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THE DESIGN AND DIMENSIONS OF LEAD ANGLES AND LARGE PITCHES OF THREAD ROLLING ROLLERS

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K e y w o r d s: thread rolling, rollers – construction and calculation.

A b s t r a c t

Possibilities of rolling threads with large pitches and lead angles. Rollers with a thread on the working part - the design and theoretical relationships for the calculation of the basic dimensions of the embossing and sizing parts.

KONSTRUKCJA I WYMIARY ROLEK DO WALCOWANIA GWINTÓW Z DUŻYMI KĄTAMI WZNIOSU I PODZIAŁKAMI

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S ł o w a k l u c z o w e: walcowanie gwintów, rolki – konstrukcja i obliczanie.

S t r e s z c z e n i e

Przedstawiono możliwości walcowania gwintów z dużymi podziałkami i kątami wzniosu linii śrubowej. Zaproponowano rolki z gwintem na części roboczej. Opracowano konstrukcję oraz zależności teoretyczne do obliczania podstawowych wymiarów części wygniatającej i kalibrującej.

Introduction

For rolling threads with small pitches P and lead angles ψ, two basic roller design versions are used:
– rollers with a ring-shaped contour,
– rollers with a thread.

The methods of rolling with these rollers in the tool-workpiece system are shown in Fig. 1.

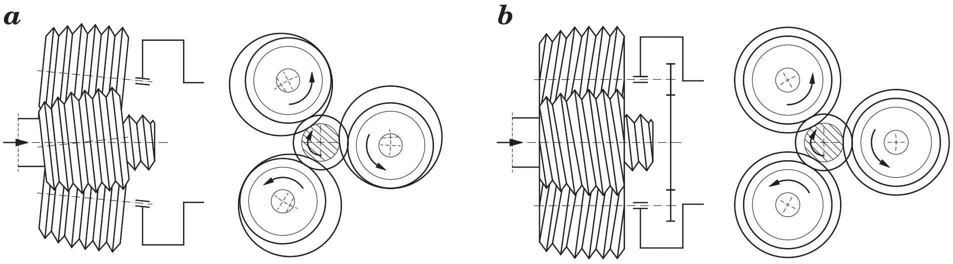

Fig. 1. Schematic diagrams of a rolling thread by the longitudinal method using rollers: with a ring-shaped contour (a), with a thread (b)

In both roller designs, the working part is composed of an embossing part that displaces material to form the thread contour, and a sizing part that imparts the final shape and dimension to the thread.

Rollers with a ring-shaped contour (Fig. 1a) are inclined in relation to the workpiece axis at the thread lead angle $\gamma R = \psi$, depending on the direction of the thread helix (right-hand or left-hand thread). Threads of the same pitch and different diameters can be made with one set or rollers. The dimensions (diameters) of rollers do not depend on the thread on the workpiece and are chosen constructionally; there is also no need to synchronize the rotations of mating tools.

Threaded rollers (Fig. 1b) have the axes perpendicular to the workpiece axis (Łyczko 2000). The working part is constituted by a multiple thread with the angle $\psi R = \psi$ and direction opposite to that of the thread being made. The rotations of the rollers must be mutually synchronized.

With larger threads a need arises to increase the inclination angle of ring-shaped rollers, or to use a larger ψR angle in threaded rollers. These changes require correction to the pitch P_R and flank angle $^1/_2\alpha_R$ of the roller thread, which makes the technology of execution difficult. Moreover, with large angles between the mating roller threads and the thread crest being formed, the threading conditions impair.

Therefore, for rolling threads with larger pitches and lead angles, a system of inclined threaded rollers is recommended.

The design of threaded rollers

The mutual position of the rollers in relation to the rolled workpiece is shown in Fig. 2.

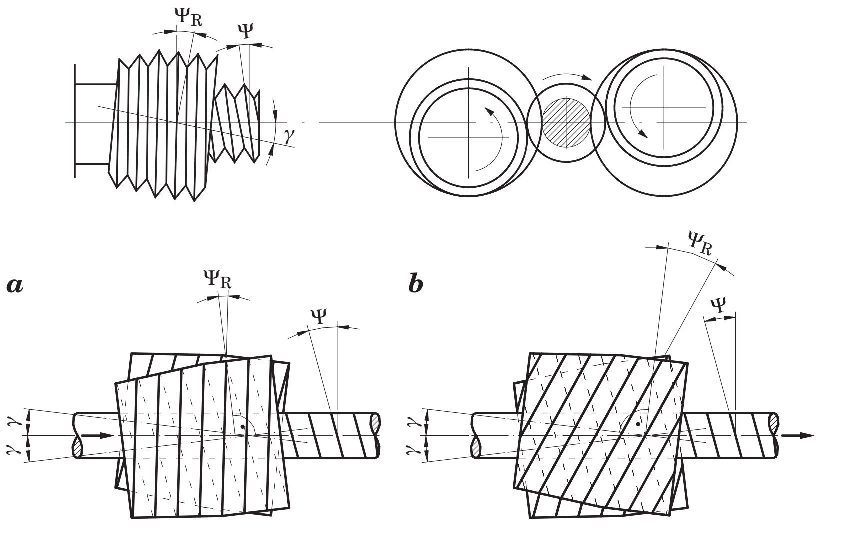

Fig. 2. Schematic diagrams of longitudinal rolling with threaded rollers and the axes inclined toward the workpiece axis

The main quantities defining the mutual position of rollers mating with each other and with the threaded workpiece include:

– the distance between the roller axes determined by the working space (e.g. in a thread-rolling machine) or the overall dimensions of the fixture (a head and a holder),
– the pitch diameter D_{2R} of the rollers and the pitch diameter d_2 or the rolled thread, and
– the roller axis inclination angle γ_R, which depends on the value of the angles Ψ_R and Ψ.

When rolling threads with larger lead angles $\Psi > 4^o$, it is recommended that the rollers should have an angle $\Psi_R < \Psi$ (Fig. 2a), and in that case the angle of rollers inclination to the workpiece axis is:

$$\gamma_R = \Psi - \Psi_R$$

– roller pitch diameter:

$$D_{2R} = d_2 \frac{k_R}{k} \frac{\sin\Psi}{\sin\Psi_R},$$

– roller pitch in the axial plane:

$$P_R = P \frac{\cos\Psi}{\cos\Psi_R},$$

whereas in the case of threads with pitches $P > 5$ mm, $\Psi_R > \Psi$ (Fig. 2b), and then:

$$\gamma_R = \Psi_R - \Psi,$$

– roller pitch diameter:

$$D_{2R} = d_2 \frac{k_R}{k} \frac{\sin\Psi \operatorname{ctg}\Psi_R}{\sin\gamma_R},$$

– roller pitch in the axial plane:

$$P_R = P \frac{\cos\Psi}{\cos\gamma_R}.$$

Figure 3 shows the design of a thread rolling roller with thread – its basic dimensions and the shape and dimensions of the working part for the case where two rollers take part in rolling.

In these tools (Fig. 3) over the whole length of the (conical embossing and cylindrical sizing) working part, the thread has a full contour with the identical radii r_w of the thread crests.

The main roller dimensions are calculated from the relationships below:

– initial roller pitch diameter:

$$D''_{2R} < L_{0\max} - d_{2śr},$$

$$d_{2śr} = 0.5(d_{2\max} - d_{2\min}),$$

$d_{2\max}, d_{2\min}$ – max and min pitch diameter of the thread being made,

$L_{0\max}$ – permissible spacing of roller axes considering the max permissible dimension D_R,

– initial roller thread multiplicity:

$$k'_R = \frac{D''_{2R}}{d_{2śr} k},$$

k – multiplicity of the thread being made,

k_R – rounded to an integer $< k'_R$,

– thread lead angle:

$$\psi = ar\operatorname{ctg} \frac{P}{\pi d_{2śr}},$$

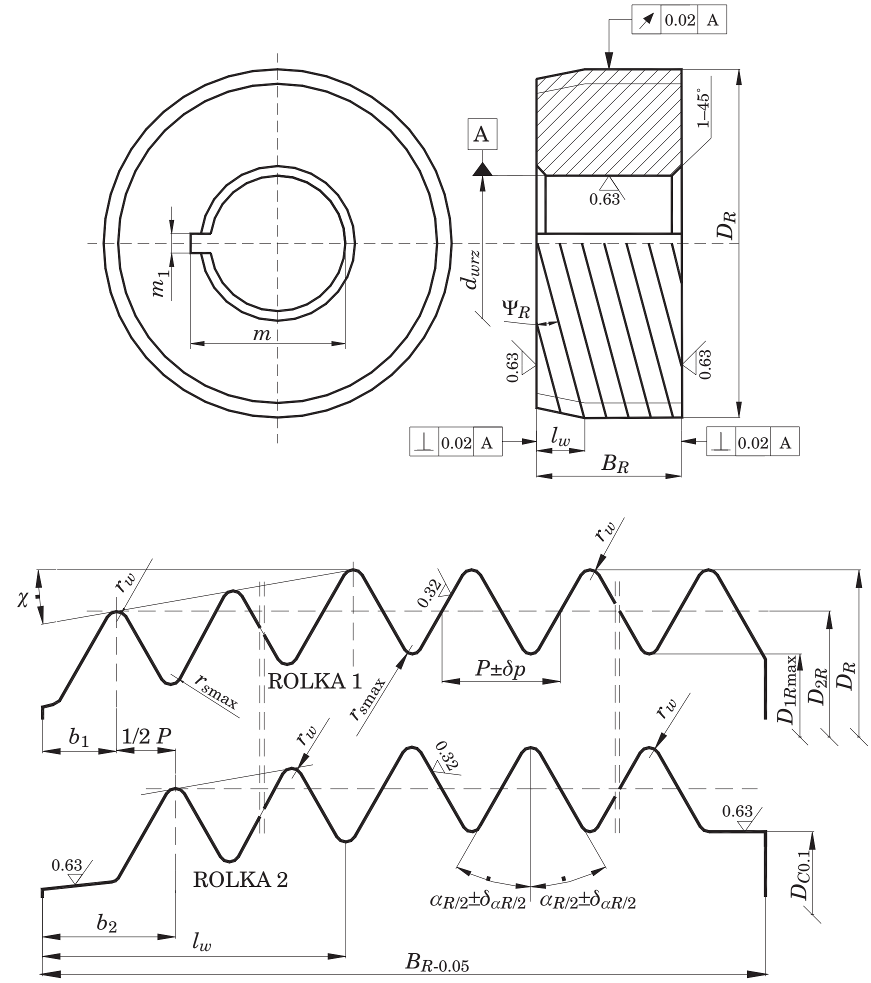

Fig. 3. Design and dimensions of thread rolling rollers

- lead angle of the thread on the roller:

$$\psi_R = 0.7\psi ,$$

- the roller axis inclination angle:

$$\gamma_R = \psi - \psi_R ,$$

- roller pitch in the axial plane:

$$P_R = P \frac{\cos\psi}{\cos\psi_R} ,$$

- roller thread pitch:

$$P_{hR} = k_R P_R ,$$

– calculation pitch diameter:

$$D'_{2R} = d_{2śr} \frac{k_R}{k} \frac{\sin\psi}{\sin\psi_R},$$

– roller pitch diameter:

$$D_{2R} = \left(D'_{2R} + \delta_z\right)_{-\delta_{D_{2R}}},$$

δ_z – allowance for regeneration = 2 mm, $d_{2śr} \le 10$,
= 2.5 mm, $d_{2śr} > 10$,

$$\delta_{D_{2R}} = 0.2\left(d_{2\max} - d_{2\min}\right),$$

– roller outer diameter:

$$D_R = \left(D_{2R} + 2h_w\right)_{-\delta_{D_R}},$$

$$\delta_{D_R} = 0.2\left(d_{\max} - d_{\min}\right),$$

h_w – thread crest head height roller (ŁYCZKO 2000a),
$d_{\max}$, $d_{\min}$ – max and min outer diameter of the thread being made,
– roller inner diameter:

$$D_{1R\max} = \left(D_{2R} - 2h_{s\min}\right),$$

$h_{s\min}$ – thread crest root height roller (ŁYCZKO 2000a),
– radius of the thread top roller:

$$r_w = \left(0.108P\right)^{-\delta_{r_w}},$$

$$\delta_{r_w} = 0.02P,$$

– radius of the groove of thread roller:

$$r_{s\max} = 0.072P,$$

– thread contour flank angle:

$$\frac{\alpha_R}{2} = \left[\frac{\alpha}{2} + \left(15' \div 20'\right)\right]^{\pm\delta\frac{\alpha_R}{2}},$$

– embossing part application angle:

$$\chi = \left[ar\,\mathrm{ctg}\frac{z_R\left(d_{w\max} - d_3\right)}{2Pz_{we}}\right]_{\pm 5'}$$

d_3 – thread minor diameter equal to ($d_{3\max}$ – 0.07 P),
$d_{w\max}$ – max starting diameter of the workpiece to be threaded,
z_R – number of rollers,
z_{we} – effective number of the embossing thread,

– embossing part length:

$$l_w = 0.8P + \frac{(z_{we} + 1)}{z_R} P,$$

– position one coil the embossing part:

$$b_1 = 0.8 \text{ P}, \; b_2 = 0{,}8P + \frac{P}{z_R},$$

– sizing part length:
$l_k = 4P, \; 5P, \; 6P,$

– roller width:
$B_R = l_w + l_k + 0.5\, P,$

– frontal diameter roller:
$D_{cR} = D_{1R\,\max} - 2l_{w\mathrm{tgc}},$

– limiting pitch diameter:
$D_{2R\,\text{zuż}} = 0.9825 D_{2R}.$

Summary

The presented theoretical interrelations can be the basis for constructional calculations describing the shapes and dimensions of rollers applied for rolling threads with a large lead angle of the screw line. Such dependences were arranged in the order the calculation should be performed, which simultaneously defines an algorithm for carrying out the computer program. Proceeding analogically with reference to the other tools, compiling simultaneously a complete database (ŁYCZKO 2003) containing data concerning making a thread, guidelines in the range of recommended parameters and rolling thread conditions, the compilation of a computer program automating the whole group of tools can be initiated. These tools can be applied not only to the axial method, but also in varied ways of radial and tangential methods.

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