EXPERIMENTAL STUDY OF MECHANICAL SPLICING

Mohamed Ben Hassen* and Faouzi Sakli**

Textile Research Unit, Ksar Hellal
High Technology Institute, Ksar Hellal
Hadj Ali Soua, 5070 Ksar-Hellal, Tunisia
Phone: + 216 73 475 900, Fax: + 216 73 475 163;
*E-mail: benrayen@yahoo.fr
**E-mail: faouzi.sakli@isetkh.rnu.tn

Abstract

An experimental design method was used in order to determine the most relevant parameters as well as the crossing effects to be considered in mechanical splicing. This approach was applied in order to establish a statistical model to predict the splicing properties of thick and medium cotton yarns for denim fabrics. This model shows that the change in the value of drafting has no influence on the properties of the mechanical splicing. Moreover, high values of untwisting and low re-twisting values improve those properties. The result proved that in optimal conditions, and in contrast to pneumatic splicing, the yarn linear density has no influence on the properties of splice. Therefore, mechanical splicing may be used for a wide range of yarns.

Key words:

mechanical splicing, winding, experimental design, denim yarns

Introduction

The achievement of an appropriate splice in winding is one of the most important factors for spinners to meet present requirements in terms of productivity and quality. Different splicing techniques, pneumatic, mechanical and electrostatic, were developed towards the end of the last century [2]. Over the last twenty years, many studies have tried to broaden the end use of pneumatic splicing, in the upward transformation process [7-9]. On the other hand, mechanical splicing has been relativelyneglected. The first patent in mechanical splicing was developed by Zellweger Uster in 1979. In this process, the broken yarn ends are first automatically untwisted, beards are then formed by pulling the two yarn ends away, and these beards are overlapped and re-twisted together again. The advantages of this method is the absence of air or any extraneous materials, and the reproducibility of the results.

The duration of untwisting, respective re-twisting, and the value of drafting are the main factors which affect the splice quality. In order to obtain good splice properties, the combination of these three parameters must be studied in depth.

In this work, we present an experimental study of mechanical splicing of ring spun denim yarns.

Materials And Methods

In our experiments we used two denim yarns with 32 and 82 tex linear density. The splices were prepared on the Orion E-1 Savio Twinsplicer 0017 using annular rubber twisting surfaces that are mounted on metal discs geared to counter-rotate. The breaking strength and elongation at break of both original and spliced yarns was tested in a Lloyd Instruments Tester in standard conditions, and the result is accepted when failure occurs in the splicing zone. The Savio Twinsplicer has three regulation points for adjusting splicing conditions: the duration of ‘untwisting’ U, the value of ‘drafting’ D and the duration of ‘re-twisting’ R. The drafting D has four levels for adjustment (1 to 4), where 1 is the minimum. The untwisting U and re-twisting R have fourteen levels of adjusting (1 to 7 with 0.5 increment), where 1 is the minimum.

In our study, two factorial sets were used. The objective of the first set was to determine the most important parameters of splicing, as well as the crossing effects to be taken into account. In the second set, we tried to find the useful value of the most important parameters while others are maintained at optimum conditions.

Results and Discussion

The breaking strength and the elongation at break of the spliced yarn are respectively expressed as the Retained Spliced Strength (RSS) and the Retained Spliced Elongation (RSE). The RSS and RSE are respectively the strength and the elongation of the spliced yarn expressed as the percentage of the parent yarn in which the splice is inserted [3-5].

Preliminary study

In the first part of this study, a factorial set of 2^4 (four parameters, each one with two levels combined in 16 configurations) was used. The aim of this set was to determine the most influential parameters and the crossing effects, also called interactions, with least combinations [1, 6].

Table 1. Parameter values

Parameter	Low Level	High level
Yarn Count Yc	32 tex	82 tex
Untwisting U	1	7
Re-twisting R	1	7
Draft E	1	4

According to experimental design methods, the parameter effects – principal and interactive – were calculated. To decide which were the most influential, variance analysis was used. Some of the results are given in Table 2, where the effect of a parameter – for example, the value of drafting D – on the spliced retained properties (for example RSS) is calculated as $\overline{\mathbf{RSS}}_{\mathbf{highD}} - \overline{\mathbf{RSS}}_{\mathbf{total}} = \mathbf{0.5} \cdot (\overline{\mathbf{RSS}}_{\mathbf{highD}} - \overline{\mathbf{RSS}}_{\mathbf{lowD}})$. Figure 1 shows the RSS variations in terms of $\overline{\mathbf{RSS}}_{\mathbf{high}}$ and $\overline{\mathbf{RSS}}_{\mathbf{low}}$. XY notation in Table 2 and Figure 1 stands for the interaction between parameters X and Y. For example, a non-negligible value of UR means that the effect of changing untwisting depends on the re-twisting level, as shown in Figure 2. By using a linear additive model which includes all significant (statistically non-negligible) effects, the model response can be estimated, i.e., the retained spliced quality in terms of RSS and RSE at any configuration.

Table 2. Parameter effects [a]

	Yc	U	R	D	YcU	YcR	YcD	UR	UD	RD
RSS	-	5.83	-11.03	-	-	3.92	-	5.08	-7.17	-
RSE	-	8.62	-7.8	-	-	-	-	-	-5.17	-

[a] Dash means an insignificant effect.

From Figure 1 and Table 2, it is obvious that untwisting U and re-twisting R are the most influential parameters on mechanical properties of the splice. The results indicate that a high level of U, and respectively a low level of R, leads to a high-quality splice. In fact, an increase in RSS of 22% is obtained when we adapted a low level of R. In the same way, an improvement in RSS of 17% is remarked when we used a high level of U. It is obvious that splicing properties depends on its internal structure. An adequate opening of beards (high U value) leads to a higher level of fibre individualisation, and a convenient re-twisting yields a good intermingling of fibres and no over-twisting. Therefore, the structure obtained has properties close to those of the original yarns.

Untwisting and re-twisting influence yarn quality not only as a main factor but also by means of their interactions UR. A non-negligible value of UR (Figure 1) indicates that the splice is symmetrical. A high value of U cannot be succeeded by a low value of R, since we have to avoid the extreme values for these two parameters; the combination, U=7 and R=1 or U=1 and R=7 leads to poor quality of splice.

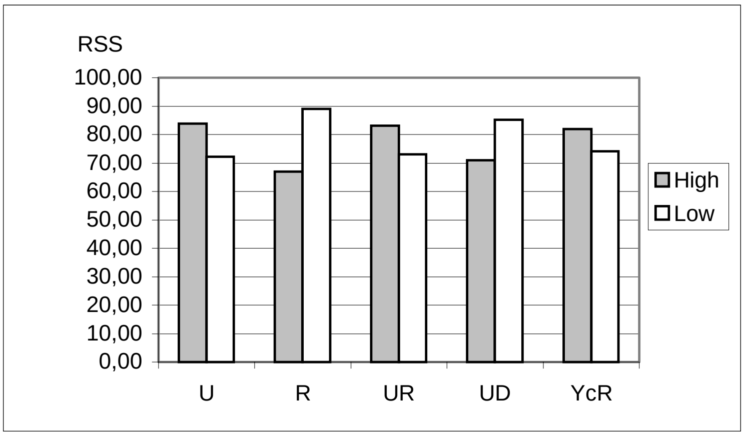

Figure 1. RSS variations

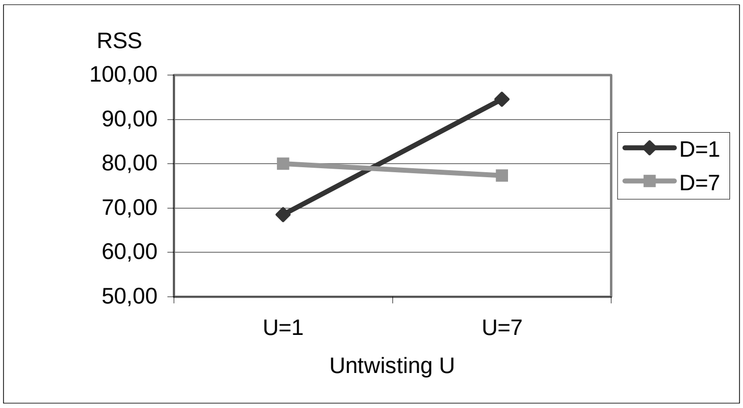

Figure 2. Interaction between the effects of the untwisting U and the re-twisting R on the RSS

The variation in the value of drafting D has no effect on the mechanical properties of splice (Table 2). When the value of drafting D rises, the number of fibres in the cross section decreases, but the length of the splice increases in the same way, and the total number of fibres remains constant, and hence balances the inter-fibre cohesion.

The interaction between the drafting and the untwisting DU shows that for high values of untwisting, low drafting should be adapted to prevent weak points and tails' failure.

Contrary to pneumatic splicing, the yarn linear density Yc had no effect on the mechanical properties of mechanically spliced yarn. Thus mechanical splicing may be used for a wide range of yarns. On the other hand, many parameters of mechanical splicing should be chosen with regard to the yarn density as shown by the crossing effect between the re-twisting and the yarn count RYc (Figure 2), which indicates that it is more convenient to choose a low value of re-twisting R for a medium yarn.

According to these conclusions, and to better understand the non-negligible interactions, we realised a factorial set of 28 samples (7 for re-twisting R and 4 for untwisting U) to find the range of re-twisting and untwisting values most suited for the two tested yarn counts, 37 and 82 tex.

Complementary study

According to the results of the preliminary study, we proceeded as follows.

1. The value of the draft was fixed at level 3.
2. To visualise the crossing effect between the yarn count and the untwisting YcU, we tested the same sets for both yarn counts.
3. The splice was carried out in optimal conditions as described in the preliminary study, with seven levels for the re-twisting R – the most influential parameters in the yarn's physical properties – and four levels for the untwisting U.

Table 3. Parameter values

Parameter values	untwisting U	re-twisting R
1	2	2
2	4	2,5
3	5	3
4	6	3,5
5	-	4
6	-	5
7	-	6

From Figures 3 to 6, it is evident that the RSS and RSE for untwisting U and re-twisting R vary in the same way. This confirms the good interaction between the elongation at break and the breaking strength of the spliced yarn. The analysis of one of these properties is therefore enough to define the mechanical properties of the splice.

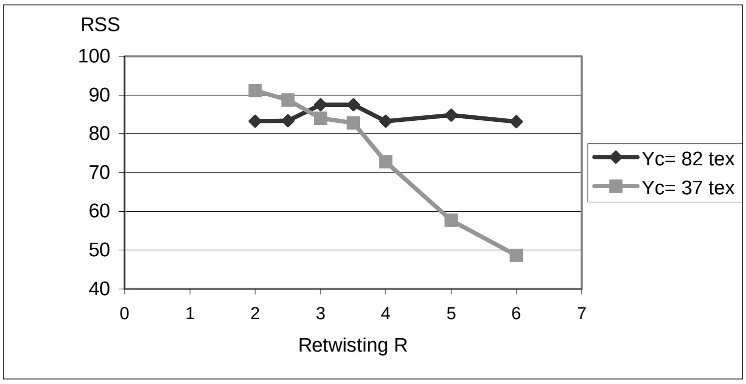

Figure 3. Relationship between RSS and R for the both yarns

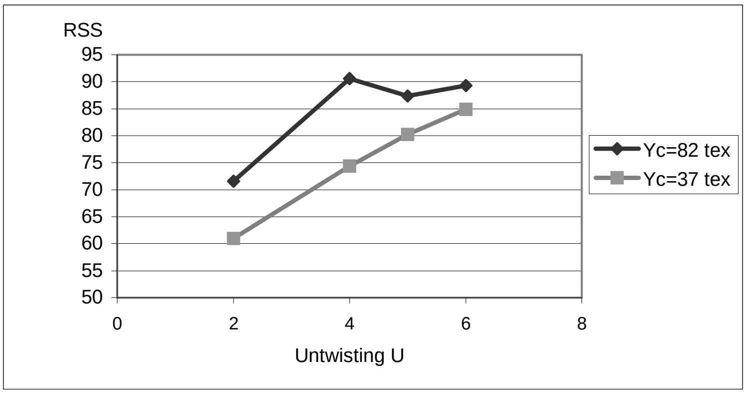

Figure 4. Relationship between RSS and U for the both yarns

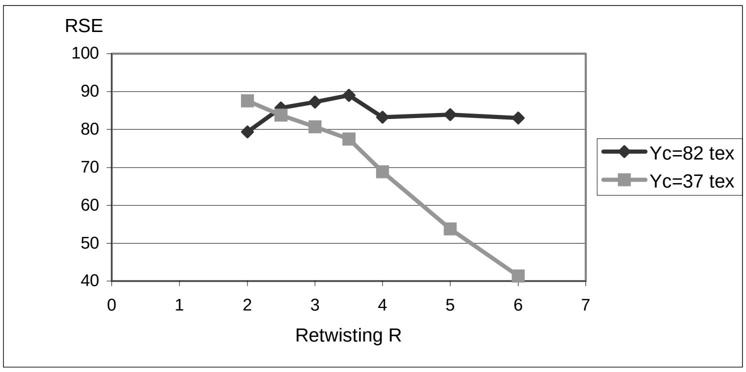

Figure 5. Relationship between RSE and R for the both yarns

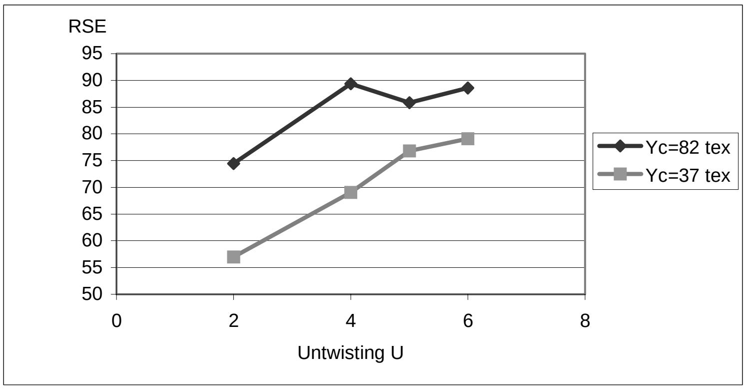

Figure 6. Relationship between RSE and U for the both yarns

Figure 3 shows that the variation of RSS with the re-twisting R, consists of two parts. For low values of R, the value of RSS exceeded 80% with slightly better properties for 37 tex yarn. For high levels of R, a sharp decrease was noticed for this yarn, while the 82 tex yarn remained almost unchanged. This result confirms the non-negligible interaction between the yarn count and the re-twisting YcR. To obtain a high quality of splice, the re-twisting R should be within the range of 2 to 3.

Figure 4 indicates that the RSS has a linear relationship to the untwisting U. For high levels of U, the values of RSS could exceed 90%. Moreover, thicker yarns lead to higher RSS values. However, the value of RSS for both yarns decreased for high levels of U. According to Figures 4 and 6, we recommend a range of 5 to 6 for U for best properties.

Conclusions

Untwisting and re-twisting are the most influential parameters on the mechanical properties of mechanically spliced yarns. To achieve high splicing quality , an adequate opening of the yarn ends and a convenient re-twisting should be used. In optimal conditions, it is possible to splice medium and thick cotton yarns using the same device, which is the advantage of mechanical splicing. With two factorial sets, it was possible to obtain the most influential parameters on mechanical properties of the splice and the range of values to adapt in mechanical splicing.

References

1. *Benoist, D., Tourbier, Y., and Germain-Tourbier, S.; “Plans d’Expériences, Constructions et Analyses’’, Edition Lavoisier, France, 1994*
2. *Bissman, O.; ‘Knotfree Yarns Joins by Splicing’, International Textile Bulletin Spinning, 3/81, 281 (1981).*
3. *Cheng, K. P. S. and Lam, H. L. I.; ‘Strength of Pneumatic Spliced Polyester/Cotton Ring Spun Yarns’, Textile Research Journal, 70(3), 243-246 (2000).*
4. *Cheng, K. P. S. and Lam, H. L. I.; ‘Physical Properties of Pneumatically Spliced Cotton Ring Spun Yarns’; Textile Research Journal, 70(12), 1053-1057 (2000).*
5. *Cheng, K. P. S. and Lam, H. L. I.; ‘Evaluating and Comparing the Physical Properties of Spliced Yarns by Regression and Neural Network Techniques’, Textile Res. J. 73(02), 161-164 (2003).*
6. *Goupy, J.; “La Methode des Plans d’Expériences”, Editions Dunod, France, 1996.*
7. *Kaushik, R. C. D., Sharma, I. C., Hari, P. K.; ‘Effect of Fibre/Yarn Variables on Mechanical Properties of Spliced Yarn’, Textile Research Journal, 57 (8), 490-494 (1987).*
8. *Kaushik, R. C. D., Hari, P.K., Sharma, I. C. and Sarkar, A. K.; ‘Performance of Spliced Yarn in Warping and Weaving’, Textile Research Journal, 57 (11), 670-673 (1987).*
9. *Kaushik, R. C. D., Hari, P.K. and Sharma, I. C.; ‘Mechanism of the Splice’, Textile Research Journal, 58 (5), 263-268 (1988).*

∇∆