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Tribology is a compulsory final year subject for all students taking a BSc in Mechanical Engineering. Students continuing their study to obtain a further degree can follow another series of lectures. As yet no special courses in tribology for industry have been arranged at this university. A selection of research topics being carried out in the tribology laboratory follow.

ELASTOHYDRODYNAMIC LUBRICATION

The laboratory has two disc machines which are both operational for e.h.l. studies; a four-disc machine for study of the low slip regime and a two-disc machine for the region of high slip. Next to measuring film thickness the machines have also been instrumented to measure friction. Making use of both machines, friction can be measured at any chosen relative slip ratio.

This work has led to a more detailed insight into the mechanism of traction in an e.h.l. film of lubricant and it has been possible to accurately predict the frictional losses in an e.h.l. film provided the slip is is very small. This type of work could ultimately lead to a better understanding of the mechanisms of failure normally occurring for this type of contact (scuffing, pitting).

An interesting side-line which has developed from the work on traction in e.h.l. is the observation of a large effect on traction of the width of the discs used. Under otherwise norminally identical conditions decreasing this width leads to an increased frictional torque between the discs. The cause of this behaviour, which has also been observed by Hewko[1], is now being investigated. If the effect is real it could have an impact on the design of gears, cams, roller bearings, etc.

The two-disc machine has also been used to study traction and slip using a steel disc rolling on a rubber disc. No lubricant is used. The aim is to look into the possibilities of using this type of 'variable transmission' as a feed back element in the process of reeling of textile materials. This study is also supplying information on the general mechanism of rolling of a viscoelastic material on a hard steel surface.

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DESIGN OF FLUID FILM BEARINGS

It is becoming increasingly important that designers should not only be provided with the proper tools enabling them to design a bearing which just works but should pay particular attention to designing for optimum conditions. The procedures leading to such an optimum design should be clear and easy to understand. Therefore, research has been carried out to depict the behaviour of such bearings in the form of design charts. Using these charts it is possible to select the appropriate clearance (in the case of journal bearings) or the appropriate position of the pivot (in the case of Michell bearings) leading to either maximum film thickness or to minimum friction. The charts also enable the designer to solve much more complex optimization problems at a glance[2,3].

Work is now going on to optimize centrally grooved journal bearings and radial Michell bearings respectively. It is also possible to select the design parameters leading to maximum stiffness for these types of bearings. This criterion is often of overriding importance for the design of radial Michell bearings for turbomachinery.

As a result of this work some interesting regions of unstable behaviour have already been predicted for radial Michell pads which were hitherto unknown. The effect of elastic distortion of the bearing elements on film thickness, traction and stiffness can also be taken into account.

All of this work is based on the results of computer solutions. However experimental comparison with the predicted results using a four-bearing rig is in progress.

DYNAMICALLY LOADED BEARINGS

Some years ago Booker and Blok proposed a new method to solve the problem of predicting the movement of a journal in a bush if the bearing formed by these two elements is subjected to a dynamic load cycle. This method is used extensively in industry nowadays. It can be applied either numerically or graphically.

This work has now been extended to also cover the case of Michell pads as used in thrust bearings. The method is slightly more difficult than for journal bearings because there is one more degree of freedom. Our aim is to continue this work and to extend the method to radial Michell bearings and to centrally grooved journal bearings. The ultimate goal of this work is to enable the choide of optimum conditions for these dynamically loaded bearings, similar to the methods already presented for steadily loaded bearings[2,3].

This work is accompanied by experiments using a 'squeeze film apparatus', and will be extended to rotor stability problems.

GAS BEARINGS

Different gas bearing computer programmes, based on direct methods, are being tested. The aim is to cut down the enormous amount of computing time which is normally needed to predict the behaviour of self acting gas bearings by introducing a more efficient calculating method. Several types of gas bearings are being investigated using these programmes. grammes.

FINAL COMMENTS

Not all topics of current research could be discussed in this review. Other topics include a hydrosphere bearing, a method to obtain the optimum number and form of dimension less groups to describe any physical model, the development of a small centrifuge for high values of g (up to 200 000), the study of plastic bearings with respect to wear and friction, and work on an entirely hydrostatically supported piston.

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FRETTING CORROSION

In this report fretting corrosion not only covers oxidation reaction under mechanical treatment, but also the change of lattice structure caused by friction, and even chemical reactions between the bulk material, the lubricants and other substances in the environment. In tests carried out with unlubricated annular specimens moving in alternating rotation with very small amplitude, the wear can be taken as a measure of the influence of test parameters. Test results obtained using lubricants were not conclusive. The process of fretting corrosion in the presence of a lubricant is even more complex and also time-dependent. Steady-state conditions during a test run take a long time or sometimes never happen.

The effect of a lubricant on fretting corrosion is difficult to determine if the evaluation is based on weight loss of the specimens. To avoid this difficulty the consumed mechanical energy, measured continuously in the form of slip and friction force, was chosen as a rating standard. The energy consumption varies during a test in a characteristic manner for each lubricant.

E. p. additives need as much energy during the starting period of a test run as if there were no lubricant available, but the amount of energy consumed decreases during the test.

However, solid lubricants, used in powder form, start with a low friction energy, but lose their lubricating properties during the friction process. A combination of these two additive types gives optimum results. The surface conditions at the beginning of a test have a decreasing influence if no lubricant is present, but they must be taken into account at lubricated surfaces. Liquid lubricants are more effective on rough surfaces, while solid lubricants behave better on smooth surfaces.

The behaviour of polymer sheets in reducing fretting corrosion has been investigated. Although the results were encouraging their use in practice is limited because of their low pressure yield limit, their deformation under load and the difficulty of fastening them to surfaces. An attempt to establish an energy balance for the fretting corrosion process of polymer sheet failed because of the difficulty in evaluating the numerous factors influencing the energy consumption.

NON-NEWTONIAN LUBRICANTS

The performance of non-Newtonian, in particular structure-viscous (with increasing shear rate the viscosity decreases) lubricating liquids in journal bearings has been examined. To find out the load-carrying capacity of the bearings lubricated by these oils, temperature, oil consumption, friction and eccentricity were measured. It was found that the 'mean effective viscosity', related to the temperature in the clearance and to the shear rate, was very important. The effect of pressure on viscosity was not taken into account. If Newtonian and non-Newtonian oils are compared, a valid basis must be found. Two types of oil were investigated by theory and experiment:

1 Quasi-equivalent oils: straight-viscous and structure-viscous oils which have the same viscosity measured in a standard viscometer
2 Equivalent oils: straight-viscous and structure-viscous oils which have the same effective viscosity within the clearance of the bearing

The effective viscosity of a structure-viscous quasi-equivalent oil in a clearance is lower than for a straight-viscous quasi-equivalent oil because of the increased shear rate. This reduces the bearing friction. At the same time the oil flow rate increases and lowers the oil temperature and the bearing temperature, but because the eccentricity increases, the load carrying capacity diminishes.

Equivalent oils have the same eccentricity and the load-carrying capacity. Temperature, oil flow rate