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Zrenjanin, Serbia

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Zrenjanin, November 10-11, 2011
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INTRODUCTION

It is necessary and justified, nowadays, more than ever, to assemble the scientists and entrepreneurs in the field of textile and clothing industry. The Scientific-professional Conference "Textile Science and Economy III" (TNP2011) is organized with the goal to promote connection between Serbian entrepreneurs and scientists and experts to jointly contribute the development based on knowledge and innovations. We are aware that by establishing these development research institutions and institutions of academic education, very active participants in this process must be included.

It is necessary to keep connections and cooperation based on knowledge and experience because that leads us to sustainability and development of our textile and fashion industry. Therefore, this conference TNP2011 meets the Strategy of Scientific and Technological Development of Serbia for the period from 2010 to 2015. Through the papers of the Conference TNP2011 participants current situation in the textile and fashion industry is to be analyzed, as well as the vision of this industry in Europe up to 2020 from the standpoint of the European Technology Platform (ETP). The European Union has entered the new millennium, setting the strategic goal of achieving extremely competitive and dynamic economic development based on the innovations and technological development. Therefore, this Conference TNP2011 wants to contribute to the development strategy of the Serbian textile and fashion industry in the direction of the dynamic cooperation of science and economy.

The aim of this Conference TNP2011 is to foster the regional cooperation with the scientists, experts, businessmen from the neighboring countries as well as from the other countries, what gives this event international significance and its scientific and professional level. Therefore, it is a great pleasure that such a remarkable number of the scientists and businessmen, mainly from the region and the other countries, responded to our invitation. The submitted papers of our colleagues were published in The Conference Proceedings. Because of economic focus of this event, the business and professional papers and the papers of our graduates, now employed in many companies, have found their place in The Conference Proceedings.

At the plenary lecture we have tried to show you the European experiences related to technology transfer from the University to Economy.

In the part of inviting lectures, we have tried to assemble the leading scientists, experts and professionals from the industry whose working experiences can contribute to the Strategy of Scientific and Technological Development of the Republic of Serbia 2010-2015 (SSTDRS).

In the poster section we wanted to present scientific and professional work at our Faculty.

Technical Faculty "Mihajlo Pupin" is the only scientific institution in Vojvodina in the field of textiles and clothing. The intention of this Conference TNP2011 is to present to the entrepreneurs the Faculty's previous experiences and competences in the field of education and science. During the Conference TNP2011 and after, the Technical Faculty will promote its openness and acceptance of new ideas of improving cooperation with entrepreneurs and solving their everyday technological issues as well as those in the field of research - development projects.

The Chairman of the Organizing Committee:

Vasilije Petrovic, Ph. D., Professor

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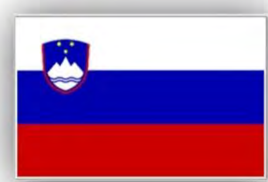

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TEKSTILNA NAUKA I PRIVREDA

CONTENTS

CONTENTS

MAXIMIZING FUSIBLE INTERLININGS BONDING STRENGTH BY OPTIMIZING THE FUSING CONDITIONS

Saska GOLOMEOVA, Goran DEMBOSKI & Sonja KORTOSHEVA

Abstract: *In this paper, Taguchi robust design methods were applied for optimization a fusing process conditions to maximize the bonding strength between a fabric and a fusible interlining before and after laundering process. Four parameters, including type of fusible interlining, fusing temperature, pressure, and time were selected to optimize the quality of fused textile system. Nine experiments were performed with respect to the L_9 orthogonal design for the Taguchi method. The results show a considerable improvement in the S/N ratio as compared to the initial condition. Taguchi method proved convenient in determining the optimum fusing conditions for the maximization of the bonding strength.*

Key words: Taguchi method, fusible interlining, optimization, bonding strength.

Introduction

Fusible interlinings are support materials, which are very important for the essential apparel quality. Fusible interlinings improve the formability of top fabric. They give not only a beautiful silhouette, but also a steady form to garment deformed from bending and shearing deformation on wearing (Cooklin ,1990, Cooklin, 2006). The bond strength between fusible interlinings and top fabric is important because consumers want to keep shape retention after repeated laundering. Review of the literature indicates that an increase in pressure or amount of pressure cycles leads to the formation of comparatively strong initial bond strength in textile systems but these become unstable after mechanical treatment (Percinlic, 1997, Gutauskas *et al*, 1996).

A good fused textile system can be produced when a right fusible interlining is chosen for a given fabric and when optimum fusing conditions are determined. In this study, we determined a optimal fusing conditions to maximize a bonding strength using Taguchi method. It offers a simple and systematic approach to optimize design for performance, quality and cost. Signal to noise ratio and orthogonal array are two major tools used in robust design. Signal to noise ratio, which measures quality with emphasis on variation, and orthogonal arrays, which accommodates many design factors simultaneously (Simpson, 2000, Ross, 1996). In this study we used ―L9(3^4)" orthogonal array because four factor (type of interlining, temperature, pressure, time) are taken as independent variables with, each variable having 3 level values. These factors can be easily controlled. Selection of the levels was based on the interlining's fusing parameters what were given in the specification by interlinings producers. (Mavruz et al, 2010).

Methods

Taguchi method was applied to define the best fusible interlining and optimal fusing conditions for one type of fabric for man's shirts and three different fusible interlinings. The experiments were carried out with four factors at three levels, as shown in Table 1. Selection of the levels is based on the interlinings fusing parameters specifications. This orthogonal array is chosen due to its capability to analyze the interactions among factors.

Table 1 Factors and levels

	Levels		
Factors	**I**	**II**	**III**
Fusing interlining(A)	FI-1	FI-2	FI-3
Temperature (B)	150 °C	160 °C	170 °C
Pressure (C)	1 bar	2 bar	3 bar
Time (D)	12 s	15 s	18 s

The fusing process was carried out in factory conditions, on continuous fusing press type Gygli TPR8M751R. The bonding strength of fused textile system was tested on tensile testing machine Tinius Olsen HT 45, in accordance with the ASTM D 2724 standard. Six fused samples were produced at each fusing conditions, three before and three after laundering process, (ASTM D 2724, 2003). The laundering process was taken as uncontrollable noise factor. For the bonding strength of fused textile system, higher value means better quality (Roy, 2001). Thus, for calculating each S/N ratio we used equation:

$$S/N = -10 \log \left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{{y_i}^2}\right)$$

where: n is the number of experiments in the orthogonal array and y_i the i^{th} value measured.
In this study all calculation were made using 'Statistica 9' program.

Findings

S/N ratios calculated for each experiment are shown in Table 2. The obtained values for bonding strength are located between 2,233 and 9,990. The S/N ratio of fused textile system shows a difference of 7.8, depending on fusing conditions.

Table 2. Experimental layout using an L_9 orthogonal array table and S/N ratio of experimental results

Exp. no	Factor and level (Fusing conditions)				SN ratio
	A	B	C	D	
1	FI-1	150	1	12	8,144
2	FI-1	160	2	15	8,177
3	FI-1	170	3	18	9,990
4	FI-2	150	2	18	2,233
5	FI-2	160	3	12	2,471
6	FI-2	170	1	15	3,039
7	FI-3	150	3	15	5,923
8	FI-3	160	1	18	5,740
9	FI-3	170	2	12	5,692

Discussion

Analysis of SN ratio, including sum of squares, average of S/N ratio and contribution are shown in table 3. From the calculated value of the sum of squares of each factor, we can see that factor A (type of fusible interlining) has the largest value at 57,491 (95,67%). Then follows factor B (temperature) with value of 1,255 (2,09 %), factor C (pressure) with value of 0,891 (1,48 %) and the last is the factor D (time) with value of 0,457(0,76 %). Whether errors can be pooled for separate fusing parameters can be determined based on the sum of squares of the S/N ratios according to the method suggested by Taguchi. The parameters C and D are pooled into error parameters considering the relatively small values of their sums of squares, indicating no significant influence on the bonding strength of the fused textile system.

Table 3 Analysis of the SN ratio of experimental results

Factor	Degree of freedom, f	Level	Sum of squares	Average of SN ratio	Contribution P	Pooling
U					5,712	
A	2	A1	57,491 (95,67 %)	8,771	3,058	N
		A2		2,581	-3,131	
		A3		5,785	0,073	
B	2	B1	1,255 (2,09 %)	5,434	-0,229	N
		B2		5,463	-0,249	
		B3		6,240	0,528	
C	2	C1	0,8912 (1,48 %)	5,641	-0,071	Y
		C2		5,367	-0,345	
		C3		6,128	0,416	
D	2	D1	0,457 (0,76 %)	5,436	-0,276	Y
		D2		5,713	0,001	
		D3		5,988	0,275	

After error pooling, of the C and D factors, ANOVA test (F-test) is performed to determinate the effects of the A and B factors, as shown in table 4.

Table 4. Anova table for the S/N ratio

Factor	Sum of squares	Degree of freedom, f	Mean square,V	$F_0=V/V(e)$	F_t (2,4,0,90)
A	57,491	2	28,745	85,297	4,32
B	1,255	2	0,627	1,86	
E	1,348	4	0,337		

Based on the results of ANOVA analysis, only the factor A has significant influence on bonding strength because $F_0= V/V_{(e)}=85,297 > F_t$ (2,4,0,90). Thus, the optimum level for factor A with highest value S/N is A1, fusible interlining FI-1.

The estimated value of the S/N ratio for fused textile system under optimum fusing conditions is:

$$\overline{S/N} = U(S/N) + Pop(A1) = 5{,}712 + 3{,}058 = 8{,}770$$

The prediction interval of the optimum S/N ratio is:

$$S/N = \overline{S/N} \mp t_{fe,1-\alpha}\sqrt{(k+1/\gamma)Ve} =$$

$$8{,}77 \mp t_{(4,0,95)}\cdot\sqrt{\left(\frac{3}{9}+\frac{1}{6}\right) x\ 0{,}337} = 8{,}77 \mp 2{,}132\ x\ 0{,}915 = 6{,}855 \div 10{,}72$$

$$\kappa = \frac{\sum f}{\sum n} = \frac{1+2}{9} = \frac{3}{9}$$

Because experimental values that gives the estimated optimum conditions, is exactly matched in the experiment, as shown in table 3, an experiment verifying the estimated optimum conditions is not necessary. Because S/N ratio under optimum conditions is 9,99 (experiment no. 3, table 3), which is located in the prediction interval, we can conclude that this analysis and obtained results can be verified. Expectation of loss under the optimum fusing conditions and current fusing condition taken as experiment number 5 (type of interlining FI-2, temperature 160°C, pressure 3 bar, time 12 s), shown in table 3.

$$S/N_O - S/N_C = 8{,}77 - 2{,}471 = 6{,}299 = d$$

$$L_C/L_O = 10^{6{,}299/10} = 4{,}26$$

The results show that the expectation of loss from the bonding strength of the fused textile system in optimum conditions can be improved 4.26 times over the expectation of loss with the current fusing conditions.

Conclusion

In this study, the optimization of fusing conditions to maximize the bonding strength of fused textile system was done using the Taguchi method. Experimental design with one shell fabric and three fusible interlining was performed. It was found that most significant factor for bonding strength of fused textile system is factor A (type of fusible interlining). Also optimal fusing conditions were established for given set of parameters. The expectation of loss of the bonding strength of fused textile system using optimal conditions can be improved by 4,26 times over current fusing conditions. The application of Taguchi robust design proved successful in defining the optimum fusing conditions and the best fusible interlining.

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