Investigation on Dimensional Properties of Eri Silk Single Jersey Fabrics

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Abstract - Fabric dimensional stability is one of the important criteria for the both manufacturers and consumers, as unusual dimensional changes affects the size, fit and garment style. The derivation of optimum process parameters would support the knitter, dyer and finisher to achieve the low residual shrinkage, and desired fabric areal density. Influence of knitting process parameters on course, wales, stitch density and areal density have been evaluated at three different relaxations states. The results show that the knitting process parameters have significant effect on the fabric dimensional properties.

Keywords: Areal density, Course, dimensional stability, Eri silk, single jersey, wales

I. INTRODUCTION

Dimensional stability is one of the important criteria for both manufacturers and consumers, as unusual dimensional changes affect the size, fit and garment style. Dimensional stability of knitted fabrics is very much influenced by material characteristics, loop length, yarn count and progressive relaxation treatments. The derivation of optimum process parameters to achieve the low residual shrinkage and desired fabric areal density, could result in savings of time and costs for new product development [1, 2]. The dimensional properties will vary for different fibre types. Sharma *et al.* (1984) investigated the dimensional stability of acrylic plain weft-knitted fabrics at subsequent relaxation states, concluded that at fully relaxed state the fabric structure was observed to be a reasonably determinate structure. Sakthivel J C & Anbumani N (2012) dealt on the dimensional properties of viscose, modal and lyocell single jersey knitted fabrics and find that the single jersey knit fabrics made up of lyocell fibres showed better dimensional properties than viscose and modal fabrics. Ramasamy et al. (2018) investigated the dimensional properties of single jersey fabrics made up of cotton/tencel of different blend ratio with three different tightness levels. Researchers found that the fibre contribution to the fabric shrinkage and mass was very less compared to the stitch length and relaxation treatments. Van Amber et al. (2010) considered the effect of laundering and water temperature on the dimensional properties of mulberry silk single jersey fabrics, conclude that the silk and silk-blend knit fabric attains dimensional stable state at sixth laundering cycle.

Eri silk is a valuable wild fibre available widely in northeastern part of India. Eri silk fabrics shows better thermal insulation value, moisture management properties (Basu 2015, Senthil kumar & Ramchandran 2018) and lower drape coefficient and weight loss during abrasion than merino wool fabrics. **(Kumar De subir & Mitra ashis 2013).** The interest among the manufacturers for utilization of machine spun eri silk yarn in the knitted fabrics is increasing in the market. Through this work an attempt has been made to optimize the knitting process parameters to achieve the low residual shrinkage and desired fabric areal density for development of eri silk knit fabric structure. A suitable stitch length range is recommended for the given count of yarn for commercial fabric production.

II. MATERIALS AND METHODS

In this research work, eri silk yarn of three different count 25.00 tex (2/80sNm), 17.78 tex (2/120sNm), and 14.26 tex (2/140sNm) was knitted on a multi-track circular knitting machine with dia. 24" and gauge 24 at three different fabric forms are: Tight -16 ± 0.2; Medium-14.5 ± 0.2; and slack 13.2 ± 0.2. Fabric loop were set according to the tightness factor by adjusting the quality assurance pulley in the knitting machines. After that, the dimensional and geometric properties of developed samples were studied at subsequent dry, wet and fully relaxation treatments to find their suitability for mass production. At each state, dimensional parameters like course density (Cd), and wale density (Wd) have been measured according to ASTM D 3887 testing standards. Dry Relaxation State: Samples were

 DOI : 10.35291/2454-9150.2020.0054

ISSN : 2454-9150 Vol-05, Issue-11, Feb 2020

kept for 24 hours on a flat surface in a conditioning room with tension free State. Wet Relaxation State: Samples were immersed in water at a temperature of 35°C and allowed to relax for 6 hours. After hydro-extraction, samples dried and evaluated.

Fully Relaxation State: To attain the fabric fully relaxed state, the six laundering cycle was carried out based on the previous experiment of results of Amber et al (2010). The wet relaxed knitted samples were washed in normal water at a room temperature of 35^{0}C for 20 minutes, and subjected to hydro extraction for 3 minutes and then dried in a flat surface until completely dry. The laundering cycle of washing, hydro extraction and flat drying were repeated for six times for all the twenty seven samples.

III. RESULTS AND DISCUSSION

Influence of Yarn Count, Loop Length and relaxation on Course and Wale Density

Table 1 shows the influence of knitting process parameters such as loop length, yarn count on the dimensional properties of eri silk knit fabric structures such as course density, Wale density, and stitch density (Sd). From the table, it is clearly understood that the dimensional behaviour of eri silk knit fabrics is in accordance with the standard knit fabric dimensional behaviour. Loop length is a prime factor influencing the dimensional parameters of eri silk single knit fabrics. The gradual increase in course density, wales and stitch density is observed by the decrease in loop length as well as the reduction in yarn linear density. The decrease in loop length reduces the loop size and thereby accommodating more courses per square unit area.

The plot (Figure 1) loop length against the reciprocal of course density (Cd) in) dry, wet and fully relaxed states shows, that the course density increases significantly with the decrease in loop length and progression of relaxation treatments. In every state of relaxation the eri silk fabric sample knitted with a tighter loop length showed a higher course density value and vice-versa. The course density values of fabric samples had a maximum increase in course density of 14.95% in dry to wet relaxation state, 7.20 in wet to fully relaxed state. This result is due to major dimensional changes of hydrophilic fibre fabrics are expected to occur with the first wet treatment.

Table 1 Dimensional properties of eri silk single jersey fabric

State	Particulars	25 Tex			16.68 Tex			14.26 Tex		
		T	M	S	T	M	S	T	M	S
Fabric parameters	Fabric Form	T	M	S	T	M	S	T	M	S
	Set loop length (cm)	0.290	0.315	0.340	0.260	0.285	0.310	0.240	0.265	0.290
	LL (cm)	0.282	0.310	0.335	0.252	0.295	0.324	0.248	0.262	0.290
	1/LL (cm)	3.68	3.23	2.99	3.97	3.39	3.09	4.03	3.82	3.45
DRS	Courses/cm	18.90	16.54	14.17	21.05	18.11	15.60	20.82	18.90	17.32
	Wales/ cm	13.04	12.22	11.20	13.62	12.28	11.90	14.30	13.52	12.52
	SD /cm^2	248.35	210.33	164.41	290.91	240.50	199.68	310.22	266.87	232.61
WRS	Courses/cm	22.17	18.90	16.54	23.47	19.96	17.72	25.04	22.12	19.69
	Wales/ cm	14.26	13.04	12.12	15.24	13.82	12.97	15.89	15.12	13.98
	SD /cm^2	316.14	246.46	200.41	357.68	275.85	229.83	397.89	334.45	275.20
FRS	Courses/cm	24.54	21.21	19.21	25.60	22.09	20.06	26.94	25.38	22.52
	Wales/ cm	15.32	13.44	12.80	16.30	14.30	13.30	16.76	16.10	14.60
	SD/cm^2	375.95	284.99	245.89	417.28	315.89	266.80	451.54	408.62	328.79

((T-Tight, M-Medium, S-Slack)

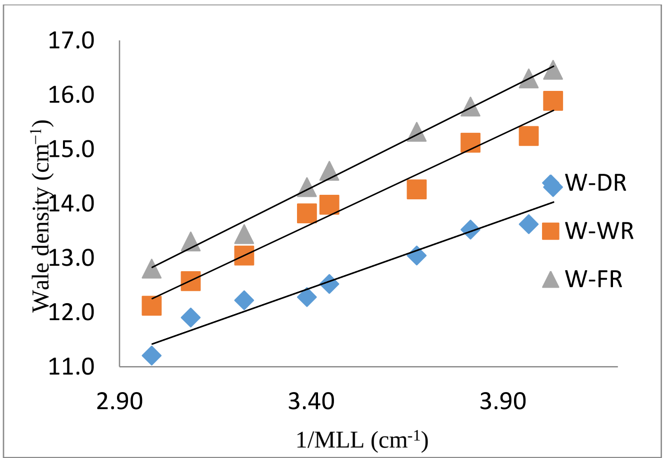

Figure 1. Influence of loop length on course density

From the Plot (Figure 2), it is observed that the wales density is linearly related to the reciprocal of loop length in different stages of relaxation. However, the effect of loop length on wale density is minimal when comparing with course density. The wale density values are low for all eri silk knit fabric samples at dry state, increase to the extent 5% during wet relaxation state and reached saturation uniformly for all the silk fabric samples at fully relaxed state. From the above two plots, it is observed that the course density than wales density curves are steep in nature. This due to the effect of loop length on course density is more significant than wales density.

Stitch density variations of eri silk knit fabric with the inverse of loop length^2 (MLL^2) is shown in Figure 3. The stitch density linearly increases with the decrease in MLL and the progression of relaxation treatments. The increase in stitch density clearly indicates the consolidation of the loop structures occurred during progression of relaxation treatments. While decreasing 10% of loop length, increment

 DOI : 10.35291/2454-9150.2020.0054

in stitch density noticed 29% (25.00 Tex), 35% (16.67Tex), and 39% (14.26 Tex), has been observed.

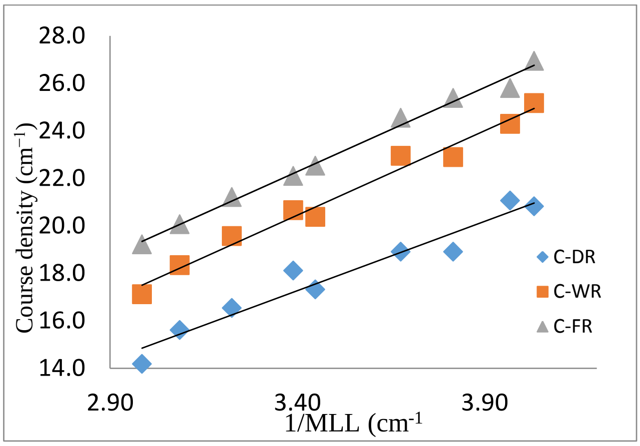

Figure 2. Influence of loop length on wales density

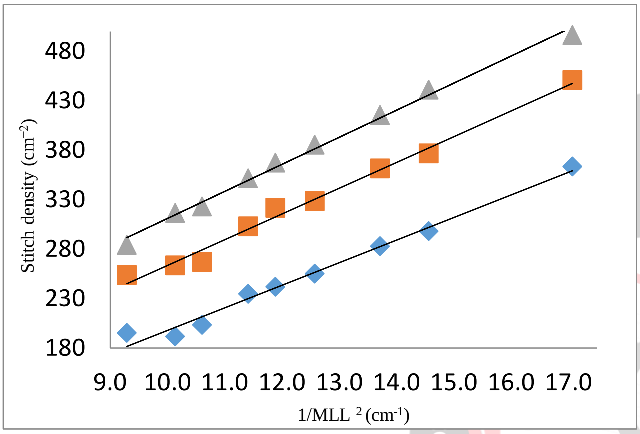

Figure 3. Influence of loop length on stitch density

Influence of Yarn Count, Loop Length and relaxation on Fabric areal density (GSM)

Fabric areal density (Grams per square meter) of eri knit fabrics influenced by the process variables such as yarn linear density, stitch length and relaxation treatment. The results shown in table 2 confirms the findings by C.D. Kane (2007), stated that GSM decreased when the stitch length increased/ yarn count decreased. The increase in tightness factor by the cause of decrease in loop length or increase in yarn linear density, leads to accommodate more loops per unit area, thereby increases the areal density of the knitted fabrics. The growth of areal density is observed to be higher from dry relax to wet relax states, ranges from 23 to 25% than wet to fully relaxed state ranges from 10 to12%. This indicates that the greater part of potential shrinkage is released at the wet relaxation stage in all eri silk knit fabric samples.

Yarn Count	LL	Fabric areal density (g/m^2)		
		DRS	WRS	FRS
25.00 Tex	0.290	171.0	215.0	252.0
	0.315	158.0	190.0	226.0
	0.340	139.0	174.0	200.0
16.68 Tex	0.260	126.0	155.0	185.0
	0.285	112.0	144.0	160.0
	0.310	104.0	130.0	147.0
14.26 Tex	0.240	117.0	141.0	160.0
	0.265	110.0	125.2	148.0
	0.290	100.0	116.0	132.0

Table 2 Dimensional properties of eri silk single jersey fabric

Dimensional stability of the samples after repeated washing cycle

It is observed from the table 3 that the maximum fabric area shrinkage occurs at first and second wash cycles of eri silk knit fabrics. This indicates that the fabric releases its maximum potential energy in the first and second wash itself and fabric attains low energy state level. It is also noticed that the eri silk knit fabric with slack structural fabrics have higher area shrinkage in all the three yarn counts. These slack structural fabric forms dimensionally tend to shrink or expand on length and widthwise directions alternatively in successive wash treatments. These dimensional changes are beyond ±5% and higher area shrinkage of ±2.5% and above. These fabrics do not attain a dimensionally stable state even after repeated wash treatments. This is due to the reduced frictional forces at the knit loop interlocking point cause to free movement of loops during washing treatments.

 DOI : 10.35291/2454-9150.2020.0054

ISSN : 2454-9150 Vol-05, Issue-11, Feb 2020

Structural form	Wash I			Wash II			Wash III			Wash IV			Wash V		
	L	W	A	L	W	A	L	W	A	L	W	A	L	W	A
25 T	-8.0	-6.0	-13.5	-3.0	0.4	-4.2	-2.4	2.0	-0.45	2.0	-3.0	-1.1	-2.0	1.6	-0.4
25 M	-9.0	-5.6	-14.1	-4.0	2.0	-4.7	-3.0	3.0	-0.09	3.0	-2.0	0.9	-3.0	4.0	0.9
25 S	-10.0	-6.0	-15.4	-6.0	4.0	-5.9	-5.6	2.4	-3.33	7.0	-4.0	2.7	-2.0	6.0	3.9
16 T	-9.0	-5.4	-13.9	-5.6	0.4	-5.2	-4.0	5.0	0.80	3.2	-2.0	1.1	1.0	-2.0	-1.0
16 M	-10.0	-6.0	-15.4	-4.0	-2.0	-5.9	-5.0	4.0	-1.20	5.0	-3.0	1.9	2.0	-3.0	-1.1
16 S	-11.0	-6.0	-16.3	-5.0	-2.0	-6.9	-6.0	7.0	-2.80	6.0	-4.0	1.8	-1.0	7.0	5.9
14 T	-10.0	-6.0	-15.4	-4.0	-1.0	-5.0	-1.0	3.0	0.98	2.0	2.0	4.0	-5.0	2.0	-3.1
14 M	-12.0	-6.0	-17.2	-5.0	2.0	-6.0	-2.0	2.0	0.94	5.0	-4.0	0.8	-4.0	-4.0	-7.8
14 S	-13.0	-7.0	-19.0	-7.0	-1.0	-6.9	-7.0	5.0	-2.35	7.0	-4.0	2.7	-2.0	6.0	3.9

Table 3 ; Dimensional stability of Eri silk knit fabrics (T-Tight, M-Medium, S-Slack)

Whereas, the fabrics produced with lower, medium loop lengths (tight structural fabric form) attain jammed condition in one or two washes, which is confirmed by the changes in dimensional measurements, less than ± 2.5% and area shrinkage of less than 1.0%. It is also interesting to note that the extent of the area shrinkage of single jersey fabrics made up of finer yarn (14.2Tex) is 3-4% more than the fabrics made up of coarser yarn (25.00Tex). The similar trend was observed with other two structures of single pique and honeycomb also. This is due to fabric open structure caused by lower ratio of yarn diameter to loop length, which cause distortion of loop during washing treatments.

IV. CONCLUSION

Eri silk knit fabrics dimensional properties such as wales density and course density are increased with the decrease in loop length of knit fabrics as well as progression of relaxation treatments in all the developed knit samples. Decreasing 10% of loop length, increment in stitch density noticed 29% (25.00 Tex), 35% (16.67Tex), and 39% (14.26 Tex), has been observed. The yarn linear density, loop length and type of relaxation highly influence the areal density of eri silk knitted fabrics. Based on the dimensional changes in the fabric length and widthwise directions, eri silk slack structural fabrics can be classified as ‘Poor dimensional stable fabric’, which will affect ease of body movement.

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 DOI : 10.35291/2454-9150.2020.0054