

# Tenacity of Cotton Yarns Joined During the Rewinding Process

Technical University of Lodz,  
Faculty of Material Technologies  
and Textile Design,  
Department of Fibre Physics and Textile Metrology,  
ul. Zeromskiego 116, 90-924 Łódź, Poland,  
e-mail: jacek.rutkowski@p.lodz.pl

## Abstract

Great technological progress and the automation of spinning processes have caused that machines, most often arranged in streamlines, work better and more efficiently. However, in spite of this advanced progress, it is impossible to produce yarns completely devoid of faults. Depending on the raw materials applied and the condition of machinery, there are places in yarn which do not correspond to the quality of yarn stream required. These are thick and thin places, as well as interwoven foreign fibres and contaminants. The last chance of eliminating such faults is the installation of a yarn quality monitoring device at the end of the spinning process, which would stop production when faults appear. The device will then remove the fault and join the yarn ends to create a continuous stream of twisted fibres. Such devices can be mounted on spinning and rewinding machines. This study contains an analysis of the strength parameters of cotton yarn knotless joints with linear densities of 20 and 25 tex, manufactured in both industrial and laboratory conditions. The yarns were rewound on a Schlafhorst Autoconer 338 rewinding machine. Then an assessment was made of the joints' strength received as a result of knotless joining with various adjustments of the splicer. The yarn tenacity before and after the rewinding was compared, and coefficients of the utilisation of the joints' resistance in the yarn tenacity after rewinding were established.

**Key words:** winding process, joining methods, splicer, tenacity.

## ■ Joining of yarn ends

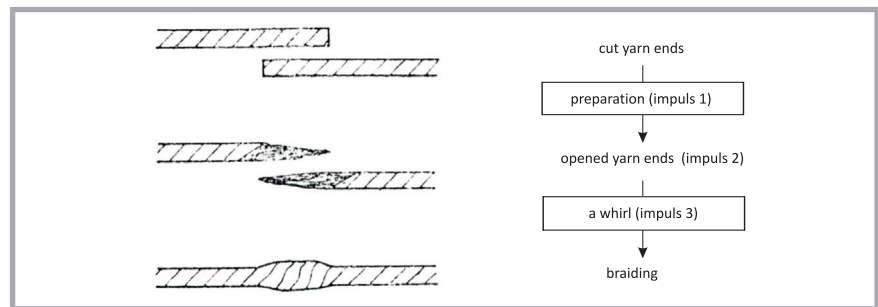
When rewinding, it is necessary to join yarn ends. This is undertaken due to breaks, fault removal and the changing of the cop. The following types of yarn end joining exist:

- knot joining,
- welding,
- splicing [1],
- wrapping with an auxiliary thread,
- electrostatic, mechanical and pneumatic braiding (**Figure 1**).

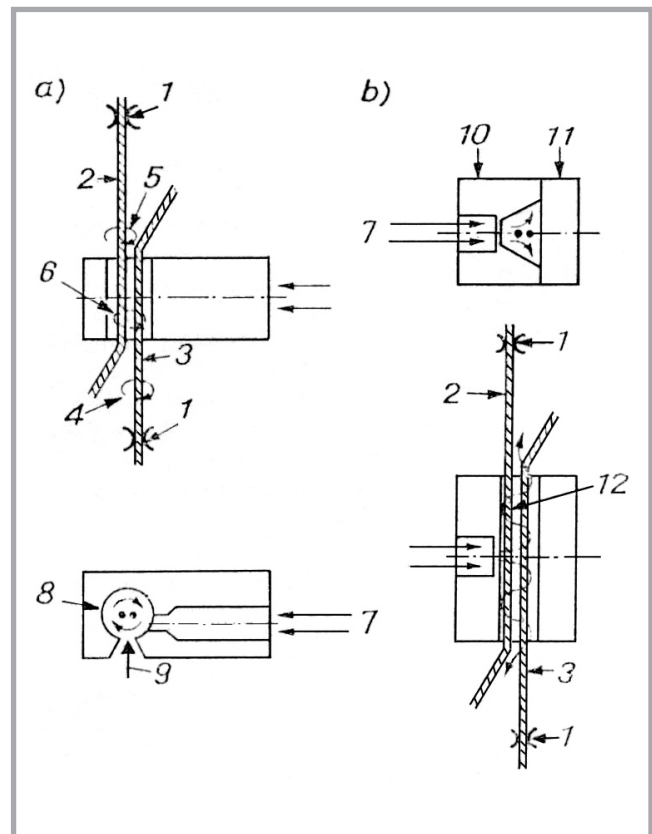
Among the methods mentioned above, the most important is the braiding technique. Joints made according to this technique are characterised by a correct look and very good strength. These are small-sized joints of a structure close to that of thread, and their creation does not require any foreign materials. The braiding technique involves three methods: the electrostatic, mechanical and pneumatic.

Nowadays, the most popular method of yarn end joining is the pneumatic one (**Figure 2**). Devices for pneumatic joining are called splicers. These could be manual or permanently installed appliances. There are two types of them:

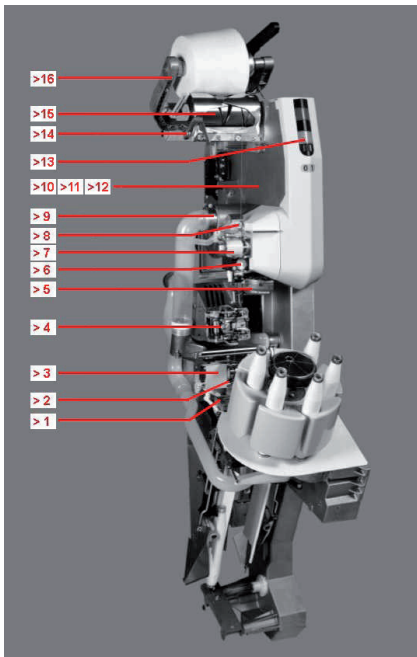
- of a static mode of operation with a round joining chamber (i. e. static air supply), constructed by the MURATA and MESDAN companies,
- of a direct mode of operation with a chamber closed with a lid, constructed by the SCHLAFHORST, MESDAN and ENKA TECNICA companies.



**Figure 1.** Yarn end joining process.



**Figure 2.** Pneumatic joining: a – device of a static mode of operation, b – device of a direct mode of operation; 1 – clamps, 2 – upper thread, 3 – bottom thread, 4 – producing twist on the thread (the thread is unwound), 5 – producing twist on the thread (the thread is twisted), 6 – twist direction in the joining chamber, 7 – compressed air supply, 8 – joining chamber (compressed air turning clockwise), 9 – draw-in slot, 10 – casing, 11 – reclining lid, 12 – air stream movement.



**Figure 3.** Single point stand of the Autoconer 338 type RM rewinding machine [10]; 1 – bottom break sensor, 2 – revolving magazine with cops, 3 – thread electromagnetic tension device, 4 – splicer, 5 – electronic yarn cleaner, 6 – Autotense FX\* thread tension device sensor, 7 – wax-finishing automat\*, 8 – gripping nozzle, 9 – sucking pipe with upper yarn sensor, 10 – rewinding unit control system, 11 – Protopack FX\*, 12 – Variopack FX\*, 13 – light signalling device, 14 – protection against winding on the roller, 15 – grooved roller, 16 – winding fork with weight adjustment, \* – option.

The first generation of splicers worked in a single phase – without a fibre opening. After feeding the yarn ends, they were joined in one working cycle. Before the compressed air supply, the yarn ends had to be a little parted in order to make the blending of both ends possible. This technique was not satisfactory for joining yarns made of short fibre, strongly twisted fibre, and fine yarns. That is why the phase of yarn end preparation was additionally introduced, whose task is to open the yarn ends to such a degree that a parallel arrangement of fibres is received. Only the ends prepared in this way are arranged one on the other, and they are mutually moved by means of the compressed air.

Up to the present numerous research works considering pneumatically spliced yarns were carried out and their results published in scientific literature. Many of them concern the theoretical relations of this technique [2], especially the predicting of tensile strength and other physical parameters [3, 4] of the yarns joined, as well as the splicing device

settings necessary for obtaining the assumed yarn features (e.g. the diameter of the joint). There are considerably less works discussing the problems of splicer designs and structures [5, 6] and the results of test carried out with splicers [7 - 9]. This article is a contribution to this latter problem.

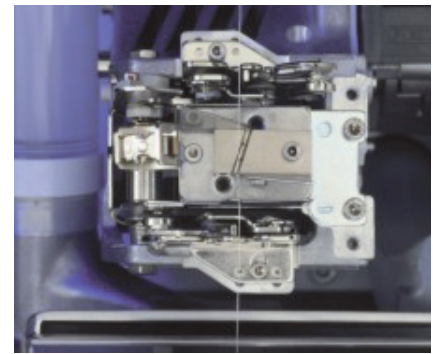
### Objects, investigation methods and variant characteristics

Test were carried out on the single-point stand of an automatic Schlafhorst Autoconer 338 rewinding machine [10], whose construction is presented on **Figure 3**. **Figure 4** presents the splicer of this device, which is controlled by an electronic Uster Quantum cleaner [11].

In order to carry out the test, 16 classical yarn variants of 20 tex and 25 tex linear density were used. Theyarns were manufactured on an industrial technological line and at the laboratory of the Department of Spinning Technology and Yarn Construction. The yarns were rewound at a speed of 250 m/min for four varying adjustments of the time of air blowing in the splicer chamber. The air pressure in the chamber was constant, the value of which was:

- 4 Bar during opening yarn ends,
- 5 Bar during the joining process.

The values of the splicer adjustments correspond to the times of air blowing in the joining chamber - (Impulse I + Impulse II + impulse III'), which are 1 – 20 ms, 2 – 40 ms, 3 – 60 ms, 4 – 80 ms, 5 – 100 ms, 6 – 120 ms, 7 – 140 ms, 8 – 160 ms, and 9 – 180 ms, respectively.



**Figure 4.** Splicer [10].

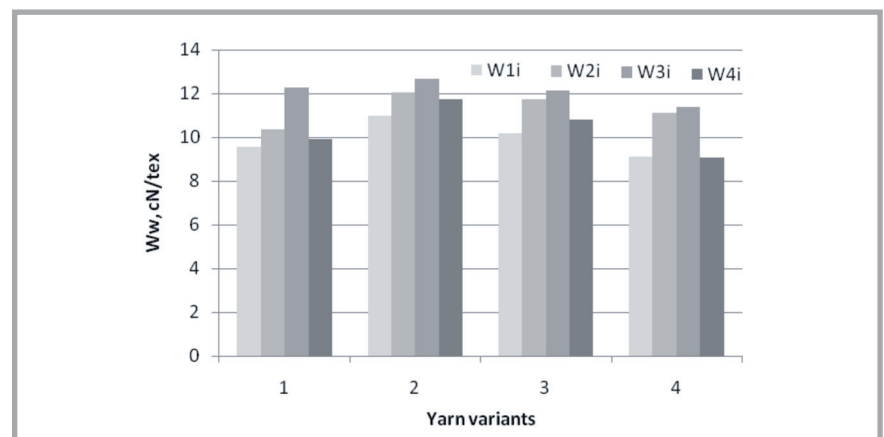
According to the rewinding machine's manufacturer, the universal settings are the following values: Impulse I : 5, Impulse II : 3, and Impulse III : 5 [5].

### Results and conclusions

Fixing the strength and breaking elongation was done on a ZWICK 1120 breaking machine, with a clamp distance of 500 mm and velocity of 500 mm/min.

For each variant 50 measurements were made. Measurements were carried out in accordance with the Polish Standard PN-EN ISO 2062. The analyses took into consideration only breaks which appeared at the points of knotless joining. Results of the breaking tests are presented on **Figure 5**.

The biggest tenacity is characterised by knotless joints with splicer adjustment 537. Similar values were also found for yarn joints with splicer adjustment 539. Whereas the smallest tenacity is characterised by knotless joints with splicer adjustments 335 and 535.



**Figure 5.** Graph of the tenacity of joined: industrial cotton yarn sections (W1i) and laboratory cotton yarn sections (W2i) of a linear density of 20 tex, industrial cotton yarn sections (W3i) and laboratory cotton yarn sections (W4i) of a linear density of 25 tex with four variants of splicer adjustment: i = 1) 535, 2) 537, 3) 539, 4) 335.

**Table 1.** Coefficient of using the tenacity of knotless joining in the yarn tenacity after rewinding, with four adjustments of the splicer.

Variant mark	535			537			539			335		
	Wwpb. cN/tex	Wwpp. cN/tex	Pp. %	Wwpb. cN/tex	Wwpp. cN/tex	Pp. %	Wwpb. cN/tex	Wwpp. cN/tex	Pp. %	Wwpb. cN/tex	Wwpp. cN/tex	Pp. %
Industrial yarn - 20 tex	9.57	15.6	61	10.97	5.79	69	10.37	14.78	68	9.09	5.28	59
Laboratory yarn - 20 tex	10.35	13.95	74	12.04	13.89	86	11.75	13.74	85	11.12	14.2	78
Industrial yarn - 25 tex	12.27	14.82	82	12.67	14.38	88	12.15	13.93	87	11.39	14.18	80
Laboratory yarn - 25 tex	9.9	13.89	71	11.74	15.21	77	10.78	14.59	73	9.08	14.52	62

In order to evaluate and compare the results of the tenacity measurements of the yarn knotless joints, test procedures were applied for verification of the hypothesis with respect to the equality of average values. For this purpose F-Fisher-Snedecora and t-Student tests were used.

From a statistical point of view, no significant differences occurred between the particular values of tenacity. The only exception is the 537/335 variant for 25 tex yarn produced in laboratory conditions, where a significant difference occurs between the average tenacity values. This testifies that using variants with a too short time of unknotting yarn ends is of no use, because the joined yarn will have significantly worse tenacity properties.

From a statistical point of view, the lack of significant differences between the other variants might show there is no need to make adjustments to the splicer. However, taking into consideration technological practice and the fact that at this stage only cotton yarns of two density variants were studied, one may state that changing the air blowing time in the joining chamber may influence the quality of the tenacity of the knotless joint, which can also affect the tenacity of the rewound yarn.

In order to confirm the above hypothesis, the dependence of the tenacity of yarn joints and the yarn tenacity after rewinding were investigated.

In order to make conclusions concerning the technological nature, the coefficient of using the tenacity of knotless joining in the yarn tenacity after rewinding was defined. This coefficient is described as  $Pp$  and is expressed by the formula:

$$Pp = \frac{Wwpb}{Wwpp} \cdot 100\% \quad (1)$$

where:

$Wwpb$  – tenacity of the yarn at the point of joining,

$Wwpp$  – tenacity of the yarn after rewinding.

The results for all variants of the test yarns are presented in **Table 1**.

The highest value of the strength of knotless joining in relation to the yarn strength after rewinding is achieved with splicer adjustment 537, which means that the unbraiding time of the fibre ends was 100 ms, the pause between the impulses 60 ms, and the braiding time was 140 ms. For industrial cotton yarn of a linear density of 25 tex, it is even 88% of the yarn strength. Splicer adjustment 539 also offers the possibility of receiving a yarn knotless joint strength value close to the yarn strength after rewinding; however, among all the variants tested, the optimal solution when rewinding is the 537 variant.

The least strength value in relation to the yarn strength after rewinding appears in joints received when the splicer is adjusted to 535 and 335. In the case of the second variant for industrial yarn of a linear density of 20 tex, it is not much over 50%. This is an important observation, as the manufacturer recommends a splicer adjustment for standard values (535); however, the results obtained show better strength indices of the joints when the braiding time is a little longer. It should be added that none of the yarn variants tested reached a strength of the knotless joint at a level close to the declaration of the device's manufacturer; hence it may be inferred that catalogue data are not always presented in an objective way.

## References

1. Drobina R., Włochowicz A., Machnio M. S.; *Multi-Criterion Assessment of Pneumatically Spliced Cotton Combed Ring-Spun Yarns. Fibres and Textiles in Eastern Europe. Vol. 16, No 5 (70) 2008 pp. 25-32.*
2. Lewandowski S., Drobina R.; *Prediction of properties of Unknotted Spliced Ends*

*of Yarns Using Multiple Regression and Artificial Neural Networks. Part I: Identification of Spliced Joints of Combed Wool Yarn by Artificial Neural Networks and Multiple Regression. Fibres and Textiles in Eastern Europe. Vol. 16, No 5 (70) 2008 pp. 33-39.*

3. Ünal P. G., Özdil N., Taşkın C.; *The Effect of Fiber Properties on the Characteristics of Spliced Yarns Part I: Prediction of Spliced Yarns Tensile Properties. Textile Research Journal, March 2010; Vol. 80, 5.*
4. Ünal P. G., Özdil N., Taşkın C.; *The Effect of Fiber Properties on the Characteristics of Spliced Yarns Part II: Prediction of Retained Spliced Diameter. Textile Research Journal, first published on March 11, 2010.*
5. Ankudowicz W., Dopierała H., Radom C., Swaczyna P.; *Linking Yarns from Staple and Filament Fibres by High-Efficiency Pneumatic Interlacing. Part I: Factors Influencing the Linking Effect and Properties of Interlaced Yarns. Analysis of Tensile Strength Parameters. Fibres and Textiles in Eastern Europe. Vol. 16, No 1 (66) 2008 pp. 37-43.*
6. Ankudowicz W., Dopierała H., Radom C., Swaczyna P.; *Linking Yarns from Staple and Filament Fibres by High-Efficiency Pneumatic Interlacing. Part II: Analysis of Hairiness, Number of Faults and Estimation of the Linking Effects. Fibres and Textiles in Eastern Europe. Vol. 16, No 2 (67) 2008 pp. 18-22.*
7. Cheng K. P. S., Lam H. L. I.; *Strength of Pneumatic Spliced Polyester/Cotton Ring Spun Yarns. Textile Research Journal, March 2000; Vol. 70, 3.*
8. Cheng K. P. S., Lam H. L. I.; *Physical Properties of Pneumatically Spliced Cotton Ring Spun Yarns. Textile Research Journal, December 2000; Vol. 70, 12.*
9. Hassen M. B., Sakli F.; *Experimental Study of Mechanical Splicing. Autex Research Journal. Vol. 5, No 2, June 2005.*
10. Autoconer 338, *Innovation, know-how, flexibility. Schlafhorst promotional leaflet.*
11. USTER QANTUM CLEARER. *On-line Quality Management in the Spinning Mill. Zellweger Uster 2002.*

Received 08.01.2010 Reviewed 18.03.2010