POWER ANALYSIS OF ROTOR FOR HEADING WIRE PRODUCTS

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Key words: rotor, heading process, the force of deformation, the punch slope, torque.

Abstract: There are two basic groups of equipment characterized by when processing is executed. Using automatics for small wire products manufacture has substantial shortcomings having mainly dynamic nature. To the author's mind, the alternative way is to apply continuous technological systems as rotory machines and lines. The paper presents analysis of active forces in the rotor for heading wire products and how they influence on the torque value and its character.

Wire products are widely used both in industry and everyday life. We mean such products as nails or rivets, i.e. ones with a head. They are able to be produced on machines that can be divided into two big groups – automatics (for example, nail ones [1]) and rotor machines [2]. The main distinction between these machines groups consists in when processing is executed. While in automatics heading is realized only provided a wire workpiece is motionless, in rotory machines productivity may be enhanced due to increasing number of working positions [2]. In the present paper we will analyze active forces in the rotor with inclined disk [3]. Geometric scheme of this rotor is shown in Fig. 1, where the following designations are indicated: R is the rotor radius; ω the angle of the disk inclination; 1 the circle wire workpieces are moved along; 2 the circle punchs are done it. Point S means the start of heading process and point E means its end.

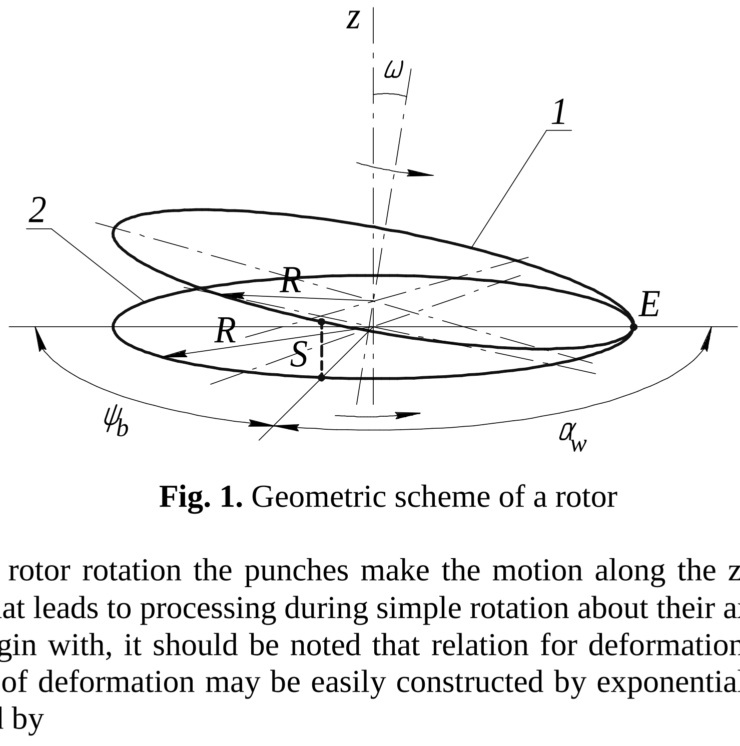

Fig. 1. Geometric scheme of a rotor

In the rotor rotation the punches make the motion along the z-axis because of the angle ω that leads to processing during simple rotation about their axis.

To begin with, it should be noted that relation for deformation force of a head versus extent of deformation may be easily constructed by exponential law. This function is defined by

$$P(x) = ae^{kx}, \qquad (1)$$

where a, k are the coefficients depending on boundary conditions; P is the heading force; x is the current coordinate from 0 to h (Fig. 2). The coefficients a, k should be determined under the fact that $P = P_s$ (x = 0) and $P = P_e$ (x = h), where P_s, P_e are the start and end forces of deformation, respectively. They can be calculated using theoretical formulas including empiric coefficients [4].

However, in this case we are to connect the heading force with rotation angle, ψ. In Eq. (1) x means $h - z$, where z coincides with coordinate along the axis of the same name in Fig. 1. This coordinate is given by [5]

$$z = R(1+\cos\psi)\sin\omega. \qquad (2)$$

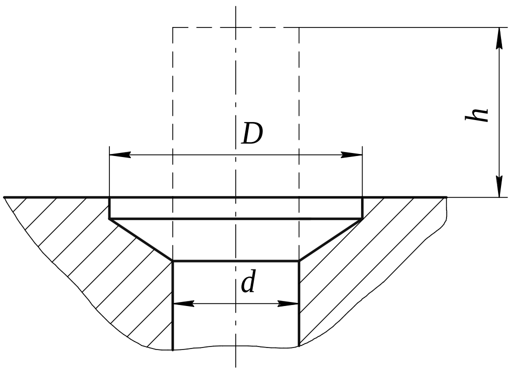

Fig. 2. The head of the nail

In this formula $\psi = 0$ leads to $z = z_{\max}$. Therefore, it is necessary to bind zero reading of ψ with point B in Fig. 1. Find the angle ψ_b under $z = h$ as:

$$\psi_b = \arccos\left(\frac{h}{R\sin\omega} - 1\right). \qquad (3)$$

Substituting Eq. (3) into Eq. (2), yields

$$z(\psi) = R\left[1+\cos\left(\psi + \arccos\left(\frac{h}{R\sin\omega} - 1\right)\right)\right]\sin\omega.$$

Because every workpiece undergoes heading operation during working angle α_w (Fig.1), using Eq. (1), the deformation force for one workpiece may be expressed as:

$$P(\psi) = \begin{cases} a\exp\left\{k\left[R\left(1+\cos\left[\psi + \arccos\left(\frac{h}{R\sin\omega} - 1\right)\right]\right)\sin\omega\right]\right\}, \psi \in [0;\alpha_w]; \\ 0, \psi \in [\alpha_w; 2\pi]. \end{cases}$$

Consider general scheme of the rotor with active forces, as shown in Fig. 3. It is easy to see that such scheme has the feature that deformation occurs under some slope of the punch face relatively to a die face [6, 7]. As shown in Fig. 4, at the moment of deformation ending this slope disappears. But during heading process it takes place.

To take it into account, consider two planes and assume that the punch has slope in each of them. Call them radial and tangential planes. Mark these angles of slope as γ_r and γ_t, respectively. Then, using Fig. 3, the following expressions for radial and tangential forces can be written: $P_r = P\ tg\gamma_r; P_t = P\ tg\gamma_t$.

Having determined required values, it is possible to define running torque as

$$T(\psi) = M_t(\psi) + M_f(\psi),$$

where M_t is the moment from the tangential forces; M_f is the moment of friction in bearings.

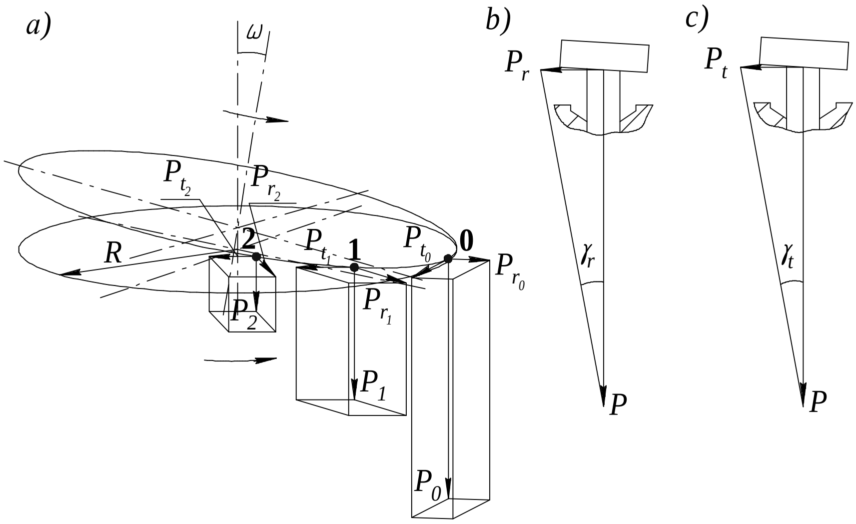

Fig. 3. The scheme of active forces: a) general view; b) section by radial plane; c) section by tangential plane

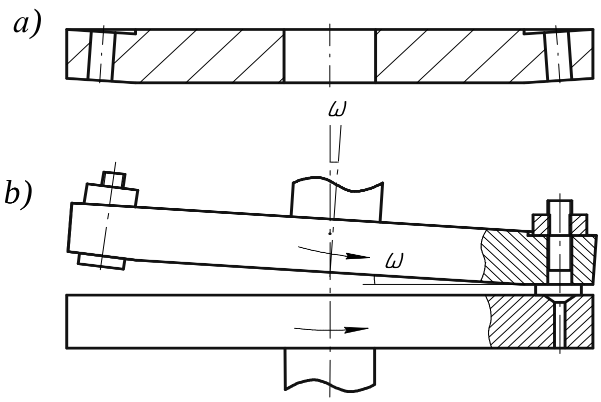

Fig. 4. The disk the punches to be placed on (a) and its principle of work (b)

The moment M_t may be characterized by the following function:

$$M_t(\psi) = R \cdot \sum_i P\left(\psi - i\frac{2\pi}{U}\right),$$

where U is the number of the rotor working positions.

The moment of friction in bearings is given by

$$M_f(\psi) = 2 \cdot F_b(\psi) \cdot f \cdot r + M_0,$$

where F_b is the reaction in the bearing;
f is the coefficient of friction;
r is the radius of the friction force $F_b \cdot f$ action in the bearing;
M_0 is the moment arising due to various errors in manufacturing and assembling.

Hence, the running torque may be computed for any values of required parameters. Assume that a workpiece is being processed and it has the following parameters values: $P = 2e^{0.85x}$ (for d = 3 mm, D = 6 mm (see Fig. 2)), h = 3.5 mm, ω = 1°, R = 200 mm, U = 12, f = 0.05, r = 100 mm, M_0 = 10 Nm. The force F_b depends on bending moment and it is the function of the force P and radius R. Relation between the running torque and the rotation angle is shown in Fig. 5.

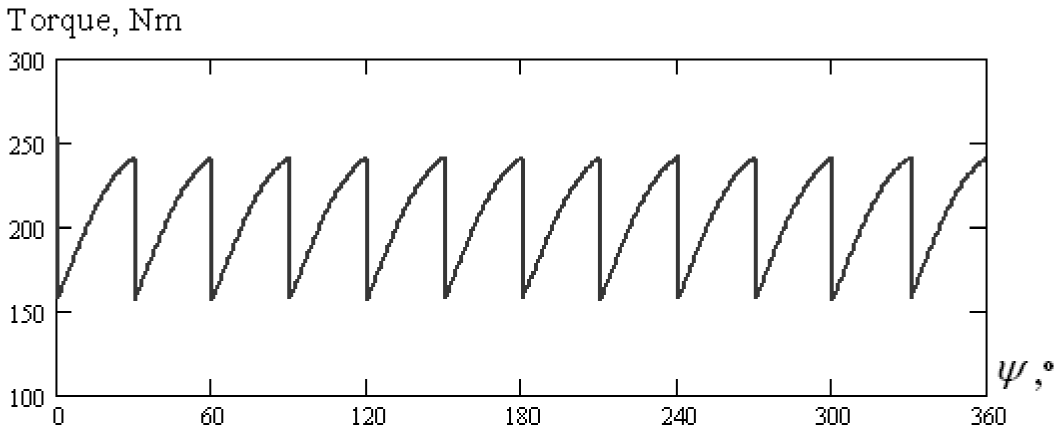

Fig. 5. Relation between the running torque and the rotation angle

As can be seen, the running torque is the impulse function that can be explained by the fact that in point E heading of each workpiece ends and the torque is sharply decreased. Further research is required to predict forced torsion oscillations.

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