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Yuan Chen, Jinbo Jiang, Xudong Peng

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Dynamic characteristics and transient sealing performance analysis of hyperelliptic curve groove dry gas seals

Yuan Chen, Jinbo Jiang, Xudong Peng*

College of Mechanical Engineering, Zhejiang University of Technology, Hangzhou 310032, China

Abstract: This paper puts forward dry gas seals with novel face grooves that are called as hyperelliptic curve grooves. At high PV value, gas film dynamic characteristic coefficients isoline distributions are obtained under the different polar angle and hyperelliptic coefficient. Disturbance behaviors of gas film thickness and pressure are studied whether there is angular excitation or not. Saltation peak and period peak are defined, and their isoline distributions are presented which reveal the influence mechanism of gas film dynamic characteristics coefficients on dynamic tracking property. A dynamic wedge-shaped gap with a fixed angle between seal faces will form under the influence of angular excitation, and it has a significant impact on transient behaviors of the dry gas seals.

Key words: high PV value; dry gas seals; hyperelliptic curve groove; dynamic and transient behaviors

1. Introduction

It is well known that spiral groove dry gas seals (S-DGSs) have a superior sealing performance, so S-DGSs have been the first choice of both the manufacturers and the end-users for the shaft-end seal of high-speed turbo compressors [1]. But with the turbo compressors developing toward the extreme operating conditions, the S-DGSs exposed a relatively worse disturbance-resist ability. So it is necessary to take a good knowledge of S-DGSs' running rule and to establish an optimization method of which improves stability and sealing performance. And for in this case, there are many research works, which assume that S-DGSs are operated in steady state conditions, have been done. Such as the parametric study on S-DGSs [2], wear behavior of high pressure S-DGSs' faces [3], the influence of real gas effects on S-DGSs [4], flow dynamics of S-DGSs [5], thermo-hydrodynamic characteristics of S-DGSs [6], leakage reduction performance analysis of S-DGSs [7] and so on. But at the ultra-high speed conditions (mean linear velocity of seal face is more than 100m/s), the research works under steady state conditions are hard to reflect the reality accurately because of the excessive vibration of rotating machines. Therefore, many scholars have studied the dynamic behavior of S-DGSs [8-17] so that the design theory of high parameters S-DGSs have been further enriched.

The above studies have guided the design of high parameters S-DGSs effectively, but in order to enlarge the running reliability of dry gas seals (DGSs), the design of the better seal face grooves have been one of the key factors. Jiang et al [18-20] have applied the bionics to the design of seal face grooves, and have invented many kinds of bionic grooves which have better stability or better sealing performance than spiral groove at tremendous speeds (mean linear velocity of seal face is more than 25m/s). Besides, in the field of gas thrust bearing, Hiromu Hashimoto et al [21-23] provide a new way, which uses spline curve to fit groove-line, to optimize the seal face groove, and the results show that the fitted curve groove thrust bearing can provide a greater load capacity. This paper, which bases on the good coverage property of hyperelliptic curve, puts forward hyperelliptic curve groove dry gas seals (HC-DGSs) and researches their dynamic characteristics and transient sealing performance. It is of great importance for the designing of high parameters DGSs.

*Corresponding author.
E-mail address: xdpeng@zjut.edu.cn, xdpeng@126.com (P. Xudong).