

USTER® *TENSOJET 4*

Application Report

Improved processing characteristics of
cotton rotor yarns by optimized conditioning
in high-performance weaving mills

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Contents

1 Introduction4

**2 Yarn moistening, a proven measure to reduce the
 tendency to crimping4**

**3 Influence of the conditioning process on the
 characteristics of cotton rotor yarns5**

3.1 Trial and test conditions.....5

3.2 Assessment of the test results7

**4 Moisture absorption through acclimatization in the
 weaving room8**

5 Conclusions.....10

1 Introduction

As a result of the continuous performance increase in today's modern weaving mills, fiber yarns are subject to increasingly higher tensile loads. The high-performance weaving process is therefore an ideal test case for the assessment of the quality parameters and characteristics that affect the processability of yarns. With the implementation of the advances in spinning technology and machine engineering made over the last two decades, the average yarn quality offered on today's market is generally quite high. But even with these improved production conditions, an average of 20 to 30% of the machine stops in a cotton weaving mill still result from disturbances that are related to yarn faults. In view of this fact, it will therefore be necessary to focus our attention on measures with a proven positive effect on characteristics that are essential to the processability, such as the working capacity of yarns. Especially since these measures also have a positive effect on the fabric quality.

The influence of temperature and moisture on the characteristics of textiles and the physical properties of textile fiber fabrics has been a frequent research object in the field of test and application technology. It has been established, for example, that the strength and elongation properties of cotton fibers increase along with the moisture content. A similar increase in the strength and elongation properties of cotton yarns as a result of proper conditioning was verified and described in 1995 by P. Toggweiler and other authors [1]. This effect can be explained, for example, by the fact that an increase in the moisture content results in an increased swelling of the fibers and, in addition to the increase in fiber strength and fiber elongation values, in a higher fiber/fiber friction in the yarn. Until now, however, the quantitative and qualitative effect of a general improvement in the tensile properties, especially on the seldom-occurring weak places in yarns, was not known. Weak places are the most common cause of end breaks in the event of overloads, which occur especially during the weft insertion as a result of the rapid yarn acceleration.

2 Yarn moistening, a proven measure to reduce the tendency to crimping

The steaming of yarns in the form of bobbins and cones, which has been known for many decades, was used mainly to reduce the tendency to crimping. In the meantime, the importance of moisture for the processability of cotton yarns has become sufficiently well known throughout the textile industry. Even if a mill decides to do without conditioning for supposed cost reasons, the desired effect is attained by storing yarn packages for the weft insertion, for example, in the air-conditioned weaving room for several days prior to processing. As demonstrated below, however, this procedure is just as inadequate as the traditional steaming methods using wet steam or water.

None of these classic steaming methods can produce a homogeneous moisture distribution over the entire yarn package, particularly in the case of cross-wound packages with the medium to high winding densities required for today's extreme delivery speeds.

However, an optimum yarn treatment can be achieved with the thermal conditioning according to the Contexxor method developed by Xorella AG, which has been used successfully for years. Thermal conditioning uses low-temperature saturated steam in the vacuum phase. The vacuum first removes the trapped air and in that way ensures an accelerated and complete penetration of the yarn package with steam. The simultaneous removal of oxygen also prevents any form of oxidation. The saturated steam (one hundred percent moisture in the gaseous phase) results in the required finest distribution of moisture in the yarn mass independent of the type of package.

3 Influence of the conditioning process on the characteristics of cotton rotor yarns

3.1 Trial and test conditions

The evaluation of measures for the prevention of filling breaks in the weaving process has shown that the number of such fabric faults caused by conditioned cotton rotor yarns is considerably smaller than that of similar, non-conditioned yarns. Filling breaks, also known as broken pick or end, are fault conditions in the fabric which can occur in tightly set fabrics with increased apron formation in the reed stop phase due to overloaded, short filling sections during the weaving start. The higher the intensity of the fabric expander the higher the risk of such filling breaks. For visual or functional reasons, especially with high-grade fabrics, these would be considered an unacceptable reduction of quality. A ticking fabric, for example, will no longer meet the requirements for down resistance if it contains such faults.

The test was carried out with OE rotor yarns of 100% cotton with a count of Nm 28 (36 tex). The conditioned yarns in the form of cross-wound packages were conditioned with the Contexxor method of Xorella AG according to the following program:

- | | | |
|-----------------------|-----------------------------|------------|
| 1 st cycle | - initial vacuum | |
| | - conditioning time: | 5 minutes |
| | - conditioning temperature: | 75° C |
| 2 nd cycle | - intermediate vacuum | |
| | - conditioning time: | 15 minutes |
| | - conditioning temperature: | 80° C |

The non-conditioned yarns and the conditioned yarns were tested for variations in the force/elongation characteristics with the high-performance tensile testing system USTER® *TENSOJET* of Uster Technologies.

The tests were repeated under different practical conditions to ensure the validity and reliability of the results. In the first variant, the conditioned yarns were tested and processed immediately after the treatment. For the repeat test, the packages were wrapped in foil and stored for a period of two weeks. Compared with the 5.5% moisture of the untreated yarn, the measurement in variant 1 showed an increase in the moisture content to between 8.0 and 8.5%. The moisture content of the second test yarn, after two weeks of storage, was still between 7.5 and 8.0%.

The results of both test variants are shown in the Table 1 and Table 2. These include both the mean values and the corresponding CV values of the following test parameters: Breaking force, breaking elongation and work-to-break as well as the different percentile values P0.01, P0.05 and P 0.1. The percentile values indicate the level of the lowest single values of a particular test parameter. With a test volume of 100'000 breaks, the P0.01 value therefore indicates that 0.01% or, in this case, 10 test values are lower or equal to that level.

Mean values

Treatment	B-force [cN]	CV% B-force	Elongation [%]	CV% elongation	Tenacity [cN/tex]	B-work [cN.cm]	CV% B-work
unconditioned	490,3	8,47	5,47	7,03	13,73	709,5	13,51
conditioned	546,9	8,12	6,84	5,95	15,31	918,8	12,24
Difference in %	11,54	-4,13	25,05	-15,36	11,51	29,50	-9,40

Perzentile values P0.01 (11)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	328,1		3,57		9,19	307,9	
conditioned	359,9		4,94		10,08	457,4	
Difference in %	9,69		38,38		9,68	48,55	

Perzentile values P0.05 (55)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	352,5		3,92		9,87	376,3	
conditioned	388,7		5,19		10,88	519,0	
Difference in %	10,27		32,40		10,23	37,92	

Perzentile values P0.1 (110)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	360,6		4,04		10,10	398,7	
conditioned	402,0		5,31		11,26	546,5	
Difference in %	11,48		31,44		11,49	37,07	

Table 1 Co, OE-rotor spun yarn, Nec 16.5 - comparison non-conditioned to conditioned: direct testing after treatment

Mean values

Treatment	B-force [cN]	CV% B-force	Elongation [%]	CV% elongation	Tenacity [cN/tex]	B-work [cN.cm]	CV% B-work
unconditioned	495,2	8,46	5,16	7,13	13,87	686,2	13,61
conditioned, stored	509,8	8,38	6,53	6,39	14,27	839,9	12,62
Difference in %	2,95	-0,95	26,55	-10,38	2,88	22,40	-7,27

Percentile values P0.01 (11)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	332,6		3,34		9,31	299,8	
conditioned, stored	345,1		4,62		9,66	427,4	
Difference in %	3,76		38,32		3,76	42,56	

Percentile values P0.05 (55)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	356,9		3,66		9,99	354,2	
conditioned, stored	366,6		4,88		10,26	479,5	
Difference in %	2,72		33,33		2,70	35,38	

Percentile values P0.1 (110)

Treatment	B-force [cN]		Elongation [%]		Tenacity [cN/tex]	B-work [cN.cm]	
unconditioned	365,1		3,79		10,22	381,1	
conditioned, stored	375,4		5,00		10,51	497,6	
Difference in %	2,82		31,93		2,84	30,57	

Table 2 Co, OE-rotor spun yarn, Nec 16.5 - comparison non-conditioned to conditioned and stored: testing after two weeks

3.2 Assessment of the test results

The tests confirm that the force/elongation characteristics of cotton yarns, in this case OE rotor yarn, can be improved considerably with proper conditioning. A small loss of moisture at the end of a prolonged storage period will reduce the improvement of the force/elongation characteristics only by a small amount. As far as the force/elongation parameters are concerned, the conditioning process has the strongest effect on the elongation. Even after two weeks of storage, the mean elongation, for example, is still 25% higher in relative or 1.4% in nominal terms than that of the untreated yarn. The mean working capacity even increases by almost 30% when the yarn has reached the highest moisture content of 8.5% after the conditioning. This value is the result of a relative increase in elongation by 25% and, in addition, of an increase in strength of over 10%. After the two-week storage, the increase in the working capacity is still 22%.

Particularly worth noting, however, is the previously unknown fact that the potential influence of the conditioning process on the seldom-occurring weak places in the yarn is even greater than the apparent effect indicated by the mean values. This can be illustrated very clearly with the percentile values.

The elongation level of the most extreme weak places (P0.01), as shown in Table 1 and Table 2, is increased by 1.3% in nominal or 38% in relative terms. In combination with the additional, although slightly smaller, increase in strength, this corresponds to an increase of the working capacity by 42% for the stored, non-conditioned yarn and 48% for the conditioned yarn without storage.

This improvement of the characteristics is particularly important with regard to the resulting, higher permissible load, which is determined by the number of weak places. Due to the increase in strength, for example, the maximum permissible load of the conditioned yarn, with a specified limit of one end break per 10⁵ picks, increases by at least 1.3 cN/tex. The importance of such a difference in load capacity is even greater for short, stressed yarn sections that are largely responsible for broken ends, because they are lacking the compensating extension offered by longer yarn sections.

Repeated tests have confirmed these findings. With conditioned weft yarns, the number of such broken ends, related to a comparable length of fabric, was many times lower than that of non-conditioned yarns.

4 Moisture absorption through acclimatization in the weaving room

In addition, the same yarns were tested for the influence of a higher absorption of humidity on the yarn characteristics achieved through acclimatization in a weaving room. The OE rotor yarn packages were stored at 75% humidity in the weaving room for three days and then processed and tested in comparison with yarn packages obtained directly from the spinning mill. Compared with the yarn that had not been stored in the weaving room, the absorption of humidity resulted in a relative improvement of the mean elongation by 10% and the working capacity by 6%. The percentile values P0.01 of the elongation and the working capacity increased by 6.5% and 7% respectively.

The Fig. 1, Fig. 2 and Fig. 3 show the scatter plots and the distribution of the peak values of the individual stress/strain curves for the untreated, the acclimatized and the conditioned yarns as determined with the high-performance tensile testing installation USTER® *TENSOJET*. Compared with the untreated yarn (Fig. 1), the scatter plots of both the acclimatized (Fig. 2) and the conditioned yarn (Fig. 3) were shifted towards higher elongation values as a result of the moistening.

CO, OE-rotor-spun yarn, Nec 16.5

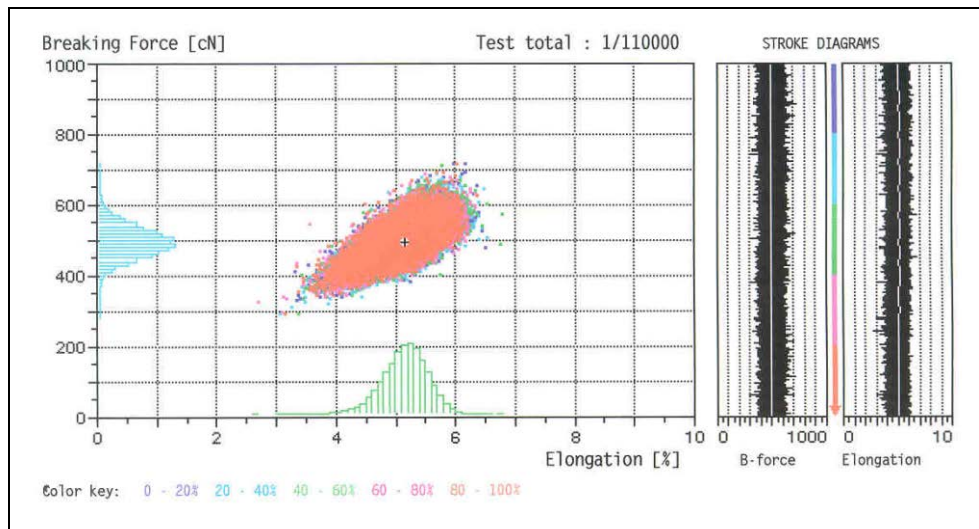


Fig. 1
Scatter plot and stroke diagram of the non-conditioned yarn

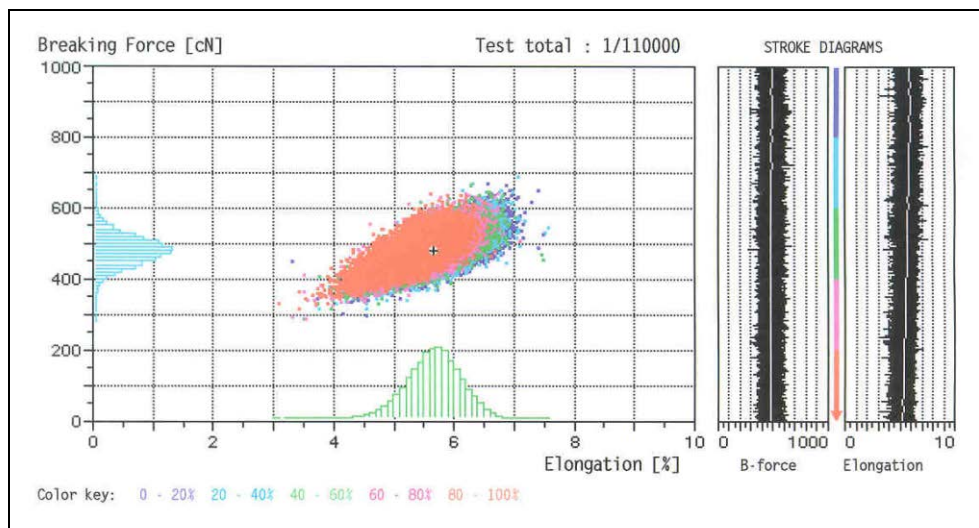


Fig. 2
Scatter plot and stroke diagram of the yarn conditioned in the weaving room

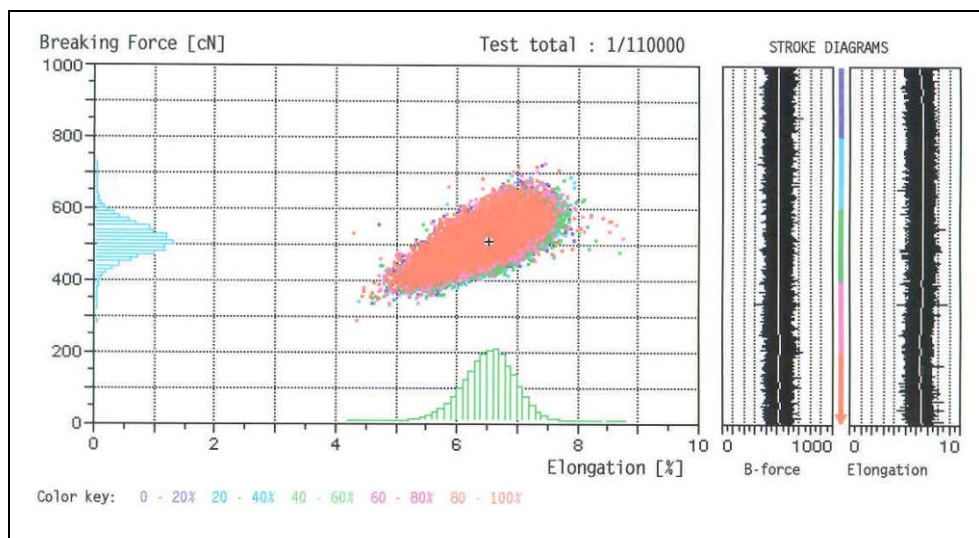


Fig. 3
Scatter plot and stroke diagram of the conditioned yarn

At the same time, however, the comparison illustrates the inadequacy of moisture absorption through acclimatization very clearly. The improvement of the characteristics as indicated by the mean values, which is considerably smaller than that of the conditioned yarn anyway, results only from the portion contributed by the outer thread layers. This is shown in a comparison of the three scatter plots with the help of a color code, whereby dark blue represents the outermost thread layers and red the inner thread layers of the package. A complete and even moisture penetration of all windings within a package, as confirmed by the tests, cannot be achieved through acclimatization but only with an optimized conditioning.

5 Conclusions

- Optimized conditioning according to the latest methods improves the processing characteristics of cotton OE rotor yarns considerably.
- A substantial improvement can be achieved in the yarn elongation and, although to a lesser extent, in the yarn strength.
- Previously unknown was the fact that the seldom-occurring weak places, in particular, show a relatively larger increase in elongation and working capacity than the mean values.
- A moistening over several days in storage, i.e. acclimatization in the weaving room, will result in a noticeable improvement of the characteristics, but the improvement is limited to the outer windings. The effect, both quantitatively and qualitatively, can therefore not be compared with that of an optimized conditioning process.
- Since end breaks in the event of overloads are primarily caused by weak places in the yarn, a conditioning will result in advantages with regard to both the frequency of possible filling stops and the fabric quality. The frequency of possible filling breaks with tight fabric settings, in particular, will be reduced considerably. This information applies primarily to the weft insertion and is valid for any insertion system.
- The advantages obtained through conditioning are put into perspective by the operational requirements (with an existing conditioning plant) with an energy consumption of 40 kWh per 1 ton of yarn. For the production location Switzerland, for example, the corresponding costs would be CHF 4.00 per ton of yarn.
- Even from an economic point of view, and especially in the high-performance weaving sector, the conditioning of yarns should therefore play a more important role.

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