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LABORATORY SYSTEMS

Application Report

Evaluation of the quality characteristics of ply yarns

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1 Introduction

Ply yarns have their own rules. As a result of the significant importance which ply yarns have gained in various areas of the textile industry, there is a considerable need for an enhanced quality management.

Uster Technologies has not yet developed USTER® *STATISTICS* for ply yarns for all materials. However, the following report will show how values for ply yarns can be derived from the existing USTER® *STATISTICS*.

Today, ply yarns are not only of importance as sewing threads or in technical applications but they are also used to increase the strength of yarns in high-quality textile applications such as worsted yarns, cashmere yarns, high-quality garments made of cotton, etc.

2 Unevenness of ply yarns

It is known that single yarns can contain weak places that cause faults or defects during the subsequent processing and in the final product. Such weak places can be considerably reduced by the formation of ply yarns. Such a process evens out weak places which means that the ply yarn has a lower unevenness than a single yarn. The doubling law is applied:

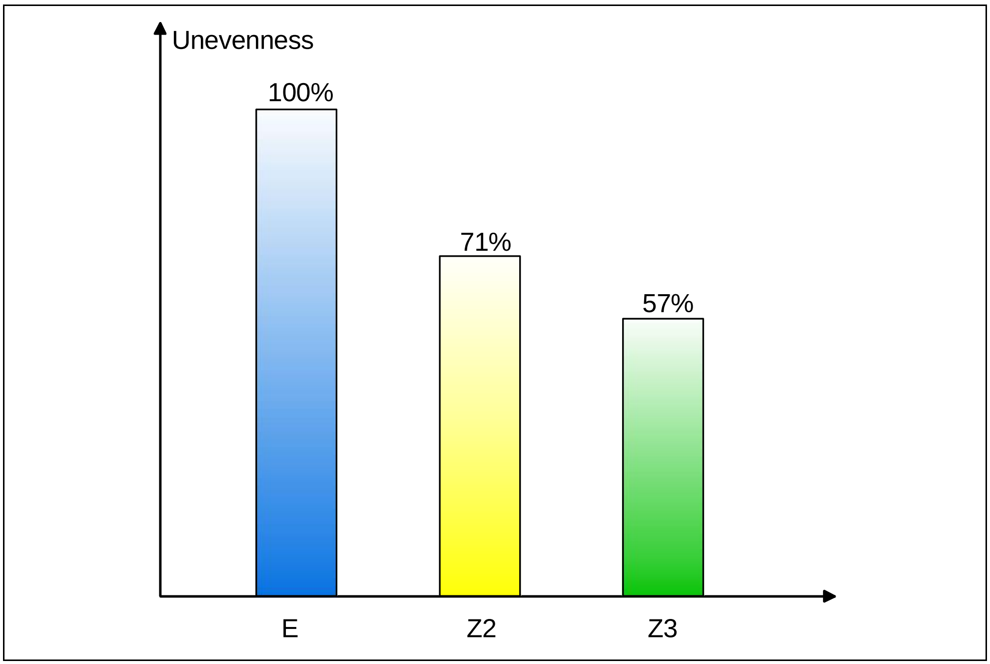
$$CV_{m(Zn)} = \frac{CV_{m(E)}}{\sqrt{n}}$$

$CV_{m\,(Zn)}$ = evenness of a ply yarn

$CV_{m\,(E)}$ = evenness of a single yarn

n = number of single yarns in a ply yarn

The coefficient of variation CV_m of the n-fold ply yarn is equal to the coefficient of variation CV_m of a single yarn divided by the square root of the number of the single yarns in the ply yarn.



E = Single yarn

Z2 = Two-ply yarn

Z3 = Three-ply yarn

Fig. 1
Evenness of ply yarns versus single yarns

The unevenness of a two-ply yarn of the same count is reduced to 71% of the value of a single yarn. The unevenness of a three-ply yarn of the same count drops to 57%.

Example:

A single yarn of combed cotton, Nec 30, has an unevenness of 13.1%. What unevenness can be expected for a two-ply yarn consisting of two yarns of count Ne 60 or three yarns of count Ne 90?

Two-ply yarn: $$CV_{m\,(Z2)} = \frac{CV_{m\,(E)}}{\sqrt{2}} = \frac{13{,}1}{\sqrt{2}} = 9{,}26\%$$

Three-ply yarn: $$CV_{m\,(Z3)} = \frac{CV_{m\,(E)}}{\sqrt{3}} = \frac{13{,}1}{\sqrt{3}} = 7{,}57\%$$

Extensive trials have proven this rule.

3 Imperfections of ply yarns

Similar observations apply for the evaluation of the imperfections of ply yarns. A thick place of +50% of a single yarn is reduced to +25% in a two-ply yarn if the thick place is positioned in the ply yarn in such way that the parallel thread on this particular place corresponds to the mean value. Therefore, considerably less imperfections may be expected in ply yarns for statistical reasons.

Extensive trials have led to the following correlation:

Ply yarn: $\log I_{Zn} = \log I_E - k \bullet \log n$

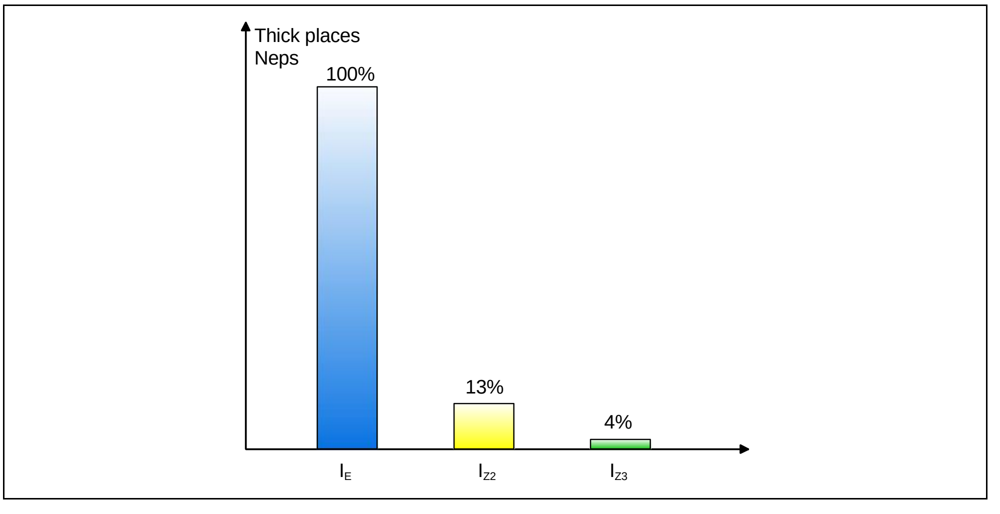
I_{Zn} = number of imperfections in a ply yarn

I_E = number of imperfections in a single yarn

k = Constant. This constant is three for thick places and neps. It is four for thin places.

n = Number of single yarns in the ply yarn

Fig. 2 and Fig. 3 show the reduction of imperfections of two- and three-ply yarns.



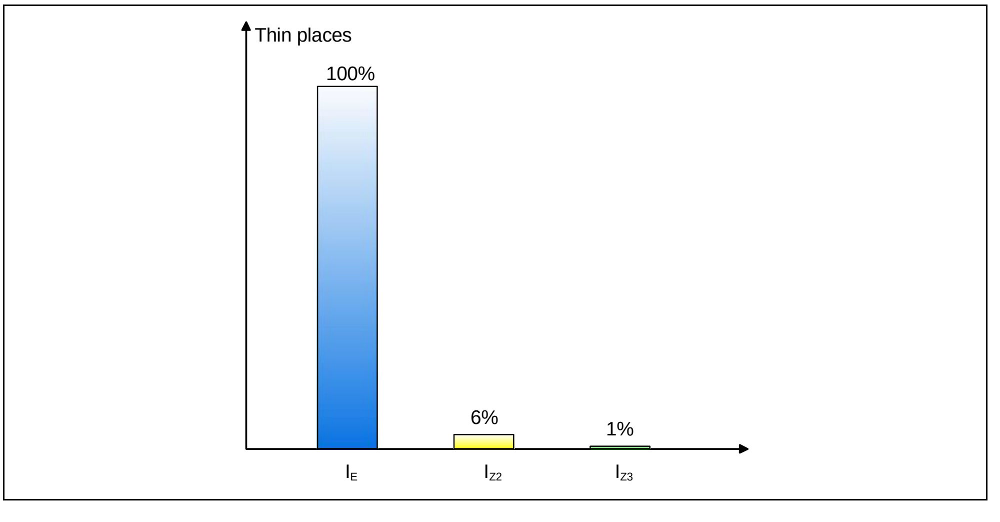
I_E = Thick places and neps of single yarns

I_{Z2} = Thick places and neps of two-ply yarns

I_{Z3} = Thick places and neps of three-ply yarns

Fig. 2
Thick places and neps; single yarns versus two-ply and three-ply yarns

The number of thick places and neps in a two-ply yarn falls to 13% compared to a single yarn and to 4% in a three-ply yarn.



I_E = Thin places of single yarns

I_{Z2} = Thin places of two-ply yarns

I_{Z3} = Thin places of three-ply yarns

Fig. 3
Thin places; single yarns versus two-ply and three-ply yarns

The number of thin places in a two-ply yarn is reduced to 6% compared to single yarn and to 1% in a three-ply yarn.

Example:

A single yarn, cotton, Nec 100, shows the following imperfections with sensitivities of thin places of –40%, thick places of +35%, neps of +140%:

Thin places: 250, thick places: 390, neps: 450.

Which values can be expected if a two-ply and a three-ply yarn are measured?

A two-ply yarn:	16 thin places,	49 thick places,	56 neps
A three-ply yarn:	3 thin places,	14 thick places,	17 neps

4 Tensile strength of ply yarns

As set out above, weak places are reduced during the twisting process. Therefore, it is to be expected that the tenacity increases if single yarns are twisted. Further, it is also to be expected that the tensile strength gets stronger if more single yarns are processed to a ply yarn.

Fig. 4 shows the result obtained during a series of trials in which the influence of the twisting process on the tensile strength is documented. The single yarn had a fineness of Nec 30. The two-ply yarn consisted of two yarns of Nec 60. The three-play yarn consisted of three single yarns of Nec 90. This is an example of a 100% cotton yarn, combed. However, depending on the twist and fiber-to-fiber friction the result may deviate from the values below (see Fig. 5). The tenacity of the single yarn was 15,5 cN/tex (100%).

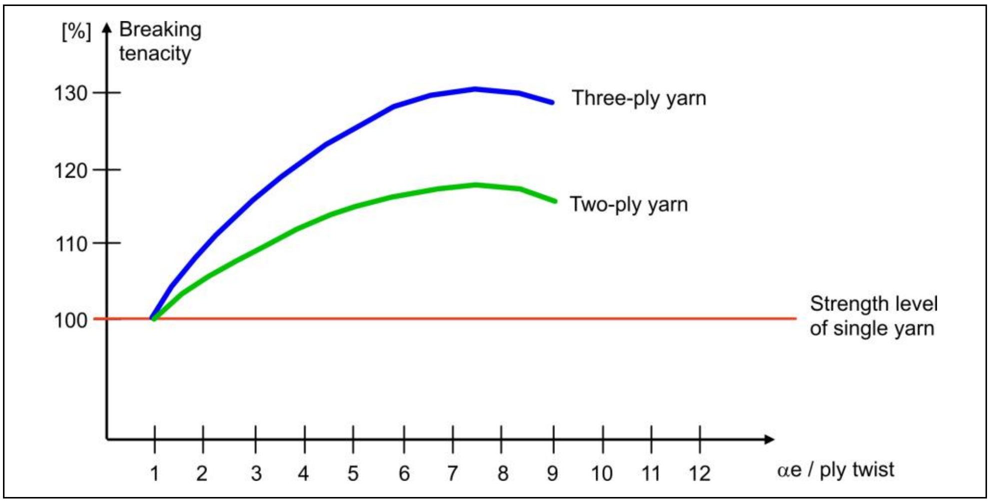


Fig. 4
Yarn strength of ply yarns; Single yarns versus two-ply and three-ply yarns

Fig. 4 shows the increase of the tensile strength of two-ply and three-ply yarns. The highest tensile strength is obtained with a ply twist of αe = 7,5. The single yarn of Fig. 4 is a combed cotton yarn, Nec 30.

The finer the yarn, the bigger the unevenness and the more significant the reduction of the unevenness of ply yarns.

Fig. 5 shows various yarns and the increase of the tensile strength in two-ply and three-ply yarns.

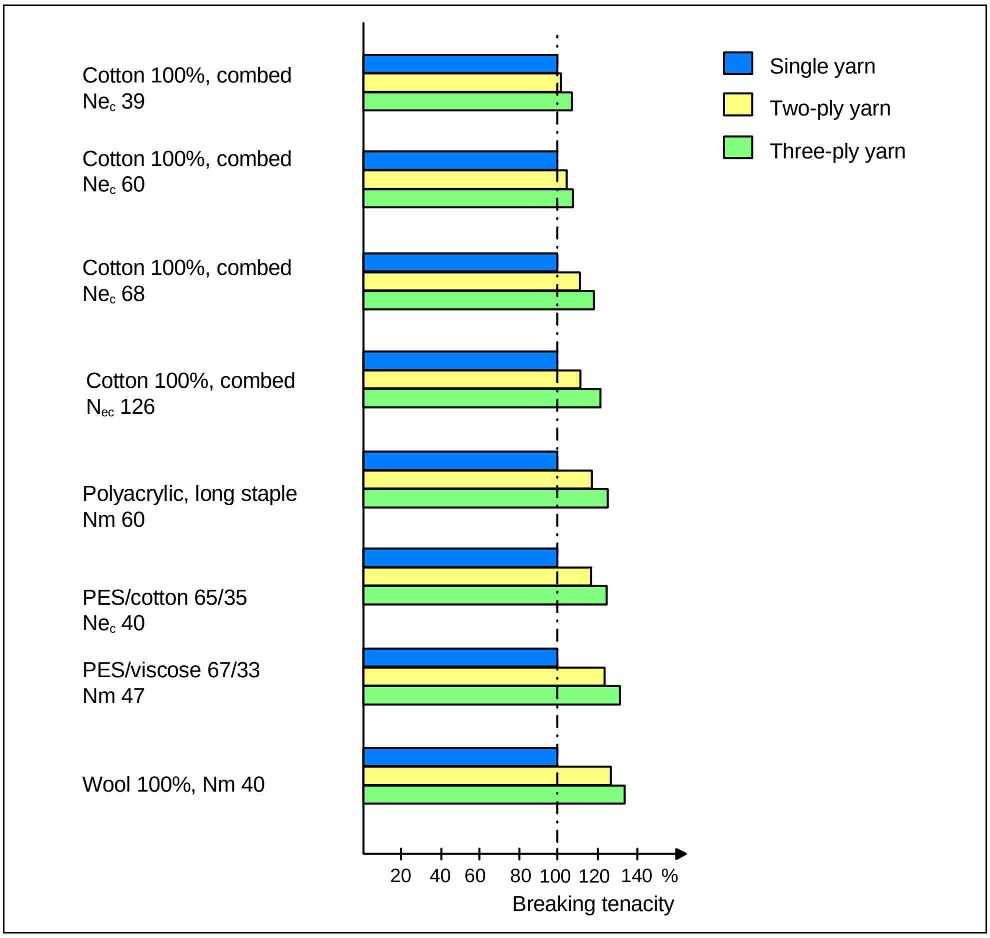


Fig. 5
Ply yarns; Impact on yarn strength

5 Variation of the tensile strength of ply yarns

The variation of the tensile strength gradually decreases from test to test when larger numbers of single yarns are processed to a ply yarn. The doubling law, as applied for unevenness, is also used here:

$$CV_{RH\,(Zn)} = \frac{CV_{RH\,(E)}}{\sqrt{n}}$$

$CV_{RH\,(Zn)}$ = Coefficient of variation of the tenacity of the ply yarn consisting of n single yarns

$CV_{RH\,(E)}$ = Coefficient of variation of the tenacity of the single yarn

n = Number of single yarns processed to a ply yarn

Example:

A single yarn is processed to a two-ply yarn. The single yarn has a coefficient of variation of the tenacity CV_{RH} of 9%. What coefficient of variation can be expected from a two-ply yarn?

$$CV_{RH(Z2)} = \frac{CV_{RH}}{\sqrt{2}} = \frac{9}{\sqrt{2}} = 6{,}4\%$$

For a three-ply yarn, the coefficient of variation would decrease to 5,2%.

6 Elongation of ply yarns

If we start from the assumption that weak places in yarns result in an end-break, it can also be assumed that ply yarns show higher elongations than single yarns Fig. 6 shows the increase of elongation in two- and three-ply yarns. These results were collected during extensive trials. The elongation of the two-ply yarn for three cotton yarns is, however, less than the one of a single yarn.

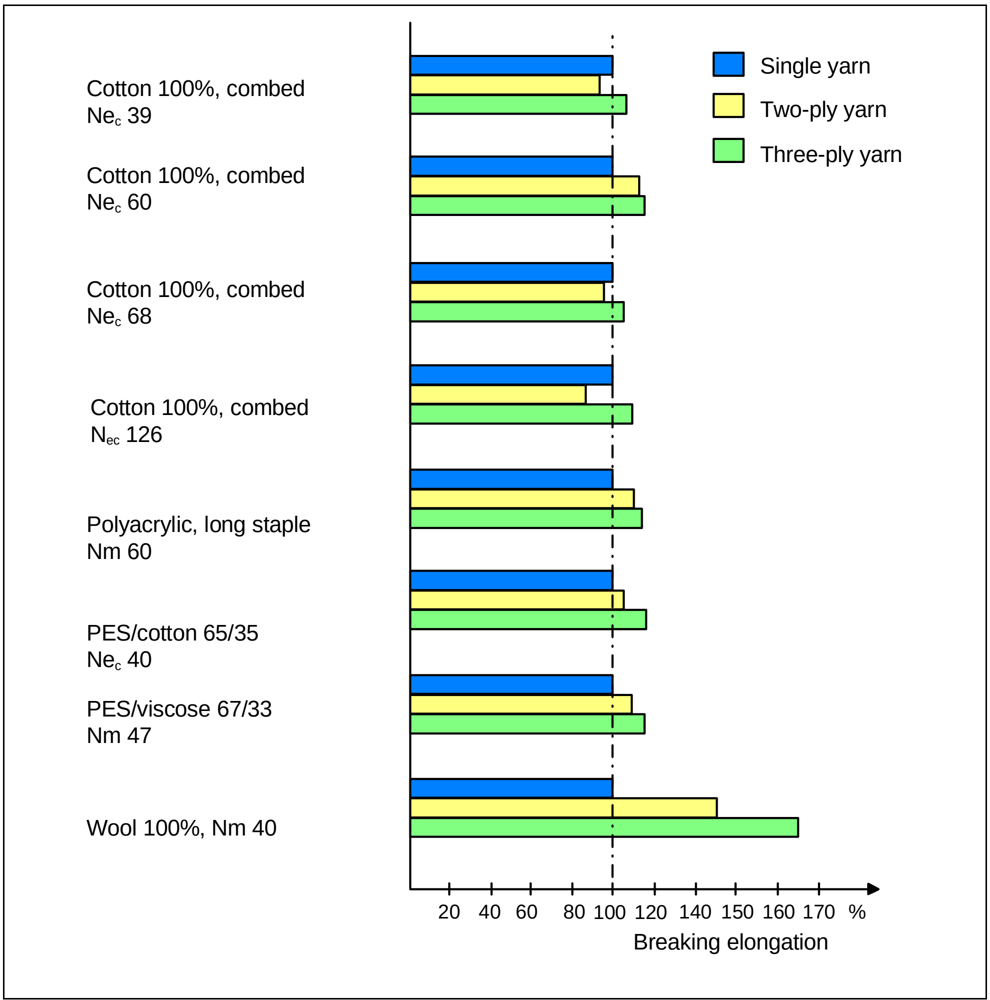


Fig. 6
Ply yarns; Impact on elongation

7 Hairiness of ply yarns

The hairiness of yarns is proportional to the number of fibers in the cross-section. The hairiness also decreases if the twist increases. If single yarns of the same twist are processed to a ply yarn, the hairiness increases because a ply yarn has double or triple the amount of fibers in the cross-section. This means that the probability of protruding fibers increases. At the same time an additional twist is applied to the ply yarn which slightly reduces the level of hairiness.

The following correlation is valid for the hairiness increase in the ply yarn process:

$$H_{Zn} = H_E + k \bullet \log n$$

H_{Zn} = hairiness of the ply yarn

H_E = hairiness of the single yarn

k = Constant. The constant is 5

n = Number of single yarns of a ply yarn

Example:

A single yarn, combed cotton, Nec 100, hairiness H = 2,9, is processed into a ply yarn*.* How much does the hairiness of a two-ply or three-ply yarn increase?

Hairiness of a two-ply yarn: $H_{Z2} = H_E + k \bullet \log n = 2{,}9 + 5 \bullet 0{,}3 = 4{,}4$

Hairiness of a three-ply yarn: $H_{Z3} = H_E + k \bullet \log n = 2{,}9 + 5 \bullet 0{,}47 = 5{,}2$

8 Comparison of the quality characteristics of ply yarns with the USTER® *STATISTICS*

Since the edition 2013 of the USTER® *STATISTICS* also statistics for plied yarns are included.

Those evaluations of plied yarns have been done for 100% cotton – in combed and carded state.

Instruments considered for the evaluation were USTER® *TESTER 5* as well as the tensile testers USTER® *TENSORAPID* and USTER® *TENSOJET*.

It is to be noted, that the yarn count mentioned, relates to the yarn count, as if the yarns would be single yarns.

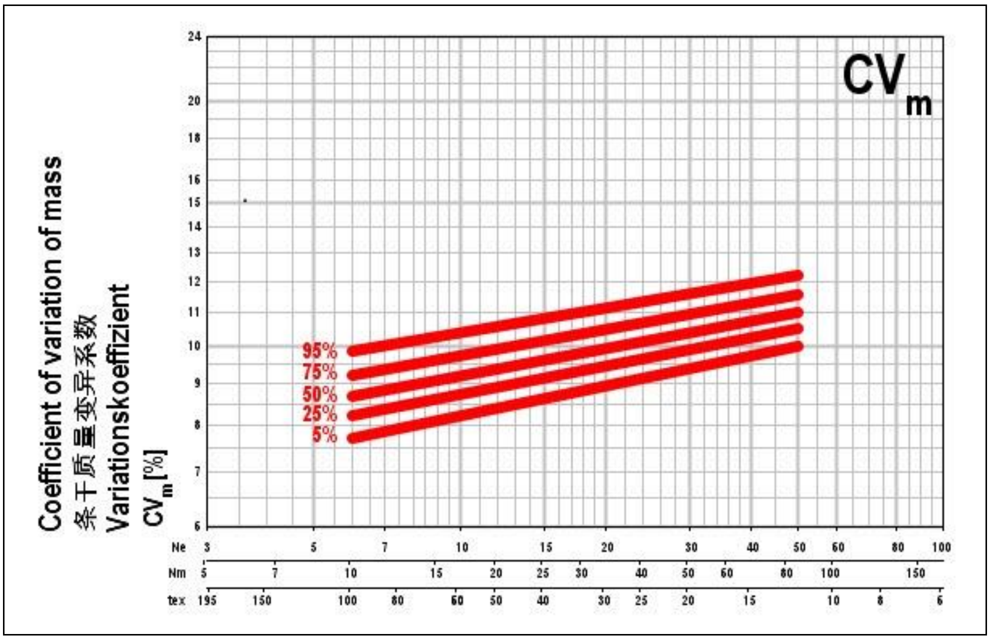


Fig. 7
USTER® *STATISTICS for 100% cotton, plied yarns*

9 Bibliography

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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

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