Effect of Yarn Delivery and Couliering Depth on Yarn Input Tension and Fabric Defects for Positive-Feed Based Circular Knitting Machines

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Background: While working in the knitting industry, the authors had identified the stitch length (SL) as the most important parameter to evaluate any knitted textile structures. The SL (also, known as loop length) refers to the length of yarn in one loop of a single weft knitted fabric and it is primarily controlled through yarn delivery rate from the Quality Adjusting Pulley (QAP) disk diameter of the positive feeding units (Lek-Uthai & Dias, 1999). The length of yarn, in a stitch or loop, is pulled, and subsequently used by needles based on the loop sinking depth (sometimes known as ‘couliering depth’) from the stitch cam. A central couliering is used to simultaneous alteration of all stitch cams whereas a vertical couliering is used to adjust the loop sinking depth of an individual stitch cam (Iyer et al., 1995). As the mixture of couliering (both central and vertical) and yarn delivery rate determine the magnitude of yarn input tension, a knitter has to consider all these factors to knit a right quality fabric. An excessive high or low yarn input tension leads some knitting-related defects that may hamper the acceptability of fabric quality. Consequently, from a knitting machine perspective, the optimized settings of QAP and couliering are highly desirable to obtain precise loop length values on acceptable state of fabric. Hossain and Islam (2019) developed a model to predict stitch length from yarn input tension and yarn delivery rate. Elkarsary and Magboula (2014) investigated the effect of yarn input tension on same properties of a circular knitted fabric and found that SL, areal density, thickness, fabric extensibility and abrasion resistance are significantly affected by yarn tension.

Purposes: The purposes of this study are i) to determine the effect of yarn delivery rate and couliering depth on yarn input tension and ii) to identify resultant knit fabric defects. **Method:** A single jersey fabric (100% Cotton 30 Ne yarn count, and 23.5 twists per inch yarn) were knitted in a circular knitting machine (24 gauge, 10” diameter, and 744 needles) with positive storage feeding system. The yarn delivery rate was maintained by different QAP disk diameter settings (i.e., 14.1, 15.1, 15.5, 15.9, 16.3, 16.7, and 17.7 cm). For each QAP diameter, cylinder bed was adjusted to four central couliering settings (i.e., low, medium, high, and very high). In addition, some specific cam boxes were adjusted to various settings (i.e., 3, 6, 12, and 18) by vertical couliering for each QAP disk diameter and central couliering setting. The MLT WESCO yarn meter was used to determine yarn tension (in cN) from the region before yarns supplied to the knitting zone. After unraveling yarns from the fabric samples, the SL was determined using a HATRA course length tester according to the British Standard (BS 5441:1988) with a preload of 10 gm (9.80 cN). A fabric inspection machine and standard fabric inspection method (4-point system) using the ASTM 5430-07 standard were employed in this study. Bivariate regression

analysis between QAP disk diameter vs. yarn tension and yarn tension vs. stitch length were conducted as well as the relationship among yarn tension, fabric defect types and the defects points per 100 m² fabric was observed.

Findings: The findings are described with three experimental conditions-

- a) With a fixed central and vertical couliering depth setting
 - Yarn tension decreased gradually with increasing QAP disk diameter (i.e., yarn delivery rate)
 - Four types of fabric defects– drop stitch, run, press off, and hole were found because of yarn tension variation.
 - Number of defects significantly increased when yarn input tension level was increased above 8 cN. Consequently, total defect points per 100 m² fabric was increased.
- b) With a fixed QAP disk diameter and vertical couliering depth setting:
 - Yarn tension increased with increasing central couliering and vertical couliering
 - Only drop stitch (associated with holes) was observed due to increase of yarn tension.
 - The frequency of drop stitch defect increased significantly when yarn tension raised above around 10 cN. Consequently, defect points per 100 m² was increased significantly at the tension level around 10 cN.
- c) With a fixed QAP disk diameter and central couliering depth setting:
 - Yarn tension increased gradually with increasing vertical couliering (loop sinking depth)
 - Drop stitch and run defects were mostly observed due to increase of yarn tension
 - The frequency of drop stitch and run defects were increased with growing yarn tension and maximum yarn tension attained around 25 cN. Consequently, defect points per 100 m² was increased.

The value of yarn input tension (Y) against QAP disk diameter (X) (within the experimental boundary) can be predicted from the regression equation: $Y = -4.51X + 80.511$ ($R^2 = 0.907$, $p = .002$). The regression equation for yarn input tension (Y) against SL (Z) (within the experimental boundary) was found as $Y = 0.0114Z + 0.099$ ($R^2 = 0.981$, $p = .000$). However, in positive feeding, when yarn delivery rate is fixed, alteration of yarn tension (within yarn's proportional limit) does not influence stitch length. **Conclusions:** The study was aimed to explore the type and number of knit fabric defects occurred due to different yarn input tensions adjusted through machine setting. Yarn input tension was altered in three different ways, and this resulted four types of fabric defects (i.e., drop stitch, hole, run, and press-off). Among these defects, drop stitches and holes were the prominent ones. No numerical setting points were available for central couliering and therefore, relative setting terms (i.e., Low, medium, high, very high) were used. Knitters will be benefitted by knowing the influence of yarn input tension due to change in some machine setting from this study.

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