Study on dynamics of gear assembly

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Abstract

The influence of assembly error on gear transmission is one of the important basic theories of gear transmission engineering. In this paper, the Euler equation is applied to the research of gear offset by analyzing the equations of rigid body translation equation, rotation equation and angular momentum equation. By combining the theory and numerical analysis, the paper analyzes the gear as well as to change the gear offset, gear speed and gear quality on the bearing force of the size of the impact.

Keywords

Gear; Assembly; Offset; Bearing force; Euler equation.

1. Introduction

Gear meshing transmission is the most widely used in the field of mechanical transmission in the world. The analysis of the influence of assembly error on the gear transmission and the effect on the rack are one of the necessary theoretical bases for the in-depth study of gear transmission [1].

Through the introduction of assembly bias, the Euler equation is applied to analyze the influence of assembly bias error on the reaction force of the transmission gear and the service life of the fulcrum bearing.not number your paper: All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question.

2. Model Establishment

2.1 Translation Equation

The mass of the object is expressed in M, and the acceleration of the force and the particle on the particle is expressed by F and a_G, then:

$$\sum F = ma_G$$

2.2 Equation of Rotation

$$\sum M_0 = \dot{H}_0 \tag{1}$$

$\sum M_0$ represents the sum of the moment of the particle (including the rigid body) to the fixed-point O, $\dot{H}_0$ represents the particle (including rigid) total angular momentum about the O point of the time rate of change.

2.3 Angular Momentum Equation

The mass of the rigid body is m and the center of mass is G. X, Y, Z are inertial coordinate systems. r_A points to A from the origin of the coordinate, ρ_A points to a small i particle from point A, If the mass of the particles is m_i, The angular momentum of the particle i on the A point is:

$$(H_i)_G = \rho_A \times m_i v_i$$

v_i is the velocity of particles known in the inertial coordinate system , ω is the acceleration of a rigid body, So the speed of point I is $v_i = v_A + \omega \times \rho_A$ therefore:

$$(H_i)_G = \rho_A \times m_i (v_A + \omega \times \rho_A)$$
$$= \rho_A m_i \times v_A + \rho_A \times (\omega \times \rho_A) m_i$$

We use integral processing, we get:

$$H_A = \int_m \rho_A \times d_m \times v_A + \int_m \rho_A \times (\omega \times \rho_A) d_m$$

On the angular momentum of a fixed point O: if the A point on the rigid body is a fixed point, then $\upsilon_A = 0$, The equation can be simplified to:

$$H_0 = \int_m \rho_0 \times (\omega \times \rho_0) d_m$$

The angular momentum of the centroid G: if A is the centroid G of the rigid body, then $\int_m \rho_A \times d_m = 0$, The equation can be simplified to:

$$H_G = \int_m \rho_G \times (\omega \times \rho_G) d_m$$

The angular momentum of an arbitrary point A: the equation can be simplified to:

$$H_A = \rho_{G/A} + H_G$$

The decomposition of angular momentum H: in order to be able to use the equation to calculate the angular momentum, the angular momentum should be written as a scalar form, so a coordinate system xyz is also needed.Relative to XYZ can be any direction[2].

For general equations, If the equation contains the following forms:

$$H = \int_m \rho \times (\omega \times \rho) d_m$$

After the numerical operation of xyz in the coordinate system, we get:

$$H_x = I_{xx}\omega_x - I_{xy}\omega_y - I_{xz}\omega_z$$
$$H_y = -I_{yx}\omega_x + I_{yy}\omega_y - I_{yz}\omega_z$$
$$H_x = -I_{zx}\omega_x - I_{zy}\omega_y + I_{zz}\omega_z$$

This formula is the main basis for the calculation of the gear bias. On this basis, we can only solve the problem by simply using relevant knowledge of theoretical mechanics. Under our given conditions, the force acting on the rack and the bearing occurs when gear is installed, and then the numerical quantitative analysis is carried out[3].

3. Influence of change of gear installation parameters on bearing

The influence of specific gear parameters, such as gear physical parameters and installation parameters, on bearing is analyzed. In this paper, a control variable method is used to analyze the change of single variable, assuming that all other parameters are given according to numerical examples.

Assume: $m = 10kg$, There is a angle θ between its axis and the axis of rotation, initial $\theta_0 = 10°$, The quality of the shaft is negligible. $I_Z = 0.1kg \bullet m^2$, $I_x = I_y = 0.05kg \bullet m^2$ angular velocity of rotation axis $\omega = 30rad/s$.

3.1 Angle change

In the analysis of the change of the angle of the sandwich, this paper only considers the change of the angle from 0 to 30 degrees. We find it time to change the angle, $A_X = B_X = 0$, It does not change with the change of the angle.And we've got it. B_Y、A_Y on the relation of θ change:

$$A_Y = 54.5 + 50\sin(2\theta/180)$$

$$B_Y = 43.6 - 50\sin(2\theta/180)$$

When the offset angle of gear changes, the force of thrust bearing and radial bearing will also change. For bearing thrust, the greater the offset angle of gear is, the greater the force it will bear. For radial bearing, the greater the offset angle is, the less force it will bear.

3.2 Rotational speed change

The research method is similar to that in the above, in the process of analyzing the change of speed.And we've got it. B_Y、A_Y on the relation of ω change:

$$A_Y = 54.5 + 0.019\omega^2$$

$$B_Y = 43.6 - 0.019\omega^2$$

For a thrust bearing, the greater the speed of the gear is, the greater the force it will bear. For the radial bearing, the greater the speed of the gear is, the stronger the force will first decrease and then increase, and the direction of force will change. At the same time, we find that when the thrust force of thrust bearing and radial bearing are in opposite direction, the torque of the rotating shaft increases rapidly with the increase of rotation speed, which is easy to cause shaft failure and bearing failure. The risk coefficient is relatively high[4].

3.3 Quality changespeed change

The research method is similar to that in the above, in the process of analyzing the change of speed.And we've got it. B_Y、A_Y on the relation of m change:

$$A_Y = 17.11 + 5.44m$$

$$B_Y = -17.11 + 4.36m$$

For the thrust bearing, the greater the speed of the gear, the greater the force it bears; for the radial bearing, the greater the speed of the gear, the greater the force it bears. We find that when the gear is lighter, thrust bearing and radial axis bear the opposite direction of force. With the increase of gear quality, the bearing direction of radial bearing changes. As the quality of the gear increases, the force of the thrust bearing A increases faster[5].

4. Conclusion

Through the derivation of the Euler equation in the process of rigid and deep understanding, considering the influence factors and results of gear assembly bias error, using examples and theoretical derivation combining method, we use the Euler equation to the system research process of gear bias; influence on bearing force analysis of the gear assembly to offset error the transmission shaft bearing and gear change analysis and assembly parameters. The following conclusions are drawn:

(1) When the offset angle of gear changes, the force of thrust bearing and radial bearing will also change. For thrust bearing, the greater the offset angle of gear is, the greater the force it will bear. For radial bearing, the larger the offset angle is, the smaller the force it will bear.

(2) For a thrust bearing, the greater the speed of the gear, the greater the force it will bear. For the radial bearing; the greater the speed of the gear, the stronger the force will first decrease and then increase, and the direction of force will change. At the same time, we find that when the thrust force of thrust bearing and radial bearing are in opposite direction, the torque of the rotating shaft increases

rapidly with the increase of rotation speed, which is easy to cause shaft damage and bearing failure, and the risk coefficient is relatively high.

(3) For the thrust bearing, the greater the speed of the gear, the greater the force it bears; for the radial bearing, the greater the speed of the gear, the greater the force it bears. We find that when the gear is lighter, the thrust bearing and the radial bearing bear the opposite direction. With the increase of gear quality, the direction of force that the radial shaft bears is changed. As the quality of the gear increases, the force of the thrust bearing increases rapidly..

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