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Effect of some feed filament parameters and weave on compressional properties of air-jet textured yarn fabrics

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The influence of some feed filament parameters and weave on compression and recovery behaviour of air-jet textured yarn fabrics has been studied and compared with their corresponding parent yarn fabrics. Fabric low load compression-recovery behaviour has been analysed by defining initial thickness, compression parameter, recovery parameter and resiliency. Fabrics made from coarser yarn (larger total yarn dtex) have higher initial thickness and compression parameter while lower recovery parameter and resiliency, as compared to fabrics made from finer yarn. Fabrics are woven with two woven structures, namely plain and twill weave to assess the effect of fabric structure on compression and recovery behaviour of the fabrics. Twill woven fabrics exhibit a higher value of all compressional parameters compared to their equivalent plain woven fabrics. Parent yarn fabrics exhibit a low value of all compressional properties, irrespective of change in any feed yarn characteristics as compared to their equivalent textured yarn fabrics.

Keywords: Air-jet textured yarns, Compressional properties, Weaving, Parent yarn, Woven fabrics

1 Introduction

Fabric properties can be explained with the help of fabric and yarn structural parameters along with their constituent yarn/filament/fibre properties. Proper knowledge of these parameters would help in engineering a new product for commercial applications and also to optimize the existing product characteristics for utilizing them effectively.

Effect of feed filament parameters such as polymer type, linear density per filament, filament cross-section, filament frictional characteristics, blend percentage and filament modulus on air-jet yarn fabric properties have been reported by many researchers[1-5]. Effect of weave on fabric compressional behaviour studied by a few researchers[6,7]. They reported that weave structure has a significant effect on compression and recovery behaviour.

Renagasamy *et al.*[1] investigated the effect of feed yarn fineness and process parameters on bending and compression properties of 'core and effect' air-jet textured yarn fabrics. They found that an increase in filament fineness causes increase in compression resilience of fabrics. Mukhopadyhay *et al.*[2] reported the effect of pick density, constituent filament fineness and heat-setting on the air-jet textured yarn fabric thickness and compressional properties before and after laundering. They found that the coarser filament textured yarn fabrics have higher thickness and compressibility than that of finer filament textured yarn fabrics.

In this investigation, the effect of feed yarn parameters such as total yarn linear density, yarn type and weave type on air-jet textured yarn fabric compression-recovery behaviour has been studied. Fabric pressure-thickness relationship of woven air-jet textured yarn fabrics in the low-load region has also been explained with suitable mathematical coefficients using empirical modelling.

2 Materials and Methods

2.1 Raw Materials

The feed filament yarn properties are given in Table 1. Yarns of fully drawn polyester multifilament yarns having same linear density (169 dtex) with different filament fineness as 1.17, 2.35 and 3.52 dtex (yarns no. **1**, **2**, **3**) were chosen to study the effect of weave on textured yarn fabric properties. For these studies, textured yarns were produced by feeding single end of yarn to the texturing nozzle.

To study the effect of total linear density of feed yarns on textured yarn fabric properties, the yarns numbered **4** and **5** (Table 1) were used as feed yarns as single end, multiple ends or in combination of specific

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Table 1 — Feed yarn properties

Yarn No.	Linear density dtex		Filament shape	Tenacity	Breaking extension	Modulus	Flexural rigidity×10^{-9}
	Yarn	Filament		cN/dtex	%	cN/dtex	Nm^2
1	169	1.17	Circular	2.52	14.7	65.9	432
2	169	2.35	Circular	2.56	13.6	68.7	3731
3	169	3.52	Circular	2.63	12.9	71.6	13184
4	78	1.11	Circular	3.39	13.0	78.6	450
5	111	1.11	Circular	3.38	13.7	73.3	419

number of ends, keeping the linear density of filament constant. Using yarns **4** and **5**, eight feed yarns can be obtained with total linear density in dtex of 78 (1×78), 111 (1×111), 156 (2×78), 189((1×78) + (1×111)), 222 (2×111), 267((2×78) + (1×111)), 300((1×78) + (2×111)) and 333 (3×111), all having the same filament fineness of 1.11 dtex.

2.2 Methods

2.2.1 Preparation of Air-Jet Textured Yarns

The parent yarns were fed on ELTEX AT/HS air-jet texturing machine using HemaJet with S325 core. The constant process parameters used in the production of air-jet textured yarns are as follows:

Wetting	:	1l/jet/h
Stabilization heater temperature	:	180º C
Mechanical stretch	:	4.3%
Winding underfeed	:	0.6%

The overfeed, air pressure and texturing speed employed for these three studies are based on the optimized values obtained by the methodology explained[8]. These parameters were: 29%, 9 bar and 400 m/min respectively.

2.2.2 Preparations of Fabric Samples

Plain weave woven fabric samples were prepared with twisted 167/144 dtex polyester multifilament yarn as warp on Lakshmi shuttle loom at 120 picks/min having a reed space of 56 inches (1422 mm). Experimental air-jet textured yarns were used as weft to prepare fabric samples. Some fabrics were also woven with equivalent twill weave structure to study the effect of fabric structure. The ends per cm and pick per cm on loom were kept 28.4 and 25.2 respectively. The grey fabrics was then relaxed in jet dying machine at boil with 1% non-ionic detergent for 45 min. The fabrics were then heat-set on stenter at 18 m/min speed with 3.5% overfeed allowing 5% width wise shrinkage at 180°C. The heat-set fabrics has ends per cm and picks per cm as 29.9 and 28.4 respectively.

2.2.3 Measurement of Compressional Properties of Fabric

A digital thickness tester was used to measure compression and recovery property. Fabric was placed between anvil and pressure foot of 114 mm diameter to apply pressure of 1.1 gf/cm^2 on the fabric for 30 s, and thickness was measured as initial thickness (T_i). The compressive loads were increased in the thirteen steps and thickness was recorded after waiting for 30 s in each step. After getting a pressure of 20.3 gf/cm^2, the pressure was gradually reduced in same steps and resultant thickness values were recorded in the same way during recovery cycles. Experimental data recording and analysis has been done by the method as reported earlier[9]. Thickness values were measured at ten different places and average values were used to fit the curve. From the best fit curve equations, compression parameter (α), recovery parameter (β) and resiliency values were obtain.

3 Results and Discussion

3.1 Effect of Weave

Effect of plain and twill weave on fabric compressional properties of parent and air jet textured weft yarn fabrics for different linear density per filament are given in Table 2. Fig. 1 shows that effect of weave on air permeability of air-jet textured yarn fabrics. It has been found that plain woven fabrics exhibit low air permeability than their equivalent twill woven fabrics. This is due to the fact that plain woven fabrics have high interlacement of yarns which results in high inter-yarn pressure that leads to more flattening of yarns in the structure than twill woven fabrics. As a consequence, the inter-yarn spaces in plain fabrics are less, resulting in more resistance to air flow, and hence they have low air permeability as compared to twill fabrics.

Table 2 and Figs 2-5 show that plain woven fabrics have a lower initial thickness, compressibility, recovery and resiliency than twill woven fabrics. Fig. 2 depicts that initial thickness is low for plain woven fabrics as compared to that for twill woven fabrics. This is due to the fact that plain weave has the highest degree of interlacement with a maximum number of intersection

Table 2 — Compressional properties of fabrics made from different type of feed yarn and linear density per filament/fibre

Yarn	Linear density, dtex		Weave	Ends/ cm	Picks/ cm	Air-permeability $cm^3/cm^2/s$	Crimp, %		Fabric weight g/m^2	Initial thickness (T_i), mm	Compressed thickness (T_f), mm	Recovered thickness (T_r), mm
	Filament	Yarn					Warp	Weft				
Parent	1.11	169	Plain	31.5	35.4	4.5 (12.0)	2.8	4.3	123.1	0.16	0.12	0.14
	2.22	169	Plain	32.0	35.4	5.9 (11.2)	3.2	3.1	124.6	0.17	0.13	0.14
	3.33	169	Plain	31.8	35.8	6.6 (14.2)	3.9	3.0	125.6	0.18	0.13	0.15
	1.11	169	Twill	31.5	35.4	19.2 (8.9)	1.8	2.7	124.1	0.18	0.13	0.15
	2.22	169	Twill	31.8	35.8	27.2 (7.8)	2.0	2.3	125.2	0.19	0.14	0.16
	3.33	169	Twill	31.5	35.8	33.2 (8.2)	2.1	2.3	126.2	0.20	0.13	0.16
	1.11	111	Plain	31.3	46.5	3.6 (10.5)	4.5	4.0	115.2	0.19	0.12	0.13
	1.11	155	Plain	32.0	40.9	5.2 (12.8)	6.3	3.9	121.8	0.18	0.13	0.14
	1.11	189	Plain	33.0	36.2	6.0 (14.2)	6.2	3.4	126.7	0.19	0.13	0.15
	1.11	222	Plain	32.5	29.9	7.5 (13.8)	7.6	1.9	124.6	0.22	0.15	0.17
	1.11	266	Plain	32.0	26.0	8.4 (12.6)	7.3	3.2	127.6	0.25	0.18	0.21
	1.11	300	Plain	32.3	22.8	8.6 (13.2)	6.4	2.3	126.7	0.24	0.18	0.21
	1.11	333	Plain	32.3	20.5	9.5 (11.4)	7.1	1.6	126.4	0.25	0.19	0.22
Textured	1.11	169	Plain	31.5	35.4	10.2 (10.7)	3.0	3.9	123.5	0.49	0.27	0.39
	2.22	169	Plain	32.0	35.4	12.2 14.5)	3.3	3.1	124.2	0.55	0.29	0.41
	3.33	169	Plain	31.8	35.8	14.5 (12.5)	4.6	2.6	123.4	0.58	0.30	0.41
	1.11	169	Twill	31.8	31.1	34.2 (7.9)	1.8	2.7	123.2	0.57	0.30	0.46
	2.22	169	Twill	31.5	31.1	39.7(6.9)	2.0	3.0	122.5	0.60	0.30	0.46
	3.33	169	Twill	31.5	30.7	46.2(7.2)	2.2	3.5	121.8	0.61	0.29	0.44
	1.11	111	Plain	32.3	41.7	10.7 (13.8)	3.4	6.1	119.7	0.42	0.26	0.36
	1.11	155	Plain	32.0	35.4	13.5 (6.9)	4.2	5.0	123.8	0.44	0.24	0.35
	1.11	189	Plain	32.8	29.9	15.5 (7.8)	4.2	4.2	124.8	0.45	0.24	0.34
	1.11	222	Plain	32.0	25.6	16.6 (10.4)	5.1	3.1	124.0	0.45	0.25	0.34
	1.11	266	Plain	32.0	21.3	16.5 (5.2)	6.0	3.6	124.7	0.48	0.25	0.34
	1.11	300	Plain	32.3	19.7	16.3 (8.1)	5.0	3.0	126.8	0.53	0.27	0.36
	1.11	333	Plain	33.0	18.1	17.0 (8.5)	5.8	3.1	128.5	0.55	0.27	0.38

Values in parentheses indicate the CV%.

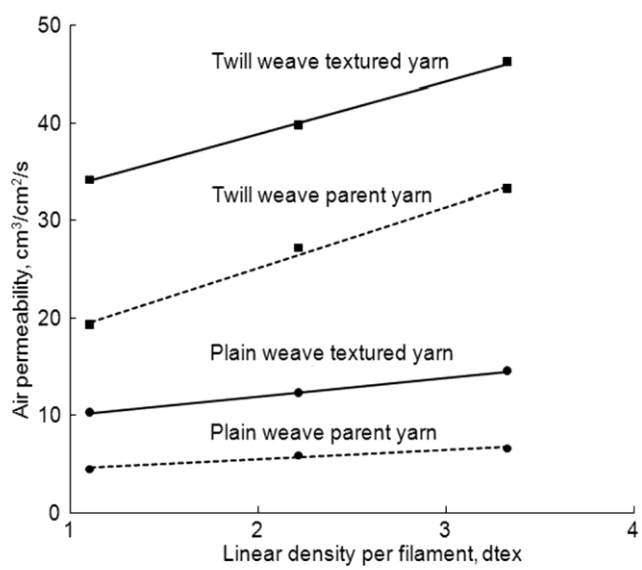

Fig. 1 — Effect of linear density per filament and weave type on air permeability of parent and air-jet textured yarn fabrics

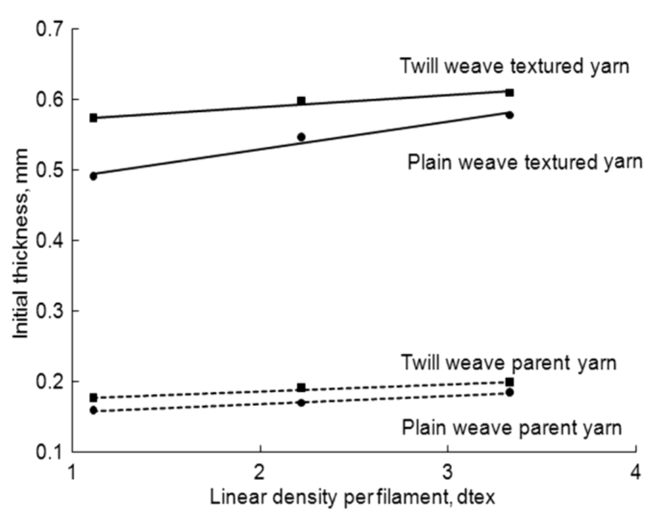

Fig. 2 — Effect of linear density per filament and weave type on initial thickness of parent and air-jet textured yarn fabrics

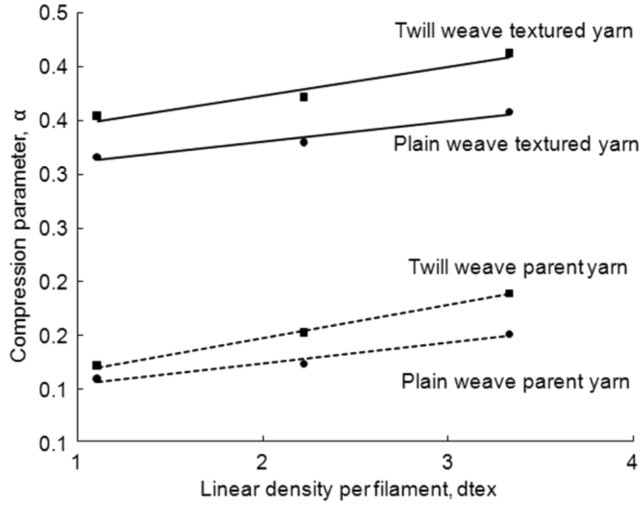

Fig. 3 — Effect of linear density per filament and weave type on compression parameter of parent and air-jet textured yarn fabrics

points, resulting in high inter-yarn pressure; as a consequence, lower initial thickness values.

Figure 3 shows that compressibility is lower for plain woven fabrics as compared to twill woven fabrics. This is because of the fact that compact structure of plain weave has a high degree of flattening of the yarns due to their high inter-yarn pressure, which results in the lesser scope of further compression on loading.

Figures 4 and 5 illustrate that recovery and resiliency are higher for twill woven fabrics as compared to plain woven fabrics. The contact area is higher in twill weave due to high number of floats which results in lower contact pressure for a same nominal load that leads to higher recovery and resiliency on the removal of the load.

3.2 Effect of Yarn Type

Table 2 presents effect of yarn type on fabric compressional properties of parent and air jet textured weft yarn fabric for different linear density per filament and total yarn linear density. Figures 2-7 show that the fabrics woven from parent yarns have lower compressional properties than that of air-jet textured yarn fabrics.

Parent yarns are flat filament yarns and hence the fabrics made of them have lower bulk than textured yarn fabrics. Parent yarn fabrics have a lower thickness, compression parameter, recovery parameter and resiliency as compared to textured yarn fabrics.

3.3 Effect of Total Yarn Linear Density

Results of the effect of total yarn linear density on parent and textured yarn compression and recovery

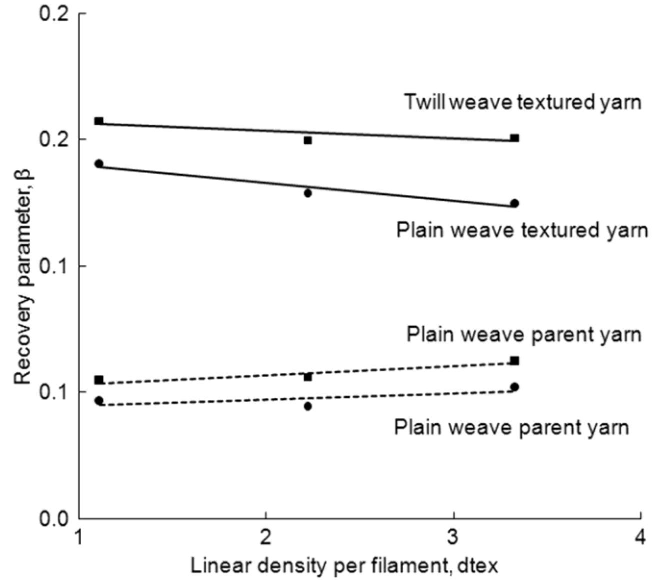

Fig. 4 — Effect of linear density per filament and weave type on recovery parameter of parent and air-jet textured yarn fabrics

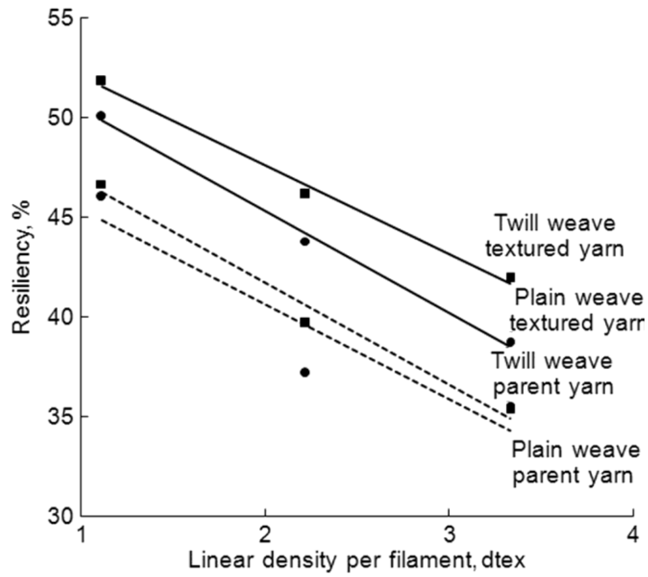

Fig. 5 — Effect of linear density per filament and weave type on resiliency of parent and air-jet textured yarn fabrics

behaviour is shown in Table 2 and Figs 6 and 7. As can be seen from Fig. 6, initial thickness and compression parameter increase with the increase in total yarn linear density. Figure 7 shows that recovery parameter and resiliency of fabrics decrease with increase in total yarn linear density. Higher total yarn linear density means more number of filaments and higher yarn bulk, resulting in a higher initial thickness of fabrics and more compressibility. However, the less compact structure of higher linear density yarns results in lower recovery parameter and resiliency.

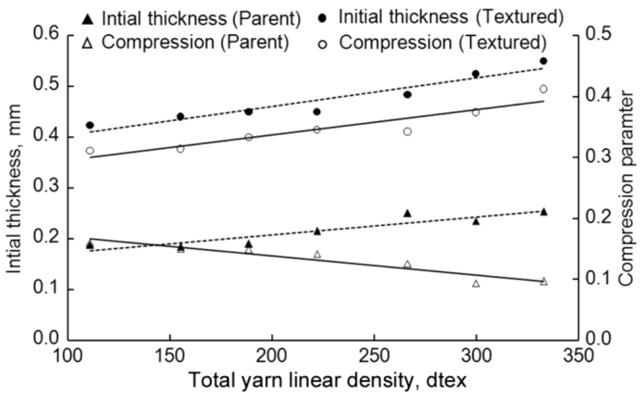

Fig. 6 — Effect of total yarn linear density on initial thickness and compression parameter of plain woven parent and air-jet textured yarn fabrics

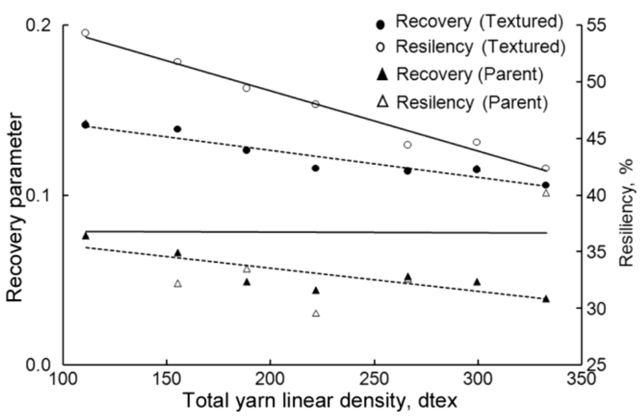

Fig. 7 — Effect of total yarn linear density on recovery parameter and resiliency of plain woven parent and air-jet textured yarn fabrics

4 Conclusion

Effect of total linear density, yarn type and weave structure on fabric compression and recovery behaviour has been investigated. With the increase in total yarn dtex, the fabric's initial thickness and compression parameter increase, whereas the recovery parameter and resiliency decrease. Parent yarn fabrics show lower compression and recovery parameters, irrespective of change in feed yarn characteristics than the corresponding air-jet textured yarn fabrics. Twill woven fabrics exhibit higher compressional parameters as compared to plain woven fabrics.

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