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Effect of linear density of feed yarn filaments and air-jet texturing process variables on compressional properties of fabrics

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Effect of filament fineness and process parameters employed in the production of air-jet textured yarns has been studied on the compression and recovery of union fabrics made from air-jet textured yarns as weft and twisted filament yarns as warp. Filament linear density and process parameters such as overfeed, air pressure and texturing speed affect the textured yarn structure and hence fabric properties. The individual effect of filament fineness and process variables in the production of air-jet textured yarn has been studied in terms of potential contribution and normalized regression coefficient on fabric low load compression behavior. Fabric low load compression-recovery behavior has been analyzed in terms of compression parameter, recovery parameter and resiliency. Analysis shows that most dominating factor to explain the low load compression properties of air-jet textured yarn fabric is overfeed percentage, while linear density per filament is most dominating factor affecting fabric resiliency.

Keywords: Air-jet textured yarns, Compression parameter, Linear density, Polyester yarn, Recovery parameter, Resiliency

1 Introduction

Air-jet texturing is used to produce bulky and spun look-like yarn from filament yarns wherein the filaments of later are disoriented and form loops on yarn surface. The air-jet textured yarn fabrics have better comfort characteristics compared to all-filament yarn fabrics. In air-jet texturing, filament yarns with certain amount of overfeed is fed in cold supersonic air stream to entangle the filaments in order to produce bulked yarn of low extensibility. It is known that the air-textured yarns have a good resemblance to spun yarns due to their unique structure. The low-load compression behavior of woven fabrics is important as it affects fabric handle and comfort. Compressibility is one of important properties of the fabric which affects the softness and fullness of the fabric. Fabric compression is strongly affected by fabric geometry, yarn structure and constituent filaments/fibres.

The analysis of compression behavior of textile ensemble was started from Schiefer[1] who developed the compression meter and defined the association between the thickness of fabric and the compression force. Later Van Wyk[2] introduced a model based on the analysis of the compression behavior of woolen fabric and this model was considerably extended by many researchers[3-5] to elaborate the compression properties of nonwovens, woven and knitted fabrics. Kothari and Das[6] studied the compression properties of nonwovens geotextile by evaluating two parameters α and β to represent the compression and recovery curves respectively by an empirical model. Matasudaira and Qin[7] analyzed the compression curve by dividing it in five zones and defined the regression constant for each. Gurumurthy[8] used fabric geometrical parameters as input to an artificial neural network model to predict fabric compression properties of different cotton woven fabrics and compared the modeled results with corresponding Kawabata testing results. Rengasamy *et al.*[9] reported the effect of feed yarn fineness and process parameters of air-jet textured yarns on fabric compression properties.

The present work is aimed at explaining the pressure-thickness relationship of woven air-jet textured yarn fabrics in low-load regions by suitable mathematical coefficients using empirical modeling. The individual effect of feed yarn parameter like linear density per filament and process parameters like overfeed, air pressure and texturing speed on the air-jet textured yarn fabric compression-recovery behavior has been studied. The contribution of each yarn feed and process parameters on the measured

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fabric properties was evaluated in terms of potential contribution and normalized regression coefficient.

2 Materials and Methods

2.1 Raw Materials

Three fully drawn polyester yarns having linear density of 111.1/100, 111.1/50 and 111.1/33 dtex with circular cross-section and semi dull luster were used for the study. Tenacity values of these yarns were 3.38, 3.35 and 3.11 cN/tex respectively

2.2 Methods

2.2.1 Preparation of Yarn Samples

Air-jet textured yarn samples were prepared at different levels of linear density per filament, overfeed, air-pressure and texturing speed. The following machine parameters were kept constant during the production of all samples:

Machine used : Eltex AT/HS
Nozzle used : Hemajet S325
No. of yarns fed together : 2
Wetting : 1l/jet/h
Stabilization heater temperature : 180 C
Mechanical stretch : 4.3%
Winding underfeed : 0.6%

A total of twenty-eight air-jet textured yarn samples were used after the randomization of experimental runs of Box-Behnken design, as per run order given in Table 1. Three different levels of each parameter at equal intervals were taken as low, medium and high (coded as -1, 0, +1) values and these values were used in different combinations according to the Box-Behnken 4-variable 3-level design.

2.2.2 Yarn Test Methods

2.2.2.1 Physical Bulk

Physical bulk of air-jet textured yarns was measured using modified[10] package density method. Parent and air-jet textured yarns were wound on cylindrical packages of equal diameter under a constant tension of 3 cN at a speed of 300 m/min for 30 min in a spindle driven precision winder. Following formula was used to obtain the physical bulk:

$$\text{Physical bulk}\,(\%) = \frac{\text{Density of parent yarn package }(\text{g}/\text{cm}^3)}{\text{Density of textured yarn package }(\text{g}/\text{cm}^3)} \times 100$$

$$\text{Package density (g/cm}^3) = \frac{M_{c+y} - M_c}{\pi L\left(R_{c+y}^2 - R_c^2\right)}$$

where M_{c+y} is the total weight of full package in g; M_c, the weight of empty package in g ; L, the traverse length of the package in cm; R_{c+y} ,the overall radius of full package in cm; and R_c, the radius of empty package in cm.

2.2.2.2 Instability

Yarn instability values of the air-jet textured yarns were measured using Du Pont's weight hanging method[11]. A weight of 0.0088 cN/dtex was hung at the end of yarn as a pre-tension and left as such on the specimen throughout test duration. A reference mark was made at 100 cm distance from the clamp. Yarn was then subjected to higher load of 0.44 cN/dtex for 30 s. The permanent extension in the length of the specimen was measured 30 s after the higher load was removed and taken as a measure of yarn instability. Average value of fifteen readings was taken from a sample package to estimate instability and between each successive reading nearly 5 m yarn was unwound from the package and discarded. Some studies shows the effect of processing parameters on instability of the textured yarn[12,13].

2.2.2.3 Tensile Properties

Tensile properties of all textured yarns were measured according to ASTM Test method D2256-95a using Instron tester (model 4301) working on CRE principle with 500 mm gauge length, 300 mm/min cross head speed and 0.055 gf/denier (0.048 cN/dtex) pretension level. Fifteen samples from each package were tested to obtain average tensile properties. Loss in tenacity was observed using the following relationship:

$$\text{Loss in tenacity}\,(\%) = \frac{T_0 - T_f}{T_0} \times 100$$

where T_0 is the tenacity of feed yarn (cN/dtex) ; and T_f, the tenacity of textured yarn (cN/dtex).

2.2.3 Preparation of Fabric Samples

Twenty-eight plain woven fabric samples were prepared with twisted 166.66/144 dtex polyester multifilament yarn as warp on Lakshmi shuttle loom at 120 picks/min and a reed space of 56 inches (1422 mm) with air-jet textured yarns (Table 1) as weft. The ends/cm and picks/cm on loom were kept 28.4 and 25.2 respectively. The grey fabrics were relaxed in jet dying machine by boiling for 45 min with 1% non-ionic detergent. The fabrics were then heat-set on stenter at 18 m/min speed with 3.5% overfeed allowing 5% widthwise shrinkage at 180°C. The heat-set fabrics had ends per cm and picks per cm 29.9 and 28.4 respectively.

Table 1 — Box-Behnken design for the variables used for study and corresponding air-jet textured yarn properties

Sample No.	Run order	Process parameters				Experimental values			
		Linear density per/filament dtex	Overfeed %	Air-pressure bar	Texturing speed m/min	Physical bulk %	Instability %	Tenacity cN/tex	Loss in tenacity %
1	3	1.11	18	8.5	400	214.3	0.22	2.64	22.0
2	24	3.33	18	8.5	400	170.6	0.65	2.57	17.5
3	26	1.11	36	8.5	400	320.0	3.60	1.87	44.7
4	12	3.33	36	8.5	400	248.8	6.26	1.98	36.2
5	11	2.22	27	7.0	300	210.3	3.15	2.39	28.6
6	18	2.22	27	10.0	300	250.1	1.65	2.13	36.3
7	16	2.22	27	7.0	500	206.5	5.01	2.51	25.0
8	4	2.22	27	10.0	500	239.8	4.35	2.24	33.2
9	22	1.11	27	8.5	300	278.2	0.95	2.25	33.3
10	14	3.33	27	8.5	300	203.4	2.95	2.22	28.7
11	23	1.11	27	8.5	500	264.0	2.15	2.34	30.9
12	28	3.33	27	8.5	500	195.4	4.65	2.31	25.8
13	7	2.22	18	7.0	400	182.2	0.39	2.71	19.1
14	13	2.22	36	7.0	400	245.6	4.69	2.33	30.5
15	15	2.22	18	10.0	400	198.5	0.80	2.61	22.2
16	19	2.22	36	10.0	400	286.4	4.30	2.03	39.5
17	17	1.11	27	7.0	400	250.2	2.85	2.21	34.5
18	20	3.33	27	7.0	400	190.3	5.26	2.30	26.2
19	27	1.11	27	10.0	400	288.4	2.34	2.04	39.6
20	1	3.33	27	10.0	400	214.3	4.95	2.08	33.2
21	8	2.22	18	8.5	300	192.1	0.38	2.66	20.6
22	9	2.22	36	8.5	300	268.2	3.25	2.09	37.5
23	5	2.22	18	8.5	500	190.2	0.54	2.73	18.4
24	10	2.22	36	8.5	500	256.2	5.64	2.20	34.4
25	2	2.22	27	8.5	400	222.6	2.68	2.15	35.8
26	17	2.22	27	8.5	400	224.3	2.86	2.17	35.2
27	21	2.22	27	8.5	400	224.2	2.74	2.20	34.2
28	15	2.22	27	8.5	400	223.2	2.65	2.18	34.8

A digital thickness tester was used to measure compression and recovery properties. Fabric was placed between anvil and pressure foot of 110 mm diameter to apply pressure of 110 Pa on the fabric for 30 s and thickness measured as initial thickness (T_i). The compressive loads were increased in thirteen steps and thickness was recorded after waiting for 30 s in each step. After achieving a pressure of 1979 Pa, it was gradually reduced in the same manner and resultant thickness values were recorded similarly during recovery cycles.

2.2.4 Experimental Data and Analysis

Figure 1 shows a typical set of data thickness-pressure loading and unloading cycle. In order to fit the appropriate curve to both for loading and unloading data of various fabrics. Following two sets, each having five equations, were tried:

Ist Set (Loading)	**IInd Set (Unloading)**
$T / T_f = e^{-\alpha (P / P_f - 1)}$	$T / T_f = e^{-\beta (P / P_f - 1)}$
$T = T_f - \alpha (P / P_f - 1)$	$T = T_f - \beta (P / P_f - 1)$
$T / T_f = (P / P_f)^{-\alpha}$	$T / T_f = (P / P_f)^{-\beta}$
$T / T_f = 1 - \alpha \times (\log_e P / P_f)$	$T / T_f = 1 - \beta \times (\log_e P / P_f)$
$T = \alpha / \log_e P$	$T = \beta / \log_e P$

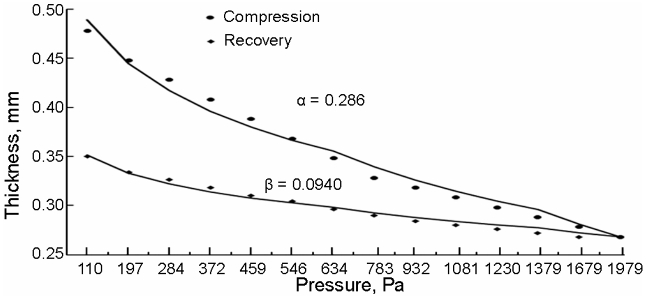

Fig. 1 — Best fitted curve for pressure-thickness data with actual values for air-jet textured yarn fabrics

In these equations α and β are compression and recovery parameters respectively; and T_f and P_f, the final thickness and final pressure respectively. We have performed curve fitting with the help of Matlab curve fitting tool for all the above equations using loading and unloading data of the fabrics. We obtained five different curves for each set of data and corresponding least square errors. It was found that curve number 4 of the first set of loading and curve number 3 of the second set of unloading fitted well for all the fabrics with minimum least square error. Therefore, the following equation represents the loading and unloading behavior of woven fabrics:

$$T / T_f = 1 - \alpha \times (\log_e P / P_f)$$

$$T / T_f = (P / P_f)^{-\beta}$$

In the above equations greater value of compression (α) parameter signifies that fabric is 'more compressible' under load and greater value of recovery (β) parameter indicates that the fabric has 'more recovery' on removal of load. Pressure-thickness curves drawn for a fabric under loading and unloading using the above equation are shown in Fig. 1. The work done during compression can be given by:

$$w_c \int_{T_i}^{T_f} P\,A\,dT = P_f A \int_{T_i}^{T_f} e^{-1/\alpha(1-\frac{T}{T_f})}\, dT$$

where T_i and T_f are the initial and final thickness respectively; and P_f, the final pressure at 1979 Pa. The work done during recovery can be given by the following equation:

$$w_r \int_{T_f}^{T_r} P\,A\,dT = P_f A \int_{T_f}^{T_r} \left(\frac{T}{T_f}\right)^{-1/\beta} dT$$

where T_r is the recovered thickness at pressure 110 Pa. Fabric resiliency was calculated with the help of following formula:

$$\text{Resiliency (\%)} = (W_r / W_c) \times 100$$

where W_r is the recovered energy under fitted recovery curve; and W_c, the compression energy under fitted compression curve.

2.2.5 Methodology of Analysis

The textured yarn samples were tested for physical bulk, instability, and loss in tenacity (Table 1). The corresponding textured yarn fabric samples were tested for loading and unloading characteristics (Table 2). To observe the effect of individual parameters, the regression equations were derived with the help of Design Expert 8.0 software package. The general form of the equation adopted is given below:

$$P = C_0+C_1X_1+C_2X_2+C_3X_3+C_4X_4+C_5X_1X_2+C_6X_1X_3+C_7X_1X_4+C_8X_2X_3+C_9X_2X_4+C_{10}X_3X_4+C_{11}X_1^2+C_{12}X_2^2+C_{13}X_3^2+C_{14}X_4^2$$

where P is the fabric property (fabric thickness; α, β and fabric resiliency); X_1, the linear density per filament; X_2, the overfeed; X_3, the air pressure; X_4, the texturing speed; and C_0-C_{14}, the regression coefficients.

The regression coefficients from the model equations as established for the all fabric properties are given in Table 3. From the established regression model, normalized regression coefficients and per cent contribution were computed for each linear, interactive, and quadratic term. To calculate normalized regression coefficient, general form of regression equation is converted into following form and then fitting of the multiple regression equation was done.

$$(P - \overline{P}) / \sigma_P = Z_0 + Z_1 (X_1 - \overline{X}_1) / \sigma_{X_1} + Z_2 (X_2 - \overline{X}_2) / \sigma_{X_2} + Z_3 (X_3 - \overline{X}_3) / \sigma_{X_3} + \ldots\ldots$$

where σ is the standard deviation of term associate; $\overline{X}_n$, the mean of the term associate; and Z_n, the normalized regression coefficient of term n.

The standardized regression coefficients represent the change in terms of standard deviation in the dependent variable that results from a change of one standard deviation in an independent variable. Normalized regression coefficients are more comparable across the independent variables due to being scaled in the same standardized matrix.

On the basis of analysis of variance, the sum of square for each individual model component was defined. The per cent of contribution for each individual term was calculated (Table 4). The

Table 2— Compression and recovery parameters of air-jet textured yarn fabric

Sample No.	Initial thickness (T_i) mm	Compressed thickness (T_f) mm	Recovered thickness (T_r) mm	Compression parameter (α)	R^2	Recovery parameter(β)	R^2	Resiliency %
1	0.460	0.266	0.338	0.264	0.995	0.0846	0.989	34.8
2	0.358	0.228	0.292	0.213	0.988	0.0886	0.989	43.4
3	0.638	0.312	0.470	0.390	0.988	0.1398	0.996	42.2
4	0.490	0.266	0.404	0.308	0.987	0.1479	0.991	54.6
5	0.472	0.262	0.356	0.285	0.994	0.1136	0.986	44.2
6	0.522	0.280	0.412	0.309	0.990	0.1297	0.987	48.5
7	0.350	0.212	0.262	0.226	0.988	0.0926	0.991	40.7
8	0.385	0.222	0.290	0.264	0.994	0.1024	0.990	42.8
9	0.592	0.306	0.438	0.354	0.992	0.1190	0.979	38.5
10	0.454	0.262	0.370	0.272	0.981	0.1236	0.979	50.2
11	0.446	0.258	0.320	0.256	0.985	0.0848	0.986	33.2
12	0.374	0.232	0.308	0.228	0.993	0.0878	0.989	43.4
13	0.302	0.194	0.228	0.185	0.976	0.0660	0.983	35.9
14	0.446	0.248	0.342	0.286	0.990	0.1160	0.989	44.6
15	0.434	0.256	0.328	0.260	0.993	0.1021	0.986	42.6
16	0.546	0.288	0.430	0.305	0.987	0.1342	0.996	48.6
17	0.478	0.268	0.350	0.286	0.987	0.0940	0.984	35.8
18	0.396	0.242	0.322	0.240	0.972	0.1025	0.982	47.2
19	0.604	0.306	0.444	0.372	0.990	0.1306	0.993	40.2
20	0.458	0.258	0.382	0.292	0.983	0.1370	0.989	53.4
21	0.412	0.248	0.314	0.238	0.978	0.0898	0.989	40.2
22	0.570	0.300	0.448	0.328	0.994	0.1400	0.986	50.2
23	0.270	0.178	0.210	0.172	0.996	0.0606	0.986	33.8
24	0.440	0.248	0.342	0.275	0.993	0.1089	0.984	43.4
25	0.456	0.252	0.344	0.280	0.993	0.1105	0.981	43.2
26	0.445	0.252	0.338	0.273	0.996	0.1090	0.982	42.7
27	0.436	0.248	0.330	0.260	0.986	0.1078	0.985	44.3
28	0.444	0.250	0.336	0.264	0.984	0.1082	0.982	44.0

Table 3 — Regression coefficient of fabric properties based on coded value of input parameters

Factor	Coefficients	Initial thickness (T_i), mm	Compression parameter (α)	Recovery parameter (β)	Resiliency %
	C_0	+0.4453	+0.2693	+0.10888	+43.557
X_1	C_1	-0.0573	-0.0308	+0.00288	+5.631
X_2	C_2	+0.0745	+0.0467	+0.02459	+4.407
X_3	C_3	+0.0421	+0.0245	+0.01261	+2.313
X_4	C_4	-0.0631	-0.0304	-0.01488	-2.877
$X_1 * X_2$	C_5	-0.0115	-0.0077	+0.00103	+0.943
$X_1 * X_3$	C_6	-0.0160	-0.0085	-0.00052	+0.456
$X_1 * X_4$	C_7	+0.0165	+0.0135	-0.00040	-0.344
$X_2 * X_3$	C_8	-0.0080	-0.0140	-0.00448	-0.692
$X_2 * X_4$	C_9	+0.0030	+0.0033	-0.00048	-0.112
$X_3 * X_4$	C_{10}	-0.0038	+0.0035	-0.00158	-0.569
X_1^2	C_{11}	+0.0418	+0.0244	+0.00492	-0.189
X_2^2	C_{12}	-0.0059	-0.0070	-0.00280	-0.515
X_3^2	C_{13}	-0.0025	+0.0038	+0.00248	+0.775
X_4^2	C_{14}	-0.0158	-0.0091	-0.00601	-1.157
R^2 value		0.951	0.915	0.886	0.938

X_1—Linear density per filament, X_2—Overfeed, X_3—Air-pressure and X_4 —Texturing speed.

Table 4—Significance of the different compontents of quadratic model on properties of air-jet textured yarn fabrics

Factor	Normalized regresssion coefficient				Sum of square				Contribution, %			
	Initial thickness (T_i)	Compression parameter (α)	Recover Parameter (β)	Resiliency	Initial thickness (T_i)	Compression parameter (α)	Recovery parameter (β)	Resiliency	Initial thickness (T_i)	Compression parameter (α)	Recovery parameter (β)	Resiliency
X_1	-0.44	-0.41	+0.09	+0.68	0.03945	0.01135	0.00010	380.5	20.7	18.2	0.8	47.6
X_2	+0.58	+0.62	+0.75	+0.53	0.06660	0.02613	0.00726	233.1	35.0	41.9	58.2	29.2
X_3	+0.33	+0.33	+0.38	+0.28	0.02125	0.00720	0.00191	64.2	11.2	11.5	15.3	8.0
X_4	-0.49	-0.41	-0.45	-0.35	0.04775	0.01110	0.00266	99.3	25.1	17.8	21.3	12.4
$X_1 *X_2$	-0.06	-0.07	+0.02	+0.08	0.00053	0.00024	0.00000	3.6	0.3	0.4	0.0	0.4
$X_1 *X_3$	-0.08	-0.08	-0.01	+0.04	0.00102	0.00029	0.00000	0.8	0.5	0.5	0.0	0.1
$X_1 *X_4$	+0.09	+0.12	-0.01	-0.03	0.00109	0.00073	0.00000	0.5	0.6	1.2	0.0	0.1
$X_2 *X_3$	-0.04	-0.12	-0.09	-0.06	0.00026	0.00078	0.00008	1.9	0.1	1.3	0.6	0.2
$X_2 *X_4$	+0.02	+0.03	-0.01	-0.01	0.00004	0.00004	0.00000	0.1	0.0	0.1	0.0	0.0
$X_3 *X_4$	-0.02	+0.03	-0.03	-0.05	0.00006	0.00005	0.00001	1.3	0.0	0.1	0.1	0.2
X_1^2	+0.22	+0.22	+0.10	-0.02	0.01050	0.00358	0.00015	0.2	5.5	5.7	1.2	0.0
X_2^2	-0.03	-0.06	-0.06	-0.04	0.00021	0.00029	0.00005	1.6	0.1	0.5	0.4	0.2
X_3^2	-0.01	+0.03	+0.05	+0.06	0.00004	0.00009	0.00004	3.6	0.0	0.1	0.3	0.5
X_4^2	-0.08	-0.08	-0.12	-0.09	0.00150	0.00050	0.00022	8.0	0.8	0.8	1.7	1.0

X_1—Linear density per filament, X_2—Overfeed , X_3—Air-pressure and X_4 —Texturing speed.

expression for calculation of per cent contribution with the help of sum of squares is given below:

$$\text{Contribution }(\%) = \frac{\text{Sum of square of individual term}}{\sum \text{Sum of square}} \times 100$$

3 Results and Discussion

To analyze the effect and contribution of feed yarn denier per filament and selected air-texturing parameters on textured yarn fabric properties, normalized values of properties have been plotted in Figs 2-5 against the coded values of independent variables. The X-axis shows the coded levels of the linear density per filament and selected texturing variables used for the study and Y-axis shows the normalized value of the textured yarn fabric properties after it has been scaled from 0 to 100. Figures 2-5 show the percentage change in the textured yarn fabric properties corresponding to the changes in the variable studied from low to high levels.

3.1 Effect of Linear Density per Filament

Figures 2-5 show that an increase in linear density per filaments in parent yarn causes decrease in air-textured yarn fabric thickness and compression parameter; however the recovery parameter and resiliency of textured yarn fabric increase.

For a constant total yarn linear density, the number of filament will be greater if the filaments are finer, hence many filaments would form loops on textured yarn surface. The flexural rigidity of filament also varies directly with square of its linear density[14], so that finer filaments will tend to bend easily as compared to the coarser filaments. The textured yarn made of finer filament possess higher loop frequency

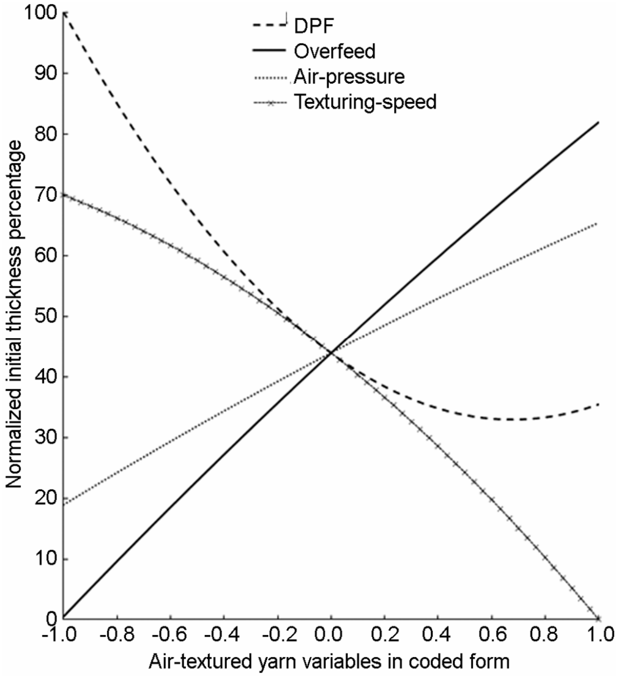

Fig. 2 — Individual effect of feed yarn denier per filament and different air-jet texturing variables on normalized initial thickness of air-jet textured yarn fabrics

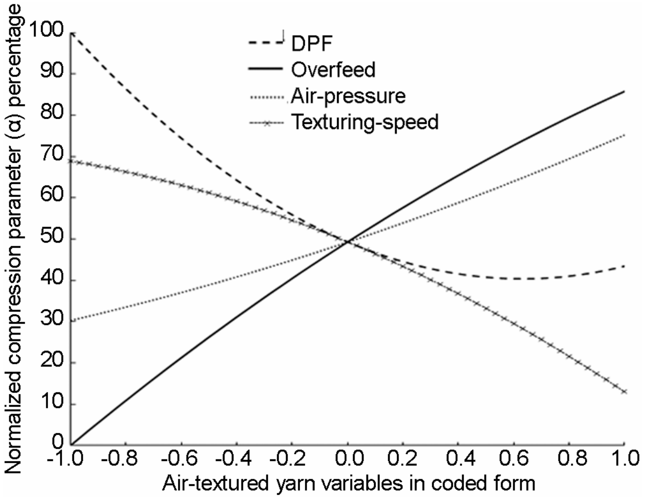

Fig. 3 — Individual effect of feed yarn denier per filament and different air-jet texturing variables on normalized compression parameter of air-jet textured yarn fabrics

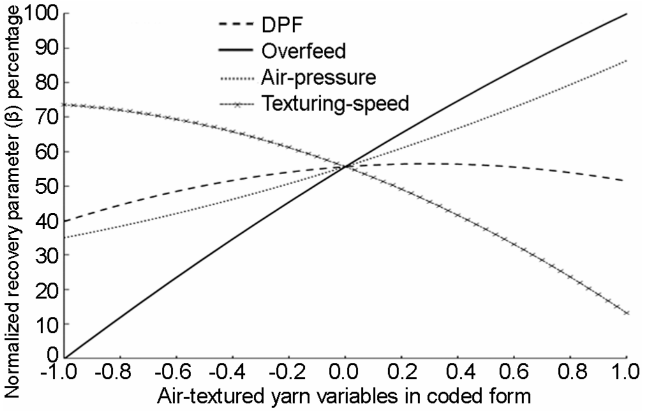

Fig. 4 — Individual effect of feed yarn denier per filament and different air-jet texturing variables on normalized recovery parameter of air-jet textured yarn fabrics

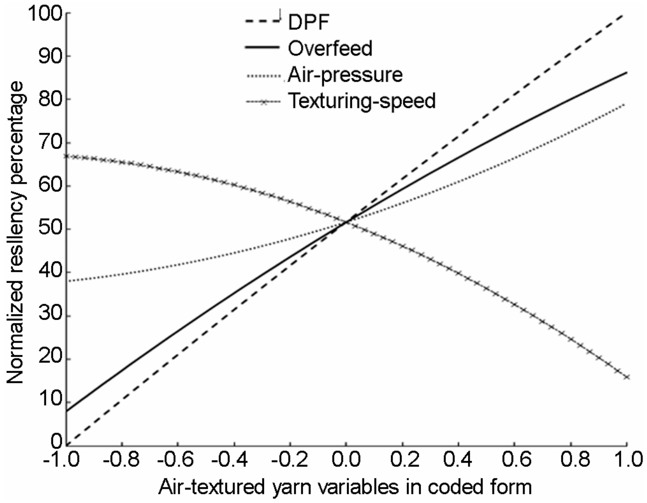

Fig. 5— Individual effect of feed yarn denier per filament and different air-jet texturing variables on normalized resiliency of air-jet textured yarn fabrics

and lower loop height[15,16]. The smaller loops are more resilient to deformation than the larger loops under lower loads; hence textured fabric made of finer filament shows larger thickness; and generate more bulk which can be compressed easily under larger load in comparison to fabrics made from coarser filaments.

The higher loop density and smaller loops of textured yarn lead to more number of filament entanglement in the core of finer filaments, and also due to easy bending increase the frictional area of contact within the yarn matrix. Hence, the chance of retention of original filament position after withdrawal of loading force decreases. Hence, the recovery and resiliency of fabric made from finer filaments are lower.

It is clear from Figs 2-5 that linear density per filament shows significant influence on all air-jet textured yarn fabric properties. On the basis of values of normalized regression coefficient and per cent contribution given in Table 4, it can be said that linear density of filament in parent yarn is the most important variable to explain variability in fabric resiliency and second most important variable to explain remaining fabric properties studied.

3.2 Effect of Overfeed

It can be observed from Figs 2-5 that there is a sharp increase in all textured yarn fabric properties with an increase in overfeed percentage of feed yarn.

The increase in fabric thickness with increase in overfeed, due to enhancement in the textured yarn physical bulk. When overfeed is increased, free length available for migration in the core and loop formation is increased. This loosens the core of textured yarn although number of loops increases.

Figures 2-5 show that for all experimental combination, overfeed percentage tends to display substantially sharp changes in air-jet textured fabric properties studied, from low to high level of overfeed. Table 4 shows that normalized regression coefficient and per cent contribution have highest value against overfeed percentage in case of thickness, compression parameter and recovery parameter and second most influencing variable in case of resiliency, indicating that air-jet textured fabric properties are most influenced by changes in the overfeed.

3.3 Effect of Air-Pressure

Figures 2-5 show that with an increase in air pressure, all the fabric properties increase. The increase in air pressure leads to enhancement in the turbulence and formation of the more number of loops which leads to higher physical bulk of the resultant air-jet textured yarns. The higher physical bulk of yarn results in an increase in fabric thickness and compressibility.

An increase in air pressure leads to more compact core of yarn structure. Due to formation of compact core, higher recovery in fabric thickness on unloading is observed. Higher values of recovery on unloading and resiliency can be seen with the increase in air pressure.

The values of normalized regression coefficient of air pressure as shown in Table 4 indicate a positive influence on all the textured yarn fabric properties as all coefficients are positive.

3.4 Effect of Texturing Speed

Fabric thickness shows a sharp decrease with an increase in texturing speed (Fig. 2). With an increase in texturing speed, a given length of filament will be exposed to the air flow for a shorter duration, resulting in less intense entanglement and increase in yarn instability. So, as the yarn subjected to higher process stress during subsequent weaving operation, it diminishes the texturing effect of the yarn. This results in lower values of thickness and compression parameter.

At higher filament speed (due to higher machine speed), the relative velocity between filaments and surrounding air-flow decreases, thus reducing the forces and torque exerted on the individual filaments, and hence there is a mutual displacement between the filaments, and a consequent decrease in loop formation tendency. Also with the increase in process speed, yarn has lesser time in air stream, resulting in less effective texturing leading to lower values of resiliency and recovery parameter.

From the values of normalized regression coefficient and per cent contribution of texturing speed in Table 4, it can be concluded that texturing speed is the second most influencing factor in case of initial thickness and recovery parameter while it has a significant contribution in case of compression parameter and fabric resiliency.

4 Conclusion

Based on the results of multiple regression model and contribution analysis of the different air-jet texturing variables on textured yarn fabric properties, the following conclusions can be drawn.

Overfeed percentage is an important factor in determining the air-jet textured fabric compression properties. A steep increase is noticeable in all textured yarn properties with increase in overfeed percentage. The second most influential variable among the four variables studied is linear density of filaments in the feed yarns. Linear density of filaments affects the fabric resiliency, fabric thickness, compression parameter and recovery parameter significantly. Although air pressure affects fabric properties the least among variables studied but have significant contribution to all fabric properties.

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