Mechanics of 1×1 rib loop formation process on a dial and cylinder machine – Analysis of modelled system

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In the present study, the theoretical analysis of the output of the models of the 1×1 rib loop formation process has been performed to get the insight into the mechanics of loop formation system. For the purpose, the important output variables of the models have been generated for 128 sets of combinations of input variable. The range of the values of input variables have been chosen keeping in view the machine and yarn parameters available for the earlier experimental work as well as relevant information available in published literature. The analyses of the output of the models reveal that the main output variables of the loop formation system, namely loop length and yarn tension (needle force), are influenced by different machine, yarn and process variables as well as timing of knitting. In some cases the response of the system, i.e. the change in output variables due to incremental changes in input variables is large, whereas in some other cases the response is moderate to marginal. In fact, the rate of change in output variables depends on the combination of the input variables as well as the range of values of input variables.

Keywords: 1×1 rib loop, Cam force, Cylinder loop, Delayed timing, Dial loop, Loop length, Peak force, Robbing

1 Introduction

System usually means a group of things or parts working together as a whole. System analysis involves the analyses of all operations with a view to seeking ways to improve efficiency, etc. of the system, using especially a computer. In the present context, the 1×1 rib loop formation system is made up of a certain combination of yarn, needles and cams. The complex interplay amongst these various elements is governed by a large number of yarn, machine and process variables. Any change in one of these variables would affect the output of the loop formation system. Hence, these variables are treated as input variables to the system. The performance of the loop formation system is, in turn, characterized by three main output variables namely loop length, profile of yarn tension inside knitting zone (KZ) and amount of robbing back (R.B.). Therefore, by changing the input variables systematically and analyzing the monitored output variables, it is possible to gain an insight into the mechanics of loop formation system.

Before coming to this approach, preliminary experimental studies were carried out by the authors on two circular rib knitting machines. Based on the knowledge gathered from the preliminary studies, and the available international literature on loop models and mechanics of loop formation, computerized models of 1×1 rib loop formation process on dial and cylinder machine for both synchronized (SYN) and two needle delayed (2 ND) timings were developed. The models were validated in terms of loop length and cam force (knitting tension). For the purpose, cam force measurement set-up was designed and incorporated in the cylinder stitch cam of the knitting machine. The validation of the model i.e. matching between the outputs of the model and of the cam force measurement system had justified the acceptance of the model developed by the authors as well as the cam force measurement set-up for carrying out further works. Further, cam force measurement was carried out under 1 ND and 3 ND timings of knitting.

In the present study, the theoretical analysis of the output of the models of the 1×1 rib loop formation process has been performed to get the insight into the mechanics of loop formation system. For the purpose, the important output variables of the models have been generated for 128 sets of combinations of input variable.
2 Methodological Approach

Computer programmes written in PROFORT (FORTRAN) language depicting the models of 1×1 rib loop formation under SYN and 2ND timings only were used for generating theoretical data on mechanics of loop formation. These data were analyzed for studying the effect of relevant yarn, machine and process variables on mechanics of loop formation. As the total number of input variables considered by the authors is sixteen, it was not possible to generate data for all possible combinations of those sixteen variables. Considering the importance of different input variables, three process variables namely yarn input tension, cylinder cam setting and dial cam setting were selected for generating all possible combinations. Three different values of each of these variables were chosen which accounted for twenty seven combinations under both SYN and 2ND timings. To study the effect of other variables on loop length and yarn tension, three or four different values of each variable were chosen and varied while the other variables were kept unchanged. In all, 128 combinations were considered for generating theoretical data using the computerized models.

The range of input variables (Table 1) was selected, keeping in view the machines and yarns available for the research work as well as relevant information available in the published literature. The values of relative rigidity of yarn and coefficient of yarn-metal friction were chosen in the range of 2000–6500 cN and 0.22–0.32 respectively, keeping in view the properties of the yarns used for the validation of the model. Values of the angle of descent of cylinder stitch cam (35°–45°) and dial stitch cam (35°–45°), angle of ascent of dial stitch cam (25°–40°) and resistance to movement of both cylinder needle (5–20 cN) and dial needle (5 - 20 cN) inside trick were selected on the basis of the values actually obtained in the machines. The ascending angle of the cylinder stitch cam was restricted to the range of 9°–15° similar to the value of the same on machine B. Dial height was varied in the range

<table>
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<tr>
<th>Input variable changed</th>
<th>Input variables range</th>
<th>SYN timing</th>
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<th>2ND timing</th>
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<tr>
<td></td>
<td>Change in loop length</td>
<td>Change in peak needle</td>
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<tr>
<td>Input tension, cN</td>
<td>4 –12</td>
<td>7.72 7.01 -9.2</td>
<td>89.5 273.7 205.9</td>
<td>6.60 6.24 -5.4</td>
<td>124.9 230.5 84.5</td>
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<td>Cyl. cam setting, mm</td>
<td>0.8 –1.5</td>
<td>7.73 8.23 12.4</td>
<td>65.4 89.1 36.3</td>
<td>5.97 6.96 16.6</td>
<td>129.3 198.2 53.2</td>
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<td>Dial cam setting, mm</td>
<td>0.6 –1.2</td>
<td>7.45 8.08 8.5</td>
<td>99.2 89.1 -10.2</td>
<td>6.49 6.64 2.3</td>
<td>87.2 277.6 218.3</td>
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<td>Yarn rigidity, cN</td>
<td>2000-6500</td>
<td>7.58 7.84 3.4</td>
<td>95.3 73.4 -22.9</td>
<td>6.48 6.77 4.5</td>
<td>115.9 147.5 27.2</td>
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<td>Yarn friction coefficient</td>
<td>0.22 –0.32</td>
<td>8.01 7.49 -6.5</td>
<td>55.3 155.0 180.4</td>
<td>6.76 6.48 -4.1</td>
<td>113.5 175.6 54.8</td>
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<td>0.6 –1.2</td>
<td>7.56 8.01 5.9</td>
<td>49.3 93.1 89.0</td>
<td>5.96 6.90 15.8</td>
<td>195.3 111.0 -43.7</td>
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<td>CN resistance in trick, cN</td>
<td>5 –20</td>
<td>7.76 7.76 -</td>
<td>89.5 88.0 -1.6</td>
<td>6.57 6.66 1.4</td>
<td>119.1 155.8 30.8</td>
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<td>DN resistance in trick, cN</td>
<td>5 –20</td>
<td>7.72 8.29 7.4</td>
<td>89.5 104.1 16.4</td>
<td>6.60 6.67 1.1</td>
<td>124.9 174.6 39.8</td>
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<td>Descending angle of cyl. cam, deg</td>
<td>35 – 45</td>
<td>7.64 7.61 -0.4</td>
<td>89.5 90.5 1.2</td>
<td>6.47 6.71 3.7</td>
<td>142.0 130.7 -8.0</td>
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<td>Descending angle of dial cam, deg</td>
<td>35 –50</td>
<td>7.70 7.85 1.9</td>
<td>83.8 93.8 11.9</td>
<td>6.83 6.55 -4.1</td>
<td>81.0 97.2 20.0</td>
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<tr>
<td>Ascending angle of cyl. cam, deg</td>
<td>9 –15</td>
<td>7.81 7.68 -1.7</td>
<td>90.9 85.1 -6.4</td>
<td>6.60 6.63 0.5</td>
<td>280.3 76.9 -72.5</td>
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<tr>
<td>Ascending angle of dial cam, deg</td>
<td>25 – 40</td>
<td>7.81 7.56 -3.2</td>
<td>92.4 86.5 -6.3</td>
<td>6.61 6.52 -1.4</td>
<td>171.6 122.2 -28.8</td>
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<td>Machine gauge</td>
<td>12 –18</td>
<td>8.04 7.69 -4.3</td>
<td>43.2 95.2 120.5</td>
<td>6.90 6.58 -4.6</td>
<td>40.9 188.8 361.4</td>
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0.6–1.2 mm, keeping in view the adjusting facility on machines and the experimental data reported by Gray & Hurt. Values of cylinder cam setting and dial cam setting were chosen in the range of 0.8–1.5 mm and 0.6–1.2 mm respectively also on the same basis. The take down load per wale was varied in the range 5–20 cN on the basis of the values reported earlier. The yarn input tension was varied in the range of 4–12 cN. According to Ratlam and Shivkumar, the popular range of cotton count used in hosiery industry is in the range 20–60 Ne, the gauge (count = gauge²/6) of the machine was chosen to vary in the range 12–18.

In the knitting zone geometry of double jersey knitting machine proposed by the authors, while a dial needle (DN₁) reaches dial knitting point (DKP) under 2 ND timing, the neighbouring cylinder needle (CN₁) reaches a distance of 4xα (α is the half needle spacing) beyond cylinder knitting point (CKP) and that point is termed as CKP4. It has been observed by the authors that very high tension is developed on the arms of a loop held by a CN stationed at CKP4 and in most cases the maximum force on CN occurs at this point. Hence, the peak forces on CN at CKP4 in addition to that at CKP were recorded and discussed as and when needed.

Moreover, in order to quantify the amount of flow back of yarn, theoretical values of robbing back (RBT) were calculated, and as there are two knitting points (CKP and DKP) two robbing back values (RBT1 and RBT2) were generated by the model for the purpose. It may be noted here that the details of the combination of the input sets, output values of the model and their plotting as well as point by point discussion of the effects of input variables on the output of the model, have been avoided to make the paper short and comprehensive one. However, only the summary of the effect of changes in input variables on the nature of change of output variables is shown in Table 1 and discussed in the undergoing.

3 Results and Discussion

The analyses of the output of the models reveal that the main output variables of the loop formation system, namely loop length and yarn tension (needle force), are influenced by different machine, yarn and process variables as well as timing of knitting. In some cases the response of the system, i.e. the change in output variables due to incremental changes in input variables is large, whereas in some other cases the response is moderate to marginal. In fact, the rate of change in output variables depends on the combination of the input variables as well as the range of values of input variables. A summary of the effect of changes in input variables on the nature of change of output variables under both SYN and 2 ND timings is listed in Table 1.

Loop length decreases as input tension increases irrespective of stitch cam settings. The extent of decrease in loop length owing to increase in input tension (4–12 cN) is greater, i.e. 7–10% in the case of SYN timing as compared to 2.87–6.94% under 2 ND timing. Moreover, a combination of lower value of cylinder cam setting and higher value of dial cam setting results in higher percentage of decrease in loop length in the case of SYN timing, whereas the trend is reversed in case of 2 ND timing. The extent of increase in loop length due to increase in cam settings is similar under both the timings, whereby the effect of increase in dial cam setting is less pronounced compared to an increase in cylinder cam setting.

Under SYN timing, the peak forces on CN and DN at the respective knitting points are proportional to the input tension, i.e. there is about three fold rise in peak force on needles as input tension increases from 4 cN to 12 cN. The peak force values on CN and DN are very close to each other with the value on CN being invariably slightly greater. The peak force values generally cluster in to two groups – one with low cylinder cam setting values and the other with medium to high cylinder cam setting values. Such clustering is due to the fact that number of needles between initial point of contact (between yarn and needle) and knitting point depends on cam setting. Moreover, the number of needles remains unchanged over a range of cam setting and then changes after a regular interval. The peak force on CN at CKP in the case of 2 ND timing is also proportional to the input tension. However, the rate of change in peak forces on CN at CKP4 and on DN at DKP due to change in input tension depends on the combination of cylinder cam setting and dial cam setting in the case of 2 ND timing. The effect of increase in cam settings on increase in peak needle force depends on timing of knitting. Under SYN timing, the effect of increase in cylinder cam setting is predominant, whereas both cylinder and dial cam settings play equal role under 2 ND timing. The peak force develops almost always on CNs, whereby the location shifts from CKP.
towards DKP as dial cam setting is increased. Changes in ascending and descending angles of cylinder and dial stitch cams affect loop length and peak needle forces very marginally under SYN timing. However, under 2 ND timing an increase in ascending angle of either cylinder or dial stitch cam causes considerable drop in peak needle force with perceptible change in loop length and RBT values. The other effects of changes in stitch cam angles are similar for the two timings.

On increasing the dial height, loop length as well as peak needle force increase under both the timings. However, the needle force rises much more sharply under SYN timing, whereas the loop length increases more rapidly under 2 ND timing. Hence, change in dial height for effecting changes in loop length would be more acceptable under 2 ND timing. Under both the timings, working on finer gauge machine would lead to a sluggish drop in loop length accompanied by a sharp rise in needle force. An increase in resistance of movement of CN inside trick from 5 cN to 20 cN has no perceptible effect on loop length and peak forces but increase in resistance of movement of DN inside trick for the range causes 7.4% increase in loop length and steady increase in peak force under SYN timing. However, under 2 ND timing due to increase in CN resistance, loop length remains unchanged but peak forces show an upward trend. So, an increase in resistance to needle movement inside trick can be expressed to result in increase in loop length and needle force, whereby the DN tends to be more sensitive in this regard and especially under SYN timing.

The take down load appears to have marginal effect on either loop length or needle force. Moreover, for the same machine the effect diminishes with increase in delay. Two yarn properties, namely relative rigidity under tension and coefficient of friction with metal, exert nearly opposing influence on loop length and needle force barring the effect of relative rigidity under 2 ND timing. There is 4.5% increase in loop length as relative rigidity increases from 2000 cN to 6500 cN with a very little change in RBT values under both SYN and 2 ND timings. Due to increase in coefficient of yarn-metal friction from 0.22 to 0.32, loop length decreases by 6.5% and 4.14% under SYN and 2 ND timings respectively. Increasing coefficient of friction results in increase in peak needle force under both the timings. But due to increase in relative rigidity, the peak needle force shows a downward trend under SYN timing, however under 2 ND timing there is no change in needle force at CKP but perceptible increase in needle force takes place on CN at CKP4 and DN at DKP.

During the analysis of the output of the modeled system, it has been observed that predicted length of final loop is always different from the theoretical length of loop at knitting points. Except in few cases, the final length of loop is, in general, shorter than theoretical length of loop at knitting points. Moreover, theoretical length of loop at DKP is greater than that at CKP. Hence, it is justified that the total length of yarn controlled by a needle at CKP/DKP does not go in to the final loop, i.e. flow back of yarn, technically known as robbing back, takes place during loop formation, irrespective of combination of input variables and knitting timing. However, the amount of flow back of yarn during loop formation depends on combination of input variables and knitting timing. Under SYN timing, the robbing back values RBT1 (with reference to theoretical loop length at CKP) ranges from 3.06% to 14.43% and RBT2 (with reference to theoretical loop length at DKP) ranges from 11.46% to 21.78% as input tension increases from 4 cN to 12 cN. RBT1 is generally lower than RBT2 and the predicted loop length is nearer to the length of loop at CKP, particularly at lower cam settings and input tension. But under 2 ND timing, RBT1 values lie in the range 1–11.7%, showing a gradual rise with input tension. RBT2 values vary in the range 8–22% but do not show any specific trend. RBT1 values are smaller than respective RBT2 values. So, final loop length is close enough to the length of loop at CKP particularly at lower input tension level. On the whole, the final length of loop appears to be getting established at a point beyond CKP and DKP called loop forming point (LFP). In general, the length of loop produced under SYN timing is greater than the length of loop produced under 2 ND timing for the same combination of input variables. So, from same combination of input variables, 2 ND timing would result in tighter fabrics than SYN timing. It is of course possible to produce same loop length under both timings by suitably adjusting values of input variables.

As recorded, maximum force on DN occurs at DKP under both timings. However, the maximum force on CN occurs at CKP under SYN timing and the same occurs at either CKP or CKP4 in the case of 2 ND timing, depending upon combination of input variables. The peak forces on CN and DN at the
respective knitting points although are not exactly same but close to each other in the case of SYN timing, whereas differ, in general, in the case of 2 ND timing. In the case of 2 ND timing, peak forces on CN at CKP4 and on DN at DKP are close to each other. There is a linear relationship between peak forces on CN and on DN inside KZ. Irrespective of timing, the highest force develops almost always on CNs, whereby the location is CKP under SYN timing and either at CKP or CKP4 under 2 ND timing. It has been observed that needles are subjected to higher force in the case of 2 ND timing than in SYN timing. The difference between the magnitudes of the maximum forces on needles under 2 ND timing and SYN timing depends on the combination of variables. This difference is very high under 2 ND timing for the combinations having higher dial cam setting. However, a combination of very high cylinder cam setting and very low dial cam setting may result in very small difference between the two and even negative difference.

From the limited studies conducted on the model, it is thus observed that different input variables may have different effects on the nature of changes in output variables. Thus, increase in cam settings, dial height and dial needle resistance inside trick lead to increase in loop length and peak needle forces in KZ. On the other hand, the increase in delay timing, yarn input tension, coefficient of friction between yarn and metal, and machine gauge cause reduction in loop length accompanied by increase in peak needle force inside KZ. Effect of some other input variables is influenced by timing. Thus, an increase in yarn relative rigidity leads to increase in loop length and peak needle force under SYN timing, whereas the same change would cause increase in loop length and decrease in peak needle force inside KZ under 2 ND timing. It is noticed that in most of the occasions, the peak needle force increases with increase in value of an input variable. However, the increase in cylinder stitch cam angle of ascent leads always to reduction in peak needle force in KZ, accompanied even by an increase in loop length under 2 ND timing. It is concluded that the increase in yarn relative rigidity (under SYN timing) and cylinder stitch cam angle of ascent (under 2 ND timing) as well as decrease in delay, yarn input tension, coefficient of friction of yarn with metal and machine gauge would lead to increase in loop length accompanied by decrease in peak needle force in KZ. Other input variables do not have much influence on the two output variables.

A 1×1 rib loop may be viewed as being made up of one cylinder loop, one dial loop and two links. It can also be viewed as being made up of a leading arm and a trailing arm. In absence of sinkers in double jersey machine, the trailing and leading arms of a loop for a particular needle of any bed start forming only when the same and the two neighbouring needles of the other bed come in contact with the feed yarn. The length of any arm is minimum (about 0.85 mm under the study) when it is just formed and mainly depends on the distance between the adjoining needles making the arm. At the beginning, the length of loop arms goes on increasing as well as the configuration of the loop arms also changes inside KZ as the needle forming the loop descends under the control of the stitch cam. To study the nature as well as the rate of change (increase/decrease) in length of loop arms and to locate the point of finalization of loop length, the varying lengths of loop arms inside as obtained from the model were plotted against the position of the corresponding needle inside KZ. In addition, the lengths of arms of the loops formed by other needles were also considered simultaneously. After initial contact between yarn and CN, both the arms increase in length continuously up to CKP. In this zone, leading arm is always longer than trailing arm. This difference in length is due to difference in position along the Z-axis of the two neighbouring dial needles (DN1 & DN2). After CKP, length of leading arm decreases as both the needles (CN1 & DN1) forming this arm ascend along their respective stitch cams. But the length of trailing arm goes on increasing till the dial needle (DN2) making this arm reaches corresponding knitting point although the CN1 making the same ascend. This is due to higher rate of descending of DN than the rate of ascending of CN inside KZ. Somewhere during this process, trailing arm becomes longer than leading arm. The moment DN2 crosses DKP, length of trailing arm also begins to decrease and during further movement of the needles, the length of trailing arm becomes equal to the length of leading arm without further change in length of loop arms. The point where it occurs is called loop forming point (LFP). For a loop controlled by a DN along with two neighbouring CNs, leading arm is formed ahead of trailing arm. There is also gradual increase in the length of leading and trailing arms up to DKP and then gradual decrease in length until both the arms become equal at a point away from the knitting point. The total length of leading and trailing arms of a loop formed by
a DN at loop forming point is equal to the total length of yarn in a loop formed by a CN at loop forming point, although their length at corresponding knitting points are different.

The possibilities of nature of yarn flowing from needle to needle – backward & forward – were also observed. So far as yarn flow back is concerned, it takes place in stages (2 or 3) as needles move from CKP to LFP inside KZ. It is also observed that final length of loop is nearly equal to the theoretical length of loop occurring around CKP2. It means that length of loop is almost finalized after the first stage of yarn flow back occurring beyond CKP. The subsequent increase and decrease in length of the arms are the just exchange of length of yarn between the arms and that does not affect the final length of yarn in loop.

The behavioural pattern of cylinder and dial loops can be summed as follows. Lengths of both cylinder and dial loops differ with timing of knitting. In general, the cylinder loop is greater than dial loop in the case of SYN timing. This relationship is however, reversed in the case of 2 ND timing. Values of both cylinder and dial loops decrease with increase in input tension. However, the percentage decrease is higher for dial loop. Higher values of cylinder cam setting results in longer cylinder loop. Similarly dial loop increases in length with rise in dial cam setting. Dial loop increases with the increase in resistance to dial needle movement inside trick and decreases with increase in machine gauge, irrespective of timing of knitting. However, length of cylinder loop remains more or less unaffected due to changes in these variables. As regard the length of leading and trailing arms of a loop held by a CN, the followings are the observations. Length of both leading and trailing arms increases continuously up to CKP. In this zone, the leading arm is always longer than trailing arm in the case of SYN timing and both are nearly same in the case of 2 ND timing. After CKP and nearly up to CKP2 the length of leading arm decreases under SYN timing but may increase or remain unchanged under 2 ND timing. After CKP and up to DKP the length of trailing arm keeps on increasing under SYN timing but decreases subsequently up to loop forming point (LPF). However, the length of trailing arm keeps on decreasing after CKP under 2 ND timing, feeding yarn, on occasions, partly to the leading arm. This is a unique case of forward robbing. Beyond CKP2 there is a mutual exchange of length of yarn between leading and trailing arms under 2 ND timing. Yarn flows back from arms under control of ascending DN to arms under control of descending DN. The final length of loop is however finalized at around CKP2 and is not affected by this mutual exchange. The loop forming point under SYN timing occurs between DKP and CKP4, whereas under 2 ND timing it occurs between DKP and CKP8 (CKP + 8x). The rate of change in the leading and trailing arms up to CKP is more steady under 2 ND timing as compared to under SYN timing. This would indicate a steadier withdrawal of yarn from package under 2 ND timing leading possibility to a more delicate treatment of yarn. Under similar conditions, the flow rate of yarn across needles is lower in the case of 2 ND timing as opposed to under SYN timing, pointing to reduced abrasion of yarn under 2 ND timing.

In order to get an idea about the yarn tension profile inside KZ, tension on leading and trailing arms of a loop and the resultant force acting on the needle hook due to yarn tension from the point of yarn contact to the loop forming point were computed with the help of the computerized model and plotted for analysis. The analyses of the tracings of yarn tension profiles inside KZ under both SYN and 2 ND timings reveal the followings. Under similar conditions, the natures of tension profiles as well as the magnitudes of tension at any instant up to CKP are almost same under both the timings. The difference starts surfacing beyond CKP. In general, yarn is subjected to higher tension inside KZ under 2 ND timing. The number of cycles of tension that a segment of yarn is subjected to during its passage through KZ would depend on the number of needle controlling this yarn segment as well as the number of neighbouring needles passing through knitting points. Thus, under SYN timing the number of cycles is two and each additional needle delay would raise this number by unity. The maximum peak tension on a yarn segment occurs when either the CN controlling this segment is stationed at knitting point (CKP) or the DN controlling this segment is stationed at knitting point (DKP). So, there are two distinct peaks in all the curves inside KZ under SYN timing – the first one occurring at CKP and the second one at CKP2. In all the cases the magnitude of first peak is higher than that of the second one. The basic nature of yarn tension profile inside KZ under SYN timing is not affected by change in cam settings and input tension but the magnitude changes. There are four distinct peaks in all the traces under 2 ND timing. The first peak occurs at CKP and the others are uniformly spaced at a distance equal to the pitch of the needle.
The magnitudes of the peaks occurring at different points inside KZ pertaining to the same set are different. Similarly, the magnitudes of peaks occurring at the same point pertaining to the different sets are also different. As observed the maximum force on CN occurs generally at CKP4, i.e. at the instant the neighbouring DN ahead of CN under consideration reaches DKP. However, for some combinations having high input tension and high cylinder cam setting, the maximum force on CN occurs at CKP. So under 2 ND timing the yarn is subjected not only to higher values of peak tension but also to higher frequency of tension variation as compared to knitting under SYN timing.

4 Conclusion

From the foregoing discussions based on theoretical analysis of 128 sets of input combinations as well as from the findings of the earlier papers of the series, following conclusions on mechanics of 1×1 rib loop formation on dial and cylinder machine are drawn:

4.1 For scientific studies a 1×1 rib loop may be viewed as being made up of either one cylinder loop, one dial loop and two links or a leading arm and a trailing arm.

4.2 Lengths of both cylinder loop and dial loop differ with timing of knitting. In general, the cylinder loop is greater than dial loop in the case of SYN timing, however the relationship is reversed in the case of 2 ND timing for the similar cam setting at cylinder and dial. A wide range of loop length can be produced on a dial and cylinder type machine only by changing the timing of knitting.

4.3 For a loop held by a CN, lengths of both leading and trailing arms increase continuously up to CKP. In this zone, the leading arm is always longer than trailing arm under SYN timing and those are nearly same under 2 ND timing. After CKP and up to loop forming point (LFP) the lengths of both leading and trailing arms may either increase or decrease or remain unaltered, depending upon the geometry of the KZ. The LFP occurs far beyond the DKP.

4.4 Both cylinder loop and dial loop increase with increase in cylinder cam setting and dial cam setting respectively. However, the effect is less pronounced in the case of delayed timing as compared to SYN timing and on dial cam setting than cylinder cam setting.

4.5 Values of cylinder loop and dial loop decrease with increase in input tension, however the percentage decrease is higher for dial loop.

4.6 Dial loop increases in length with increase in resistance to dial needle movement inside trick and decreases with increase in machine gauge, irrespective of knitting timing. However, length of cylinder loop remains more or less unaffected due to change in these variables.

4.7 Theoretical loop length at DKP > loop length at CKP > predicted loop length at LFP.

4.8 Mechanics of 1×1 rib knitting stand on the theory of robbing back. Robbing back takes place generally in two stages (at or near CKP and DKP) in rib knitting under every combination of input parameters and the values are in the range of 10–15%.

4.9 The tracings of yarn tension inside KZ under SYN and 2 ND timings reveal that under similar conditions, the nature of tension profile as well as values of tension at any instant up to CKP are almost same under both the timings. The difference starts surfacing beyond CKP. Tension in this zone is generally higher under 2 ND timing.

4.10 For similar combination of input variables, larger loop length is generated at lower cam force under SYN timing as compared to 2 ND timing. With increase in loop length the cam force may even decrease under SYN timing, whereas increasing loop length is invariably accompanied by increasing cam force under 2 ND timing.

4.11 The number of cycles of tension that a segment of yarn is subjected to during its passage through KZ under SYN timing is two and each additional needle delay would raise this number by unity.

4.12 The maximum peak tension on a yarn segment occurs when either (i) the CN controlling this segment is stationed at CKP or (ii) the DN controlling this segment is stationed at DKP.

4.13 The loop forming system is sensitive with regard to loop length to the changes in three prime input variables, namely input tension, cylinder cam setting and dial cam setting, whereby the degree of sensitivity depends on timing of knitting.

4.14 So far as cam force is concerned, the system is highly sensitive to changes in input tension under any timing. The system is more sensitive to change to dial cam setting than to change in cylinder cam setting under delayed timing. However, this relation gets reversed under SYN timing.

4.15 The degree of fit between the experimental values of loop length and yarn tension profile within KZ on one hand and their corresponding theoretical
values predicted from the programme so developed is a reasonably accurate representation of the 1×1 rib loop formation on a dial and cylinder machine.

References