A novel view on cavitating lubricant flow through sintered journal bearings

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1. ENGINEERING MOTIVATION

Sintering processes are an alternative to conventional production techniques as they allow a high level of flexibility in tailoring the physical characteristics of the processed part. In bearing manufacturing, the compaction of the powder metal is controlled in such a way that the finite part is not fully solid, but a porous matrix having certain permeability. During impregnation, the lubricant is stored between the interconnected pores, released in the lubrication gap while in operation (and brought back in the matrix when the bearing is not in use, e.g. due to capillary forces). Through this sequence of processes the bearing operates for a long time without requiring any maintenance or additional impregnation with lubricant. In common industrial applications where replacing used bearings is difficult, sintered bearings offer an advantageous alternative. Concerning the theoretical prediction of the associated lubricant flow, however, the phenomenon of cavitation remains a great challenge.

2. FLOW PROBLEM

A thorough understanding of the flow behaviour in the sinter bearing system demands the establishment of a self-consistent mathematical model. The present study treats the lubrication gap as typical Reynolds thin film flow, whereas the sinter stream of lubricant can be approximated by using the well-known Darcy's law for porous media. We condition the coupled problem by satisfying mass conservation and setting equal the pressures on both sides of the interface between the fully formed lubricant film and the inner boundary of the sinter. Nonlinear effects are introduced by the emergent phenomenon of film rupture, which is expected to occur in the divergent part of the bearing. In this region the otherwise continuous film is replaced by a homogeneous mixture of lubricant and vapour, which under the current assumptions exhibits a compressible behaviour in terms of a variable density, ρ. This quantity inevitably exhibits a jump at the point of recondensation, which ultimately is accentuated with the increasing of the load or, equivalently, as the eccentricity ratio, ε, approaches its upper limiting value, 1; the higher the eccentricity ratio is, the steeper is the transition from the 2-phase mixture to the fully liquid phase (exemplified in the figure below: ρ in a plane between that of symmetry and the edge of the bearing versus the coordinate in circumferential direction of the bearing, θ).

A correct regularisation of this jump is amongst our targets. Another issue regards a threshold for ε above which the numerical solutions apparently fail, rendering the current flow description inadequate. Finally, we address the problem of an analytical expression for the permeability by homogenisation, which agrees with available experimental data.