Predictions of input pinion floating on concentric face gear transmission static load sharing

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Abstract. A static load sharing analysis model of concentric face gear transmission associated with the input pinion floating is constructed, and the calculation method of static load sharing is proposed. The influence of the input pinion floating on static load sharing is predicted. The results show the input pinion floating stiffness reduction could benefit for the concentric face gear transmission static load sharing.

Keywords: concentric face gear transmission, input pinion floating, static load sharing.

1. Introduction

The concentric face gear transmission shows the advantages in weight, transmission efficiency and reliability, compared with the traditional gear torque split transmission. Therefore, it is focused by the helicopter transmission researchers.

For the gear split torque transmission, uneven load distribution on gears is one of the key problems for the split transmission design. Therefore, many scholars studied the load sharing behavior of various split transmission, such as planetary gear transmissions [1-5], cylindrical gear split torque transmissions [6-12] and traditional face gear split torque transmissions [13-15]. However, there are few studies on the concentric face gear transmission. Thus, in the paper, the static load sharing of the concentric face gear transmission is studied. A static load sharing analysis model and a static load sharing calculation method associated with the input pinion floating are constructed. Then, the influence of the floating support stiffness on the static load sharing of the system is simulated. The results would be helpful to the concentric face gear transmission design.

2. Analysis model and calculation method constructions

The concentric face gear transmission is composed of two coaxial face gears, two input pinions and two idler gears, as show in Fig. 1. In the system, torque split to upper and lower face gears by two input pinions, the low face gear transfers torque to the up face gear by the idler gears, and the torque is output by the upper face gear finally. The static load sharing model associated with the input pinion floating is proposed, as shown in Fig. 2.

Illustrated in Fig. 2., Z_1 and Z_2 are the input pinions, Z_3 and Z_4 are the idlers, Z_U and Z_L are the upper and lower face gears, T_1 and T_2 are the input torques, T_O is the output torque, k_t is the floating support stiffness, k_{ij} is the mesh stiffness. Moreover, F_{ij} is defined as the mesh force between gear j and gear i.

Based on the equilibrium conditions, the static load sharing equation is obtained by:

$$\begin{cases}(F_{1U}+F_{1L})\cos\alpha = T_1/r_{b1}, \\ (F_{2U}+F_{2L})\cos\alpha = T_2/r_{b1}, \\ F_{3U}-F_{L3}=0, \\ F_{4U}-F_{L4}=0, \\ \left(-F_{1_L}-F_{2_L}+F_{L3}+F_{L4}\right)\cos\alpha = 0,\end{cases} \tag{1}$$

and the floating support equation could be derived by:

$$\begin{cases}F_{1U}-F_{1L}-k_t s_1 = 0, \\ F_{2U}-F_{2L}-k_t s_2 = 0,\end{cases} \tag{2}$$

and the gear meshing force could be expressed as:

$$F_{ij} = k_{ij} r_{bi} \varphi_{ij}, \tag{3}$$

where, r_{ib} is the gear i base circle radius, and φ_{ij} is the deflection angle between the gear i and the gear j.

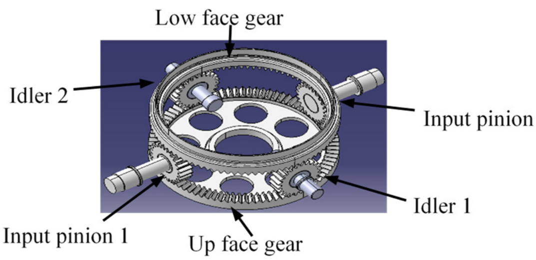


Fig. 1. The concentric face gear transmission

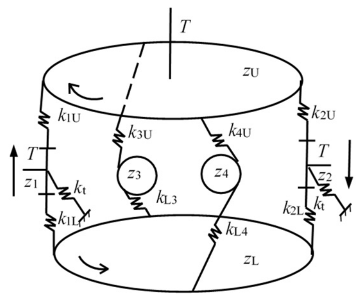


Fig. 2. The static load sharing model

For static load sharing of input pinions, the distribution ratio and maximum distribution ratio between upper and lower face gears could be obtained by:

$$\begin{cases}\Omega_{iU} = \dfrac{F_{iU}}{T_i/r_{bi}}, \\ \Omega_{iL} = \dfrac{F_{iL}}{T_i/r_{bi}}, \quad i = 1, 2,\end{cases} \tag{4}$$

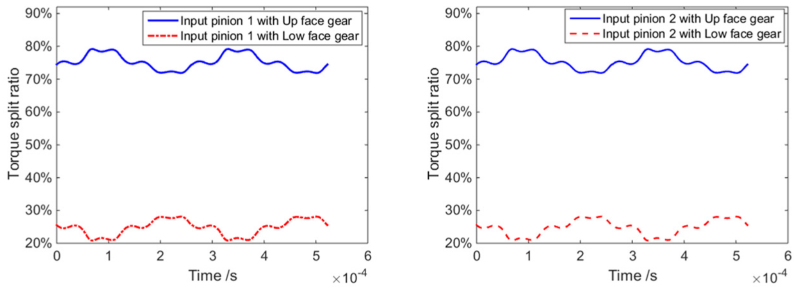
$$\Omega_{\max} = \max(\Omega_{iU}, \Omega_{iL}). \tag{5}$$

3. Simulations

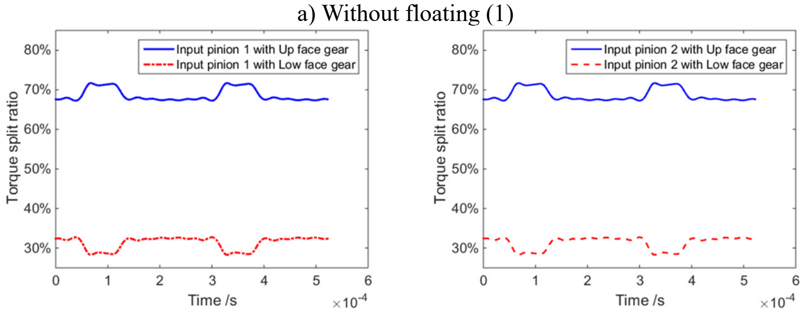
In order to predict the influence of floating support stiffness on static load sharing of the concentric face gear transmission, the parameters of an example case are listed in Table 1.

Table 1. Parameters of system

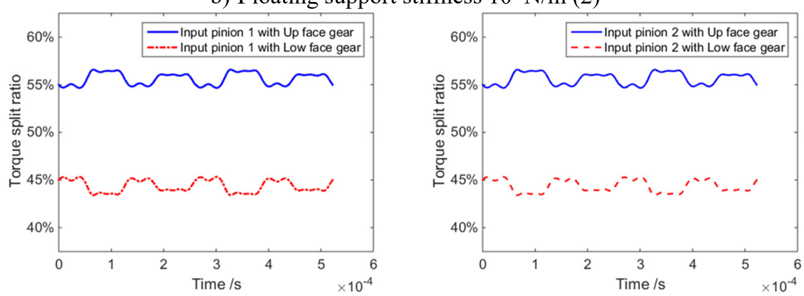
Symbol name	Value	Unit
Modulus / m	4	mm
Pressure angle / α	20	°
Tooth number of face gear / z_f	86	–
Tooth number of cylindrical gears / z_p	24	–
Tooth number of shaper / z_t	25	–
Addendum coefficient / h_a^*	1	–
Clearance coefficient / c^*	0.25	–



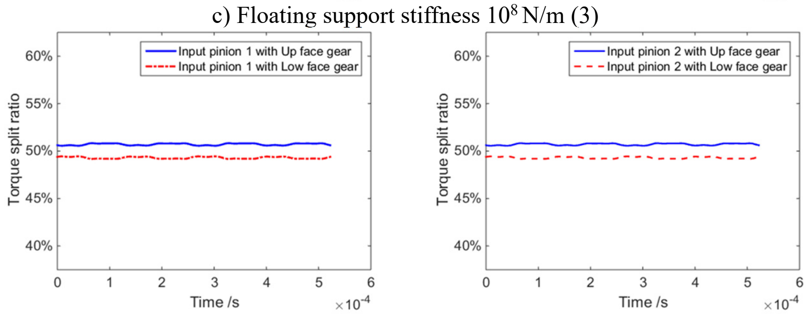
a) Without floating (1)



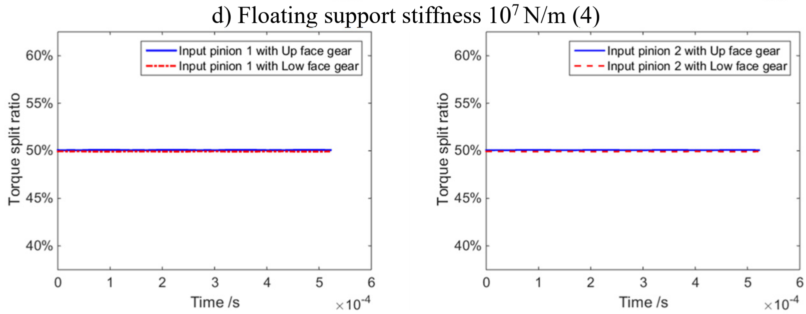
b) Floating support stiffness 10^9 N/m (2)



c) Floating support stiffness 10^8 N/m (3)



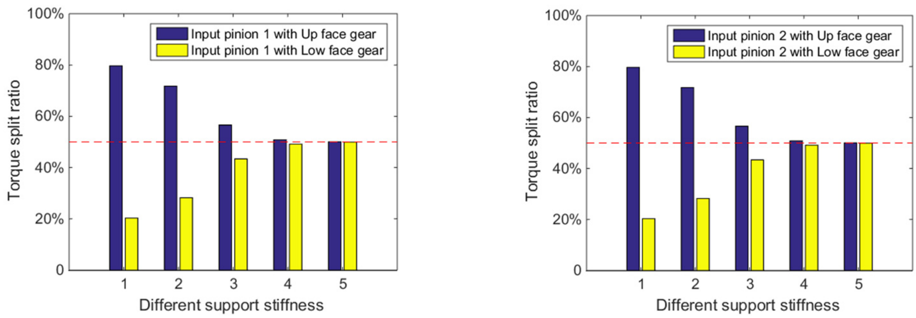
d) Floating support stiffness 10^7 N/m (4)



e) Floating support stiffness 10^6 N/m (5)

Fig. 3. Static load sharing with different floating support stiffness

According to the static load sharing model and calculation method, as well as the parameters listed in Table 1, the influences of the input pinion floating on the static load sharing are simulated. The results are shown in Fig. 3 and Fig. 4.



a) Input pinion 1 b) Input pinion 2

Fig. 4. Maximum static load sharing under different floating support stiffness

4. Conclusions

The works of the issue are as follows:

1) The static load sharing model and calculation method of the concentric face gear transmission associated with the input pinion floating are proposed.

2) The influences of floating support stiffness on static load sharings are simulated, and the results indicate the floating support stiffness reduction is benefit for static load sharings.

These contributions would be helpful to the concentric face gear transmission design.

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