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EFFECT OF SPANDEX DENIER ON STRUCTURAL PROPERTIES OF SINGLE JERSEY KNITTED FABRIC

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ABSTRACT
Spandex is an elastomeric manufactured fiber and amalgamation of it effects various properties of yarn and fabric. In the present study,single jersey knit fabrics were developed using cover spun yarns of lyocell and spandex. Cover spun yarns were developed using 20D and 40D spandex filament placed in the core of the yarn whereas lyocell yarn was used as the sheath. The aim of the study is to determine theeffect of spandex count on structural properties of single jersey knit fabric. The investigation showed that manifestation and change in denier of spandex effects the tested properties of the developed fabrics. Statistical analysis also showed that results were significant for fabric weight, fabric thickness, wales per inch, courses per inch and stitch density

KEYWORDS: Lyocell, Spandex, yarn linear density,cover spun yarn.

I. INTRODUCTION
The generic name 'spandex' as defined by FTC is "A manufactured fiber in which fiber forming substance is a long chain synthetic polymer comprised of at least 85% of a segmented polyurethane" (**Spandex Fiber, 2015**). Asia is a major production centre of spandex with 84% of the total, followed by America and Europe. So far as major consumers are concerned, North America consumes leads the tally with 53 percent of the total. In 2010, India consumed only 2 percent of global spandex but has been growing at the rate of 15% per annum in contrast to the world's average growth of 7-8 percent per year. This rapid increase isIndian context is due to itssecond highest GDP growth rateand a healthy growth in organized retail segment and branded clothing**Gupta (2011)**.

The name "spandex" is the anagram of the word expands (**Kadolph, 2009**). Chemically, spandex is synthetic linear macromolecule with a long chain containing alternating hard and soft segments linked by [– NH – CO – O –] urethane bonds. The soft structure is of polyurethane block copolymer which delivers elasticity to fibre, while hard chain segment contributes molecular interaction force to fibre which confirms fibre strength and long term stability (**Bardhan&Sule, 2004**).

Spandex is known for its exceptional elasticity and replaces natural rubber as it can withstand body oils, sweat, soaps and detergents. Spandex has better mechanical and physical properties than rubber fibre in terms ofantiaging, linear density, dye ability and tenacity (Spandex is about 5 to 9.5cN/tex compared to 2.2 cN/tex for natural rubber). It possess very low moisture regain (1 to 13%). The breaking elongation of Spandexranges between 450%-700% depending upon denier and type of Spandex fibre. The thermal behaviour of Spandex at low temperature is governed by the soft segments while at high temperatureit depends on the molecular weight, the type of chain extension and orientation of the hard segment. At temperature above 170°C, a noticeable thermal degradation of the fibre is observed**(Goswami, 2005).**Spandex was first developed at Dupont by Joseph Shivers in 1959 and first appeared in 1986 Olympics as swim wear and stretch ski suits. The singer Madona plays an important role in popularizing the use of spandex in high street fashion by wearing its outfit **(Teegarden, 2004).**The bare spandex filaments are used in stretch fabrics, foundation garments, swimwears and hosiery. The stretchable yarns are produced by core sheath method using different spinning techniques like modified ring spinning, siro spinning, air jet spinning, hollow spindle spinning, friction spinning and rotor spinning. **(Das &Chakraborty, 2013).** Yarns developed through these spinning techniques are used in knitting, weaving and nonwovens of fabrics (**Goswami*et al*., 2005**).Spandex filaments are compatible with different fibers like cotton, bamboo, viscose, wool, silk, polyester, etc.

Different studies have been conducted to developed knit fabrics from yarns consistingnatural, regenerated or manufactured fibers as sheath,havingspandex ascore.**Mona (2013)** studied the physical and mechanical properties of cotton and spandex single jersey fabric and concluded that percentage of spandex in a fabric played an important role in determining the dimensional stability and air permeability.Bursting strength, crease recovery and pilling resistance were also affected by the same. **Duenser(2003)** explored an alternative way to plating techniques by the use of core spun yarn having spandex as core in the circular knitting machine.**Gokarneshan and Thangamani(2013)**investigated themechanical properties of core and plated cotton/spandex, polyester/spandex and viscose/spandex blended knits. It was concluded that core and plated knits shows different nature towards fabric geometry and mechanical properties.**Abdessalem***et al.***(2009)** studied the influence of elastane consumption on characteristics of plated plain knit fabrics and reported that the fabric width, weight and elasticity were affected by the presence of spandex.

In the present investigation,effect of linear mass density ofspandex on structural properties of knit fabrics were studied with the constant parameters viz. machine settings and yarn components.With this aim, plain knit/single jersey fabrics were prepared with cover spun yarns having spandex filament as core and lyocell yarn as sheath.

II. MATERIALS AND METHODS

A. Preparation of fabric samples

Two fabricsamples were prepared with 20D/22dtex spandex lyocell cover yarn and 40D/44 dtex spandex lyocellcover yarn. Cover spun yarns were developed using hollow spindle spinning frame. For control sample,lyocell fabric was made using pure lyocell yarn. Properties of lyocell yarnand cover spun yarns are given in Table 1.Circular knitmachine specifications are provided in Table 2.

Table 1: Properties of yarns

S.No.	Yarn Properties	Lyocell yarn	Lyocell/22dtex Spandex	Lyocell/44dtex Spandex
1	Yarn count, Ne	40	38.51	31.63
2	Twist per inch	22.0	11.43	12.10
3	Tenacity, g/den	2.05	1.55	1.54
4	Breaking force, g	272	214	260
5	Elongation, %	5.90	7.07	8.02
6	% of spandex	-	4.8	7.9

Table 2: Knitting Machine Parameters

S.No.	Parameters	Knitting Machine
1.	Type	Single Jersey circular knitting machine
2.	Make	Indian
3.	Feeders	2
4.	Gauze	6 needle per inch
5.	Diameter	4 inch
6.	Total needle count	120
7.	Knitting speed	80rpm

B. Testing of the prepared samples

1. *Fabric weight:* The weight of single jersey knit fabric samples were tested according to the IS: 1964 (2001). Samples (10cm X 10cm) were cut and their corresponding weight were noted down. Following formula were used to calculate the weight of the sample:

$$\text{Mass per unit area, (g/m}^2) = M \times 10^4 / A \times B$$

Where:
M = weight of measured fabric
A = 10cm (length)
B = 10cm (width)

2. *Fabric thickness:* Fabric thickness was measured using fabric thickness tester of Paramount Instrument Pvt. Ltd., according to the specifications of IS: 7702 (2012).Average value from 10 readings was calculated.

3. *Wales and Coursesper inch:* Wales/inch (WPI) and courses/inch (CPI) of the prepared sample were determined using ASTM D-3887. A square inch was marked on fabric sample and with the help of pick glass, wales and courses were counted. Average value from 10 readings was calculated.

4. *Determination of stitch density***:** Stitch Density (SD) refers to the total no. of loops in a measured area of fabric. According to **Khalil (2014),**stitch density was determined by multiplying the number of courses by the number of wales i.e.

$$SD = WPI \times CPI$$

5. *Loop length/Stitch length*: Loop length was derived by counting no. of wales in a measured area followed by revealing 10 course yarns. Average length of the stretched courseyarns was calculated divided by no. of wales.

$$SL = X/Y$$

Where:
 X = avg. length of the yarn
Y= no. of wales

6. *Statistical analysis:* SPSS software was used to analyse significant difference betweendeveloped fabrics.

III.   RESULTS AND DISCUSSIONS
Abbreviation: S1= 100% Lyocell knitted fabric, S2= 22dtexLyocellspandex knitted fabric, S3= 44dtex Lyocellspandex knitted fabric.

A.   Fabric weight and thickness
It can be seen from Fig.1that fabric weight and the count of spandex are directly related to each other. The control sample S1 had least fabric weight due to the absence of spandex whereas S3 showedhighest weight. The significant difference was due to increase in denseness of fabric as the count and percentage of spandex was increased. The same result was obtained with thickness i.e. as the spandex content increased fabric thickness was also increased (Fig. 1). The results were supported by the findings of **Mona (2013),** i.e. increased in spandex percentage increased the fabric weight, because greater the amount of spandexmore dense the fabric.
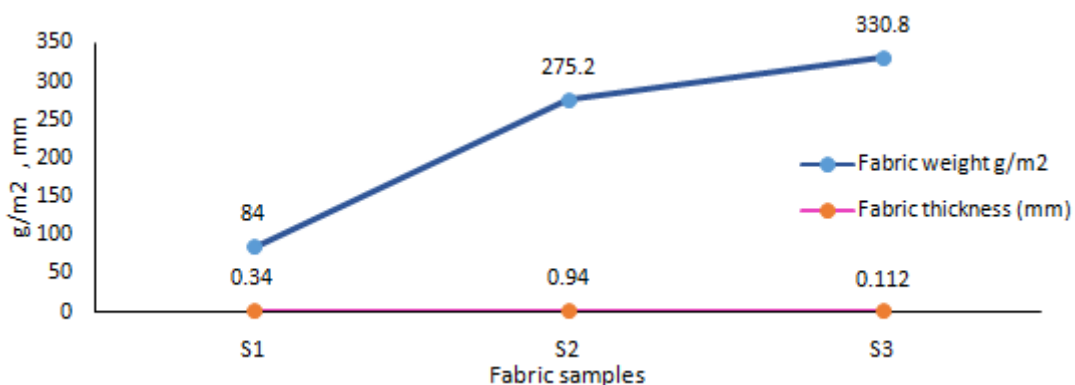

Fig.1: Effect of Spandex Count on Fabric weight and thickness

As fabric thickness and fabric weight are positively correlated (r = 0.99), the effect on fabric weight affects the fabric thickness.

B.   Wales, courses and stitch density
It can be observed from the Fig. 2 and Fig. 3 that wales density, courses density and stitch density showed increasing trend with increased in the count of spandex from 22dtex to 44dtex. It may be ascribed to the fact that

spandex made fabric dense and with an increased count, compactness of the fabric is increased. The upsurge in wales density and courses density effected the stitch density of the fabric as it is the product of these two.
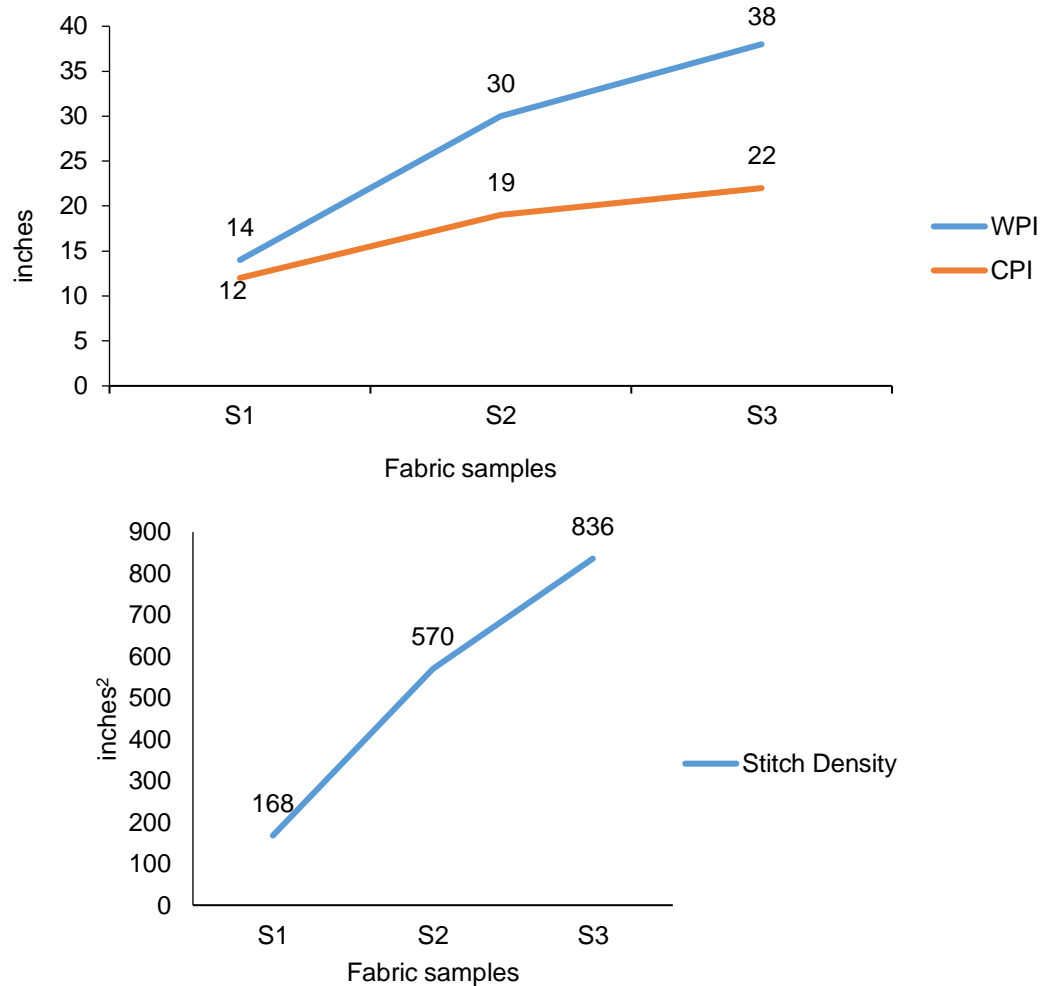

Fig 3: Effect of Spandex count on Stitch Density

Change in linear density of spandex enhanced wales density to 65% and courses density to 45%. The same results were reported by **Senthilkumar et al. (2012),** the linear density of spandex effected the geometrical properties of the fabric. It was concluded that when spandex denier increases the wales and courses density also increases. Result of ANOVA also confirmed that there was significant effect of spandex count on wales density, courses density and stitch density (Table 3).

C. Loop length

It is evident from the Fig. 4 that loop length of pure lyocell fabric is longer as compared to spandexlyocellfabrics. It may be due to the stretch ability of spandex during production of fabric whichshrinkedback when relaxed. However, the amount of yarn stretch remained unchanged during fabric production hence the loop length of both the fabric S2 and S3 were same. The outcomes were supported by**Marmarali (2003)**that loop length values remained nearly the same as the amount of spandex was increased resulting in decrease in spaces between wales and courses. The statistical analysis (ANOVA) proved that denier of spandex had significant influence on loop lengthat 5 per cent level of significance (Table 3).
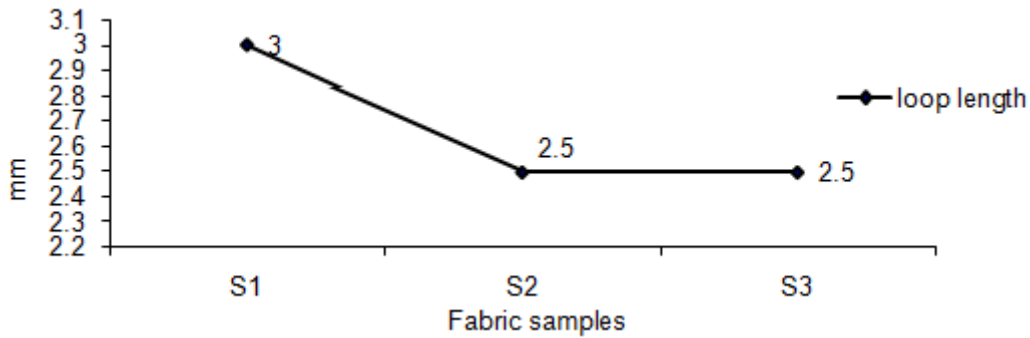

Fig 4: Effect of Spandex on Loop Length

Table 3: Statistical Comparison

Process variable	Fabric Wt. (g/m^2)		Fabric Thickness (mm)		WPI		CPI		SD	
	F value	P value	F value	P value	F value	P value	F value	P value	F value	P value
Spandex count	29771	.000*	1823	000*	3761	.000*	658	.000*	4810	.000*

***significant for α = 0.05**
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IV.   CONCLUSION

The structural properties of single jersey knit fabrics developed from pure lyocell yarn and cover spun yarns of lyocell and spandex with 20D/22dtex and 40D/44dtex were investigated. It was observed that all three samples showed difference in the values of WPI, CPI and SD as they were significantly affected by the presence and denier of spandex. An increased in denier of spandex increasedthe weight and thickness of fabrics. The loop length of knit fabrics were found to be decreased when spandex yarns were used but no difference was noted with the change in denier of spandex.

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