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Impact of fabric parameters and properties on a 2D cutting and stitching line

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ABSTRACT

The paper presents the influence of fabric parameters and properties on the circle shape precision confectioning in the 2D plane. The properties of textiles affect the fit of the entire product, which is often subject to the subjective assessment of a technologist. In the case of cutting lines made in the two-dimensional area, it seems that there should be no problem with its implementation. Unfortunately, in the clothing, furniture, and automotive industries there are difficulties in combining the same and different textile and non-textile materials (leather). There is no objective method of predicting the precision of circle cutting shape, for different types and properties of fabrics. The work analyzes the shape of a circle cutting and stitching line in a two-dimensional area, taking into account selected properties of textiles (surface weight, elongation, relative bending stiffness). It turns out that the different properties of textiles cause, to a greater or lesser extent, the accuracy of a given circle shape. The fabric with the three-component composition of raw materials and the highest surface mass, as well as the smallest stiffness and high elongation obtained the highest precision of the circle shape reproduction. The least precision, i.e. the ability to maintain a given circle shape, was obtained in viscose fabric with low surface mass, high stiffness, and the highest relative elongation. Correlation analysis showed a significant relationship between shape and surface mass and the number of warp threads.

Keywords
pattern making,
cutting,
stitching lines,
textiles parameters and properties

1 Introduction

The properties of textiles determine the creation of clothing patterns, but also decorative and technical products. Textile properties have an impact on the possibilities of shaping and matching a more or less complicated garment design and estimating the value of construction and technological additions. Estimating the value of additions and the shape of the cutting line is always subject to the subjective assessment of the designer/technologist [1].

The aim of the work cycle and research is to determine objectively quantitative relationships in the field of the impact of parameters and properties of textiles on the clothing patterns. In the first stage of research work, the influence of parameters and properties of knitted fabrics on the structure as well as the product's drapability and fitting were determined [2-4]. Particular attention was paid to the raw material, internal mesh geometry, and structural parameters, which have a decisive influence on the elongation properties and the pressure on the body. It has been shown that individual parameters, properties of a flat textile product, and especially the weakest parameter determine the product's drapability, fitting, and durability.

In the case of fabrics [5,6], important parameters are weight, thickness, stretching, elongation, bending stiffness, shrinkage, draping, and structural parameters of the weave and raw material. Also important are internal thread friction, deformation angles that affect stability, and the ability to shape the spatial form on the body of the human body in real life or during 3D visualization. Parameters contained in KES and FAST systems can be equally useful when forecasting the shape of clothing construction forms [7].

Individual structural parameters of textiles have a huge impact on the deformation and shaping of a given form in 3D space [8]. The shape of forms is also important in building spatial forms [9, 10].

In the case of a cutting line, e.g. a circle made in a two-dimensional area, it seems that there should be no problem with its implementation. Unfortunately, in the clothing, furniture, and automotive industries there are difficulties in combining the same and different textile and non-textile materials (leather). There is no objective method of checking and predicting the precision of obtaining the oval shape of the cutting line, e.g. in the shape of a circle, as well as confectioning accessories for different types of textiles with different properties. In this work, the shape of the structural cutting line of a circle in a two-dimensional area was analyzed, taking into account selected properties of textiles (surface mass, elongation, and bending stiffness). The various properties of textiles will, to a greater or lesser extent, make the shape of the circle evaluated.

This work presents the influence of fabric parameters and properties on the precision of a shape in the process of confectioning oval lines, e.g. a circle shape in a 2D plane. The purpose of these tests is to determine the ability to maintain a given oval shape of the cutting line at the given values of additives for various properties of textiles.

2 Methods

Five samples of plain weave fabric (Fig. 1) differentiated by parameters and properties were used in the experiment. These are fabrics for various purposes, from viscose lining 1_P, to viscose fabric for blouses 2_P, to clothing fabrics 3_P - 5_P with a higher surface mass and more stable than lining and blouse fabrics. This diversity in terms of one weave will show differences in the behavior of the shape of the circle sewn in from the same fabric.

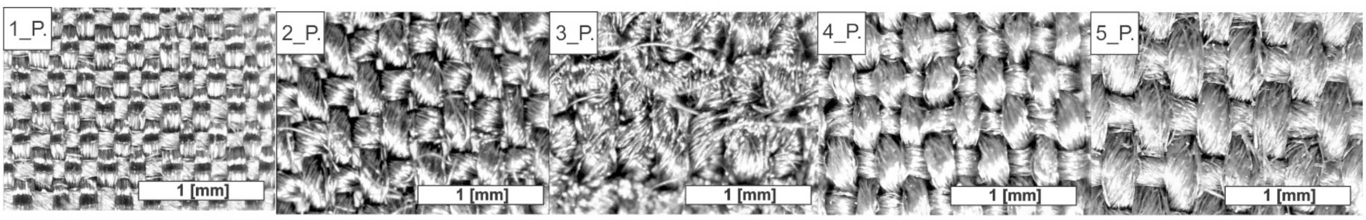

Fig. 1 Fabric samples for the experiment.

Fabrics are differentiated by the following parameters: raw material, surface mass, weft, and warp density. Their properties of bending stiffness by the loop method and relative elongation under normal conditions at 20 °C, humidity 65% [11] were also examined (Table 1).

The bending stiffness of the loop method determines the falling value of the strip of fabric tied into a loop. So, if the belt falls more, it has a higher value in mm, that is, the fabric has less rigidity.

Table 1. Fabric parameters and properties

	parameters						**properties**	
fabrics	**raw material**	**type of weave**	**type of material**	**Mp (g/m²)**	**D_wp (threads/dm)**	**D_wf (threads/dm)**	**C (mm)**	**E (%)**
1_P	viscose	plain	lining	78	800	450	15.40	19.50
2_P	viscose	plain	blouse	116	450	300	15.90	23.00
3_P	PET+ C+E	plain	clothing	222	350	250	18.10	20.00
4_P	PET + E	plain	clothing	196	500	350	18.10	19.50
5_P	PET+C	plain	clothing	176	410	250	16.50	10.50

D_wp (threads/dm) warp density

D_wf (threads/dm) weft density

Mp (g/m²) surface mass

C (mm) bending stiffness by the loop method

E (%) relative elongation

In the first stage, a circle template was prepared with the location of the sewing and cutting line. Sewing allowance values for a 90 mm diameter circle are 5 mm (Fig. 2).

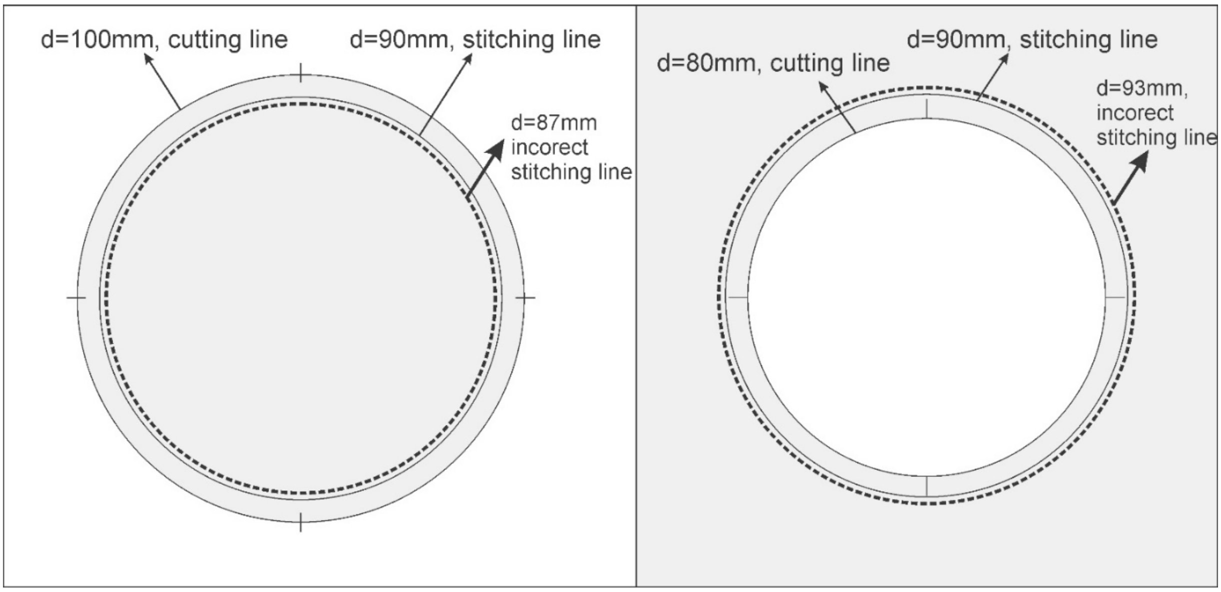

Fig. 2 Pattern of the cutting and stitching lines.

Stitching tests were carried out by the designated sewing lines (Fig. 3a) and with the incorrect setting of the sewing lines (Fig. 3b). The example below shows how the accuracy and the effect of sewing the circle deteriorates. Inaccurate stitching in the sewing line already causes a large distortion of shape and fit. Wrinkles and stretches are visible (Fig. 3). The difference of 3 mm in the position of the stitching line (Fig. 2) means that part of the circle template has a diameter d = 87 mm, L = 524.38 mm, while part of the plane template has a diameter d = 93 mm, L = 584.04 mm. This is a 59.66 mm difference in matching the circuits. That is why it is so important to accurately identify the stitching lines in this type of shape on a 2D surface.

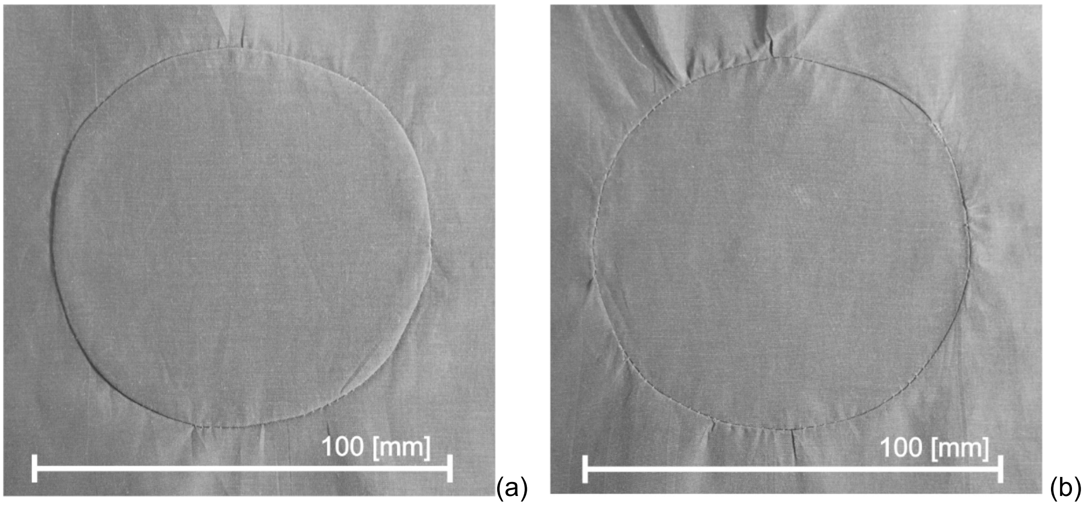

Fig. 3 Samples with changing of cutting and stitching lines.

3 Test/Data

For five samples of plain weave, a circle stitching line was made according to the template (Fig. 2). Then the photos of the samples taken were taken with a Nikon Z6 camera with a 24-70 mm lens of 4528 x 3016 in the form of .NEF. The contour of the stitching line was determined on each image of the performed experimental test (Fig. 4).

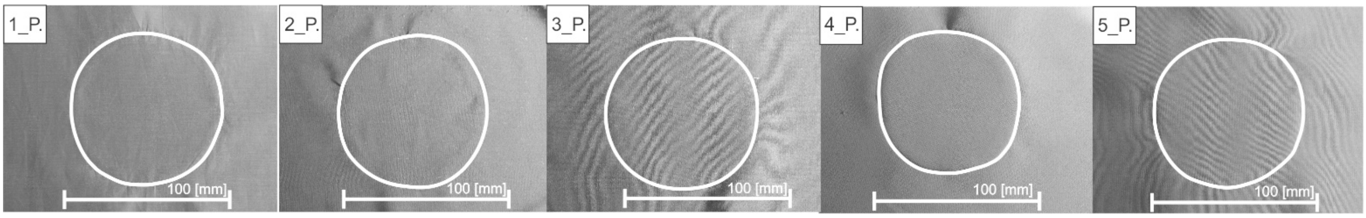

Fig. 4 Fabric samples with stitching lines.

The raw camera images were prepared for processing in the form of a bitmap with a size of 1024 x 1024 pixels. The area marked with the stitching contour line was subjected to computer image analysis in the author's MagFABRIC program (Fig. 5).

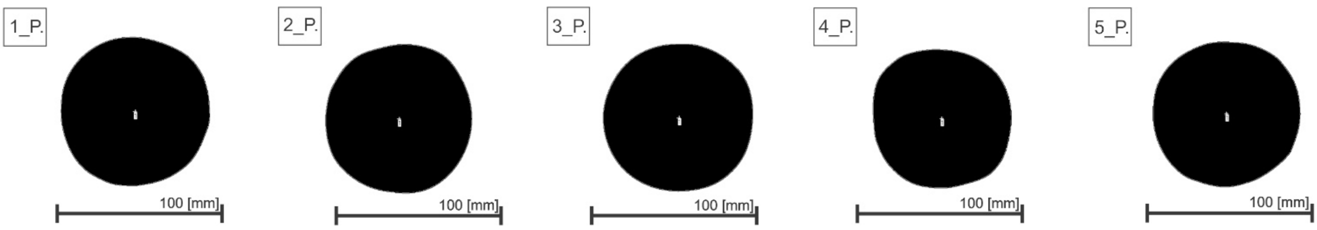

Fig. 5 Image analysis of the stitching lines in the MagFABRIC.

The shape of the stitching line in the experimental tests differs from the ideal shape of the circle. The differences in circumference and shape for all experimental trials are shown in (Fig. 6a). To quantify these differences, a morphometric stitching line analysis was performed in computer image analysis. All experimental trials were described with size and shape parameters. These parameters include circle surface area A (mm^2), minimum and maximum circle diameters Dmin, Dmax (mm), circle circumference L (mm) and circle shape parameters dForm (%) (1), AspectR (2) and FormF (3) (Fig. 6b).

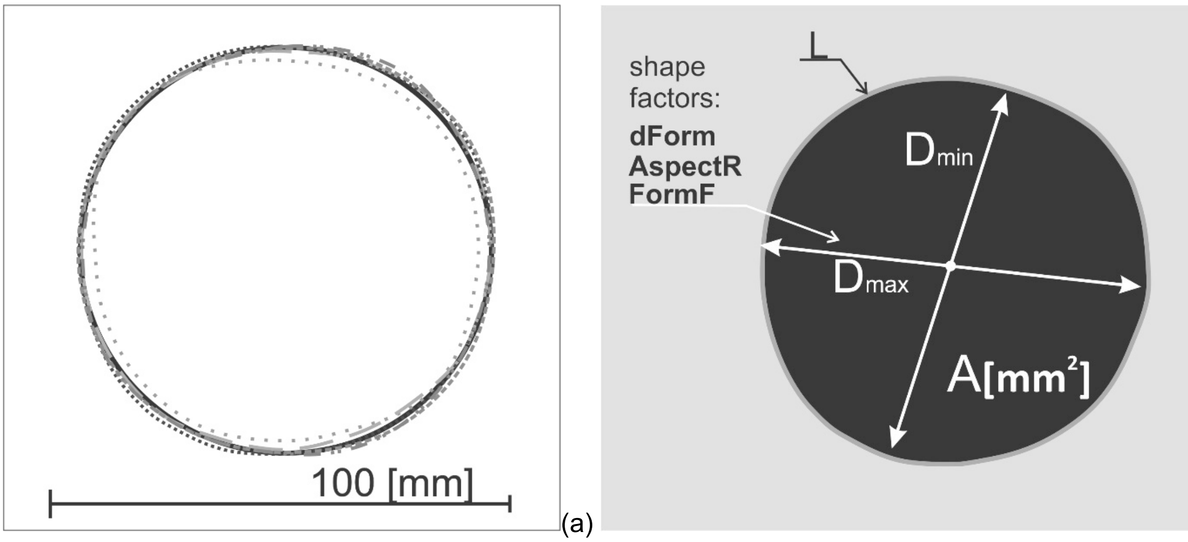

Fig. 6 Morphometrical analysis of the stitching lines: (a) The stitching lines in the fabrics samples, (b) the morphometric parameters of the stitching line.

The circle shape parameters describe three different shape factors that determine the following variation in the shape of the circle field:

- **dForm (%)** – degree of circle shape deformation:

$$dForm = \frac{Dmax - Dmin}{Dmax} * 100; \quad (1)$$

- **AspectR** – degree of ellipticity:

$$AspecR = \frac{D_{MIN}}{D_{Max}}; \quad (2)$$

where: Dmin, Dmax (mm) – min. and max. field diameters

- **FormF** – edge development:

$$FormF = \frac{4\Pi \cdot A}{L^2}; \quad (3)$$

where: A (mm^2) – surface area, L (mm) – field circumference – contour.

4 Results

The values of the parameters of the morphometric analysis of the size and shape of the circles from the experimental fabric samples are summarized in the following table (Table 2). The experimental tests were combined with a standard sample – the ideal 0_S circle.

From Table 2 and Fig. 7, the thesis is confirmed that the differentiation in the shape of a circle of stitching lines in research samples depends on the parameters and properties of textiles. The 3_P fabric obtained the highest precision of the circle shape mapping by the lowest value of the deformation coefficient dForm = 4.28% and the closest value to 1.00 in the case of the ellipticity coefficient AspectR = 0.96, which indicates a similar shape to the circle. The smallest precision, i.e. the ability to keep the given shape of the circle, was obtained by the 2_P viscose fabric with the highest deformation coefficient dForm = 9.35% and the least close to 1.00 in the case of the elliptic coefficient AspectR = 0.91, which indicates the least similar shape to the circle. The coefficient of the degree of edge development for the 2_P fabric showed the highest value of FormF = 1.05 among all research tests.

Table 2. Results of image analysis of the stitching line of fabric samples.

Fabrics	A (mm^2)	L (mm)	Dmax (mm)	Dmin (mm)	dForm (%)	AspecR	FormF
0_S	6358.50	282.60	90.44	89.38	0.00	1.00	1.00
1_P	6251.30	277.67	91.30	86.96	4.75	0.95	1.02
2_P	5560.19	258.42	88.69	80.40	**9.35**	**0.91**	**1.05**
3_P	6245.61	277.54	91.06	87.16	**<u>4.28</u>**	**<u>0.96</u>**	1.02
4_P	6026.71	272.98	89.38	84.72	5.21	0.95	1.02
5_P	6165.67	275.69	91.83	86.24	6.09	0.94	1.02

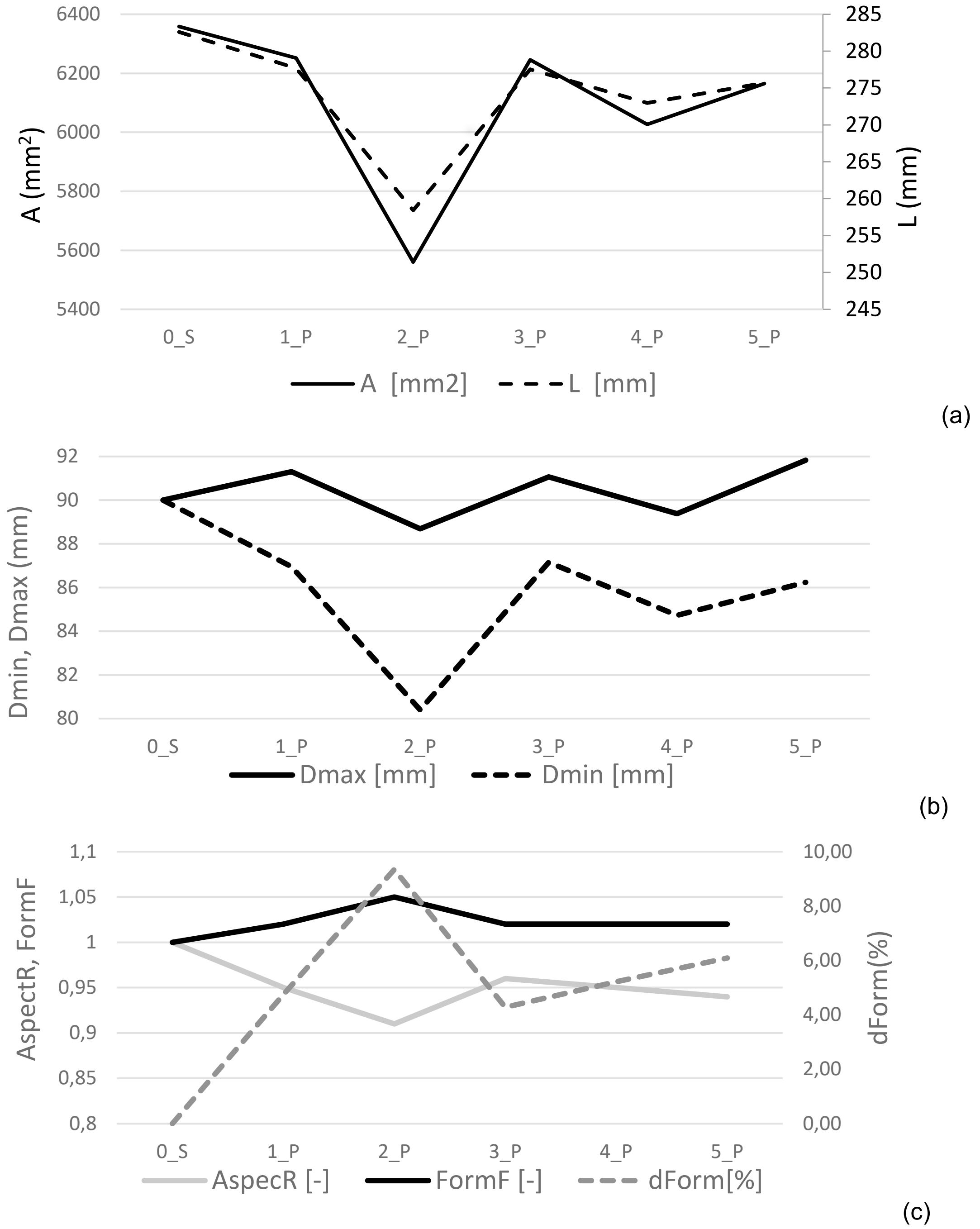

Fig. 7 Results of the stitching lines image analysis: (a) area A (mm^2) and contour L (mm), (b) minimum and maximum diameters Dmin, Dmax (mm), (c) shape factors: AspecR and FormF, dForm (%).

Taking into account the parameters and properties of fabrics, the 3_P fabric with three component raw material composition and the highest surface mass as well as the lowest stiffness and high relative elongation obtained the highest precision in mapping the shape of the circle. However, the smallest precision, i.e. the ability to maintain the given shape of the circle, was obtained by 2_P viscose fabric with a low surface mass, high stiffness, and the highest relative elongation.

A regression analysis of variable dependent shape coefficients with parameters and properties of fabrics was also carried out. Correlation analysis showed a significant dependence of shape on surface mass and warp density (Fig. 8). The strongest correlation was obtained by FormF – the degree of development of the edges (Fig. 8a). The determination coefficients R, R2, and R^2, in this case, are 0.998, which means that 99% of the overall variability of the FormF dependent variable is explained by the model. The standard error of estimation equal to 0.00129 allows for estimating the size of random deviations of the model at a low level. BETA coefficients illustrate the largest dependence of independent variables Mp and Mp^2, regardless of the unit, at levels -8.20 and 8.09, respectively. However, the t-Student p level does not exceed 0.05, therefore the variables Mp and Mp^2 are significant. Only the Dwp variable has p = 0.06, which means an insignificant relationship. The regression model is as follows (4):

$$FormF= 1.19 - 0.002 \cdot Mp + 0.00001 \cdot Mp^2 - 0.00008 \cdot Dwp \quad (4)$$

where: Mp – surface mass (g/m^2), Dwp – warp density (threads/dm)

Even greater significant correlation of surface mass and warp density was obtained by the morphometric parameter of the circumference of the circle L (mm) (Fig. 8b). The determination coefficients R, R2, and R^2, in this case, are 0.999, which means that 99% of the total variability of the dependent variable L (mm) is explained by the model. The standard error of estimation of 0.20379 allows for estimating the size of random deviations of the model at a low level. BETA coefficients illustrate the largest dependence of independent variables Mp, Mp^2, (regardless of the unit), at levels 6.29 and -6.58 and Dwp at 0.66, respectively. However, the t-Student p level does not exceed 0.05, therefore the variables Mp, Mp^2, Dwp are significant. The regression model is as follows (5):

$$L= 204.28 + 0.86 \cdot Mp - 0.003 \cdot Mp^2 + 0.03 \cdot Dwp \quad (5)$$

where: Mp – surface mass (g/m^2), Dwp – warp density (threads/dm)

Dalej... R= ,99883783 R2= ,99767702 Popraw. R^2= ,99070807
F(3,1)=143,16 p<,06134 Błąd std. estymacji: ,00129

N=5	BETA	Błąd st. BETA	B	Błąd st. B	t(1)	poziom p
W. wolny			1,188879	,012587	94,4550	,006740
MP___G_M	-8,20764	,542407	-,001867	,000123	-15,1319	,042010
MP2	8,08781	,492081	,000006	,000000	16,4359	,038686
D_WP__TR	-,98988	,100121	-,000076	,000008	-9,8868	,064173

a)

Dalej... R= ,99992037 R2= ,99984074 Popraw. R^2= ,99936295
F(3,1)=2092,6 p<,01607 Błąd std. estymacji: ,20379

N=5	BETA	Błąd st. BETA	B	Błąd st. B	t(1)	poziom p
W. wolny			204,2754	1,983422	102,9914	,006181
MP	6,29919	,142024	,8625	,019445	44,3531	,014351
MP2	-6,58226	,128846	-,0030	,000059	-51,0861	,012460
D_WP	,65934	,026216	,0303	,001207	25,1505	,025299

b)

Fig. 8 Results the best regression analysis (in Statistica) between fabric parameters and: (a) shape FormF stitching line; (b) size contour L (mm) stitching line.

5 Conclusions

It turns out that the different properties of textiles cause, to a greater or lesser degree, the precision of the given circle shape. The fabric with the three-component raw material composition and the highest surface mass as well as the smallest stiffness and high stretchability obtained the highest precision of the circle shape mapping. The smallest precision, i.e. the ability to maintain the given shape of the circle, was obtained by the viscose fabric with a low surface mass, high stiffness, and the highest relative elongation. Correlation analysis showed a significant relationship between shape and surface mass and warp density. The experiment is a preliminary study in the consideration of only one group of plain weave fabrics. It confirms the thesis of the relationship between the shapes obtained, e.g. a circle in a 2D plane, and fabric parameters. This allows you to predict the behavior of fabrics with a specific surface mass in this type of shape. A broader treatment of the issue in the aspect of including a larger group of different fabric weaves will allow us to determine the possibilities in a wider scope. The second aspect extending the scope of research are sewing parameters (sewing speed, type of transport, lubrication, presser foot pressure, thread tension, sewing step) and the type of sewing needle (number, tip) and thread structure (staple fibers, type of core) and sewing thread properties (composition, linear density, twist, twist unevenness), which can have a significant effect on the precision of the shape when cutting and sewing in the two-dimensional area.

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