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Calculation of Some Geometric Elements of Conical Wheels with Circularly Arched Teeth

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Abstract

This paper shows the method for calculating the main geometric elements of the conical gear with circularly arched teeth type 528 Saratov.

Key words: *wheel, gear, module, division diameter, the head diameter*

General Considerations

Wheels with slanted teeth are used in conditions of peripheral velocities less than 12 m/s, and wheels with round teeth are recommended and used for velocities between 3 and 40 m/s (fig. 1) [1, 2].

For greater velocities, the teeth are rectified after the thermal improvement treatment, in which case wheels with circularly arched teeth are used.

Conic gears with round teeth function silently, have a great degree of coverage, high durability to usage, and allow the making of high engagement ratios compared to other types of conic gears, have a small gauge and reduced axial forces.

These types of concurrent conic gears are usually orthogonal.

The slanting direction of the teeth (left-right or reverse, as seen from the tip of the wheel's cone (fig. 1) is established according to the rotation direction of the leading wheel, such that the effect of the axial force (axial component) is to increases the matching of the teeth, avoiding any blockages [3, 4].

The slanting angles of the teeth are: the exterior dividing slating angle, β_e, the interior dividing slating angle, β_i, the angle between a radial perpendicular line that intersects the dividing line of a flank of the cog of the plane wheel of defining reference, in a point found at the exterior, interior extremity of the teeth and the tangent at that point to the dividing line of the flank of the teeth of the plane wheel (fig. 2).

The principle that lies at the base of the processing of conic wheel with circularly arched teeth consists of generating a single cog of the plane wheel through an imaginary plane wheel materialized through the teething tool (fig. 3) [5].

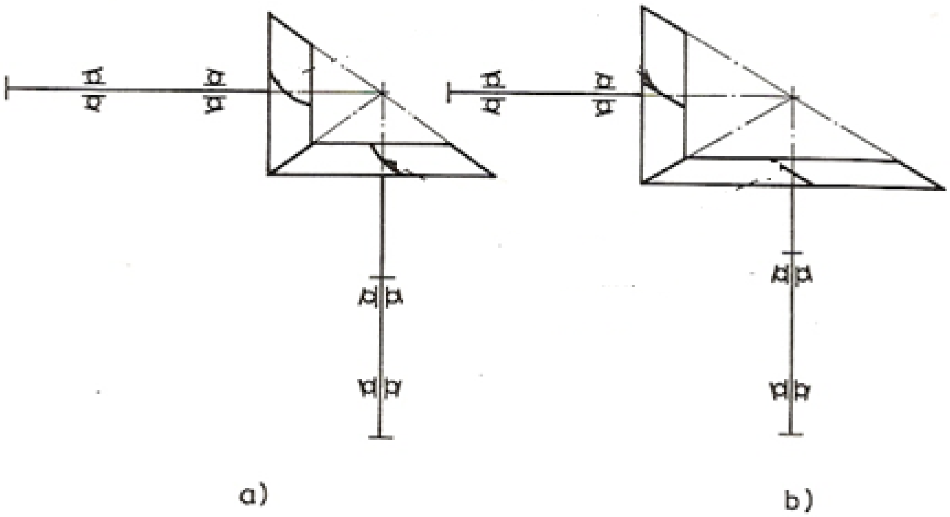

Fig 1. Conic gears with: a - round teeth; b- slanted teeth

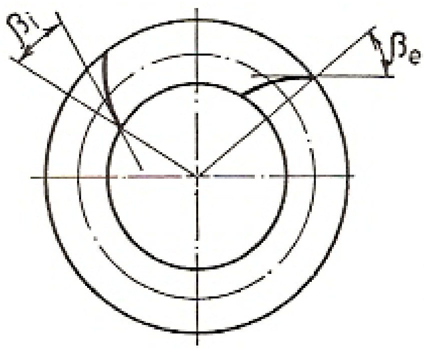

Fig.2. The exterior dividing slanting angle β_e and the interior dividing slanting angle β_i

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The main geometric elements of the conic gear with circularly arched teeth are shown in Figure 4 and are determined as such:

- the exterior (frontal) module: *m*;
- the coefficient for the width of the teeth:

$$k_b = \frac{R}{b} = (3 \ldots 4), \tag{1}$$

where *R* is the (exterior) length of the division generator, and *b* is the width of the teeth;

- the coefficient for the radial movement of the pinion profile:
  - of the pinion (1):

$$x_{r1} = 0{,}49 \cdot \cos\left[\beta\left(1 - \frac{1}{u^2}\right)\right], \tag{2}$$

where β is the median slanting angle, and *u* is the engagement ratio;

- at the wheel (2):

$$x_{r2} = -x_{r1} \;; \tag{3}$$

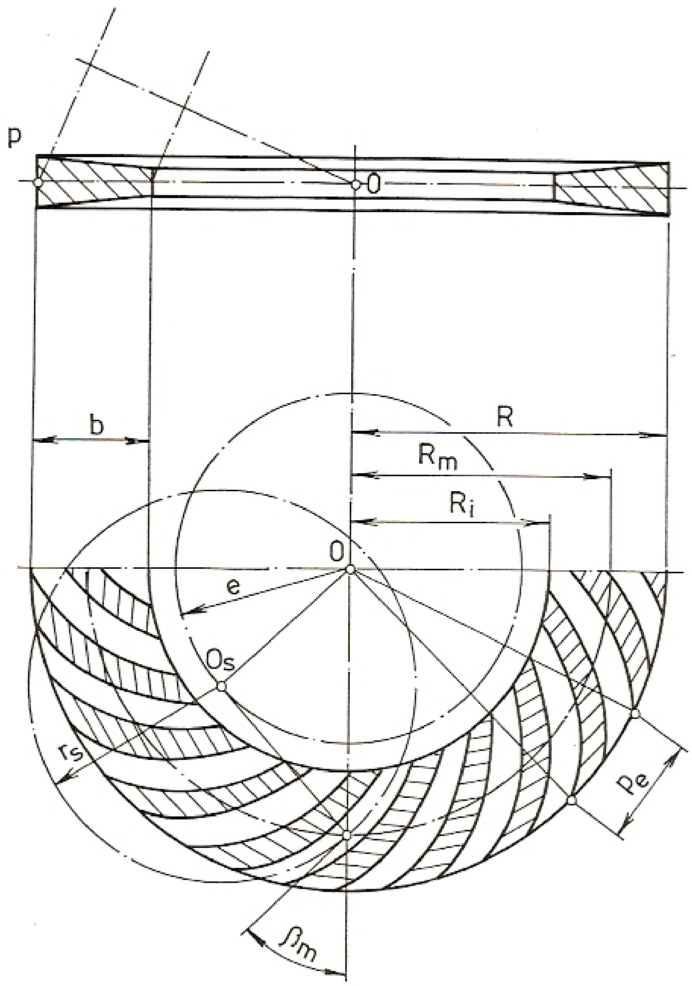

Fig. 3. Plane wheel of the circularly arched teeth

- angle of the dividing cone:

  - of the pinion (1):

$$\delta_1 = arctg\left(\frac{1}{u}\right); \tag{4}$$

  - of the wheel (2):

$$\delta_2 = arctg\, u \;; \tag{5}$$

- (interior) module:

$$m_i = m \cdot \frac{k_b - 1}{k_b} \;; \tag{6}$$

- exterior division slating angle:

$$\sin\beta_e = \frac{2\cdot k_b - 1}{2\cdot k_b}\cdot \sin\beta + \left[1 - \left(\frac{2\cdot k_b - 1}{2\cdot k_b}\right)^2\right]\cdot\frac{R}{D_s} \tag{7}$$

where D_s is the nominal diameter of the tool head [6];

- interior division slating angle:

$$\sin\beta_i = \frac{2\cdot k_b - 1}{2\cdot(k_b - 1)}\cdot\sin\beta + \frac{3 - 4\cdot k_b}{4\cdot(k_b - 1)}\cdot\frac{R}{D_s\cdot k_b} \tag{8}$$

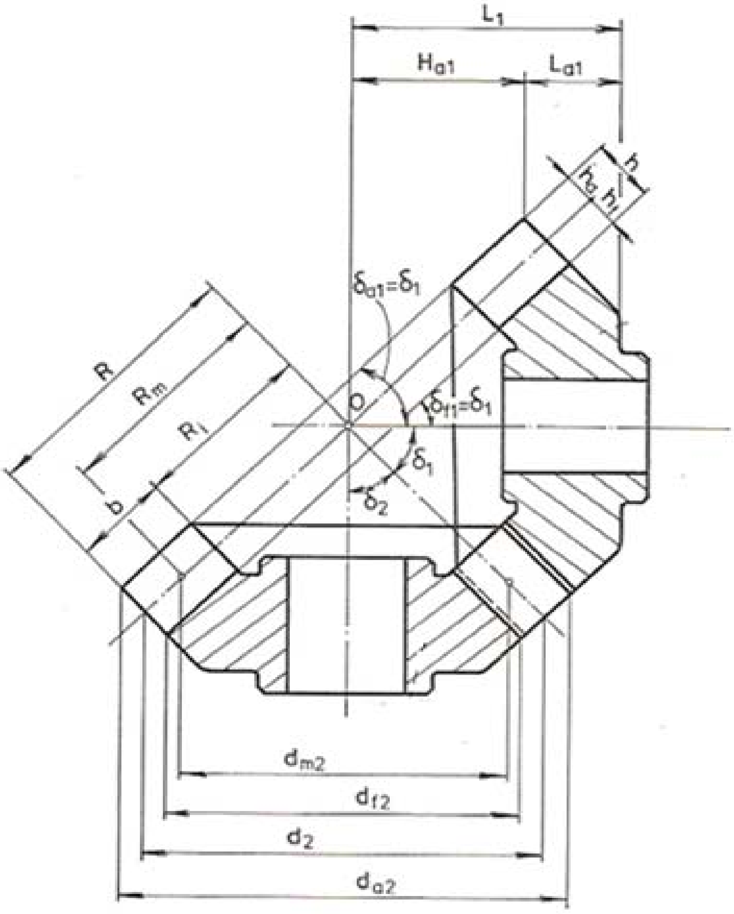

Fig 4. Geometric elements of conic gears with circularly arched cogs of constant height

Calculation of Control Elements for Circularly Arched Teeth and Constant Height 528 Saratov Model

- cog frontal division arc:
  - at the pinion (1):

$$s_{t1} = \frac{\pi m}{2} + 2\cdot\frac{x_{r1}\cdot tg\alpha_n}{\cos\beta_e}, \tag{9}$$

where α_n is the normal division pressure angle ($\alpha_n = 20^0$) ;

- at the wheel (2):

$$s_{t2} = \pi\cdot m - s_{t1}\ ; \tag{10}$$

- intermediate coefficient:

$$G_2 = \frac{1}{2}\cdot\sin\beta_e\cdot\cos\beta_e\ ; \tag{11}$$

- reduction coefficient of the cog:
  - at the pinion (1) :

$$k_1 = 1 - \frac{s_{t1}}{R} \cdot G_2; \tag{12}$$

$$k_2 = 1 - \frac{s_{t2}}{R} \cdot G_2; \tag{13}$$

- central half-angle corresponding to the girth of the cog in the normal section:
  - at the pinion (1) :

$$\omega_1 = \frac{s_{t1}}{d_1} \cdot cos^3\beta_e \cdot cos\delta_1; \tag{14}$$

  - at the wheel (2):

$$\omega_2 = \frac{s_{t2}}{d_2} \cdot cos^3\beta_e \cdot cos\delta_2, \tag{15}$$

where d_1 is the division diameter of the pinion ($d_1 = m\ z_1$) , and d_2 is the division diameter of the wheel ($d_2 = m\ z_2$);

- coefficients calculation:
  - at the pinion (1) :

$$k_{11} \cong 1 - \frac{{\omega_1}^2}{6}; k_{21} \cong \frac{\omega_1}{4}; \tag{16}$$

  - at the wheel (2):

$$k_{12} \cong 1 - \frac{\omega_2^2}{6}; k_{22} \cong \frac{\omega_2}{4}; \tag{17}$$

- cog width measured on a constant chord at the exterior extremity:
  - at the pinion (1):

$$s_{cn1} = k_{11} \cdot s_{t1} \cdot k_1 \cdot cos\beta_e; \tag{18}$$

  - at the wheel (2):

$$s_{cn2} = k_{12} \cdot s_{c2} \cdot k_2 \cdot cos\beta_e; \tag{19}$$

- sharpness of the cog:
  - at the pinion (1):

$$\Delta h_1 = k_{21} \cdot s_{t1} \cdot cos\beta_e; \tag{20}$$

  - at the wheel (2):

$$\Delta h_2 = k_{22} \cdot s_{c2} \cdot cos\beta_e; \tag{21}$$

- height measured at the constant chord:
  - at the pinion (1):

$$h_{cn1} = h_{a1} + k_1 \cdot \Delta h_1; \tag{22}$$

  - at the wheel (2):

$$h_{cn2} - h_{a2} + k_2 \cdot \Delta h_2; \tag{23}$$

h_{a1} and h_{a2} represent the height of the (division) head of the cog for the pinion and the wheel having the mathematical expressions:

$$h_{a1} = (h_a^* + x_{r1}) \cdot m_t \tag{24}$$

$$h_{a2} = (h_a^* + x_{r2}) \cdot m_t \tag{25}$$

where h_a^* is the coefficient of the reference hard of the cog ($h_a^* = 1.0$).

Conclusions

Considering the special advantages of these types of gears (high coverage degree, etc.) this paper shows the method for calculating the main geometric elements of conic wheel with circularly arched cogs of constant height 528 Saratov.

The rigorous calculations of the control elements for the circularly arched cogs of constant height must also be noted.

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Calculul unor elemente geometrice ale roților conice cu dantura în arc de cerc

Rezumat

Angrenajele conice cu dantura în arc de cerc au o largă utilizare în construcția de maşini datorită unor avantaje deosebite ca : funcționare silențioasă, grad mare de acoperire, etc. În lucrare se prezintă modul de calcul al principalelor elemente geometrice ale roților conice cu dinți în arc de cerc de inălțime constantă 528 Saratov. Lucrarea are o aplicabilitate practică imediată atât în ce priveşte proiectarea angrenajelor conice cu dantură în arc de cerc cât şi privitor la repararea utilajelor tehnologice care au în componența lor angrenaje conice.