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EFFECTS OF TENSION VARIATIONS OF INDIVIDUAL YARNS ON QUALITY OF WARP KNITTED FABRICS

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ABSTRACT

Yarns of warp beams to knit on warp knitting machines need to be wound at equal tensions. The tension variations lead to produce valleys and ridges of warp yarns on the beam and hence different lengths of individual warp yarns. These length variations lead to loop length variations in warp knitted fabrics and may cause defects along the wales. This research aimed at investigating the warp length variations caused by tension variations and its effect on the quality of the fabrics knitted. Tension variations of individual warp yarns on warp beams for warp knitting were examined. 16% of warp yarns were outside the permissible tension range in practical environment. The length measurements of 1128 individual yarns of a warp beam show that 0-1.7% length variations exist among the yarns. The fabrics knitted at different tension values ranging from 4cN to 20cN show 6.6% increase in wale density. Although the fabric weight variation is below 5%, the microscopic view of the fabrics shows significant change in the size of loops and rupture of filaments. This has caused visual colour difference in the fabric.

KEYWORDS: locknit, run-in, warping, warp knitting, yarn tension

I. INTRODUCTION

In warp knitting and weaving, one of the main yarn preparatory process is winding the yarns on to a beam. The number of beams used on a weaving machine in general is one, whereas in warp knitting, yarns are wound on few beam sections and used as one beam on the machine [1]. Thus the quality of winding for warp knitting should be same in each beam section and between beam sections. When the yarns are delivered through few guide bars, each guide bar is supplied yarns with a separate set of warp beams [1] and the tension of the yarns in each guide bar should be the same. A tricot machine may use 1-4 warp sets/guide bars in general to produce warp knitted fabrics. The delivery of yarn from each beam is individually controlled to deliver yarns at different rates as required. The amount of yarn delivered is measured/set by a parameter termed as 'run-in'; which indicates the length of yarn delivered to the machine to produce 480 courses [2]. The delivering of yarns to needles of a warp knitting machine is the most important factor to manufacture a quality knitted fabric. Thus the yarns delivered by each warp beam/guide bar should be uniform in tension and the relaxed length. However, the length of yarns wound on a warp beam may vary according to the tension on the yarn. The tension of the yarns wound on warp beams may vary due to various reasons. Researchers have investigated the parameters that affect the warping process and the warp knitting process. The length of the yarns wound at higher tensions may be shorter in the fully relaxed fabric and vice versa.

The quality of warp knitted fabrics is directly related to the quality of warping the yarns onto warp beams. The quality of warping depends on various factors and most of them affect to change the tension of individual warp yarns and thus yarns of different tensions are wound on the beam. The quality differences of yarns itself due to varying conditions of texturing and the fibre extrusion process of synthetic yarns, the distance between the individual yarn cones to the warping machine, the size of the individual packages are main factors to change the warping tension [3]. Based on the experience of Havas and Lazar [3], the yarn tension variations of 20mN-30mN do not cause significant change to the quality of warping. The individual yarn tension variations beyond this limit may cause different yarn shrinkages and dye take-up. The difference in the size of yarn packages has shown significant change in the tension variations and the significance can be reduced by positioning the yarn

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packages of smaller diameter closer to the warping machine [3]. However, positioning the yarn cones based on the diameter is practically a difficult task. The problem of yarn tension variations is further become complicated in warp knitting compared to weaving due to the use of 2-6 sectional warp beams to supply yarns to one guide bar. This further becomes complicated when two or more guide bars supply yarns for similar guide bar movements. If yarn tension of several yarns close to each other is same but different to the band of yarns next to this set of yarns, the fabric may appear to have strips along the length.

Employing sufficient tension to the warp yarn in essential for good warping. The increased warp yarn tension may cause fabric deformation and the over stress of yarns may cause permanent change to the internal structure of the fibre [4]. The short yarn lengths cause the stitches produced to be shorter and thus the luster of the fabric to decline [5,6]. If there are tension variations of the individual yarns across the beam, there will be tension valleys and ridges. When these warp yarns are unwound for weaving or warp knitting, some of the ends will be tighter due to short lengths and some of them will be slack due to excessive yarn lengths [7]. Further, in addition to the yarn tension variations during warping, the fluctuations of yarn tension due to yarn oscillation in the loop forming cycle may affect the quality of the fabric formed [8]. During knitting, some of the yarns are unwound from the warp beams to have zero tension due to very low tensions and hence excessive yarn lengths in the warp beam. When the yarn tension goes below zero, there is no control of the yarn during loop formation and there is a risk of not lapping the yarn on the needle causing defects in the fabric [8]. The yarn tension is increased for increased length of underlaps and the length of the stitch too has an effect on yarn tension variations [9].

II. MATERIALS AND METHODS

Materials used

The structure used in the experiments is the locknit structure, where two sets of yarns are used; 44 denier nylon yarns and 44 dtex lycra yarn. The run-in of the two yarns are 1325 mm for nylon and 550 mm for lycra. The width of the fabric knitted is 130cm and knitted on 36 gauge tricot warp knitting machine.

Experiment 01- Yarn Tension Variations in Warping for Warp Knitting

In order to study the tension variations during warping, the tensions of 150 individual warp yarns were measured. The 150 yarns were selected to represent all the distances of the yarn cones in the creel from the warping machine. Thus 50 yarns in the middle of the beam 50 from left and right edges of the warp sheet were selected randomly.

In practice, the allowable range of tension values in winding varies according to the type of yarn and the count of the yarn, which for nylon - 44 denier yarn is 6.5 - 9.5 cN. This is a practically established value that would expect to cause only acceptable loop length change in a warp knitted fabric. As shown in the Table 1, out of the tensions of 150 yarns, the warping tensions of 24 yarns lie outside the acceptable warp tension limits. Thus 16% of yarns are outside the acceptable limits. The 9.3% yarns with the tension value below the acceptable range are longer than the acceptable warp length and those may cause noticeable loop length increases. The 6.7% yarns wound at higher tension produce warp knitted loops shorter than the accepted. Thus 16% yarns will cause long and short stitches than the accepted loop length as shown in Table 1.

The Experiment 02 is designed to capture the variations of the lengths of individual warp yarns in a warp beam.

Experiment 02 – Measurement of Lengths of Individual Warp Yarns

A 12 meter length of the relaxed warp yarn sheet is selected to measure the lengths of individual warp yarns, which are wound on a warp beam under normal practical setup. A weight of 30g, which was practically selected to avoid sagging of the warp yarns is hung at one end of the yarn. The total number of yarn used in the experiment is 1128. The lengths of yarns in excess to the length of warp sheet (12m) are tabulated in suitable ranges as shown in the Table 2. The yarns used are 44 dtex nylon and the warping speed was 700m/min.

The lengths of yarns in the warp sheet are normally distributed with a mean of 1226.4cm and standard deviation of 3.34. The shortest yarn in the sheet is 9.4 cm (0.8%) shorter than the average and the longest yarn is 10.8 cm (0.9%) longer than the average warp yarn in the sheet.

The results of this experiments shows that the length variations exist in individual warp yarns of a warp beam for warp knitting in controlled practical environment is less than 1%, though 16% of yarns are outside the permissible tension range in practical knitting as revealed from the results of the experiment 1.

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Experiment 03 – Fabric Bands Knitted using Different Tensions

In order to investigate the loop length variations caused by the tension of warp yarns, a warp knitted fabric with six lengthwise bands of different warp yarn tension was prepared. The warp yarns of 44 dtex/12 nylon 6-6 are wound at tensions of 4, 6, 8, 12, 16 and 20 cN. 670 yarns are wound from each tension.

The warping parameter variations are kept controlled by using yarn cones of same size for a given warp beam and distance from cone to warping machine is kept as much as constant for each of the warps of same tension. The warping speed was kept at 700m/min. The arrangement of warp yarns in the beam is as shown in figure 1.

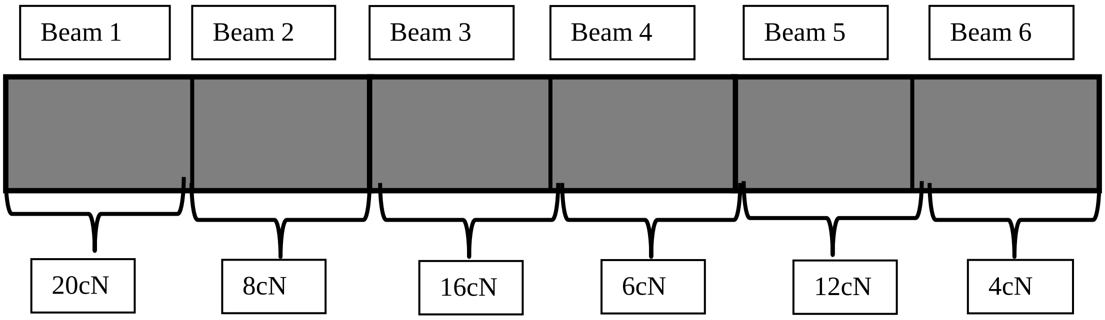


Figure 1- warp beams and tension in the test fabric

The fabric produced is 'locknit' and the second yarn used is lycra® yarns and it was kept constant for all six stripes of fabrics. After carrying out tests; grams per square meter, wales and courses count, the fabric was subjected to the next steps of the finishing process. The processes involved are presetting, scouring, bleaching and dyeing. The six samples after dyeing was viewed through the spectrophotometer (D65 light source and 10 degrees).

III. RESULTS AND DISCUSSION

The figures 2 and 3 respectively illustrate the effect of warp yarn tension on the course and wale densities and the weights of the fabrics. The increase in the warp tension causes to reduce the effective/relaxed length of yarn, hence increase wale and course densities and the fabric weight.

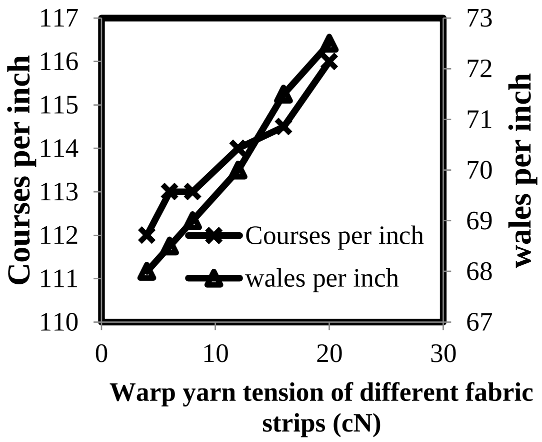


Figure 2- Course and wale densities of fabrics under different warp tensions

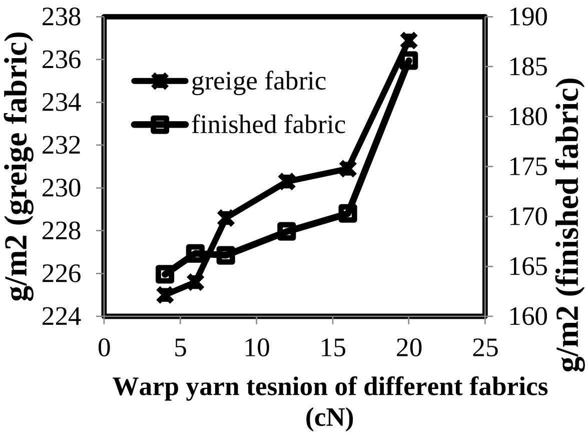
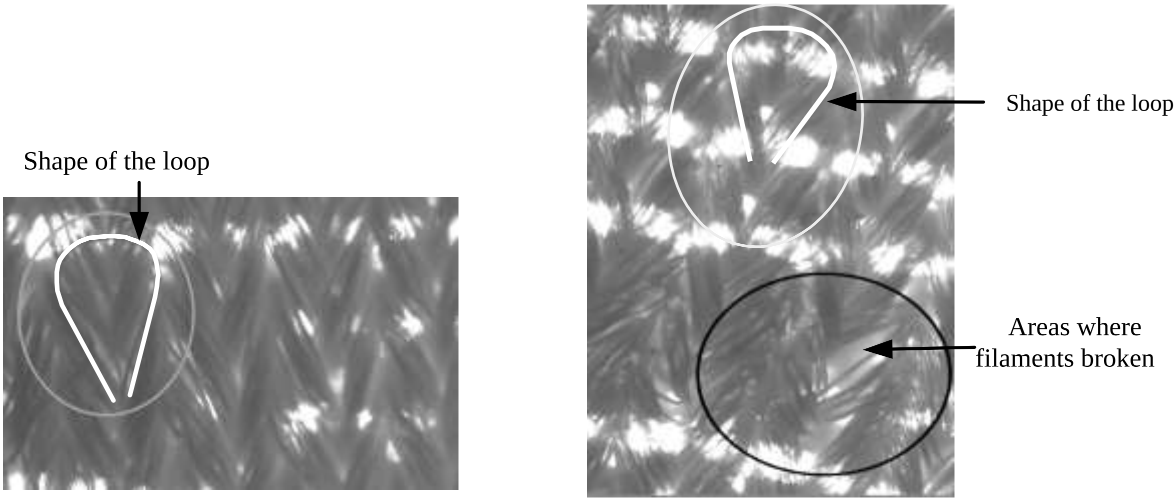


Figure 3-Weight of knitted fabrics under different warp yarn tensions

The figure 2 shows a linear relationship of the warp yarn tension with the course and wale densities with correlation coefficients of 0.96 and 0.99 respectively. Further, this effect on wales per inch is more than on courses per inch. Figure 3 indicates that the greige and finished fabric weights are increased with increasing warp yarn tension and both correlate to second order polynomials with correlation coefficients of 0.93 and 0.92 respectively.

The comparison of the microscopic view of the two fabric strips knitted at 4cN and 20cN shows that the loops lengths of the fabric knitted at 4cN are longer and larger than that of 20cN (figure 4). Further, it was observed that the filaments of the yarns have been broken due to high tension of 20cN. The high tension causes the loop lengths to be shorter and therefore produce tight fabrics.



a. warp yarn tension 4cN b. warp yarn tension 20cN

Figure 4- Microscopic view of knitted structures (magnification-60)

The shade variation is observed between the samples knitted at different warp tensions. Considering the fabric knitted at 8cN warp tension as the reference sample, the color difference ΔE was calculated. The results in Table 3 show that the colour difference ΔE value of the fabrics knitted under warp tensions of 16cN and 20cN is more than 1 and therefore a visual colour difference exists.

Table 1: Tension of warp yarns in three sections, left, middle and right of the warp sheet

Tension (t)	Frequency			Total	Percentage
	Left	Middle	Right		
$5.5 < t \leq 6.5$	6	1	7	14	9.3
$6.5 < t \leq 7.5$	4	0	3	7	4.7
$7.5 < t \leq 8.5$	28	26	23	77	51.3
$8.5 < t \leq 9.5$	10	16	16	42	28.0
$9.5 < t \leq 10.5$	2	7	1	10	6.7
number below the lower limit	6	1	7	14	9.3
number within limit	42	42	42	126	84
number outside the upper limit	2	7	1	10	6.7
total number outside the limits	8	8	8	24	16.0

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Table 2: Lengths of individual yarns in the warp sheet

Length X (cm)	Frequency	Percentage of yarns (%)
16.5 ≤ X < 17.5	1	0.09
17.5 ≤ X < 18.5	0	0.00
18.5 ≤ X < 19.5	8	0.71
19.5 ≤ X < 20.5	29	2.57
20.5 ≤ X < 21.5	27	2.39
21.5 ≤ X < 22.5	91	8.07
22.5 ≤ X < 23.5	52	4.61
23.5 ≤ X < 24.5	109	9.66
24.5 ≤ X < 25.5	144	12.77
25.5 ≤ X < 26.5	130	11.52
26.5 ≤ X < 27.5	118	10.46
27.5 ≤ X < 28.5	137	12.15
28.5 ≤ X < 29.5	97	8.60
29.5 ≤ X < 30.5	80	7.09
30.5 ≤ X < 31.5	29	2.57
31.5 ≤ X < 32.5	31	2.75
32.5 ≤ X < 33.5	30	2.66
33.5 ≤ X < 34.5	18	1.60
34.5 ≤ X < 35.5	3	0.27
35.5 ≤ X < 36.5	4	0.35
36.5 ≤ X < 37.5	1	0.09

Table 3: Effect of warp yarn tension on the colour of the fabrics

Warp yarn tension (cN)	Colour difference (ΔE)
4	0.12
6	0.15
8	Reference sample
12	0.72
16	1.19
20	1.50

IV. CONCLUSION

In a practical warping environment for warp knitted fabric production, tension variations on individual warp yarns are inevitable as the warping tension depends on many factors. Therefore, in practical environments a narrow range of tensions are allowed. An investigation to the yarn tension at practical situation shows that around 16% of yarns lie outside the permitted tension limits. These yarn tension variations cause variation in length of individual yarns. The length variations up to 1.7% were found to be existed.

The fabrics of warps wound at different warping tensions ranging 4-20cN revels that there is about 4-5% variation in course and wales densities. The increase of 5% variation in the fabric weight of the fabrics knitted using warp yarns of 4cN and 20cN was observed. However the microscopic view clearly illustrates that there is a noticeable loop size change. If two different yarns of very low and high tensions are wound next to each other, the two wales will show a significant difference in appearance and hence the fabric will fail despite the weight of the fabric and other specifications comply and lie within the permitted tolerances. The results of the spectrometer and the calculation of the ΔE value reveals that a noticeable colour difference of ΔE more than 1 exist in the samples knitted at warp tensions 16cN and 20cN. This reveals that any warp yarn at high tensions causes to reflect as a defect due to the visual colour change. The observed colour change could be due to the increase in cristalinity of nylon filaments and hence lower dye uptake as some fibre have been extensively stretched until rupture as shown in Figure 3. Further, the visual colour different could be due to difference surface texture created by difference in loop lengths, hence the wale and course densities.

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