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## 动静压混合式气体密封追随性及主动调控振动特性数值分析

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## Numerical Analysis for the Tracking Property and Active Regulation Vibration Characteristics of Dynamic-hydrostatic Hybrid Gas Seals

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摘要

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**摘要** 动静压混合式气体密封(DHHGS)运行中,静环对动环轴向窜动和角向摆动的跟踪响应(追随性)能够降低外界干扰对密封稳定性造成的影响。将DHHGS简化为弹簧-阻尼-质量系统,基于摄动法求解了DHHGS的动态非线性Reynolds方程,得到了表征密封动态特性的气膜刚度和阻尼系数。研究了两种DHHGS(泵入式和泵出式)在3个方向简谐激励作用下的追随性,并得到了阻封气压力对追随性的影响规律,分析了主动调控时静环的轴向自振稳定性,并给出了轴向自振的临界失稳判据。研究表明:即使激励振幅足够大,DHHGS仍具有良好的追随性;阻封气压力增大,密封的追随性增强;主动调控时,静环自由振动是非往复的衰减运动,密封仍能稳定运转。

**关键词:** 动静压混合式气体密封(DHHGS) 追随性 主动调控 阻封气 动态特性系数 振动

**Abstract:** The stator dynamic response to the axial pulsation and angular wobbling of the rotor (i.e., tracking property) tends to reduce the influence of external disturbances on the seal stability in most practical dynamic-hydrostatic hybrid gas seals (DHHGS). In this paper the DHHGS assembly is converted to an equivalent spring-damper-mass system. The gas film stiffness and damping coefficients for the DHHGS are obtained from the unsteady nonlinear Reynolds equation using the perturbation method. The tracking property of two different end face structures of the DHHGS (pump in and pump out) is analyzed under three directional simple harmonic excitations, and the influence of quench gas pressure on tracking property is investigated. Stability of the free axial vibration of the stator is investigated for active regulation, and critical instability criterion is provided. Results show that the DHHGS still possesses perfect tracking property even if the amplitudes of simple harmonic excitation are large. With the increase of quench gas pressure, the tracking property of the DHHGS is enhanced. For active regulation, the motion of the stator is non-reciprocating attenuation vibration, while the seal remains stable.

**Keywords:** dynamic-hydrostatic hybrid gas seal (DHHGS) tracking property active regulation quench gas dynamic characteristic coefficient vibrations

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