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Mathematical modeling of the process of rolling body rolls with needed rollers

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Abstract

The processes of needle roller rolling with the wide cavity and archimedean worms are investigated. A method of rolling in threads and worms with large angles of elevation of the coil line by means of flexible needle rollers is suggested.

Key words: needle rollers,rolling screw surfaces needle rollers, curvature of a screw surface, a roughness.

Introduction

The processes of needle roller rolling with the wide cavity and archimedean worms are investigated. A method of rolling in threads and worms with large angles of elevation of the coil line by means of flexible needle rollers is suggested.

Research methodology

We have conducted a study of modeling the process of rolling of screw surfaces with needle rollers in order to expand the nomenclature of threads and worms that can be rolled up by cylindrical rollers and to increase their durability, reliability, extend the service life of parts; while maintaining the equality of curvature of the contacting bodies and the rate of slippage in the deformation zone. Establish the ability to roll with needle rollers with deformation along the entire depth of the Archimedes Worms profile.

For modeling, archimedean worms with 10-24 mm modules, which have large angles of elevation of the coil lines, are taken. Trapezoidal and thrust threads have significantly smaller angles of elevation of the coil line and less deep recesses that have not been modeled. The nomenclature of threads and worms that can be rolled up by cylindrical rollers with a straight line is limited by the limiting magnitude of the curvature of the screw surface in the plane of the rollers. This curvature depends on the diameter, the angles of elevation of the coil line and the thread profile.

Large threads are threaded by self-adjusting cylindrical rollers of small diameter [1]. When rolling threads with large lift angles, the plane of the rollers is rotated about an axis passing through the middle of the trough to the angle λ_p, in General, different from the angle of lift λ. In addition, the plane of the rollers is displaced relative to the axial section of the workpiece by an amount sufficient h to form an angle between the plane of the rollers and the thread β in the middle diameter of the cutting. This $\beta = 6^0$ creates a force component that pushes the rollers to the housing of the device. Shift and reversal of the roller plane lead to the appearance of a final (positive or negative) curvature of the thread profile in the roller plane.

The nomenclature of threads and worms, which can be rolled up by cylindrical rollers, based on the possibility of their deformation along the entire depth of the profile, was determined experimentally by the rolling of models.

The rolling of the screw surfaces with positive curvature in the plane of the rollers was simulated by the rolling of the cones, and of the surfaces with negative curvature by the rolling of the hyperboloids.

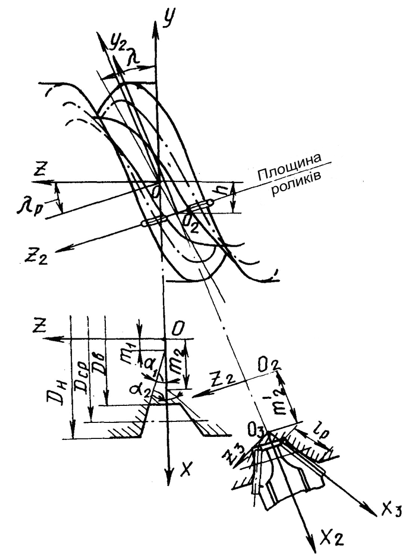
When running models, the following process parameters are preserved: a) curvature of the running surface in the plane of the rollers; b) the amount of relative sliding in contact of the roller with the workpiece.

The radius of curvature $\left(R_B\right)$ of the cone β surface in the plane of the roller (X_2, Z_2, Fig. 1), obtained by turning the angle of the axial section of the cone around the perpendicular to its formation, will be determined by Euler formula [2]:

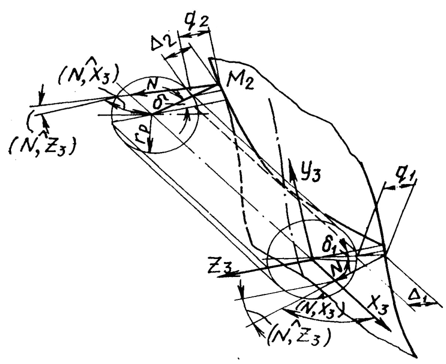
$$R_K = \frac{r_{cp}}{\sin\alpha_K \cdot \sin^2\beta}, \tag{1}$$

where r_{cr} – is the average radius of the cone;

α_K – the angle at the base of the cone.



a



b

Fig. 1. Threading with large lift angles

Given the condition of relative sliding in the direction perpendicular to the axis of the roller, we have:

$$r_{cp} = \frac{D_{cp} \cdot \sin\alpha_K}{2\cos\alpha}, \tag{2}$$

where D_{cp} – average diameter and angle of thread profile.

The angle of the cone α_K, given (1) and (2), $R_K = 1/K_B$ is determined:

$$\alpha_K = \mathrm{arctg}\left[\frac{D_{cp} \cdot K_B}{2\cos\alpha \cdot \sin^2\beta}\right]. \quad (3)$$

The results

From the solution of the geometric problem of intersection of the cylinder with the generating and conical surfaces, we determine the values of the lengths of contact of the roller with the surface of the thread and the layout, the ratio of these values is equal to the coefficient of refinement (K_Y). Taking into account [1] the equations of the screw surface in the coordinate system are written X_3, Y_3, Z_3, (Fig. 1, a) where X_3 is the axis of the roller. The distance Δ_1 and Δ_2 between the points M_1 and M_2 the screw surface, respectively, on the outer and inner diameter of the thread and the surface of the roller at the point contact of the roller with the surface of the thread on the average diameter of the thread (Fig. 1, b) is determined by:

$$\Delta = \left|\frac{Z_3 \sin(NX_3)}{\cos(NZ_3)}\right| - r_P, \quad (4)$$

where r_P – roller radius;

NX_3 and NZ_3 – respectively, the angles between the axes X_3 and Z_3 and the normal N to the helical surface passing through the points M_1 and M_2 and X_3 the axis.

The magnitude of the indentation of the roller in the direction of the axis until Z_3 the contact of the surface of the roller points M_1 and M_2 the screw surface:

$$q_{cp} = \frac{1}{2}\left(\frac{\Delta_1}{\cos\delta_1} + \frac{\Delta_2}{\cos\delta_2}\right), \quad (5)$$

where the angles δ_1 and δ_2 are determined by equality:

$$\mathrm{tg}\delta = \frac{Y_3}{Z_3}. \quad (6)$$

The length of contact of the roller (l_P) with the helical surface is defined as the difference of the abscissa X_3 points M_1 and M_2.

The coordinates X_3, Y_3, Z_3 of the points M_1 and M_2 are determined by the joint solution of equations (3), (4), (5), (6) of the screw surface and the normal N equation. The length of contact of the roller with the conical surface of the maket (l_P), measured in the direction of the axis of the roller, is calculated by a joint solution of the cylinder and cone equations in the coordinate system X_3, Y_3, Z_3, related to the axis of the roller, provided that the roller is pressed into the cone by the magnitude q_{cp} (Fig. 2) and is equal to the difference between the coordinates Z_3 of the points M_1 and M_2 the conical surface.

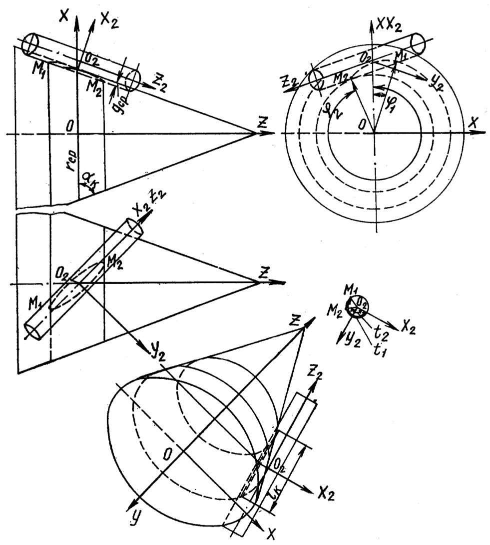


Fig. 2. Scheme to calculate the contact length of the roller with the conical surface of the layout

A hyperboloid, which is a model of a screw surface with a negative curvature in the plane of the rollers, is formed by machining a straight cutting edge of the cutter. The cutting edge, initially coinciding with the generating cone with the angle at the base α_2, rotates around the perpendicular to the generating conus by the angle γ_P (Fig. 3). When the workpiece is rotated, the conical surface becomes a medium-radius hyperboloid by cutting the allowance r_2.

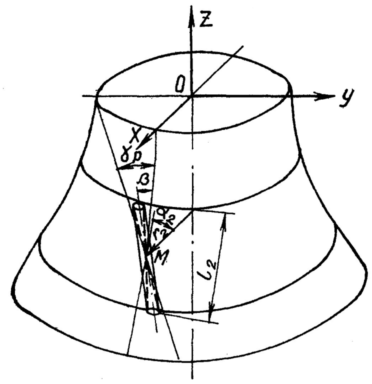


Fig. 3. Scheme of conical surface conversion into a hyperboloid

The plane of the roller when rolling hyperboloid forms with its axial section angle $\beta = 6^0$. The curvature of the intersection of the hyperboloid with the plane of the roller at a point M according to [2] will be determined by:

$$\frac{1}{R} = \frac{\cos^2\beta}{R_1} + \frac{\sin^2\beta}{R_2}, \tag{7}$$

where R_1 – is the radius of curvature of the generating hyperboloid;

R_2 – is the radius of curvature of the intersection, normal to the formation.

Applying formula (7) to the cutting edge line, we obtain:

$$\frac{\cos^2\gamma_2}{R_1} + \frac{\sin^2\gamma_2}{R_2} = 0. \tag{8}$$

Solving together equations (7) and (8) with given $R_2 = \frac{r_2}{\sin\alpha}$, we obtain $\frac{1}{R} = K_B$ the formula for calculating the angle of rotation of the cutting edge of the cutter:

$$\gamma_P = \mathrm{arctg}\left[\sqrt{\mathrm{tg}^2\beta - \frac{r_2 \cdot R_B}{\cos^2\beta \cdot \sin\alpha_2}}\right]. \quad (9)$$

The values r_2 in formula (9) should be equal to the values of the radii r_{cp} calculated by the formula (2) at $\alpha_K = \alpha_2 = 60^0$. The geometric dimensions of the models r_K, r_2, and α_K the refinement coefficient K_V were calculated on a PC.

Modeling was performed by a device with a self-adjusting cylindrical roller-cam on a lathe [10].

As a result of this work, it is shown that cylindrical rollers can run almost all threads with a lift angle of not more than 10^0.

Conclusions

Features of rolling of worms and worms with a wide hollow are investigated. The modeling of rolling of the screw surfaces by needle rollers was carried out. The convex surfaces were modeled by cone-self, concave by unipolar hyperboloids. In doing so, the curvature of the contacting bodies and the rate of slippage in the deformation zone were maintained.

It has been found that needle rollers can be deformed with the entire depth of the profile by archimedean worms with a rotation angle of $\lambda < 10^\circ$.

It is proposed to roll Archimedean worms with $\lambda > 10^\circ$ flexible needle rollers, a device for this purpose was granted a patent of Ukraine for the invention and a patent of Ukraine for a utility model. In this way, the nomenclature of threading and archimedean worms was expanded.

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Зубєхіна-Хайят О.В., Марченко Д.Д. Математичне моделювання процесу обкатування тіл обертання голчастими роликами.

Досліджено процеси обкатування голчастими роликами різьб з широкою впадиною і архімедових черв'яків. Запропоновано спосіб обкатування різьб і черв'яків з великими кутами підйому лінії витку за допомогою гнучких голчастих роликів.

Ключові слова: голчасті ролики, обкатування гвинтових поверхонь голчастими роликами, кривизна гвинтової поверхні, шорсткість.