SLUB YARN QUALITY OPTIMIZATION BY USING DIAGRAMS OF SUPERIMPOSED CONTOURS

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Abstract

Quality is a subjective notion that is related to customer needs. Generally, to respond customer requirements, different criteria should be satisfied at the same time. For textile materials, this objective is not evident because of the interdependence of the properties and the experimental constraints. In order to optimize all yarn parameters simultaneously, we tried, through this research, to find a compromise zone that could satisfy to the best set of the objectives of slub yarns. For this goal, we have optimized Slub yarn quality including the major physical properties of cotton Slub yarn by using diagrams of superimposed contours.

Index Terms: *Slub yarn, quality, diagrams of superimposed contours, optimization***.**

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1. INTRODUCTION

The quality of Slub yarns is very important in determining their application possibilities (ITB 2004). In fact, the random variation in the count of the base yarn which contains thick places of different thicknesses and lengths, gives a wide range of effects. This ensures the use of Slub yarns in many applications like denim, shirting, knitwear, casual wear and also in ladies dress material. Seeing that yarn quality is a multi-criteria phenomenon that requires the satisfaction of several properties at the same time, we have examined the major yarn properties. For this purpose, we have used the method of optimization based on the diagrams of superimposed contours. In this way, the optimal values of parameters were found. These values are regrouped in zones of compromise, where the properties retained for definition of the global quality of the yarn are satisfied in an experimental domain of interest.

Over the past several years, methods for predicting yarn performance, namely the statistical analysis or the soft computing techniques treat yarn properties separately (Cheng et al 1995; El Mogahzy et al 1990; Ramesh et al 1995; Rangaswamy et al 1997; Morris et al 1999; Ning 2001; Ramey et al 1977). Therefore, it is desirable to predict an averall yarn quality that considers all yarn characteristics simultaneously.

In this study, we have studied Slub yarns used in denim industry. For the case, we were interested in finding a compromise for best satisfying all yarn quality parameters.

2. MATERIALS AND METHODS

In order to study Slub yarn overall quality, we have used the international standards using the Uster Tester 3 and Uster Tensiorapid 3 testing systems by considering the major known yarn characteristics (Table 1). An experimental data base has been elaborated for 800 yarns. The Slub yarn is spun with “programmable” characteristics- electronically controlled and reproducible by means of the Amsler device (ITB 2004). These characteristics are produced via a program controlled drafting system which varies acceleration of back and middle rollers in case of ring spinning, at the same time maintaining the front roller at a constant speed. This controlled acceleration produces variation in Slubs (or flames) count (TSlub), spacing (or pause) length (Lpause) and spacing count (Tpause) ’’Fig. 1’’.

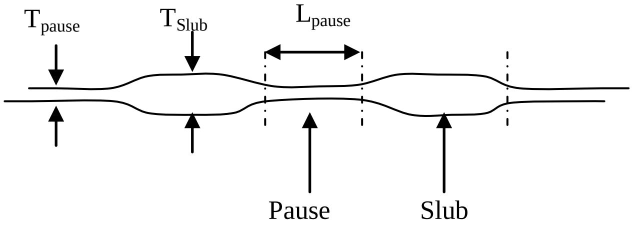

Fig. 1: Slub yarn configuration

The determinant structural parameters introduced in the Amsler device program conferring to the Slub yarn configuration are respectively:

- The number of Slubs per meter (N_{Slubs})
- And the slub length (L_{Slub}).

Yarn property	**Symbol**	**Mean**	**Standard deviation**	**Min value**	**Max value**
Tenacity (CN/ Tex)	RKM	17,32	1,23	14,64	22,12
Tenacity evenness (%)	CVRKM	6,85	3,17	4,54	7,96
Breaking elongation (%)	E%	7,87	0,77	5,27	11,72
Breaking elongation evenness (%)	CVE%	4,1	2,64	0,77	15,76
Breaking work (Joule)	TR	2,83	0,85	1,27	6,58
Breaking work evenness (%)	CVTR %	12,07	3,39	0,00	16,27
Slub length (m)	L_{slub}	0,15	2,50	0,10	0,20
Number of Slubs/meter (m^{-1})	N_{Slubs}	2.47	0.98	1.18	5.36
Twist value (turns/m)	Twist	463	26,65	364	629
Yarn count($m/10^{-3}$ kg)	T_{yarn}	13,07	3,46	10,10	21,12

Table 1: Summary statistics for Slub yarn properties

As global quality, we have defined the objectives of each property as shown in Table 2. The definition of quality is subjective and it can be modified for the case. The principle of the use of the graphic method of diagrams of superimposed contours consists of giving an objective and a zone of acceptance for every property, then searching graphically for the zones that answer the criteria.

The factors we have studied are yarn count, yarn twist, the slub length and the number of slubs per meter. The choice of each factor boundaries is very determinant for spinner to reach all yarn properties as required by the customer. In diagrams of superimposed contours for optimization, slub yarn properties are maintained at a certain value, while searching the zones of feasibility of each pair of the factors mentioned. Each set of contours defines the boundaries of acceptable response values and each overlaid contour plot consists of a pair of factors (one for X-axis, one for Y-axis)

Slub yarn Reponses	**Inferior limit**	**Superior limit**
RKM	16	19
CVRKM	0	15
E%	5	11
CVE%	0	15
TR	0.86	6.24
CVTR%	0	15

Table 2: Slub yarn quality definition

3. RESULTS AND DISCUSSION

In the first graph ’’Fig.1’’, twist and yarn count are plotted on the X- and Y-axes, respectively. Through this study, we search for the suitable and feasible ranges of the metric yarn count (Nm) and twists that the spinner can apply while holding the properties restrain imposed by the consumer at certain settings (Table 2). The contours of each response are displayed in a different color. The solid contour is the lower bound and the dotted contour is the upper bound. The graphics are two overlaid contour plots ’’Fig. 2 drawn by using “Minitab” software for data analysis.

The white area inside each plot is the feasible region which is the area formed by the two factors, where the criteria for each response variables are satisfied. When the quality definition of the yarn is as described in Table 2, the zone of feasibility (or compromise zone) is obtained with yarn count (Nm) belonging to the interval [11.75; 17.75] and a twist belonging to the interval [445; 660] (Figure2.a).

Figure 2.b shows the variation of slub parameters (Slub length (Lslub) and Slub number (Nbslub)). The white zone, satisfying the criteria mentioned at right of the figure, is restricted for a slub number between [1.2 ; 3.24] and a slub length between [0.11 ; 0.17]. It seems from this figure that yarn objectives are not satisfied for higher slub numbers. It can be deduced that with higher slub numbers, the yarn shows more pauses which constitute places of weakness in the slub yarn.

If we change yarn properties values according to customer demands, the spinner would have other optimal couples of yarn count and twist (Nm, Twist) and slub number and length (Nbslub ,Lslub).

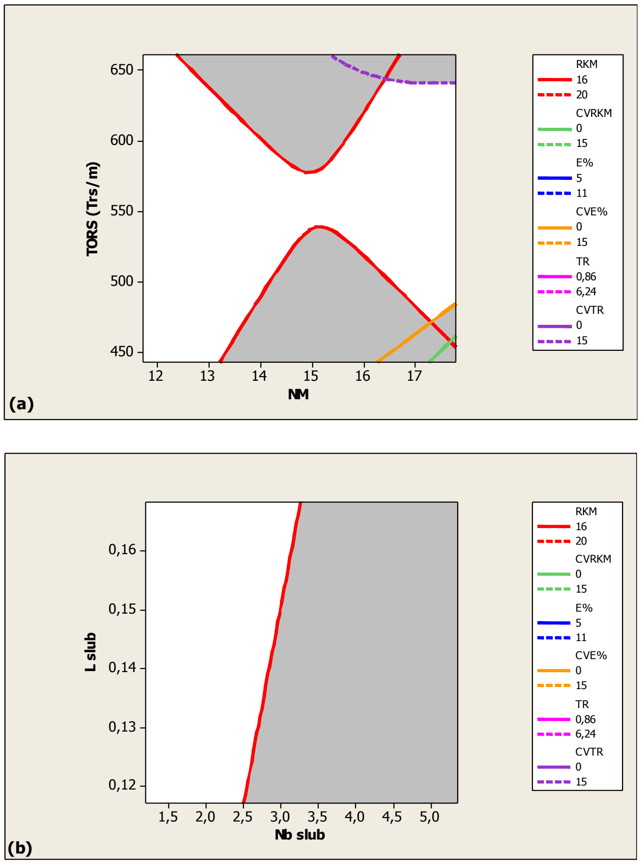

Fig. 2: Diagrams of Superimposed contours for slub parameters

3.1. Superimposed contours for a constant slub length

If we maintain the slub length at fixed value, varying the yarn count (Nm) and twist, the diagrams represented in the ''Fig. 3'' are obtained. For a slub length egal to 0.1 m, the zone of compromise (white zone) permitting the satisfaction of all the yarn properties indicates the necessity to use yarns with Nm belonging to the interval [9.6 ; 16.] with absence of compromise zone between [Nm= 16.5 . Nm=25.8]. The twist number belongs to the interval [395 ; 713].

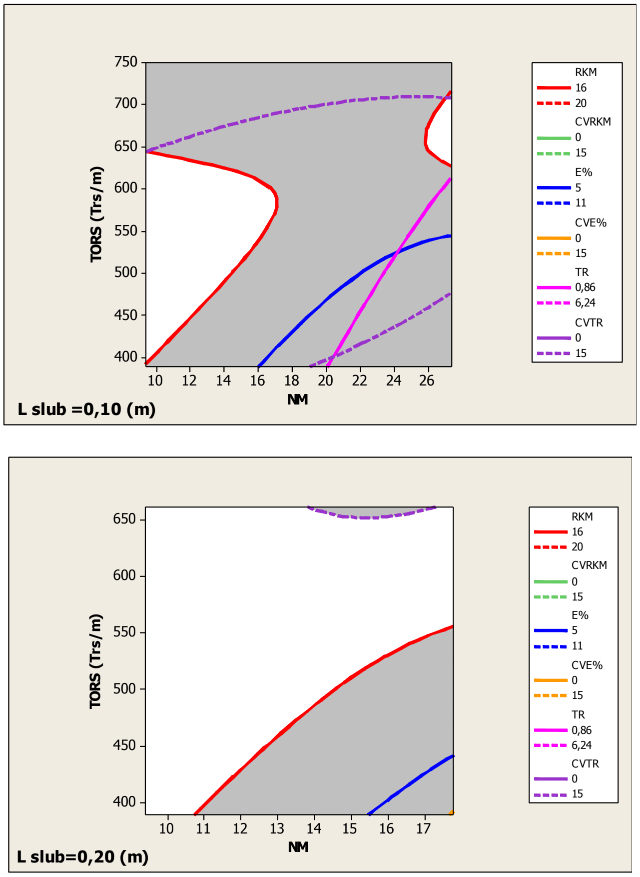

Fig. 3: Diagrams of superimposed contours for a constant slub length

For a slub length egal to 0.2 m , the feasible region (white area) is larger than the previous one (L_{slub} =0.1 m). The feasible region is obtained with Nm belonging to the interval [9.45 ; 17.7] and twist belonging to the interval [391 ; 660]. Here, we can affirm that with larger slub length, the yarn is more uniform and presents less thin places which confers better mechanical properties (RKM and TR).

3.2. Superimposed contours for a constant slub number

The number of flames in the slub yarn confers a special aspect of the future denim fabric. This parameter, programmed by the spinner, is controlled by the Amsler device producing the slub yarn. For our database, three values of the present factor are studied ''Fig. 3''. The white area is the region formed by yarn count (Nm) and twist number (Tors), given slub number (Nb_{slub}), such that the acceptable values for the four responses are between their respective contours. Any factor settings for yarn count (Nm) and twist number (Tors) that fall in this region should produce a yarn with acceptable responses.

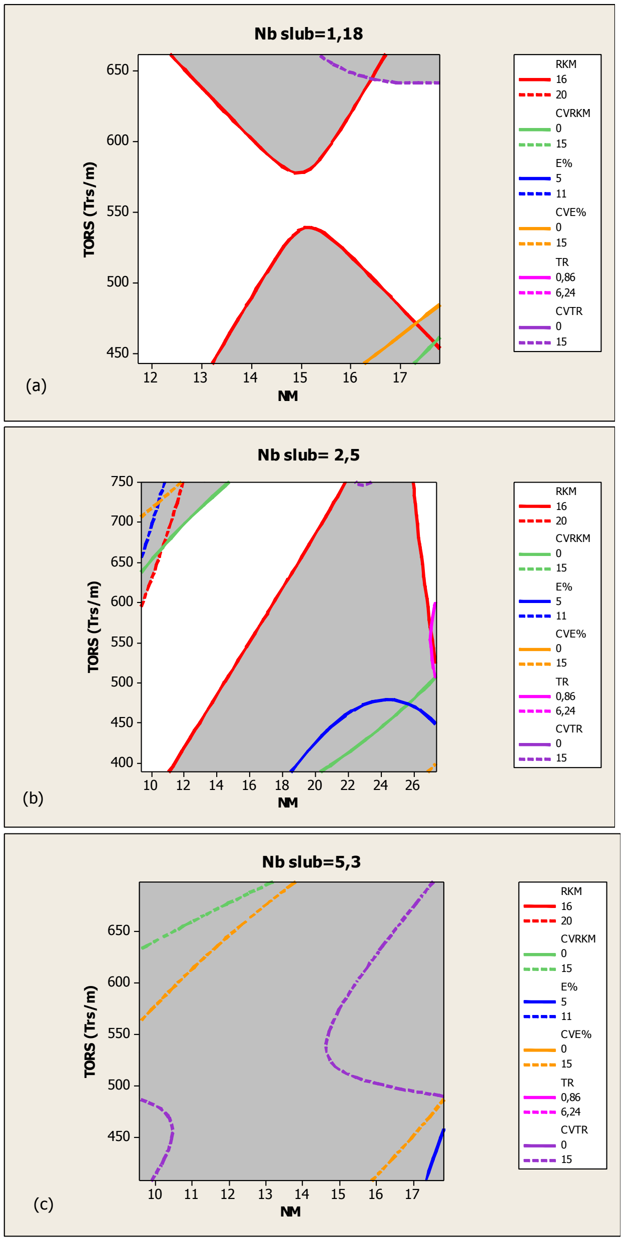

Fig. 4: Diagrams of Superimposed contours for a constant slub number

When changing this factor, the white zone (zone of feasibility) of slub yarn responses becomes more limited. For a slub number Nb_{slub} =5,3 (Fig 4.c), there is no zone of compromise in the experimental domain of interest. It can be deduced that with slub number egal to 5.3, the responses are out of the boundaries predefined.

Because only a pair of factors can be displayed on each overlaid contour plot, and any additional factors are held at a fixed level, a single contour plot may not provide a complete picture of the feasible region. You might consider creating overlaid contour plots for all possible pairs of factors, and changing the hold values of the additional factors.

CONCLUSION

The present work shows a manner to optimize Slub yarn global quality by including different criteria in the same time, while searching for the best sets of the 4 factors yarn count, twist, slub length and slub number contributing to the best quality. The method we have used is the diagrams of superimposed contours. This method has contributed to the optimal values of the indicated factors. The compromise zones where the required properties are satisfied have shown different regions. This method can help the spinner to choose the suitable yarn parameters (yarn count and twist) when varying slub yarn manufacture factors (slub length and slub number). The use of diagrams of superimposed contours has allowed to jointly evaluate multiple responses which will closely depict the perception of yam quality as preferred by the consumers.

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