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DYNAMIC-MATHEMATICAL MODEL OF VERTICAL MOTION OF SEWING MACHINE SUPPORTER

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ABSTRACT
Vertical motions of sewing machine supporter, material and spring and their parameters in the sewing process requires exactly harmonizing within needed limits. Dynamic-mathematical model of vertical motion will help us to derive dynamic pressure of supporter on the material because the quality of sewing process depends on this pressure. In the moment when support contacts material the pressure od supporter is bigger then static pressure because of vibrations which leads to material damage from lathe cogs and to additional ballast to the transmitting mechanism. In this paper there are analyzed forces which leads to those facts.
Keywords: Sewing machine, supporter, material, forces, pressure

1. INTRODUCTION

Vertical motions of sewing machine supporter, material and spring and their parameters [1,2,3,6] in the sewing process requires exactly harmonizing within needed limits. Dynamic-mathematical model of vertical motion will help us to derive dynamic pressure of supporter on the material because the quality of sewing process depends on this pressure.

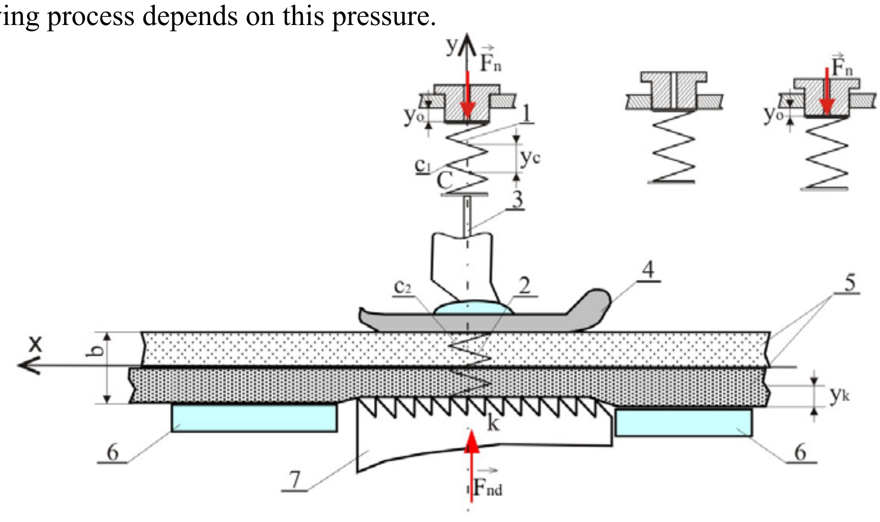

Figure 1. Dynamic model of vertical movement

Figure 1 presents dynamical model of textile-supporter-spring system.
Statical pressure of supporteron the material is:

$$F_n = c_1 \cdot y_0 \tag{1}$$

Figure 2 shows material utilisation during displacement.

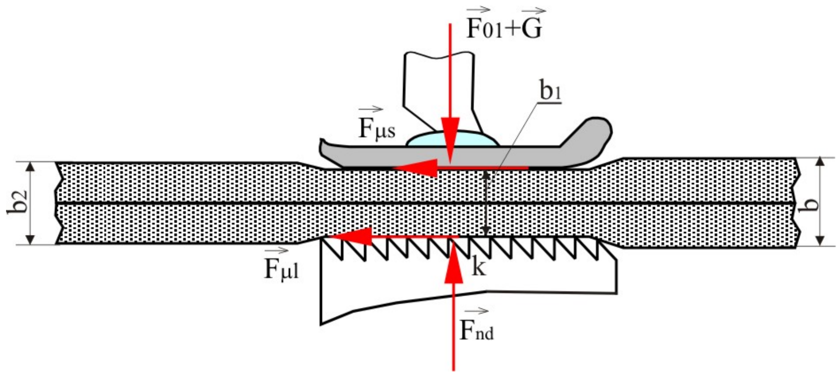

Figure 2. Material utilisation during displacement.

Material demand with outside forces is:

$$\begin{aligned} F_{01} &= c_1(y_0 + y_c) \\ F_{\mu s} &= (F_{01} + G)\mu \\ F_{\mu l} &= \mu_l \cdot F_{nd} \end{aligned} \tag{2}$$

2. DYNAMIC MODEL OF VERTICAL MOVEMENT

Differential equation of movement in vector format is [1,2,6]:

$$\frac{G}{g} \cdot \vec{a} = \vec{F}_{01} + \vec{F}_{02} \tag{3}$$

Equation (3) on the y axis is:

$$\frac{G}{g} \cdot \ddot{y}_c = -c_1(y_0 + y_c) + c_2(y_k - y_c) \tag{4}$$

where y_k is movement of peak k which is middle lath cam.
Equation (4) can be written as:

$$\frac{G}{g} \cdot \ddot{y}_c + (c_1 + c_2)y_c = c_2 y_k - c_1 y_0 \tag{5}$$

if we suppose that $y_k \succ y_c$, where y_c is movement of system center.
Right side of equation (5) is reaction of disturbed force on supporter.

$$F_{por} = c_2 y_k - c_1 y_0 \tag{6}$$

If left side of equation is equalized with 0 we will get supporter self frequency.

$$\frac{G}{g}\ddot{y}_c + (c_1 + c_2)y_c = 0 \quad / \cdot \frac{g}{G}$$

$$\ddot{y}_c + \frac{g(c_1 + c_2)}{G} \cdot y_c = 0$$

If we replace $\omega_s{}^2 = \frac{g(c_1 + c_2)}{G}$ the equation will be:

$$\ddot{y}_c + \omega_s{}^2 y_c = 0 \tag{7}$$

Self velocity of shaft and tab frequency is

$$\omega_s = \sqrt{\frac{g(c_1 + c_2)}{G}} \tag{8}$$

Chart of peak k movementis presented in figure 3. Full line is for sewing machine 22-A [6].

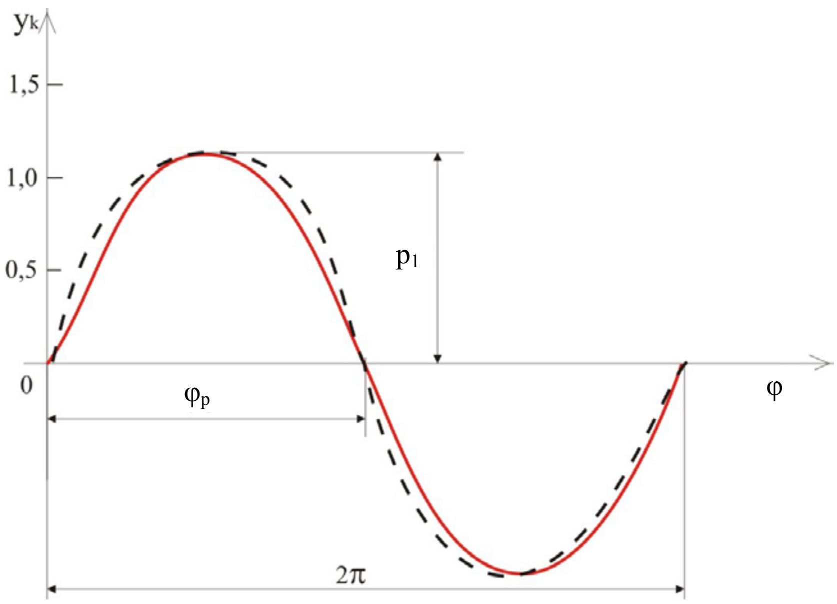

Figure 3. Peak k movement chart

Axis y is upper surface of needle plate. Movement of peak k has got sinusiode curve.

$$y_k = p_1 \cdot \sin \omega \cdot t \tag{9}$$

Disturbed force (6) has now got following formulation:

$$F_{por} = c_2 r_1 \sin \omega \cdot t - c_1 y_0 \tag{10}$$

To analyze additional load of tab pressure we should replace load of spring 2 with following formulation:

$$F_{02} = c_2\left(y_k - y_c\right) \tag{11}$$

After analysis equation (11) will be:

$$F_{02} = \frac{c_2 g}{G} F_n + \frac{c_2 r_1 \left(\frac{c_1 g}{G\omega_s^2} - \frac{\omega^2}{\omega_s^2} \right)}{1 - \frac{\omega^2}{\omega_s^2}} \cdot \sin\omega \cdot t \tag{12}$$

Maximal dynamic pressure will be for $\sin\omega \cdot t = 1$.

3. CONCLUSION

Dynamic pressure depends on self frequency of shaft and tab ω_s . For larger value of ω_s it is smaller difference between dynamic pressure F_{o2max} from static pressure F_n. To increase self frequency it is necessary to decrease weight G of removable parts and to take shorter spring. Decreasing of weight G is possible with construction of parts with lighter materials and with good construction characteristics, like titan. For the case when self frequency of shaft and tab ω_s is almost equal to disturbed force frequency it is possible to become resonance which must be avoided. For resonance case shaft is departed from material which leads to the material defects and process errors. In the moment when tab touchesmaterial the pressure oftab is biggerthen static pressure which gives additional pressureto the material and the material can be damaged.

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