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ASSESSING THE STRUCTURE AND ABRASION RESISTANCE OF FABRICS WITH DIFFERENT FIBER COMPOSITIONS

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Abstract. This article presents a comprehensive study of the structure and abrasion resistance of bed linen fabrics with different fiber compositions from both theoretical and experimental perspectives. The influence of the mutual arrangement of warp and weft yarns, their tension, linear density, and bending wave height as key structural factors in plain weave fabrics has been analyzed. The values of interaction pressure between warp and weft yarns were calculated, and a comparative analysis was carried out for weft-faced, warp-faced, and balanced fabrics.The results show that in weft-faced fabrics, the bending wave height of the weft yarns is higher, while in warp-faced fabrics the opposite trend is observed, leading to a decrease in abrasion resistance by up to 35–40%. In balanced fabrics, the bending wave heights of warp and weft yarns are nearly equal, which contributes to improved wear resistance. In addition, the abrasion resistance of fabrics with different fiber compositions (100% polyester, 100% cotton, and blended fabrics) was determined using the M 235/3 device and compared with theoretical calculations. The analysis revealed that the discrepancy between experimental and theoretical results ranges from 1.0 to 2.5%, confirming the high accuracy of the applied calculation methods. The obtained results are important for optimizing fabric structure and improving quality characteristics.

Keywords: yarn linear density, tension, weft-supported, warp-supported, balanced fabrics, yarn bending heights, mutual pressure, abrasion resistance.

From the sources studied, it was found that the structure of all manufactured plain weave fabrics is considered to be warp-faced. In warp-faced fabrics, the bending wave height of the warp yarns is higher than the bending wave height of the warp yarns. This indicates that the abrasion resistance of fabrics with warp or warp-faced fabrics is 35 ÷ 40% lower than that of fabrics with even surfaces. The formation of even surfaces can be justified by analyzing the structure of the plain weave fabric and conducting theoretical research.

The structure of all fabrics is formed under the mutual pressure of warp and weft threads. Therefore, using the formulas of Professor E.A.Onikov and S.A.Khamraeva [1], ***the mutual pressure value of the warp and weft yarns*** was determined in one element of the fabric with a plain surface, even surface and tan surface.

1. For a fabric with a warp surface (Fig. 1), the following specifications were obtained: the tension of the warp and weft threads is $F_t = 28$ cH, $F_a = 12$ cH, the linear density of the threads *is* $T_t = 36$ tex, *and the mutual pressure of the warp and weft threads is* $T_a = 36$ tex [2]:

$$N_t = 2F_t \cdot \sin 22^0 = 2 \cdot 28 \cdot 0.3746 = 20.98$$

$$N_a = 2F_a \cdot \sin 43^0 = 2 \cdot 12 \cdot 0.682 = 16.37$$

Figures 1-2 show the geometric models of cross-sections of fabrics with warp and weft in warp and weft directions , which were used to find the following solutions.

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The distance between the centers of the body and the warp threads (geometric density) :

$l_t = l_a = d_t + d_a = 0.214 + 0.214 = 0.428\ mm$

Determining the calculated diameter of the fabric in terms of warp and weft threads:

$$d = 0{,}0357\sqrt{\frac{T}{\delta}} = 0{,}0357\ \sqrt{\frac{36}{1}} = 0{,}214\ мм$$

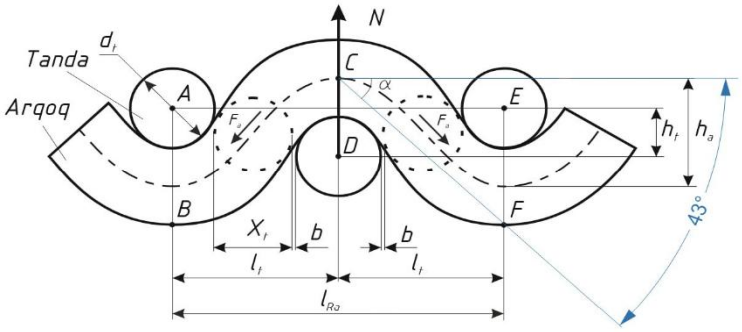


Figure 1. Cross-section of a fabric with a plain weave in the warp direction.

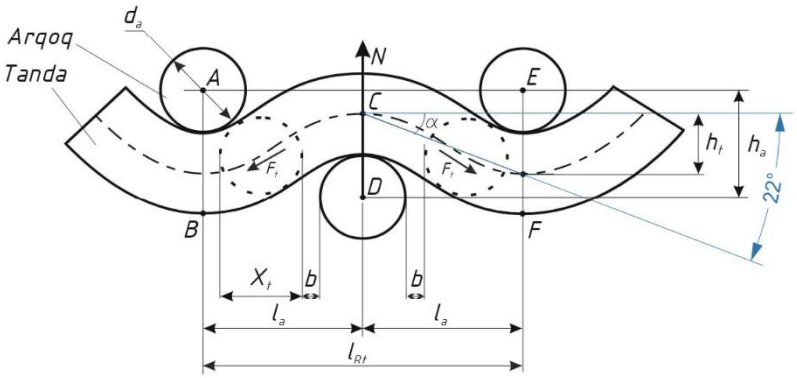


Figure 2. Cross-section of a fabric with a thin surface in the direction of the grain.

One rapport length of warp and weft threads in a fabric with a linen-wefted surface [3]:

$$l_{R_t} = \frac{R_t \cdot 10}{P_a} = \frac{2 \cdot 10}{20{,}2} = 0{,}99 mm$$

$$l_{R_a} = \frac{R_a \cdot 10}{P_t} = \frac{2 \cdot 10}{19{,}7} = 1{,}01 mmm$$

where: $R_t; R_a$ – weave ratio in the warp and weft; $R_a; R_t$ – fabric density in the warp and weft (thread/1 cm).

In the case of a woven fabric, the coefficient is b , and the distance between the joints, taking into account the angle of rotation of the warp and weft yarns at the intersection, is x:

$x_t = d_t + b_t = 0.214 + 0.281 = 0.495\ mm;$

$x_a = d_a + b_a = 0.214 + 0.291 = 0.505\ mm;$

$$b_t = \frac{0,99 - 2 \cdot 0,214}{2} = 0,281 \ мм .$$

$$b_a = \frac{1,01 - 2 \cdot 0,214}{2} = 0,291 \ мм .$$

The distance between the center of the body and the center of the warp in a plain weave fabric:

$$l_t = \frac{(0,214 + 0,214)^2}{2} + 2 \cdot 0,281 / 2 = 0,372 \ мм ;$$

$$l_a = \frac{(0,214 + 0,214)^2}{2} + 2 \cdot 0,291 / 2 = 0,382 \ мм ;$$

Bending wave heights of the warp and weft yarns in a fabric with a linen-weave surface :

$$h_t = \frac{N_t \ l_t}{2 \ F_t} = \frac{20,98 \ \ 0,372}{2 \ \ 28} = 0,139\ mm;$$

$$h_a = \frac{N_a \ l_a}{2 \ F_a} = \frac{16,37 \ \ 0,382}{2 \ \ 12} = 0,261 \ mm$$

2. For a fabric with a uniform surface (Fig. 3), the following specifications were obtained: the tension of the warp and weft threads is $F_t = 28cN$, $F_a = 18\ cN$, the linear density of the threads is $T_t = 36$ tex, and the mutual pressure of the warp and weft threads is $T_a = 36$ tex [4-5]:

$N_t = 2F_t \cdot \sin 23^0 = 2 \cdot 28 \cdot 0.391 = 21.896$

$N_a = 2F_a \cdot \sin 22^0 = 2 \cdot 18 \cdot 0.375 = 13 .5$

In pictures 3 and 4 geometrical models of the cross-section of flat-weave fabrics in the warp and weft direction are presented and used to find the following solutions.

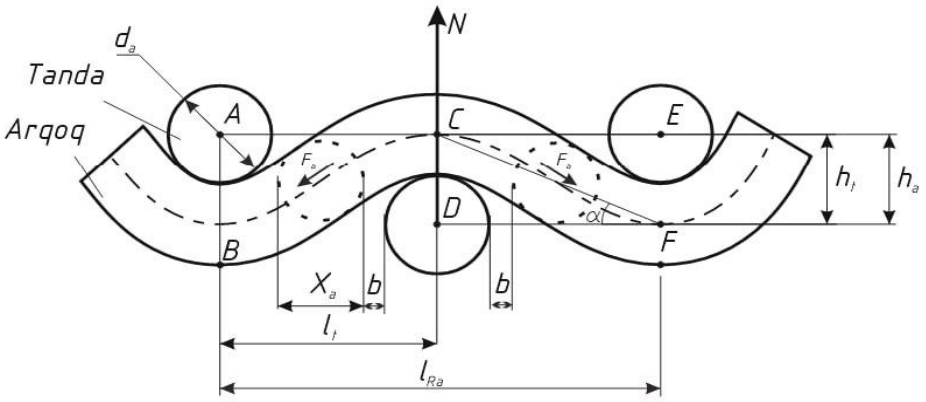


Figure 3. The cut of a cloth with an even surface in the warp direction (a=22^0).

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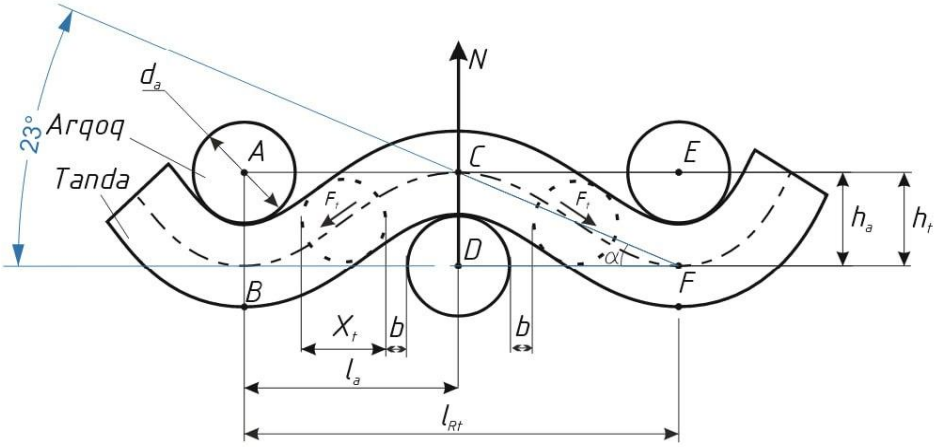


Figure 4. A cut in the grain direction of an even surface fabric with a canvas shear.

Bending wave heights of warp and weft yarns in flat-surface fabric with plain weave:

$$h_t = \frac{N_t \; l_t}{2 \; F_t} = \frac{21,9 \;\; 0,372}{2 \;\; 28} = 0,145 \;\; mm$$

$$h_a = \frac{N_a \; l_a}{2 \; F_a} = \frac{13,5 \;\; 0,382}{2 \;\; 18} = 0,143 \;\; mm \; .$$

3. For a warp-faced fabric (Fig. 5-6), the following specifications were obtained: the tension of the warp and weft threads $F_t = 20s\ N$, $F_a = 18s\ N$, the linear density of the threads When $T_t = 36$ tex, $T_a = 36$ tex, the mutual pressure of the warp and weft yarns is [6-7]:

$N_t = 2F_t \cdot \sin 43^0 = 2 \cdot 20 \cdot 0.682 = 27.28$

$N_a = 2F_a \cdot \sin 20^0 = 2 \cdot 18 \cdot 0.342 = 12 .31$

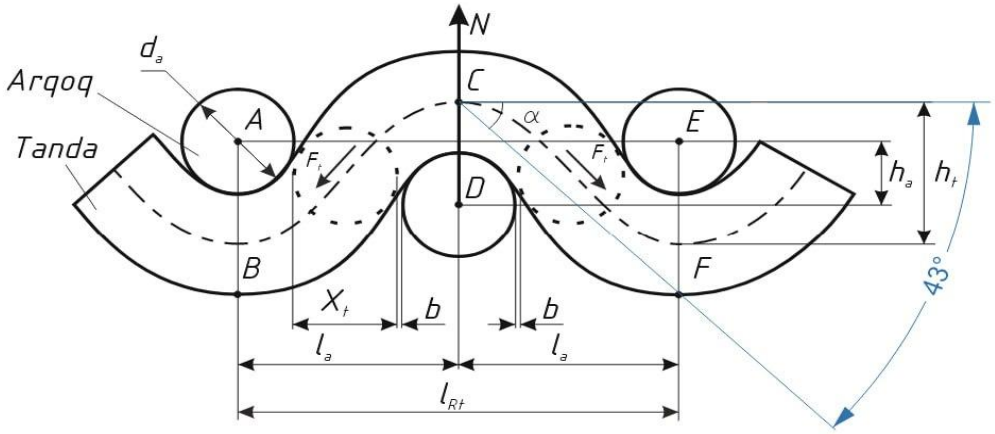


Figure-5. The tan of the surface of the cloth with canvas shearing

cut in direction.

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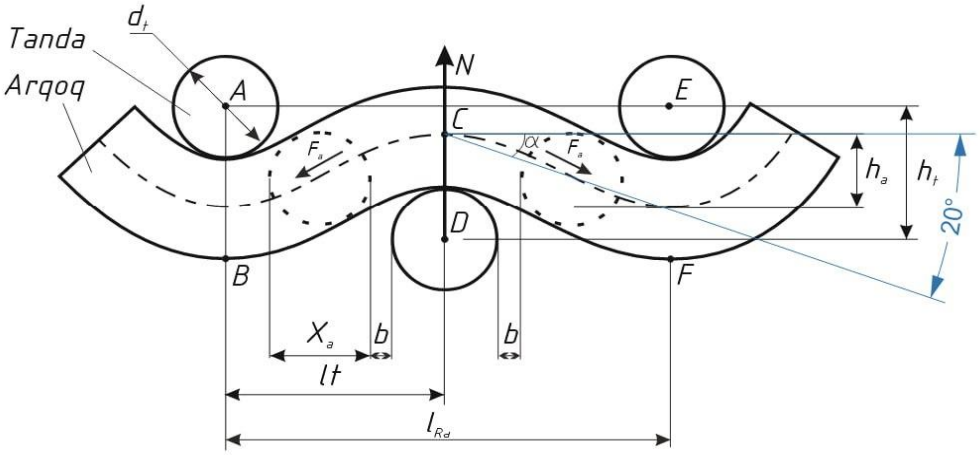


Figure 6. Cross-sectional geometrical model of a fabric with a plain weave surface in the direction of the grain.

Bending wave heights of warp and weft yarns in canvas-spun tanned surface fabric:

$$h_t = \frac{N_t \; l_t}{2 \; F_t} = \frac{27{,}28 \;\; 0{,}372}{2 \;\; 20} = 0{,}254\, mm;$$

$$h_a = \frac{N_a \; l_a}{2 \; F_a} = \frac{12{,}31 \;\; 0{,}382}{2 \;\; 18} = 0{,}131\ mm$$

According to the results of the structure and theoretical analysis of fabrics with different fiber compositions, it was found that the warp yarn bending wave height in a warped fabric is h_t=0.139 mm, the warp yarn bending wave height is h_a=0.261 mm, in a wefted fabric is h_t=0.254 mm, h_a =0.279 mm, in a smooth fabric is h_t=0.145 mm, h_a=0.143 mm. From these results, it can be concluded that the equalization of the warp yarn bending wave heights in a smooth fabric indicates an increase in the resistance to friction. The resistance of the fabric to friction is a factor determining its quality [8].

The results of the comparison of the abrasion resistance of sample fabrics with different fiber compositions and surfaces with the values obtained by theoretical calculations using the M 235/3 instrument are presented in Table 1.

Table 1

with different fiber content and base surface

t №	Different fiber content fabrics	Abrasion resistance, cycle		
		Practical	Theoretical	Difference, %

Thin-skinned				
11	100% polyester fiber	96 44	9891	2.4
22	100% cotton fiber	6798	6973	2, 5
33	Tanda thread is 100% polyester, jute thread is 50% cotton + 50% polyester fiber	86 99	8756	0 , 7
44	Body 100% polyester, 60% cotton, 40% polyester	8290	8432	1, 7
55	Body: 100% polyester, 70% cotton, 30 % polyester	7730	7621	1, 4
The body is superficial.				
16	100% polyester fiber	9,853	10,054	2, 0
27	100% cotton fiber	73 90	7459	2.0
38	Tanda thread is 100% polyester, jute thread is 50% cotton + 50% polyester fiber	88 69	8,919	1, 0
49	Body 100% polyester, 60% cotton, 40% polyester	86 52	8594	0 , 67
510	Body: 100% polyester, 70% cotton, 30 % polyester	8 2 59	8108	1 , 86
Flat surface				
111	100% polyester fiber	12647	12,972	2 , 5
212	100% cotton fiber	8433	8 5 94	1, 9
313	Tanda thread is 100% polyester, jute thread is 50% cotton + 50% polyester fiber	11798	12000	1, 7
414	Body 100% polyester, 60% cotton, 40% polyester	103 46	10,378	0 , 3
515	Body: 100% polyester, 70% cotton, 30 % polyester	9321	9,567	2 , 6

with different fiber composition and base surface are presented in Figures 8-10.

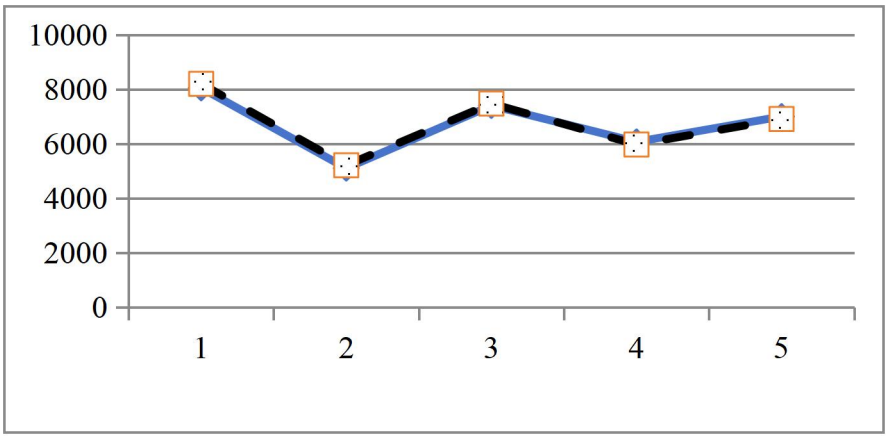


Figure 8. Changes in abrasion resistance of fabrics with different fiber content and thin surface.

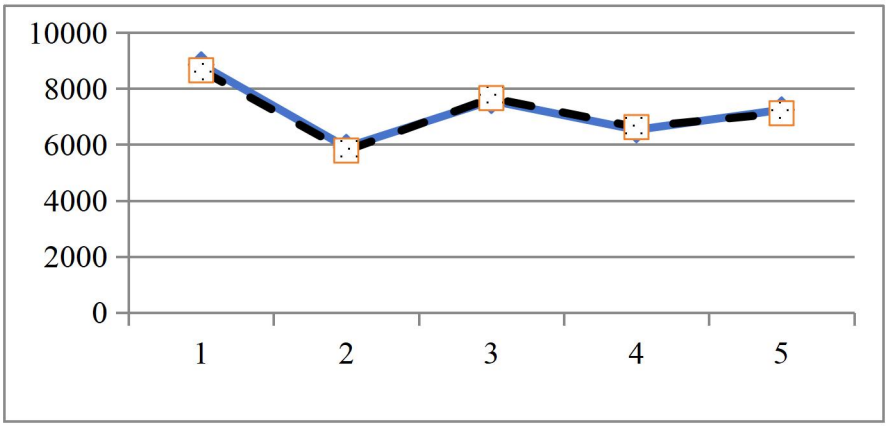
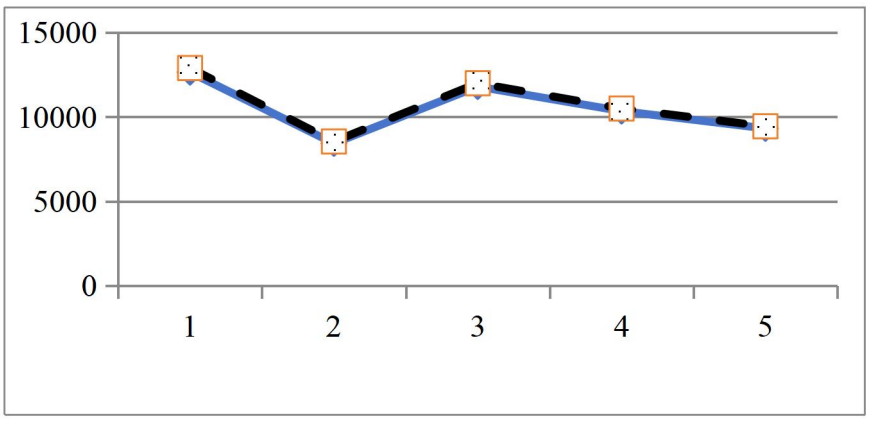


Figure 9. Changes in abrasion resistance of fabrics with different fiber content and base surface.



Options

Figure 10. Variation of abrasion resistance of fabrics with different fiber content and equal surface area.

with different fiber content and base surface were analyzed. 100% polyester fiber yarn, tan and even surface fabrics The abrasion resistance index obtained by practical and theoretical methods is from 1.9% to 2.5%. The abrasion resistance index obtained by practical and theoretical methods of 100% cotton yarn, tan and even surface fabrics is from 1.4% to 2.1%. resistance index from 1.0% to 1.6%, tanda yarn 100% polyester, hemp yarn 60% cotton+40% polyester hemp, tanda and even surface fabrics obtained by practical and theoretical abrasion resistance index from 1.4% to 1.6%, tanda yarn 100% Polyester, cotton yarn 70% cotton + 30% polyester fiber , the abrasion resistance index of cotton and even surface fabrics obtained by practical and theoretical methods differed from 1.3% to 1.7% [9-10].

In conclusion, it was found that the abrasion resistance values of fabrics with different fiber content and base surface obtained by practical and theoretical methods differed from 1.0% to 2.5%, and the results of theoretical calculations were found to be less than 5% of practical values.

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