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Design Development and Justification of Parameters of the Device for Drawing a Polymer Composition on the Stitches of Stable Materials in a Sewing Machine

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ABSTRACT: The article presents the scheme and principle of operation of the recommended device for applying a polymeric composition on the stitching of stitched materials. On the basis of theoretical and experimental research, the main parameters of the system are substantiated.

KEYWORDS: Sewing machine, polymer composition, lines, fabric, composite rollers, application, strength, vibration, amplitude, frequency, quality.

I. PROBLEM STATEMENT

The quality of manufactured garments largely depends on the strength - deformation characteristics of lines [1]. It is important to increase the strength characteristics of the stitching lines of materials by coating them with additional polymer compositions [2]. At present, effective technologies and devices that increase the strength of the stitched material lines are not sufficient.

II. DEVICE WORKING OUT

The proposed design for applying a polymer composition to the worn-out parts of clothing [3, 4, 5] contains a housing 1, upper and lower composite rollers mounted on shafts 2 and having elastic (rubber) bushings 3, plastic porous bushings 4 with truncated conical through holes 5 on their surface and protrusions 18, along the edges of the sleeves 4 and, bearings 6 and 7, the upper bath 8 with the polymer composition, the lower bath 19 with the polymer composition, feeding tube 9 with the polymer feed regulator 10 (see. Fig. 1).

The proposed device operates as follows. When grinding, textile materials are pressed by foot 14 to the toothed rack 15 and the needle plate 17. The fabric is moved by the amount of stitch by a toothed rack located in the slot of the needle plate. The rake feeds materials only under the needle 16, and the worker sets the direction of movement of materials when the line is executed. When the needle 16 is engaged with the shuttle (not shown in the drawing), the lock stitch is formed. Next, the materials to be ground fall under the mutually rotating upper and lower composite rollers mounted on shafts 2 and connected to the body of the sewing machine 1 by means of bearings 6 and 7.

In the process of moving the tissues from the upper bath 8 through the feeding tube 9, the polymer composite flows to a porous sleeve with truncated through conical holes 5 of the upper roller and is applied to the upper layer 11 of the fabric in the form of a film 13. The supply of the polymer composition is controlled by means of the regulator 10. the layer 12 of the fabric to be machined is applied to the polymer composition 13 by means of a deformable porous sleeve 4, a lower roller having also a porous surface and truncated conical through holes on the surface of the sleeve and partially embedded in a solution of the polymer composition in the lower tub 19.

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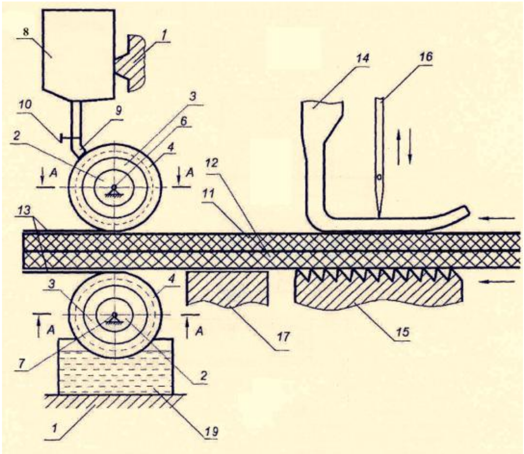
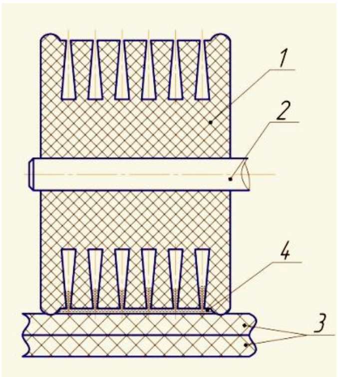
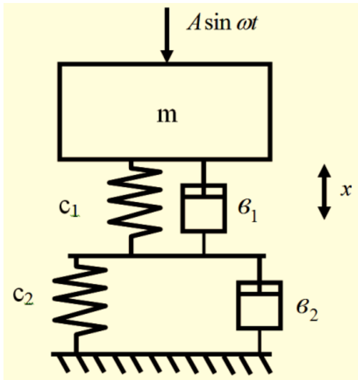


a- The general scheme



b- Rubberroller



c-The settlement scheme of vertical fluctuations of an axis of a roller of the device

Fig. 1. Devices for applying a polymer composition to the parts to be cut

In the process of grinding, the polymer composition is applied in a 15-18 mm wide strip, so that the seam is in the center of the strip. To ensure uniformity of the width of the application of the polymer composition 13 to the materials to be ground, 11, 12 sleeves 4 of the rotating rollers are made with protrusions 18 (0.5-1.0 cm) at both edges. These protrusions 18 smoothly mate with the outer cylindrical surfaces of the sleeve 4. In the process of applying the polymer composite 13 due to the heterogeneity of the materials to be ground 11,12, the sleeves 4 copy these irregularities due to their deformation, as well as the elastic sleeves of 3 rollers. When the supply of polymer material is insufficient due to its capillarity and wet ability, the stock of polymer material flows out of truncated conical holes 5 of the sleeves 4.
In the process of operation of the proposed device for applying polymer compositions to the worn parts of clothes due to the heterogeneity of the materials being grinded, the polymer composite and the uneven rotation of the composite roller, the roller shaft is oscillated vertically. It should be noted that the quality of the application of the polymer composite depends on the degree of its filling in the pores of the materials. In this case, the filling of the pores with the polymer composite depends on the frequency and amplitude of the vertical oscillations of the composite roller. Therefore, we consider the design scheme presented in Fig. 1 b oscillation roller.
Using the Lagrange equation of the second kind [6, 7, 8, 9], we construct the differential equation for the vertical oscillations of the device's composite roller in accordance with the calculation scheme in Fig. 1 c. In this case, the differential equation describing the vertical movement of the roller axis is:

$$(m_в + m_{рв} + m_к)\ddot{X} + (в_1 + в_2)\dot{X} + \frac{c_1 c_2}{c_1 + c_2} = A\sin\omega t \qquad (1)$$

A, ω - the amplitude and frequency of the disturbing force, $m_в$ - the mass of the axis of the roller, kg; $m_{ρв}$ - mass of rubber roller sleeve, kg; $m_к$ - the mass of the polymer composite, which is in the holes of the roller, kg. c_1, c_2 - respectively, the stiffness coefficients of the rubber bushing roller and grind materials. $в_1 в_2$ - respectively, the dissipation coefficients of the rubber sleeve of the roller and the grind materials.
Analytical solution (1) will be obtained using the method given in [6,7]:

$$X = \frac{A\sin(\omega t + \gamma)}{\sqrt{\left[\frac{c_1 c_2}{(c_1 + c_2)(m_в + m_{ρв} + m_к)} - \omega^2\right] + \left[\frac{(в_1 + в_2)\omega}{m_в + m_{ρв} + m_к}\right]^2}} \quad (2)$$

Where γ - phase shift of the disturbing force.
The frequency of natural oscillations of the axis of the roller device is determined from the expression.

$$f_c = \sqrt{\frac{c_1 c_2}{(m_в + m_{ρв} + m_к)(c_1 + c_2)}}. \quad (3)$$

The numerical solution of the problem was carried out with the following initial values of the parameters: c_1 – $1{,}5 \cdot 10^3$Н/м; c_2 – $0{,}5 \cdot 10^3$N/м; A=1,6 N; $m_в = 3{,}8 \cdot 10^{-2}$kg; $m_{ρв} = 2{,}3 \cdot 10^{-2}$kg; $m_к = 0{,}15 \cdot 10^{-3}$kg; $в_1 = 0{,}31$Нс/м; $в_2 = 0{,}17$ Нс/м.

In fig. 2a shows graphic patterns of the change in the natural frequency of the vertical oscillations of the roller shaft of a device for applying polymer compositions to stitches of stitched materials from variations in the total mass of the system. From the analysis of the graphs obtained, it was revealed that an increase in the reduced mass of the composite roller leads to a decrease in the natural frequency of the vertical oscillations of the roller shaft according to nonlinear regularities. Thus, with an increase in the mass of mnp from 22 g to 124 g, the natural frequency of the vertical oscillations of the roller decreases from 20.5 Hz to 9.72 Hz with a stiffness coefficient c1 = 2.0 · 103 N / m. With a decrease in the stiffness coefficients of the elastic rubber sleeve of the roller c1 and the stitched materials c2, the general pattern of reducing the values of the natural frequency of the roller shaft oscillation remains the same, but the values will be different (see graphs 2.4 in Fig. 2 a). With an increase in the frequency of vertical oscillations of the roller of the device, polymer compositions will more fully fill the pores of the stitched materials, which ultimately leads to an increase in the bond strength of the materials. Therefore, the recommended values for the parameters of the composite roller are: c1 = (2.0 ÷ 2.5) 103 N / m; c1 = (0.8 ÷ 1.5) · 103 N / m; mnp ≤ (3,5 ÷ 5,0)) · 10-2 kg.
It should be noted that the change in the amount of deformation of stitched materials when interacting with the rollers of the device directly affect the amplitude of oscillations of the roller, thereby affecting the quality and uniformity of the layer of polymer composition applied to the seams of the materials to be ground. In fig. 2 b shows the constructed graphical dependences of the change in the amplitude of oscillations of the roller shaft on the change in the values of the stiffness coefficient of the rubber sleeve of the roller. It can be seen from the graphs that an increase in the stiffness coefficient of the rubber bush from 0.26 · 103 N / m to 2.8 · 103 N / m leads to a decrease in the amplitude of oscillations of the rubber roller from 12.6 · 10-4 m to 5.1 10 -4 m, with ω = 385 s-1, and with increasing ω to 428 s-1, the amplitude of oscillation Ax decreases from 7.63 3 10-4 m to 1.21 10-4 m according to nonlinear regularity.

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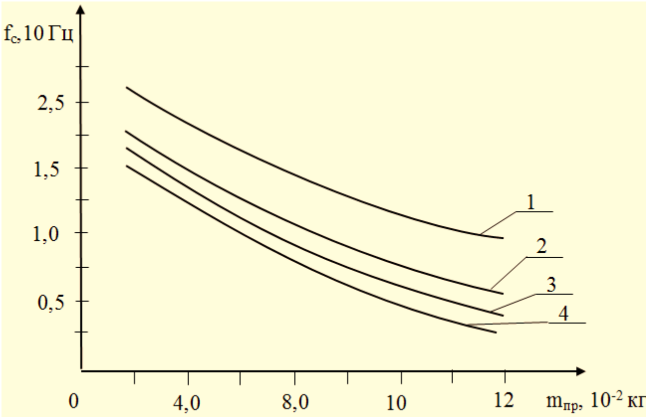
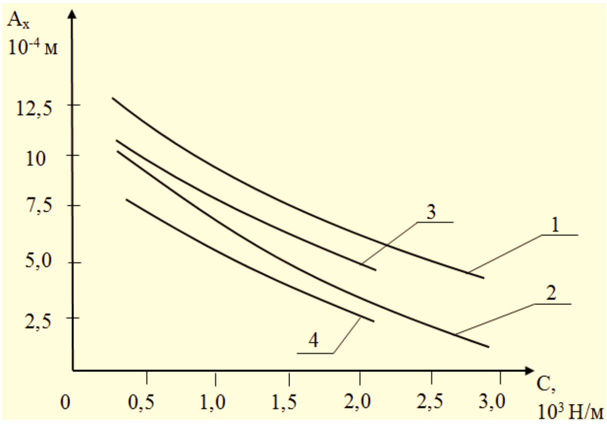


where 1 – atc_1 – $2{,}0\cdot10^3$N/м; 2 – atc_1 – $1{,}2\cdot10^3$N/м; 3 – atc_2 – $0{,}5\cdot10^3$N/м; 4 – atc_2 – $0{,}3\cdot10^3$N/м

a– the dependence of the change in the natural frequency of the vertical oscillations of the rubber roller shaft on the variation in the reduced mass of the roller



where, 1,2-Ax = $f(c_1)$; 3,4-Ax = $f(c_2)$; 1,3-atω = 385 c^{-1}; 2,4-atω =428 c^{-1}

б – graphic dependences of the change in the amplitude of vertical oscillations of the roller shaft on the change in the stiffness coefficients of the rubber roller and stitched materials

Fig. 2. Graphic dependencies

At the same time, a similar pattern is observed with an increase in the stiffness coefficient of the materials being sewn (more dense materials) (see curves 3.4, Fig. 2. b). This is explained by the fact that with an increase in the frequency of cross linking of materials, the rollers oscillate with a smaller amplitude due to the influence of the dissipation coefficients B1 and 2.

Therefore, when grinding more dense materials to sufficiently cover the polymer composition of the stitching line, the use of stitches with longer length and lower frequency of rotation of the main shaft of the sewing machine is appropriate.

III. RESULTS OF TESTS

Tests conducted on experimental and serial sewing machines and compared the results. During the tests, an experienced sewing machine with a new device for applying a polymer composition to the fabric was not a failure, there were no missing stitches during high-speed modes of operation [10, 11, 12]. In fig. 3 shows a general view of a sewing machine with a device for applying a polymer composition to stitching materials.

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а-frontview

б-the process of applying the polymer composition to the lines

Fig. 3. General view of a sewing machine with a device for applying a polymer composition to stitching materials

Production tests on a prototype of a sewing machine were carried out at different speeds and on different materials. Studies have shown that the density of the connection of the upper and lower threads of a two-layer material correspond to the norm of the transverse direction.

The quality of the lines obtained on the recommended sewing machine meets the regulatory and technological requirements (there is almost no needle breakage, thread breakage, skipping stitches and folds of materials, the separation of threads in the fabric is sharply reduced).

At the same time, technological tests showed that the recommended device for applying a polymer composition has several advantages over existing methods and in the simplicity of design, the possibility of resource saving, a small number of operations and increased productivity, as well as stitches and stitches.

The fibrous composition of tissues and their structural features are shown in Table 1.

Table 1
Characteristics of the investigated tissues

Fabric	Thearticle	Fibrousstructure		Number of threads on 10 sm		Superficialdensity, g/м^2	Interlacing
		dasis	ducks	dasis	ducks		
Adras	65144	cotton	viscose	300	180	140	Thelinen
Atlas	32590	silk	acetate	520	260	110	Thesatiny
Silk	52010	kapron	kapron	560	80	80	Thesatiny

They varied: the supply of fabric in the range of 2.3.4 mm, and the emulsion consumption per 1 cm of fabric length from 0.1 to 0.4 g / cm2. The average values of the breaking load of the thread seams on the basis and on the weft of the tissues under study are shown in Table 2.

Table 2
Explosive load of seams, H

Fabricgiving,mm	Emulsion consumption per 1 cm of tissue, g / cm2	Adras		Atlas		Silk	
		dasis	ducks	dasis	ducks	dasis	ducks
2	0,1	60	33,9	46,5	22,9	35,2	36,0
	0,2	61,5	35,5	50,1	24,1	40	38,2
	0,3	62,5	36,3	53,2	26,2	47,8	39,6
	0,4	63,0	37,2	56,1	28,1	51,7	42,2
3	0,1	55,0	30,0	40,	21,1	40	26,1
	0,2	60,0	34,0	48,5	23,4	47,2	27,9
	0,3	61,5	37,1	50	27,1	50,3	29,4
	0,4	62,5	42,5	52	31,2	51,2	31,2
4	0,1	50,0	28,0	38	20,1	38,4	25,0
	0,2	58,0	31,2	43	25,0	42,5	27,3
	0,3	61,0	33,4	47,5	27,3	47,4	29,0
	0,4	62,0	37,2	50	30,0	49,9	30,1

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The application of the polymer composition to the edges of the parts to be grinded along the seam increases the strength of the seam by fastening the fabric structure [11,12]. The strength of the seams increases with the increase in the frequency of stitches and with an increase in the emulsion on the fabric by 1.5–2.3 times, in fact there are no missing stitches, the thread breakage decreases 10 times.

The results of the production tests confirmed the operability of the developed device for applying the polymer composition to the parts of garments to be grinded in real industrial conditions with high technological parameters.

IV. CONCLUSIONS

An effective device has been developed for applying a polymer composition to the lines of materials being grinded in a sewing machine. The results of theoretical studies obtained the law of movement of the rubber roller. Based on the analysis of the constructed graphical dependencies, the system parameters are justified. According to the results of comparative tests of a modernized sewing machine, it has been proved that the device for applying the polymer composition has been effectively used.

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