ABSTRACT

Two similar and yet diverse problems in the field of contact mechanics have been investigated: (i) study of contact pressure distribution between contacting bodies having arbitrary profiles and (ii) evaluation of elastic shear modulus of lubricants under elastohydrodynamic conditions.

In dealing with the contact pressure distribution a numerical method is developed for calculating the pressure distribution and the shape of the contact area between two elastic bodies of arbitrary profiles which make contact over a slender contact area i.e. where the relative curvature of two profiles is much smaller in the longitudinal direction than in the transverse direction. The pressure distribution is assumed to be piecewise linear in the longitudinal direction and semi-elliptical in the transverse direction. No a priori relationship is assumed between the shape of the contact area and the longitudinal variation in pressure; they are found simultaneously from dual integral equations for the compatibility of (a) the normal displacement and (b) the transverse curvature along the longitudinal axis of the contact zone.

In cases where the profiles of contacting bodies are smooth and continuous, up to, and beyond, the ends of the contact area, the method gives a very reliable measure of the contact pressure distribution. Where discontinuities in profiles are present, at roller ends for example, stress singularities are to be expected and like any other numerical method, only approximate values of the stress concentration can be found. In the cases studied the concentration of pressure associated with a 'sharp' edge of contact
is found to be very local. The method has been applied to both cylindrical and variously 'crowned' rollers, also to a ball 'over-riding' the edge of a closely conforming groove. The shape of the contact area for cylindrical and partially crowned rollers has been experimentally verified by footprint technique and has been found to be satisfactory.

Determination of the fundamental rheological property of lubricants under elastohydrodynamic conditions is limited to the low slip region when the sliding takes place in the direction of rolling. At high contact pressures the fluid in an elastohydrodynamic contact becomes glassy (elastic) and at small sliding speeds shears as an elastic solid. In order to determine the elastic shear modulus of lubricants from the linear slopes of the traction curves, obtained from disc machine traction tests, it is necessary to apply a correction for the compliance of the discs. An integral equation has been developed combining the elastic deformation of discs and the intervening lubricant film and has been numerically solved to determine the correction factors for shear modulus of lubricants at different pressures. The traction tests in low slip region have been carried out in a two disc machine for Santotrac-40 using steel and tungsten carbide discs in line contact and steel discs in point contact at two different speeds. The critical viscosity hypothesis, supported by the well known Maxwell viscoelastic model, has been put forward to predict the critical pressure above which the lubricant behaves like an elastic solid. The extracted shear modulus from traction tests have been corrected by the new method of compliance correction.
This new method of compliance correction is found to give consistent values of modulus under different disc materials, contact conditions and speeds.

For convenience the dissertation is written in five parts. Part I gives the introduction and interaction between two problems as well as their deviation from Hertz theory of contact. In part II and III the details of the work carried out for contact pressure distribution and evaluation of shear modulus of lubricants from disc machine traction tests are respectively discussed. Part IV gives the combined conclusion including the recommendations for further research whereas Part V includes the appendices, references and list of figures etc. As far as possible all the numerical values in the dissertation are given in S.I. Units.