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# CALCULATION OF THE LOAD ON THE FRICTION CLUTCH OF THE SEWING MACHINE

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**Annotation.** The article considers a disc friction clutch, a sewing machine drive, the condition for its performance, the calculation of axial force, and the wear resistance of a friction pair. In the process of switching on the friction clutch, sliding occurs between the parts with which the clutch halves are engaged. It is noted that the adhesion strength in the clutch depends on the coefficient of friction and its stability when changing the sliding speed, pressure and temperature.

**Keywords:** friction clutch, clutch, sliding, shaft, friction forces, coupling half, belt drive, wear resistance, heat resistance, adhesion, cohesion, friction moment, friction coefficient.

Of the controlled mechanical clutches, friction clutches are the most common, since they provide smooth engagement and disengagement of the sewing machine drive shafts [1-4]. Such coupling of the shafts is provided by frictional forces between the mating parts of the coupling half, which can be easily adjusted by changing the degree of compression of these parts. In the process of switching on the friction clutch, sliding occurs between the parts with which the clutch halves are engaged. With steady motion, this slip is absent. During overloads, such slipping is possible and, therefore, the friction clutch can serve as a safety device. In addition, the working principle of the friction clutch is the basis of the sewing machine speed control widely used in modern machines.

Electric drives with friction clutches are widely used. Such drives are used in sewing machines for general purposes, in machines for performing tightening operations, etc. [5, 6].

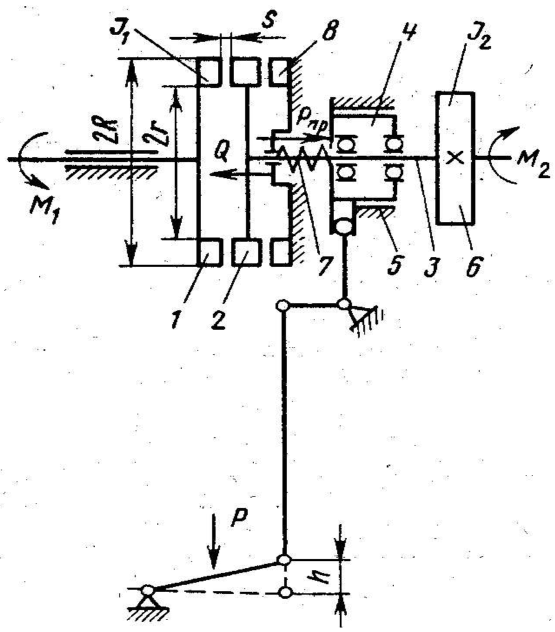

**Fig.1. Kinematic diagram of the friction clutch of the sewing machine drive**

A schematic diagram of a drive with a friction clutch of sewing machines is shown in fig. 1. The driving part of the drive is the half-coupling 1 with a flywheel, and the driven part is the half-coupling 2, sitting on the shaft 3. The shaft is placed in the bearings of the glass 4, which has the possibility of axial movement of the guide 5. At the right end of the shaft 3, a pulley 6 is fixed, connected by a belt drive with the drive shaft of the sewing machine. A spring 7 is placed between the cup 4 and the frame, which presses the driven part of the clutch to the fixed brake ring 8. In the idle state, the driven half-clutch is pressed against the ring by a spring and cannot rotate, and the driving half rotates at a constant speed equal to the idle speed of the electric motor $\omega_o$. To turn on the clutch, it is necessary to move the cup 4 together with the half-coupling 2 to the left and press it against the leading half-coupling with force Q.

It should be noted that friction clutches do not allow shaft misalignment. The centering of the coupling halves is achieved either by their location on one shaft, or by using special centering rings.

During the inclusion of the friction clutch, slippage of the rubbing surfaces is inevitable, accompanied by the release of heat. Therefore, friction materials used in couplings must be wear-resistant and heat-resistant [7-10]. The strength of the clutch in the clutch depends on the coefficient of friction and its stability when changing the sliding speed, pressure and temperature. The condition of operability, lack of slippage of the friction clutch is written as follows:

$$M_{fr}=T\cdot K, \text{ (Nm)} \qquad (1)$$

where $M_{fr}$ is the moment of friction on the coupling halves; K = 1.25 ... 1.5 - coefficient of adhesion reserve;

M is the torque transmitted by the clutch (the product of M is called the calculated torque).

**Friction moment:**

$$\mathrm{M} = fQ\frac{D}{2} \qquad (2)$$

where $f$ is the coefficient of sliding friction; $Q$ – axial force, N.

**Reduced diameter of friction pairs:**

$$D_{re} = \frac{2D^3 - D_1^3}{2D^2 - D_1^2} \qquad (3)$$

where D and $D_1$ are the outer and inner diameters of the friction surfaces, mm.

Axial force required to engage the clutch

$$Q = \frac{2T_{fr}}{fD_{re}} \qquad (4)$$

To reduce the force Q, it is possible to increase the coefficient of friction $f$, for which one disk is lined with an overlay made of friction material, asbo-friction material. Such clutches run dry, so these discs are made of cast iron.

Friction clutch disks are checked for wear resistance according to the condition:

$$P = \frac{4Q}{\pi(D^2 - D_{1)}^2} \leq [p] \qquad (5)$$

where [P] is the allowable pressure on the working surface of the coupling. In order for the wear of the discs to be sufficiently uniform, they usually take D ≤ (1.5 ... 2) $D_1$.

The permissible value [$p$] and the values of the friction coefficient $f$ are established on the basis of operating experience, and depend on the material of the rubbing surfaces.

The contact friction force (P), according to the molecular mechanical theory of friction, is the sum of the adhesive and cohesive components. Since the interaction of these components is carried out on the actual contact area (A), then the specific friction force (τ) can be represented as a formula:

$$\tau = \frac{F}{A_r} = \tau_a + \tau_k \qquad (6)$$

where F is the friction force at contact, (N);

$\tau_a$ and $\tau_k$ – adhesive and cohesive components, MPa.

In this case, the adhesive ($\tau_a$) component is characterized by the dependencies :

$$\tau_a = \tau_0 + \beta_2\sigma_n;$$
$$\sigma_n = \frac{P}{A_r} \qquad (7)$$

$A_r$ - actual contact area, (mm$^2$);

where $\tau_0$ are shear stresses independent of normal ones, (MPa);

$\beta_2$ is the molecular friction constant;

$\sigma_n$ is the design strength of the material, (MPa).

Based on this, the adhesive component of the friction coefficient (fa) in plastic contact can be written as

$$f = \frac{\tau_0}{\mathrm{HB}}\beta_2 = const \qquad (8)$$

Analysis of the relationship of various parameters, in the aspect of creating a rational friction mode, it is possible to use friction discs with a positive hardness gradient ($G_h$), which can be represented as an inequality:

$$G_h = \frac{dH}{dh} > 0 \qquad (10)$$

Where *dH* is the microhardness distribution, (Hv);

*dh* is the depth of measurement of the hardness of the material, mm.

A decrease in the hardness of the surface layer under conditions of plastic contact will lead to an increase in the friction coefficient ($£_{fr}$), facilitating the formation of the friction surface of friction discs with a larger actual contact area and a lower specific friction force, which will increase its bearing capacity, allowing an increase in the FM resource. However, a decrease in specific loads can lead to an increase in slippage, a decrease in the friction coefficient, a friction moment of the FM, expressed by dependence (12) and a violation of its operation mode:

$$M_\psi = Qf_{fr}R_{fr} \qquad (11)$$

where $M_\psi$ is the friction moment of a fully engaged clutch, (Nm); $R_{fr}$ – friction radius, (m); *Q* is the total axial force of the disks, (N).

Thus, from the point of view of FM resource assessment, it is necessary to consider the relationship between the friction coefficient and the hardness gradient of the working surface of the friction disc.

The general tribological law, presented in the form of expression (8), as applied to the work of FM, shows the feasibility of increasing the adhesive ($F_a$) component and reducing the cohesive ($F_к$) component of the friction force:

$$F_{fr} = F_a + F_k \qquad (12)$$

where $F_{fr}$ – friction resistance, (N); $F_a$-adhesion resistance, (N); $F_k$ - cohesive resistance, (N).

In pairing friction discs, this can be achieved either by increasing the actual contact area, or by increasing the load on the compressing discs in the contact zone [11]. The most preferable of them is an increase in the actual contact area, which is confirmed by the molecular mechanical theory of friction, according to which the friction coefficient is described by I.V. Kragelsky [10] in the form of the expression:

$$f = \frac{\alpha_2 A}{Q} + \beta_2 \qquad (13)$$

where $Q$ is the normal contact load, N; $\alpha_2$ and $\beta_2$ are the constants of the friction pair under study.

A rational way to achieve this is to modify the friction surface of FM friction disks by applying a functional coating by friction-mechanical brassing at the stage of their manufacture.

Based on the analysis of the tribological system of friction discs with a positive hardness gradient and the relationship between the parameters of the friction process, it is possible to represent the moment of friction of friction discs as a criterion for evaluating one of the parameters of the friction mode, expressed as a functional dependence of the hardness of friction pairs, the presence of lubrication, diffusion of soft materials, load on the friction couple and the temperature of the surface layer.

To conduct experimental research, we have developed an experimental setup based on the TOYOTA sewing machine with the preservation of the kinematic and operating modes of the sewing machine. The general view and block diagram of which are shown in Figures 2 and 3.

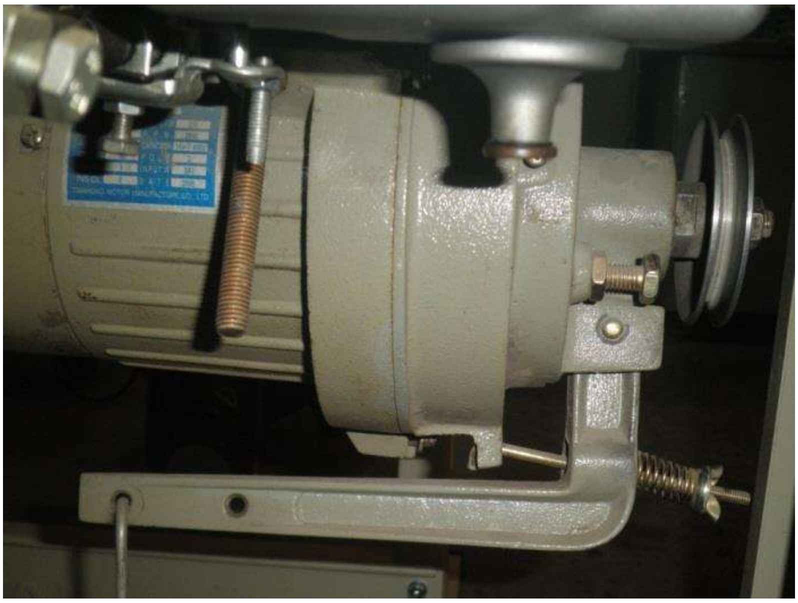

**Fig.2. General view of the sewing machine drive**

For experimental studies, the standard modes of operation of the sewing machine were adopted. The frequency of rotation of the main shaft of the electric motor was 3000 turn/m, with an electric motor power of 0.45 kW.

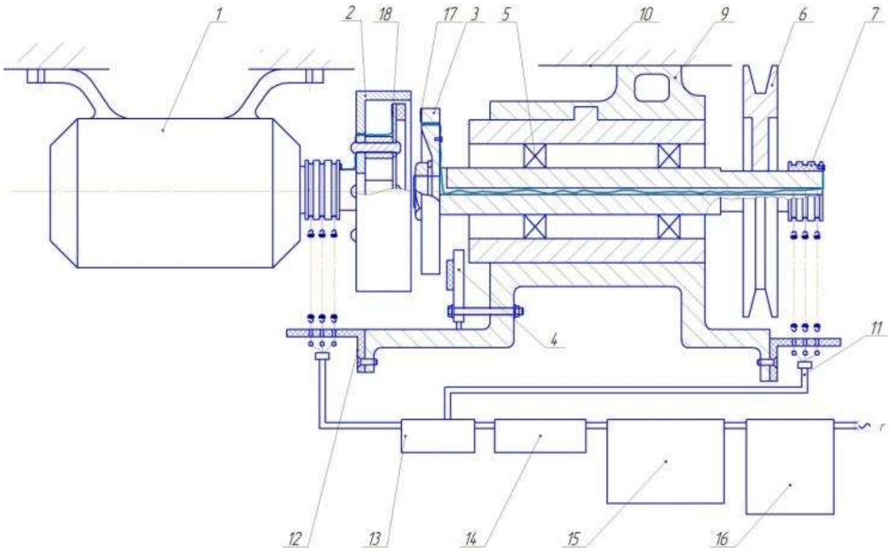


**Fig.3. Scheme of the experimental setup for measuring the torque on the drive clutch of the sewing machine**

1 – sewing machine drive electric motor. 2 – drive flywheel. 3-driven drive of the sewing machine. 4-brake clutch. 5 - rolling bearings for installing the driven shaft. 6 - sewing machine drive pulley. 7 – current collectors for strain gauges mounted on the driven drive shaft of the friction clutch. 8 slippers on the flywheel drive shaft. 9 – friction clutch housing. 10 - bed of the sewing machine. 11-terminals of current collectors. 12-bracket for installing current collector terminals. 13 – strain gauge amplifier UT-4-1. 14 – analog-to-digital converter LTR-154. 15 – oscilloscope and pulse modulator with a timer. 16 – computer

The ongoing research makes it possible to experimentally determine the value of the transmitted moment depending on the number of friction surfaces and various values of the compression force of the disks with the redistributed dimensions and material of the disks themselves. In addition, the results obtained can be compared with theoretical calculations and experimentally determined the coefficient of friction between rubbing surfaces.

The calculation of an additive criterion based on the results of an experimental assessment of the change in wear rate, temperature and friction torque in the interface, taking into account the change in the friction mode of the compression sleeve and the hardness of the surface layers of the friction discs, will allow us to build graphical dependencies and response surfaces, which make it possible to determine the optimal combination of the average hardness of the interface and thereby assess the impact of the proposed structural and technological changes on the service life of the friction clutch of the sewing machine.

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# IMPROVEMENT OF THE DESIGN OF THE SHUTTLE DRUM IN THE SEWING MACHINE

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**Abstract**:

**Objective.** Today, in the process of sewing gauze, the lack of the ability to untie the shuttle thread, to ensure its tension evenly, is considered a disadvantage of this shuttle tube design. our goal is to improve the new construction of the shuttle bobbin in the sewing machine.

**Methods.** The experiment was carried out on sewing machines of "Shafirkon equatorial" enterprise. the structural scheme and working principles of the component tube with elastic bushing and plastic fingers were studied. a tube winder with a base, frame, guide wheel, tube, hook mechanism, thread tension mechanism and thread trimming mechanism in a sewing machine, along with recommendations for improving productivity.

**Results.** According to the results, a new effective structure of the component tube was developed. based on theoretical studies, a formula was obtained to determine the friction between the winding thread and plastic fingers.

**Conclusion.**The article provides a structural diagram and the principle of operation of a composite bobbin with an elastic sleeve and plastic sticks. An analytical method is given for determining the moment

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