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Orientation effect of orderly roughness microstructure on spiral groove dry gas seal

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Abstract: Research related to the effect of roughness on the sealing performance was reviewed, and the orientation effect of a microstructure with orderly roughness was introduced to improve the performance of dry gas seal. A microstructure was established for the flow field of dry gas film in a pair of seals. The results showed that the microstructure improves the opening performance while maintaining a reasonable leakage rate. The microstructure depth, width, and spacing significantly impact the orientation effect. Both the groove and microstructure depths have optimal values for increasing the opening force while maintaining lower leakage rate. The opening force of the microstructure has a positive influence on microscale operation. This makes the microstructure of the dry gas seal more stable and thus more suitable for high-speed and high-pressure working conditions.

Keywords: Dry gas seal; Orderly roughness; Microstructure; Orientation effect; Numerical analysis

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1. Introduction

Dry gas seals with laser surface texturing (LST) are widely used in high-speed rotating equipment because of their low friction and wear, low leakage rate, and long service life [1][2][3]. The surface quality is important to the properties of dry gas seal, and the surface roughness plays an important role in determining the hydrodynamic behaviour during the operation. In 1978, Patir et al. [4] established an average flow model (PC model), where they introduced flow factors to represent the roughness effect. Makino et al. [5] extended the PC model and applied it to the thin-film gas lubrication on the basis of several previous studies [6][7][8][9]; their developed model is now frequently used to study the lubrication effect of surface roughness. For example, Peng et al. [10][11] used their model to analyse the sealing property of dry gas seal with surface roughness. Their results indicated that a rough end face improved the opening force, stiffness, friction torque, and leakage compare to a smooth end face under certain working conditions.

Li's research [12] further indicated that the surface roughness has a negligible influence on the sealing performance when the ratio of the film thickness to the mean square root of the roughness is greater than 3-4. Greater roughness can improve the stiffness and opening force but also significantly increases the leakage. Recent studies [13][14][15][16] have shown that a reasonable reconstruction or