Prediction of Stitch Length of knitted fabric from yarn input tension and yarn delivery: An independent technique than what industry practitioners use

A. K. M. Mobarok Hossain, Ahsanullah University of Science and Technology, Bangladesh
Md Imranul Islam, Fashion Institute of Technology, USA

Keywords: Stitch length, course length, yarn tension, knitted fabric

Background: Unlike woven fabric, the knitted fabric is stretchy in nature and the role of stitch length is paramount to the quality of the fabric. The stitch length (also, known as loop length) is the length of yarn in one loop of a single weft knitted fabric usually expressed as an average of several or many measured loops. It is measured as:

$$\text{Stitch length} = \frac{\textit{Course length}}{\textit{Total number of knitting needles}} \quad (1)$$

The stitch length contributes to a number of fabric properties, such as fabric weight and area density, dimensional stability, width, physical performance like bursting strength and pilling resistance etc. Based on the yarn size, fabric weight and area density, the industry practitioners set up a yarn delivery rate to have the required stitch length. In a multi-feed circular knitting machine, a constant yarn delivery is maintained in order to have a certain stitch length through the belt speed of the positive yarn feed system. The industry practitioners calculated required yarn delivery rate and adjusted the Quality Adjustment Pulley (QAP) to match between the drive belt speed and required yarn delivery rate. Using these set ups, a positive yarn feed system first stores the required amount of yarn to have a certain stitch length and then, supplies to the needle or knitting zone. This technique makes it possible to supply almost equal length of yarn in all feeds and maintains uniform tension of the input yarn. However, the required yarn delivery rate and subsequent stitch length is always higher than the actual stitch length in the fabric measured after knitting (Abou-iiana, 2000). Delivering an extended yarn (due to yarn tension) to the needles and subsequent relaxation of the yarn in the fabric is the main reason for the difference, even though the feed system operates flawlessly (Dias & Lanarolle, 2002). While measuring course length, a small load is applied to straighten the yarn without stretching. However, selecting precise load is quite difficult (Booth, 1968) and researchers used different regulatory preloads based on yarn count (Pavko-Cuden & Sluga, 2015). The difficulty in selecting precise load could be another reason for the stitch length measurement variation. **Purposes:** The purpose of this study is a) to predict the stitch length from the measurement of yarn input tension and yarn delivery b) to determine the actual value of stitch length, and c) to determine the difference between these two independent measurements. **Method:** Four cotton single jersey fabric specimens were knitted in a large diameter circular knitting machine (24 gauge, 26” diameter, and 1,920 needles) and yarn delivery rate was kept constant by a fixed QAP setting (130). These fabrics were knitted with four known but varying yarn counts and yarn tensions through stitch cam setting. After knitting, all specimens were dry relaxed and yarns were de-knitted from the fabric. Mechanical properties of all four yarns from both before and after knitting stages were determined by the Titan universal strength tester using ASTM D2256-10 (2015) method. This test was to observe any indication of permanent deformation in yarn due to knitting action. A linear regression analysis was then implemented to predict course length at zero tension. Two independent variables- yarn input tension and corresponding yarn delivery per revolution were considered in this analysis. After unraveling yarns from the fabric samples, the actual course lengths were then measured using a HATRA course length tester according to the British Standard (BS 5441:1988) with a preload of 10 gm. The stitch lengths were determined using the equation (1) from predicted course lengths and actual course lengths, and then difference between them were calculated. Six, two sample t-test were carried out for the actual course lengths (measured through HATRA course length tester) and all four yarn counts to observe the influence of yarn count over course length found in the fabric. **Findings:** The analyzed data represented that the average actual course length was higher than the predicted one. According to Booth’s (1968) finding, it could be explained by the application of preload of 10 gm (9.80 cN) while measuring the actual course length through HATRA instrument; yarn may have stretched somewhat after straightening. However, the difference in course length between the actual and predicted ones was nominal and the resulted stitch length difference was found around 0.02 mm. **Conclusions and Implications:** This study on cotton jersey fabric with four yarn counts showed that the difference between predicted and actual course lengths was less than 1 percent, and the resulted stitch lengths variation was found minimal. In addition to that, the T values and corresponding P values generated through each two-sample t-test clearly indicates that the actual course length (obtained by a HATRA course length tester) showed no statistically significant difference for various yarn counts. Therefore, it is possible to predict course length as well as the stitch length of a jersey fabric from some knitting parameters such as yarn input tension and yarn delivery. This study would be a good substitute the industry practiced and time-consuming measurement of course length with HATRA course length tester. The technique applied in this study may also be considered for similar research on various weft knit structures with other types of yarn.

References

Abou-iiana, M. (2000). Dynamic Knitting Tension. *Knit Technol, 2*(3), 18-19.

American Society for Testing and Materials (2015). ASTM D 2256-10(2015): Standard test method for tensile properties of yarns by the single-strand method. USA: ASTM International.

Booth, John E. (1968). *Principles of textile testing: An introduction to physical methods of testing textile fibres, yarns and fabrics*. London: Heywood Books

British Standards Institute (1988). BS 5441:1988-Methods of test for knitted fabrics.UK: BSI

Dias, T., & Lanarolle, G. (2002). Stitch length variation in circular knitting machines due to yarn winding tension variation in the storage yarn feed wheel. *Textile Research Journal, 72*(11), 997-1001.

Pavko-Cuden, A., & Sluga, F. (2015). Measuring loop lengths of elasticised knitted fabrics. The *Journal of the Textile Institute, 106*(3), 225-235