IMPACT OF THE SPLICER PARAMETERS ON THE SPLICED OPEN-END DENIM SPUN-YARNS PHYSICO-MECHANICAL PERFORMANCES

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Abstract:

In this work, the open end splicer parameters as the compressed air (pressure, P and durations of tearing, Dt), the fibres feeding during splicing operation (1S10 and EII), and the recalling yarn codes (RI, RII and RIII) were investigated. In order to evaluate the contribution of the splicing conditions on the open end splice physico-mechanical behaviour, we used the experimental Tagauchi design method. This kind of experimental design allows us, using simplification method, to reduce the amount of the experiments. To evaluate the splice appearance, the subjective (the experts notes) method and the objective (referring to a developed Thickness index value) one are compared. In our experimental field of interest, the results show that the feeding fibres parameter level increase gives the lowest Thickness index value which means good splice appearance. However, the compressed air remains the most important parameter because it represents the influential one on both the strength and the longitudinal characteristics of the spliced open-end spun-yarns (length of splice and the expert judgments).

Key words:

Open-end Denim spun-yarn, splice, physico-mechanical performance, appearance.

Introduction

Because some irregularities (knots, thicknesses, weakest zones, etc.) on the yarn, it can generate several stoppages during spinning or winding processes, it is necessary to ensure the yarn continuity by splicing which replaced well the knotting methods. The ultimate aim is to join a yarn so that the join region has the same appearance and physical properties as the rest of the yam [2]. The splicing method is the technique which can join two ends (juxtaposed side by side on a chamber called the prism) in order to obtain the yarn continuity by applying a blast of compressed air [3]. Before splicing operation, a high-pressure turbulent flow of compressed air was applied to the two ends in order to overlap them adequately. The air within the splicing chamber is that of high turbulence (Reynolds number typically about 105) [1]. Compared to the splicing operation on the prism, the open end one is different because a neat strong bond was formed due to the prepared yarn end and the staple of fibres without twist. As a result, the open end yarn is produced [4, 5]. The adoption of splicing process has greatly reduced problems in weaving, knitting and dyeing [6] and significantly improves the joint quality and factory productivity.

However, the splicing operation on the open end machine is a variable and a complicated process that can lead to unpredictable characteristics of physico-mechanical properties especially the strength and the appearance of the formed splice. The majority of the published works studied the spliced yarn inside the winding machine [6 - 10] because of two raisons. First the complexity of the spliced open end spun yarns localisation and second the non easy splicing conditions changing. The open end yarn was considered as the non conventional yarn which can highly gives several specific characteristics. This technique of joining consists to join, on the rotor, the yarn end with the open yarn one coming from the carded or the combed sliver as shown in Figure 1. Indeed, we can obtain the nap, weft, warp and soft twist yarns [1].

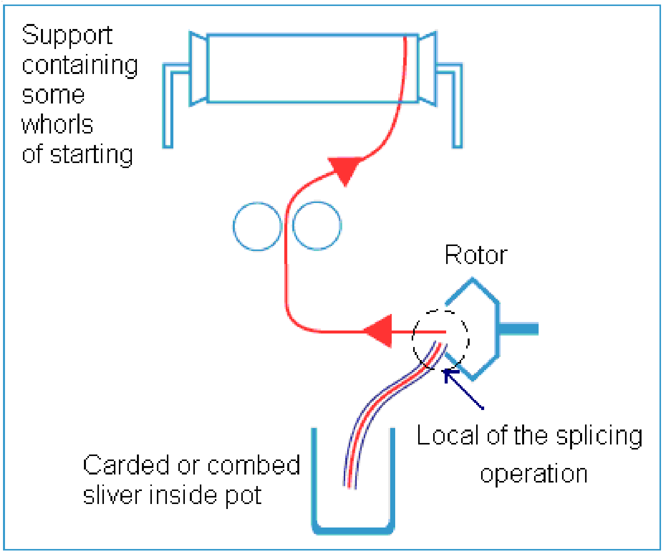

Figure 1. The local of the splicing operation of the two ends coming from the carded or combed sliver and from the bobbin respectively.

Experimental

The 50 g/m cotton yarn was produced on the Schlafhorst Autocoro ACO 240. Figure 2 shows the overall spliced yarn samples which were used to our investigation. The open yarn ends represented in blue and red colours were spliced on the Schlafhorst dry pneumatic splicer. The rotor diameter used is 46 mm. The number of prepared splice is 540 specimens which represents our experimental database. The splicer is equipped with some used points of adjustment: the compressed air parameters ("Cap"), the recalling yarn parameters ("Yrp") and the feeding fibre parameters ("Ffp"). Indeed, the duration of tearing, Dt (196.45-1163.5 ms) and the pressure of air joining, P (4-6 bars) represent the compressed air parameters. Although, the first converted yarn recall code, RI (276-290 mm), the second converted yarn recalls code RII (135-145 mm) and the third converted yarn recall one RIII (10-17 mm). However, the feeding parameters are represented by both EII (67-82 mm) and 1S10 (20-36 mm) converted codes.

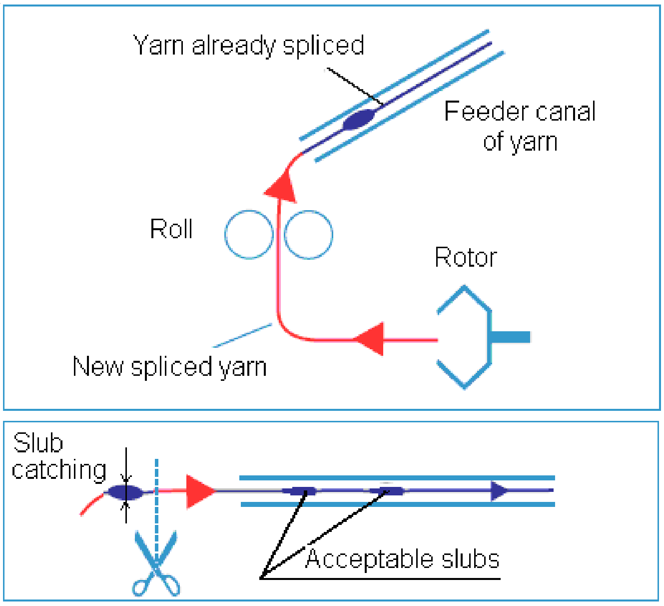

Figure 2. The spliced open-end-spun-yarn operation and the slub-catching one.

These overall regulations were changed during the splice preparation referring to the elaborated orthogonal Tagauchi design (27 combinations). Table 1 shows the fixed adjustments used to produce the open end spliced yarn samples and their correspondent levels. Referring to Schlafhorst recommendation [4], and since they are frequently used in industry, these adjustments are selected and used in our experiment.

In this work, the splice thickness analysis was realized using an electron microscope standard Sodemat (using MATIC IMAGE PLUS software) with an enlarging ranging 10 to 40. The diameter of the samples were tested and compared to the parent yarn thickness sections.

Table 1. Levels of the overall tested Schlafhorst splicer input parameters.

Levels	Compressed air parameters		Yarn recall parameters			Feeding parameters	
	Pressure P, bar	Duration of tearing D_t, ms	RI, mm	RII, mm	RIII, mm	EII, mm	1S10, mm
1	4	196,45	276	131	10	67	20
2	6	680	283	138	14	72	30
3	8	1163,5	290	145	17	87	36

The observation of the scanning images of the spliced zone (Figure 3) allowed us to identify the most important characteristics of the splice slub-zones and their lengths.

In addition, the expert's notes (10 experts within higher industrial experience) were saved in order to evaluate subjectively the appearance of the samples. Each sample of the experimental design was tested on the Lloyd tensile tester in order to carry out the retained strength of spliced yarns. The number of tests is 20 for each combination and the retained strength mean values were calculated. The length of the specimens is 100 mm according to Cheng and Kaushik [7, 10]. The average test speed was regulated according to the duration of the test which is of 20±3 seconds according to the standards, NFG 07-003 [11]. The preliminary tension of the tested yarn was 0,5 cN/tex. The spliced and original tested yarns were wound manually and the method of testing was identical to the testing of both the spliced and the parent yarns.

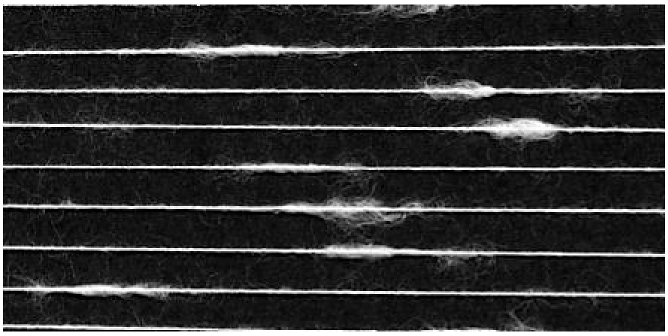

Figure 3. Spliced open-end spun-yarns using Autocoro Schlafhorst type ACO 240.

The retained breaking strength of splice, RSS was tested. The correspondent expression is shown in Equation 1. The measure of the thickness (Thickness%) of cross morphological spliced zones compared to the parent yarn ones is given using Equation 2. In this previous equation we consider that the spliced and parent open end yarns cross sections have cylindrical shape (Dspliced yarn and Dparent yarn). The mean diameter values of specimens were carried out using microscopic and scanning method.

$$RSS\ (\%) = 100 \times \left(\frac{Bs_{splice}}{Bs_{parent\ yarn}} \right) \qquad \text{Equation 1}$$

$$Thickness\ (\%) = \frac{D_{spliced\ yarn}}{D_{parent\ yarn}} \qquad \text{Equation 2}$$

where:

Bs_{splice} and $Bs_{parent\ yarn}$: Mean breaking strength of both spliced and parent open end yarns (N).
$D_{spliced\ yarn}$ and $D_{parent\ yarn}$: Mean diameters of cross morphology of spliced and parent open end yarns (mm).

Results and discussion

Figure 4 shows the variation of the retained strength of spliced open-end spun-yarns as a function of the pneumatic splicer input parameters. The majority of the input parameters contribute to the mechanical behaviour of the splices.

In order to analyse the variation of the most important parameters, Figure 5 shows the impact of each one: compressed air parameter ("Cap"), the yarn recalls parameters ("Yrp") and the feeding fibre ones ("Ffp"). We conclude that the increase of both the compressed air and the feeding fibres parameters increases the strength of the splice.

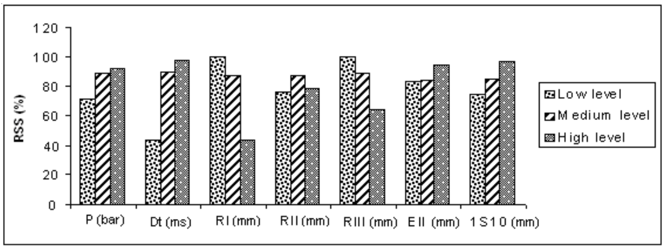

Figure 4. Variation of the RSS as function of tested pneumatic splicer parameters.

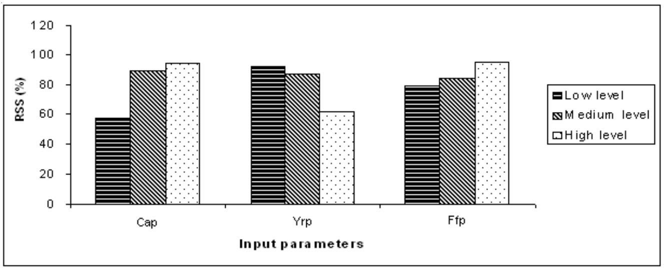

Figure 5. Impact of the input Open End splicer parameter on RSS.

According to our earlier works and cheng results [6], the pressure (P) and the duration of tearing (Dt) affect the splice mechanical behaviour. Preparing suitably the yarn end before splicing and during higher tearing duration (Dt) increases the formed spliced zone and ensures its continuity. The feeding parameters (EII and 1S10) increase the spliced yarn resistance because these parameters participate effectively on the splicing operation. Indeed, when the number of fibres on the rotor system during splicing operation is few the splice becomes thin and we obtained a weakest spliced zone. For these previous parameters, it is suitable to use higher splicer coded levels to encourage the splice behaviour before further use especially during weaving process.

We noted an increase of 37.32 % in the retained breaking strength of the splices when the compressed air increases from the lower level to the higher one. In spite of the little increase (16.32 %), of the splice resistance compared to the previous input parameter contribution, this result improves the feeding parameters effectiveness. The feeding fibres parameters remain an influential splicer parameter. The mean RSS value of the spliced open end spun yarn in the analysed experimental design of interest is 85.92%, which explain the effectiveness of the splice strength.

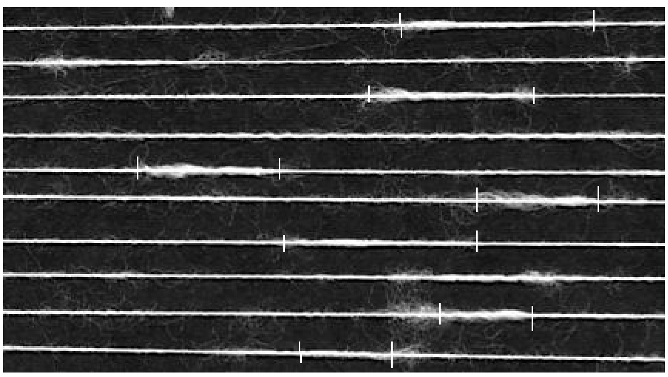

Figure 6: Limited zones of the spliced yarns length variations.

However, according to our findings, it seems that the mechanical behaviour of the spliced yarns decreases when the recalling yarn parameters (RI, RII and RIII) have the highest levels. In our experimental field of interest, the results shown in Figure 3 present that it is better to use lower levels of the recalling yarn parameters. When the yarn recall levels have a high values, the two ends present a splices without sufficient strength. The contribution percentage of this parameter is estimated to 30 % when we changed a higher level by lower one.

According to Figure 6, the open end spliced zone (represented as limited zones) has length ranging from 3.44 mm to 17.01 mm.

Figure 7 shows the contribution of the increase of the splicer parameters on the splice length. The increase of the overall input parameter levels increases the length of the spliced yarns. Indeed, when the compressed air during splicing changes from the lower level to the higher one, the splice length increases 5.2 mm. As shown in Figure 7, the splice length increases of 2.29 mm when we increased the recalling yarn code levels. However, we observed an increase of the value of splice length 1.39 mm only when the feeding fibre parameters increase from lower level to higher one. The results of this work show that the mean length of splice in our experimental design is 10.86 mm.

Hence, our tested splicer input parameters (“Cap”, “Yrp” and “Ffp”) affect the length of spliced open end yarns. This defines their influence on the splice longitudinal appearance because length and global morphology of the splice structure are related.

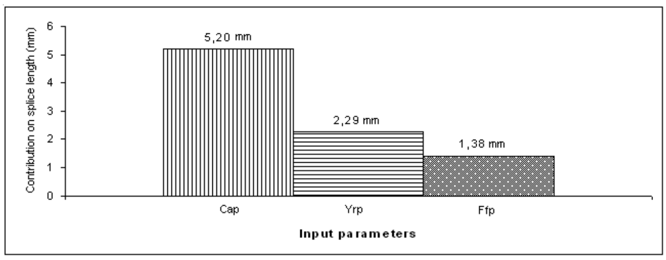

Figure 7. The increase of splice length as function of increase of Schlafhorst splicer parameters levels.

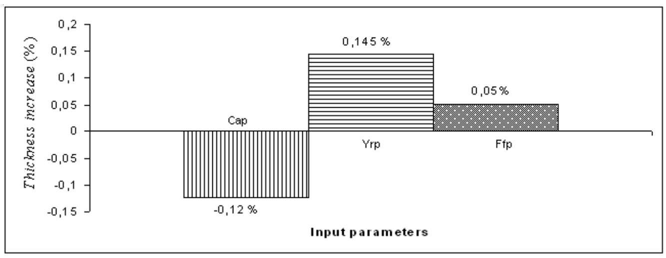

Figure 8. Contribution of the splicer inputs level increases on the cross morphology of spliced open end yarns.

To analyse the impact of changing the levels of the splicer parameters on the cross morphology of specimens, our microscopic results show that the variation of the feeding fibres during the splicing operation contributes positively (minimal contribution percentage =0.05 % compared to the other contribution ones) on the splice appearance. Figure 8 shows the variation of the rate of diameters of both spliced and parent yarns as function of splicer parameter levels increase. According to Figure 8, it seems that the splicer inputs increase the splice appearance because minimal contribution percentages were remarked. The mean value of the developed index is 102.70 % which indicate the decrease of appearance.

Figure 9 shows the variation of the expert's notes as function of splicer parameters. It seems that the mean note values are not higher. According to the same figure, we conclude the increase of the expert evaluations when "Cap" increases. But the increase of the "Yrp" levels decreases the expert's notes. The subjective evaluation of the experts has a good relationship with the compressed air applied to both two yarn ends. In fact, this means that the opening ends contribute positively on splice appearance evaluation.

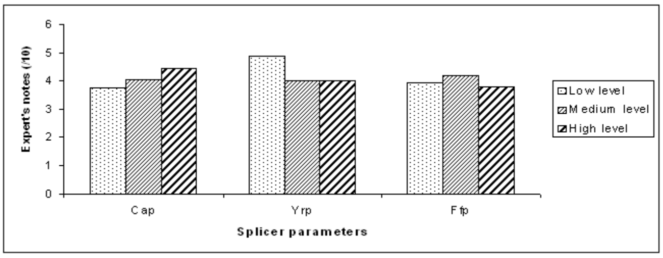

Figure 9. Expert's notes as function of the splicer Schlafhorst Autocoro ACO 240 adjustments.

On the other hand, according to our results, the decrease of the expert's judgments can be due to increase of the recalling yarn parameters.

Conclusion

The impact of the overall controllable splicer parameters on the physico-mechanical performance of the dry spliced open-end spun-yarns was established. Our findings showed that the most important parameter is the compressed air. In fact, this influential parameter remains the factor which affects both the retained strength of splice and also the appearance of this structure (judged by experts and investigated using the microscopic and scanning methods). Hence, it is really clear that the increase of both the compressed air parameters and the feeding fibres ones increase the splice resistance compared to the parent yarn one. Moreover, the change of the levels of the recalling yarn parameters affects the splice resistance. In addition, the studied overall contributions of the correspondent splicer parameters on the splice length shows that the most important impact is due firstly to the compressed air parameters, secondly the recalling yarn parameters and finally the feeding fibres ones. This conclusion seems in high agreement with the subjective decision and the objective developed index (Thickness). According to our findings, we conclude that a compromise between mechanical and physical characteristics should be taken into account in order to judge and optimise the splice performance in the experimental design of interest. This can help further studies to predict the spliced open end yarns behaviour especially in the weaving, dyeing, and knitting processes.

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