ANALYSIS OF THE STICH FORMATION PROCESS AND MODELLING OF THE YARN MOVEMENT IN HIGH PERFORMANCE TRICOT KNITTING MACHINES

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ABSTRACT

In the textile industry, the development and production of sophisticated textiles characterized by extremely high quality and performance as well as additional functions is continuously enhanced. The warp knitting process offers excellent conditions due to the high variety of pattern design. The processing of low-stretch yarn materials, such as staple fibers or high-tenacity yarns, is challenging, particularly at high production rates. Therefore, the interactions between knitting elements and yarn in the stitch formation process are modeled.

Key Words: warp knitting, model of stitch formation process, processing of low-stretch yarn materials

1. INTRODUCTION

The yarn-processing textile industry is constantly facing new challenges due to the constantly growing number of different yarn materials to be processed with very different characteristics. The processing of low-stretch yarn materials, such as staple fibers or high-tenacity yarns, is challenging, particularly at high production rates. It requires the specific adjustment and further development of the yarn guide elements of textile machines. In the case of high-performance warp knitting on tricot machines, this task can only be completed if the stitch forming process and its interactions and dependencies with the machine elements are precisely understood. The complexity of machine-specific and machine-technological parameters makes it difficult to recognize their interrelationships. For the modelling of the correlations, in-depth analyses of the warp-knitting process are indispensable. In the field of warp knitting, research has already been carried out to describe the process and the textiles [1 - 7]. In this research work, however, the interactions between machine elements and yarn and their effect on the stitch formation process have not yet been precisely described. This is indispensable for a thorough understanding of the influence of the machine elements on the yarn movement in the warp knitting process and the resulting yarn tensile force. The aim of this paper is the analytical description of the stitch formation process of a high performance tricot-knitting machine and the measurement of the yarn movement.

2. MATERIALS AND METHODS

2.1 Tricot-knitting machine

The high performance tricot-knitting machine used is a Copcentra 3K from the company KARL MAYER Textilmaschinenfabrik GmbH. The machine are shown in Figure 1. The warp yarns run from the warp beams via yarn deflectors, yarn combs and yarn tension compensators into the stitch formation zone. Here the yarns are formed into stitches and joined together by the working elements (guide bars, sinker, closing wire and knitting needle). The resulting textile surface is pulled off by the take-down roller and stored on a fabric beam.

Figure 1. Tricot knitting machine Copcentra 3K

On this warp knitting machine, the warp yarns are continuously supplied to the warp knitting point, and the knitted fabric is continuously taken off but yarn consumption is highly discontinuous. This results in different yarn lengths, which must be equalized by the yarn tension compensators. With the currently used passive systems, however, excitation occurs in their natural frequency range with increasing machine speed, resulting in excessive vibrations and phase displacements. As a result, the exact compensation of yarn length differences is no longer feasible, which can lead to incorrect positioning or yarn breakage during the processing of low-stretch yarn materials.

2.2 Creation of a vector model of the yarn movement

For the analysis of the stitch formation on the tricot knitting machine, a vector-based model was developed with which the known interactions between stitch formation elements and yarn paths and consumption during stitch formation can be described. For this purpose, the stitch formation process is subdivided into single steps. In each step the yarn moves through the machine elements on a aligned path. These paths are dependent on the distances between the machine elements and their movement during one machine cycle. This allows the yarn movement (s in mm/°) to be described mathematically using a function via the machine rotation angle (φ in °) (see formula 1).

$$\bar{\mathbf{s}}=\mathbf{f}(\boldsymbol{\varphi}) \tag{1}$$

This function is dependent on an initial length (l in mm) and the temporal change of this length (Δl in mm/°) by the directional movement of the machine elements (formula 2). The yarn length which is set between the knitting needles and the guide needles at the lowest position of the knitting needles is regarded as the initial length in the model. For simplification, only the vectorial movements of the knitting needles (n in mm/°) and guide needles (g in mm/°) are considered in the model (formula 3 to 5).

$$\bar{s}=l+\Delta\bar{l} \tag{2}$$

$$\Delta\bar{l}=(\bar{g}+\bar{n})\frac{d}{d\varphi} \tag{3}$$

$$\bar{g}=\sqrt{g_x^2+g_y^2+g_z^2} \tag{4}$$

$$\bar{n}=\sqrt{n_x^2+n_y^2} \tag{5}$$

2.3 Analysis of the machine

For the model development it is important to describe the movements of the machine elements exactly. Therefore, these movements were recorded with an optical measuring stand (Figure 2). For this purpose, distance measuring marks were attached to the machine elements, which are captured with two high-speed cameras. Using dynamic 3D analysis software from GOM mbH, the movements of the machine elements can then be precisely determined via the machine rotation angle.

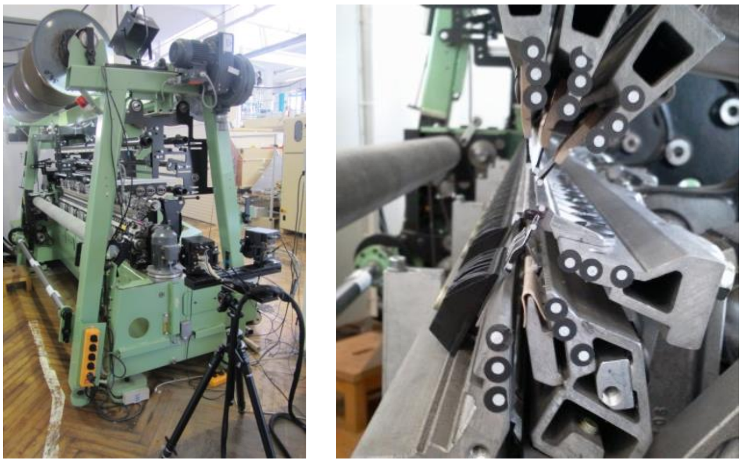

Figure 2. Optical measuring stand

3. RESULTS

Based on the evaluation, the motion sequences of the machine elements shown in Figure 3 were obtained. The knitting needles are in their lowest position at a machine rotation angle of 0°. The guide bars move at 40° into the swing through movement and at 180° into the swing back movement. At a machine rotation angle of 265°, the knitting needle is closed and moves back to the zero position.

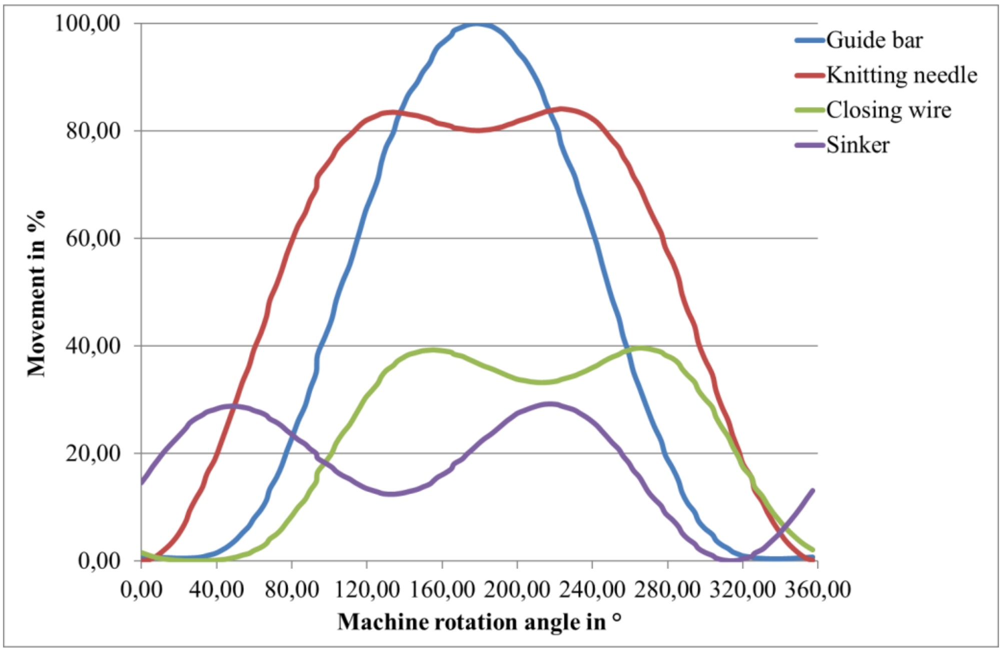

Figure 3. Movement of the machine elements

The theoretical yarn path can be determined from the machine element movements in connection with the specified mathematical conditions. The yarn path is shown in Figure 4.

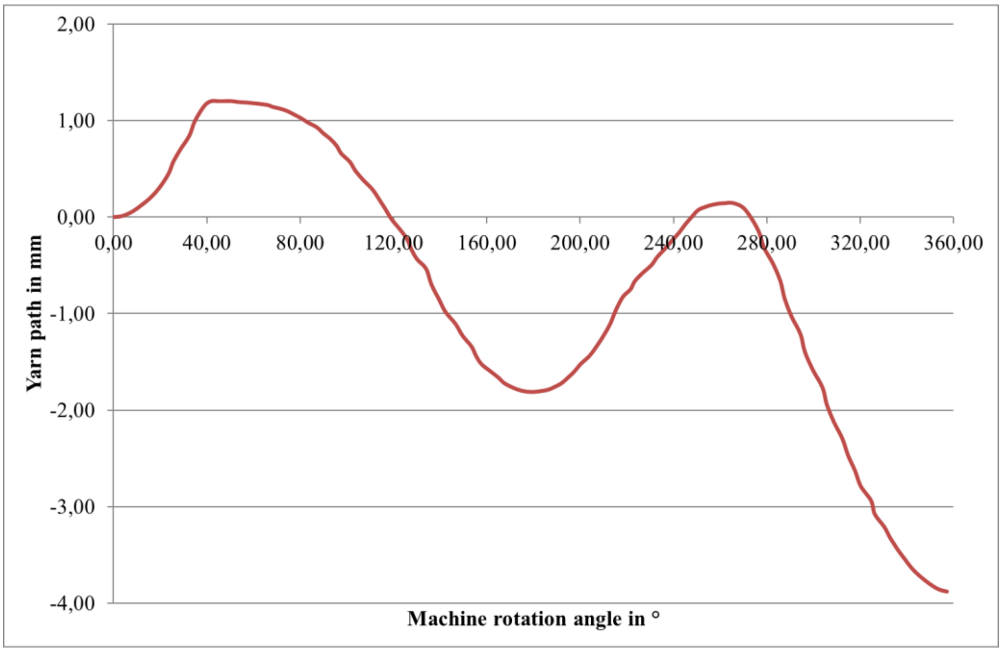

Figure 4. Yarn path

In the course of the yarn path, rising draw frames mean yarns that become loose, which must be temporarily stored by the yarn tension compensator. Falling draw frames mean tensioning yarns which must be released by the yarn tension compensator. To validate the theoretical yarn path, an optical measuring stand was set up on the tricot knitting machine and the yarn path measured (Figure 5).

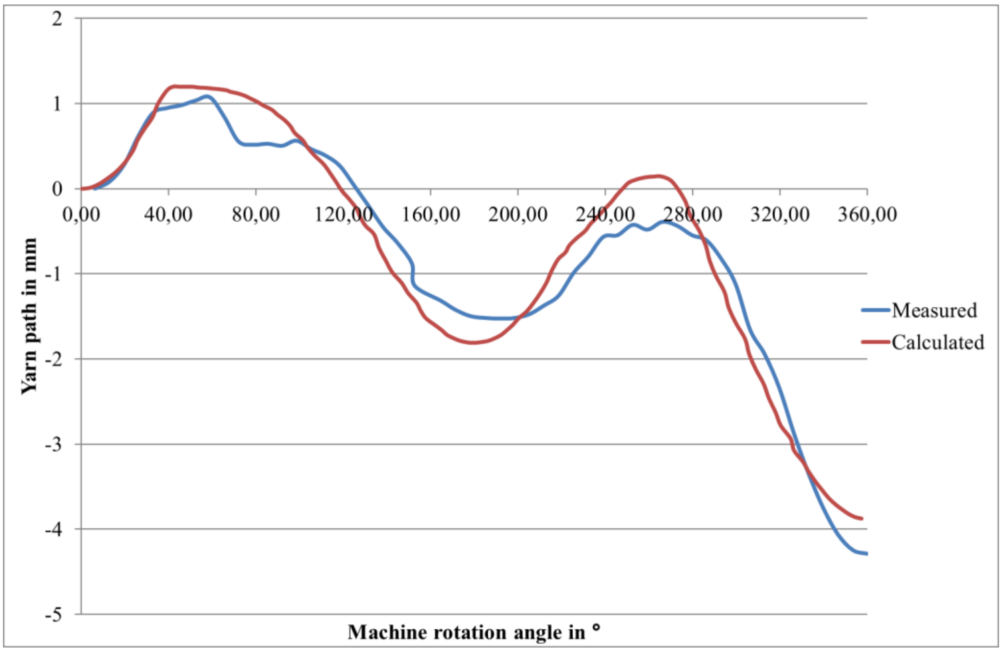

Figure 5. Comparison of calculated and measured yarn paths

The diagram shows that the curves are very similar. The deviating behaviour can be explained by the elongation and damping properties of the yarns, which are not yet considered in the preliminary model.

4. CONCLUSION

By means of the modeling, the main factors influencing yarn requirements could be determined, i.e. the swinging movement of the guide bars and the lifting movement of the knitting needle. The influencing factors of these machine elements must be taken into account for further developments on the tricot knitting machines, especially for processing low-stretch yarns. However, the physical properties of the yarns must also be described in more detail and combined in a single model.

5. ACKNOWLEDGEMENT

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