USTER® *TENSOJET 4*

Application Report

Experience with high-speed strength testing in spinning mills

Textile Technology / April 2008 / SE 618

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1 Introduction

The yarn measuring technology of today allows a detailed analysis of yarns in a very short time. Therefore, the yarn test results can be used for a better understanding and improvement of the manufacturing process and for a comparison with benchmarks.

In 1992 a high-speed strength testing system was introduced in the market with the intention to increase the testing speed of strength testers by more than 40 times compared to conventional testers. This instrument is known as the USTER® *TENSOJET*.

This instrument has brought a new understanding to the textile community, particularly in the area of isolated weak places. It could be demonstrated that these weak places correlate with the end breaks of yarns on weaving machines. In order to find these weak places it was necessary to increase the testing speed considerably. Therefore, it is not only required to know the mean strength and mean elongation of yarns, but also the weak places.

Two examples of yarns are shown in Fig. 1 and Fig. 2. Fig. 1 demonstrates the scatter plot of strength and elongation with many weak places, whereas Fig. 2 shows the opposite.

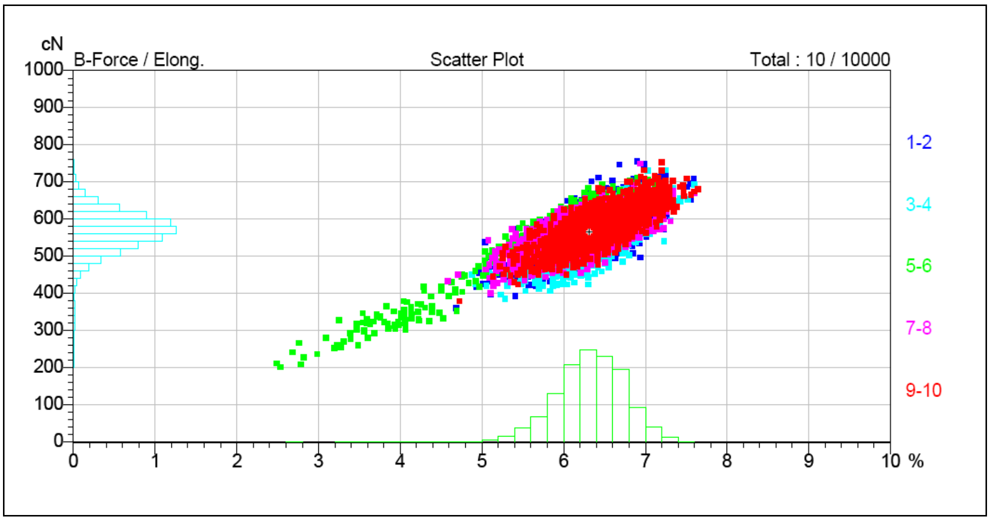

Fig. 1
Ring yarn, carded, Ne 24, cotton 100%, 10'000 tests, with a high amount of weak places

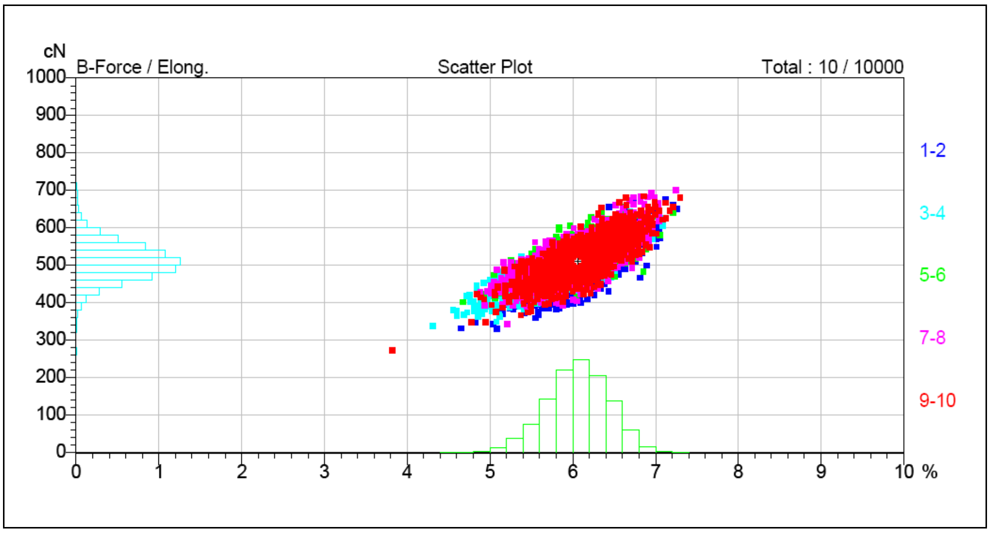

Fig. 2
Ring yarn, carded, Ne 24, cotton 100%, 10'000 tests, with hardly any weak places

Each dot represents a strength test with a defined force and elongation value.

The high number of single events on the left hand side of the scatter plot in Fig. 1 indicates that the spinning process is not under control. There is a high risk that these weak places will lower the efficiency of the weaving machines considerably. There is a high probability that the weaving process will be time-consuming because a high number of end breaks have to be repaired.

2 Strength testing for knitting yarns

There is a wrong perception in many spinning mills that strength testing is not required for knitting yarns, because the force applied on yarns during the knitting process is considerably lower than for weaving processes. In contrary to this perception, some researchers studied the physical characteristics of yarns (including strength and elongation) and found that these characteristics play an important role in the knitting performance of a yarn. For example Iyer, C., *et al.*, [3] mentioned that the strength of the yarn must be sufficient to resist tensile strain occurring during the knitting process, especially during withdrawl from the cone and in the region of needles, sinkers and cams during stitch formation. They also stated that yarn elongation is necessary, so that it can resist the bending strains or neutralize them by getting extended in such a way that the yarn does not break. The high speed of needles of modern knitting machines increase the tenacity requirements of yarn. In staple fiber yarns the strength is to a very large extent directly proportional to the level of twist inserted during spinning to a twist multiplier αe of about 4,5. [3]

When we consider knitting performance of a yarn, we also have to explain the term “knittability” [4]. The knittability of a yarn expresses if the knitting process with a yarn is easy or not. Knittability is a factor which affects directly stop-motions of a knitting machine, the productivity of the knitting process, the quality of a knitted fabric, and production costs. This property does not only depend on the characteristics of fibers from which yarns are produced but also on its own physical and structural properties. It’s very important to determine yarns having lower degree of knittability before knitting [1].

Other researchers [1, 2] have also investigated the knittability of a yarn before knitting. 30 different cotton yarns, many of them of commercial value, were used in the experiments. 12 of the yarn samples (100 % cotton, ring-spun yarns) were selected and given in Table 1. All the yarns were knitted into 1x1 rib structures and fabric take-down and machine speed values were kept constant. Samples were knitted at three different loop length values, representing a range of tight, medium, and loose fabrics. The knitting process was observed during 2000 revolutions, and the number of machine stops, yarn breaks, and holes were recorded. By using multiple regression analysis, yarn-yarn and yarn-needle friction equations that depend on yarns characteristics were found. In the last stage, they used these equations, machine tightness factor, and machine speed values in order to determine knittability.

Number	Yarn Count (Ne)	Twist Mulitplier αe	CVm (%)	Thin places (1/km)	Thick Places (1/km)	Neps (1/km)	Hairiness	Extension at break (%)	Tenacity (cN / tex)
1	20/1	3.83	10.88	0	2	6	8.11	7.56	15.39
2		3.72	13.42	0	66	68	8.58	7.03	14.12
3		3.7	10.64	0	4	8	8.19	7.34	16.34
4		3.83	13.97	2	96	87	8.68	6.39	13.89
5		4.36	16.68	36	172	613	6.18	6.99	10.84
6	30/1	3.69	12.58	0	10	26	7.61	6.54	15.23
7		3.55	16.65	62	280	300	8.49	5.70	11.37
8		3.5	12.91	2	30	22	6.87	5.73	13.16
9		4.13	12.71	2	17	28	5.91	6.73	17.86
10	40/1	3.77	13.75	6	35	58	6.12	5.62	15.47
11		3.6	14.63	10	148	82	7.25	5.12	12.41
12		4.13	13.16	2	34	72	5.77	5.54	19.42

Table 1 Physical properties of 100 % cotton ring-spun yarns [1]

Quality Characteristics		Coefficient of yarn-needle friction	Coefficient of yarn-yarn friction	Total number of machine stops, yarn breakages and holes per defined number of machine revolutions
Yarn Count (Ne)	🡅	🡅	🡅	🡅
CVm (%)	🡅	⇩	🡅	🡅
Thin places (1/km)	🡅	⇩	🡅	🡅
Thick Places(1/km)	🡅	⇩	🡅	🡅
Neps (1/km)	🡅	⇩	🡅	🡅
Hairiness	🡅	⇩	⇩	
Extension at break (%)	🡅	⇩	🡅	⇩

Table 2 Evaluating the relation between yarn properties, friction values and fabric faults [1]

🡅 = increase / ⇩ = decrease

According to statistical analyses, they have found that yarn characteristics have a significant effect not only on the fabric quality, but also on the friction values. During the knitting process, from bobbin to knitted fabric, yarn-yarn and yarn-needle friction is occurring between yarn and parts of the knitting machine and this causes an increase in yarn tension. The increase in yarn tension causes a higher number of yarn breakages and a decrease in productivity of the knitting process. For this reason, it is expected to retain yarn-yarn and yarn-needle friction at the lowest possible level. [3]

We try to explain the importance of yarn characteristics in determining knitting performance of a yarn by giving some examples from previous studies. As it is mentioned before, by using high speed yarn evenness and strength testing systems, these yarn characteristics can be measured easily and in a very short time.

After having gained experience for more than 15 years with USTER® *TENSOJET*, it became obvious that spinning deficiencies can be detected with this instrument which cannot be discovered by just measuring the evenness. Since this testing system is able to carry out 30'000 test per hour or 500 tests per minute, some hidden manufacturing problems show up which cannot be found by any other textile test. With the high amount of tests there exists a sound statistical platform. There are many events in spinning mills which result in a reduction of strength and elongation, but many of these events cannot be detected by evenness testing only because the defect does not lead to a mass variation.

Fig. 3 shows an example of cones with bobbin from the same spinning machine with a poor preventive maintenance. The ring spinning machine had various contaminated spindles with the result that these spindles did not produce yarns with nominal twist (slow spindles). Yarn: Cotton 100%, carded, Ne 16, ring-spun yarn.

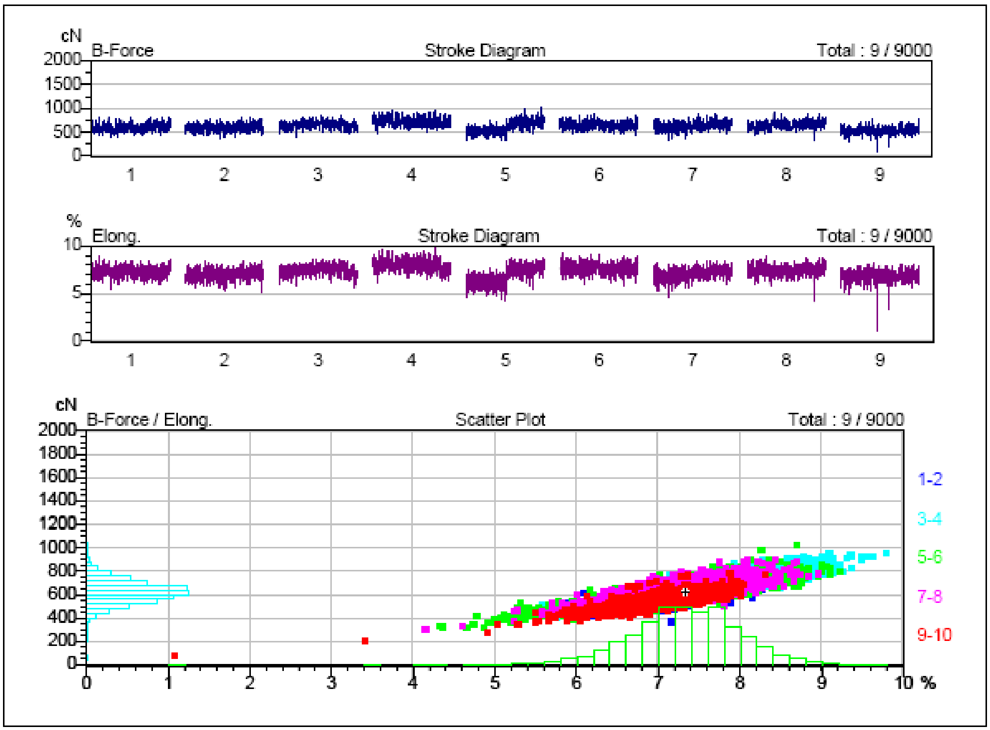

Fig. 3
Results of a USTER® TENSOJET, some bobbins of slow spindles

The stroke diagrams on top of Fig. 3 demonstrate the variation of the strength and the elongation. The manufacturing problems are mostly more pronounced in the stroke diagram of elongation. A stroke diagram represents each single test as a vertical line. The length of the line is equivalent to the force and elongation. Fig. 3 only shows the end of the line. The stroke diagrams also indicate that 9 bobbins were tested, and 1000 tests were carried out at each bobbin. Due to the manufacturing problems the scatter plot in the lower graph of Fig. 3 is very long.

Since slow spindles do not lead to mass variations, this manufacturing problem cannot be recognized with evenness tests only.

3 Conclusion

In order to make a successful assessment of yarn's quality level, various physical yarn characteristics should be measured in the laboratory. The results based on laboratory tests can be used to predict the performance of a yarn in subsequent processes. Two of the most important yarn characteristics are the tensile strength and the elongation.

A yarn should have a certain minimum tensile strength and elongation value which depends on the type of the textile process. For example yarns which are used on a weaving machine require a considerable strength; on the other hand, the yarns which are processed on modern knitting machines demand better elongation properties.

As it is mentioned before, the tensile force and elongation values can be used for prediction of the suitability of a yarn for a designated textile process. Another usage will be the analysis of the yarn production process and problems originated from production.

The USTER® *TENSOJET* high-speed strength tester can be used for both knitting and weaving yarns for detection of weak places in the yarn which cannot be detected with evenness testing but later can cause problems during the weaving and knitting production.

Since USTER® *TENSOJET* operate at very high speed, the test jobs in the laboratory can also be organized with the same pace for all testing instruments, and the strength tests can be synchronized with the evenness tests. With high-speed strength testers if is not only possible to carry out evenness and strength tests in the same period, but also determine isolated weak places simultaneously.

4 Literature

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Uster Technologies AG
Sonnenbergstrasse 10
CH-8610 Uster / Switzerland

Phone +41 43 366 36 36
Fax +41 43 366 36 37

www.uster.com
textile.technology@uster.com