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Fluid Film Dynamic Coefficients in Mechanical Face Seals[1]

B. S. Nau.[2] The authors have presented a usefully simplified formulation of stiffness and damping coefficients for mechanical seals, the faces of which are allowed to be flat or coned. The main simplifications in the analysis depend on two assumptions:

(*i*) A linearized, small perturbation of displacement.
(*ii*) The absence of cavitation.

An attempt to establish the limitations presented by (i) has been made, the percent errors for a tilt parameter value of 0.3 are presented for a range of coning angles. However, it would by very useful to know the variation in the error with the tilt parameter as well. Can the authors provide this information when their paper is published?

The cavitation assumption is mathematically very convenient but it is arguable to what extent it is physically realistic. For instance, cavitation can affect the system analysed in two ways:

(*i*) Cavitation due to hydrodynamic pressures produced by the relative circumferential rotation of the seal faces, results in the destruction of the antisymmetric nature of hydrodynamic pressure field, which is essential to the present analysis.
(*ii*) Cavitation due to squeeze-film pressures as the seal faces move apart. This is a rate-dependent phenomenon which would be expected to affect damping quite considerably, and possibly the stiffness too. This would be particularly important for a film which diverges in the leakage flow direction.

The authors should be encouraged to explore these effects quantitatively, if only to establish the bounds within which they can safely be ignored.

The authors conclude, among other things, that "flat seal faces do not have any axial stiffness." This can indeed be true under certain conditions, however, there are also conditions where the situation is not so simple. I recall that in a paper published as long ago as 1960 (Nau, B. S. and Turnbull, D. E. Paper D3, 1st Int. Conf. on Fluid Sealing, BHRA) it was pointed out that the use of carbon as one face provided the possibility of self-induced coning. The carbon being a low modulus material can be differentially compressed in a high pressure seal, such that an effectively conical face profile results. This was shown to have inherent stiffness, this stiffness (or spring-rate) was plotted against an "inherent coning" parameter.

It would be interesting if the authors could compare the magnitudes of stiffness due to fixed geometric conicality and the elastohydrostatic conicality, when these are of comparable extent.

[1] I. Green and I. Etsion, published in the April, 1983, issue of the JOURNAL OF LUBRICATION TECHNOLOGY, Vol. 105, No. 2, p. 296.
[2] BHRA Fluid Engineering, Cranfield, Bedford, U.K.

Author's Closure

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Additional information on the percentage error variation with the tilt parameter, ϵ, is given in the table below. Only the optimum coning case is presented since it is the most desired one. Results are given for the errors in $(M_1)_s$, M_2 and $(M_1)_q$ for a typical radius ratio $R_i = 0.8$. The error will increase or decrease with a corresponding change in R_i or β similar to the behavior in Figs. 4 to 6.

ϵ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$(M_1)_s$	0.1	0.5	1.1	1.9	3.0	4.3	5.9	7.7	9.8
M_2	0.3	1.3	2.9	5.1	7.9	11	16	20	26
$(M_1)_q$	0.9	3.8	8.3	14	21	30	38	47	56

Cavitation effects can be fully accounted for in a numerical analysis not limited to small perturbation. It is our feeling, however, that exploring cavitation effect on the overall dynamic behavior rather than on individual dynamic coefficients will be more useful. This is hoped to be done in the near future.

The effect of the coning origin whether it is fixed, elastohydrostatic, thermal or any other source on the dynamic coefficient is null. As long as the coning exists, no matter why, the dynamic coefficients will be the same.