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Stability of fluid film bearings under laminar and turbulent regimes

Linear and non-linear stability of a flexible rotor-bearing system supported on short and long journal bearings is studied for both laminar and turbulent operating conditions. The turbulent pressure distribution and forces are calculated analytically from the modified Reynolds equation based on two turbulent models: Constantinescu's and Ng–Pan–Elrod. Hopf bifurcation theory was utilized to estimate the local stability of periodic solutions near bifurcating operating points. The shaft stiffness was found to play an important role in bifurcating regions on the stable boundaries. It was found that for shafts supported on short journal bearings with shaft stiffness above a critical value, the dangerous subcritical region can be eliminated from a range of operating conditions with high static load. The results presented have been verified by published results in the open literature. Dynamic coefficients of a finite length journal bearing are numerically calculated under laminar and turbulent regimes based on Ng–Pan–Elrod and Constantinescu models. Linear stability charts of a flexible rotor supported on laminar and turbulent journal bearings are found by calculating the threshold speed of instability associated to the start of instable oil whirl phenomenon. Local journal trajectories of the rotor-bearing system were found at different operating conditions solely based on the calculated dynamic coefficients in laminar and turbulent flow. Results show no difference between laminar and turbulent models at low loading while significant change of the size of the stable region was observed by increasing the Reynolds number in turbulent models. Stable margins based on the laminar flow at relatively low Sommerfeld number $S \leq 0.05$ were shown to fall inside the unstable region and hence rendering the laminar stability curves obsolete at high Reynolds numbers. Ng-Pan turbulent model was found to be generally more conservative and hence is recommended for rotor-bearing design.

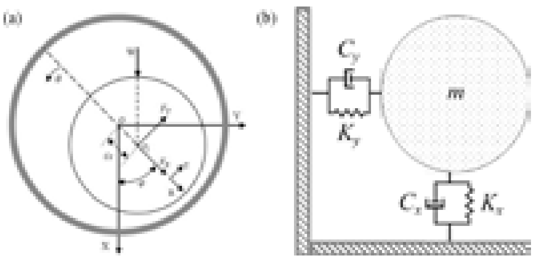

Figure 1: (a) Schematic of a journal bearing, and (b) journal bearings fluid film model using linear stiffness and damping coefficients.

Recent Publications

1. J M Vance, B Murphy, F Zeidan (2010) Machinery Vibration and Rotordynamics. Wiley Online Library. ISBN: 978-0-470-91607-0.
2. Miraskari M, Hemmati F, Jalali M, and Gadala M S (2016) A robust modification to the universal cavitation algorithm in journal bearings. Journal of Tribology, 139 (3): 031703 (17 pages).
3. S Muzakkir, H Hirani, G Thakre (2013) Lubricant for heavily loaded slow-speed journal bearing, Tribol. Trans. 56 (6): 1060–1068.
4. Hemmati F, Miraskari M, Gadala MS (2017) Dynamic analysis of short & long journal bearings in laminar & turbulent regimes critical shaft stiffness determination. Applied Mathematical Modelling. 48:451-475.

Biography

Mohamed Gadala is a Professor Emeritus of Mechanical Engineering at the University of British Columbia in Vancouver, Canada. Also, he is the Chair of Mechanical Engineering Department at Abu Dhabi University in UAE. His current research interests include finite element and numerical simulation of structural & CFD problems; online monitoring of rotating equipment & turbo machinery; inverse heat transfer analysis for cooling on runout table, fracture mechanics and design optimization. He is the recipient of the NSERC University-Industry Synergy award; Patrick Campbell Chair in Design in Mechanical Engineering at UBC for 12 years. He established PACE (Partner for Advancement of CAE Education) lab in UBC with multi million dollars industrial contributions of hardware & software licenses. He has authored & co-authored over 180 refereed papers, 4 book chapters, 4 patents and 4 software manuals. Before joining academia, he has worked in various industries in the US and Canada for more than twelve years and also taught at the University of Michigan-Dearborn.

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