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New Approach to the Designing of Curtains – Decorative Multilayer Woven Structures

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Abstract
Special conditions of applying curtain fabrics, i.e. vertical hanging and lightening with transmitted light, require a different approach to designing. It was found that weaving patterns can significantly affect the continuity of the structure, particularly in the pattern area. In such cases, the effect of patterning may be disturbed by the light transmitted through uncontrolled clearances of a fabric. The study identifies the need to modify the structure, based on basic knowledge of the geometry of a fabric's structure. A repair system aided by an original computer program was developed on such a basis. The method was validated for structures with a stratified system of thread that were produced with a Picanol rapier loom. For the purposes of results presentation, ImageJ software for computer image analysis was used.

Key words: *curtains, multilayer fabrics, woven structures, geometry of fabric's structure, weaving structural modules (SMS), clearances, computer image analysis.*

Introduction

Many researchers and practitioners have been engaged in the subject of the purposeful designing of textiles, especially in cases of special applications. Purposeful designing remains in close connection with the practical application of a product in an industry. It aims to solve technical problems actually occurring during manufacture or the process of use. This is the response of science to the needs of industry.

The assortment of decorative fabrics designed for use in window spaces demands the adaptation of the design process to the specificity of that area. This work presents reflections on the conditions of a light that streams through and its impact on the perception of the effect of patterning in curtain fabrics made with the jacquard technique. The research work was carried out on samples of fabrics made with the technology of a stratified system of weft threads. It was found that the process of patterning induces structure discontinuities (clearances) that could negatively affect the feeling of an observer. In fabrics of complex design, there are greater opportunities to modify the structure [1]. The task of the designer is to qualify such places for defects and consequently repair them. Knowledge of the structural design of fabrics, including the geometry of the structure, allows to recognise the specific areas in the fabric, and to describe them with the basic weaving structural modules (SMS). Optical characteristics of each module are known. S. Becker [2] presented a graphical form of the basic structural modules as early as in 1951. Then he studied the impact of their structures on the porosity of woven constructions. In Poland, Szosland [3], and then Dulęba-Majek [4] studied the geometry of the structure of fabric. Next in the paper there is a proposal of the elimination of defective modules from the structure of a fabric within the place of patterning. For this purpose a computer program was created as a tool to support the process of repairing curtain jacquard fabrics.

Experiments

Materials for the research

Due to their application, curtain fabrics must have two equivalent qualities: aesthetic - decoration and functional - and limiting the amount of light in the room. The use of curtains is inseparably connected with the decoration of an interior, building a mood, and with a sense of security. The following saying is in use - "interior dressed in fabrics" [5]. Their importance in interiors of public utility is being emphasised. Reputable hotels often owe their success to fabrics [6]. Fabrics intended for window decorations and other decorative fabrics make interiors more attractive thanks to a properly selected design, and above all they determine the individual character of an interior.

The second function - reducing the impact of solar radiation - affects use comfort during both work and leisure. It belongs to the category of the user's basic requirements.

The study highlights the need to assess the patterns of curtain fabrics under real conditions of the fabric's functioning, ie. vertical suspension with low workload, as well as transmitted light. Three cases of patterning were analysed: striped, ornamental and nonfigurative. Three artistic designs were produced based on the same fabric structure with a triple stratified weft, modelled on the basis of satin weaves in accordance with the principles of creating complex weaves and the correctness of the weaving process [7, 8]. Polyester multifilament yarn was used for the weft and warp: weft 167/48, warp 167×2/48. The process of weaving was performed on a Picanol GAMMA 8-J rapier loom (Belgium). Pictures of fabrics views were taken under actual use conditions, at a distance of 30 cm from the window glass, with the fabrics in vertical suspension.

It was observed that under conditions of light streaming through the object, an additional effect of patterning with the light appears. Glowing points associated with each of the patterns are observed. The perception of such points varies and depends on the artistic design of a fabric. In this situation, the question arises: Does this phenomenon enhance the effect of patterning, or rather spoils it. If the impact is negative, then it is difficult to eliminate by known standard methods. Accidentally the contour of the pattern could be unintentionally destroyed, which leads to an adverse result. The role of the perception of light pattern was highlighted [9]. The human brain interprets an arrangement of points in space in the manner it has learned from earlier experience. It

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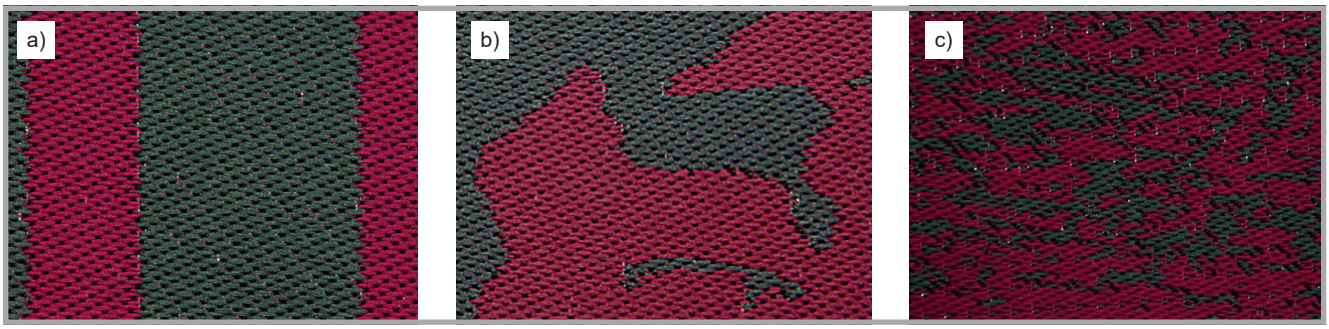

Figure 1. *View of curtain fabrics of various artistic designs: a) striped, b) ornamental, c) nonfigurative.*

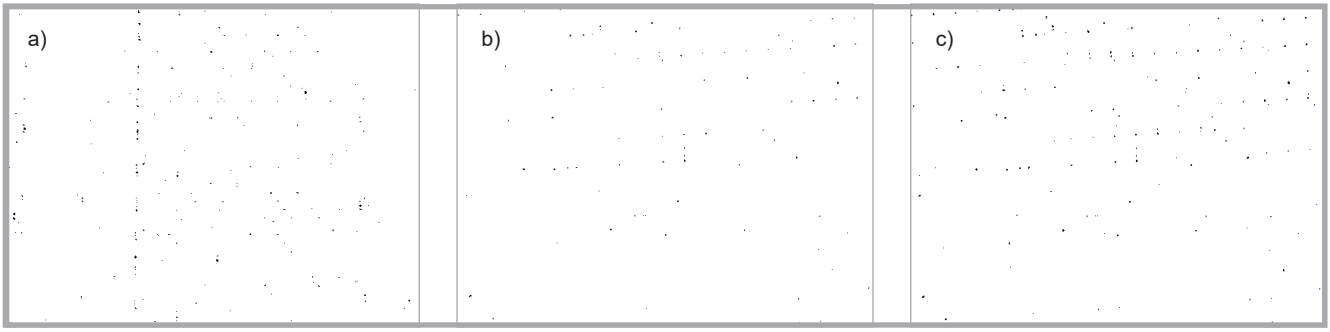

Figure 2. *View of the clearances that appear in the fabric's structure; a) sample of S1 fabric, striped pattern; b) sample of S2 fabric, ornamental pattern; c) sample of S3 fabric, nonfigurative pattern.*

Table 1. *Summary of the results of digital image analysis based on the number, size and total area of the clearances, and the percentage of the clearances in the S1, S2 i S3 fabrics structures.*

Sample	Number of clearances, pixels	Total area of clearances, pixels	Mean size of clearances, pixels	Area of clearances, %
S1	111	260	2.342	0.111
S2	133	291	2.188	0.125
S3	180	568	3.156	0.244

associates the sequences appearing and replays recorded images. It could therefore lead to a situation where the random effect would be more noticeable than it actually is. It should be emphasised that the sense of vision is intrinsically linked with the presence of light, the occurrence of contrasts and interpretation of images by the human brain. Thus, in darkened room conditions, a greater role will be played by the light pattern than the actual colour pattern. This phenomenon is also conditional upon the specifics of the scotopic view, ie. night vision

Methodology of the research

On the basis of fabrics photographs shown in ***Figure 1***, computer analysis of the fabric structures was performed. It is a tool well known today to analyse the morphology of the structure of textiles [11]. ImageJ - a widely available computer program - was used. Processing was performed on the basis of simple functions, i.e.: conversion to the greyscale, brightness and contrast balance, and thresholding. This way, the clearances were extracted from the fabric's structure. The result is shown in ***Figure 2***.

Then, continuing the image analysis, the structural characteristics of the clearances were defined. The results are shown in ***Table 1***.

Quantitative analysis indicated objectively the difference between the fabrics. According to the methodology applied, the worst recorder results were for the abstract pattern. However, this result does not confirm the subjective interpretation. The clearances occurring in the fabric with a striped pattern were the most noticeable and irritating. Therefore a contradiction between the objective analysis and subjective feeling is proof that scientific research should take place with regard to the interpretation by the observer. The patterns that generate a string of repetitive clearances are the most unfavourable. In the subjective evaluation, the weakest impact of clearances is noticeable in the nonfigurative or irregular patterns. Then an impression is possible where the clearances create a desired effect to support the design of curtain fabrics.

However, if we consider the unintended patterning defect, an attempt to repair it is necessary. Such activities, if possible, should consist in the complete removal of the defect or making it less noticeable. At the Institute of Architecture of Textiles of Lodz University of Technology, in cooperation with the University of Information Technology and Skills in Lodz, a method and software were developed for the elimination of disruptions in fabric structures.

The Picanol loom has an interface to read the design of a fabric pattern from files of the JC5 format. A view of a modern pattern card in digital form is shown in ***Figure 3***.

It is a collection of data in the 0-1 system, where 0 means weft coverage (clear field) and 1 means warp coverage (colour-highlighted). Backer [2] was the first

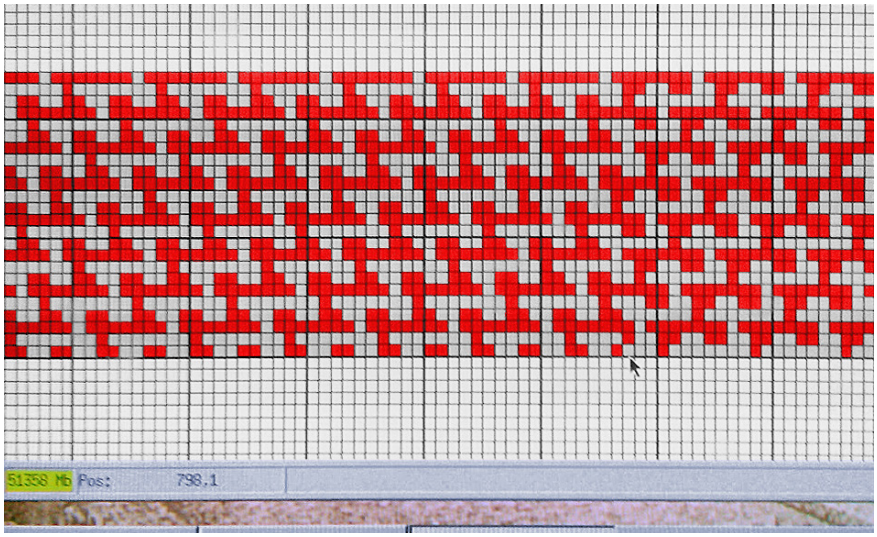

Figure 3. *Project window and view of pattern card in Sophis Socrates Jacquard software.*

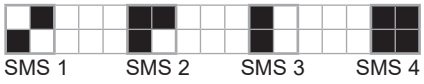

Figure 4. *Weaving structural modules in the weaving notation.*

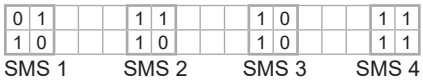

Figure 5. *Weaving structural modules in mathematical 0-1 notation.*

to prove that each weave of a fabric can be schematically recorded with the four basic structural modules only (***Figure 4***) or simple modifications of them (by rotation).

Continuing the deliberations on the geometry of the structure of a fabric, we can establish a mathematical approach to fabric weave. Since the structural modules are composed of only weft and warp coverings, they can be written in a mathematical 0-1 system, as illustrated in ***Figure 5***.

Presenting the weave of a fabric as mathematical modules creates data for subsequent computer processing. The resulting sheet data is editable. Editing the pattern card can take place only in a dedicated program compatible with the loom, such as Sophis Socrates Jacquard. At the first stage of the corrective action it is necessary to convert the JC5 file into a file of the BMP graphic format. For this purpose the program ArahPaint 5.0 was used. The result of these initial steps is shown in ***Figure 6***.

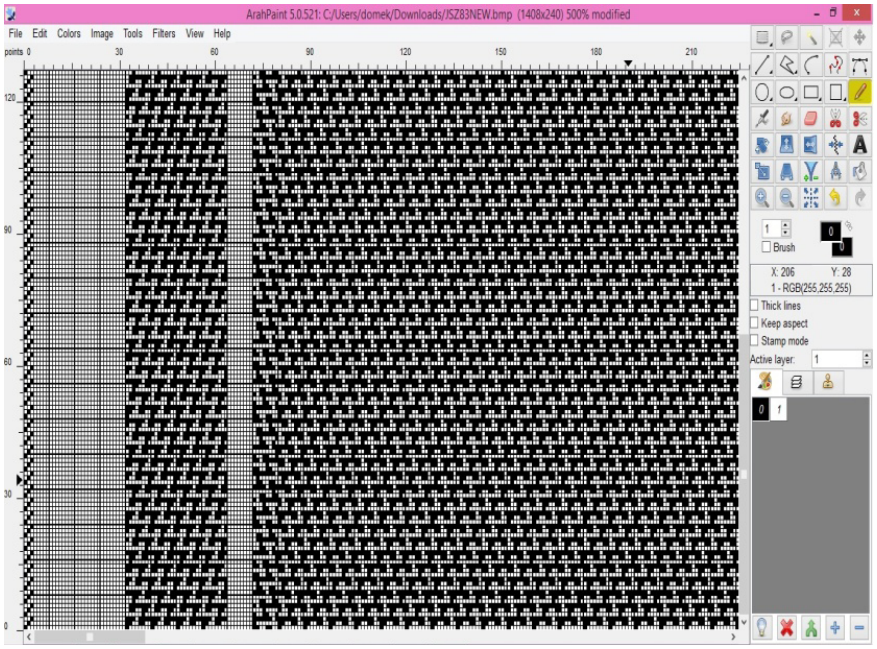

Figure 6. *ArahPaint software window after conversion of a JC5 file into the BMP format.*

Transformation of the fabric weave into mathematic modules creates data for further computer processing. The resulting data sheet allows identification of errors in the weave of fabric and their elimination at the stage of designing.

At the subsequent stage, faulty configurations of threads were identified by assigning them appropriate structural modules. Thorough microscopic analysis of clearances was performed. Within three patterns the same flaw was identified. Views of the fabrics are presented in ***Figure 7***.

Using the standard procedure for image analysis, based on the basic functions, the extraction of clearances from the fabric structure was made. The results are presented in ***Figure 8***.

In the next part of the study, an attempt to identify the location of defect occurrences was made. Two successive clearance occurencess were identified, which were located one above the other. The arrangements of weft and warp were recognised which were responsible for clearances arising in the structure of the fabrics. ***Figure 9*** shows a view of the fabric structure in the place of patterning, with the visible defect described with structural modules.

The corrective proceeding is described with the algorithm in ***Figure 10***.

The recognition of a colour (weave) change which reflects an artistic pattern is the basis for the identification of a defect and developing the corrective algorithm. The location of two adjacent warps at the border of patterns during the layer exchange is the first step of identifying a clearance along the Y-axis. Recognition of a faulty thread configuration of the double SMS1 modules arranged one above the other in a line of colour change allows the detection of clearance along the X-axis and full recognition of the defect position. Thus the program informas in which column of a pattern card (corresponding to the next warp hitch) the change in colour occurs. In the subsequent stage, the program recognises the faulty modules and gives their precise location in the data matrix. Then the designer selects coverages for correction, i.e replaces the modules, for example SMS1 with the SMS2. The change is en-

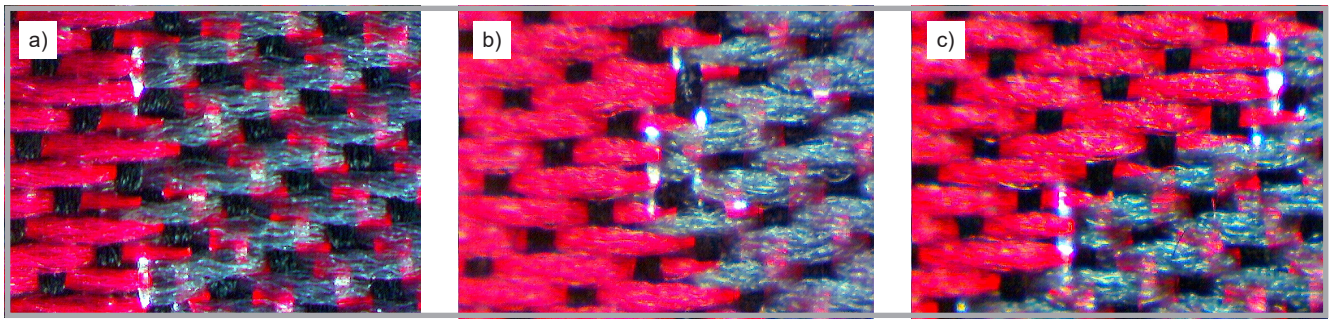

Figure 7. *View of the structures of curtain fabrics under the light that streams through; a) structure of the S1 fabric with stripped pattern, b) structure of the S2 fabric with ornamental pattern, c) structure of the S3 fabric with nonfigurative pattern.*

Figure 8. *Views of clearances obtained by digital processing of images with the ImageJ software; a) clearances in the S1 sample, b) clearances in the S2 sample, c) clearances in the S3 sample.*

coded and the replacement of coverings identified by the program is effected according to the specified positions in the final pattern card of the Sophis Socrates Jacquard software.

Summarising it can be concluded that the system for automatic correction of the fabric structure consists of three stages: recognition of the geometry of the fabric structure, translation of the weave notation of the fabric structure into the IT language, coding and then editing data for the target software.

Results of the research

Validation of the program and verification of the effectiveness of the entire corrective system was made for the example of a fabric with a striped pattern. This choice is justified by the facilitated observation of changes in the structure with a straight line. ***Figure 11*** shows saved images of fabric structures before and after modification (see page 98).

Further analysis was carried out on a portion of the structure that contained a characteristic arrangement of clearances. Views of structures before and after modification according to the original method of repair are shown in ***Figure 12*** (see page 98).

Quantitative analysis of the result of fabric defect repair based on the key indicators of evaluation of the digital image analysis is presented in the ***Table 2*** (see page 98).

The effectiveness of the repair methodology proposed is clearly shown in ***Figures 9.a*** and ***9.b***. The quantitative assessment presented in ***Table 2*** shows that the total area of clearances decreased by

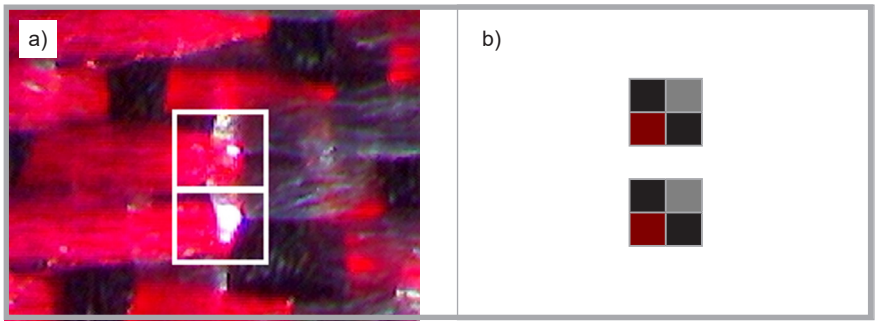

Figure 9. *View of faulty configuration of SMS1 modules located one above the other.*

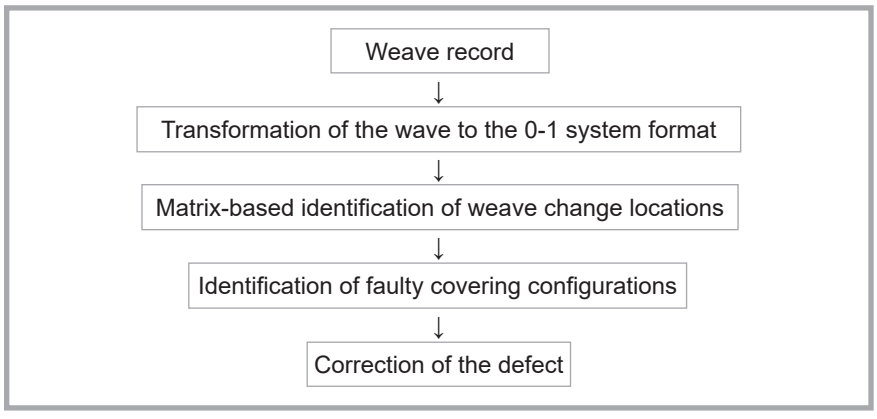

Figure 10. *Proceeding algorithm of fault detection and correction.*

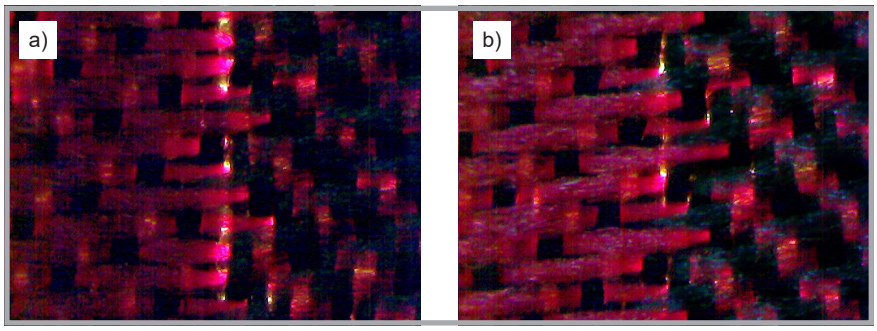

Figure 11. *Microscopic image of a fabric structure before and after modification.*

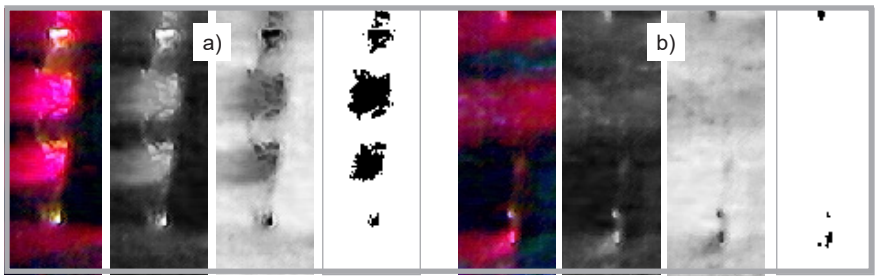

Figure 12. *Views of a portion of a fabric structure with a defect: a) before modification, b) after modification.*

Table 2. *Comparison of the results of digital image analysis of structures before and after modification based on the number, size and total area of the clearances, and the percentage of clearances in the structure of fabrics (total number of pixels 54 × 149)*

Sample	Number of clearances, pixels	Total area of clearances, pixels	Mean size of clearances, pixels	Area of clearances, %
a	12	1862	155.167	19.766
b	4	983	245.750	9.909

more than 50%, while their cardinality observed on the fabric surface decreased three times.

The intervention in the fabric structure proposed, supported by a program for automatic adjustment of the structure, is not an invasive process. It does not cause significant negative effects in the design of fabrics. The program operation range is very small; hence, in the case described, only one covering in the SMS module is changed. It is an interference not observable with the naked eye.

Summary and conclusions

The structure of jacquard fabrics designed for curtains was analyzed under real use conditions. A significant impact was observed of the transmitted light on the visual impression of the pattern, as received by the user. As it turned out, the light passing through additionally altered the artistic patterns in a special way.

Subjective interpretation - positive or negative - of this effect depends on the type of artistic pattern. In nonfigurative, irregular, or fine patterns it does not cause deterioration of the receiver's impression. In other cases, such an effect should be considered a fault.

In order to eliminate or reduce the impact of unintended patterning with light transmitted through an irregular, complex structure of jacquard fabrics, an original computer program for correcting that defect was proposed. The program detects the location of patterning, i.e. changes in weave, then shows a faulty SMS module configuration and points out the covering to change, according to the scheme specified.

The result of research aimed at repairing the defects is the improvement in the quality of the structure. Based on the results shown in ***Table 2***, the conclusion is justified of a three-times reduction in the quantity of clearances in the structure, expressed by the number of pixels, as well as a more than 50% reduction in the area occupied by the pores in the fabric, related to the total number of pixels in the sample. It should be emphasised that micro-modification was proposed for the exchange of one cover repeat in the clearance at the edge of the pattern. Interference with one SMS module does not cause deterioration of the visual effect.

The method of purposeful shaping of the structure of fabric for Jacquard curtains presented improves the characteristics of fabrics, to meet the growing expectations of customers.

Works on the structure and geometry of fabrics are being performed at the Institute of Architecture of Textiles, within the framework of a doctoral dissertation.

The computer program was developed in cooperation with the Institute of Architecture of Textiles and University of Computer Sciences and Skills in Lodz, for the needs of a thesis entitled "Supporting the development of fabrics for special applications"

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