DETERMINATION OF TOOTH SURFACE MISMATCH SHAPE IN BEVEL GEARS

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The operational efficiency, load distribution, and noise level of bevel gear transmissions are directly dependent on the geometric accuracy of tooth surfaces and the degree of their mutual conformity. Technological deviations during manufacturing, setup errors, and operating conditions lead to deviations of the actual tooth surfaces from the theoretical profile. As a result, contact zones shift, local contact stresses increase, and the wear process is intensified.

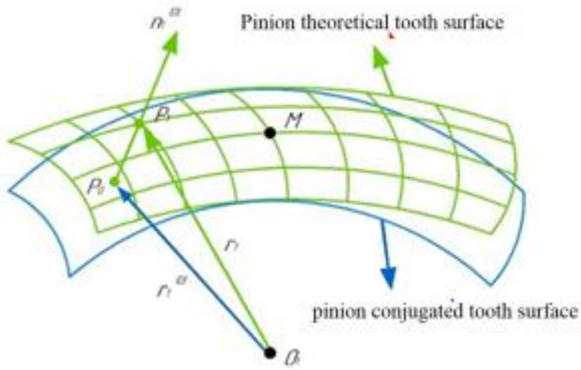

Figure 1 illustrates the geometric relationship between the theoretical and actual tooth surfaces of the driving bevel gear.

For the purpose of determining the mismatch shape of tooth surfaces, the obtained surface is assumed to be the theoretical tooth surface of the driving bevel gear and is denoted by r_1. The actual (conjugate) tooth surface of the driving gear is represented by $r_1^{(0)}$. The spatial geometric differences arising between the theoretical and actual tooth surfaces are considered as deviation values, which characterize the degree of tooth surface mismatch.

Figure 1 shows the spatial relationship between the theoretical and actual tooth surfaces of the driving gear. Point M represents the midpoint of the tooth surface along the face width. If the vector equation of an arbitrary point P_0 on the actual tooth surface is given as

$$r_1^{(0)}(u_2,\theta_2,\phi_2)=\begin{bmatrix} x_1^{(0)}(u_2,\theta_2,\phi_2) \\ y_1^{(0)}(u_2,\theta_2,\phi_2) \\ z_1^{(0)}(u_2,\theta_2,\phi_2) \end{bmatrix}$$

then the unit normal vector at this point can be expressed as:

$$n_1^{(0)}(u_2,\theta_2,\phi_2)=\begin{bmatrix} n_{x1}^{(0)}(u_2,\theta_2,\phi_2) \\ n_{y1}^{(0)}(u_2,\theta_2,\phi_2) \\ n_{z1}^{(0)}(u_2,\theta_2,\phi_2) \end{bmatrix}$$

The normal line drawn from point P_0 intersects the theoretical tooth surface at point P_1, whose coordinates are defined accordingly. The distance between points P_0 and P_1 is determined as:

$$\vartriangle\delta=\left|P_0P_1\right|$$

which represents the deviation magnitude between the tooth surfaces, that is, the degree of mismatch.

According to the vector relationship shown in Figure 1, the following equation can be written:

$$r_1=r_1^{(0)}+\vartriangle\delta n_1^{(0)}$$

By expressing this relation in component form and combining the resulting equations, the following system of equations is obtained:

$$r_1^{(0)}(u_2,\theta_2,\phi_2)=\begin{cases} x_1^{(0)}(u_2,\theta_2,\phi_2)+\vartriangle\delta n_{x1}^{(0)}(u_2,\theta_2,\phi_2)=x_{p1} \\ y_1^{(0)}(u_2,\theta_2,\phi_2)+\vartriangle\delta n_{y1}^{(0)}(u_2,\theta_2,\phi_2)=y_{p1} \\ z_1^{(0)}(u_2,\theta_2,\phi_2)+\vartriangle\delta n_{z1}^{(0)}(u_2,\theta_2,\phi_2)=z_{p1} \\ f_2(u_2,\theta_2,\phi_2)=0 \end{cases}$$

By substituting the coordinates of all mesh points of the theoretical tooth surface into the above system and solving it sequentially, the deviation values $\Delta\delta_i$ ($i = 1, 2, 3, \ldots, m\times n$) at each point are determined. These values represent the degree of geometric mismatch between the theoretical and actual tooth surfaces of the driving gear. The set of deviation values at all points forms the mismatch shape of the tooth surfaces. This shape indirectly characterizes the level of geometric accuracy between the tooth surfaces and has a direct influence on contact accuracy, load distribution, and noise level.

The results of the study demonstrate that the method of determining the geometric mismatch between the theoretical and actual tooth surfaces of the driving bevel gear along the normal direction makes it possible to quantitatively evaluate their spatial deviations. The obtained set of deviations effectively characterizes the mismatch shape of the tooth surfaces and serves as an efficient criterion for assessing contact accuracy and load distribution.

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