USTER® *TENSOJET 4*

Application Report

Efficient use of suppliers' yarns with the help of high-performance strength testing

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1 Introduction

Every company is asked to use their means effectively and efficiently during these changing times and the steadily increasing pressure of competition. In other words, companies are asked to adjust themselves innovatively to the latest conditions. This is also valid for the procurement of yarn.

The market has become a „global village“ in this the multi-media era. Online yarn trading has long established itself and offers customers an unlimited variety of yarns. Better process control and specific use of yarn material and a well-targeted use of the yarn and yarn purchase are the main topics for many weaving mills.

The detection of exceptions is summarized by the term “management of exceptions“. “Management by exceptions” means that samples with particularly bad results are detected, recognized and eliminated before the yarn reaches weaving preparation.

The detection of exceptions gains in importance because experience has shown that an increasing number of yarn defects or weak places appear in only few samples. Such yarn defects or weak places play an important part in quality deterioration. Yarn with inferior quality leads to problems during subsequent processing steps such as end breaks in warping or warp and weft end breaks in the weaving mill. The source of such problems are foreign fibers, thick and thin places.

Meaningful statements can be made about the usability of a yarn with the help of high-performance testing.

2 Conventional strength testing

A yarn needs a given minimum tenacity or elongation in order to survive without being damaged or broken during the processing steps up to the final product.

The further processing steps dictate the requirements put on the textile product and the characteristics which the yarn has to fulfil. In particular, extremely high strains are reached in weaving mills due to the different weft insertion principles. Weaving machines, which run ever faster, also lead to additional strength requirements for yarn.

The question that forces itself to be asked is: Does a higher strain on the yarn automatically lead to lower productivity? This question has to be answered with an absolute ‘no’ because productivity can actually be maintained or even raised with a clever selection of the yarns.

The conventional yarn strength tester carries out exemplary strength and elongation tests. Statements can be made regarding the average quality of a yarn because of mean values and coefficients of variation.

It is the frequency of the seldom-occurring weak places, irrespective of the raw material, spinning procedure, yarn construction or yarn price, which is decisive for the behaviour during the manufacturing process. This is true in particular in a weaving mill, and not, as might be wrongly assumed, the mean strength and elongation of a yarn. Such seldom-occurring weak places can lead to end breaks and efficiency loss. Recent studies have shown that weak places below 4.0 cN/tex almost invariably cause a weft break and elongations below 2.0% lead to a warp break.

With only a few samples available, weak places that occur only very rarely at a normally distributed frequency cannot be detected by the conventional low-speed strength testers.

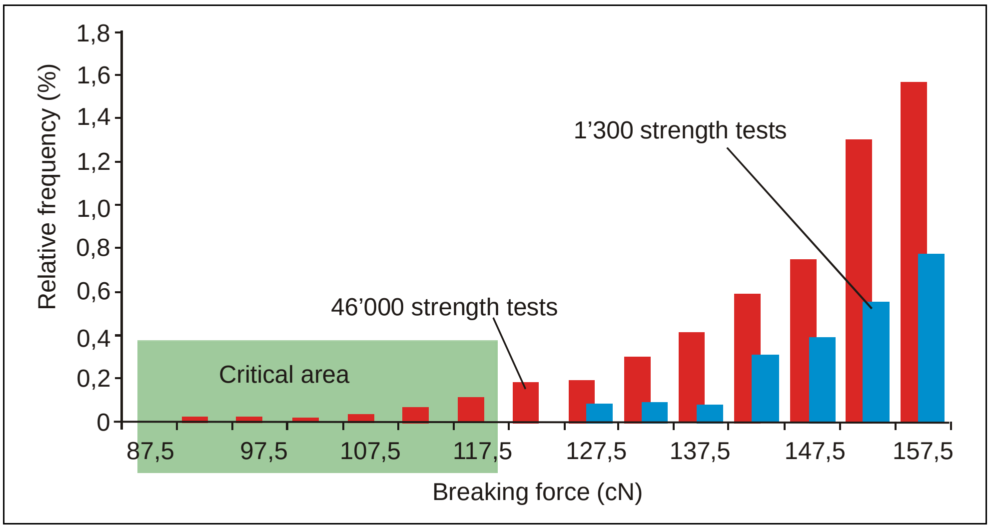


Fig. 1
Calculation of the minimum strength by increasing the number of samples 1

Therefore, the number of samples has to be increased in order to obtain a basic population as high as possible. The test speed has to be increased as well in order to produce meaningful results. However, a significant statement can be made with the high-performance strength testing made with the USTER® *TENSOJET 4* about the processing quality of a yarn at a test speed of 400/min. 30,000 individual strength tests are carried out per hour with this testing system.

Fig. 1 clearly shows that the weak places, which are so dangerous for a weaving mill, can only be detected by taking more samples!

3 High-performance strength testing – Principle of the USTER® *TENSOJET 4*

The USTER® *TENSOJET 4*, with its 30,000 breaks, offers a wealth of advantages and very meaningful results. Such a high information density can only be obtained if new ways are taken, outside of conventional strength testing. The following graph will explain the individual steps of the high-performance strength testing. The weft insertion of a yarn is made by compressed air, similar to the weft insertion of air-jet weaving machines. On the USTER® *TENSOJET 4*, the yarn is inserted into rollers which rotate in opposite direction by compressed air instead of accelerating and breaking a yarn clamp during the measuring process. This method means that only the yarn mass has to be accelerated during the measuring process, and, therefore, only little energy is used, and the machine structure is treated gently.

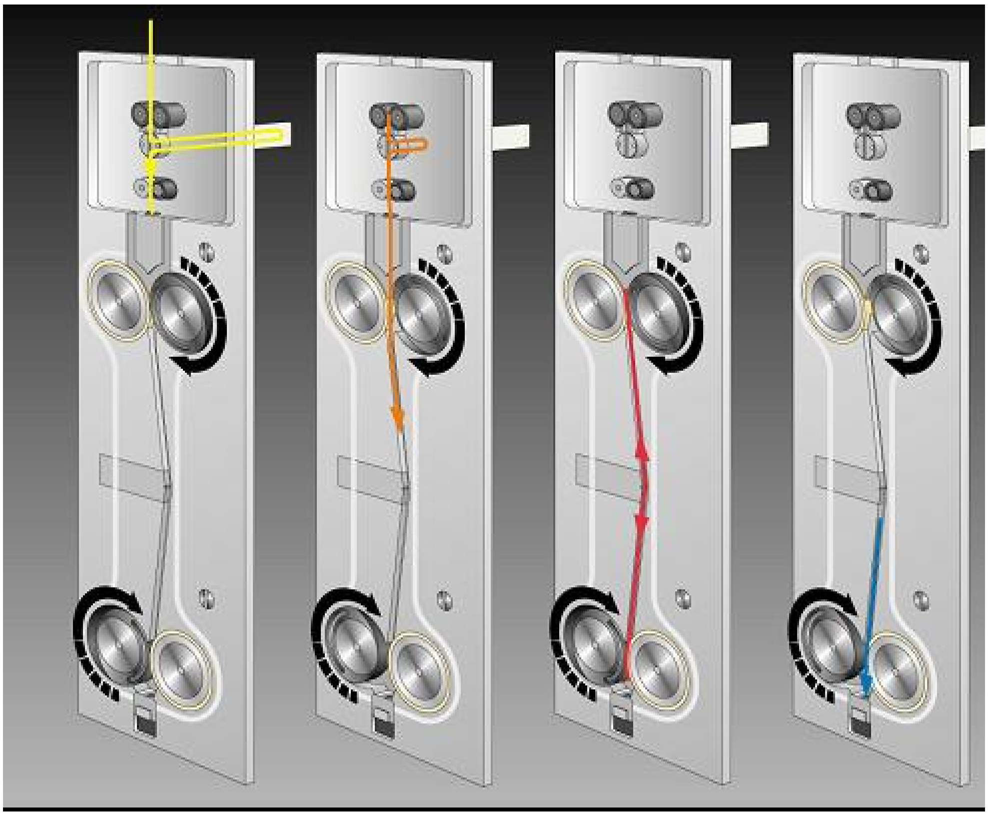


Fig. 2
Illustration of the four phases: yarn insertion, yarn testing and elimination of yarn fragments

The measuring process is made in four steps:

Step 1, yarn moving mechanism into temporary storage:

The moving rollers pull the yarn continuously from the yarn package with the pre-selected test speed. The yarn is sucked into temporary yarn storage by a suction nozzle. The closed controlling rollers prevent a premature insertion into the measuring field.

Step 2, insertion of the yarn into the measuring field:

The two roller pairs have now moved so far that the flat area on the perimeter of the metal rollers open the measuring channel. Simultaneously, the controlling rollers have opened up which leaves the yarn exposed. The yarn is now inserted with the help of the suction nozzle and the difference in pressure into the measure field.

Step 3, tensile strength testing:

The measuring field is closed by the two clamp rollers which keep moving. Then, the yarn is clamped between the rubber and the metal rollers of the upper and lower two clamp rollers. The two rollers which rotate in opposite direction keep on moving and put a strain on the yarn until it breaks. The sensors determine the strength and elongation values.

Step 4, suction of the lint:

The air channel is opened by the continuous rotation of the two clamp rollers once the yarn has broken. The lint is sucked by the suction nozzles into the yarn lint box.

During a test, steps 1 and 3 as well as steps 2 and 4 take place simultaneously. In other words, the next yarn piece is already prepared in the temporary storage during a strength test, and the following yarn piece is inserted into the measuring field during the removal of the remaining yarn fragments.

4 Weaving requirements regarding strength and elongation

Weaving mills have to use yarns which have no weak places (i.e. exceptions with low strength and elongation). These yarns have to withstand the peak loads on the weaving machine. Tests have shown that force is applied on yarns within about 3 ms until they break. The high test speed of the USTER® *TENSOJET 4* therefore also simulates, like in reality, the dynamometric stress of the yarn during the weft insertion process which occurs during 3 – 6 ms[1].

[1] Weissenberger, W.: Prozessübergreifende Qualitätssicherung aus der Sicht vom Gewebe zum Garn, Melliand Textilberichte 4/93

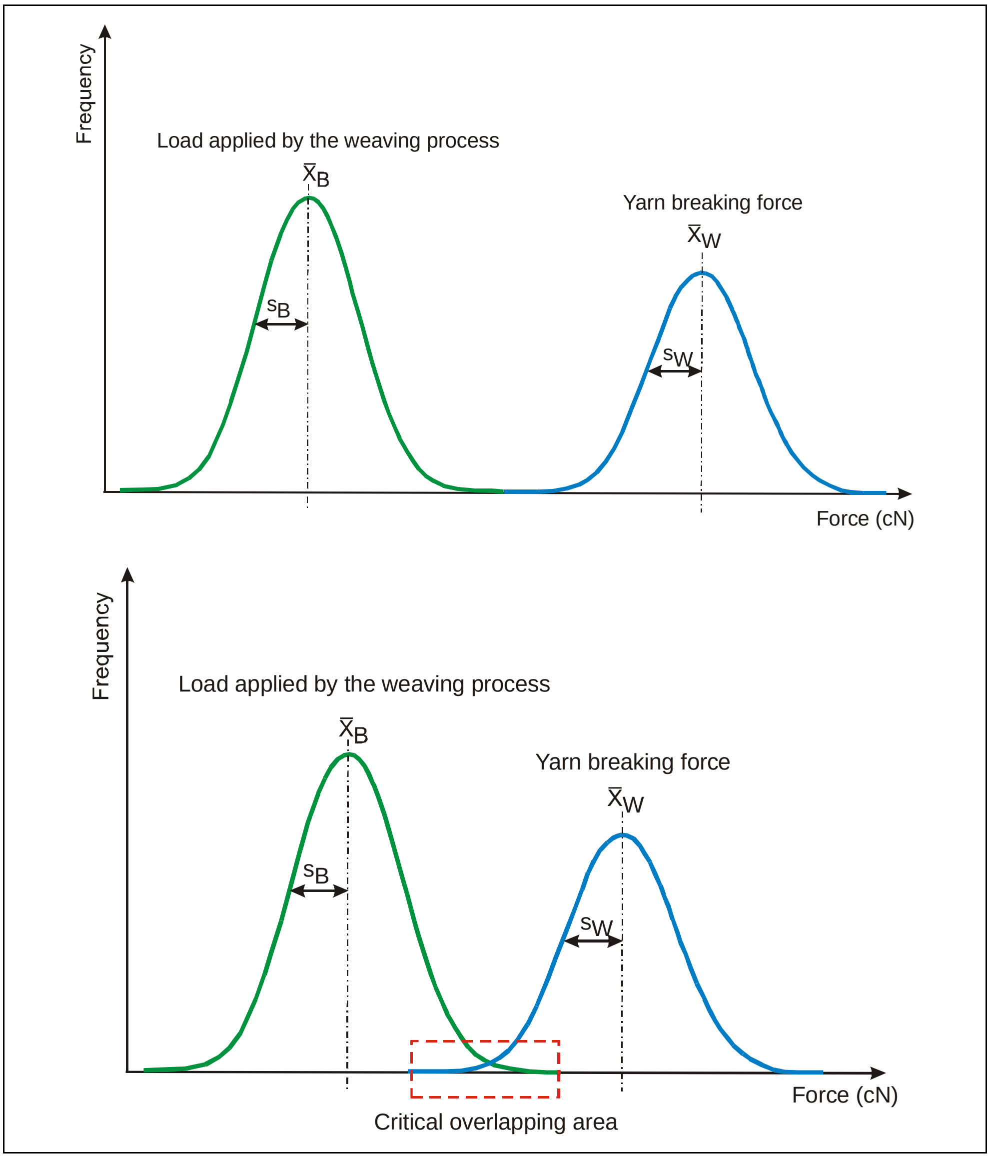


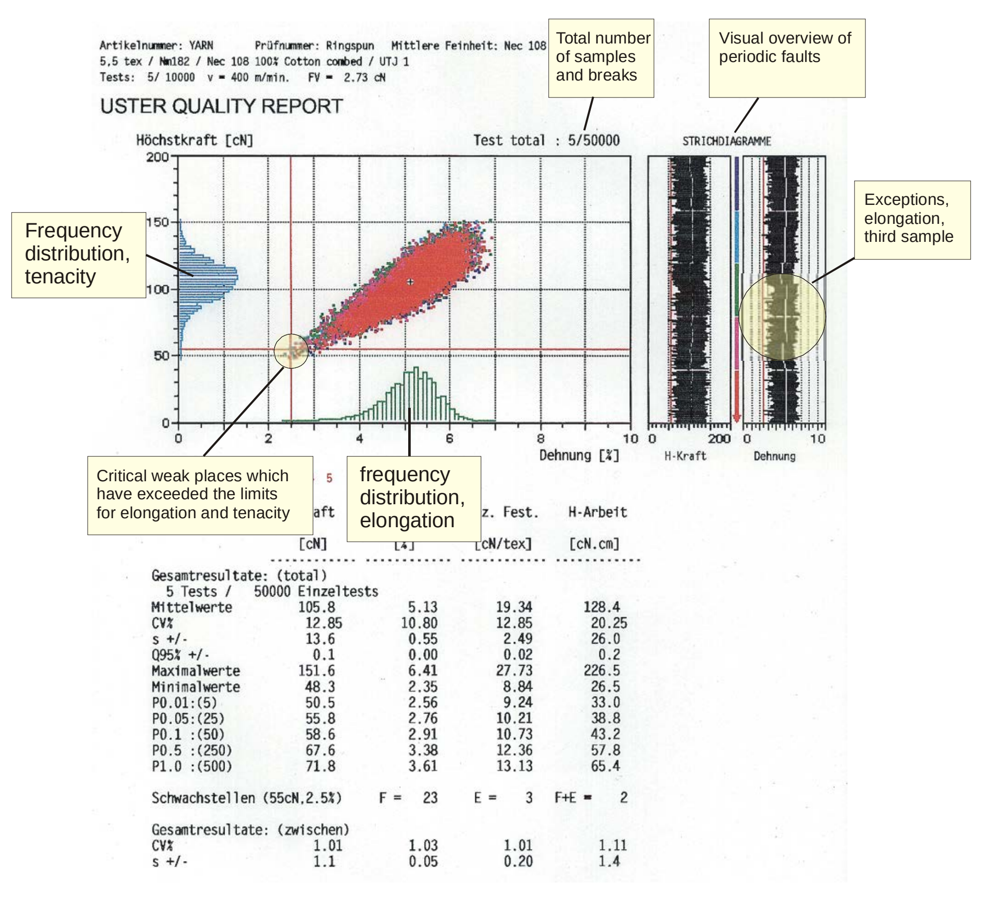
Fig. 3
Summary of the yarn strength and yarn elongation during the weaving process

This graph reflects the strength applied on yarns in the weaving process which should not overlap the yarn with the maximum tenacity in order to avoid end breaks and stops. In the worst case, there will be end breaks in the overlapping area marked as critical when the lowermost strength of the yarn is smaller than the maximum force applied on the yarn in weaving process.

5 Protocol of the USTER® *TENSOJET 4* – Quality Report

The aim of the high-performance tensile strength testing is to obtain meaningful results of seldom-occurring defects with a large number of samples in order to forecast the weavability of the yarn.

The most important statements are summarized on one page on the Quality Report of the USTER® *TENSOJET 4*. The following Quality Report will demonstrate the individual possibilities of interpretation.



	aft [cN]	[%]	z. Fest. [cN/tex]	H-Arbeit [cN.cm]
Gesamtresultate: (total)				
5 Tests / 50000 Einzeltests				
Mittelwerte	105.8	5.13	19.34	128.4
CV%	12.85	10.80	12.85	20.25
s +/-	13.6	0.55	2.49	26.0
Q95% +/-	0.1	0.00	0.02	0.2
Maximalwerte	151.6	6.41	27.73	226.5
Minimalwerte	48.3	2.35	8.84	26.5
P0.01:(5)	50.5	2.56	9.24	33.0
P0.05:(25)	55.8	2.76	10.21	38.8
P0.1 :(50)	58.6	2.91	10.73	43.2
P0.5 :(250)	67.6	3.38	12.36	57.8
P1.0 :(500)	71.8	3.61	13.13	65.4
Schwachstellen (55cN,2.5%)	F = 23	E = 3	F+E = 2	
Gesamtresultate: (zwischen)				
CV%	1.01	1.03	1.01	1.11
s +/-	1.1	0.05	0.20	1.4

Fig. 4
USTER® Quality Report

Every break is shown in colour in a force-extension scatter plot. The colour legend provides information about the test sequence. The window marked with '+' in the center of the scatter plot shows the mean of the measurement. Further, the frequency distribution of force and elongation are also depicted in the scatter plot.

The number of tested samples and the total number of all break tests are illustrated above the force-extension scatter plot. The stroke diagram shows the tests chronologically and also provides information about trends and possible periodic defects. Fig. 4 indicates the mean of force, elongation, tenacity and the work done to break as well as the standard deviation, the coefficient of variation and the 95% confidence range. Further, percentile values and maximum and minimum values are shown as well.

The percentile values are divided into five classes. Class $P_{0,01}$ means that 0.01% of all measurements are smaller or equal to the indicated strength, elongation and work. The figures in brackets indicate the exact number of the measurement in this class.

Our example has five measured values for $P_{0,01}$ which is 0.01% of the test series of 50,000 measurements. This means that these five values are either smaller or equal to 50.5 cN. These percentile values are very important because $P_{0,01}$ in particular gives direct evidence of the weft stops[2].

6 Examples from practical experience

The benefits of the high-performance strength testing, in particular for weaving mills, will be shown with impressive examples.

6.1 Example 1: Purchase of a warp yarn (50/50 PES/CO, Ne 35/1)

The correct purchase of a 50/50 PES/CO warp yarn, count Ne 35 was the aim of this test. There are four yarns available from different suppliers. Standard tests were made with all four yarns in the laboratory to find the most suitable yarn.

			Yarn 1	**Yarn 2**	**Yarn 3**	**Yarn 4**
USTER® *TENSOJET 4*	Strength R_H	cN/tex	20,5	20,5	22,1	21,7
	$CV(R_H)$	%	14,2	10,4	9,6	10,8
	Elongation ε_H	%	8,7	8,7	8,4	8,8
	$CV(\varepsilon_H)$	%	13,5	10,4	10,2	11,6
USTER® *TENSORAPID 3*	Strength R_H	cN/tex	18,2	18,4	19,5	19,5
	USTER® *STATISTICS*	%	50	25-50	25-50	25-50
	$CV(R_H)$	%	12,6	10.1	9,5	10,8
	USTER® *STATISTICS*	%	75-95	50-75	5-25	50-75
	Elongation ε_H	%	8,8	8,9	8,7	9,3
	USTER® *STATISTICS*	%	25	5-25	25-50	5-25
	$CV(\varepsilon_H)$	%	14,6	10,2	8,7	8,9
USTER® *TESTER 3*	Evenness CV_m	%	22,0	19,2	18,8	19,7
	USTER® *STATISTICS*	%	> 95	75-95	75-95	95
	Thin places 1)	1/km	322	72	62	123
	Thick places 2)	1/km	1730	981	857	1064
	Neps 3)	1/km	1704	907	672	922

1) $\sum$(-35%, -40%, -50%)   2) $\sum$(+35%, +50%)   3) $\sum$(+140, +200%)

Table 1 Quality parameters of the yarns available

[2] Bergold, K: Einfluss von on-line –geprüften Qualitätsmerkmalen in der Spulerei auf die Garnweiterverarbeitung, Abschlussarbeit 1994, FH Reutlingen, Deutschland

A first choice can be made with the mean values. Yarn 3 appears to be the best yarn but the differences between yarns 2, 3 and 4 are small. Yarn 1, however, obviously has the worst values in all quality parameters. Each of these three yarns (2, 3, 4) has strengths and weaknesses which could easily lead to a decision based on the price.

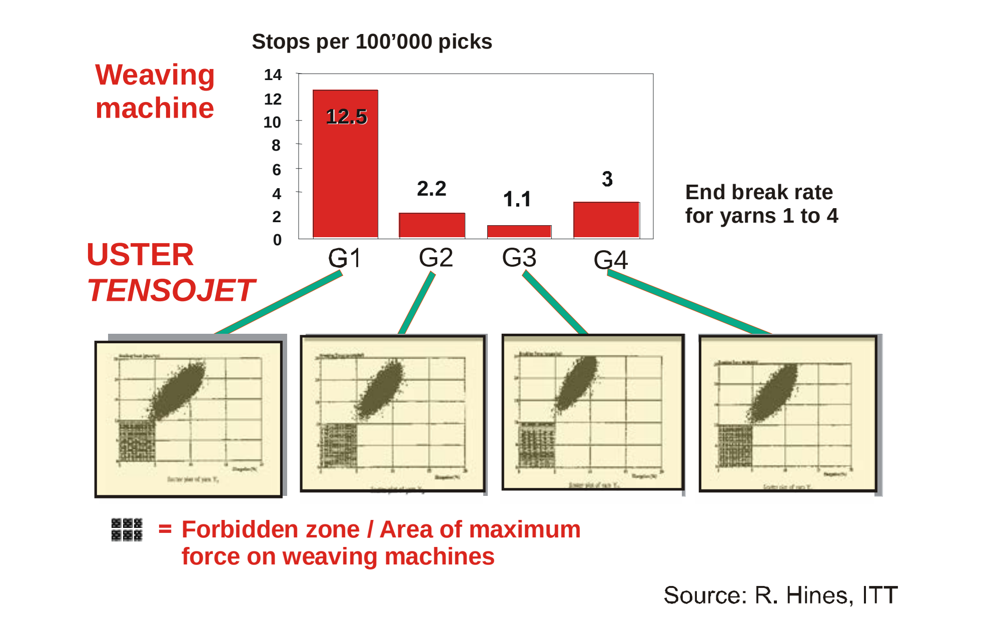


Fig. 5
Weaving machine stops and force-extension scatter plots

Only the comparison of the force-extension scatter plots with the frequence of the warp end breaks, determined in a test shown in the following graph, clarifies the situation, and only then can the most suitable yarn be determined with certainty.

50,000 measurements were made with each yarn lot. The limits of the critical range in the scatter plot are 12.0 cN/tex and 5% elongation. The visualization of the force and elongation distribution clearly shows that yarn 1 has considerably more weak places within the critical range than the other three yarns. Yarn 1 will therefore also produce more yarn end breaks during the weaving process! The mean values determined in the tests do not show any significant difference. However, it also becomes clear that yarn 3 has the least number of weak places, and its scatter plot is the most compact.

This test shows in an impressive way that the analysis of the weak places provides information about how the yarn will behave during its further processing.

6.2 Example 2: Purchase of a warp yarn (100% CV, Nm 50/2)

The purchase of two viscose ply yarns, count Nm 50/2, was the aim of this test. A quick and right decision can be made here as well with the help of the force-extension scatter plot.

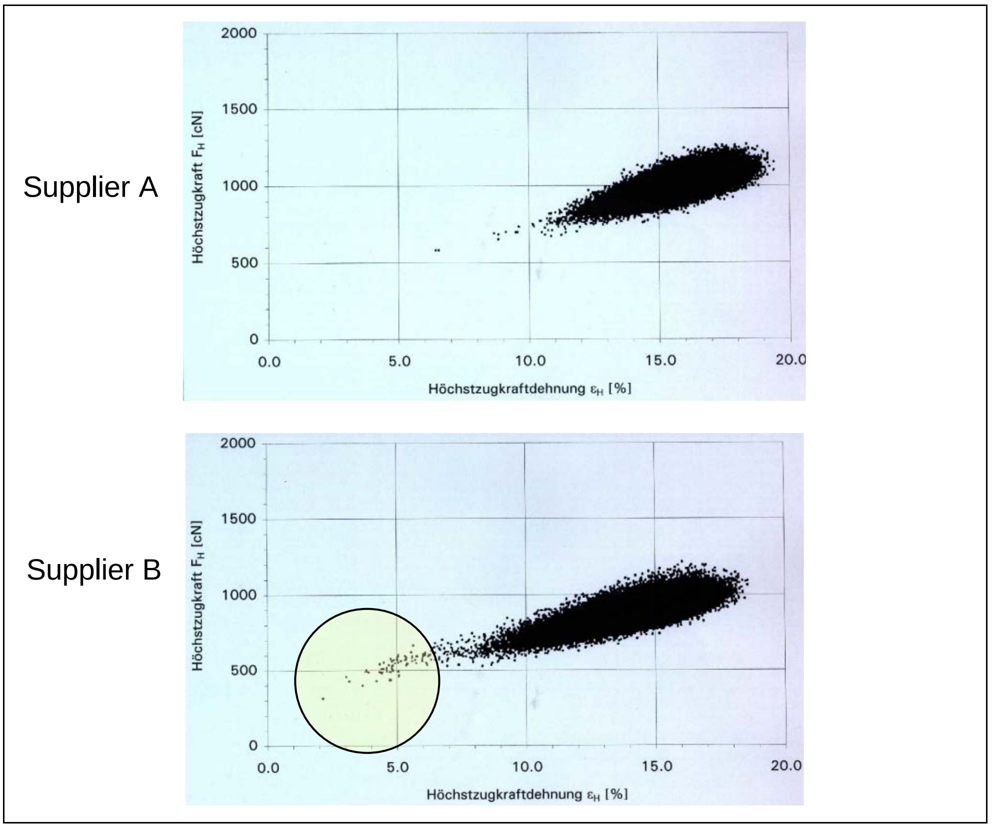


Fig. 6
Force-extension scatter plot of yarns from different suppliers

22 cones with 10,000 breaks each were tested. The comparison of the two scatter plots shows that the yarn from supplier B has lower strength and elongation values, but considerably more weak places. This result suggests that this yarn will have bad operational characteristics in the weaving mill, and, is therefore not suitable.

7 Summary

High-performance strength testing using the USTER® *TENSOJET 4* is well in tune with the further processing steps required in the weaving mill.

All other efforts made with the help of spot checks to predict how the yarn will behave during its further processing including its weak places or the machine stops are not able to produce the desired results because the number of tests is too small.

These examples show the correlation of the analysis of weak places and the frequency of yarn end breaks in an impressive way and prove that forecasts about the further processing of the yarn can be made!

8 Annex

8.1 Explanations and calculation for example 1: Purchase of a warp yarn (50/50 PES/CO, Ne 35/1)

The fabric made in this test is a plain weave article made of ring-spun yarn 50/50 PES/CO, Ne 35/1 in the warp (4,800 threads, 30 threads/cm) and a ring-spun yarn 100% CO, Ne 35/1 in the weft (26 threads/cm, 160 cm weaving width). The number of revolutions of the weaving machine was 700 min^{-1}. The costs caused by warp stops are US$ 0.47 per 100,000 weft insertions. The total yearly costs amount to US$ 1,186 per warp stop per weaving machine with a production time of 6,000 hours per year. It has to be realized that a weft end break in the finished textile fabric is always a visible defect which will either have to be left or mended. This will always lead to quality reductions or quality costs which are not considered here.

Table 2, line 1, compares the frequency of stops and the relevant yearly costs arising from these stops of the four yarns. Line 2 shows how much cheaper yarns 1, 2 and 4 would have to be in order to compensate the higher costs arising from stops via the yarn price. This calculation is for 30 weaving machines running with this yarn which results in a requirement of 236.6 metric tons of warp yarn per year.

Yarn 3 should be selected because of technological reasons and because of the low costs caused by stops which the analysis of weak places using the USTER® *TENSOJET 4* clearly shows. Yarn 2 could be a cost-neutral alternative if it were actually sold for US$ 0.16/kg less. Assuming that yarn 3 was chosen, and yarns 2 and 3 cost the same, the cost savings of US$ 0.16/kg yarn resulting from the selection of yarn 3 would justify an investment in an USTER® *TENSOJET 4*.

		Yarn 1	Yarn 2	Yarn 3	Yarn 4
Weft stops per 10^5 weft insertions		12.5	2.2	1.1	3.0
Costs caused by stops per year and per machine	USD	14'824.-	2'609.-	1'305.-	3'558.-
Required price difference per kg of yarn at identical production costs	USD	1.72	0.16	0.00	0.29

Table 2 Quality parameters and frequency of weft stops of the yarn to be chosen from

It has to be said that the warp material used was a raw yarn. Normally, the sizing causes an increase in the force and a reduction of the strength. However, weak places are not caused by sizing and cannot be removed by sizing.

9 References

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