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Research Paper

Properties of stretchable lyocell yarns developed using modified ring spinning frame

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■ **ABSTRACT :** Stretchable fabrics provide a better fitting in addition to unhindered body movement. These stretchable fabrics are usually developed using composite yarns esp. core spun yarns having spandex as core. In the current research, stretchable yarns were developed using spandex and lyocell fibres. Spandex filaments were used as a core and lyocell fibres were used as a covering sheath. Two deniers of spandex were used in order to study the effect of deniers on the properties of yarns. Core spun yarns were developed by modified ring spinning frame at constant drawing ratio *i.e.* 3. Results of the study showed that presence of spandex, as well as change in its deniers, affected yarn count, tenacity, elongation and imperfection. However, breaking force and unevenness of yarns were remain unaffected by the presence of spandex as core in yarns.

■ **KEY WORDS:** Lyocell, Spandex, Ring spinning, Stretchable yarns

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Clothing comfort is judged by different parameters like physiological comfort, sensorial comfort, ergonomic comfort and psychological comfort. Now a days, consumers demands such clothes which provide complete comfort, compellinggarment industries to focus on each and every aspect of clothing like fit, quality, comfort and fashion. Fitting in apparels are achieved by flawless stitching as well as by using stretchable materials/yarns. Stretchability in garments provides not only non-hindered body movement but also deliver proper fitting. Stretchable fab- rics are required to expand comfortably along with body movements and also maintain their original shape after stretching, which is only possible by using spandex fibres/yarns while developing apparels fabrics.

Spandex was developed at DuPont by Joseph Shivers in 1959 as a replacement for relatively heavy rubber threads. Lycra was the computer-generated name chosen for this new product. Spandex fibres, unlike rubber, do not break in the presence of body oils, perspiration, lotions or detergents. First, it was used in foundation garments, soon thereafter, spandex swimwear appeared, followed by stretch ski suits introduced at the 1986 Olympics. Other sports soon adopted the fibre, causing a revolution in sports fashions. Performance given by pop singer Madonna wearing spandex outfit in the 1980s, initiated a trend in street wear fashions (Teegarden, 2004). According to Eichhorn *et al.* (2009), trade names of spandex or elastane are Invista's brand name "Lycra" and "Elaspan". The generic name 'Spandex', is approved by the Federal Trade Commission (FTC), defines a manufactured fibre in which the fibre forming substance is a long-chain synthetic polymer comprised of at least 85% of a segmented polyurethane. (McIntyre, 2005). According to Gupta (2011) in 2010, 84 per cent of spandex were produced by Asia while the rest 16 per cent were produced by America and Europe. China produces 399,000 tons per annum which are accounted for nearly 70 per cent of the total global production of spandex per year. The North America is the major consumer of spandex with a share of 53 per cent, followed by Latin America with 10 per cent, with Europe, China and other countries making up for the rest of spandex consumption. India consumes only 2 per cent of the total consumption. Gupta (2011) stated that Indian spandex usage is growing at 15 per cent per annum as compared to world's expected growth of 7-8 per cent per year. This increase is due to the second highest GDP growth rate and a robust growth in organized retail segment and the branded clothing.Indian direct consumption of bare spandex is around 6,000 tons per annum, all of which is imported, with 37 per cent being consumed by the circular knitting sector, followed by air covered yarns with 27 per cent, 19 per cent from core spun yarns and the rest by narrow fabrics.

Core spun yarns of spandex are developed by using different spinning techniques like modified ring spinning, siro-spinning, air jet spinning, hollow spindle spinning, friction spinning and rotor spinning (Das and Chakraborty, 2013). Yarns developed through these spinning techniques are used in knitting, weavings and nonwovens of fabrics which can be used in various applications. For example, the core spun yarns are used in wide range of woven fabrics like denim, stretch dress materials etc. (Goswami *et al*., 2005). ASTM Method D 123 defines a core spun yarn as "a compound structure in which a filament or strands serves as an axis around which a cover of either loose fibre or yarn is wound." According to end uses, fibres are selected for core and sheath of yarns.

In the current research, core spun yarns were developed from lyocell fibres and spandex filament by using ring spinning frame with lycra attachment (modified ring spinning frame). Ring spinning frame was selected because it is the most commonly used spinning frame with an ability to produce a wide range of yarn counts and also have an advantage of the simple structure and economic production. The principle of ring spinning with lycra attachment (modified ring spinning frame) is shown in Fig. A. In ring spinning frame, strand of roving was fed from the spool through rollers. The function of rollers was to elongate rovings, which then passed to the eyelet and moved down, through the traveler. The traveler moved freely around the stationary ring. Spindle turned bobbin at a constant speed and this turning of the bobbin and movement of the traveler imparts twist to the yarn. Twisted yarns wounds onto the bobbins. However, in order to develop core spun yarns, elastane delivery units were used. The main function of this unit was to impart stretch to elastomeric filament before it entered the spinning unit (Zhang *et al*., 2005). These stretched filaments were feed through the V-groove guide to the front roller of the machine.

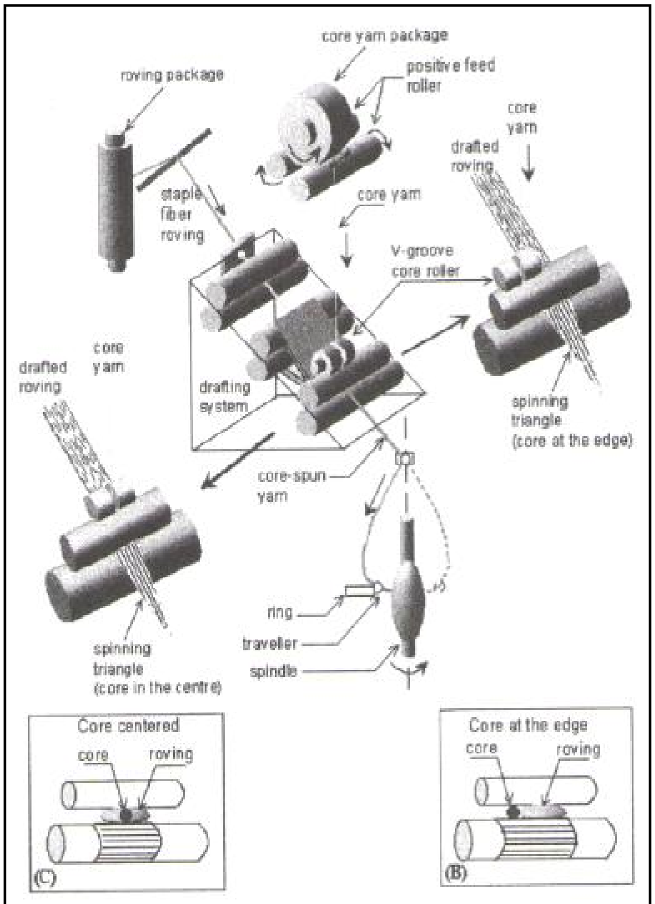

Fig. A : Modified ring spinning system with core attachment
Source: Babaarslan (2001)

■ RESEARCH METHODS

Spandex of different deniers *viz.*, 20 and 40 were selected for studying the effect of deniers on the properties of core spun yarns. Lyocell fibres were used as sheath for covering spandex core. These yarns were made in NITRA, Ghaziabad using "United Ring Frame" having a "Kunal Drafting System". The procedures opted for development of core spun yarns included opening, carding and drawing of lyocell fibres. The slivers obtained from drawing units were subjected to speed frame units to attenuate the slivers, provide small twist in an attenuated rove to impart strength and to wind the rove on a bobbin with uniform tension so that it can be unwounded during spinning without any stretch. Spandex filaments were inserted in yarns using elastane delivery units.

Developed stretchable yarns were tested for various properties as given in Table 1 and compared with pure lyocell yarn. Yarn count of lyocell yarn in Ne was calculated by dividing 64 by weight of lea of 120 yards of yarn. Developed stretchable yarns were measured in their fully stretched condition by placing a known weight at one end of yarn and clipping the other end of yarn to the measuring instrument. Weight was dropped and one meter of yarn was measured and its count was calculated by using mentioned formula. The strength of yarn samples was measured by Uster Tensorapid 4 as directed in IS 1670-98:02 method and elongation was measured as per method in IS 1670-91:02. The unevenness and total imperfection of yarn samples were measured by Premier iQ2. Elastane content of the developed yarns were calculated by using following formula:

$$\text{Core content} = \frac{\text{Denier of elastane / Draft of elastane}}{\text{Core or covered yarn denier}} \times 100$$

SPSS was used as a tool for statistical analysis.

■ RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Yarn count :

It is evident from the Table 1 that count of Lyocell (Ly), CLy_{sp20} and CLy_{sp40} yarns was 40, 26 and 24.89, respectively. CLy_{sp40} yarn showed lowest count which means that it was the coarsest yarn. The presence of spandex, as well as its high percentage as core, is the reason for CLy_{sp40} coarseness. Highly significant difference was found between developed core yarns and their pure yarns at 5 per cent level of significance, confirming variation in yarn count.The results were well supported by Gauri and Goel (2011) who studied the effect of spandex draw ratio on the properties of stretchable silk yarns and fabrics where it was concluded that composite yarns containing spandex as core were coarser than control yarns.

Yarn tenacity, breaking force and elongation :

It can be noticed from the Table 1 thattenacity of Ly, CLy_{sp20} and CLy_{s40} yarns was 2.05 g/den, 1.43g/den and 1.52g/den, respectively. Developed CLy_{sp20} and CLy_{s40} core spun yarns showed lower tenacity than pure lyocell yarn (2.05g/den) which might be due to the presence of core component *i.e.* spandex. Spandex filament has poor tenacity due to its molecular structure as these are regarded as block copolymer having short stiffer section joined to long flexible structure by urethane bond. The stiffer sections are made up of polymeric di-isocyanate molecules which are responsible for strength of the fibre (Negahban, 1993). Xiao and Frisch (1995) mentioned that strength of the spandex filament can be increased by increasing the rigidity and symmetry of di-

Table 1 : Properties of developed core spun yarns

Sr. No.	Yarn properties	Lyocell (Ly)	CLy_{sp20}	CLy_{sp40}	p-value
1.	Yarn count, Ne	40/1	26.0	24.89	0.00
2.	Tenacity, g/den	2.05	1.43	1.52	0.00
3.	Breaking force, g	272	292	326	0.58
4.	Elongation, %	5.90	6.98	7.52	0.00
5.	% of core in yarn	-	3.25	6.30	-
6.	Unevenness (%)	10.66	10.78	11.0	0.82
7.	Total imperfection (per km of yarn)	305.33	193.4	196	0.00

CLy_{sp20} (Sheath: Lyocell fibres, Core: 20D Spandex),
CLy_{sp40} (Sheath: Lyocell fibres, Core: 40D Spandex)

isocyanate molecules but it decreases elasticity of the filament. CLy_{sp20} and CLy_{sp40} also showed difference in tenacity which was may be due to different core content percentage. It can be viewed from results that increase in core content percentage, tenacity of core spun yarn was increased despite having same drawing ratio *i.e.* 3. However, on a contrary Etrati *et al.* (2011) reported that composite yarn samples almost have a higher tenacity value than normal yarns, except at a draw ratio of 3, in which the value of tenacity is the same as the normal yarn value.

Breaking force of developed core yarns *viz.*, Ly, CLy_{sp20} and CLy_{sp40} were found to be 272g, 292g and 326g. ANOVA showed non-significant difference at 5 per cent level of significance which may be due to the use of spandex of different deniers. The results were well supported by the study of Pramanik and Patil (2009) that a lower percentage of filament at the core may not contribute more to the strength of the yarn. However, when the percentage of filament was increased substantially at the core, both strength and elongation jointly led to higher energy to break.

Elongation percentage of Ly, CLy_{sp20} and CLy_{sp40} was 5.09, 6.98 and 7.52, respectively. Core spun yarns exhibited higher percentage of elongation than their respective pure yarns due to the use of core having good elongation property. The difference in elongation percentage of CLy_{sp20} and CLy_{sp40} was due to the difference in denier of spandex and their core content. This can be supported by the existence of significance difference between elongation of pure and developed core spun yarns as observed from the ANOVA at 5 per cent level of significance. According to Das and Chakraborty (2013), the core spun yarn can be extended to the point where nonelastic sheath portion of the yarn is stretched to its limit, thus resisting the further extension of the core-spun yarn.

It can be observed from the above results that tenacity and elongation were basically dependent upon the properties of core yarn/filament used in the development of yarn. The same was stated by Alagirusamy and Das (2008) that core spun yarn has the strength and elongation of the central component and other characteristics are influenced by surface staple fibres.

Core content :

The core content of CLy_{sp20} and CLy_{sp40} was found to be 3.25% and 6.30% as given in Table 1. The difference in core content was the result of different deniers of spandex used in the study as CLy_{sp20} had 20D spandex whereas CLy_{sp40} had 40D spandex. It can be concluded from the result that despite same drawing ratio, core content of core spun yarns changes *i.e.* by increasing the denier of spandex core content in an elastomeric yarn increases. Alagirusamy and Das (2008) has also stated that the properties of yarns can be changed by changing core filament denier and developed yarn count.

Yarn unevenness and total imperfection :

It is apparent from the Table 1 that unevenness of Ly, CLy_{sp20} and CLy_{sp40} yarns was 10.66%, 10.78% and 11%, respectively. The total imperfection of CLy_{sp20} and CLy_{sp40} was 193.6 and 196 (per km of yarn) which was much less than total imperfection of pure lyocell yarn 305.3. Pure lyocell yarn (Ly), CLy_{sp20} and CLy_{sp40} yarns showed no significant difference between their unevenness however high significant difference was showed in terms of total imperfection. A decrease in imperfection was mainly due to decrease in the count of developed yarns. The results were supported by the conclusion reported in the study conducted by Pramanik and Patil (2009) that when the percentage of filaments was increased at the core it was observed that imperfection values were reduced in ring-spun core yarns According to Sheikh (1994) yarn irregularity was a measure of cross-sectional variation in the yarn and closely associated with imperfections in the yarn. Alagirusamy and Das (2008) stated that in order to improve irregularity of core spun yarns, core content in yarns should be increased.

Conclusion :

It can be concluded from the results that presence of spandex as core had significant effect on the properties of yarns *viz.*, count, tenacity, elongation and total imperfection. Increased in denier of spandex resulted in decreased imperfection and count, and increased elongation and tenacity of yarns. The core content of spandex was found to be increased with increase in spandex denier, without altering drawing ratio. Thus, it can be said that lyocell elastomeric core spun yarns were different from normal lyocell ring spun yarns which can be used in development of stretchable fabrics.

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