ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 5 , May 2021

To the Calculation of Thread Tensioning Discs in Sewing Machines

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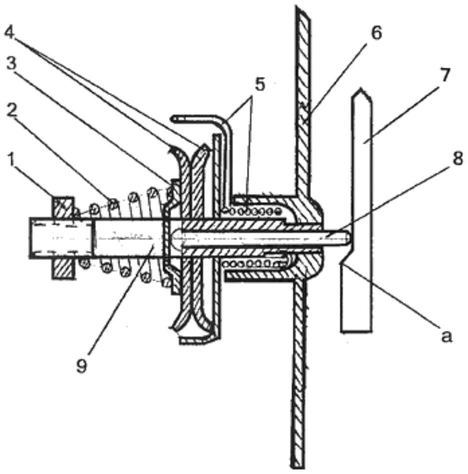
ABSTRACT:The article presents the method of calculation of thread tensioners for sewing machines. The scheme and principle of operation are described in detail and the method of calculation of the recommended effective design of a disc thread-tensioner for a sewing machine needle thread.

KEY WORDS: Sewing machine, thread, thread tensioner, disc, spring, adjustment, force, stiffness, calculation procedure

I.INTRODUCTION

In order to achieve a normally tight stitch with a thread knot in the middle of the fabric, a certain tension must be created in the upper and lower threads. This tension is created by the friction braking of the threads in special thread tension regulators [1].

The upper thread tension regulator is usually mounted on the side wall of the sewing machine, and for the lower thread is a flat spring mounted on the side of the bobbin case. A general view and cross section is shown in figure 1.



a

b

a – Cross-section of sewing machine disc tensioner **b – overall view of the device**

1 - Adjusting screw; 2 - cone spring; 3 - alignment and spring washer; 4 - pallet washers;
5 - return spring; 6 - machine housing; 7 - stopper; 8 - pallet thrust rod.

The operation of the tension regulator consists in squeezing the thread passing between two convex tension washers 4 placed on the screw 9. The washer 4 facing the nut 1 is pressed by the spiral cone spring 2. Between the right-hand washer and the spring there is a washer with a bridge 4. This washer is used to release the thread when the foot is lifted by the stem 8. The screw together with the compensation spring 5 is installed in a housing which is fixed

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in the machine head. The upper thread tension regulator is designed so that when the presser foot is lifted, the tension washers move apart and the tension is released, allowing the thread to be wound off the spool when the fabric is removed. Let's calculate the tensioner [2,3].

The force Q_1 required to tighten the stitch is created by the friction force of the thread when the screw shaft bends back and the friction force when the thread passes between the tension washers. The value of this force can be determined using the formula:

$$Q_1 = Q_2 e^{f_1 \alpha} + \frac{P(f_1+f_2)}{f_1 \alpha}\left(e^{f_1-1}\right) \qquad (1)$$

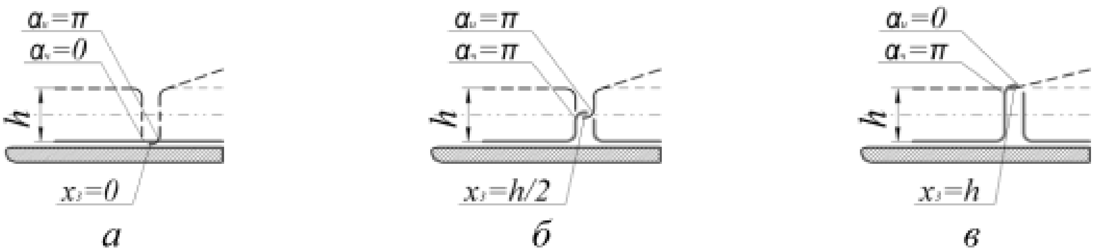
Where Q_1 - force required to wind the thread from the coil; P - pressure force of coil spring; f_1 - coefficient of thread friction on the cylindrical screw surface (f_1=0,15÷0,20); f_2 and f_3 - coefficients of thread friction on the end faces of the washer (f_2= f_3= 0,15÷0,20); α - angle of coverage (α = π/2).

The force generated by the coil spring depends on the spring stiffness, the ratio of the largest and the smallest radius of the working part of the coils and the spring settlement:

$$P = \frac{C\lambda}{\pi i (r_2^2 + r_1^2)(r_2 + r_1)} \qquad (2)$$

Where i- number of working turns of spring; r_1 and r_2 - smallest and largest radius of turns of working part of spring; λ - draft of spring; C - stiffness of spring, C=GJp; G - modulus of elasticity 11-rod for steel wire G=8*105 kgs/sm^2; Jp - polar moment of inertia of wire section diameter d (sm^4).

It was found that a difference in thread tension disturbs the stitch formation as shown in Fig. 2. Approximate stitch positions at different values of thread tension. Fig.2



a) the lower thread is overstretched; b) the thread tension is equal; c) the upper thread is overstretched

Fig.2. Stitch position diagrams.

The lower thread tension is created by the friction forces between the thread and a leaf spring mounted on the side of the bobbin case, which is secured by screws.

The tension of the bobbin thread can be determined using the formula

$$Q_3 = P(\mu_1 + \mu_2) \qquad (3)$$

Where P is the spring force; μ_1 and μ_2 are the coefficients of belt friction on the spring and on the bobbin case.

During the tightening of the resulting stitches in the sewing machine must ensure the required tension of the hook and needle threads, at which the weave knots will be located as close as possible to the middle of the materials being sewn. Sewing machines are equipped with hook and needle thread tension adjustment devices. The tension of the needle thread most often regulated by the disc regulator, installed on the head of the sewing machine. One of the variants of our proposed design is shown in Fig. 3. The device is a disc regulator with two springs.

A helical spring 4 rests at one end on a knurled nut and at the other end on a tensioning actuator. On the opposite side, there is a spring 7 clamped between the other tensioning actuator 2 and the support device 8. The two helical springs 4, 7 are positioned concentrically in relation to the guide axis 1, pressing the tensioning actuators 2 and 3 against each other while centering them at the same time. If the helical springs 4, 7 are made relatively flexible, so that the resonance frequency of the mass spring system formed by the helical springs 4, 7 and the tensioning actuators 3 is significantly lower than the frequency of excitation of the oscillations of the supporting device 8, then also in this example implementation of the invention the tensioning actuators remain essentially at rest, while they slowly rotate. Therefore, also in this example embodiment of the invention, the aforementioned advantages due to the axial vibration of the support device 8 are provided [4].

Fig. 4 shows the construction of the thread tensioner of the proposed design with two plate compression springs with different spring stiffness parameters. The main difference of this tensioner is the possibility to move the plates autonomously when changing both the thread tension and the thickness of the thread, which allows to keep the tension of the supplied thread constant when sewing. A general view is shown in Fig. 2.

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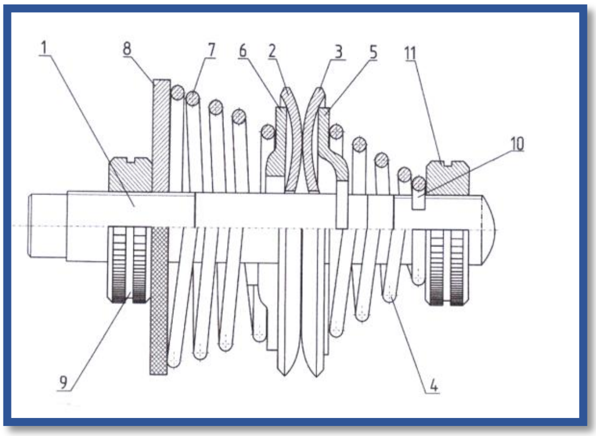

Fig.3. Diagram of the yarn tensioner regulator.

Fig.4. Photograph of the recommended thread tensioner.

The force generated by a coil spring depends on the spring stiffness, the ratio of the largest and smallest coil radii and the spring settlement:

$$P = \frac{K\lambda}{\pi i(r_2^2+r_1^2)(r_2+r_1)} \qquad (4)$$

Where i is the number of working coils of the spring; r_1 and r_2 are the smallest and largest radii of the working part of the spring; λ is the spring seat.

The spring stiffness in relation to the deformation can be variable or constant. Products whose stiffness remains unchanged when deformed are called linear. And those in which there is a dependence of stiffness coefficient on changes in the position of coils, are called "progressive".

The determination of the stiffness value depends on the following input data:

- The type of raw material used in manufacture;
- The diameter of the metal wire turns (D_w);
- Diameter of the spring (average value is taken into account) (D_m);
- Number of spring turns (Na).

The formula is used to calculate the stiffness coefficient:

$$k = G_c * (D_w)^4 / 8 * Na * (D_m)^3,$$

where G is the shear modulus. This value can be omitted from the calculation as it is given in the tables for different materials.

For example, for ordinary steel it is 80 GPa, for spring steel it is 78.5 GPa. It is clear from the formula that the biggest influence on the spring stiffness coefficient is exerted by the remaining three values: diameter and number of turns, and the diameter of the spring itself. In order to achieve the required stiffness values, these are to be changed. The stiffness coefficient can be calculated experimentally by means of simple tools: a spring, a ruler and a weight which will act on the prototype. In our case the body is connected with two springs. Determining the stiffness in this case is much more difficult. Some of the features of the connection are as follows: the parallel connection is characterized by the fact that the parts are placed in series. This method increases the elasticity of the system considerably. The serial method is characterized by the fact that the parts are connected to each other. This method of connection considerably reduces the elasticity, but allows a substantial increase in maximum elongation. In some cases it is the maximum elongation that is required.

In both cases, a certain formula is applied which defines the specifics of the connection. The modulus of elasticity may vary considerably depending on the specific features of the individual product [5].

When the products are connected in series, the index is calculated as follows:

$$l/k=l/kl+l/k2+...+l/kn.$$

The figure in question is considered to be a rather important property, in this case it is reduced. The parallel connection method is calculated as follows:

$$k=kl+k2+... kn.$$

The above coefficient of stiffness of the part in parallel or series connection determines many characteristics of the connection. Quite often a determination is made as to what the elongation of the spring equals. Among the features of the parallel or series connection are the following:

When connected in parallel, the elongation of both products will be equal. It should not be forgotten that both variants should be characterised by the same length in the free position. In the case of a series connection, the figure is doubled.

The free position is the situation in which the workpiece is in the free position without a load being applied. This is what is taken into account in most calculations.

The stiffness factor varies depending on the connection method used. In case of parallel connection the figure is doubled, in case of series connection it is reduced.

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