

CFD ANALYSIS OF THE UNSTEADY COMPRESSIBLE FLOW IN AN ORIFICE RESTRICTOR OF A GAS BEARING

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ABSTRACT

Aerostatic journal and thrust bearings are designed with orifice restrictors feeding directly the thin film or very shallow recesses. The correct prediction of the recess pressure is strongly related to the flow through the restrictor and therefore this latter is of paramount importance for the accurate prediction of the static and dynamic characteristics of pressure fed gas bearings. The restrictor is described by the equation of the compressible flow through an orifice. The area used in this equation is the surface of the orifice if the restrictor feeds a deep recess, the curtain area if the compressible lubricant is injected directly into the thin film or a harmonic average of these two for intermediate situations. It was shown that this approximation performs quite well for steady operating conditions. The situation is different for unsteady regimes encountered under dynamic operating conditions because the equation for flow through an orifice contains no temporal variation. This means that the flow would be time independent and the orifice would respond instantly to any pressure variation.

A CFD analysis was performed to verify the validity of the compressible orifice flow equation by considering a realistic geometry of an aerostatic journal bearing (Figure 1). Unsteady operating conditions were simulated by the time variation of the thin film thickness in conjunction with a deforming grid approach. Simulations were performed for excitation frequencies up to 10 kHz. Values in this range can be encountered in small size, high speed rotating machinery.

The results depicted in Figure 2 showed that, the impact of the excitation frequency on the orifice mass flow rate and on the recess pressure becomes significant beyond 1 kHz. Both the amplitude and the phase of the orifice mass flow rate and of the recess pressure are affected by the excitation frequency. The equation of the compressible orifice flow can only partially reproduce the CFD results. The phase of the unsteady orifice mass flow rate predicted by CFD at 10 kHz is larger than the

one predicted by the compressible orifice formula indicating that a pneumatic hammer instability may appear at very high excitation frequencies without it being able to be detected by calculations.

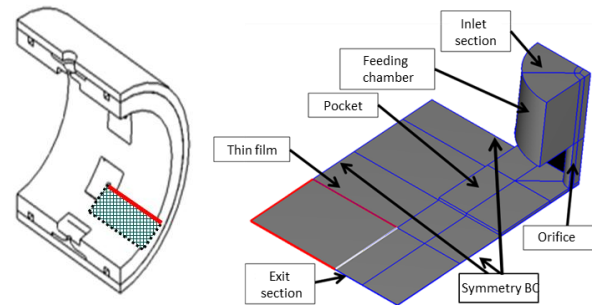


Fig.1 The geometry of the aerostatic journal bearing and the calculation domain

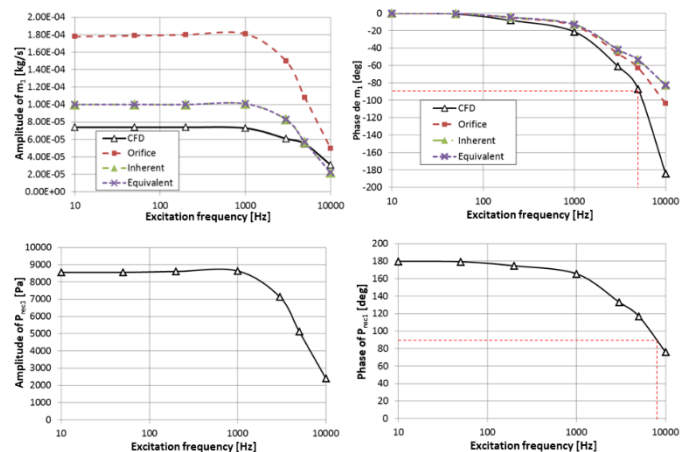


Fig.2 The unsteady orifice mass flow rate (top) and recess pressure (bottom), amplitude (left) and phase (right)

REFERENCES

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