Influence of Centrifugal Forces on Oil Flow in Journal Bearing of Planetary Gear

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Long Abstract

Introduction

Planetary gears have a wide application in different areas of industry. At present moment, they find application in geared turbofan aircraft engine. For high speed or heavy-loaded gears fluid film bearings used in supports. Main characteristics of fluid film bearing such as stiffness and damping based upon hydrodynamic fluid pressure caused by relative motion of sliding surfaces. In most of applications, fluid inertia forces are negligible in comparison with hydrodynamic forces, but if some applications their influence on bearing characteristics could be sufficient and should be taken into account. Planet wheel journal bearing are an example where influence of fluid inertia forces have an influence on bearing characteristics. For taking into account inertia forces acting on oil film in journal bearing of planet wheel the conventional mathematical model for oil flow in journal bearing based on Reynolds equation requires modification.

1. Inertia forces

For any type of planetary gear each planet wheel (2) taking a part in compound motion: rotation with carrier (H) with angular speed ω_H and rotation about self axis with angular speed ω_2 (Figure 1). One sliding surface of bearing is a part of carrier and another is a part of planet wheel and this causes fluid velocity distribution in bearing gap. Therefore centrifugal and Coriolis forces acting on fluid in bearing gap. These forces can be determined using carrier and planet wheel angular speeds that receiving for selected type of planetary gear and transmission ratio. Centrifugal and Coriolis forces in fluid should be taken into account in fluid flow in bearing mathematical model.

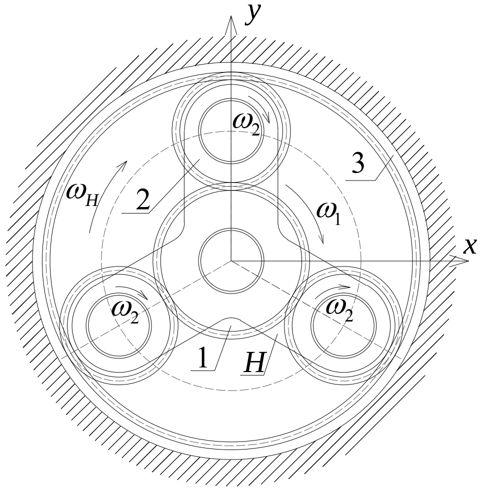

Figure 1. Planetary gear
1 – sun wheel; *H* – carrier; 2 – planet wheel; 3 – ring wheel

2. Mathematical model

Bearing mathematical model that taken into account centrifugal and Coriolis forces acting in fluid film based on Reynolds equation [1, 2]. Modified Reynolds equation with taking into account mass forces corresponded centrifugal and Coriolis forces in Navier-Stokes equations. Numerical solution of modified Reynolds equation carried out using finite-element discretization procedure. Developed bearing model taking into account carrier and planet wheel rotations and allows calculating pressure distribution in bearing for various relations between ω_H and ω_2 for any shaft journal eccentricity caused by gear of planet wheel with sun and ring wheels.

3. Model verification and results

Bearing mathematical model was verified for the case of long bearing by comparison with analytical solution and numerical solution in STAR-CD software based on full Navier-Stokes equations. In both cases, results are close to numerical results received by modified Reynolds equation.
Pressure distribution in bearing for a number of ratios of bearing wheels angular speeds calculated for different shaft journal eccentricity in bearing. For some cases, fluid inertia forces have a sufficient influence on pressure distribution in bearing (Figure 2).
Developed mathematical model based on modified Reynolds equation taking into account centrifugal and Coriolis forces acting in fluid in bearing gap. This model gives an ability for more accurate determination of planet wheel position in bearing and calculation of bearing carrying force depending upon load comes from gear.

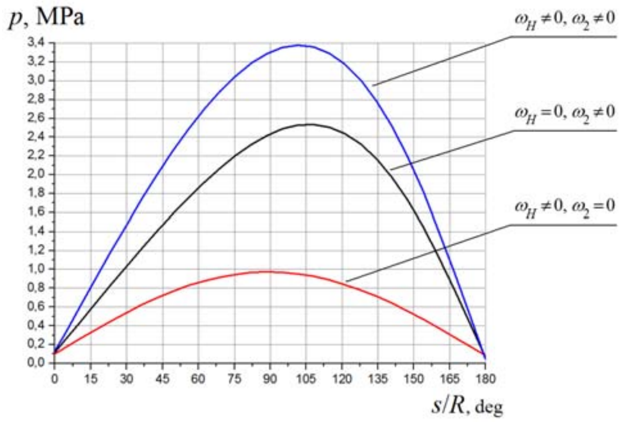

Figure 2. Pressure distribution in bearing middle section for different planet wheel rotation conditions

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