

**PRODUCTION TECHNOLOGY OF DOUBLE-LAYERED KNITWEAR**

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**Abstract**

Research on methods for producing double-layered knitted fabric with improved quality indicators, enhanced physical and mechanical properties, and reduced raw material consumption using the technological capabilities of flat knitting machines.

**Keywords:** PAN, flat knitting machine, loop, press, loop arc, double-layer, fabric structure, graphical notation.

**Introduction**

A set of measures is being implemented in the republic aimed at organizing the production of a wide range of high-quality textile, clothing, and knitwear products, localizing their production, as well as increasing the export potential of domestic manufacturers[1].

In the textile industry, tasks such as improving and enhancing the quality indicators of knitted products and expanding the product range are considered relevant. From this perspective, the development of knitted fabric theory in our country, the creation of knitted fabrics with new structures, and the achievement of optimal property indicators are being addressed through high-quality production technology.

The demand for high-quality and visually appealing knitted goods is growing day by day. Currently, knitting enterprises are equipped with a sufficient number of modern flat knitting machines. These machines offer extensive technological capabilities for producing new competitive types of products. One of the pressing tasks today is the need to reduce raw material consumption and improve the quality

of knitted products by manufacturing double-layered knitwear with a new structure, fully utilizing the technological capabilities of flat knitting machines.

Research objectives include: analyzing existing structures and methods of knitting double-layered knitwear; studying the technological capabilities of modern flat knitting machines installed at production facilities in our republic; creating new structures and methods for producing double-layered knitwear using these capabilities; and developing recommendations for production.

Several scientists, including Z. Akhmetova, S. Bayzhanova, and M. Mukimov, express the following views in their research: A known method for creating two-layer knitted fabric involves the following sequence: to simultaneously perform an incomplete operation, the front needle bed needles are raised to form open loops, while loops of the front layer are knitted on the back needle bed needles, and loops of the back layer are formed as a transverse plain stitch on the front needle bed needles. The front and back layers are connected using the open loops [2; pp. 34-40]. 34-40b].

### Materials and Methods

The structure and schematic representation of a double-layered knitted fabric obtained by connecting two fabrics with a warp yarn are shown in Figure 1. The knitted fabric consists of elongated back loops 1, front loops 2, half loops 3, and float threads 4 (Fig. 1, a).

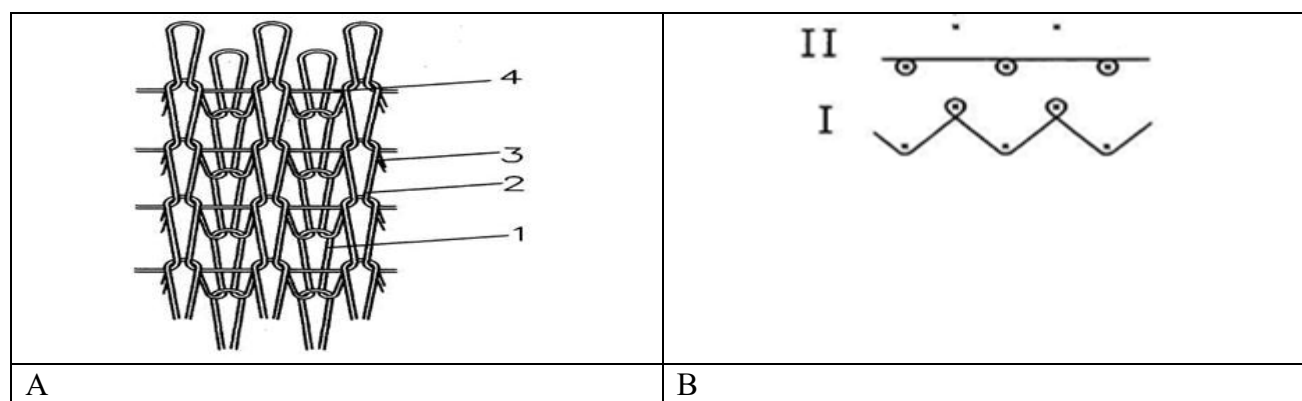


Figure 1. Structure and schematic representation of double-layered knitted fabric

The disadvantage of this method is that the resulting double-layered knit has loops protruding on the face side of the fabric, which significantly negatively affects the appearance and quality indicators of the produced fabric.

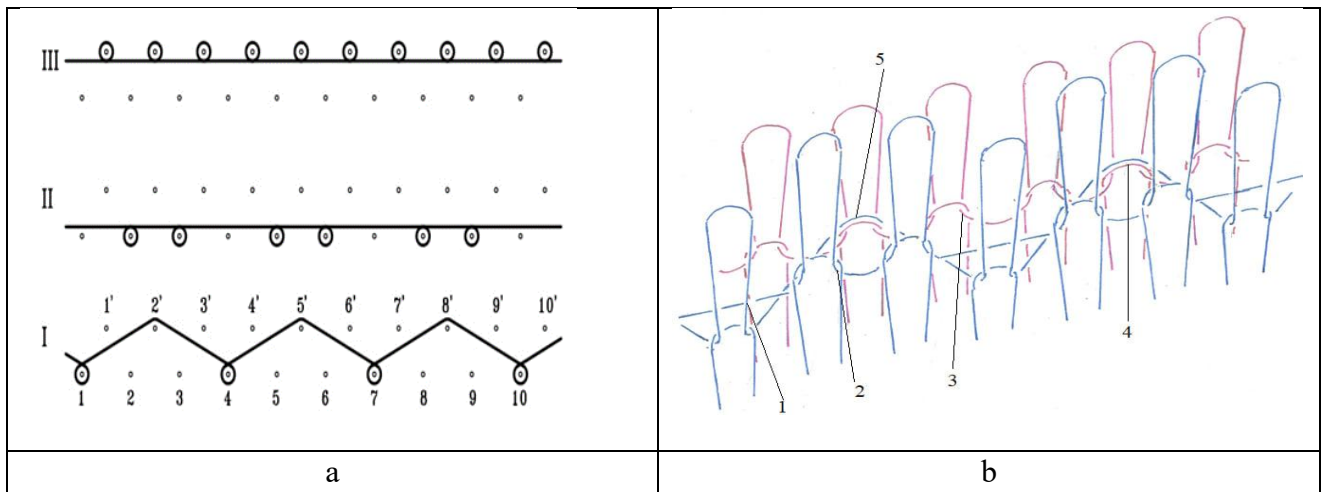
In our republic and abroad, a number of scientists are conducting research on the creation of new types of fabrics that conserve raw materials [3-12].

In order to continue research in this direction, in the laboratory of the "Textile Technology" department at the Tashkent Institute of Textile and Light Industry, 5 variants of double-layered knitted fabric samples with a new structure were produced using PAN 31\*2 yarn on the "LONG-XING" LXA-252 flat knitting machine, and their production technology was presented.

### Result and Discussion

To reduce raw material consumption and improve the physical and mechanical properties of knitted fabrics, the first version of the double-layered knitted fabric sample with a new structure was proposed.

The graphical representation of the first variant sample and the fabric structure are shown in Figure 2.



**Figure 2. Graphical representation and structure of the double-layered knitted fabric sample of the 1st variant**

Figure 2a shows that the double-layered knitted fabric consists of two separate layers. The pattern of the double-layered knitted fabric consists of one row of tuck stitches I, the second row of incomplete rib II on the front needles, and the third row of plain jersey III on the back needles.

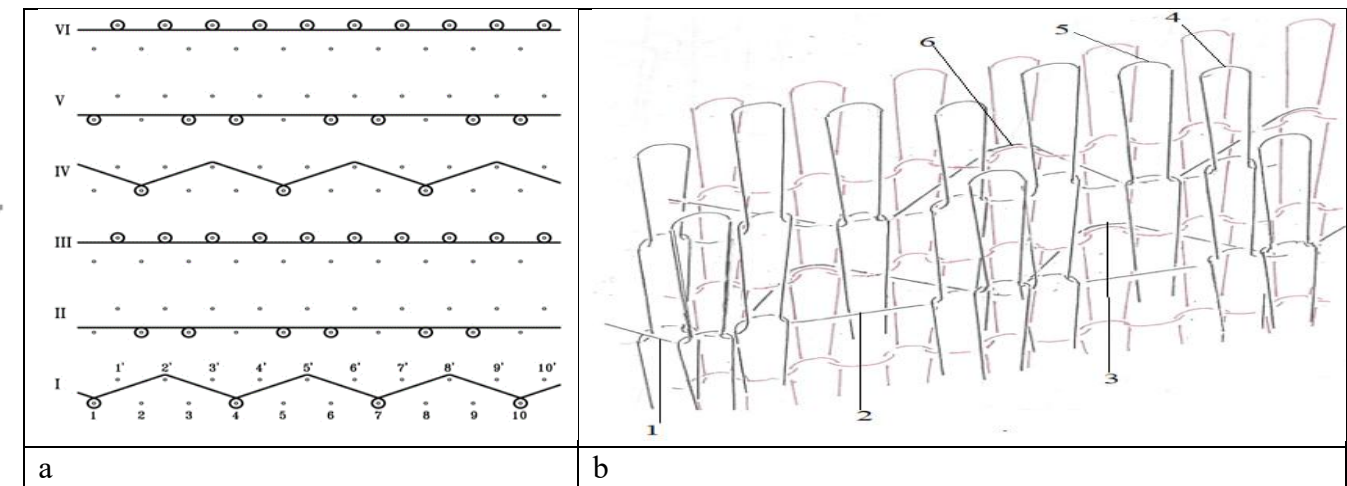
The double-layered knitted fabric, as shown in Figure 2b, consists of double-layered tuck stitch rows 1, single-layered incomplete rib rows 2, plain jersey 3, and connecting loops of 4-5 tuck floats.

The flat knitting machine for producing the 1st variant of double-layer knitted fabric sample is programmed so that when the first loop-forming system of the machine moves from left to right, needles 1, 4, 7, 10 of the front needle bed are raised to complete the formation of full loop rows, while needles 2<sup>1</sup>, 5<sup>1</sup>, 8<sup>1</sup> of the back needle bed are raised for incomplete formation, creating tuck loop rows. In the second row, in the second system of the machine, incomplete rows of plain loops are knitted on needles 2, 3, 5, 6, 8, 9 of the front needle bed. During the return of the first loop-forming system from right to left on all needles of the back needle bed, as a result of knitting plain knitted rows, the double-layered knitted fabric is connected with the tuck loop rows, as shown in Figure 2,a.

On the flat knitting machine, the reduction in raw material consumption and improvement of physical and mechanical properties were achieved by alternating the needles during the production of loop rows in the 1st variant sample.

To enhance the shape stability of double-layered knitwear, a 2nd variant of double-layered knitwear with a new structure was proposed.

The graphical representation of the second variant sample and the fabric structure are presented in Figure 3.



**Figure 3. Graphical representation and structure of the two-layer knitted fabric sample of the 2nd variant**

Figure 3a shows that the two-layered knitted fabric consists of two separate layers. It can be seen that the pattern repeat of the double-layered knit is formed as follows: the first row - press I, the second row - incomplete plain stitch on the front needle bed II, the third row - plain stitch on the back needle bed III, the fourth row - press IV, the fifth row - incomplete plain stitch on the front needle bed V, the sixth row - plain stitch on the back needle bed VI. The difference in the pattern repeat rows is that the loop rows are formed on the needles in a checkerboard pattern.

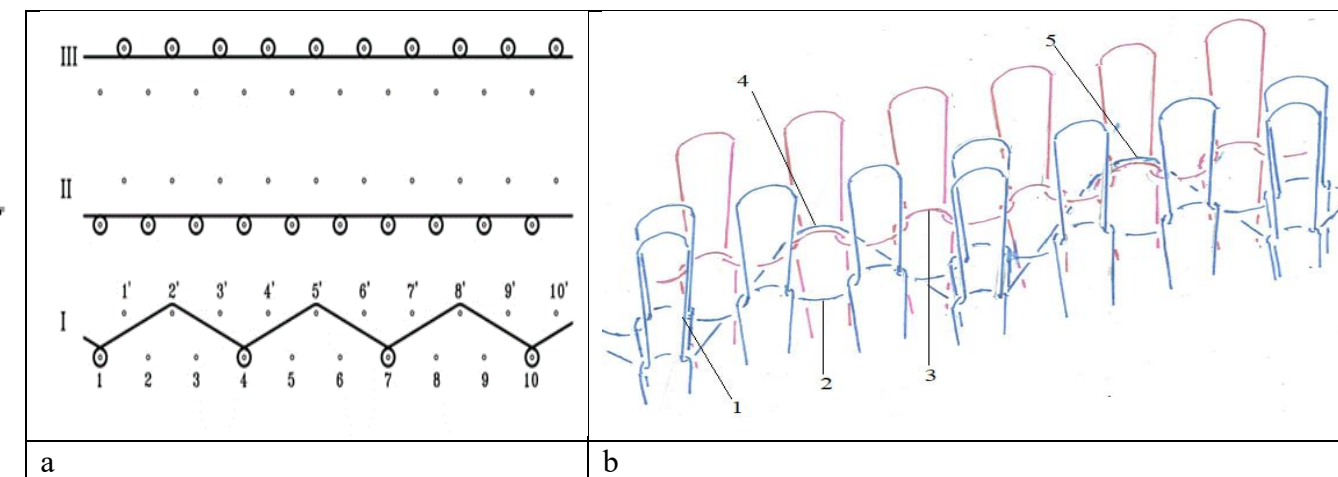
The double-layered knit in Figure 3b consists of double-layered press loop rows 1-2, single-layered incomplete plain rows 3-4, and press loop arcs 5-6 connecting the press and plain rows.

The machine for producing the 2nd variant of double-layer knitted fabric on a flat-needle machine is programmed in such a way that during the movement of the first loop-forming system from left to right, needles 1, 4, 7, 10 of the front needle bed are raised to complete the process and form full loop rows, while <sup>needles 21, 51, 81</sup> of the rear needle bed are raised for incomplete process completion and formation of a pressed loop row. In the second row, in the second system of the machine, needles 2, 3, 5, 6, 8, 9 of the front needle bed are raised for full process completion, forming incomplete rows of plain stitches. In the third row, when the first loop-forming system returns from right to left, a row of plain stitches is knitted on all needles of the rear needle bed. Rows 4-5-6 work in the same order, except that the fourth row of pressed loops is knitted on needles 2, 5, 8, and <sup>on needles 31, 61, 91</sup> of the rear needle bed, there is an incomplete completion of the pressed loop row formation process. The fifth incomplete row of plain stitches is knitted on needles 1, 3, 4, 6, 7, 9, 10, and the sixth row of plain stitches is knitted on all needles of the rear needle bed. As a result, a sample of the 2nd variant of double-layered knitted fabric with a six-row repeat is obtained, as shown in Figure 3a.

When producing the double-layer sample of the 2nd variant on a flat knitting machine, it was possible to improve the shape stability of the knitted fabrics.

In the research work, aimed at expanding the range of knitted fabrics and meeting consumer demands, a third variant of a two-layer knitted fabric sample with a new structure was proposed.

The graphical representation and weave structure of the two-layer knitted fabric sample of the third variant are shown in Figure 4.



**Figure 4. Graphical representation and structure of the two-layer knitted fabric sample of the 3rd variant**

In Figure 4a, in the first row (I) of the graphical representation, the needles of the front needle bed form complete loops, while the needles of the back needle bed form half loops, creating one row of press knit. In the second row (II), the needles of the front needle bed form plain knit, and in the third row (III), the needles of the back needle bed also form plain knit. Rows IV, V, and VI are formed similarly, with the needles alternating in a checkerboard pattern, creating a two-layer sample of the 3rd variant.

Figure 4b shows the fabric structure, where in the first row, the needles of the front needle bed form complete loops 1, and the needles of the back needle bed form half loops, creating one row of press knit. In the second row, the needles of the front needle bed form plain knit 2, and in the third row, the needles of the back needle bed form plain knit 3. The layers are connected using pressed loop arcs, forming a two-layer sample of the 3rd variant.

The loop formation process of the double-layer sample of variant 2 on the flat-bed knitting machine is programmed in such a way that, as a result of the machine's loop formation system moving from left to right, needles 1, 4, 7, 10 of the front needle bed are raised for the complete knitting process, while needles 2, 5, 8 of the back needle bed are raised for the incomplete knitting process, forming half-loops and having the ability to knit the first tuck row. The second machine system allows knitting loop rows on all needles of the front needle bed and a plain row on the needles of the back needle bed when the loop formation system moves backward from right to left, as shown in Figure 4a.

Thus, the third variant of two-layer knitted fabric with a three-row repeat is knitted with connections using tuck loops.

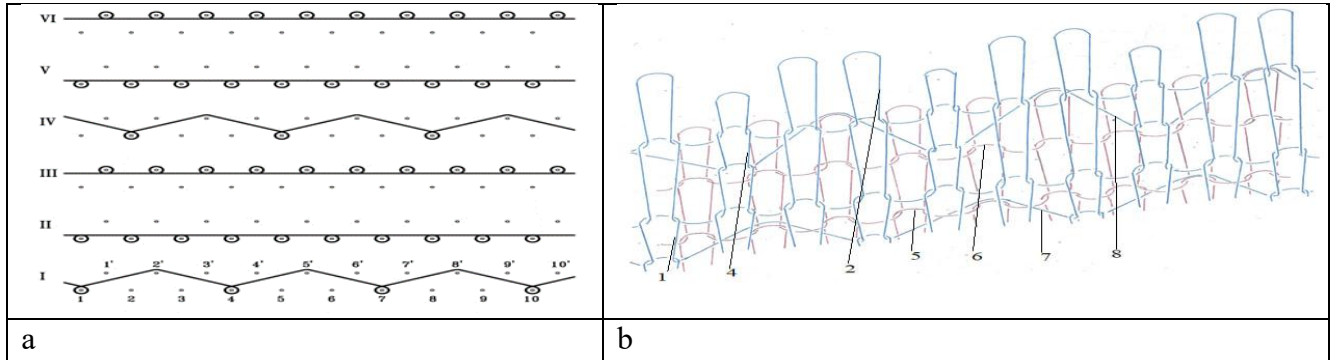
The production of the third variant sample utilizing the capabilities of the flat-bed knitting machine serves to expand the range of knitted fabrics and meet consumer demands.

In order to improve the quality indicators of double-layered knitwear, a sample of the 4th variant of double-layered knitwear with a new structure was proposed.

The graphical representation of the fourth variant sample and the fabric structure are presented in Figure 5.

Figure 5a shows that the two-layer knitted fabric consists of two separate layers. The pattern of the two-layer knit is formed from the first row of tuck stitches I, the second row of plain stitches on the front needles II, the third row of plain stitches on the back needles III, the fourth row of tuck stitches IV, the

fifth row of plain stitches on the front needles V, and the sixth row of plain stitches on the back needles VI. The difference between the rows of the pattern lies in the alternation of stitch rows on the needles in a checkerboard order.



**Figure 5. Graphical representation and structure of the two-layer knitted fabric sample, 4th variant**

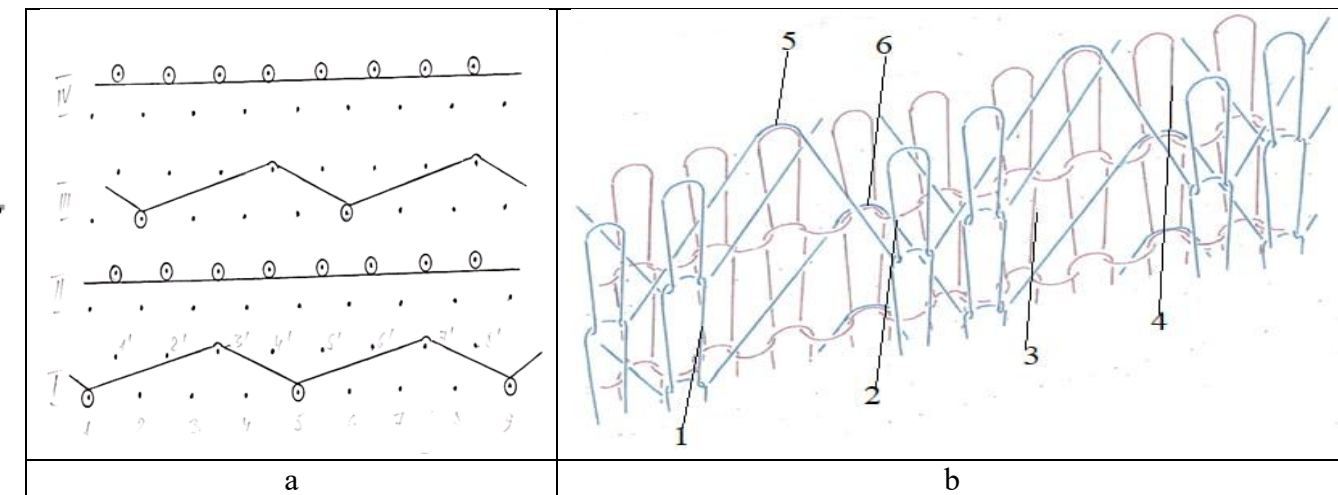
The two-layer knitted fabric in Figure 5b consists of rows of two-layer tuck stitches 1-4, rows of single-layer front plain stitches 2-5, rows of single-layer back plain stitches 3-6, and connecting tuck floats 7-8.

The machine for producing a 4-variant double-layer knitted fabric sample on a flat knitting machine is programmed in such a way that during the movement of the first loop-forming system from left to right, needles 1, 4, 7, 10 of the front needle bed rise for the final process, forming complete loop rows, while needles 2, 5, 8 of the back needle bed rise for an incomplete final process, forming a press loop row. In the second row, using the machine's second system, rows of plain stitches are formed on the front needle bed needles. In the third row, as the first loop-forming system returns from right to left, a row of plain stitches is knitted on the back needle bed needles. Rows 4-5-6 operate in the same order, except that in the fourth row, complete loop rows are formed on needles 2, 5, 8 of the front needle bed, while on needles 1, 4, 7, 10 of the back needle bed, an incomplete process occurs, forming a press loop row. As a result of knitting the fifth row of plain stitches on the front needle bed and the sixth row of plain stitches on the back needle bed, the 4th sample of a double-layered knitted fabric with a six-row repeat is produced, as shown in Figure 5a.

When producing the double-layer sample of the 4th variant on a flat knitting machine, an improvement in the quality indicators of knitted fabrics was achieved.

To reduce raw material consumption for double-layered knitwear, a 5-variant sample of double-layered knitwear with a new structure was proposed.

The graphical representation of the fifth variant sample and the fabric structure is shown in Figure 6.



**Figure 6. Graphical representation and structure of the two-layer knitted fabric sample of variant 5**

Figure 6a shows that the two-layer knitted fabric consists of two separate layers. The repeat pattern of the two-layer knitted fabric is formed as follows: first row - press stitch I, second row - plain stitch on the back needle bed II, third row - press stitch III, fourth row - plain stitch on the back needle bed IV.

The two-layer knitted fabric in Figure 6b consists of two-layer press stitch rows 1-2, single plain stitch rows 2, 4, and press stitch floats 5-6, connecting the front press stitch and back plain stitch rows.

The machine for producing the 5th variant of two-layer knitted fabric on a flat knitting machine is programmed so that when the first loop-forming system of the machine moves from left to right to knit the first row (I), needles 1, 5, 9 of the front needle bed are raised to fully complete the process and form a complete loop row, while needles 31, 71 of the back needle bed are raised to partially complete the process and form a tuck loop row. In the second row (II), a row of plain stitches is formed on the needles of the back needle bed by the second system of the machine. In the third row (III), during the return of the machine's first loop-forming system from right to left, needles 2, 6 of the front needle bed are raised to fully complete the process and form a complete loop row, while needles 41, 81 of the back needle bed are raised to partially complete the process and form a tuck loop row. As a result of knitting a row of plain stitches on the back needle bed needles in the fourth row (IV), the 5th sample of two-layer knitted fabric with a four-row repeat was produced, as shown in Figure 6a.

### Conclusion

Production of the two-layer sample variant 5 on a flat knitting machine was aimed at expanding the range of knitted fabrics and reducing raw material consumption.

The second variant of the double-layer knitted fabric sample has higher shape-retention properties compared to other samples, improved physical and mechanical characteristics, and meets quality indicators and consumer requirements.

As a result of an in-depth study of the technological capabilities of the "LONG-XING" LXA-252 flat knitting machine and further expansion of its capabilities, it became possible to produce 5 samples of double-layered knitwear. All samples are made from PAN 31\*2 tex yarn.

Connecting the layers of double-layered knitted fabric with rows of press loops using press loop arcs without modifying the mechanism and design of the flat knitting machine does not negatively affect the

machine's performance. This method of producing knitted fabrics allows for the placement of each layer of double-layered fabrics separately on the face and reverse sides of the knitwear.

The production of double-layered knit samples on flat knitting machines has expanded the range of knitted fabrics, improved quality indicators, reduced raw material consumption, enhanced physical and mechanical properties, and satisfied consumer demand.

The proposed 5 variants of double-layered knitwear samples are recommended for outerwear production.

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