USTER® TENSOJET 4

APPLICATION REPORT

Decision criteria for the procurement of worsted yarns in spinning mills

THE WEAVABILITY® MEASUREMENT SYSTEM

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1 Introduction

The use of modern test processes serves as a valuable source of information for the innovative worsted yarn weaving mill, and forms the basis of yarn selection and purchasing decisions, the simultaneous optimization of quality, processing behavior and costs.

Due to the increasing opening up and networking of markets, objective assessment of the international supply of semi-finished textile products for the modern worsted yarn weaving mill is increasingly becoming the central element of purchasing strategy. Opportune yarn buying follows the rules of the "global sourcing" game, and here the consistent use of quality and price advantages, which can be determined by direct comparison of the products of alternative sources of supply, are in the foreground. While the sphere of action for traditional yarn purchase is limited mainly to house and home suppliers, the buyer with an international horizon has available an almost unlimited quality and price range. Such diversity is associated with both opportunity and risk. There is of course the easy gratification of currency advantages and falling world labor costs, but there are limits to international logistics and there is also the problem of constancy of delivery. With this method of supply, the center of attention is again and again the question of how the quality of a yarn – not just the price – can be assessed in accordance with objective standards?

The quality parameters of a yarn ultimately determine the mechanical, aesthetic, tactile and physiological characteristics of a textile product. The further processing behavior of a yarn is no less significant from the economic standpoint. The aim of an objective supply strategy is accordingly to determine the optimum in terms of yarn price, further processing behavior and fabric properties.

2 Traditional yarn test processes and the step to high-capacity tensile strength testing

There is a range of established and internationally standardized test processes for determining the quality parameters of worsted yarns. The basis for all other yarn testing is determining yarn count. Here, particular attention is paid to count variation within a batch, since this parameter is directly connected with the visual impression of the end product. Yarn or ply twist is also an elementary construction feature with definite reference to the finished product. Determining yarn evenness and yarn hairiness is absolutely imperative. Evenness testing provides information on the type and extent of weight variation along the yarn axis and on the number of faults (thin and thick places and nepes), forming the bridge between yarn structure and the visual appearance of the fabric. Hairiness measurement provides information about the nature of the yarn surface. The rare yarn faults can be determined with the aid of "Classimat" back-winding.
The number of yarn faults remaining after yarn cleaning provides information on yarn cleaning effectiveness and general spinning processing.

More recent studies also show that the dynamometric characteristics of a yarn have a direct effect on further processing behavior. Yarns whose maximum tensile strength or maximum elongation under load is locally too low cause yarn breakage in further processing even under normal loading. The consequences are machine stoppages and efficiency losses. Knots or starting marks are always visible faults in the end-product, and carry further consequences in their train, the rare weak points in the yarn being mainly responsible for these problems even with adequate mean values for strength and elongation. Locating rare weak points however inevitably means a tremendously high random sample dimension. This alone imposes completely new requirements on a yarn testing system. In addition, such a test system must be oriented to the actual processing conditions, i.e. it must simulate as closely as possible the dynamic loadings of a modern weaving machine.

With the new USTER® TENSOJET high-capacity tensile strength tester it is possible today to arrive within a very short time at a representative random sample size with dynamic yarn loadings similar to those during weft insertion on an air jet weaving machine. Thus the unit offers at the maximum test speed of 400 m·min⁻¹ the possibility of carrying out 30,000 tensile strength tests in an hour. In comparison with the standardized test speed of 0.25 m·min⁻¹, this clearly still means a higher testing capacity (factor of 238), and in the fast test at 5 m·min⁻¹, an increase factor of 42. Only with a sufficiently high random sample size will sufficient measured data be available to enable rare incidents, i.e. weak places, to be recorded.

With its evaluating potential, the USTER® TENSOJET takes a step into the future in that all quality information is summed up on a single page. Such a test record (USTER® quality report) is presented in Figs. 2, 3 and 4. Each point within the colored force/elongation scatter graph corresponds to the maximum tensile force and the maximum elongation under load of a tearing process. The window marked ‘+’ in the middle of the dot cluster shows the mean measurement, the weak points always lying at the bottom left-hand end of the dot cluster. The bar chart provides information on the measurement time curve, and supplies information on trends and periodic faults. The statistics block also contains the so-called percentage values in addition to the usual statistical parameters. The percentage values are subdivided into five classes. Class P0.01 means that 0.01% of all measurements are smaller than or identical with the force, elongation or work indicated. The figures in brackets represent the exact number of measurements in this class.
3 A practical case study – worsted

The following study was carried out in conjunction with Sulzer Textil (CH) and a well-known German weaving mill. The yarns to be studied are of nominal count Nm 64/1 (15.5 tex) worsted yarns which are used as weft yarns for high-grade men’s and boyswear. These types of yarn are offered on the international market by numerous producers. After thorough preselection in this case, samples from three different suppliers are available.

![Fig. 1 Qualitative comparison of the test results of yarn A, B and C](image)

3.1 Fiber and yarn parameters

Fig. 1 surveys the fiber and yarn parameters determined from the three yarns. The test parameters marked '*' reveal statistically significant differences at a preselected significance level of $\alpha = 0.95$.

With identical fiber fineness, there is first of all a distinctive difference in staple length. Percentually, yarn from supplier A reveals a 30% shorter fiber length than that from supplier C. Yarn B lies midway between A and C. The shorter staple length of yarn A is naturally expressed in the selected yarn twist, which, in the interest of adequate yarn strength, is about 11% higher than with yarn B, and about 14% higher than with yarn C.

Nevertheless, in the case of yarn evenness, there is a statistically significant difference despite relatively small absolute differences. If the USTER® STATISTICS are used as aids, one finds the coefficients of variation of yarn mass variation (CVM) of the three yarns in the 50% line zone. Nor should the occasionally statistically significant differences be overestimated as far as faults are concerned. If the IPI values are considered as a whole, they lie around the USTER® STATISTICS 50% line. Yarns A and B have a nominal count of Nm 64, while yarn C is about 6% finer in count. There are no recognizable differences in hairiness.
The mean maximum tensile strength values, determined in accordance with the traditional CRE method at 5 m·min⁻¹, reveal negligibly higher values for yarn B than for yarns A and C. A significant drop in maximum elongation at break is observed in yarn A in consequence of the shorter staple length and the harder twist.

Yarn codes were prepared in addition to the numerical yarn test values. The code of yarn A differs quite clearly from those of yarns B and C, conveying something of the aesthetics of a short staple fiber yarn. Based on divergent views of the required character of a worsted yarn for the prescribed end-use, yarn A was assessed as even better by just under a majority of the weaving technicians.

In view of this situation, the question now arises as to which yarn is to be preferred. If the different test results are objectively and impartially considered, the choice falls first of all on supplier B’s yarn, but further tests were conducted before a final decision was made.

3.2 High-capacity tensile strength testing

The USTER® TENSOJET force/elongation scatter graphs are presented for the three yarns in Fig. 2, Fig. 3 and Fig. 4. Especially striking is the scatter graph of yarn A (Fig. 2) as compared with yarns B and C (Fig. 3, Fig. 4). Yarn A’s dot cluster lacks the high elongation scatter typical of worsted yarn, revealing an unusually low coefficient of variation for wool. The reason for this is the higher yarn twist, compensating for the shorter staple length.

The following consideration provides unambiguous clues as to weak places in the yarn, which, as rare events, cannot be reliably determined by traditional statistical methods, and by which of course further processing behavior on the weaving machine is decisively affected.
Table 1 shows the maximum tensile strength and the maximum elongation at break of yarns A, B and C as mean values of the USTER® TENSOJET test and as a percentage of $P_{0.01}$. The figures explain the drastic differences between mean values and rare weak places, the remarkable fact being that, in 100,000 individual strength tests, ten measurements in each case are still smaller than the percentage indicated here, it being obvious that not only are the mean values and scatters decisive to further processing behavior, but the number and markedness of the rare weak places too. If the mean maximum tensile strength values are compared with the associated percentage values, diametric trends are registered in the ranking.

The yarn with the lowest lowermost tensile strength value (yarn A) reveals the lowest percentage value. The maximum tensile strength of yarn C is in fact only insignificantly higher, but reveals the best percentage values. This phenomenon becomes even clearer with elongation, where yarn B has clear advantages in the form of higher maximum elongation at break, together with the most pronounced weak places, whereas the exact opposite is true of yarn A. It can be established that the mean value of the dynamometric characteristics of a yarn is not directly connected with the frequency and markedness of the rare weak places. Even assessment of mean values and coefficients of variation permits no adequate characterization of weak places.
In view of these results, the preliminary decision was revised in favor of yarn B. Yarn A could lead to serious problems in further processing. Consequently, yarn C represents the optimum on the basis of the satisfactory results of classic yarn testing, the predicted advantages in further processing behavior due to weak place analysis and because of its competitive price.

3.3 Testing the conclusions by weaving trials

The three yarns were woven as weft yarns under production conditions on a 180 cm wide weaving machine at a speed of 360 min⁻¹. On weft yarn breakage, yarn loadings were measured and recorded by a special unit. Maximum tensile strengths lay between 6 and 25 cN. Only weft yarn breaks caused by genuine yarn weak places were considered. In Fig. 5 the weft yarn breaks per 10⁵ picks are compared with the maximum tensile strength percentages P0.01. With these three data sets a correlation calculation was made, which, at r² = 0.998, demonstrates a clear and significant connection on the 95% level between percentage values P0.01 and weft yarn-induced stoppages. Incidentally, the yarn break difference frequencies determined between the two extremes, yarn A and C, are fully and completely identical with experience from long-term weaving mill observation.
This analysis shows that success has been achieved in adapting the mean value of yarn A to the strength level of the two other yarns by increasing the twist; against that, it is apparently impossible to compensate for the contribution of the shorter fibers for the occurrence of weak places. Yarn C causes the smallest number of weft-induced stoppages. The decision in favor of yarn C proves therefore to be technologically and economically correct. Selection based on traditional yarn test values or only on the basis of yarn price for instance would possibly have led to a decision error of serious consequence.

4 Economic considerations

The cost of one weft-induced stoppage per 105 picks amounts to about 0.37 cents, giving rise to stoppage costs at a level of 476 USD per weft yarn break per weaving machine with an annual production time of 6000 hrs. There is therefore a cost reduction of 4288 USD per year per weaving machine from the difference between the weft-induced stoppage frequencies with the use of yarn C instead of yarn A. In order to achieve this reduction via the yarn price, yarn A would have to be 1.18 USD/kg lower than yarn C with an annual requirement of 3.65 tonnes per loom. With assumed yarn price equality, and the clothing of ten weaving machines with only this one special product, an USTER® TENSOJET will be amortized in 2.6 years. The additional organization and labor costs occurring with use are taken fully comprehensively into account in this respect.

Producer B’s yarn is around 2.94 USD/kg higher in price than yarn C, resulting in an increased yarn cost of 10’147 USD/kg per year per loom in addition to the approximately 476 USD higher stoppage costs. The unjustified additional expenditure amounts therefore to 10’624 USD per year per loom. In this case a USTER® TENSOJET is clearly amortized in less than a year.
5 Summary

In terms of this study, it can be seen that it is quite possible to reduce fabric losses and increase efficiency at a reduced yarn cost, although this is generally felt to be inconsistent. From the standpoint of further processing behavior, i.e. of machine stoppages and production efficiency, the modern high-capacity tensile test represents an effective optimizing tool, though the fact that the visual appearance of a woven fabric is dictated, as ever decisively by yarn properties like count variation, regularity, imperfections, hairiness, and yarn fault frequency should not be overlooked. The objective testing and assessment of these parameters continues accordingly to be of unlimited importance.

6 References


