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# Development of an Effective and Substantiation of the Parameters of the Mechanism of the Pull-Down Device of the Knitting Machine

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**ABSTRACT:** The article presents an effective diagram and principle of operation of a pull-down device for a flat knitting machine. Based on the engineering solution to the problem, graphical dependencies of the system parameters are constructed and recommended.

**KEYWORDS:** knitting, roller, flat knitting machine, deformation, pull-out, physic-mechanical, flat knitting.

## I.INTRODUCTION

The mechanism for drawing the web is designed to constantly pull the bound web. Due to this, flawless formation of new loops is guaranteed, as well as reliable transfer of loops. The machine is equipped with three mechanisms for drawing the blade, which complement each other.

The main guy mechanism is located under the needle beds and consists of sections in the form of pull rollers that are connected to the shaft by means of spiral springs. Pinch rollers, which press the knit to the pull-down rollers, have for each section adjustment of the pressing force by a spring using a screw. The knit is clamped between the pull-down and pinch rollers and is pulled off when the shaft rotates from the stepper motor, which receives commands from the processor and when knitting works with a constant force specified by the program [1].

In another known construction of the knitwear pulling mechanism, a load is used that is directly suspended from the web [2-3].

In the device for automatic drawing of the product on a flat knitting mechanical machine, including receiving and clamping sectional shafts [4]. In the mechanism of the knitwear drawback, including a drawbar with grooved sectional rollers that are connected by a gear wheel, the adjustment of the drawback force passing through the grooved rollers and the clamping shaft is carried out by a special device that includes a compression spring and an adjusting screw [5]. The disadvantage of this device is the design complexity. The design does not ensure uniformity of the guy line across the entire width of the knitwear.

## II. DEVELOPMENT OF AN EFFECTIVE MECHANISM OF THE PULL-OUT DEVICE OF THE FLAT KNITTING MACHINE

The recommended knit drawback mechanism consists of sections in the form of pull-out corrugated rollers 1, which are mounted on the shaft 5 with a rubber sleeve 6, made integral along the entire length of the shaft 5. In this case, the rubber sleeve 6 can be made separately, for each section with different thicknesses. The greatest thickness of the rubber sleeve 6 in the extreme sections, and the smallest in the middle section, the pressure rollers 2 are also made sectional. The pressure rollers 2 pressing the jersey to the exhaust rollers 1 have, for each section, adjustment of the pressing force by the spring 3 using the adjusting screw 4. The pressure rollers 2 can be made corrugated (Fig. 1.).

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The design works as follows. The incoming knitwear is clamped between the pull-off 1 and pinch rollers 2 and moves when the shaft 5 rotates from the stepper one (it is not shown in the figure). At the same time, in each section of the exhaust roller 1 and the pressure roller 2, it is pre-installed with the necessary clamping force with the adjusting screw 4 and spring 3 (Fig. 1.).

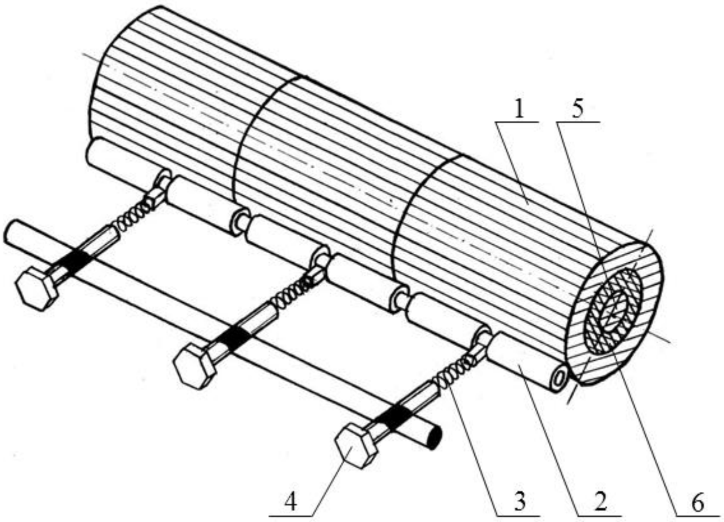


Fig. 1. The mechanism of pull-out device

In this case, changes in the thickness of the knitwear, bending of the shaft 5 can lead to unevenness of the drawback of the jersey, across the entire width of the drawback mechanism. Depending on the change in the value of the thickness of the knitwear and the bending of the shaft 5, deformation (compression) of the rubber sleeve 6 occurs. This leads to uniformity of the stretch of the knitwear. In the development of multilayer knitwear, as well as knitwear with different densities, uniformity of the stretch of knitwear over the entire width is ensured by using a rubber sleeve 6 separately for each section and with different thicknesses. Given that the bend of the shaft 5 is the largest in the middle part, the thickness of the rubber sleeve 6 in this zone will be the smallest, as well as in the extreme sections of the guy, respectively, the thickness of the rubber sleeve 6 will be the largest. The difference between the largest and smallest thickness of the rubber bushings 6 is chosen equal to or less than the thickness of the drawn knit. The design allows the uniformity of the drawdown of the knitted fabric along its entire width.

## III. EXPERIMMENTS AND DISCUSSION

It is important to justify the parameters of the exhaust rollers taking into account the deformation of the rubber sleeve.

Using the second-order Lagrange equations [6,7], we obtain the following differential equation describing the oscillations of the pull-out roller with a rubber sleeve, taking into account the deformation of the pull-out jersey and the force of the pinch roller.

$$\frac{d^2x}{dt^2}+\frac{(в_1-в_2-в_3)}{m_{op}}\cdot\frac{dx}{dt}+\frac{c_1\cdot c_2\cdot c_3}{m_{op}\cdot[c_2\cdot c_3-c_1\cdot(c_2+c_3)]}\cdot x=\frac{A}{m_{op}}\sin\omega t \quad (1)$$

where, $m_{op}$-is the mass of the extraction roller; x - mixing of the extraction roller along the line of action of the pressure roller and the deformation of the drawn knitwear; $C_1$, $в_1$ - stiffness and disipation coefficients of the rubber sleeve; $C_2$, $в_2$ - stiffness and disipation coefficients of the drawn knitwear; $C_3$, $в_3$ - stiffness and disipation coefficients of the spring of the pressure roller. A, ωt is the amplitude and frequency of oscillations of the perturbing force from changes in the heterogeneity and thickness of the drawn knitwear.

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The analytical solution of differential equation (1) was carried out using the technique of the above papers [7,8] and taking into account the initial conditions, at t=0; $x$=0, $\overset{0}{\tilde{o}}=0$ and get:

$$\tilde{O} = \hat{A}\tilde{O}^{\frac{Dt}{2}}(D\cos kt + M\sin kt) + \frac{B}{\omega}\left[\left(E^2 - \omega^2\right)\sin\omega t - 2D\omega\cos\omega t\right] \quad (2)$$

where, $B = \frac{A\omega}{(E^2 - \omega^2) + 4\omega^2 \cdot D^2}$; $E = \sqrt{\frac{C_1 \cdot C_2 \cdot C_3}{m_{op} \cdot \left[C_2 \cdot C_3 - C_1 \cdot (C_2 + C_3)\right]}}$;

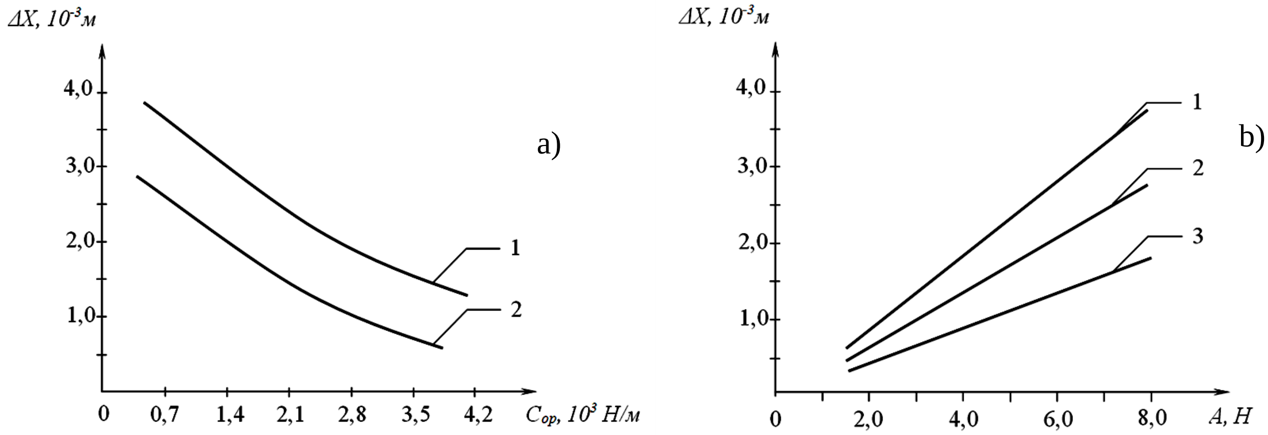
$$D = \frac{(\hat{a}_1 - \hat{a}_2 - \hat{a}_3)}{2 \cdot m_{\hat{\imath}\eth}};\; K = \sqrt{E^2 - D^2};\; M = \frac{1}{K}(2 \cdot D^2 + \omega^2 - E^2)$$

We carry out the numerical solution of the differential equation with the following calculated values of the parameters of the extraction roller:

$m_{op}$= (4,0 ÷ 5,0) $\cdot 10^{-2}$ kg;
$C_1$ =(0,3 ÷ 0,4)$\cdot 10^4$ N/m;
$C_2$ =(0,11 ÷ 0,18) $\cdot 10^4$ N/m;
$C_3$ =(0,6 ÷ 0,65) $\cdot 10^4$ N/m;
$в_1$ =(1,8 ÷ 2,5) Nc/m;
$в_2$ =(2,2 ÷ 3,0) Nc/m;
$в_3$ =(4,0 ÷ 4,2) Nc/M; ω =(1,5 ÷ 2,0) $c^{-1}$;

Based on the processing of the obtained numerical solutions to problem (2), graphical dependencies of the variation in the swing range of the exhaust roller on the measurement of the stiffness coefficient of the rubber sleeve (Fig. 2.)

At the same time, with an increase in the stiffness coefficient of the rubber sleeve of the sectional exhaust roller from $0,7\cdot 10^3$ N/m to $4,2\cdot 10^3$ N/m, the amplitude of ΔX oscillations decreases from $3,85\cdot 10^3$ m to $1,45\cdot 10^{-3}$ m with a mass of $m_{op}=2,8\cdot 10^{-2}$ according to a nonlinear regularity. With an increase in the mass of the sectional pull-down roller of a flat-knit knitting machine up to $4,5\cdot 10^{-2}$ kg, the swing range of the pull-out roller decreases with the pressure of the knit by the pressure-reducing roller from $2,78\cdot 10^{-3}$ m to $0,61\cdot 10^{-3}$ m. It should be noted that the larger the mass of the sectional pull-down roller, the smaller the amplitude of its oscillations. In this case, the amplitude of the pull-out roller oscillations should not exceed the total value of the deformation of the rubber sleeve and pull-out knitwear. Therefore, to ensure the magnitude of the oscillation range of the exhaust roller within $(2,5\div 3,5)\cdot 10^{-3}$, the recommended system values are: $C_1=(0,2\div 0,25)\cdot 10^{-3}$ m; $m_{op}=(3,5\div 4,0)\cdot 10^{-4}$ kg.

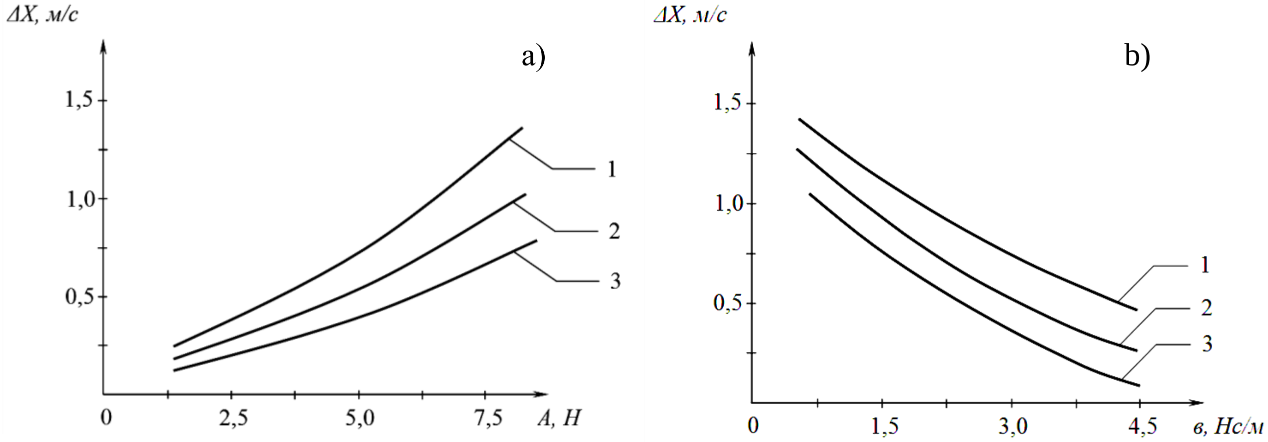



where, 1 – at $m_{op}=28\cdot 10^{-3}$ kg; 2 – at $m_{op}=45\cdot 10^{-3}$ kg;
a - changes in the range of oscillations of the exhaust roller from changes in the stiffness coefficient of the rubber sleeve; b - changes in the swing range of the pull-out roller from changes in the amplitude of the disturbing force from the pulled jersey.

1–at $C_1=0,3\cdot10^4$ *N/m*; $C_2=0,11\cdot10^4$ *N/m*; $C_3=0,6\cdot10^4$ *N/m*;
2–at $C_1=0,35\cdot10^4$ *N/m*; $C_2=0,15\cdot10^4$ *N/m*; $C_3=0,625\cdot10^4$ *N/m*;
3–at $C_1=0,4\cdot10^4$ *N/m*; $C_2=0,18\cdot10^4$ *N/m*; $C_3=0,65\cdot10^4$ *N/m*;

Fig. 2. Patterns of change in the swing range of the exhaust roller.

An increase in the amplitude of the perturbing force from the pulled jersey leads to an increase in the amplitude of oscillations of the composite pulley according to a nonlinear regularity. In fig. Figure 4b presents the obtained graphical dependences of the variation in the range of oscillations of the pull-out roller on the change in the amplitude of the arising force on the pulled knit. The graphs show that with increasing A from 2,0 N to 8,0 N at $C_1=0,3\cdot10^4$ N/m, $C_2=0,11\cdot10^4$ N/m, $C_3=0,6\cdot10^4$ N/m leads to an increase in the swing range of the exhaust roller from $0,62\cdot10^{-3}$ m to $3,8\cdot10^{-3}$ m. With values $C_1=0,4\cdot10^4$ N/m, $C_2=0,18\cdot10^4$ N/m, $C_3=0,65\cdot10^4$ N/m , the swing range of the pull roller increases from $0,22\cdot10^{-3}$ m to $1,92\cdot10^{-3}$ N/m. In this case, an increase in the stiffness characteristics of the rubber sleeve, the pulled jersey, and also the spring of the pinch roller reduces the oscillation amplitude of the pull roller by half (see Fig. 2, curves 1.3).




where, 1 – at $m_{op}=25\cdot10^{-3}$ kg; 2 – at $m_{op}=35\cdot10^{-3}$ kg; 3 – $m_{op}=45\cdot10^{-3}$ *kg*;

a-swing of the oscillation speed of the pulling roller from a change in the amplitude of the disturbing force from the pulled jersey; b-swing of the oscillation speed of the extraction sleeve of the roller from a change in the reduced coefficient of dissipation of the rubber sleeve of the extraction roller and the spring of the receiving roller.

Fig. 3. Graphical dependence of the variation in the speed range of the extraction roller in a flat knitting machine.

Given that the amplitude of the pulley is not perfect $(0,8\div1,8)\cdot10^{-3}$ m, the recommended values of the stiffness coefficients of the elastic elements in the pull-out device are; $C_1=(0,35\div0,38)\cdot10^4$ N/m, $C_2=(0,15\div0,16)\cdot10^4$ N/m, $C_3=(0,62\div0,63)\cdot10^4$ N/m.

Figure 3 shows the constructed graphical dependences of the variation in the amplitude of the oscillation velocity of the composite draw roller on the variation in the amplitude of the oscillations of the acting force from the drawn jersey.

## IV. FINALY COMPARISON ANALYS AND CONCLUTION

The importance of changing the oscillation speed of the exhaust roller is due to the fact that during operation, when the sectional exhaust roller returns to its original position, it must be instantaneous. This is mainly provided by the dissipation characteristics of the rubber sleeve of the draw roller. The range of fluctuations in the speed of the extraction roller depends on the disturbing force and on the mass of the extraction roller. Based on the analysis of the graphs in Fig. 4 and providing $\Delta\mathring{\tilde{O}}\geq(0,8\div1,0)$ m/s, the recommended values are $m_{op}=(3,5\div4,0)\cdot10^{-4}$ kg, A=(4,0÷5,0) N.

Chart analysis in fig. 4b shows that an increase in the coefficient of disinformation of the rubber sleeve of the exhaust roller from 0,75 Nc/m to 3,5 Nc /m leads to a decrease $\Delta\mathring{\tilde{O}}$ from 0,92 m/s to 0,14 m/s at a load of A=3,0 N. With a load of A=7,0 N the range of fluctuations in the speed of the pull-out roller decreases from 1,33 m/s to 0,41 m/s that is, with an increase in the load from the pull-out knit, the speed of the swing-out pulley also increases significantly. Therefore, to ensure $\Delta\mathring{\tilde{O}}\geq(0,8\div1,0)$ m/s, the recommended values are: $в=(2,5\div3,0)$ Nc/m, A=(4,0 ÷ 5,0) N.

An effective self-adjusting design of a pull-down device for a flat-knit knitting machine has been developed. Based on theoretical studies of the vibrations of the extraction roller, system parameters are recommended.

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