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Thermohydrodynamic analysis of high speed water-lubricated spiral groove thrust bearing considering effects of cavitation, inertia and turbulence

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Abstract: A thermohydrodynamic cavitating flow lubrication model including effects of cavitation, inertia and turbulence for high speed water-lubricated spiral groove thrust bearing was established. The static characteristics of the water-lubricated spiral groove thrust bearing at high speed condition were investigated using this model. The numerical calculation results have shown that load carrying capacity and friction torque reduce due to inertia and cavitation in high speed condition, while that load carrying capacity and friction torque increase due to turbulence. The maximum temperature rise increases due to inertia effect, and reduces due to cavitation effect. In addition, the influence of inertia effect on the static characteristics of water-lubricated spiral groove thrust bearing was greater than the cavitation effect under high speed condition.

Keywords: spiral groove thrust bearing; cavitation effect; inertial effect; thermohydrodynamic; turbulence.

1. Introduction

Spiral groove thrust bearing exhibits a variety of advantages (such as low friction, large loading capacity, good stability). Therefore, the spiral groove thrust bearing is widely used in high speed rotating machinery [1-3]. Gas or oil is often used as the lubricant in spiral groove thrust bearings. However, the load capacity of the bearing is lower with gas lubricant and the bearing temperature rise is higher with oil lubricant at high speed condition. In order to improve the above problems, the water-lubricated spiral groove thrust bearing has been proposed by researchers in recent years [4-6], and the water lubricated spiral groove thrust bearing offers a number of advantages (such as low temperature rise, low vibration noise, high rotating accuracy, low wear, and low pollution etc). Given its comprehensive advantages in terms of performance, it has become a hot trend to use water lubricated spiral groove bearings as the supporting system for high speed rotating machinery.

The study of spiral groove thrust bearing dates back to as early as 1949 by Whipple[7], since then, numerous theories have been developed to solve the pressure and flow problem dealing with spiral groove thrust bearing. Notable early contributions include the narrow groove theory proposed by Muijderman et al[8, 9]. The narrow-groove theory[10] assumes that there are infinite numbers of grooves on a thrust bearing. This makes it possible to treat the problem as a one-dimensional problem and solve the problem by ignoring the geometrical discontinuity and complicated boundary shape. The thermohydrodynamic model of spiral groove thrust bearing is solved using a commercial software CFD by Khonsari[11]; Ren Liu et al[12, 13] proposed a design for a micro fabricated spiral groove thrust bearing; other available approaches include: Numerical treatments based on the Reynolds' equation and finite difference method [14, 15], finite

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