Kazimierz Kopias

New Technique for Producing Weft-Warp Knitted Fabrics

Department of Knitting Technology
Technical University of Lodz,
ul. Żeromskiego 116, 90-924 Łódź, Poland
E-mail: kazimierz.kopias@p.lodz.pl

Abstract
The combination of two groups of knitted structures, weft knitted and warp knitted fabrics, into one constitutive weft-warp knitted stitch enables to obtain new properties of knitted fabrics. This paper presents a new technique for producing weft-warp knitted fabrics with the use of a cylindrical knitting machine of modified structure that ensures a high quality of the knitting process.

Key words: *weft-warp knitting stitches, cylindrical knitting machine.*

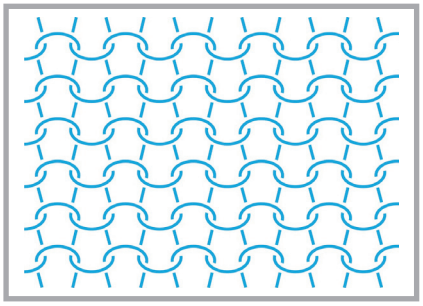

Figure 1. *Weft-knitted fabric.*

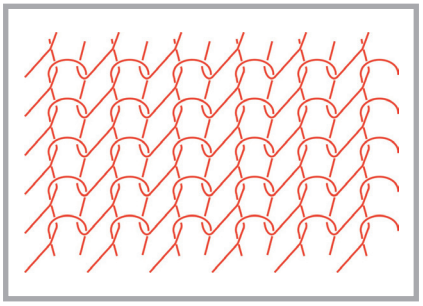

Figure 2. *Warp knitted fabric.*

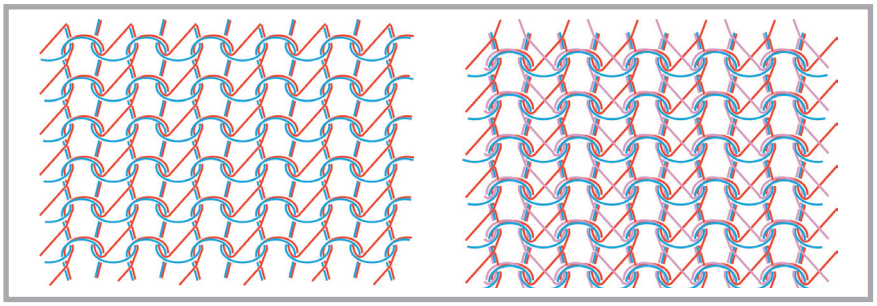

Figure 3. *Weft-warp knitted stitch.*

Introduction

Knitted fabrics are commonly used as clothing and technical products, whose users expect them to have new properties helping to fulfil their requirements.

The properties of knitted fabrics are greatly influenced by their structure, which is a result of the arrangement of yarns in a stitch. The kind of stitch used depends on the specific knitting technique applied. Two kinds of this technique, the weft-knitting and warp-knitting, are commonly used for obtaining:

- weft-knitted fabrics, in which stitches are characterised by yarn forming subsequent loops in a course (***Figure 1***).
- warp-knitted fabrics, in which stitches are characterised by yarn forming subsequent loops in subsequent courses (***Figure 2***).

These two different arrangements of yarn presented in the above-mentioned groups of stitches of the knitted fabric significantly influence the properties of these products.

Therefore, the combination of these two groups of stitches into one weft-warp stitch (***Figure 3***) enables to obtain new properties of knitted fabrics.

Mainly it concerns mechanical properties (strength, elongation and elasticity in different directions of stretching), which is especially important for knitted fabrics designed for technical products.

Prevailing reports indicate that weft-warp knitted fabrics are of great interest for some research centres [1, 2, 5]. However, the properties of these knitted fabrics have not been hitherto investigated thoroughly enough [3], mainly because of the lack of knitting machines designed for manufacturing these fabrics. Both a device constructed in the 70s at the Department of Knitting Technology of the Technical University of Lodz and the flat knitting machine manufactured by Shima Seiki company are based on a very sophisticated and low efficient method of knitting, which is caused by the presence of two working stages in the process of forming each of the courses of loops. In the first stage warp threads are introduced under a needle beard, forming a warp stitch. In the second stage loops of the weft knitted fabric are formed by yarn unwounded from a beam. Moreover, the arrangement of yarn forming the warp knitted stitch has to change the direction of run of underlaps at every few courses, disturbing the structure of the stitch and the whole technological process.

The disadvantages of the prevailing technological solutions mentioned above were eliminated in the knitting technique presented in [5], which is the basis for the technology of weft-warp knitted fabrics.

New technique of forming weft-warp knitted fabrics

The device used in this new technique for producing weft-warp knitted fabrics works in a single-stage process, which means that this process is a continuous one, simplifying the technological process and obtaining highly efficient production in comparison with the techniques of producing these fabrics used nowadays. This simplification of producing a knitted fabric and the possibility of increasing the efficiency of this process, as well as the possibility of obtaining new, novel knitted structures is guaranteed by the use of technology based on the process of producing a knitted fabric using a machine with a needle bearing of cylindrical shape. The novelty of these structures is in the fact that the warp threads forming the warp knitted stitch are arranged in the same direction in all courses in the knitted fabric, making the structure of the knitted fabric uniform over its whole surface.

The knitting technique applied, which enables to produce warp knitted fabrics using machines with a cylindrical needling configuration, is novel on a global scale. Although in the 30's cylindrical knitting machines (Maratti) were manufactured for the production of warp knitted stitches, they were based on a different knitting technique, characterised by low efficiency, which caused the recalling of these machines from the market [4]. Not to mention the fact that these machines were used only for the production of warp knitting stitches, with no possibilities of forming weft-warp knitted structures.

The solution to this problem is the invention [5] of a new way of forming weft-warp knitted fabrics and a novel device for their production.
An example of a device for producing knitted fabrics with weft-warp stitches is presented in ***Figure 4***, showing a general view, and in ***Figure 5***, showing a fragment of a cross-section of the device in the axial plane of a cylindrical needle bearing.

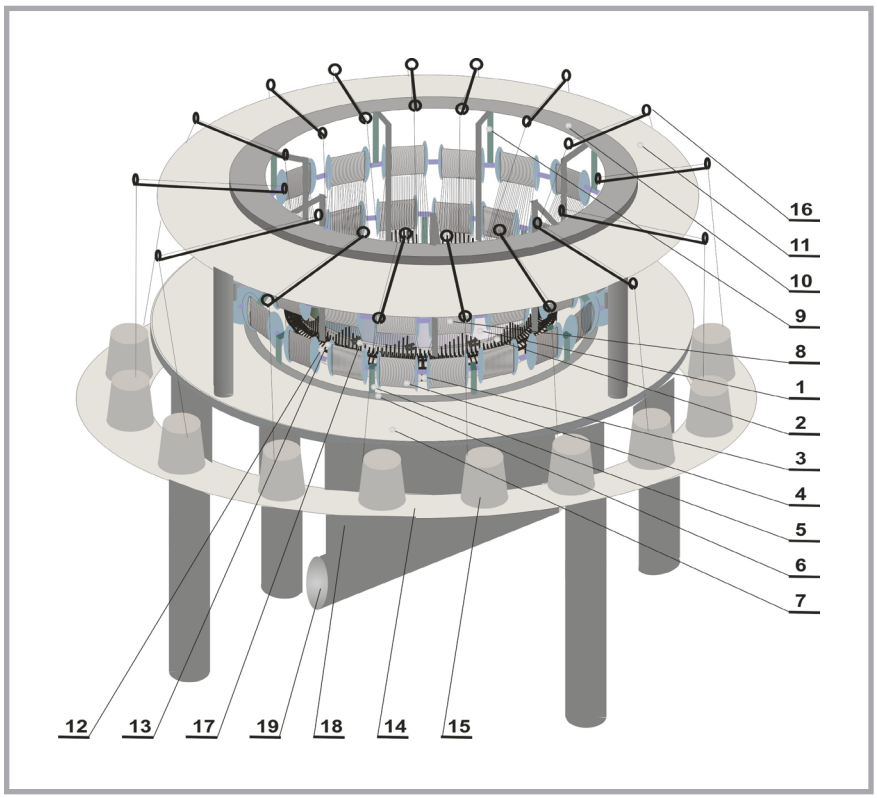

Figure 4. *General view of the machine.*

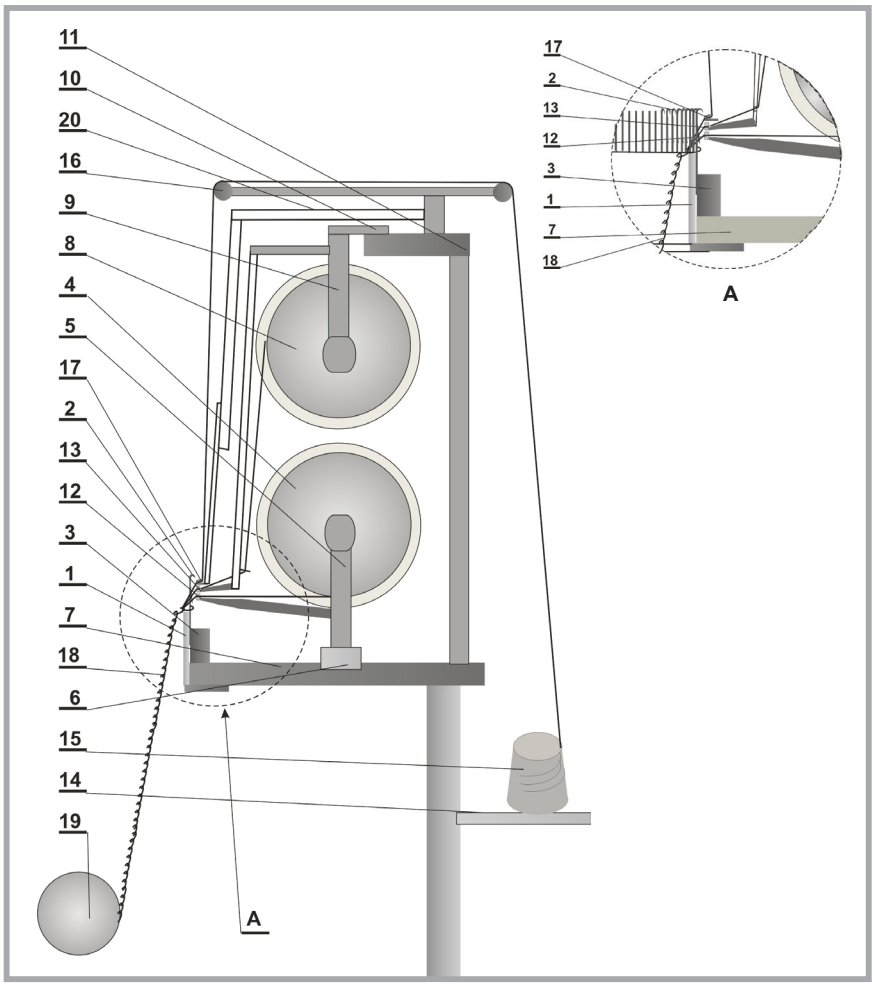

Figure 5. *Cross-section of the machine and loop forming elements presented in as fragment A.*

The needles (2) are placed on the circumference of a cylindrical bearing (1), where camboxes are acting on their butts (3). Outside of the needle bearing, a bottom warp is wound on flanged beams (4), fixed on brackets (5) and connected by a ring (6) placed on the bottom plate (7). The top warp wound on flanged beams (8) is fixed to guide bar brackets (9) connected by a ring (10) placed on the top plate (11). The needle bar (12) introducing the bottom warp threads is also fixed to brackets (5), while the needle bar (13) introducing the top warp threads is fixed to guide bar brackets (9). Bobbins (15) are placed on the base of the machine (14), and then the threads are unwound and led by the guides (16) to the thread carriers (17), introducing the threads under the needle (2) hooks. The carriers (17) are mounted on the top plate (11). A knitted fabric (18) is then wound on the beam (19).

According to the invention, the process of forming a course of loops occurs as a result of simultaneously introducing both warp and weft threads under the needle hooks, this way forming a warp knitted and a weft knitted structure. For this purpose, the needles, needle bearing, warps and needle bars introducing the warp threads move in relation to the motionless camboxes.

The warp threads running from the newly formed loops, which are behind the needles, to the needle arms placed before the needles must be introduced under the hooks of the needles in the final stage of each working space. In order to fulfil this condition, the warp threads should be introduced into the space between the needles in the first stage of each working space, whereas in the final stage, the warp threads should be introduced before the needle hooks. This is achieved thanks to a certain arrangement of the needle arm's orifice and needles, as well as to a certain relation of the speeds of the needles and the needle arms.

Therefore, the pitch of warp threads in a needle bar equals the quotient of length, on which the needles are arranged in one working space of the cambox, and the number of needles decreased or increased by a value of 1. It results from the fact that the number of orifices of the needle bars over the length of one working space is higher or lower of one orifice depending on the number of needles in one working space. An increase or decrease in the number of orifices of the needle arms depends on the direction of warp threads knitted in the fabric.

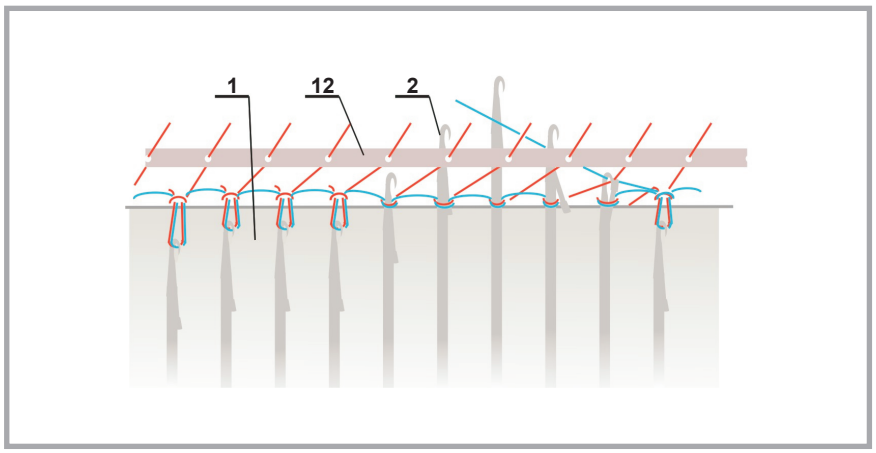

Figure 6. *Pitch of warp threads and orifices of needle arms in the working space.*

Moreover, depending on the direction of warp threads knitted in a fabric, the needle bars and warps have to move in relation to the needles, in each working space, over a length of a path bigger or smaller than one pitch of warp threads in the needle bearing.

By fulfilling the conditions mentioned above, warp threads are introduced between the needles at the beginning of the loop course forming cycle, and next the threads are wrapped around the needle shanks from the side of the hooks due to further motion of the needles and warps with regard to the cams. The process is presented in ***Figure 6***.

At the same time, threads forming the weft knitted structure are also introduced under the needle hooks. Therefore, the warp and weft threads are knitted into a fabric during the displacement of needles reaching the position in which the loops are formed.

Summary

The new technique of forming weft-warp knitted structures presented in the article enables to produce knitted fabrics of new properties, resulting from the possibility of obtaining hitherto unknown knitted structures. The structures of these knitted fabrics can be composed of a few configurations of threads running along the courses of loops and in skew directions to the line of the courses of loops. Such a configuration of threads in a stitch enables to obtain, for example, knitted fabrics of higher tensile strength and lower deformability in all directions.

The technique of forming weft-warp knitted structures with the use of adequately modified cylindrical warp-knitting machines enables to predict the high efficiency of the knitting process.

It seems that machines using this novel technique of forming weft-warp knitted structures would meet with the great interest of manufacturers of knitted fabrics due to the new properties of these knitted fabrics, which are important for traditional products as well as for new technical applications.

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