term and long-term mass variations, thick places, thin places, neps and periodic mass variations belong to this category.
Below standard appearance of fabrics which are caused by the surface of the yarns

- The hairiness, the surface structure, the diameter and the shape (roundness) of the yarn belong to this group.

Below standard appearance of fabrics which are caused by the impurity of the yarns

- Seed coat fragments, remaining trash and dust particles and foreign fibers belong to this category.

Below standard appearance of fabrics which are caused by the bulk and bulk variations of the yarns

- The count, the density and the twist of the yarn fall into this category.

In order to provide the complete quality data of the yarn a multi-purpose laboratory system for spun yarns with 6 sensors was developed. The instrument is a modular system, i.e. some of the sensors are optional.

The following is a description of the opportunities for quality specialists to improve the consistency of the yarn quality with this new measuring system.

3 Below standard appearance of fabrics caused by evenness variations in yarns

The drawing processes in the spinning mills are measured with a capacitive measuring system (type CS). With this system it is easy to analyze slivers, rovings and yarns by means of a measuring comb. Since the measuring signal is proportional to the cross-section of the fiber assembly, the signals of a capacitive sensor are significant. Fig. 2 shows the detection of periodic mass variations in a cotton yarn by means of the spectrograms and the interpretation of the origin by the help of the knowledge based system of the instrument. In this case it was the front roller of the ring spinning machine which generated the red peaks in the spectrograms and which is marked in red color in the gearing diagram.
Fig. 3 shows the result of a slub yarn measurement. Each dot represents a slub. The slubs lengths vary between 3 and 7 cm, the mass increase between +100 and +300%.
All kinds of mass variations, therefore, can easily be measured with this type of sensor. Deviations of evenness to existing benchmarks which cause disturbances in the fabrics can be identified easily.

4 Below standard appearance of fabrics caused by the surface structure of yarns

A yarn may have a constant mass, but a varying surface structure which can affect the appearance of fabrics as well. In order to measure the surface structure two optical sensors were developed.

One optical sensor (type OH) is able to measure the hairiness. In order to avoid a high hairiness level or considerable hairiness variations between bobbins or cones the hairiness in a mill must be under control. Fig. 4 shows two pieces of fabric. The fabric on the left hand side is a reference fabric. The dark stripes which are visible in the fabric on the right hand side were caused by an excessive hairiness of individual bobbins.

The hairiness measuring system has a high reproducibility. Therefore, hairiness deviations can be analyzed with a high accuracy.

A second optical sensor (type OM) generates two light beams with an angle of 90 degrees. The yarn, therefore, is illuminated from two different sides. As a result, the sensor allows the measurement of the yarn diameter, the evenness based on diameter variations, the yarn roundness or shape, the surface structure and the density.

The yarn shape is defined as the ratio of the shortest to the longest distance of an elliptic cross-section of the yarn.
Table 1 shows the shape and the density of yarns of different spinning processes.

<table>
<thead>
<tr>
<th>Spinning Method</th>
<th>Shape</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact, combed, 100% cotton</td>
<td>0.81 – 0.88</td>
<td>~0.58</td>
</tr>
<tr>
<td>Ring, combed, 100% cotton</td>
<td>0.83 – 0.86</td>
<td>~0.51</td>
</tr>
<tr>
<td>Ring, carded, 100% cotton</td>
<td>0.79 – 0.82</td>
<td>~0.44</td>
</tr>
<tr>
<td>OE-rotor, carded, 100% cotton</td>
<td>0.68 – 0.77</td>
<td>~0.38</td>
</tr>
<tr>
<td>Air-jet, carded, 100% cotton</td>
<td>0.73 – 0.81</td>
<td>~0.48</td>
</tr>
</tbody>
</table>

The hairiness, the diameter, the diameter variation, the shape as well as the density can affect the appearance of fabrics, particularly after dyeing. The density of yarns will also be treated in chapter 6.

5 Below standard appearance of fabrics caused by the impurity of yarns

There are again two sensors available for the measurement of impurities:

One sensor (type OI) serves for the measurement of seed coat fragments, dust and trash particles. This sensor requires a very intensive light in the measuring zone to detect small particles at a speed of up to 800 m/min.

The measuring system, therefore, is able to identify the contamination of the raw material with dust and trash particles and to determine the cleaning efficiency of the cards, combers and opening rollers of OE-rotor spinning machines.
Fig. 5 is a comparison of the remaining trash and dust particles of carded and combed yarns produced from the same raw material.

The dark bars in Fig. 5 represent the trash particles, the light bars the dust particles of a sample of 10 bobbins. It is obvious that the combers have eliminated most of the trash particles and a considerable part of the dust particles as well.

A second sensor (type FM) detects foreign fibers. Therefore, the sensor permits the analysis of the raw material with respect to foreign fibers. With the Inspection Stop feature the detected foreign fibers can be fixed on a blackboard to analyze the origin of the foreign fibers. The detected foreign fibers can be printed out as a scatter plot on an intensity versus length matrix (Fig. 6) or as a numerical matrix.

![Fig. 5](image)

Efficiency of the comber with respect to dust and trash particles

![Fig. 6](image)

Distribution of foreign fibers per 100 km / Intensity versus length of foreign fibers
6 Below standard appearance of fabrics caused by bulk

It was mentioned in chapter 1 that the count, the density and the twist belong to this category.

The density was already discussed in chapter 4, because an optical sensor (type OM) for the measurement of the diameter is required. The density can be calculated with the knowledge of the count and the diameter of the yarn.

The twist also can affect the appearance of fabrics. Therefore, in a spinning mill with a good quality management the detection of slow spindles is required. If the twist of a yarn is below the nominal value, the diameter of the yarn increases. Diameter variations, however, can be recognized easily in a woven or knitted fabrics. If the count is correct, deviations of the diameter or the density indicate that the twist of the yarn is not correct.

The USTER® TESTER 5 is able to automatically determine the count of the yarn. After a measured yarn length of 100 m a cutter separates a yarn sample which is automatically transferred to a scale. The sample is measured gravimetrically and ejected after the test.

Count deviations or count variations are also recognized as faults in fabrics. Particularly critical are count problems in the warp because it can deteriorate the entire fabric. According to various trials count variations of more than 1,8% (CV_{cb}) in ring-spun yarns can be recognized with the human eye.

7 Summary

With the development of the USTER® TESTER 5 a new approach was taken to define the yarn characteristics. These characteristics were classified into evenness variations, surface variations, impurity and bulk.

The USTER® TESTER 5 has 6 sensors to measure all the above mentioned characteristics. Therefore, new options are available nowadays to improve the analysis of yarns in the textile laboratory.