

# Development of a Weaving Method for Spatial Two-Layer Innovative Structure Linen Fabric

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## Abstract

During the global technological progress, including in the textile field, it has become necessary to look for innovative solutions to make fabric designs that can be characterised by special texture and relief, as well as opportunities to create them with modern weaving looms. Most commonly, such innovative fabric structures can be woven by using several different methods, and sometimes by several weaving looms of different designs and uses. Thus this article provides an introduction and thorough analysis of two weaving methods used to weave such linen fabrics of innovative structure by modern computerised looms of different types and designs: the terry gripper weaving loom Smit GS940F and smooth fabric gripper jacquard weaving loom Dornier PTS 6/J C. In both cases the structure effects of those fabrics were rather similar. Most fabric properties are better for the fabrics woven by the second technique. For that kind of fabric structure it is therefore advisable to use the second weaving method, i. e. the smooth fabric gripper weaving loom Dornier PTS 6/J C. Smooth fabric looms are more versatile, and they do not require a set of specific complex mechanisms that are usually used on a terry gripper weaving loom.

**Key words:** innovative fabric structure, modern weaving loom, spatial fabric relief, fabric properties.

## Introduction

In Lithuania, the main fabric structure researchers are V. Milašius, R. Milašius, A. Milašius, E. Kumpikaitė, and Ž. Rukuižienė [1 - 5]. They have mainly analysed fabric weaves and their design problems, theoretical fabric models and their links with design, composing techniques for plans of weave, automated fabric design systems, and fabric structure links with their properties. However, studies of these scientists are more theoretical, connected with theoretical fabric models, single-layer fabric weaves and their simulations, as well as theoretical principles of making weaves. Meanwhile in this article the practical implementation of these theoretical principles by way of creating a realistic and innovative structure of two-layer expressive specific relief fabric is more relevant. Weaving techniques and their design possibilities have also been investigated by foreign scientists: D. Goerner [6], M. Selby [7], E. Drude [8], J. Wilson [9], J. L. Larsen [10], N. A. Hoskins [11], J. Shenton [12], A. Richards [13] and so on. All of them have analysed the weaves of classic and distinctive structure fabrics, their weaving principles, fabric weave and color matching issues, the coordination between various combinations of fabrics, links between fabric structure and texture, and similar questions. From these

authors' works one can get inspired by ideas for developing innovative structure fabrics; however, their implementation options, intended fabric textures and innovative structures will be different.

Paying attention to the fashion trends presented at the home textile exhibition "Heimtextil", we can see that the fabrics in which unity of science and beauty are connected are topical. The hand, spatial texture and sense of textile are also very important. Thus it is relevant to look for new woven fabrics structures which can give spatial effect, expressive relief and texture of the fabric [14].

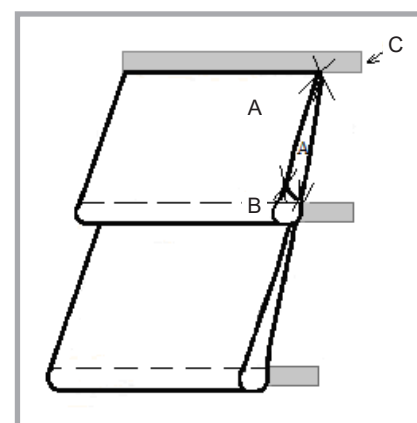
Hence during the global technological progress, including the textile field, it has become necessary to look for innovative solutions to make fabric designs that can be characterised by special texture and relief, as well as opportunities to create them with a modern weaving loom. Such fabric design problems are especially relevant for both modern fabric textile company employees and designers. Since in most cases the development of the fabric structure effects desired can be obtained by several different methods, therefore conveying the designer's ideas, by selecting the best way for the structure implementation desired, is very important. Recent textile trends show the prevalence of natural fibers and colours, as they are ecological, environmentally- and human-friendly, which is highly appreciated in today's industry. Thus natural fiber yarns will be also used for the anticipated production of new fabric structure. The objective of this research was to obtain a

spatial two-layer structure of linen with two different methods and modern weaving looms, and to choose a better, simpler and more expressive solution to produce such structured fabric.

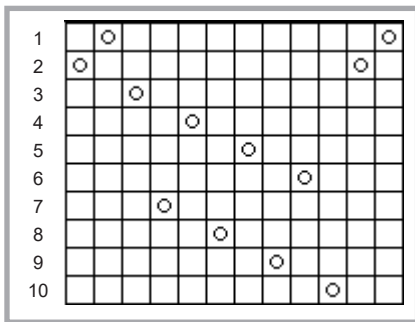
## Methods

Thus an innovative spatial structure of a two-layer linen fabric was obtained in two different ways using highly different modern industrialised weaving looms: a terry gripper weaving loom Smit GS940F (Italy) and smooth fabric gripper jacquard weaving loom Dornier PTS 6/J C (Germany). Different fabric formation ways and opportunities of these weaving loom are essential.

Using method No. 1, spatial two-layer innovative structure fabrics were wo-



**Figure 1.** Structure scheme of spatial two-layer innovative structure fabric, woven by a terry gripper weaving loom.



**Figure 2.** Scheme of warp drawing-in into heald shafts; fabric woven by a terry gripper weaving loom.

ven from single wet spinning long fibre linen yarns 56 tex by a terry gripper weaving loom *Smit GS940F* at the JSC “A group” (Lithuania). The warp setting was 240 dm<sup>-1</sup>. Different fabric parts had different weft settings. The weaves of the face and back layers were plain.

**Figure 1** shows the structure scheme of a spatial two-layer innovative structure fabric. Part A shows the woven ground and face part of the wave. The two separate layers are woven. In this part the weft setting for both layers is 200 dm<sup>-1</sup>. In part B the upper wave closing is woven until a connection point is reached, i. e. only the face layer of the fabric is formed. In this part, the weft setting is 100 dm<sup>-1</sup> (for the face layer only). Part C is the connection of the two layers. Only one fabric layer is woven; the terry gripper weaving loom fully beats up the wave that was formed in the face layer of the fabric. In this layer, the fabric warp and weft form a layer where the weft setting is 200 cm<sup>-1</sup>. This fabric structure can only be formed by a terry gripper weaving loom that has

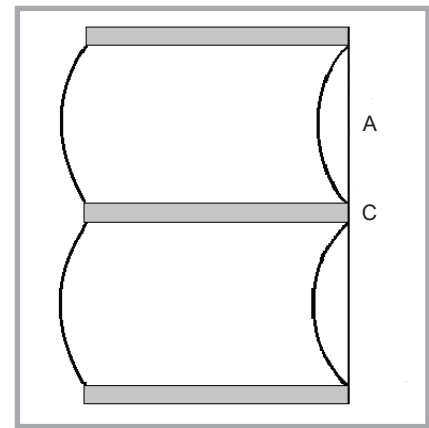
the function to incompletely beat up the weft.

By using a grouped draft, the warp of the fabric was drawn-in into eight heald shafts. A schematic view of the draft drawing the fabric warp into heald shafts is shown in **Figure 2**. As can be seen from the scheme, the first two heald shafts are allowed for the selvages, which are formed by rib weave in a single layer. The face layer warp of the fabric is drawn-in into the heald shafts of the first group (3-6 heald shafts). The back layer warp is drawn-in into the heald shafts of the second group, i. e. 7-10 heald shafts. Thus the number of heald shafts required for this woven fabric is 10 at least. The fabric weave cards are shown in **Figure 3**.

The two-layer weave of fabric that was woven by the terry gripper weaving loom was plain. The warp layer ratio in the two-layer part was 1 face, 1 back warp. The weft layer ratio in the two-layer part was 2 face, 2 back weft.

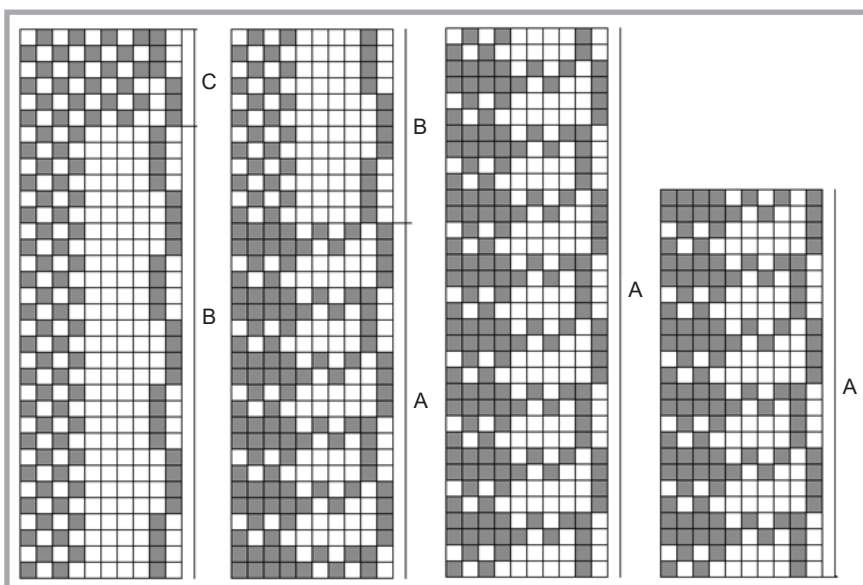
Another spatial two-layer fabric was woven at JSC “Lincasa”, Kaunas district, by a smooth fabric gripper jacquard weaving loom *Dornier PTS 6/J C*, with 50 tex linen single yarns in the warp and 38 tex linen wet spinning long fibre single yarns in the weft. The warp setting was 210 dm<sup>-1</sup>, and the weft 330 dm<sup>-1</sup> (for both fabric layers).

The fabric structure of fabric No. 2 is presented in **Figure 4**, where it can be seen that this fabric has a spatial two-layer structure, which was the result of the face

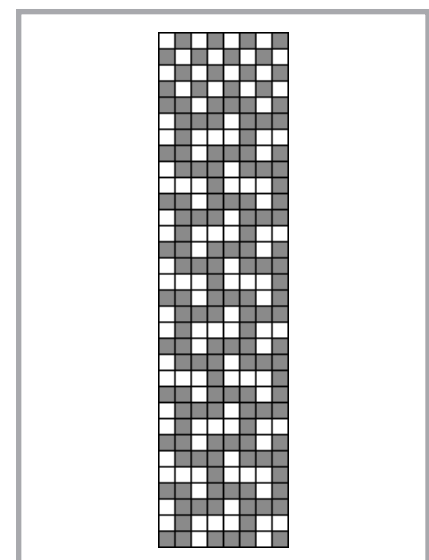


**Figure 4.** Structure scheme of spatial two-layer innovative structure fabric woven by a smooth gripper weaving loom

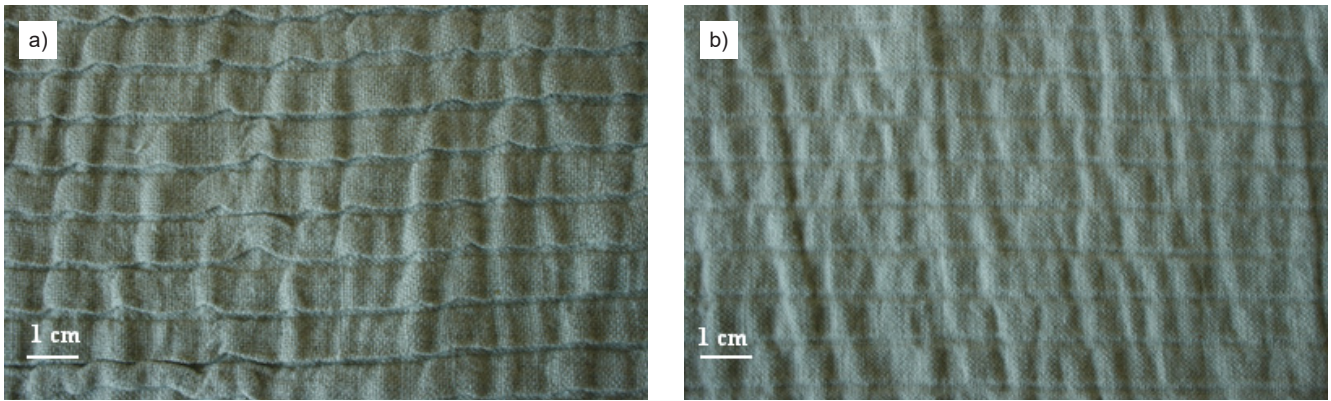
layer being longer than the back (part A). The weft setting of the face layer was 220 dm<sup>-1</sup> and the warp setting of the back layer 110 dm<sup>-1</sup>, i.e. the weft setting in the face layer was twice higher than that of the back, which was obtained by choosing the appropriate ratio of weft yarn layers in part A (**Figure 4**). The weft yarn layer ratio was 2 face yarns and one back. Through both layers, fabric “waves” are connected with a plain weave in part C (**Figure 4**). The weft setting in this part was 330 dm<sup>-1</sup>. The warp yarn layer ratio was 1 face yarn and one back. Both the face and back fabric layers were also woven in plain weave, but due to the said selected ratio, the face layer was longer than the back. The fabric weave is shown in **Figure 5**, from which it can be seen that both fabric layers in part A (**Figure 4**) were woven in plain weave and in different yarns ratios in the warp and



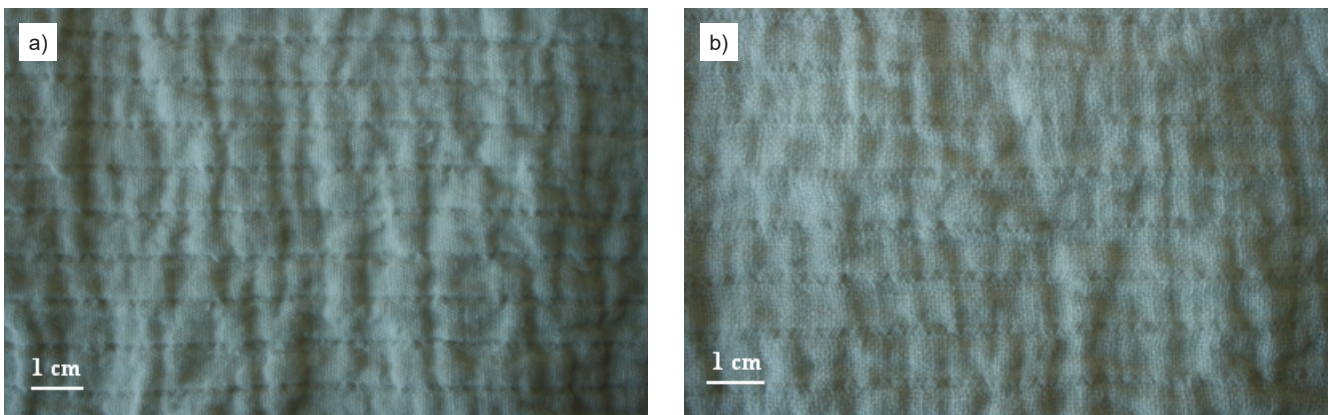
**Figure 3.** Card scheme of fabric woven by a terry gripper weaving loom.



**Figure 5.** Weaving scheme of fabric woven by a smooth loom.



**Figure 6.** Image of fabric woven by a terry gripper weaving loom: a – right side; b – left side.



**Figure 7.** Fabric, woven by a smooth fabric weaving loom: a – right side; b – left side.

weft. Also all the face warp must be lifted when the back weft is inserted.

Since the fabric is woven by a jacquard loom, warp drawing-in into the heald shafts is not presented, and the weave cards correspond with the fabric weaving scheme.

The main difference between the two weaving techniques suggested is that in the second technique there is no part B in **Figure 4** in comparison with **Figure 1** of fabric structure No. 1. That fact is also seen in the weave schemes in **Figures 3** and **5**. From **Figure 3** it can be seen that in part B only the face layer of the fabric was woven, whereas in the second technique two fabric layers were always woven together, as shown in **Figure 5**, which is the main difference of the two weaving techniques presented.

The surface mass of the cut samples was established in accordance with international standard ISO 12127. Fabric samples were weighted by an EW 150-3M electronic balance (Kern & Sohn GmbH, Germany).

Fabric tensile tests were carried out in accordance with international standard ISO

13934-1 [15], at standard environment conditions (temperature of  $20 \pm 2$  °C and relative humidity of  $65 \pm 2\%$ ), with the use of a Zwick/Z005 standard tensile testing machine (Switzerland). The stretching speed was 100 mm/min and the distance between clamps 200 mm.

The yarns were tested on standard test equipment using standard test methods. The abrasion resistance of fancy yarn fabric samples were established on a Martindale Abrasion and Pilling Tester MESDAN-LAB, Code 2561E (SDL ATLAS, England), in accordance with the standard ISO 12947-2.

The fabrics were conditioned at a temperature and relative humidity of  $20 \pm 2$  °C and  $65 \pm 2\%$ , respectively, as specified in the standard ISO 139:2005.

## Results

Two different spatial two-layer innovative structure fabrics were woven by two basically different methods using a weaving loom of different construction and weaving methods: a terry gripper weaving loom *Smit GS940F* and smooth

fabric gripper weaving loom *Dornier PTS 6/JC*.

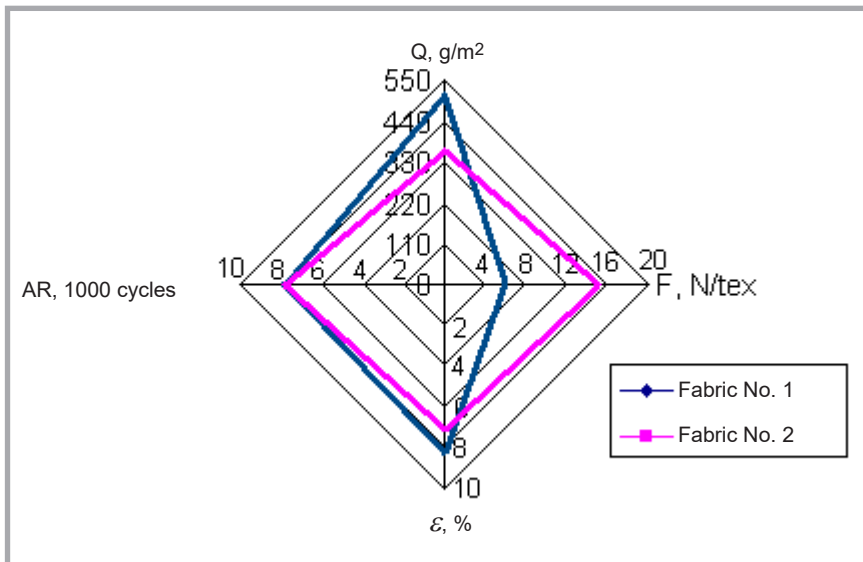
An image of fabric No. 1, woven by the terry gripper weaving loom, is shown in **Figure 5**. It can be seen that the fabric has an expressive relief, with face layer formed from expressed fabric “waves”. The back fabric layer is significantly shorter than the face.

**Figure 6** shows the fabric woven by the smooth fabric weaving loom. It appears that the fabric is similar to that woven by the terry gripper weaving loom; however, the fabric relief is slightly less expressive.

The second method showed a similar fabric structure effect. The smooth weaving loom is more versatile and, compared with the terry gripper loom, has a simpler construction – as they do not contain certain special-purpose complex machinery, which is essential for the purposes of the terry gripper loom and formation of specific terry fabric structures.

However, choosing fabrics only by their appearance is not enough: The fabric properties are important as well. Fabrics of innovative structure will be used as interior fabrics. Hence the important fabric





**Figure 8.** Graph of main properties of fabrics No. 1 and No. 2:  $Q$  – area density,  $F$  – specific breaking force,  $\varepsilon$  – specific elongation at break,  $AR$  – abrasion resistance.

properties are tensile strength, extensibility, and abrasion resistance. Despite high values of these properties, low area density is required. Thus an optimal case for the fabric structure and its properties should be found. For this reason the fabrics were weighted and tensile and abrasion tests performed for them (Figure 8).

Investigation of fabric tensile properties showed that both fabrics broke on the left side first, which is understandable because the back layer is tenser than the face layer. Values of the specific breaking force of fabric No. 1 was 6.17 N/tex and that of fabric No. 2 – 15.78 N/tex (Figure 8). The specific elongation at break of fabric No. 1 was 8.19 % and that of fabric No. 2 – 7.24 %. Hence fabric No. 2 had much higher strength and a little lower extension than fabric No. 1, despite the lower linear density of yarns in fabric No. 2. The abrasion resistance of both fabrics was high and the same in both fabrics, i.e. the fabrics withstood 80000 abrasion cycles. Also the area density of both fabrics was established. The area density of fabric No. 1 was 515.7 g/m<sup>2</sup>, and that of fabric No. 2 – 387.1 g/m<sup>2</sup>. It can be seen that this parameter is also better for fabric No. 2. Consequently analysis of the properties of both fabric structures showed that all properties of fabric No. 2 are better or the same than those of fabric No. 1. The structural parameters were higher for fabric No. 1, but properties of this fabric were worse. Thus, it can be stated that the structure of this fabric is worse than of fabric No. 2. This is the reason for choosing of the structure of fabric No. 2 as a better one.

Both of these techniques of spatial two-layer fabrics are new and they have no prototypes in contemporary textile. Thus, it is not possible to compare them with earlier fabrics woven in a similar way.

It should be highlighted that the purpose of this article is to present only two different weaving techniques for two-layer fabrics, but the creation of a pattern in these new structures also has many possibilities, which will be analysed in the near future.

## Conclusions

- It was found that a two-layer spatial fabric structure can be obtained in two ways: by means of a terry gripper weaving loom *Smit GS940F* and smooth fabric gripper weaving loom *Dornier PTS 6/J C*.
- When weaving by means of a terry gripper weaving loom, the innovative structure fabrics obtain a stronger/more expressive relief than by weaving them on a smooth fabric gripper weaving loom.
- The tensile properties, abrasion resistance and area density were better or the same for fabric woven by the smooth fabric weaving loom.
- Since both methods create a similar effect on the woven fabric structure, but properties of fabric No. 2 (woven by smooth weaving loom) are better, it is recommended to create the innovative structure of fabric e by means

of the smooth fabric weaving loom *Dornier PTS 6/J C*.

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## References

1. Milašius V. An Integrated Structure Factor for Woven Fabrics. Part I: Estimation of the Weave. *Journal of the Textile Institute* 2000; 91, 1, 2: 268-276.
2. Milašius V. An Integrated Structure Factor for Woven Fabrics. Part II: The Fabric-firmness Factor. *Journal of the Textile Institute* 2000; 91, 1, 2: 277-284.
3. Milašius A, Milašius V. New Representation of the Fabric Weave Factor. *Fibres & Textiles in Eastern Europe* 2008; 16, 4(69): 48-51.
4. Malčiauskienė E, Milašius A, Milašius R. Weave Factor for Seam Slippage Prediction of Unbalance Fabrics. *Fibres & Textiles in Eastern Europe* 2011; 19, 4(87): 101-104.
5. Rukuižienė Ž, Kumpikaitė E. Investigation of Initial Warp Tension and Weave Influence on Warp Yarn Diameter Projections. *Fibres & Textiles in Eastern Europe* 2013; 21, 5(101): 43-48.
6. Goerner D. *Woven Structure and Design. Part 2 – Compound Structures*. Ed. British Textile Technology Group, Leeds, 1989, p. 140.
7. Selby M. *Color and Texture in Weaving, 150 Contemporary Designs*. Ed. Interweave Press, Loveland, 2011, p. 144.
8. Drudi E. *Fabric Textures & Patterns*. Ed. The Pepin Press, Amsterdam, 2008, p. 352.
9. Wilson J. *Classic and Modern Fabrics. The Complete Illustrated Sourcebook*. Ed. Thames & Hudson Ltd, London, 2010, p. 320.
10. Larsen JL. *Material Wealth. Living with Luxurious Fabrics*. Ed. Abbeville Press, New York, 1989, p. 240.
11. Hoskins NA. *Weft-Faced Pattern Weaves. Tabby to Taquete*. Ed. Schiffer Publishing Ltd, Atglen, 1992, p. 352.
12. Shenton J. *Woven Textile Design*. Ed. Laurence King Publishing, London, 2014, p. 224.
13. Richards A. *Weaving Textiles that Shape Themselves*. The Crowood Press Ltd, Ramsbury, 2012, p. 192.
14. Experience, Heimtextile Trends, 2015.

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