PRINCIPLE OF CREATING 3D EFFECTS ON KNITTED FABRICS DEVELOPED ON ELECTRONIC FLAT KNITTING MACHINES

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Abstract. The paper relates to the basic principles of creating 3D effects on the knitted fabrics produced by using electronic flat knitting machines. The research aims at outlining the technical potential of this technology, based on examples developed on CMS 330 E5 and CMS 530 E 6.2 Stoll machines and programs designed on M1 pattern stations. The selected examples emphasise the knitted structure versatility for being used in different applications, from outerwear to technical end uses, by exploiting the unique capabilities of flat knitting machines to produce fabrics with a large variety of applications.

Key words: 3D effects, electronic flat knitting machines.

1. Introduction

Knitting is a process of converting yarn to fabric by forming a series of loops dependent on each other. Knitting technology can be used to create products with outstanding characteristics, such as: knitting to shape, great flexibility in production (geometry, shape, and yarns), controlled mechanical properties, excellent formability, stretchability [1].

Knitting to shape is an important feature of knitting technology because enables the formation of shaped fabrics in 2D and 3D dimensions. The technical features of the modern developed electronic V-bed flat knitting machines which give them the capability of manufacturing complex shaped engineering structures are [2]:

a) Electronic needle selection;

b) CAD systems with significant contribution to the design capability;

c) Quick set-up of the knitting machines and technological parameters;

d) Knitting different shapes.

1 This is the full version of the paper, presented at ISKA 2010, Volume of Abstracts
The main techniques that can be successfully applied for producing 3D knitted fabrics or fabrics with 3D effects [3] on electronic weft flat knitting machines are:
- Applications on the knitted fabrics surface;
- Knit and tuck stitches with racking technique;
- Flexible stitch technique;
- Knit and wear technique;
- Double/multilayer (sandwich fabrics);
- Wedge technique (partial knitting);
- Combination of surfaces with different structural parameters.

2. Principle of Creating 3D Effects

The 3D fabrics or fabrics with 3D effects exhibit a higher thickness, compared to the single yarn diameter. The above mentioned techniques will be described through the knitted fabrics produced on CMS 330 TC, E7 and CMS 530 E 6.2 –Stoll, Germany. The programs were designed on M1 pattern station.

2.1. Applications on the Knitted Fabrics

Applications on the knitted fabric are protruding elements, created by modern “V” bed flat knitting machines, with the contribution of the holding down sinkers to knit, without the aid of the take-down mechanism. This ability has led to the development of elaborate design elements such as ‘applications’, which can be ‘closed’ or ‘open’ as presented in Figs. 1 and 2 [4]. The principle is not new and pressing elements (sinkers) have been used to prevent ‘riding – up” on older machine types. The holding down sinkers simplified the production of protruding elements and allowed the design techniques to reach new heights. These elements are made in a continuous knitting process, without using any seams. The connection between the application and the body panel is made by knitting operation, which increase a lot the fabric quality.

![Fig. 1 – ‘Closed’ application.](image1.png)

![Fig. 2 – ‘Open’ application.](image2.png)
The principle can be applied to design pockets on the fabric, as shown in Fig. 3.

![Knitted pocket with double pipe bag and flap.](image)

Fig. 3 – Knitted pocket with double pipe bag and flap.

The quality aspect of the pocket edge is higher comparing to the cut and sewn pockets. The low raw material consumption and any additional costly hand operations are also important.

### 2.2. Knit and Tuck Stitches with Racking Technique

A pronounced 3D effect is obtained using racking technique on a fabric with cardigan structure placed differently on the fabric. The effect is given by the racking movement of the back needle bed, combined with the different position on the same row of the knit and tuck stitches, as it can be seen in Fig. 4. A more spectacular design is obtained by applying the same principle combined with Intarsia pattern with a certain number of colours (Fig. 5).

![3D effects with racking movement.](image)

![3D effects with Intarsia pattern.](image)

Fig. 4 – 3D effects with racking movement.

Fig. 5 – 3D effects with Intarsia pattern.
2.3. Flexible Stitch Technique

This technique provides 3D effect by using stitches with different dimension in the same row of areas placed on the fabric. For this, the stitch cam is modifying its position during knitting one row, and depending on the difference between stitch depths on neighbour areas, the result is more or less obvious. This principle developed with different structures is given various aspects of the fabric (Fig. 6).

![Fig. 6 - Flexible stitch technique on different basic structures.](image)

2.4. Knit and Wear Technique

In garments, complete knitting is used with the purpose of producing knitwear that provides higher quality, because the process of sewing or linking is eliminated.

![Fig. 7 - Three dimensional seamless knitted garment.](image)
The seamless garments have the advantage of a low risk of defects and damages appearing. Completely sweaters are based on three simultaneously knitted tubes for arm sleeves and body part (Fig. 7). The tubes are combined by transfer and linking operations in order to get the whole garment.

2.5. Double/Multilayer Fabrics (Sandwich Fabrics)

The structure of double layer knitted fabric comprises of two main connected by yarns transformed in tucks or loops, by various connecting points (Fig. 8).

![Double layer knitted fabrics connected by loops or tucks.](image)

The principle of a multilayer knitted fabric production is illustrated in Fig. 9. It can be seen that such an assembly consists of the outer fabrics 1 and 4, joined together by the connecting layers 2 and 3. The points A, B and C are holding together the layers, therefore are called joint points.

According to the connecting points between the outer fabrics and the connection layers or between the connecting layers, the geometry of the cross section can be modified in order to control the fabric properties for certain end uses. Three layer fabrics with horizontal, diagonal or vertical cells can be obtained (Fig. 10).

![Principle of a multilayer knitted fabric.](image)

![Three-layer knitted fabric with vertical cells.](image)
2.6. Wedge Technique (Partial Knitting)

This technique provides a 3D effect on the surface of the fabric, by creating cells, as modules disposed by different patterns. The symmetric parts of the cell (Fig. 11) are linked together by bind off technique given by the needles which were taken out from knitting and re-introduced in the opposite symmetric rows. The structure used is a single jersey structure and the fashioned lines are given by the partial knitting of the rows (Fig. 12).

![Fig. 11 – Pattern cell.](image1)

![Fig. 12 – 3D effect with wedge technique.](image2)

2.7. Combination of Surfaces with Different Structural Parameters

Using a combination of different knitted structures made from different types of yarns it can be obtained surfaces with different structural parameters.

Like in the example from the Fig. 13, the protruding effect is given by the combination of structures used in different areas of the fabric (cardigan with single jersey structure) made from an acrylic yarn with alternation of rows knitted in a single jersey structure using an elastomeric type of yarn.

![Fig. 13 – Surfaces with different stitch densities.](image3)
According to the designer technical skills, combinations of the presented individual technique can be created and fabrics with different shapes and 3D effects can be further developed.

3. Conclusions

The computer controlled electronic flat knitting machines are capable of manufacturing shaped engineering structures using its modern and flexible technical features at low manufacturing costs.

The fabrics with 3D forms, or 3D effects can be used either for outerwear or for technical destinations, with the appropriate raw materials required by destination.

The described principles can be applied on a standard knitting machine (no additional mechanisms, no additional costs). The various shapes are produced in a single stage on the knitting machine, which means:

− Simplified manufacturing process;
− High quality of the product;
− Lower costs with the machinery.

Despite of the disadvantages that may be found on achieving these types of 3D forms or 3D effects (possible high knitting time for complex shapes, difficult programming and design stage) the products have large possibilities of diversification, by:

a) Engineering their thickness;
b) Developing different structure and opacity independently on either faces;
c) Filling the space between the two outer fabrics, with materials;
d) Designing the cross section geometry [6].

The presented fabrics have a large potential that can be exploited as well for designing products with controlled properties for technical fields, such as: medicine, composites for buildings, protective equipments.

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REFERENCES

PRINCIPIII DE REALIZARE A EFECTELOR 3D ÎN TRICOTURI PRODUSE PE MAȘINI RECTILINII DE TRICOTAT

(Rezumat)

Lucrarea prezintă principiile pentru realizarea efectelor 3D în tricoturi produse pe mașini rectilinii de tricotat electronice. Scopul lucrării este de a sublinia potențialul tehnic al acestei tehnologii, utilizând exemple de tricoturi produse pe mașini Stoll CMS 330 E5 și CMS 530 E 6.2, programele fiind realizeate pe o stație M1. Structurile alese ilustrează versatilitatea acestora din punct de vedere al destinației, de la produse de îmbrăcăminte la aplicații tehnice, versatilitate sprijinită de diversitatea de tricoturi care pot fi produse pe mașini rectilinii de tricotat.