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Sewing Performance of PV & PES Air-Jet Textured Sewing Threads in Denim Fabrics

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ABSTRACT

At present, mainly three types of sewing thread constructions are used in high speed sewing namely spun polyester thread, cotton wrapped poly core thread and poly wrapped poly core thread. As the manufacturing processes of these threads are very costly, air-jet textured sewing threads are the most economical option available today, and their introduction into the clothing industry is one of the best ways of reducing production costs. PES air-jet textured sewing thread gives higher seam efficiency, seam slippage and seam pucker as compared to PV air-jet textured sewing thread. PV air-jet textured sewing thread is more suitable for lighter denim whereas PES air-jet textured sewing thread is suitable for heavier denim.

Keywords: Sewability, Seam efficiency, Seam pucker, Seam slippage, Needle cutting index

Introduction

Sewing technology has entered the new millennium with its familiar needs, and is waiting for new solutions from textile technology. Sewing threads have been used for many centuries, and are used in the same manner even now, but demand for sewing threads is another matter. Modern high-speed sewing machines require sewing threads of high toughness for satisfactory performance. Polyester yarn and multifilament threads have almost replaced cotton sewing threads in the market due to their very high strength and durability; however their thermoplastic nature makes them susceptible to change in their properties when they become heated during sewing[1]. Sometimes, the melting of thread also leads to blockage of needle eye. In this respect, the threads with sufficient bulk viz. spun and air-jet textured threads, are the ideal choice[2].

Air-jet textured threads frictional properties are much like those of spun threads, from the presence of numerous loops, which in effect duplicate the hairiness of spun yarns[1]. The air-bulking produces small loops in the continuous-filament yarn and therefore give a discontinuous surface to the thread, which helps to reduce the danger of thread fusion at high sewing speeds. Such threads have a less slippery feel than normal continuous filament yarns and provide a better lock in the fabric[3].

From the serviceability point of view, the seam strength, seam security and shrinkage of sewing threads are important[4]. Synthetic filament threads suffer from the problem of inferior sewing performance and can give some seam stability problems[5]. Air-jet-texturing offers sufficiently thick sewing threads, which ensures the stability of the seams[6]. At high sewing speeds with synthetic threads especially the filament threads, the parts of surface filaments melt and this causes thread break and poor stitch appearance. For value added garments, seam appearance is highly critical. Air-jet textured threads are ideal choice for these kinds of applications[2].

At present, mainly three types of sewing thread constructions are used in high speed sewing namely spun polyester thread, cotton wrapped poly core thread and poly wrapped poly core thread. As the manufacturing processes of these threads are very costly, air-jet textured sewing threads are the most economical option available today, and their introduction into the clothing industry is one of the best ways of reducing production costs[6].

The work in the field of sewing performance of air-jet textured sewing threads is scantly available [2, 6]. In this connection; an understanding of the sewing characteristics of PV and PES air-jet textured sewing threads on high speed sewing machine is of fundamental importance and would be worthwhile to be studied. The present work has, therefore, been undertaken to compare the sewability performance of PV and PES air-jet textured sewing threads.

Materials and Methods

Materials

Sewing Thread Samples

In the present work, polyester and viscose multifilament yarns, having the properties as shown in Table 1, were selected to produce PV and PES air-jet textured yarns.

Table 1 – Properties of parent yarns

Yarn type	Yarn tex	No. of filaments	Tenacity (g/tex)	Strain at break (%)	Modulus (g/tex)
Viscose	8.4	24	26.74	12.44	560.40
Polyester	8.7	34	42.86	24.01	497.30

Polyester and viscose multifilament yarns were blended during air-jet texturing. Yarns from four feeder packages were fed simultaneously to the jet. Initially, all four packages were of polyester yarn, and then two polyester yarn packages were replaced by two viscose yarn packages to produce 100% PES and 50:50 blend of PV air-jet textured yarn respectively. Details of these air-jet textured yarns are given in Table 2. Eltex AT/HS air-jet texturing machine was used to produce these air-jet textured yarns with the following texturing parameters: Texturing speed: 300 m/min, Air pressure: 9kgf/cm^2, Overfeed: 30%, Mechanical stretch: 4.7%, Water pressure: 2kgf/cm^2, Water consumption: 0.5 Liter/jet/h, Air nozzle: HemaJet core T-100, Heater temperature: 220°C.

Table 2 - Details of air-jet textured yarns

Yarn type	No of ends	Yarn tex	Yarn code
PV	4 (2 PES + 2 Viscose)	48.6	A_1
PES	4	50.3	A_2

Both these air-jet textured yarn were then doubled on a ring twister at 8 twists/inch for preparation of sewing thread. To keep the needle cool during sewing, eliminating thread breakage and skipping, a commercial spin finish Clearco silicone wax thread finish 3261 was applied on sewing threads with 3% concentration on winding machine. The details of PV and PES air-jet textured sewing threads are given in Table 3.

Table 3 - Details of air-jet textured sewing threads used for stitching

Yarn code	Number of ply	Yarn tex	Tex ticket number	Sewing thread code
A_1	2-ply	102	90	T_1
A_2	2-ply	102	90	T_2

Fabric Samples

In order to assess the performance of air-jet textured sewing thread in denim-based garments, six different blue denim fabrics produced by pioneer denim manufacturers of India and commonly used for clothing were selected for study. Details of these fabrics are given in Table 4.

Table 4 - Fabric constructional parameters and dimensional properties

Weight (g/m^2)	Weave	Fabric code	EPI	PPI	Yarn count (Ne)		Thickness (mm)	Crimp (%)		Cover factor		
					Warp	Weft		Warp	Weft	Warp	Weft	Cloth
506	1/3 Twill	F_1	72	45	7.3	6.4	1.16	29.9	9.6	26.6	17.8	27.5
361	1/2 Twill	F_2	69	41	9.0	10.3	0.81	22.9	5.8	23	12.8	25.3
471	1/3 Twill	F_3	61	48	6.8	5.7	0.84	19.8	11.4	23.4	20.1	26.7
439	1/3 Twill	F_4	75	47	7.4	7.7	1.02	27.4	6.9	27.6	16.9	27.8
223	1/2 Twill	F_5	85	48	17.3	18.7	0.52	23.1	11.3	20.4	11.1	23.4
192	1/2 Twill	F_6	82	45	16.0	15.9	0.48	11.0	13.4	20.5	11.3	

Methods

Sewing Thread Properties

Yarn count was measured using the ASTM-D 1059 method and Tex Ticket number was determined according to ASTM-D 3823.The tensile test for measurement of breaking strength & elongation, loop strength and knot strength was carried out according to ASTM-D 204 test method, on the Instron Tensile Tester. The gauge length was kept 500 mm and a jaw separation rate of 300mm/min was used.

Fabric Constructional Parameters

The fabric thickness was measured according to the ASTM-D 1777 test method, on the R & B Cloth thickness tester. Fabric weight was measured with the help of fabric round cutter and an electronic weighing balance according to the ASTM-D 3776. End and pick density were measured using the ASTM-D 3775 method. Crimp in warp and weft was measured according to ASTM-D 3883 test methods, on the Prolific crimp tester. Yarn count of warp and weft was measured using the ASTM-D 1059 method.

Sewing

A singer industrial lockstitch machine Model 191 D 200AA was used for these trails. The standard sewing conditions maintained for the test sample were as follows:

Machine speed	:	2500 stitches/min.
Seam geometry	:	plain lock stitch seam.
Stitch density	:	eight stitches/inch.
Needle size (Singer System)	:	16 and 18 for lighter and heavier denims respectively.

The seams were made with two layers of fabric in superimposed position. The tension of the bobbin-thread was adjusted so that a slight unwinding occurred when the bobbin case was hold by the end of the thread. The tension of the needle-thread was adjusted so that the seam was best balanced. Thread tension was adjusted for each fabric and each sewing thread.

Evaluation of Sewability

Seam qualities were measured by seam parameters such as seam efficiency, seam pucker, seam slippage and needle cutting index.

Seam efficiency

Seam strength was measured according to the ASTM-D 1683 test method for failure in sewn seams of woven fabrics, on the SDL Tensile Tester. Seam efficiency was calculated using the following formula:

$$\text{Seam efficiency (\%)} = \frac{\text{Seam Tensile Strength}}{\text{Fabric Tensile Strength}} \times 100$$

Seam Slippage

The seam slippage test was done as per ASTM-D1683 on the SDL Tensile Tester. The load-elongation curve of fabric was superimposed over a load-elongation curve of the same fabric with a standard seam sewn parallel to the yarns being tested. The force at which the load-elongation curve of the fabric with the seam is a predetermined distance greater than the load elongation of the fabric without a seam is reported as resistance to yarn slippage. The above test was carried out using following test parameters:

Gauge length	:	75 mm
Test speed	:	305 mm/min
Seam opening	:	6 mm

Seam Pucker

Seam pucker was determined by measuring the difference in fabric and seam thickness under a constant compressive load on the SDL Tensile Tester. The seam thickness strain was calculated using the formula:

$$\text{Thickness Strain (\%)} = \frac{t_s - 2t}{2t} \times 100$$

where t_s is seam thickness, and t is fabric thickness.

Seam damage

The seam damage test was conducted according to the ASTM-D 1908 test method for needle related damage due to sewing in woven fabrics, on the Mitsubishi Micro Watcher with a magnification of 500. For each sample, needle-cutting index was determined using the following formula:

$$\text{Needle Cutting Index (\%)} = \frac{\text{No. of yarns cut/inch}}{\text{No. of yarns in fabric/inch}} \times 100$$

Results and Discussion

Tensile Properties of Sewing Threads

Table 5 shows the tenacity, breaking strain, and modulus of both the sewing threads tested in the single-strand (straight), loop and knot test method. From the table it can be observed that the PES air-jet textured sewing thread shows the higher values of tenacity and strain as compared to PV air-jet textured sewing thread. This may be due to higher strength and extensibility of PES parent yarn as compared to PV yarn. It can be also observed from the results, that the modulus of PES air-jet textured sewing thread is lower than PV air-jet textured sewing thread. This is due to higher extensibility of PES air-jet textured sewing thread for a given load.

Table 5 - Tensile properties of air-jet textured sewing threads

	Straight strength		Loop strength		Knot strength	
Parameters	T_1	T_2	T_1	T_2	T_1	T_2
Tenacity (g/tex)	23.75	35.04	38.98	56.96	17.61	24.90
Strain at break (%)	16.29	30.01	9.82	14.81	9.16	12.09
Modulus (g/tex)	280.10	257.20	693.00	629.70	294.30	273.40

Sewability

Sewability is defined as the ability and ease with which fabric components can be qualitatively and quantitatively seamed together, to convert a garment[7]. The characteristics of a high seam are strength, elasticity, stability and appearance. The sewability performance of PV air-jet textured sewing thread (T_1) and PES air-jet textured sewing thread (T_2) are given in Table 6, Table 7 and Table 8 respectively.

Table 6 – Sewability performance of PV air-jet textured sewing thread (T_1)

Fabric code	Seam efficiency (%)		Seam slippage (Kgf)		Seam puckering (%)	Needle cutting index (%)	
	Warp	Weft	Warp	Weft		Warp	Weft
F_1	52.65	61.93	-	-	7.69	7.76	5.37
F_2	75.19	108.96	-	21.84	21.12	5.23	4.38
F_3	55.10	70.88	-	-	41.01	5.55	3.78
F_4	51.59	91.99	33.42	-	14.67	7.47	3.39
F_5	110.41	98.25	-	14.09	33.98	5.20	4.19
F_6	72.43	124.57	-	8.85	38.74	5.37	3.62

- indicates no seam slippage at maximum load

Table 7 – Sewability performance of PES air-jet textured sewing thread (T_2)

Fabric code	Seam efficiency (%)		Seam slippage (Kgf)		Seam puckering (%)	Needle cutting index (%)	
	Warp	Weft	Warp	Weft		Warp	Weft
F_1	63.75	90.54	-	38.59	14.34	3.89	2.95
F_2	89.54	100.09	52.74	23.4	25.14	3.48	4.07
F_3	72.70	87.13	55.93	36.39	43.16	4.92	3.39
F_4	68.92	96.77	35.83	32.6	20.80	6.14	2.11
F_5	117.63	104.78	2.55	17.26	35.04	4.96	3.35
F_6	94.97	110.99	36.28	11.56	39.37	3.67	2.25

- indicates no seam slippage at maximum load

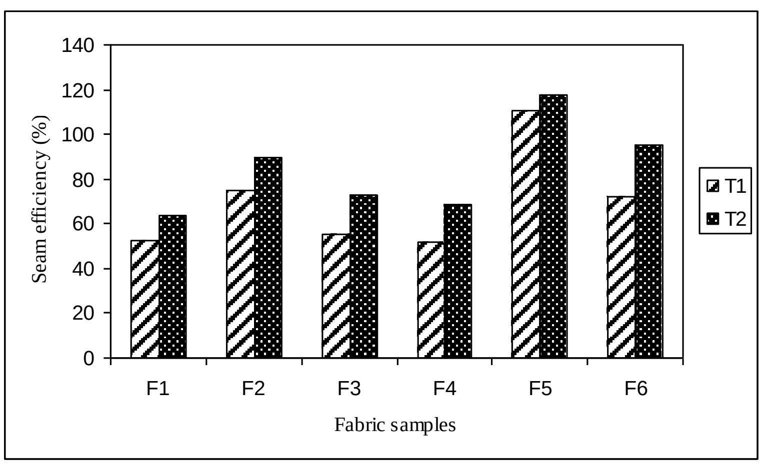
Seam Efficiency

The retention of strength in a seamed fabric after sewing with respect original fabric strength is measured in terms of seam efficiency[8]. From the results, it can be observed that seam efficiency decreases with the increase in fabric weight. In case of lightweight denims the values of seam efficiency have been observed more than 100%. This is due to early occurrence of fabric breakage than the seam breakage. From Table 6, Table 7 and Table 8, lower seam efficiency has been observed in heavyweight denims as compared to lightweight denims. It may be also observed that warp and weft seam efficiency largely depend on the mass value of warp and weft respectively. Among all fabrics, Denim F_4 has higher mass value in warp direction and F_3 has higher mass value in weft direction, which gives lower warp and weft seam efficiency respectively. Heavy weight fabrics have higher bending rigidity values, which causes increase in fabric strength and decrease in the seam efficiency. From Figure 1, it has been further observed that fabrics sewn with PES air-jet textured sewing thread (T_2) have higher seam efficiency values as compared to fabrics sewn with PV air-jet textured sewing thread (T_1). This is due to higher tensile strength of PES air-jet textured sewing thread (T_2) as compared to PV air-jet textured sewing thread (T_1).

Table 8 - Coefficient of correlation between sewability parameters and fabric physical and dimensional properties

Fabric Dimensional Properties	Seam Efficiency		Seam Slippage		Seam Puckering		Needle cutting Index	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
Fabric Weight (oz/yd^2)	-0.84	-0.93	□	0.61	-0.51	-0.45	0.72	0.35
	-0.83	-0.93	0.92	0.98			0.21	-0.06
Strength (Warp), Kgf	-0.93	-0.98	□	0.70	-0.55	-0.49	0.77	0.25
Strength (Weft), Kgf	-0.92	-0.98	1.00	0.98	-0.35	-0.29	0.31	0.09
EPI	0.66	0.68	□	-0.86	0.07	0.01	-0.12	0.02
PPI	-0.37	-0.21	-0.66	0.18	0.36	0.38	-0.35	-0.40
Warp Count	0.84	0.91	□	-0.78	0.52	0.46	-0.58	-0.19
Weft Count	0.71	0.89	-0.73	-0.92	0.46	0.40	-0.19	-0.03
Thickness (mm)	-0.76	-0.88	□	0.54	-0.81	-0.76	0.85	0.21
	-0.76	-0.79	0.96	0.91			0.44	-0.05
Warp Crimp (%)	-0.24	-0.44	□	-0.13	-0.83	-0.81	0.71	0.35
Weft Crimp (%)	0.09	0.28	-0.99	-0.37	0.69	0.68	0.63	-0.30
Warp Cover Factor	-0.78	-0.87	□	0.38	-0.80	-0.76	0.91	0.42
Weft Cover Factor	-0.85	-0.94	0.87	0.94	-0.25	-0.18	0.10	-0.06
Fabric Cover Factor	-0.85	-0.93	□	0.55	-0.65	-0.59	0.81	0.40
	-0.74	-0.83	0.90	0.94			0.18	-0.16

- indicates no seam slippage at maximum load



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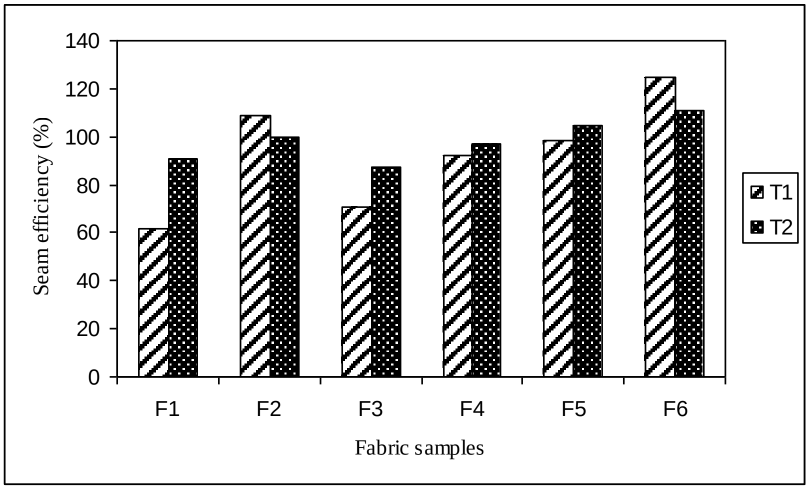
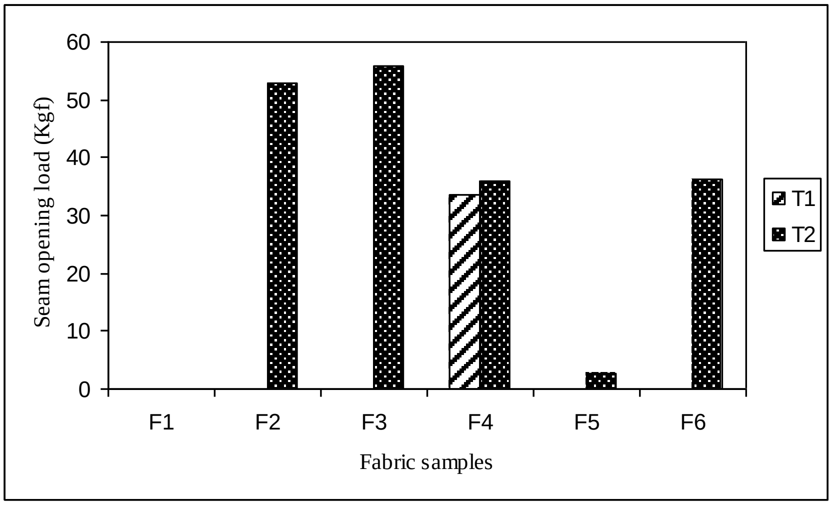


(b)

Fig. 1 Seam efficiency of fabrics sewn with PV air-jet textured sewing thread (T_1) and PES air - jet textured sewing thread (T_2) (a) in warp direction and (b) in weft direction

Seam Slippage

A partial or complete loss of seam integrity manifested by yarn slippage parallel to stitch line is considered as seam slippage[9]. Results for seam slippage are given in Table 6, Table 7 and Table 8. It may be observed from the results that denim F_1 shows high resistance to seam slippage with both the sewing threads. This may be due to better interlooping of sewing thread with fabric and higher contact area due to high fabric weight and thickness. It has been also observed that the lighter denims F_5 and F_6 show less resistance to seam slippage. It may also be noticed that all denims are highly resistance to seam slippage in warp direction when sewn with PV air-jet textured sewing thread. This is due to higher warp cover factor of fabrics and lower extensibility of sewing thread does not allow the yarns to slip. It can be observed from Figure 2 that fabrics sewn with PV air-jet textured sewing thread give less seam slippage than the fabrics sewn with PES air-jet textured sewing thread. It may be due to higher extensibility of PES air-jet textured sewing thread as compared to PV air-jet textured sewing thread.



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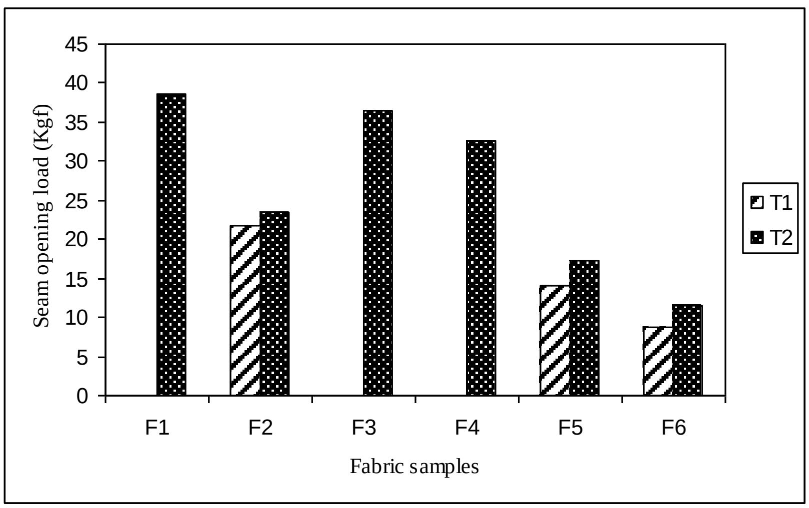


(b)

Fig. 2 Seam slippage of fabrics sewn with PV air-jet textured sewing thread (T_1) and PES air-jet textured sewing thread (T_2) (a) in warp direction and (b) in weft direction

Seam Pucker

Seam pucker is a distortion in the surface of a sewn fabric and appears as a swollen effect along the line of the seam. It is determined by measuring the percentage increase in the thickness of the seamed fabric over the original fabric under a constant load [9, 10]. The results for seam pucker are given in Tables 6 and Table 7. It may be observed from the results that the puckering consistently decreases with the increase in fabric weight, thread density, cover and thickness in fabrics. This may be due to the increase in plane compressional resistance. As the values of flexural rigidity increase seam pucker decreases. Among all fabrics, denim F_3 has exceptionally high puckering tendency due to poor dimensional stability caused by its lowest relaxation shrinkage and hygral expansion values. From Figure 3, it may be also observed that the fabrics sewn with PES air-jet textured sewing thread (T_2) give higher puckering values than the fabrics sewn with PV air-jet textured sewing thread (T_1). This may be due to higher extensibility of PES air-jet textured sewing thread, compared to PV air-jet textured sewing thread.

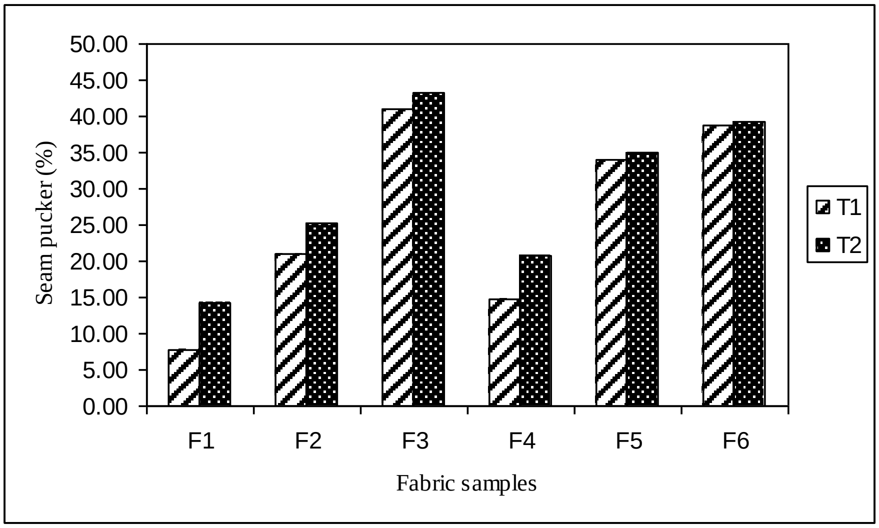
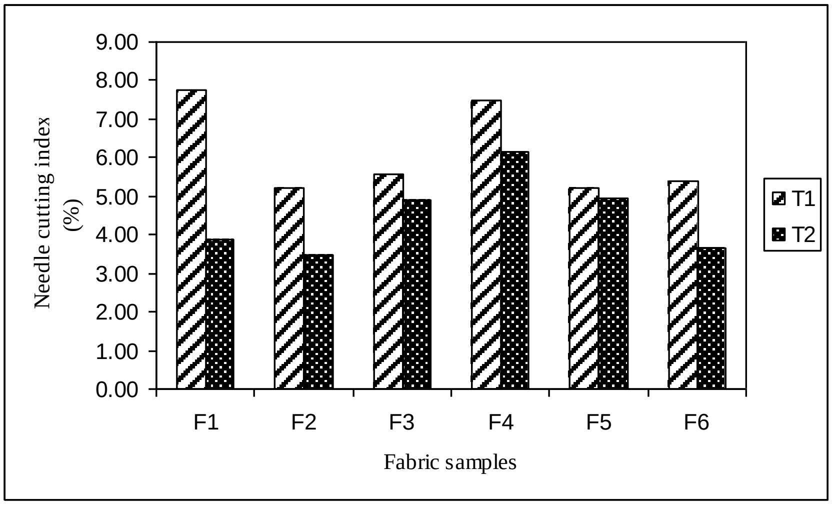


Fig. 3 Seam pucker of fabrics sewn with PV air-jet textured sewing thread (T_1) and PES air-jet textured sewing thread (T_2)

Needle Cutting Index

Needle cutting index in the fabric is objectionable because it may result in reduced seam strength or poor appearance or both due to frayed yarns[10]. The results for needle cutting index (damage of the warp and weft yarns) are shown in Table 6, Table 7 and Table 8. It may be observed in results that the extent of yarn damage during sewing mainly depends on fabric sett, cover factor, weave and surface properties of the sewing thread. High weft yarn damages have been observed in lighter denims. This may be due to lower float length restricts the yarn mobility. Damages along the warp direction are high due to higher warp cover as compared to weft cover. It may be further observed from the Figure 4 that the fabrics sewn with PV air-jet textured sewing thread give higher damages than the fabrics sewn with PES air-jet textured sewing thread. This may be due to low frictional surface of PES air-jet textured sewing thread as compared to PV air-jet textured sewing thread.



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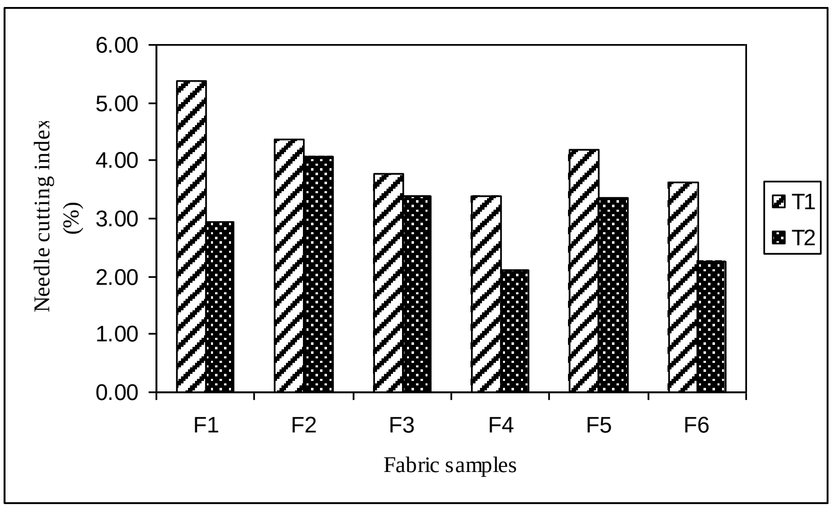

(b)

Fig. 4 Needle cutting index of fabrics sewn with PV air-jet textured sewing thread (T_1) and PES air-jet textured sewing thread (T_2) (a) in warp direction and (b) in weft direction

Conclusions

PES air-jet textured sewing thread gives higher seam efficiency, seam slippage and seam pucker as compared to PV air-jet textured sewing thread. Apart of thread density and fabric thickness, the seam slippage also depends on warp cover and crimp of the fabrics sewn with PV air-jet textured sewing thread. But in case of PES air-jet textured sewing thread, level of seam slippage mainly depends on fabric weight, thread density, and fabric thickness. The difference between sewing thread and fabric extensibility also affects the seam slippage. PV air-jet textured sewing thread gives less seam slippage than PES air-jet textured sewing thread. The value of seam puckering depends on extensibility of both sewing thread and fabric to be sewn. The fabrics sewn with PES air-jet textured sewing thread give higher seam puckering values than the fabrics sewn with PV air-jet textured sewing thread. Needle cutting index increases with increase in fabric cover factor and frictional surface of sewing thread. Fabrics sewn with PV air-jet textured sewing thread give higher damages than the fabrics sewn with PES air-jet textured sewing thread.

Finally, on the basis of these observations it can be concluded that PV air-jet textured sewing thread is more suitable for lighter denim whereas PES air-jet textured sewing thread is suitable for heavier denims.

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