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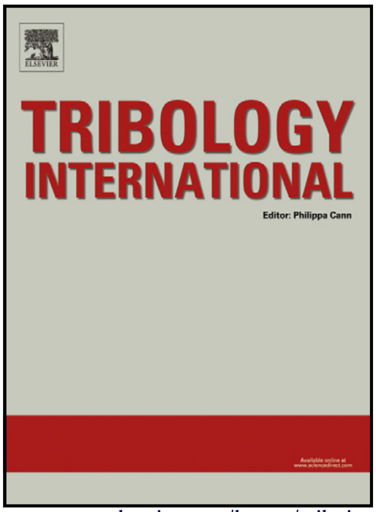

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Tri-dimensional eccentricity model of a rod lip seal

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Abstract
In this work, an analytical tri-dimensional eccentricity model of a rod lip seal is presented. In the specific, a thermoplastic polyurethane (TPU) rod lip seal was considered. The analytical model was completed and adjusted by means of numerical results. Experimental tests on selected seals were carried out on a suitable test rig designed to measure reaction forces on seals as a function of rod misalignment. A cross validation between analytical model and experimental results is provided. The model is used to calculate the contact force distribution on a seal when it is subjected to an eccentric mounting.

Keywords: lip seal; rod misalignment; eccentricity; contact force

1 Introduction

Lip seals are commonly used in many mechanical devices, such as pneumatic and hydraulic actuators, engines, machine tools and gas springs, among others. They are characterized by a sealing lip, also known as dynamic lip, properly designed to ensure the sealing and pumping mechanisms of a specific fluid under a wide range of working conditions. Moreover, the design of lip seals must reach a compromise between dynamic sealing and good lubrication [1].

The performance of a specific lip seal is affected by its geometry, the material and roughness of the seal and its counterparts, and its operating conditions. Lip seals provide a unidirectional sealing and their contact pressure profile under particular sealing conditions strongly depends on the lip angles at the air and fluid sides. Some designs may include two lips in the sealing area in order to enhance the sealing capability at low pressures and to avoid the entry of dirt from the side opened to the atmosphere.

In general, most of the lip seals available for reciprocating applications are made of polyurethanes (PU) and nitrile rubbers (NBR) due to the low cost and good performance of these materials. Both materials, however, have a limitation in temperature since their maximum operating temperature is about 100 ºC. Furthermore, this temperature constraint involves a working velocity limitation of seals due to frictional heating phenomena [2, 3]. Thus, the main alternative in applications with high sliding velocity requirements are seals made of PTFE composites because of their thermal resistance and low friction properties. Regarding the roughness, both the asperities of the lip and the roughness of the counterparts, play an important role in sealing operation [4-6].

Seals are mounted in grooves with a degree of interference in order to ensure an appropriate sealing at the interface. Hence, contact pressure distribution is one of the most important parameters to take into account when a specific seal is being designed. Unfortunately, measuring the contact pressure between a seal and its counterparts could be a difficult task. In order to measure static contact pressures, technologies such as photoelastic techniques [7], pressure film sensors [8, 9], radial force integration techniques [10] and manganin wires [11], among others, have been widely used. In any case, however, there is not a standard technique or device useful to measure contact forces in a rod or piston seal regardless the seal size.