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Geometric and Kinematic Parameters of Conical Gears

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ABSTRACT: The article presents a method for calculating the geometric and kinematic parameters of bevel gears that affect the wear resistance of gear teeth during friction with lubrication, and the laws of changing the actual gear ratio depending on the height ratio of gearing are obtained. In gearing, rolling occurs in the contact zone of the pitch circles of the gears and at the same time rolling of the teeth occurs with slippage, the degree of slippage increases with increasing distance from the rolling zone to the point of contact of the teeth, the greatest slippage occurs at the head and leg of the teeth.

KEY WORDS: Kinematics, Toothed Gear, Friction Gear Radius.

I.INTRODUCTION

When moving the point of contact of the teeth of the bevel gears along the engagement line, the radii of curvature of the profiles of the driving and driven gears continuously change, since each elementary part is characterized by its own radius of curvature. As the gearing gears rotate, if the radius of curvature of the driving profile increases, and the radius of curvature of the profile of the driven gear decreases.

II. EXPRESSION FOR THE GRAIN SENSOR CAPACITY

However, the sum of the curvature of the profiles of the teeth of the driving and driven wheels is of a constant value. Then the relationship between these radii of curvature of the profiles is described by the following expression:

$$\rho_w + \rho_k = R\sin\alpha\,; \qquad (1)$$

Where ρ_w- the radius of curvature of the contact point of the profile of the pinion gear; ρ_k - radius of curvature of the point of contact of the profile of the driven gear; α – gearing engagement angle.

Fig. 1 shows the scheme for calculating the main geometrical parameters of a bevel gear, where R - is the average cone distance $R = R_e - 0{,}5b$; here R_e - outer cone distance $R_e = 0{,}5d/\sin\delta$ (*d*- mean pitch diameter $d = mz$; δ – pitch cone angle; δ_2 – pitch angle of driven gear, $\delta_2 = arctgi$; δ_1 – pitch cone angle pinion $\delta_1 = 90^0 - \delta_2$; *L*-gear tooth length $b \le 0{,}3\cdot R_e$.

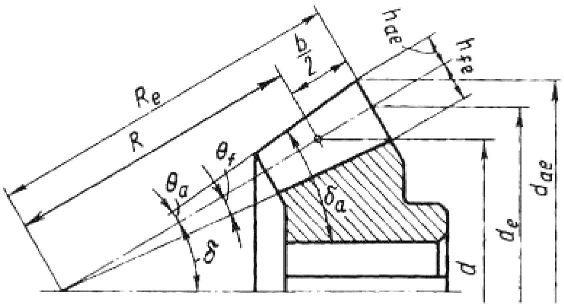

Fig.1. Scheme for calculating the basic geometrical parameters of the bevel gear

In the pole of the gearing, where rolling occurs without slipping, the ratio of the radii of curvature of the drive and driven profiles is:

$$\frac{\rho_w}{\rho_k} = \frac{1}{i}$$

where i – the gear ratio of the gear, the value of which is determined by the following relationship,

$$i = \frac{\sin\delta_1}{\sin\delta_2} = tg\delta_2 = ctg\delta_1 = \frac{z_2}{z_1}$$

Then the radius of curvature of the tooth profile of the leading bevel gear is [1, 2, 3]:

$$\rho_{wcc} = 0{,}5m\sqrt{z_w^2\sin^2\alpha + 4kz_w + 4k^2}\text{ , м,}$$

where m –average district module, *(m_e*– external district module); z_w– number of teeth of the pinion gear; z_k – number of teeth of the driven gear; *k* – tooth height factor value k varies within the following limits *k*=0… 1.

Then the radius of curvature of the tooth profile of the driven bevel gear, taking into account the profile curvature radius of the leading bevel gear, is equal to:

$$\rho_{kcc} = 0{,}5m(z_w(1+i) - \sqrt{z_w^2\sin^2\alpha + 4kz_w + 4k^2})$$

The radii of curvature of the profiles of the teeth of bevel gears characteristic points of engagement.

1. k=0, those the teeth of the drive and driven bevel gear meshes in the pole, then the radius of curvature of the tooth profile

pinion gear,

$$\rho_{wcc} = 0{,}5mz_w\sin\alpha\text{ , m;}$$

driven gear

$$\rho_{kcc} = 0{,}5mz_w i\sin\alpha\text{ , m.}$$

2. When tooth engagement occurs at the head or at the tooth cusp, the value of the tooth height factor is important in the aisles k = ±1:

a) if the bevel gears engage between the head of the tooth leading and the tooth foot, driven gears, then the radius of curvature at the point of contact of the profiles:

heads of tooth of the leading bevel gear

$$\rho_{wcc} = 0{,}5m\sqrt{z_w^2\sin^2\alpha + 4z_w + 4}\text{ , m;}$$

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$$\rho_{kcc} = 0{,}5m\left(z_w(i+1)\sin\alpha - \sqrt{z_w^2\sin^2\alpha + 4z_w + 4}\right)\text{, m;}$$

b) if the bevel gears engage between the driven tooth head and the tooth pinion, the pinion gear, then the radius of curvature at the point of contact of the profiles:

driven bevel gear tooth heads

$$\rho_{kcc} = 0{,}5m\sqrt{z_w^2\sin^2\alpha + 4z_w - 4}\text{ , m;}$$

legs of tooth of the leading bevel gear

$$\rho_{kcc} = 0{,}5m\left(z_w(i+1)\sin\alpha - \sqrt{z_w^2\sin^2\alpha + 4z_w - 4}\right)\text{, m}$$

The degree of slippage between the teeth of the leading and driven bevel gears in general is determined by the expression:

$$\xi_{w,k} = \frac{v_w - v_k}{v_{w,k}}$$

In the pole of the gearing bevel gears, the rolling speed of the gear teeth is:

$$v_{w,kcc} = \pi m z_w i n_k \sin\alpha ,$$

The rolling speeds of the teeth of the leading and driven conical gears are the same, i.e. the degree of slippage in the pinion gearing bevel gear is zero.

For the general case, the rolling speed of the teeth of the bevel gears:

pinion gear

$$v_{w(b)cp} = \pi m z_w i n_k \sin\alpha \sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2} \text{ , m/s;}$$

driven gear

$$v_{k(b)cp} = \pi n_k m\left(z_w(i+1)\sin\alpha - \sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2}\right)\text{, m/s.}$$

The degree of slippage between the teeth of bevel gears depends on the rolling speed of the teeth of the driving and driven gears in the area of their contact:

a) gearing bevel gears occurs between the head of the tooth leading and the leg of the tooth, driven gears:

relative to the tooth head of the leading bevel gear,

$$\xi_w = \frac{(i+1)\left(\sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2} - z_w \sin\alpha\right)}{i\sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2}};$$

relative to the tooth legs of the leading bevel gear,

$$\xi_k = \frac{(i+1)\left(\sqrt{z_w^2 \sin^2\alpha + 4kz_w - 4k^2} - z_w \sin\alpha\right)}{i\sqrt{z_w^2 \sin^2\alpha + 4kz_w - 4k^2}}.$$

б) gearing bevel gears occurs between the tooth leg and the head of the tooth, driven gears:

relative to the tooth head driven bevel gear,

$$\xi_k = \frac{\sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2}}{(i+1)\left(\sqrt{z_w^2 \sin^2\alpha + 4kz_w + 4k^2} - z_w \sin\alpha\right)i}$$

relative to the tooth legs driven bevel gear,

$$\xi_k = \frac{\sqrt{z_w^2 \sin^2\alpha + 4kz_w - 4k^2}}{(i+1)\left(\sqrt{z_w^2 \sin^2\alpha + 4kz_w - 4k^2} - z_w \sin\alpha\right)i}$$

The results of the calculation of the relative slip between the teeth of bevel gears can be positive or negative. Its positive value corresponds to when the gearing in the gear occurs between the head of the tooth leading and the tooth foot of the driven gear, its negative value belongs when the gearing occurs between the tooth foot leading and the tooth head of the driven gear.

Sliding speed between the teeth of the driving and driven bevel gears in the area of their contact occurs:

when gear teeth engagement occurs between the head of the tooth, the drive and the pinion gear

$$v_{ckck} = \pi n_k m\left(z_w(i+1)\sqrt{z_w^2 \sin^2\alpha + 4k_w + 4k^2} - z_w \sin\alpha\right)\text{, m/s;}$$

when gear teeth engagement occurs between the leg, the leader and the tooth head of the driven bevel gear,

$$v_{ckck} = \pi n_k m\left(z_w(i+1)\sqrt{z_w^2 \sin^2\alpha + 4k_w - 4k^2} - z_w \sin\alpha\right)\text{, m/s.}$$

A positive value of the sliding speed corresponds to when the engagement occurs between the head of the tooth and the leading tooth of the driven bevel gear. Its negative value indicates that the rolling speed of the head of the tooth of the driven gear in this area of the tooth is more than the rolling speed of the pinion gear.

The total rolling speed of the teeth of the gears characterizes the thickness of the oil film between the gear teeth and is the sum of the rolling speeds of the teeth of the driving and driven gears at the point of contact:

the total rolling speed of the head, the leading and the legs of the driven bevel gears,

$$v_{сумср} = \pi n_k m\left(z_w(i+1)\sin\alpha(i-1)(z_w{}^2\sin^2\alpha + kz_w + 4k^2)^{1/2}\right), \text{ m/s.}$$

the total rolling speed of the legs, the leading and the heads of the driven bevel gears,

$$v_{сумср} = \pi n_k m\left(z_w(i+1)\sin\alpha(i-1)(z_w{}^2\sin^2\alpha + kz_w - 4k^2)^{1/2}\right), \text{ m/s.}$$

The slip path between the gear teeth determines the tooth wear rate, and it depends on the gearing module, the degree of slippage and the number of teeth of the internal gear. To calculate the sliding path between the teeth of bevel gears, the dependence is obtained:

$$S = \frac{\pi m(i+1)\left(z_w^2\sin^2\alpha + kz_w \pm 4k^2 - z_w\sin\alpha\right)}{z_k}, \text{ m.} \qquad (2)$$

As usual, the gear ratio of the gearing is calculated by the ratio of the radii of rotation of the driven gear to the radius of the pinion gear along the pitch circles of the gear wheels that are engaged. In fact, in the work of a gear drive, the location of the contact teeth of the gears constantly changes relative to the pitch circle along the engagement line in accordance with it, the radii of rotation of the gear teeth also change. As in the process of engagement, the location of the contact relative to the axis of rotation of the gears is constantly changing with a constant center gear distance [1]. In this case, the gear ratio gearing bevel gears at the point of contact of the teeth is determined when the teeth gearing occurs:

between the head of the tooth of the pinion gear and the leg of the tooth of the driven gear,

$$i = \frac{d_{ikck} - km}{d_{iwcw} + km} = \frac{z_k - k}{z_w + k},$$

between the pinion tooth pinion and the pinion gear tooth,

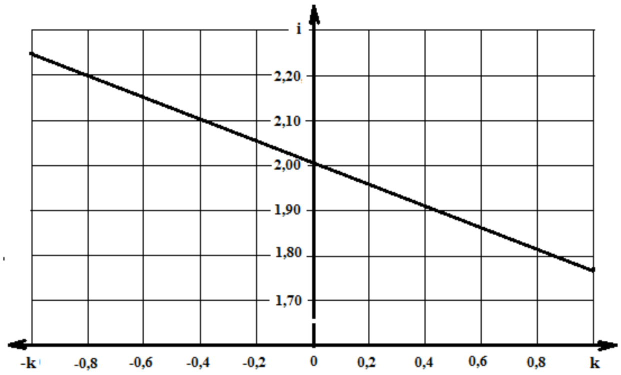

Fig.2. Changes in the actual gear ratio of the bevel gear transmission depending on the tooth height ratio

$$i = \frac{d_{ikck} + km}{d_{iwcw} - km} = \frac{z_k + k}{z_w - k}$$

According to the graph presented in Fig. 2 it can be judged that the actual gear ratio of the bevel gear transmission, depending on the ratio of the height of the tooth, will change according to a linear pattern.

III. CONCLUSION

Thus, the obtained analytical expressions allow one to numerically estimate the following geometrical and kinematic parameters of the contact of the teeth of bevel gears during friction:

1. In gearing, rolling occurs in the contact zone of the pitch circles of gears and at the same time rolling of the teeth occurs with slippage, the degree of slippage increases with increasing distance from the rolling zone to the point of contact of the teeth, the greatest slippage occurs at the head and leg of the teeth.

2. The actual gear ratio between gearing gears occurs according to a linear pattern, its greatest value is when the engagement occurs between the tooth head driven and the tooth pinion, the driving gears, the least value is if the gearing occurs between the tooth head leading and the tooth legs driven gears.

REFERENCES

[1]Irgashev B.A. Forecasting the Consumption of Spare Parts in Machines Based on the Content of Wear Particles in Oil Journal of Friction and Wear, Allerton Press. 2015, Vol. 36, No. 5, pp. 441–447.
[2]Dubovik E.A. Features of wear gear transmissions // Friction and lubrication in machines and mechanisms. - 2015, № 3, 31-35.
[3]Gorlenko O.A., Makarov G. N., Shnyrikov I. O. Increasing the contact endurance of teeth of spur spur gears // Friction and lubrication in machines and mechanisms. - 2014, № 6, 25-27.