STUDY OF LOOP FORMATION PROCESS ON 1X1 V-BED RIB KNITTING MACHINE: THE FACTORS AFFECTING LOOP LENGTH AND VALIDATION OF MODEL

1SRINIVASULU K, 2MONICA SIKKA, 1J HAYAVADANA

1Department of Textile Technology, Osmania university, Hyderabad, India, 500007.
2Department of Textile Technology, National Institute of Technology, Jalandhar, India, 144011

ABSTRACT

A study of loop formation process on 1x1 V-bed flat knitting machine is initiated with experiments designed by considering three knitting process variables: Yarn input tension, Cam setting and Take down load. The interaction between these factors and their effect on loop length and the percentage of contribution of variables on Final loop length is determined. It was observed from the results that the contribution of cam setting on loop length is more than the take down load which have a marginal effect only.

The proposed model is validated both experimentally and statistically. The unroved loop length, the theoretical loop length were linearly related with an average of 5% error at 95% significance level.

Key words: Yarn input tension, cam setting, Takedown load, Unroved loop length, Theoretical loop length.

1. INTRODUCTION

For the last twenty years by far the most important development in knitting has been the extraordinary rise in popularity of double jersey cloth, particularly for ladies’ outwear and even more recently in outer wear garments for men. For instance, the amount of double jersey(Rib) fabric produced today is at least three times than that of ten years ago.
Properties of the knitted fabrics are mainly governed by two parameters (i.e. length of loop and shape of the loop), the shape of the loop can be finalized during relaxation treatment but the loop length is decided during formation process only. So it is important that the stitch length of knitted fabric should be uniformly controlled to produce a superior fabric.

Loop length plays an important role in knitted fabric production in order to meet buyer specifications and consumer satisfaction and the investigation of geometrical loop length or theoretical loop length which makes the production of knitted fabric easy for knitter and it consumes time to produce the fabric of different specifications. Ultimately the rate of production will increase if we know the theoretical calculations of knitted fabric parameters.

The loop formation process became a subjective matter of research from past 50 years, and some studies related to loop formation process are available in literature. The mechanism of single jersey loop formation process as explained by Knapton and Munden (1966) was based on the concept of robbing back (%). A mathematical model of the single jersey weft knitted process involving flat bottom stitch cam was formulated by Alsaka. Peat and Spicer developed a geometrical model of single jersey loop formation process. A mathematical model of single jersey loop formation process involving non-linear stitch cam and incorporating five different stages of initial geometry of knitting zone was developed by Lau and Knapton.

A model of single jersey loop formation process based on the concept of balancing forces acting on needle that decides the loop forming point by Ghosh and Banerjee, and a model of 1x1 rib loop formation developed by Sadhan Chandra ray and Banerjee on dial and cylinder machine.

In present work an attempt has made to study the impact knitting processing variables like yarn Input tension, Cam Setting, and Take down Load on loop length and developed a mathematical model of loop formation on 1x1 rib loop formation process on V-Bed flat knitting machine.

The model is developed by considering two-dimensional coordinates of knitting elements by rotating both front bed and back bed to 45° and considering the tuck point as an origin of coordinate system. Based on 2D geometry a mathematical model has been developed for rib loop length. The model is validated experimentally and statistically.

2. EXPERIMENTAL

2.1. Materials
The material selected for producing samples is three-ply Acrylic yarn of count 229TEX. Experimental samples were produced on Hand driven V-bed machine by combinations of 3 processing variables (i.e. Yarn input tension, Cam setting, Take down load). For identifying the role of one variable, and other variables kept as constant.

2.2. Methods
2.2.1. Measurement of Yarn input tension
To identify the effect of yarn input tension, 9 samples were produced by varying input tension from 5g, 15g, and 25g by keeping cam setting and takedown load constant for a set. The unroved loop length was subsequently measured for all samples. The Tensioner used for varying yarn input tension is spring disc type and tension variation can be measured by tension meter as shown in figure 1.
2.2.2. Measurement of Cam setting
There are 18 samples produced in order to identify the role of cam setting on loop length. The samples are produced by keeping yarn input tension, take down load as constant and cam setting varying from 5mm-15mm. Out of 18 samples 9 samples are produced by varying front bed cam setting, keeping back bed setting constant and vice versa for remaining samples. The unroved loop length can be measured simultaneously after producing samples. Cam setting is changed by rotating cam jack screw as in figure 3.
2.2.3. Measurement of Take down load

Sample fabric were knitted over a range of 1500g, 2000g, 2500g of take down load this is achieved by maintaining yarn input tension, cam setting as constant. There are 9 samples produced by hanging dead weights over width of 25 needles. The unroved loop lengths are measured simultaneously after removal of weights. The take load is varied by changing weights as shown figure 4.

3. MEASUREMENT OF STITCH CAM CHARACTERISTICS

The length of the yarn in the kitted loop is decide by stitch cam the characteristics as shown in figure 5. Where a represents distance between neighboring Front bed and Back bed needles, while α, β represents cam angles and C1 &C2 are some constants. The stitch cam angles can be determined by observing movement of yarn up to knitting point.

![Figure 4. Take down load set up](image)

![Figure 5. Stitch cam characteristics of V-bed flat knitting machine](image)
4. MEASUREMENT OF YARN NEEDLE DIMENSIONS

The dimensions of yarn and needles like diameter, movement of yarn path can be measured by using image analyzer. For each sample, one hundred readings were taken for working out the average value. The modulus of yarn is tested on Zwick tensile tester. The movement of yarn and configuration inside the knitting zone are taken as images by digital camera and the dimensions of needle, wrap angles ($\theta_L$, $\theta_T$ and $\delta_L$) around the front bed and back bed needles, angle of path ($\psi$) of yarn between bed verges were measured.

4.1. Observation of yarn and needle movements under Quasi-static condition

By moving the hand lever very slowly, one front bed needle (FN) is made to catch the feed yarn. In that position, a mark was applied on the yarn lying across the preceding back bed needle (BN) with indelible ink. The coordinates of marked point and of relevant FN and BN were recorded. The machine was moved to short distance and the new positions of the marked point and relevant needles were recorded. This procedure was continued till the FN under observation reached the running position after passing through the knitting points.

5. DETERMINATION OF UNROVED LOOP LENGTH

The fabric was prepared in such a manner that the length of yarn forming complete knitted courses can be unroved. The lengths of yarn are measured in a straightened state under suitable tension (BS: 5441). The straightened state is achieved by removing the knitting crimp and/or yarn crimp as found in textured filament yarn. The stitch length can be calculate by counting the number of Wales available for fabric sample and divide the course length by the number of needles used and express the results in cm.

6. RESULTS AND DISCUSSION

6.1 Effect of process variables on loop length

6.1.1 Effect of yarn input tension on loop length

Loop lengths are calculated over a range of yarn input tension (from 5g to 25g) and cam setting (from 5mm to 15mm), and take down load kept constant. The values are plotted in graph (figure 6). And the 3-Dimensional graphs were plotted with help of MATLAB software.

Figure 6 Effect of yarn input tension on loop length
It is observed from the graph 6 that, at a constant value of take down load and cam setting, an increase of yarn input tension level from 5g to 25 g always results in linearly decrease in loop length. And the trend is same in all 3 level of cam setting (5mm, 10mm, and 15mm). For higher cam settings, the curves shifts upwards, the shape remains the same. In general, the rate of increase in loop length with an increase in input tension decreases for higher cam settings.

6.2. Effect of cam setting on loop length
6.2.1. Effect of front bed cam setting on Loop length

The samples were produced in order to see the effect of cam setting on Loop length. Loop lengths were measured over a range of cam setting (from 5mm to 15mm) and the input tension and take down load kept as constant. And the measured values were plotted in graph (figure 7)

![Figure 7. Effect of front bed cam setting on Loop length](image)

It is observed from the graph 7 that at constant values of input tension, take down load, an increase in the stitch cam setting results in linearly increase in loop length at 3 levels of back bed cam setting (5mm, 10mm, and 15mm). The trend of the graph is nearly same as the authors worked on single jersey (Banerjee P K, and Ghosh S, 1999) and 1x1 circular Bed knitting machine (Ray S C, 2003) but the slope of curve is different because of linear cam profile of 1x1 V-bed flat rib knitting machine.

6.3. Effect of back bed setting on loop length

The samples were produced by varying back bed cam setting from 5mm to 15mm at three levels of front bed cam setting (at 5mm, 10mm, and 15mm), the variables input tension, take down load kept constant. The measured values were plotted on graph (figure 8).
Figure 8 Effect of back bed setting on loop length

From the graph it shows that the increase in loop length trend is same as front bed cam setting but the slope of the curve is exactly linear as compared to front bed cam setting it is due to cam profile of V-bed machine.

6.4. Effect of Take down load on Loop length

Loop lengths were calculated over range of take down load from 1500g to 2500g and cam setting levels at 5mm, 10mm, and 15mm, and yarn input tension kept as constant value. There were 9 samples produced in order to see the effect take down load on loop length. The values of loop length are on graph (Figure 9).

Figure 9 Effect of Take down load on Loop length

It is observed from the graph that there is a nearly linear increase of loop length with an increase in take down load. Compare to other variables there is marginal effect of take down load on loop length (Banerjee P K, Ray S C, 2003) and (Banerjee P.K, Ghosh.S, 1999).
7. STATISTICAL INTERPRETATION OF EFFECT OF VARIABLES ON LOOP LENGTH

To determine the impact of Input variables on output variable (Loop Length) the complete data (Measured Loop length values) was analyzed by using STATISTICA SOFTWARE. The result in terms of contribution of each variable on loop length is determined. And the analytical data is explained by plotting graphs of input variables in terms of chi-square value (Figure 10).

During loop formation process an interaction takes place between these three input variables over loop length, and this interaction is explained in terms of regression equation. The interaction result is show through regression equation in terms of F-value.

The equation as follows

\[ \text{loop length} = 1.719341 + 0.0785FCS + 0.626BCS - 0.0001TL - 0.00147IT \]

Where

FCS- Front bed cam setting, BCS-Back bed cam setting, TL-Take down load, IT-Input tension.

7.1 Impact of input variables over Loop length

![Figure 10. Impact of input variables over Loop length](image-url)
8. VALIDATION OF THE MODEL

8.1 Comparison of Unroved and Theoretical loop length (From Mathematical Model)

In order to validating the model the values of unroved loop length and theoretical values should be compared. The computed or theoretical values were determined by generating a JAVA programme (Sinivasulu K, 2013) and the actual values for calculation of theoretical loop length are taken from machine (angles and distances) for every combination of samples. The computed values of 3 variables of samples is given in table

Table 1: Experimental and theoretical (from the model) values of output variables

<table>
<thead>
<tr>
<th>S.No</th>
<th>Unroved Loop length(Lu)(cms)</th>
<th>Theoretical Loop length(Lt)(cms)</th>
<th>% Error</th>
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<td>3.68</td>
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Figure 11. A scatter plot between theoretical and unroved loop length

From the table and graph it is observed that there is an average of 5% error between theoretical loop length and unroved loop length, and the linear relation is given by graph

\[ Lt = 0.0784 + 1.006 \times lu \]

And it is concluded that both experimentally and statistically the proposed model (Srinivasulu K, 2013) on 1x1 V-bed rib knitting machine is feasible.

9. CONCLUSIONS

Following are the conclusions drawn from the experimental work conducted.
- An increase of yarn input tension results in linearly decreasing loop length. For higher cam settings, the curves shifts upwards, but the shape remains the same. In general, the rate of increase in loop length with an increase in input tension decreases for higher cam settings.
- Back bed cam setting gives more loop length value as compared to front bed cam setting, and the variation is due to difference in profile of stitch cam for both the beds.
- Effect of take down load on loop length is very marginal as compared to other variables.
- The results of the work suggest that suitable combinations of variables can be used (i.e the critical adjustment of the yarn input tension, stitch-cam setting and take down load in conjunction with the properties of the yarn to be knitted,) to produce high quality fabric and to meet the requirements or specifications of the buyer.
- A two dimensional mathematical model is proposed to determine the loop length of v-bed rib knitted structure. This theoretical value can be used to produce a knitted fabric of particular specifications. (G.S.M and Tightness factor).
10. REFERENCES