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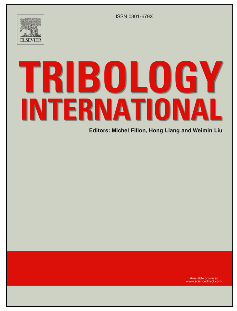

Influence of the real dimple shape on the performance of a textured mechanical seal

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Influence of the real dimple shape on the performance of a textured mechanical seal

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Abstract

Surface texturing the friction faces of a mechanical seal reduces friction as well as leakage and wear, where dimples machined on the surface enhance the formation of a full lubricating film in the seal interface. Numerical simulation is used to determine the optimal surface texturing for the investigated operating conditions of the seal. The geometry of the dimples introduced in the model assume a perfect shape, but machining causes the dimple shapes to be imperfect in terms of the roughness in the dimples, absence of sharp angles, deformed boundaries, and so on. The effect of the real geometry must be considered to confirm that surface texturing will provide the desired results. In the present work, surface texturing is performed using low-temperature plasma coupled with a thermo-chemical surface treatment on stainless steel sealing rings. The real dimple shapes are analysed and considered within the hydrodynamic lubrication model. The influence of different types of defects is studied. It is shown that there is a limit above which surface imperfections dispel the texture's positive effects. Controlling the dimple shapes is important when performing surface texturing.

1. Introduction

A mechanical seal is a sealing device that is widely used in industry such as those utilizing pumps and compressors. It mainly consists of two rings (the stator and the rotor), where one of them is linked to the housing and the other to the shaft. The sealing function is ensured by the mating faces of these two rings, which constitute a mechanical seal. A thin fluid film that is a few microns thick is created in the gap between the rotating faces, which reduces the risk of contact, and therefore, the risk of wear. To preserve the main function of mechanical seals (that is, sealing), the induced leakage should be eliminated or minimized to an acceptable level. Thus, the optimal configuration of a mechanical seal is one that minimizes the friction as well as the leakage.

One of the main methods studied and discussed in tribology literature is the performance enhancement of mechanical seals through surface texturing. In 1966, Hamilton *et al.* [1] discovered the effect of surface texturing when studying roughness effects by means of artificial asperities possessing a cylindrical shape. The authors explained that each pillar is like a micro-bearing that assists in fluid film generation and friction reduction. A few years later, Anno *et al.* [2] showed that cavities can be more beneficial for mechanical seals because they preserved a low leakage rate and allowed hydrodynamic fluid film generation between the seal faces. In 1997, Etsion *et al.* [3], showed that it was possible to increase a seal life when dimples were created on the seal surfaces with a laser texturing method. The possibility of enhanced performance in terms of lower friction and a higher critical load before seizure has been confirmed by several other studies [4, 5, 6]. However, the experimental results yielded a great dependence on texture geometrical parameters [6], such as the area ratio covered by the cavities, and the diameter and depth of the dimples. For certain parameters, it is possible to obtain worse performance with textured surfaces than with flat surfaces [7]. This is because the shapes of the dimples are unlimited [8], which highlights the need for an optimization process.

Numerical simulation offers a good solution for optimizing dimple shapes [8, 9]. A recent review of Gropper *et al.* [10] revealed that several papers were dedicated to simulating the hydrodynamic lubrication of textured surfaces. Additionally, Etsion [11] provided some advice for solving the