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Effect of rheological parameters of elastomeric ring materials on dynamic of face seals

Czeslaw Kundera[a]*,Volodymyr Martsynkowskyy[b], Sergii Gudkov[b], Tomasz Kozior[a]

[a]*Kielce University of Technology, Faculty of Mechatronics and Machinery Design, Al. 1000-lecia P. P. 7, 25-314 Kielce, Poland*
[b]*Sumy State University, Department of General Mechanics and Machine Dynamics, R.- Korsakova 2 Str., 40007 Sumy, Ukraine*

Abstract

The paper is focused on the seal face dynamics taking into account the elastic and damping properties of the elastomeric ring. Properties of the elastomeric O-rings were determined by the results of experimental relaxation tests. Determined rheological parameters of the Standard I model were used for analysis of dynamic face seals of two configurations of an axially flexible seal ring. The amplitude characteristics were determined for the kinematic excitation.

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Keywords: face seal; design; dynamics;

1. Introduction

The shaft seals in centrifugal pumps and compressors are important elements having an essential effect on their operational conditions. In recent years, many works were published concerning theoretical and experimental studies of the dynamics of face seals, for example [1-3]. The review of those works has shown that the properties of the dynamic seals have a significant impact on the dynamics of the whole fluid flow machines.

* Corresponding author.
E-mail address: kundera@tu.kielce.pl

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Nomenclature

A, B, C, D, E, F, G, H	equation coefficients
A_1, A_2	amplitude - frequency characteristics
k	coefficient of elasticity of the spring
k_s	equivalent coefficient of elasticity
k_1, k_2, c_1	parameters of the rheological model Standard I
m	mass of the ring
M	mass of the shaft
p	pressure of the sealed fluid
P	hydraulic force
P_o	amplitude of forcing excitation
Z_e	amplitude of kinematic excitation

There are two issues in formulation of the dynamic model of face seals. The first relates to determining forces arising in a film medium of the gap formed by the faces of two sealing rings. It includes an analysis of flow through a narrow gap with regard to thermal phenomena and deformations of the surface forming the gap. The problem is complex and still present, especially in analytical solutions [4-6].

The second issue relates to a flexible housing of the one of the sealing rings. This comes down to model properties of the elastomeric ring fulfilling the role of the so-called secondary seal. It is known that a secondary seals play an important role in construction and reliable work of the face seals, so that their elastic-damping properties must be taken into account in the dynamic analysis.

This paper discusses a two-mass dynamic model of a coupled system consisting of a shaft and a flexible housing with a sealing ring. Equations of motion were formulated for two design configurations of the face seals. The aim of the paper is to determine the influence of the viscoelastic properties of elastomeric O-ring on the axial vibrations of the flexibly mounted seal ring. The results should be treated as supplementary to the dynamical model of the face packing seal, which is presented in Refs. [7, 8].

2. Problem formulation

The schematic diagrams of the analyzed design configurations of the face seals are given in Fig. 1. The two most popular types of the face seals are the Flexibly Mounted Rotor (Fig. 1a), hereafter referred to as FMR, in which the flexibly mounted ring (1) is rotary, and the Flexibly Mounted Stator (Fig.1b), hereafter referred to as FMS, in which the flexibly mounted ring (1) is stationary. Their dynamic properties have been compared.

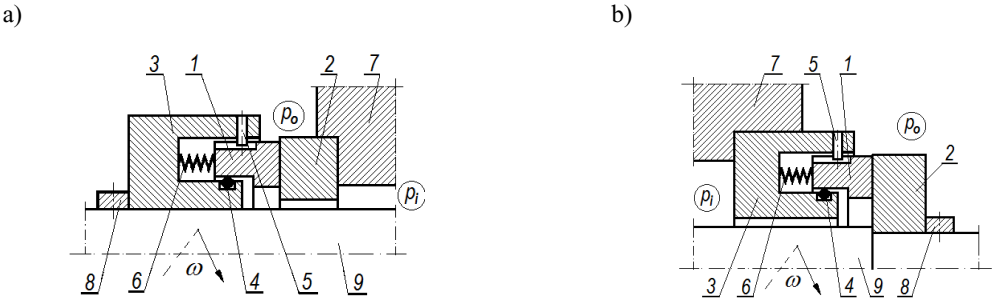

Fig. 1. Schematics of the face seals: (a) FMR; (b) FMS: 1, 2- seal rings; 3- housing of the flexibly mounted ring; 4- elastomeric secondary seal; 5– anti-rotation lock; 6- spring; 7- housing of the pump; 8- positive drive device, 9- shaft.