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EXPERIMENTAL DETERMINATION OF FABRIC DEFORMATION VARIATION IN WEAVING LOOM

DOKUMA TEZGAHINDA KUMAŞ DEFORMASYON DEĞİŞİMİNİN DENEYSEL BELİRLENMESİ

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ABSTRACT: There is an experimental method for determining the deformation of warp threads and fabric directly on the loom. However, using this method to determine fabric deformation in the area where the fabric is formed on the loom and is under tension may cause a decrease in measurement accuracy. In this study, an experimental method was applied and tested that makes it possible to accurately determine the degree of deformation of the fabric and warp threads in this area. The results of this study can be used to control warp threads and fabric deformation directly on the loom during the production of main woven fabrics. This technique can also be used on warp knitting machines.

Keywords: Weaving loom, fabric deformation, digital camera, computer system.

DOKUMA TEZGAHINDA KUMAŞ DEFORMASYON DEĞİŞİMİNİN DENEYSEL BELİRLENMESİ

ÖZ: Çözgü ipliklerinin ve kumaşın deformasyonunu doğrudan tezgâh üzerinde belirlemek için deneysel bir yöntem bulunmaktadır. Ancak kumaşın tezgâhta oluştuğu ve gerginlik altında olduğu bölgesinde kumaş deformasyonunu belirlemek için bu yöntemin kullanılması ölçüm doğruluğunun azalmasına neden olabilmektedir. Bu çalışmada kumaşın ve çözgü ipliklerinin tezgâhın bu alandaki deformasyonun doğru bir şekilde belirlenmesini mümkün kılan deneysel bir yöntem uygulanmış ve test edilmiştir. Bu çalışmanın sonuçları dokuma kumaşların üretimi sırasında çözgü iplikleri ve kumaş deformasyonunun direkt tezgâh üzerinde kontrol edilmesi için kullanılabilir. Bu teknik çözgülü örme makinelerinde de kullanılabilir.

Anahtar kelimeler: Dokuma tezgâhı, kumaş deformasyonu, dijital kamera, bilgisayar sistemi

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1. INTRODUCTION

One of the important issues in the weaving process is to reduce the breakage of warp and weft threads on the loom. The number of breaks in the warp threads largely depends on the magnitude of the total cyclic deformation of the elastic system of the loom and the operating state of the interrelated mechanisms of the loom [1]. Total warp deformation consists of the deformations that occur during shedding, including of the weft thread to the fabric line, pulling of the fabric by the regulator, and unwinding of the warp threads from the beam. The magnitude of deformation occurring in the fabric and warp threads during the pulling of the fabric with a pulling mechanism is one of the important technological indicators in fabric formation.

Knowing these deformations, it is possible to determine the total amount of deformation of the elastic system of the loom, which will enable the evaluation of the working condition of the fabric pulling mechanism [2].

These issues were first addressed in [3], where formulas in the form of trigonometric polynomials were obtained that determine the total deformation of the warp threads on the weaving machine. In this study, the yarn length (equivalent length) exposed to deformation in the upper layers of the beam winding was determined and the theoretical equations of the total warp deformation occurring in the system were given. Meanwhile, the length of the yarn exposed to deformation in the upper layers of the beam winding was determined and theoretical equations were given for the total warp deformation occurring in the system. This formula is then further developed in a study [4] and a formula is obtained to determine the total deformation value in the elastic loading system of the machine.

Studies have been carried out to detect the deformation and tension of the warp threads and fabric on the loom. In a study [5], suitable formulas were obtained by making an analysis of the effect of the operating parameters of the warp release mechanism on the change in yarn tension when running the entire warp from the beam. This issue was also discussed in another study [6]. In this paper, a mathematical analysis of warp elongation is carried out in weaving machines with positive backrest system. Here, it is concluded that by producing different movement curves with the motor-driven positive backrest, optimum warp elongation or warp tension curves can be obtained for the weaving of different fabric types. Similar research was conducted in a study [7] for the СТБ (Zülser type) micro shuttle weaving machine. In another study [8], a method was developed with genetic algorithm and gradient-based method was used to calculate the optimized settings for the fabric production process with optimum warp thread tensions.

However, the theoretical formulas obtained in these studies make it possible to determine the deformation of the threads occurring in certain parts of the loom in the elastic loading system. Experimental studies to determine the deformation and tension of warp threads and fabric on the loom were carried out in a study [9]. Here, experiments were carried out to determine the effect of warp oscillation parameters on the deformation of the warp and fabric on the ATPR type air jet weaving machine. In this study, a model for the variation of warp and fabric tension across the width of the machine was obtained and a device for measuring woven fabric tension was proposed. The study on the change of warp tension across the loom width during weaving is given in a study [10]. Here, the effect of weft density and weft number on warp tension was investigated. In a study [11], it was stated that it is more appropriate to use the stiffness coefficient instead of the elastic modulus (Young's modulus) to calculate the yarn tension. Because the calculation of the elastic modulus is associated with the complex shape of the yarn and its sharply varying cross-sectional area. The hardness coefficient is determined as the ratio of the deformation force F divided by the amount of deformation (elongation) ΔL caused by this force. The hardness coefficient of textile materials is obtained using various devices and mechanisms. Information on this subject is given in [12,13] and other sources. The values of the hardness coefficients used in the article were taken from the information given in another study [12].

An experimental method has been proposed [14] for determining the deformation of warp threads directly on a weaving loom. According to this method, two parallel lines are drawn on the winding surface of the warp beam at a distance of l from each other along its width. As the warp threads are unraveled from the beam, elongation (deformation) occurs in the threads under the influence of longitudinal tensile forces. Meanwhile, the two points left by the two lines on the warp wires are gradually moving away from each other. When the points on the warp wires of the front line reach the fabric formation line, the distance l increases and reaches a certain size L. In this case, the value of the L-l difference between the L and l distances shows the extent of warp deformation occurring between the warp beam of the warp wires and the fabric formation line.

Studies using this method have been carried out in some studies [15,16,17]. In a study [15], pilot studies were carried out to identify warp and fabric warp yarns during the production of plain and twill weave cotton fabrics on a Toyota loom. In this case, the distance l between two straight lines drawn on the surface of the base beam is taken to be 50 mm. During the experiment, a ruler was used to measure the distances L and l. Similar studies were carried out in articles [16,17] for main weave cotton fabrics with different weft densities. The disadvantage of the studies carried out in [14-17] is that the distances between the points left by the two lines on the warp thread and the fabric are measured with a ruler.

To overcome this disadvantage, remote sensing method was used in [18]. According to this method, the distances between two points left by two lines on the warp and fabric are recorded with a digital camera connected to the computer and the resulting image is processed by the computer using an image analysis program. This increases the accuracy of measurements compared to the previous method. Studies in the same direction were later published [19,20,21].

Another option for experimentally determining the deformations of the warp and fabric by drawing two lines on the surface of the beam is given in article [1]. The difference between this study and previous ones is that the distances between the points left by two lines are measured with a digital caliper on images obtained with a digital camera, on papers printed on a printer via a computer.

In the studies conducted [1,14-21], the detection of warp and fabric deformations in the fabric area of the loom is made by drawing two parallel straight lines on the surface of the warp beam. During the use of this method, as the points on the warp threads approach the fabric line, the threads pass through the lamellar and heddle eyes, between the comb teeth and come into contact with the weft, the visibility of the points deteriorates. For this reason, it becomes difficult to take measurements from the fabric surface. In addition, in cases where the points on the warp thread are located under the wefts in the fabric, these points are not visible (especially in weavings where the weft cover is wide). Accordingly, it is not possible to measure the L distances between points in these areas.

As can be seen from the literature review, examining the deformation of the warp thread and fabric in the area where the fabric is formed on the weaving machine and is under tension is one of the important issues in weaving. The aim of this study is to detect with high accuracy the deformation occurring in the fabric and warp threads in the region where the fabric is formed and under tension. It is aimed to improve and test the existing experimental technique to achieve the goal.

2. MATERIALS AND RESEARCH METHODS

2.1 Materials

The following materials were used during the study: Pıcanol Ominplus-Summum pneumatic loom, plain and twill cotton fabrics, Canon EOS M200 camera, HP computer, Canon MF 3010 printer, electronic caliper (Digital Caliper). The main parameters of the loom are as follows: warp swing width - 2500 cm, main shaft speed - 700 min-1, estimated warp length on the loom - 1350, length of fabric area on the loom - 1500 mm. Technical parameters of the fabrics are given in table 1.

The experimental technique given in [1] was taken as basis to determine the deformation in the warp thread and fabric during the study. Processing of experimental data and obtaining mathematical models were carried out using the EXCEL program. The sequence of operations during the experiment is shown in Fig. 1

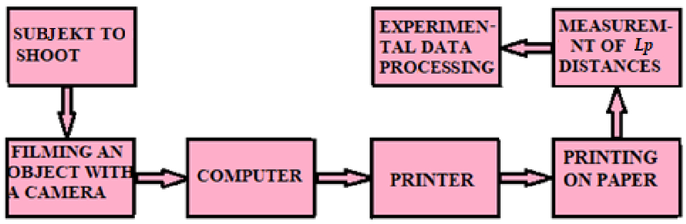

Fig. 1 Sequence of operations during the experiment

2.2 Determination of fabric and warp deformation in the area where the fabric is formed and is under tension.

This method is based on determining the difference between the distance between two parallel lines drawn close to the fabric formation line in the working area of the loom and the increasing distance when the lines reach the fabric wrapping point. The working area of the fabric on the loom is perceived as the area where the fabric is formed and exposed to tension. This area covers the distance between the fabric line (1) and the point where the fabric is wrapped on the fabric roller (5) (Figure 2). To determine the deformation of the fabric and warp threads in this region, lines (3) and (4) parallel to each other are drawn across the width of the fabric at a distance of 10-15 mm from the selvedges. The distance between the lines l_T should not be less than 50 mm. To measure the change in deformation across the width of the fabric, 10 mm wide sections (8) are marked in 6 places on the line (4). Then, photographs of the selected areas are taken and the resulting images are transferred to the printer for printing via the computer. After this the weaving machine is started and the fabric moves towards the fabric roller. In this case, longitudinal deformation of the fabric occurs under the influence of the tension of the warp threads and the fabric pulling mechanism of the machine. As a result, the l_F distance between the lines (3) and (4) increases and reaches the L_F value when the fabric roller is approached. In this case (3) and (4) straight lines (6) and (7) become curved lines. When the line (7) approaches the fabric roll, the machine is stopped and pictures of the selected areas (8) are taken and transferred to the printer for printing. In order to increase the precision of the measurement, the size of the l_P and L_P distances on the paper printed by the printer is increased by at least three to four times the size of the actual l_F and L_F distances on the fabric.

Table 1. Technical parameters of fabric

Name of fabrics	Fabric width, cm	Number of warp threads in the fabric.	Linear density of threads, Tex		Yarn density, n/cm		Contraction of fabrics, %	
			Warp thread	Weft threads,	By warp threads	By weft ducks	By warp threads	By weft threads
1	2	3	4	5	6	7	8	9
Plain	235	5410	20	20	200	220	6,8	6,3
Twill	240	6500	20	20	270	300	6,2	6,7

The L_P distance is measured with an electronic caliper in 5 places in each of the selected areas (8) and $L_{P1}...L_{P5}$ values are obtained. Next, the average L_{Pav} value of these distances is determined for each area.

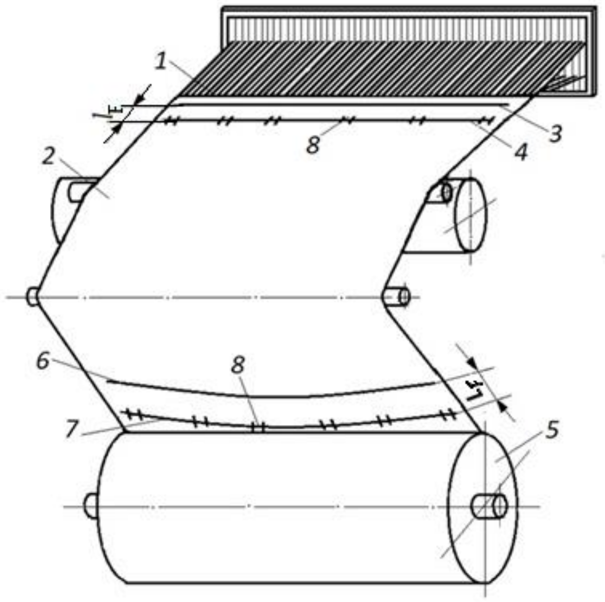

Fig. 2. Scheme for determining the deformation of the fabric on the PIKANOL machine

The experiment was repeated three times. The calculation of the deformation of the fabric and warp threads is based on the data taken from the paper printed on the printer. The fabric deformation in any area is determined by the difference between the elongated and initial lengths $L_P – l_P$. In this case, the amount of deformation will increase as many times as these distances on paper increase. Therefore, to determine the amount of deformation from these data, it is necessary to use the proportionality coefficient determined by the formula:

$$K_p = l_P / l_F; \qquad (1)$$

where K_P- is the coefficient of proportionality, l_P - initial distance on paper, l_F - is the initial distance on the fabric.

At l_P =150 mm and l_F =50 mm, the proportionality coefficient will be equal to three, that is, K_P = 3. To determine the actual value of fabric deformation, it is necessary to divide the deformation value obtained on paper by K_P. In this case, the amount of fabric deformation in the working area of the machine will be calculated using the following formula:

$$\lambda_F = \frac{L_{Pav} - l_P}{K_p}; \qquad (2)$$

where L_{Pav} -is the average value of the distances $L_{P1}..., L_{P5}$ for each selected area.

The magnitude of the deformation λ_{Fv} calculated using formula (2) represents the deformation occurring in the working area of the fabric, that is, the deformation occurring in the length L_W between the fabric formation line and the fabric roller. However, in the future, when determining the tension of the fabric, the amount of deformation per meter length of the fabric calculated according to the formula below will be used.

$$\lambda_{FM} = \frac{\lambda_F 1000}{L_W}; \qquad (3)$$

By knowing the deformation per meter of the fabric length, it is possible to determine the tension value F_F of the fabric on the loom according to the following formula;

$$F_F = \lambda_F C_F M_W; \qquad (4)$$

where C_F - is the stiffness coefficient of a single strand of warp thread in a 1-meter piece of fabric, M_W - is the number of warp threads in the fabric.The deformation of the warp threads in the working area of the fabric can be determined by the formula,

$$\lambda_W = \frac{L_{pav} - L_p}{(1 - 0,01a_W) K_p L_W}; \qquad (5)$$

where a_w - is the contraction of the warp threads during the formation of the fabric on the loom. L_W - is the length of the main threads in the working area of the loom. Using the deformation λ_W the value of the tension of the main threads in the fabric zone on the loom is determined, according to the formula;

$$F_W = \lambda_W C_W \qquad (6)$$

where C_W - is the stiffness coefficient of a meter length of the warp threads, F_W - tension value of the warp threads in the working area of the fabric.

The values of the stiffness coefficients of single warp yarn and free warp yarns in the fabric C_F and C_W are taken from the information in [2]. Various devices and setups are used to determine the stiffness coefficient of textile materials. The stiffness coefficient values used in this article were obtained by means of a device developed to determine the stiffness coefficients of textile materials with forced repeated deformations, as described in [12].

3. RESULTS and DISCUSSION

To determine the deformation and tension of the fabric and warp threads in the working area of the fabric on a loom, two parallel lines were drawn on the fabric with a distance of 50 mm between them along its width at a distance of 15 mm from the line of fabric formation. On paper printed on a printer, this distance increases to 150 mm and at the same time the proportionality factor becomes equal to three. Deformation measurements were made in selected areas (8) at the same distance from each other along the width of the fabric (Fig.2).

The experiment was repeated three times and a total of 15 (5x3) measurements were taken in each region. Accordingly, the L_P distance is the average distance obtained from 15 measurements for each area.

Next, calculations were made using formulas (2), (3) and (5) and the values of deformation of fabrics and warp threads in the working area of the fabric were determined at L_P equal to 150 mm. Then, according to formulas (4) and (6), the values of the tension of fabrics and warp threads in the working area of the fabric on the machine were determined. In this case, the value of the stiffness coefficient C_W for meter lengths of a single warp thread is taken equal to 0.2 kg/cm, and the stiffness coefficient C_F of a meter length of fabric, per one warp thread, is 0.1 kg/cm [2].

In newtons, these coefficients are 0.1x9.80665 = 9.806 N/cm and 0.2x9.80665=19.61 N/cm, respectively. The results of calculations for the deformation and tension of the fabric in the working area of the fabric on the loom are shown in Table 2.

As can be seen from Table 2, the amount of fabric deformation at the selvedges is less than in the middle areas. Since the deformation values of meter lengths of both fabrics are 1.38 mm and 1.06 mm along the left edge and take maximum values of 2.82 mm and 2.12 mm in the middle. The average deformation values are 2,07 mm, 1,55 mm, respectively, which is about 1.33 times greater than the deformation at the selvedges. Similar results were obtained in works [2] and [13] in the study of changes in the deformation of warp yarns and fabrics during the production of cotton and polyester fabrics. on weaving machines.

It can be said that this is due to the effect of the tweezers that ensure the stability of the fabric width on the loom. Because the tweezers hold the fabric from the edges and weaken the surf effect in these places, and the loose middle parts of the fabric are more exposed to the surf effect. For this reason, the deformation and tension values In the middle parts of the fabric are higher than the edges.

When analyzing the data in Table 2, it becomes clear that the average deformation value is 25.12% higher in plain fabric than in twill fabric. This situation is due to the difference in the weft density values of the fabrics. It has been determined by experimental research that the deformation value occurring during weaving in fabrics with high weft density is smaller than in those with low weft density. The theoretical expression of this can be seen from the equation $\delta = 1/S_a$ given in [2] (where δ- fabric deformation occurring in one revolution of the loom main shaft, cm, S_a weft density, number of wefts in 1 cm).

Graphic images of these changes in the form of diagrams built using the EXCEL program are shown in Fig. 3 and Fig. 4. On these and all graphs, which are presented in the following figures, the solid lines show the experimental curves, and the dots show the theoretical ones. In all drawings, "Row 1" shows the curves for plain and "Row 2" for twill.

According to Table 2, the deformations of both fabrics were calculated using formulas (2) and (3), and diagrams were built using the EXCEL program, shown in Fig. 3.

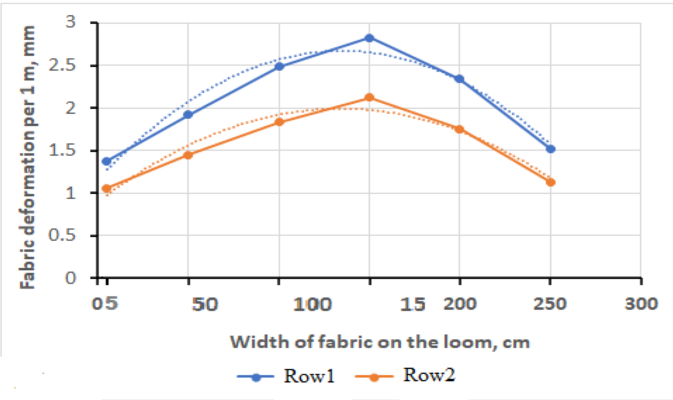

Fig. 3 Variation of fabric deformation across the width of the loom

Table 2. Fabric deformation and tension values in the working area of the fabric on the loom

Fabric width, cm	Fabric deformation in the fabric working area *λ, mm*				Fabric tension in the fabric working area, *N*	
	For working length		One meter of fabric			
	Plain	Twill	Plain	Twill	Plain	Twill
1	4	5	6	7	6	8
5	2,07	1,59	1,38	1,0,6	732,1	675,6
50	2,88	2,17	1,92	1,45	1018,6	924,2
100	3,72	2,74	2,48	1,83	1315,7	1166,5
150	4,23	3,18	2,82	2,12	1496,1	1351,3
200	3,51	2,63	2,34	1,75	1241,4	1102,7
250	2,28	1,69	1,52	1,13	806,4	720,3
Averages	3,10	2,33	2,07	1,55	1098,2	982,0

As can be seen from Fig. 3, the change in the deformation of both fabrics during their formation on a loom occurs in the same way and is parabolic in nature. The value of the deformation, starting from the left edge, increases, and in the middle sections it acquires a maximum value, and as you approach the other selvedge, the values of the deformation begin to decrease. In this case, the greatest values of deformations occur at a width of fabrics of 150 mm.

To determine the empirical relationship between the strain λ_F and the width of the fabrics, the EXCEL program was used and the following formulas were obtained.

$$\lambda_{Fp} = -8E\text{-}05B_p^2 + 0{,}0223B_p + 1{,}1638; \quad R^2 = 0{,}9535 \quad (7)$$

$$\lambda_{Ft} = -6E\text{-}05B_t^2 + 0{,}0163B_t + 0{,}8959; \quad R^2 = 0{,}9509 \quad (8)$$

Where λ_{Fp} and λ_{Ft} - are deformations of plain and twill fabrics in the working area on the machine, respectively; B_p and B_t - are the widths of plain and twill fabrics, respectively; R^2 - are the coefficients of determination for plain and twill fabrics, respectively.

As can be seen from Fig. 3, the curves constructed on the basis of the experimental data coincide to a large extent with the theoretical ones described by formulas (7) and (8), which is confirmed by the high values of the coefficient of determination R^2. Figure 4 shows the graphs of changes in fabric tension depending on the loom width, calculated by formula (6). From Fig. 3 it follows that the change in the tension of both fabrics on the loom occurs in the same way as the deformation of the fabric's changes, that is, parabolic. Here again, the maximum tension value is obtained at a width of 150 cm of both fabrics. However, in contrast to the previous case, the ends of the lines at the extreme points are located at a closer distance to each other.

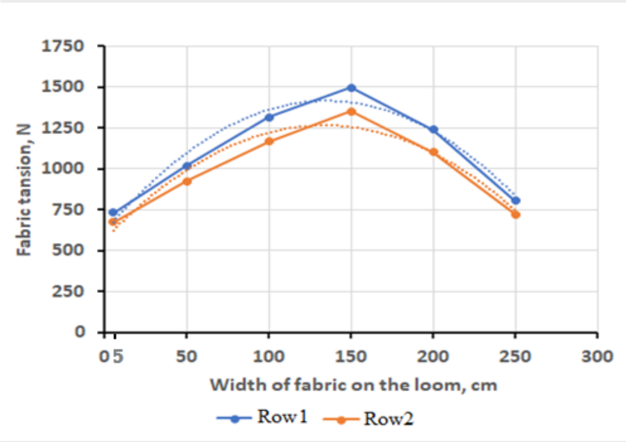

Fig.4. Changing the deformation of the fabric on the loom along its width

The regression equations for the dependence of fabric tension on its width and the coefficient of determination R^2, obtained using the EXCEL program, are presented below;

$$F_{Ft} = -0{,}0439B_t^2 + 11{,}847B_t + 617{,}4; \quad R^2 = 0{,}9535 \quad (9)$$

$$F_{Tp} = -0{,}0386B_p^2 + 10{,}352B_p + 573{,}29; \quad R^2 = 0{,}942 \quad (10)$$

Where, F_{Fp} and F_{Ft} -are the tension of plain and twill fabrics in the working area of the fabric on the machine, respectively; B_p and B_t - are the widths of plain and twill fabrics, respectively; K^2- coefficient of determination.

As can be seen from these formulas, the coefficients of determination R^2 have higher values than in formulas (7) and (8).

The values of deformation and tension of the warp threads in the working area of the loom, calculated by formulas (5) and (6) are shown in Table 3.

Table 3. Deformation and tension values of warp threads in the working area of the fabric on the loom

Fabric width, cm	Deformation of the warp threads in the working area of the fabric λ, mm				Tension of one warp thread in the working area of the fabric F, cN	
	For working length		For one meter of fabric			
	Plain	Twill	Plain	Twill	Plain	Twill
1	2	3	4	5	6	7
5	2,22	1,69	1,48	1,13	29,01	22,08
50	3,09	2,31	2,06	1,54	40,37	30,18
100	3,99	2,91	2,66	1,94	52,14	38,02
150	4,54	3,42	3,03	2,28	59,32	44,69
200	3,76	2,80	2,51	1,87	49,13	36,58
250	2,44	1,81	1,62	1,2	31,88	23,65
Averages	3,33	2,50	2,22	1,66	43,51	32,66

As can be seen from Table 3, the amount of deformation and tension of the warp threads in the working area of the fabric on the machine changes in the same way as the deformation and tension of the fabric change. At the same time, the average value of the deformation of the warp per thread for the plain is 2,12 mm, and for the twill 1,66 mm, which is 1,34 times less than the deformation of the plain. The average value of the tension of one warp thread is 43,51 cN and 32,66 cN for plain and twill, respectively. It can be seen that the tension of the main threads in the twill fabric is 1.3 times (26.53%) less than the tension of the warp threads in the plain fabric. This is due to the value of the density of the weft threads in the fabric. The amount of deformation of the warp yarns in a fabric with a high weft density is less than in a fabric with a low weft density. This situation was also stated in the studies of [2] and [13].

According to table 3, graphs of changes in the deformation and tension of the warp threads along the width of the fabric in its working area on a loom were built. Since changes in the deformation and tension of the warp threads occur in the same way as in the fabric, it was considered inappropriate to give graphic images. We present only the regression formulas that characterize the change in the deformation and tension of the warp threads in the fabric zone on the loom along its width, obtained using the EXCEL program.

Deformation formulas for warp threads;

$$\lambda_{Wc} = -\,9E\text{-}05B_p^2 + 0{,}0241B_p + 1{,}2459\ ; \qquad R^2 = 0{,}9524 \qquad (11)$$

$$\lambda_{Wt} = -7E\text{-}05B_t^2 + 0{,}0175B_t + 0{,}9445 \qquad R^2 = 0{,}9327 \qquad (12)$$

where E - is the power of the number 10 when writing the number in exponential format (E-05= 10-5)

Tension formulas for warp threads;

$$F_{Wp} = -\,0{,}0017B_p^2 + 0{,}47B_p + 24{,}458; \qquad R^2=0{,}9532 \qquad (13)$$

$$F_{Wt} = -\,0{,}0013B_t^2 + 0{,}3434B_t + 18{,}579 \qquad R^2=0{,}9338 \qquad (14)$$

According to formulas (7) - (14), with sufficient accuracy, it is possible to calculate the values of deformation and tension of the fabric and warp threads of these and similar fabrics in the working area of looms. As can be seen, the values of the R^2 coefficient of determination for these regression equations are around 0.94-0.95, which is very close to 1. This shows that the experimental values obtained are very close to the appropriate regression line

Experiments carried out to determine the deformation and tension of the fabric and the warp thread in the fabric by drawing two parallel straight lines on the fabric on the loom showed that the results obtained almost coincide with the results obtained by the traditional method. The advantage of this method is that the deformation change can be constantly observed visually on the working machine. In other words, the deformation change diagram is created live on the fabric. This allows the machine's fabric-related mechanisms to be monitored and errors to be responded to immediately.

In traditional methods, the tension of yarn, fabric and other textile materials is measured directly with various types of tension measuring devices (dynamometer, tensimeter, sensor devices and various devices, etc.) or determined indirectly by processing the received graphics. Then, the deformation of the material is calculated using Young's modulus or hardness coefficient according to the stress values. Diagrams are then created to determine how changes in stress or deformation vary depending on various parameters.

The difference of this study from traditional methods is that the warp threads and fabric deformations are determined by measuring them with a very simple method on the loom and their tension is determined according to the deformation value. Using this method allows you to visually monitor the distribution of deformation over the width of the fabric directly on the machine. Thanks to this, it becomes possible to detect deficiencies in the operation of the fabric regulator and other relevant mechanisms of the loom and take timely measures to eliminate them.

4. CONCLUSIONS

Studies were carried out on the weaving machine for plain and twill fabrics to apply the technique of drawing two linear lines on the fabric in order to determine the fabric and warp deformation in the area where the fabric is formed and under tension. The amount of fabric deformation and tension occurring in this region is determined by formulas (2) and (3), and the deformation and tension values of the warp yarn are determined by formulas (5) and (6). It was determined that the average deformation value of the fabric per meter is 2.07 mm, 1.55 mm, and the average deformation value of the warp yarn is 2.22 mm and 1.66 mm, respectively. For these fabrics, regression equations (11)-(14) with a high coefficient of determination R^2 were obtained to calculate the deformation and tension of the fabric and warp yarns across the width of the machine.

REFERENCES

1. Makhmudova N. (2022). *Experimental method for determining the deformation of warp threads on looms.* Eastern-European Journal of Enterprise Technologies, 1 (1 (115)), p. 76-84 88485.
2. Gordeev V. A. Volkov P. V. (1984). Weaving. Publishing house Light and food industry, Moscow, 1984, 486 p.p. 353-354.
3. Gordeev V. A. (1959). *Study of the cyclic deformation of the elastic system of threading a loom.* Izv. Universities, Technology of the Textile Industry: No. 3,1959, Art. 103-108.
4. Kashnikova M.L. (1984). *Optimization of threading a loom by the value the total work of deformation of the warp threads due to surf,* PhD thesis. Kostroma, 1984. https://rusneb.ru/catalog/000199_000009_004027525/.

5. Bashmetov V.S. (2016). *Determining the tension of warp threads on looms.* Bulletin of the Vitebsk State Technological University, 2016, No. 1 (30) p.p.7-11. https://cloud.mail.ru/attaches/16408894920699716129%3B0%3B1?folder-id=0&cvg=sg-2.

6. Celik, O, Eren, R. (2014). *Mathematical analysis of warp elongation in weaving machines with positive backrest system*. Tekstil ve Konfeksiyon, 24 (1), p.p. 56–65.

7. Bolotny A.P., Brut-Brulyako A.B., Erohova M.N. (2012). *Dependence Of Warp Tension On The Parameters Of Thread Tension Regulator Setting-Up,* № 2 (338) Tekhnologii tekstil'noy promyshlennosti 2012.

8. Gloy, Y.-S., Renkens, W., Herty, M., Gries, T. (2015). *Simulation and optimization of warp tension in the weaving process*. Journal of Textile Science & Engineering, 5 (1). doi: https://doi.org/10.4172/2165-8064.1000179.

9. Oshioma I. A. (1982). *Ways to improve the technological performance of the elastic filling system for shutterless looms ATPR,* Ph.D. dissertation, Leningrad, 1982, art., 121-127.

10. Süle, G. (2015). *Warp Tension Variation Over The Warp Width Weaving.* The Journal Textiles and Engineers, 15(72).

11. Gordeev V. A. (1955). *Calculation of the stiffness coefficient of an elastic system for filling a loom.* Textile Industry №5, 1955, N5 NEB (rusneb.ru).

12. Gordeev, V. A. (1965). *Dynamics of warp release and tension mechanisms of weaving machines.* publishing house “Light Industry”, M. 1965. P. 62-66

13. Üren N., Okur A. (2014*): Kumaşların Kayma Deformasyonu ve Ölçüm Yöntemleri,* Tekstil ve Mühendis, 21: 95, 51-65.

14. Fatdakhov R. M. (2002). *Method for determining the deformation of warp threads on a loom.* Materials of the International Scientific and Technical Conference “Modern Technologies and Equipment in the Textile Industry” (TEXTIL-2002), Moscow.

15. Kaplan V. (2005). *Dokuma Esnasında Çözgü Deformasyonunun Belirlenmesi Yöntemlerinin Analizi ve Geliştirilmesi*, PAU. Fen Bilimleri Enstitüsü, Tekstil Müh. A.B.D. Yüksek Lisans Tezi, 2005, Denizli, Tez No 238120.

16. Fettahov R., Kaplan V. (2005). *“Dokuma Makinalarında Çözgü Deformasyonun Deneysel İncelenmesi***” “**Tekstil Teknolojileri ve Tekstil Makinaları” Ulusal kongresinin bildiriler kitabı, 11/12 Kasım 2005, s. 28-32, GAZİANTEP.

17. Fettahov R., Kaplan V., Keskin R. (2005). *Determination of warp elongation during weaving.* Textile Marathon, May/June. 2005. Adana-Türkiye.

18. Kaplan V. (2014). *Remote Detection Waгp Tension During the Weaving.* PhD Thesis, Suleyman Demirel University, İsparta, 2014. 153 p. file:///C:/Users/rfett/Downloads/373034%20(1).pdf.

19. Kaplan V, Dayık M.(2014). *Detection Of Warp Elongation Using Image Processing In Plain Fabric,* 15th International Material Symposium in Denizli, 2014.

20. Kaplan V., M. Dayık, N. Varan, Y. TURHAN, and G. Durur, (2016). *“Detection of Warp Elongation in Satin Woven Cotton Fabrics Using Image Processing,”* Fibers and Textile in Eastern Europa, pp. 0–0, 2016.

21. Kaplan V. (2021). *Detection of Remote Sensing Warp Tension during Weaving on Plain Twill and Satin Fabrics.* 35 FIBRES & TEXTILES in Eastern Europe 2021; 29, 1(145): 35-39. DOI: 10.5604/01.3001.0014.2726.