

DISCUSSION

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If an unloaded pad cannot assume a static equilibrium condition, and since its orientation and location are confined within a well-defined envelope, the development of a self-excited motion into a limit cycle type periodic motion seems to be inevitable. The question of whether or not a static equilibrium condition exists is somewhat nebulous. Thus the authors had to resort to the numerical computation of a nonlinear formulation.

The authors took pain to present the equations of motion in the quasi-linear form, equations (7) and (8). Afterwards an analytically derived solution, equations (B3) and (B4), is used to describe the motion instead of the conventional approach of stepping in time numerically. The derived analytical solution is transcendental in form and may assume either a sinusoidal or an exponential character. One may observe, that so long as the conditions of quasi-linearization remain valid, the complete analytical form is applicable for a finite and even long time interval. In this sense, the authors have imbedded a linear analysis into a nonlinear computation procedure.

The assumption of a stationary rotor needs a word of caution. This can be justified on the basis of a relatively large rotor mass in comparison with the inertia parameters of an isolated pad. However, there is the theoretical possibility that the frequency of pad flutter may coincide with the condition of an undamped rotor resonance. In such a circumstance, the rotor motion can contribute significantly to the time-dependent fluid film force.

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Authors' Closure

Drs. Yao and Pan raise three main points which we will respond to in the order given.

To our knowledge, there is no prior treatment in the literature exposing the self-excited vibration phenomenon in unloaded tilting pads. Our treatment shows how it occurs, the influence of various parameters and that the basic phenomenon is a manifestation of the classical rotor bearing instability problem (i.e., Ω/ω occurs between 0.4 and 0.5). To say that this is all inevitable we take as a compliment to the correctness of our computations and to the clarity of our technical writing. However, we fail to see what is nebulous about whether or not a stable static equilibrium position exists.

We also feel that Appendix B of this paper is quite clear to the serious reader. Equations (B3) and (B4) are not analytical solutions for application to large time intervals. These equations are used at each time step of our numerical integration to compute the pad position and velocity at time $(t + \Delta t)$ based on conditions at time (t) , as clearly stated.

Surely, if the rotor has substantial vibration, the statically unloaded pads will exhibit the influence of the rotor motion, as will the loaded pads. The purpose of this investigation was to study pad flutter, apart from whether or not the rotor (journal) has significant vibration. Rotor vibration was therefore assumed to be zero. In spirit, this is no different than studying the general area of rotor-bearing instability without allowing simultaneous inclusion of rotor unbalance. Of all the many papers written on rotor-bearing instability, most ignore rotor unbalance so as not to confuse the basic issue of stability with forced vibration. Specifically concerning the coincidence of pad flutter frequency with an undamped rotor resonance, we fail to see this as an important consideration within the context of this paper.

The authors appreciate this opportunity given by Drs. Yao and Pan to further amplify what is in the paper.