OPTIMIZATION OF THE WEAVING PROCESS IN THE PRODUCTION OF HEAVY FABRIC

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Annotation

A preliminary study of the object of research showed that the goal of optimizing the weaving process is to achieve the maximum level of equipment productivity. Reducing the level of thread breakage in the weaving process to the greatest extent (at a constant speed of the main shaft of the loom) contributes to achieving this goal. This allows it possible to select a minimum of warp end breaks as the main criterion for optimizing the weaving process. On the one hand, it defines indicators such as weaver's workload, equipment utilization rate, which significantly affect the productivity of labor and equipment. On the other hand, the indicator of the thread breakage can be unambiguously defined the conditions of fabric formation on the loom, depending on technological parameters of its filling and set at a minimum value of thread breakage, the most favorable conditions of fabric formation. Thus, adopted criterion of optimization allows characterizing effectiveness of research object with the highest degree of completeness. During production of heavy fabrics for minimal thread breakage it is recommended to set the following optimal parameters: warp tension 60 cN (per thread); cloth fell position - 10 mm; the position of the back rest relative to front rest - (+ 10) mm.

Keywords: warp, fabric, parameters, tension, cloth fell position, front rest, optimization, breakage, criterion, efficiency.

Introduction

Three main parameters were chosen, i.e. three main independent variables: x1-filling warp tension, cN; x2-value of the spade, mm; x3 is the position of the rock relative to the chest in height, mm [1]. Then, as the tension of the warp increases, the breakage decreases and, with its further increase, again increases due to overvoltage of the warp threads. The size of the spade affects the conditions for surf of the weft thread and, as a consequence, the size of the surf strip. With an increase in the spade, the conditions for surf of the weft thread improve and the size of the surf strip decreases. Therefore, when fabricating a fabric with a high filling ratio, a larger spade is recommended. With a decrease in the size of the spade, the size of the surf strip increases and a dynamic impact phenomenon occurs, which can increase the breakage of the warp threads. With different tensions of the branches of the shed, more favorable conditions are created for the surf of the weft thread, i.e., the conditions for tissue formation improve and the breakage of the threads along the warp decreases. On the other hand, large deviations from the level of a symmetrical throat can create a weakening of tension in one branch and an increase in it in another, i.e. with. lead to breakage of weakly stretched main threads [2]. The difference in the tension of the upper and lower branches of the pharynx can be adjusted by the height of the rock. The selected factors meet all the requirements of the theory of mathematical planning of an experiment: there is no interchangeability of factors, they can be measured by available means, they can vary within a fairly wide range of minimum and maximum values and take them with the required accuracy [3]. As for the rest of the technological parameters of filling the machine, they were all constant during the experiment. Since the weaving process is non-stationary in time, and when a large number of experiments are carried out, the results are distorted due to various violations of the process, randomization of experiments was used when planning the experiment. In the work, the central compositional method of planning the experiment of the second order was adopted, which makes it possible to study in detail, describe and optimize the weaving process in the optimization area under study [4]. The choice of intervals and values of factors for five levels of variation was carried out taking into account the technological capabilities of filling the machine, which is presented in Table 1.

Table 1 Levels of factor variation

Factor	Levels of factor variation					Interval
	-1,682	-1,0	0	+1,0	+1,682	
x1-filling warp tension, cN	54	60	70	80	86	10
x2-size of the spade, mm	10	14	20	26	30	6
x3-position of the rock relative to the chest, mm	-17	-15	0	+10	+17	10

Theoretical Part

The work of the standard central compositional experiment (RCCE) is carried out to describe the stationary section of the response surface, and the experiment conducted on the selected matrix allows us to obtain a second-order mathematical model describing the influence of the factors x1, x2, x3 on the selected optimization parameters of the following form [5]

$$y = в_0 + в_1 x_1 + в_2 x_2 + в_3 x_3 + в_{12} x_1 x_2 + в_{23} x_2 x_3 + в_{13} x_1 x_3 + в_{11} x_1^2 + в_{22} x_2^2 + в_{33} x_3^2 \quad (1)$$

Where :в0, вi, вij, вii – regression coefficient; в0 – free member ;в1,в2,в – regression coefficients with linear terms; в12, в23,в13– coefficients in the interaction of factors ;в11, в22,в33– square term regression coefficients.

Table 2 RCKE Planning Matrix

Randomization Order	Experience number	Factors			Optimization criterion Y_u breakage of warp threads	$(Y_u-Y_R)^2$
		x_1	x_2	x_3		
20	1	+	+	+	0,29	0,000049
19	2	+	+	-	0,21	0,000061
18	3	+	-	+	0,29	0,00001
17	4	+	-	-	0,35	0,000026
16	5	-	+	+	0,38	0,000052
15	6	-	+	-	0,43	0,000073
14	7	-	-	+	0,29	0,000057
13	8	-	-	-	0,49	0,000016
1	9	0	0	0	0,26	0,0001
2	10	0	0	0	0,25	0,0001
3	11	0	0	0	0,27	0,0001
4	12	0	0	0	0,26	0
5	13	0	0	0	0,25	0,0001
6	14	0	0	0	0,25	0,0001
11	15	+1,682	0	0	0,50	0,000010
12	16	-1,682	0	0	0,65	0,000100
9	17	0	+1,682	0	0,33	0,000292
10	18	0	-1,682	0	0,40	0,000015
7	19	0	0	+1,682	0,18	0,000090
8	20	0	0	-1,682	0,21	0,000034
					6,54	0,00125

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According to the methodology for processing the results of the experiment, we determine the regression coefficient and their dispersion, and then the dispersion of the output parameter in the experiment or the dispersion of reproducibility. Student's t-test is used to determine the significance of the regression coefficients. In this case, not all coefficients are significant, in particular, the regression coefficient of the square term at x2 has a smaller value, so we discard it from further processing. The mathematical model describing the dependence of the breakage on the selected factors has the form

$$Y_R = 0{,}26 - 0{,}051x_1 - 0{,}06x_2 - 0{,}02x_3 - 0{,}021x_1x_2 + 0{,}036x_2x_3 + +0{,}034x_1x_3 + 0{,}104x_1^2 - 0{,}05x_3^2 \quad (2)$$

To test the hypothesis about the adequacy of the resulting model, we use the Fisher criterion, the calculated value of which is compared with the tabular one, since the calculated value is less than the tabular value, then the hypothesis about the adequacy of the resulting model is not rejected.

Experimental

Tables 3-5 show the results of calculating the output parameter for one variable and two constant values of the input parameters calculated according to equation (2).

Table 3 Calculation results Y=f(x1) at constant x2 и x3

№	Constant values of factors	Breakage of warp threads Y values of the factor x1 variables				
		-1,682	-1	0	+1	+1,682
1	x_2=-1, x_3=-1	0,726	0,494	0,326	0,324	0,526
2	x_2=-1, x_3=0	0,67	0,454	0,32	0,394	0,57
3	x_2=-1, x_3=1	0,514	0,314	0,214	0,322	0,514
4	x_2=0, x_3=-1	0,66	0,419	0,23	0,249	0,4
5	x_2=0, x_3=0	0,64	0,415	0,26	0,313	0,48
6	x_2=0, x_3=1	0,52	0,311	0,19	0,277	0,46
7	x_2=1, x_3=-1	0,594	0,344	0,134	0,132	0,40
8	x_2=1, x_3=0	0,61	0,376	0,2	0,232	0,39
9	x_2=1, x_3=1	0,526	0,308	0,166	0,232	0,406

Table 4 Calculation results Y=f(x1) at constant x1 и x3

№	Constant values of factors	Breakage of warp threads Y values of the factor x2 variables				
		-1,682	-1	0	+1	+1,682
1	x_1=-1, x_3=-1	0,85	0,8	0,725	0,236	0,184
2	x_1=-1, x_3=0	0,48	0,454	0,415	0,168	0,14
3	x_1=-1, x_3=1	0,01	0,008	0,005	0,1	0,09
4	x_1=0, x_3=-1	0,39	0,326	0,23	0,234	0,16
5	x_1=0, x_3=0	0,36	0,32	0,26	0,2	0,159
6	x_1=0, x_3=1	0,23	0,214	0,19	0,166	0,149
7	x_1=1, x_3=-1	0,13	0,06	0,349	0,227	0,152
8	x_1=1, x_3=0	0,44	0,394	0,313	0,22	0,176
9	x_1=1, x_3=1	0,65	0,628	0,256	0,32	0,201
10	x_1=0, x_3=1,682	0,35	0,376	0,084	0,314	0,085

Table 5 Calculation results Y=f(x1) at constant x1 и x2

№	Constant values of factors	Breakage of warp threads Y values of the factor x3 variables				
		-1,682	-1	0	+1	+1,682
1	x_1=-1, x_2=-1	0,538	0,386	0,246	0,106	0,212
2	x_1=-1, x_2=0	0,439	0,311	0,207	0,103	0,191
3	x_1=-1, x_2=1	0,339	0,236	0,168	0,1	0,312
4	x_1=0, x_2=-1	0,555	0,306	0,32	0,094	0,086
5	x_1=0, x_2=0	0,435	0,33	0,26	0,19	0,084
6	x_1=0, x_2=1	0,314	0,234	0,2	0,166	0,085
7	x_1=1, x_2=-1	0,572	0,466	0,394	0,322	0,215
8	x_1=1, x_2=0	0,430	0,349	0,313	0,277	0,195
9	x_1=1, x_2=1	0,289	0,232	0,182	0,232	0,174

Discussions

We assessed the technological experiment using slices: Y = f (x1) at constant x2, x3; Y= f (x2) at constant x1, x3 ; Y = f (x3) at constant x1, x2. The analysis of tables 3-5 shows that all the equations of discontinuity from the input factors are the equation of a parabola. It also follows from the tables that the change in y at x1=-1, x3=1 in all variants at x2=: -1.682; -1.0; 0; +1;+ 1.682 has a lower value of thread breakage per 1m of fabric and ranges from 0.01-0.1. This leads to the fact that the greatest influence on the breakage of the warp threads is exerted by the tension of the warp threads and the position of the rock relative to the chest of the loom. The optimal parameters will have the following values: tension of the main threads - 60 cN (per 1 thread); spade size - 10 mm; the position of the rock relative to the chest is (+ 10) mm. With these values of the parameters, the breakage of the warp threads will not exceed 0.01 breaks per 1m. fabrics.

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Findings

1. A mathematical model has been developed for the breakage of the main threads depending on their parameters, in particular, on the tension of the main threads, the size of the spade and the position of the rock relative to the chest.

2. When weaving heavy fabrics, it is recommended to set the optimal parameters on looms: the tension of the warp threads is 60 cN (per 1 thread); spade size - 10 mm; the position of the rock relative to the chest is (+ 10) mm. With these values of the parameters, the breakage of the main threads will not exceed 0.01 breaks per 1 m. In addition, this combination of technological parameters allows better preservation of the strength properties of the thread in the fabric.

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