CFD Research on Hydrodynamic Gas Bearings with Different styles of Grooves

J. Li [1, 2], S. Q. Yang [2, 3], X. M. Li [2, 3], **J. H. Wu** [2, 3], Q. Li [1, 2, 3]

1. School of Energy Power and Engineering, Huazhong University of Science and Technology, Wuhan, Hubei, 430074, P. R. China
2. State key Laboratory of Technologies in Space Cryogenic Propellants， Beijing, 100190, P. R. China
3. University of Chinese Academy of Sciences, Beijing 100049, P. R. China

Background

Gas bearing use gas as lubricant which is widely used in turbo-expander in large cryogenic systems for its inherent characteristic of oil-free and high-speed capability. Self-acting bearings are more efficient compared with externally pressurized gas bearing due to no pressured gas consumption, but not enough stability to reach the designed operating speed. Etching some grooves on shaft or bearing is proved to be effective by experiments to improve its static and dynamic performance. The hydrodynamic gas bearing performance parameters, such as load capacity and stiffness, are dominated by styles and geometric parameters of groove.

Objectives

- Investigate the effects of structure parameter of groove to the load capacity and stiffness. And get the optimum structure for different styles of groove.
- Design a novel style which makes a better static and dynamic performance.

Conclusion

- The bearings with π grooves have better steady static performance than bearings with spiral groove due to the hydrodynamic effects of the straight grooves.
- Spiral angle has influence on compression effects in both two styles of grooves. When the value is in the range (25°,30°)，the load capacity and stiffness reached maximum.
- The optimum of the length of spiral groove for π style grooves is 6mm, while the optimum length is 7mm for spiral grooves; the optimum width of grooves for both two styles of grooves is 0.45.
- The optimum depth of grooves is 18 micrometers. This value is suitable for both two styles of groove. The tendency of stiffness is similar for both two styles of grooves, but the value change is small.
- The novel style of groove has better static performance than both two styles of grooves for the better compression effect in the groove.

Methods

Tools

Ansys is a commercial software which is widely used in the flow field calculation, three-dimension models are built to calculate the pressure distribution and then get the force of gas film

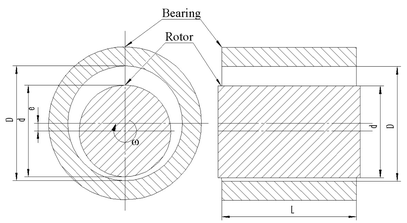
Assumptions

- ✓ **Isothermal condition.** Due to the ability of bearing materials (Copper) to conduct away heat is much greater than the heat generating capacity of gas film (low viscosity), the gas lubricating films are very nearly isothermal.
- ✓ **Ideal gas.** The gas in the film can be regard as ideal gas, so the density is only the function of pressure and temperature.
- ✓ **The side flow is neglected**. (flow of gas in and out of the side of the bearing
- ✓ **Constant viscosity**. We assumed that the gas viscosity has nothing to do with the pressure, and the temperature of gas virtually is constant.

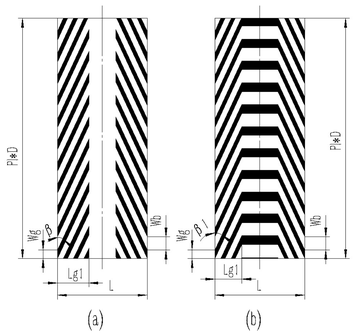
Models

Structure and Dimensions

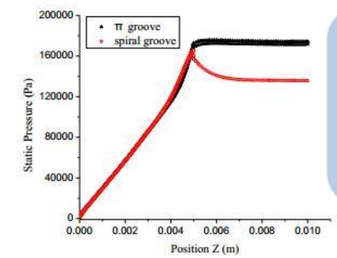
Gas film clearance: 10 micrometers
Length of the bearing: 20millimeters
Diameter of the shaft: 17 millimeters



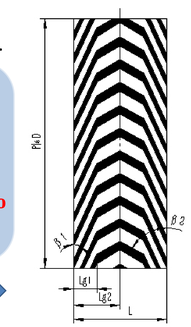
Style of Grooves



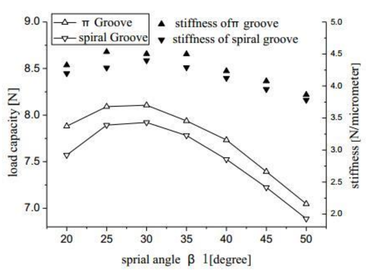
Gas compressed in the spiral grooves, and maintain the max pressure in straight grooves; For spiral-style grooves, compressed in spiral part, and then declined to a lower value.

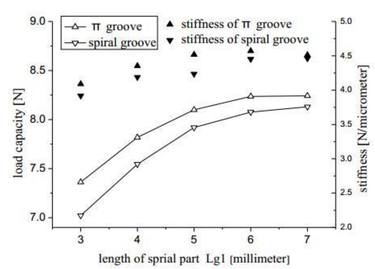


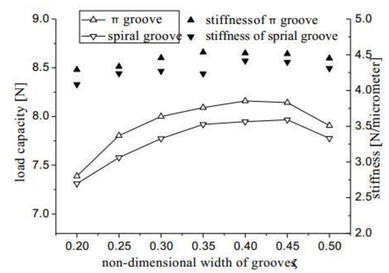
To improve the effects of compression in the groove, change the straight groove into spiral groove

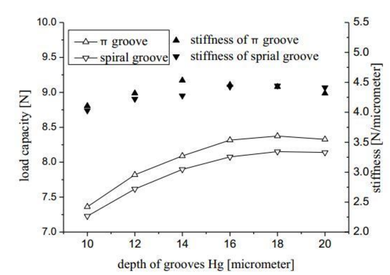


Results

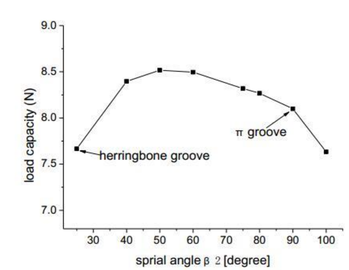




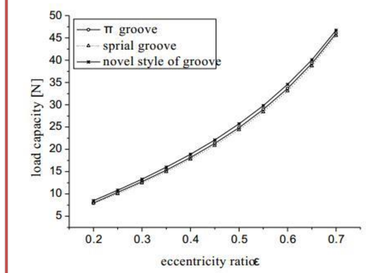




Structure parameters such as spiral angle, length of spiral groove, width of groove, depth of groove were calculated and optimized. There is a optimum value which makes the load capacity and static stiffness maximum for each structure parameter. The load capacity of bearings with π style groove is bigger than the bearings with spiral-style grooves. When the spiral angle is in the range (25°,30°), the load capacity reach maximum; The optimum length of spiral part forπ style groove is 6mm, and 7mm for spiral style groove. When the non-dimensionless width of groove is 0.45, the load capacity reach maximum for both two styles groove. The optimum depth of groove for both two style groove is 18um, 1.8 times of gas film clearance.



Make $\beta 1$ constant (25°), change the value of $\beta 2$, when the $\beta 2$ is equal to 50 degree, the load capacity reach maximum.



Load capacity versus eccentricity ratio for three types of groove. The load capacity of the novel style groove is the biggest

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