ABSTRACT

Present study brings out some special features of the behaviour of dilute viscoelastic solutions as lubricants in short journal bearings. Experimental studies reveal that at high shear rates, which occur in the journal bearing clearance space, the Weissenberg effect is degraded while the relaxation time remains undiminished. Harnoy proposed a constitutive equation which decouples the Weissenberg effect and relaxation time and it may be used to depict the constitutive relations for lubricants under above mentioned conditions. Harnoy's constitutive relation, continuity equation and equation of equilibrium are used together with a perturbation procedure to find the total film force on the journal. Following Routh-Hurwitz method of analysis of relative instability, a search for stability of a symmetrical horizontal rigid rotor mounted on two identical short bearings is conducted for small rotor vibrations both for Newtonian and viscoelastic lubricants. Exact points of instability at each eccentricity ratio are found by using Bolzana bisection technique for different values of relaxation times. The study reveals that an apparent inertia tensor, arising out of linearized elasto-viscous acceleration dependent forces, has a predominant effect on the stability of such rotors. As the stability map is considerably modified

by the use of viscoelastic lubricants, the high speed instability limits are extended providing an incentive for using this type of lubricants. However, some new instability patches show off which correspond to lower speeds of a rotor. Nature of their instabilities is still to be established. A rotor may, however, be so designed that it never falls inside such patches of instability during its operation and speeding up period.

Next the total forces on the journal developed by the fluid film with enhanced feed pressure is presented. Then the influence of feed pressure and flexibility of rotor on stability maps are studied. Later the effect of rotating unbalance response on elastic rotors is also presented. Stability analysis for rigid rotors with enhanced supply pressure is done following the same procedure as mentioned earlier. It is clear from the stability charts for rigid rotors with pressurized Newtonian lubricants can be regained to the value of unpressurized Newtonian lubricants by using dilute viscoelastic lubricants under pressurized conditions. Results are encouraging at 0.35 to 0.7 eccentricity ratio which is commonly used in large class of industrial rotors. In discussing stability of flexible rotors their vibrations are devided into two parts i.e. small vibrations and large vibrations. Small vibration analysis reveals that flexibility is detrimental to stability of rotor when coupled with viscoelastic effects. From large vibration analysis it may be concluded that like Newtonian lubricants, viscoelastic lubricants also exhibit large whirls at speeds

nearly equal to twice the critical speed and may be at higher speeds. However, these large whirls may occur only if the equilibrium point has already become unstable and viscoelasticity does not solve the problem of large whirls of flexible rotors. From the study of rotating unbalance response of elastic rotors it is revealed that there is not much reduction of disk amplitude with the use of dilute viscoelastic lubricants with different relaxation times, whereas with increase in relaxation time the reduction in journal amplitude at the bearing position increases considerably thereby gaining the advantage in safety of the bearing.

In the second phase the well known linear elastic dumbbell model of polymeric molecule, is modified by introducing extra polarizable internal damping tensors. Two plausible hypotheses for the existence of such tensors are given. A differential constitutive equation, which is objective, is obtained under the assumption of smoothed-out Brownian motion in the light of Giesekus. This constitutive equation which is similar to that proposed by Harnoy is capable of decoupling the relaxation and normal stress effects and describing the viscoelastic behaviour of dilute polymeric solutions under the influence of externally imposed travelling fields and in lubricants at high rates of shear. This part is highly hypothetical and needs further refinements and experimental investigation to create rational rheological models for dilute polymeric solutions as lubricants.

Lastly experiments on stiff and elastic rotors mounted on short bearings using Newtonian and dilute viscoelastic lubricants are conducted and some of the conclusions drawn during theoretical investigation are verified.