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Assessment of Knitting Conditions at States of Discontinuous Robbing Back in the Knitting Zone on Weft-knitting Machines

Abstract

On the basis of a deterministic digital model of the knitting process, loop formation conditions were identified at the states of discontinuous robbing back in the knitting zone. A linear cam of descending angle γ=50° and raising angle β=30° was taken as an example. It was proved that exhaustion of the yarn reserve on the needle which has been previously raised and situated beyond the maximum descending depth point determines the occurrence of the discontinuous phenomenon of thread robbing back in the knitting zone. This effect is to be observed when the horizontal coordinate value of needle raising point (x_K) is lower than the needle spacing (t) (x_K<t). It was ascertained that, depending on the value of parameter (x_K) and descending depth (z), the values of maximum forces in threads in the knitting zone are up to 2.2 times higher than in continuous robbing back conditions.

Key words: *knitting process, knitting zone, robbing back effect, raising cam, dynamic forces.*

Introduction

The knitting zone is a critical place of every weft-knitting machine. The cam's contour in the knitting zone is still not unified. Beside linear contours, non-linear contours are also applied. Non-linear cams are used because of dynamic factors in the needle-cam system so as to increase the linear velocities of the cylinder. Contours of that type should be designed and tested not only with regard to force minimalisation of needle pressure on the cam, but also from the point of view of force minimalisation in threads in the knitting zone.

In works [1-3], on the basis of a computer simulation and an experimental test, the dynamic forces in threads were assessed in the knitting zone for linear cams [1] and cams of a composite linear-circular function contour with a circumference [2,3]. This research concerned cams with unlimited height of needles rising in the knitting zone at constant tension (negative) feeding. The effect of thread robbing back lasted until the end of the loop formation cycle.

The following work is a continuation of the previous research [1,2] and concerns the identification of knitting process conditions for cams with limited height of needles rising in the knitting zone which so far have not been included in optimalisation tests. These cams are characterised by the possibility of a discontinuous robbing back effect appearing in the knitting zone. The characteristic of the discontinuous robbing back effect is a repeated robbing of thread from the lap to the needle after it has descended at the end of the loop formation cycle. The reason for this effect is the exhaustion of the yarn reserve on the needle after it has been previously raised and placed beyond the point of the maximum descent depth.

Course of Loop Formation Process with Discontinuous Robbing Back

Computer simulation conditions

A sample course of the loop forming process in the case of discontinuous robbing back of the thread was discussed for the cam (Figure 1) of descending angle G=γ= 50° and raising angle B=β= 30°, the needle's guiding length in the knitting zone x_F=0.4 mm and the needle raising point coordinate x_K=0.8·t, for needle spacing t=1.81 mm (x_K<t). Computer simulation was carried out for the following basic parameters: initial tension F_0=5 cN, take-up force F_A=3 cN, descending depth z=3.0 mm, knitting velocity v=1 m/s.

Figure 2 presents results of the simulation for the cam described above obtained on the basis of the deterministic model discussed in the work [2].

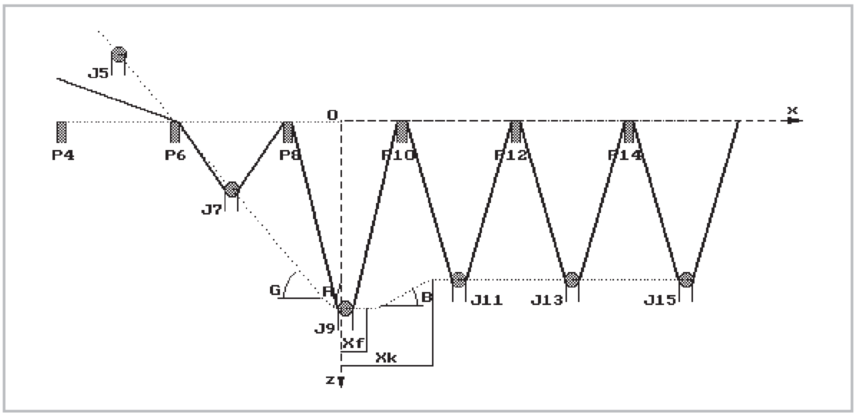

Figure 1. Sample cam of limited height of needle raising in the knitting zone.

The analysis of knitted-in balance conditions on individual friction barriers following displacement of the cylinder by Δx is the core of calculation of forces, time course in threads and length of knitted-in thread. Meanwhile, calculation of yarn length requirement in the area of the descended needles and of the yarn reserve in the zone of raised needles takes place. The geometric balance of the above-mentioned lengths for the area of reversing motion forms the basis for calculation of the knitted-in thread length.

In the bottom left-hand corner (Figure 2) a knitting zone scheme was drawn, for which a time course in threads were drawn on the left of the figure forces. The top course refers to the force/ values in threads on the right side of the sinker $F_{(i)}$, which means for odd segments, and the bottom course for even segments $F_{(i+1)}$. The axis of abscissa graduation refers to the cylinder moving by one needle spacing. The maximum value of forces in yarns in the knitting zone during the loop formation cycle is printed over the figure of the knitting zone. The theoretical curves of growing values of stitch length coefficient W_t=l/t (top right hand corner) describe the length of thread segments (i) and (i+1) hung on the needle after its descent. Horizontal segments of the graph indicate the appearance of the robbing back effect, which fully compensates the yarn requirement for the segment placed on the descended needle. The sum of the yarn length values robbed from the lap to individual segments at the point of maximum descending depth in relation to needle spacing is relative to the value of the stitch length coefficient W_t. The W_t values are printed in the top part of the figure.

Course of loop formation process

Needle I_9, after descent of the guiding part x_F, starts to be raised, which causes a decrease in forces in the thread segments wrapping round this needle. On the other hand, forces in the thread segments hung on the descended needle I_7 increase as a result of wrapping angle growth. If the forces in the right thread segment hung on the descended needle I_7 exceed the value of friction resistance on the sinker P_8, robbing back will occur from segment P_8I_9 to P_8I_7. This phenomenon is known as the robbing back effect. It is illustrated by the horizontal part of the growth curve of the graduated knitted-in coefficient for segment P_8I_7, for which robbing back, in this case from segments P_8I_7 and P_8I_9, compensates the whole yarn requirement. After exhausting the yarn reserve on needle I_9 (when it starts to move along the straight horizontal line), the yarn requirement is again compensated by robbing the thread from the lap. This is confirmed on the graph of stitch length coefficient by repeated growth of the W_t value for segment P_8I_7 before needle I_7 reaches the point of maximum descent depth. Repeated robbing of the thread from the lap causes a sudden growth in forces in the threads of segment hung on needle I_7, as this needle is at the same time located close to the maximum descent depth point, and needle I_5 appears in the knitting zone. The maximum value of tension is set when needle I_7 reaches its maximum descent depth.

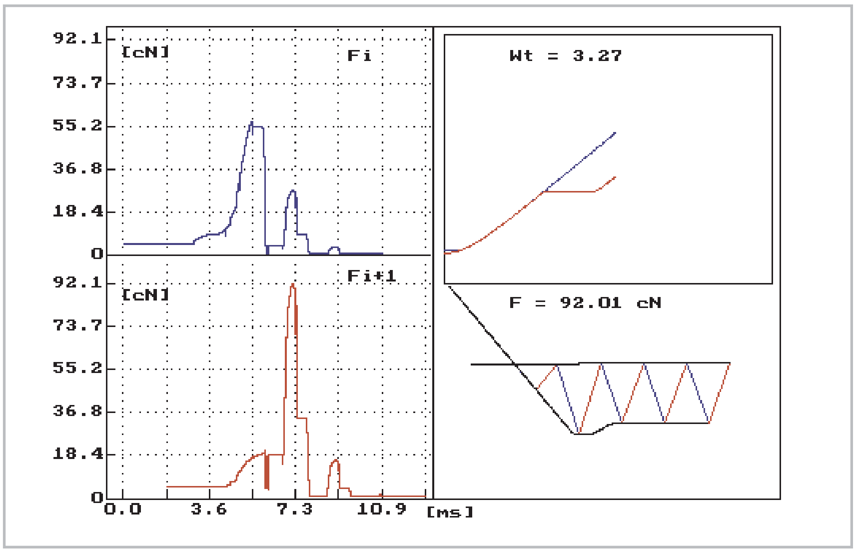

Figure 2. Results of knitting process digital simulation in the form of dynamic forces' time course in threads and growth curves of stitch length coefficient for individual segments of a formed loop (calculation parameters: γ=50°, β=30°, x_F=0.4 mm, x_K=0.8·t, t=1.81 mm, z=3.0 mm, F_0=5 cN, F_A=3 cN, v=1 m/s).

The course of loop formation process with discontinuous robbing back is unfavourable, as the value of dynamic thread loading in the knitting zone is relatively high in relation to thread length in a loop. This value is even higher than for cams at which robbing back effect does not occur (x_F>3-4t), because for the same thread length in a loop, a smaller descent depth is demanded in order to guarantee lower values of thread wrapping angle around the loop forming elements.

Research Program

Simulation tests were conducted for the linear cam with the following parameters: γ=50°, β=30° and guiding part length x_F=0.4 mm. This is a particular case of descending angle (γ) and raising angle (β) relationship. For linear cams, at descending angle γ =50° and raising angle β=30°, the yarn requirement for one segment hung on the needle after descent is compensated from two segments hung on the needle after being raised [1,2].

The value of descent depth (z) and the horizontal coordinate of the needle raising point (x_K) were changed in such a way so that the value of the stitch length coefficient W_t=l/t (where l - the thread length in a loop) was constrained in the interval W_t=2.0-4.2, which covers the practical range of coefficient value (W_t). Computer simulations of knitting process were carried out at constant value of initial tension F_0=5 cN, take-up force F_A=3 cN and needle spacing t=1.81 mm. The test results concern cotton yarn 36 tex, whose parameters of rheological properties are included in work [2].

Research Results Analysis

Effect of needle raising point coordinate (x_t) and descent depth value (z) on the value of stitch length coefficient

Figure 3 presents the relationship between the value of the needle raising point coordinate in the knitting zone (x_t=x_K/t) and the value of the stitch length coefficient (W_t), a relationship hitherto not described in the literature. From Figure 3, it follows that together with the growth in value (x_t), a linear decrease in knitted-in thread length takes place in relation to the needle spacing, and reaches a set value dependent on the descent depth value (z). The decrease in value (W_t) together with the growth of parameter (x_t) result from the robbing back effect

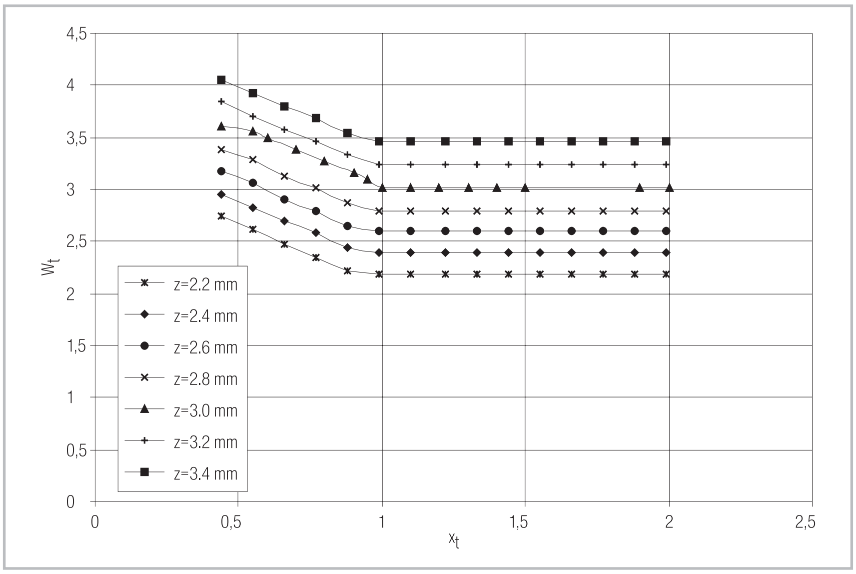

Figure 3. Relationship between the value of needles raising point coordinate (x_t) and the value of stitch length coefficient (W_t) for the cam 50°/30°.

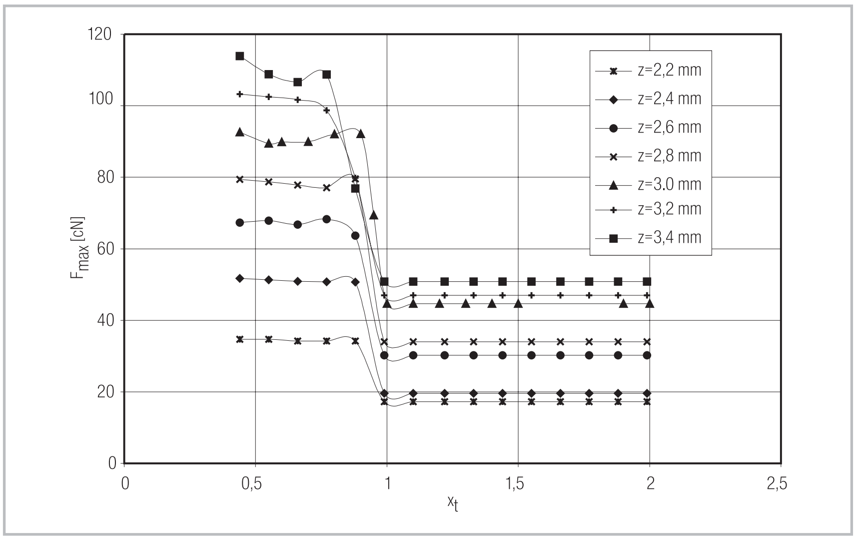

Figure 4. Relationship between the value of needles raising point coordinate (x_t) and maximum tension (F_{max}) for the cam 50°/30°.

from the raised needle to the loop hung on the descended needle. The higher the value of coordinate (x_t), the higher the thread length released from the raised needle which can be robbed to the loop being formed, lowering the thread's real length in the loop. The horizontal parts of the value line (W_t) indicate that further increase of value (x_t) does not lead to an increase of the area affected by robbing back.

Effect of needle raising point coordinate (x_t) and descent depth value (z) on the values of maximum forces in threads (F_{max})

From the analysis of Figure 4 it follows that for low values of (x_t), values of maximum forces in threads in the knitting zone for a defined descent depth (z) remain at constant level. This conclusion refers to conditions where the discontinuous robbing back effect occurs. In such cases, maximum force value in threads is set at the time when the needle reaches the point of maximum descent depth. Considering that the wrapping angle of the loop forming elements is constant for a defined knocking over depth, and that the thread is robbed from the lap at the end of the loop formation cycle, the values of tensions remain the same. Then, if x_K=t (x_t≥1), the forces in threads decrease and reach a set value. For the cams analysed, depending on the descent depth value, this value is ≈2.2 times lower than when x_K>t. The decrease in maximum tension values in the knitting zone, after (x_K) has exceeded the value of needle spacing (t), should be ascribed to the fact that the robbing back effect lasts until the end of the loop formation process. It is conditioned by the constant slowing down of threads by the raised needle. Thus, significant reduction of maximum tensions can be explained as the range of robbing back is small because it occurs from the first needle. The digital simulations conducted indicate the possibilities of carrying out the knitting process in conditions of controlled robbing back in the knitting zone.

Summary and Conclusions

Identification of loop formation conditions was made on the basis of a deterministic model of the knitting process during the states of discontinuous robbing back of thread in the knitting zone. A linear cam of descending angle γ=50° and raising angle β=30° was taken as an example. The results and analyses of this digital simulation allow us to formulate the following conclusions:

- The characteristic of the discontinuous robbing back effect is the repeated robbing of thread from the lap to the needle after descent at the end of the loop formation cycle. This concerns cams of limited needle raising height. The reason for the discontinuity of the robbing back effect is the exhaustion of yarn reserve on the needle after it has been raised and situated beyond the maximum point of descent depth.
- The maximum values of tensions in conditions of discontinuous robbing back are 2.2 times higher, depending on the cam type and descent depth, than in conditions of continuous robbing back.
- Increasing the needle raising horizontal coordinate (x_K) in the knitting zone for linear cams causes a linear decrease in stitch length coefficient to the set value, as determined by the range of robbing back, which for constant technological parameters does not change together with the growth of parameter (x_K).

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