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EFFECT OF SOME FACTORS ON PROPERTIES OF OPEN-END YARNS MANUFACTURED FROM WOOL, COTTON & POLYESTER BLENDS

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Abstract

Different blends ratio of wool, cooton and polyester fibres had been spun through the open-end spinning system under different rotor operating conditions. The variable processing factors consists of rotor speed, opening roller speed and air vacuum. The mixture experimental design for three independent and three interdependent was applied. The effect of blend ratios and spinning parameter on yarn properties had been investigated. The significant response relations which enable the prediction of working conditions for a required yarn specification were determined. The yarn tenacity, thick places and thin places in yarn are affected by the fibre blends while all the other properties are affected by rotor operating conditions.

Nomenclature

X_1 = Percentage Wool fiber

X_2 = Percentage Cotton fiber

X_3 = Percentage Polyester fiber

X_4 = Rotor speed (r.p.m.)

X_5 = Opening roller speed (r.p.m.)

X_6 = Air suction (mm H20)

Introduction

Blending different types of fibers has become an important trend in the spinning technology. Most of the published works concern blending of two fibre components, [1-10]. No researches concerning three blend components had been identified. Most of the researches are concerned with the percentage blends, some take into consideration the processing conditions, [11-14]. In this work the mixture experimental design involving process variables [15-17] will be applied. The determination of response relation concerning the factors under consideration and some yarn properties will enable the prediction of the working condition for the required yarn specifications.

Material And Experimental Procedure

The properties of fibres under investigation are given in table I

Table I

Properties Of Different Fibres

Fibre	Length mm	Fineness	Extension at break	Tenacity g/tex
Cotton	35	4.7 micronaire	5.3	36.7
Wool	33	21 micronaire	42	11
Polyester	39.8	1.5 Denier	23	54

The fibres were obtained on sliver form, blended at the first draw-frame, processed on second and third drawing then on open-end m/c (Rieter Spin Trainer) having a rotor diameter of 55 mm for obtaining a yarn of 33 tex. An experimental design which consist of three mixtures and three process factors was chosen [15] with some modification to coincide with the initial experimental condition. The mixture components (dependent) consist of cotton, wool, polyester while the process variable (independent) consist of rotor speed, opening roller speed, air suction. The levels of process variables are shown in table

2. The experimental Design Applied Is Shown In Table III

Table II

The Level of The Process Variables

Variable /Level	-2	-1	0	1	2
Rotor speed rpm	30000	35000	40000	45000	500000
Opening-oller speed rpm	5500	6000	6500	7000	7500
Air suction mm H20	350	400	450	500	550

The yarn strength, elongation, work of rupture, evenness imperfections and Quality index were determined for the obtained yarns under standard atmospheric conditions.

Experimental Results

The results obtained for the experimental combinations are shown in table III. The results were analyzed on a PC computer, for obtaining the equations of the response surfaces, the variance analysis, the correlations and significance between the regression model and the

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TABLE III

EXPERIMENTAL CONDITION AND RESULTS FOR YARN PARAMETERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
X1	1/2	1/2	1/2	1/2	1/2	1/2	1/4	1/4	1/4	1/4	1/4	1/4	0	0	0	0	0	0	1/2	1/2	1/2	1/2	1/2
X2	1/2	1/2	1/2	1/2	1/2	1/2	3/8	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2	1/2	1/2	0	0	0	0	0
X3	0	0	0	0	0	0	3/8	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
X4	1	0	-2	0	-1	1	0	-1	2	0	1	0	0	-1	0	-2	1	1	1	0	0	-1	0
X5	-1	1	0	0	-1	1	1	0	0	-2	-1	0	-1	0	2	0	-1	1	0	2	0	-1	0
X6	0	-1	0	2	-1	-1	1	-1	0	0	-1	0	1	-1	0	0	1	1	1	0	-2	1	0
I	10.3	10.5	7.63	11.4	10.6	9.78	17.6	17.4	16.0	18.6	17.5	14.5	19.1	25.8	20.2	25.4	19.3	19.4	13.9	13.4	13.1	13.5	13.7
II	8.5	9.5	9.1	10.7	8.1	9.5	14.4	12.4	11	13.2	14	9.6	7.4	7	7.3	7.3	7.5	9	16.3	17.5	17.3	15.4	16.3
III	6.6	7	7.8	8	8.2	6.8	10	11.5	8	11.4	10	8.1	11.6	12.8	11.8	6.3	11.3	11	14.5	13.3	13.4	14.6	13.6
IV	5.2	10.3	7.1	5.8	5.4	7.4	8.3	10.5	16.1	8.3	10.5	9.6	5.6	4.6	5.3	13	15.2	5.9	18.1	6.2	9.3	6.7	5.6
V	14.1	15.7	15	10.7	14.3	15.9	14.1	21.1	20.2	23.5	21.7	28.1	12.7	10.9	12.6	11.3	13.3	12.7	21.9	20.8	22.5	24.7	12.1
VI	80	540	120	20	20	60	20	0	80	0	0	20	160	80	100	20	180	80	720	380	660	0	200
VII	20	340	140	40	40	0	20	60	80	20	20	20	120	20	0	0	100	0	260	480	780	20	60
VIII	528	2536	1968	968	1560	3268	8	2456	4968	672	192	2976	408	16	192	24	368	216	9576	7824	9816	616	2304

X1 = WOOL Ratio X2 = COTTON Ratio X3 = POLYESTER Ratio X4 = Rotor speed X5 = Opening roller speed X6 = Air suction

I = Tenacity g/tex II = C.V. Strength III = Percentage Elongation IV = C.V. Elongation
V = C.V. Evenness VI = Neps/1000 mt VII = Thick places/1000 mt VIII = Thin places/1000 mt

experimental results. Coefficients of significance higher than 95% were only considered, and are compiled for each parameter in table IV.

Discussion

Tenacity

The regression relation obtained in table IV indicates that tenacity is significantly affected by the blend ratio only. The effect of wool fibres is obtained with cotton fibre interaction. The polyester fibres highly affect the yarn strength. The multiple regression coefficient attains a value of 0.999 which indicates a highly significance of regression to the experimental results. This is also indicated by the analysis of variance test.

Strength Coefficient of Variation

The coefficient of variation of strength is mainly influenced by the percentage of the polyester fibres and to a lesser degree by the wool fibres. The maximum effect of wool is at 50% blend. The cotton fibres has no significant effect within the range of experimentation with report to the two other fibres under study. The regression proposed is highly significant as shown in table IV.

The regression equation can be written in the following form:

$$34.1\ X_1\ (1-X_1) + 14.79\ X_3$$

For that the X_1 factor was transformed to $X_1\ (1-X_1)$ and the regression obtained is in the form:

TABLE IV

THE REGRESSION EQUATION FOR DIFFERENT YARN PROPERTIES

Parameter	Significant regression relation	Mult. R	F	T and sig. level for coefficients					
Tenacity g/tex	$12.74 X_2 + 27.65 X_3 + 16.10 X_{12}$	0.9986	2427.5 **	11.8 **	36.81 **	6.31 **			
C.V.% Strength	$35.44 X_1 + 14.79 X_3 - 34.11 X_{11}$	0.9961	852.2 **	8.96 **	19.7 **	-4.2 **			
Elongation %	$21.97 X_3 + 16.18 X_{12} + 12.21 X_{11} - 1.26 X_{24}$	0.9966	703.8 **	35.5 **	6.8 **	5.9 **	-2.4 0.025		
C.V.% Elongation	$37.77 X_1 + 20.8 X_{23} - 46.81 X_{11} - 1.05 X_{45} - 1.36 X_{16}$	0.9918	217.4 **	7.7 **	12.0 **	-4.0 *	-2.8 0.013	-2.4 0.025	
K. of R. g.cm/tex	$4328.26 X_3 + 2891.95 X_{22} + 912.64 X_{11}$	0.9929	464.4 **	22.7 **	7.1 **	2.2 0.037			
Regularity	$20 X_1 + 23.5 X_3 + 15.4 X_{12} - 1.8 X_{26} + .75 X_{55} - 1.6 X_{35}$	0.9981	730.65 **	13.1 **	20.4 **	4.1 **	-2.6 .031	2.5 .011	-2.8 .012
Quality Index	$418.12 X_3 + 1057.97 X_{22} - 514.57 X_{12} - 73.75 X_{34}$	0.9901	236.4 **	11.4 **	9.6 **	-4.0 *	-2.5 0.021		
Neps/1000 meter	$1262.25 X_{13}$	0.8187	44.74 **	6.7 **					
Thick place per 1000 mt	$9130.5 X_1 + 23417.43 X_{13}$	0.841	25.4 **	2.9 *	2.5 0.021				
Thin places per 1000 mt	$338.84 X_{13} + 23.71 X_{66} - 54.19 X_{16}$	0.8353	15.4 **	3.5 .002	2.6 .011	-2.1 .046			

** = Significance level at 0.0005   * = Significance level at 0.001   T = T calculated   F = F calculated

$36.64\ X_1 + 14.72\ X_3$ With R = 0.9961 and F = 1335.3 which

represent the relation with a higher accuracy. Also X_1 shows a Quadratic effect.

Percentage Elongation

Results in table IV show that the main effect is due to polyester, then by the Wool. The effect of cotton is interacted with wool. While the percentage elongation decreases with the increase of rotor speed.

Elongation Coefficient of Variation

As shown in table IV, this is the only property in which all the factors are represented in the regression equation, either directly or in an interaction form. The same effect of Wool fibre in case of C.V. strength is detected here and a Quadratic relation of wool fibre is observed. The same transformation applied in C.V. tenacity is applied in this case and the regression is of the form:

$$30.35\ X_1 + 22.0\ X_{23} - 1.15\ X_{45} - 1.41\ X_{16}$$

with R = 0.992 and F = 280.6. From that the % wool has also a Quadratic effect on C.V. elongation.

Work of Rupture

This is represented by half the product of tencity and elongation (which is first approximation of work of rupture). All the fibre percentage are represented in the regression equation. The mostly significant is the polyester fibre than the cotton fibre, no interaction between fibres are detected in this property, in contrary to both tenacity and percent elongation. In the mean time, the effect of rotor speed become non significant, while it was detected at the elongation percent.

Regularity

All the factors except the rotor speed X_4 are represented in the regression equation. The mixture factors dominate the regularity with report to the process variables. The increase in both opening roller speed and air suction will tend to an increase in yarn regularity, only the opening roller speed will have a reverse influence for polyester fibre lesser than 40 %.

Yarn Quality Index

This consists of a conjunction of regularity, strength and elongation. From table IV, the percentage polyester shows the most significant factor as usual in increasing the yarn Quality index while the wool percentage causes a decrease in this index. The same effect is obtained when increasing the rotor speed.

Yarn Imperfection

The regression equations of yarn imperfections are shown in table IV. For the three properties, the interaction between polyester and wool are always significant, and it affects only the neps, while the thick places is affected to a greater extent by the percentage wool. The thin places is the only imperfection which is influenced by a process variable; the air suction. Transferring the regression relation to the form: 23.7 X_6 (X_6 - 2.3 X_1) we can conclude that a lesser number of thin places will be obtained when the air suction is greater than 450. The correlation matrix of the yarn imperfection and yarn regularity is shown in table V. From which it is easy to detect that a high correlation between yarn imperfection is higher than 0.001 and between regularity and imperfections is at 0.1. For that, the factor X_{13} is the more dominating in the regression relation.

TABLE V

Correlation Matrix For Yarn Regularity and Imperfections

Parameters:	Eveness	Neps	Thick	Thin
Evenness	1.0000	0.5853*	0.6021*	0.4955*
Neps	0.5853*	1.0000	0.7040**	0.8119**
Thick	0.6021*	0.7040**	1.0000	0.7274**
Thin	0.4955*	0.8119**	0.7274**	1.0000

Significance: * 0.01 ** 0.001

Due to that, the thin places/1000 mt. can be the only property used for the determination of the response surface representing the yarn imperfection.

Conclusion

1. The application of mixture experimental designs permit us to simulate the properties of Open-End yarn produced from three

blends of wool, cotton and polyester under variable process conditions with fewer number of experiments.

2. From the regression equation obtained, the polyester fibre percent affects greatly all the yarn properties tested.
3. The yarn tenacity, elongation, work of rupture and yarn imperfection is essentially influenced by the fibre blend percentage.
4. The different coefficient of variation are affected by the process variable and the fibre blends.
5. Both C.V. elongation and the yarn evenness represent most of the factors under study and can be considered the properties highly influenced by factor variations.
6. The factor X_1 is transferred to X_1 $(1-X_1)$ for both C.V. strength and C.V. elongation and is more representative than the X_1 factor.
7. The correlation coefficient between yarn imperfection and regularity are highly significant from that the thin places/1000mt can be used for the determination of the response surface of yarn imperfection.

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