INVESTIGATION OF ASPERITY LEVEL CONFORMITY IN EHD LUBRICATION

by

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CERTIFICATE

This is to certify that the thesis entitled, "INVESTIGATION OF APERITY LEVEL CONFORMITY IN EHD LUBRICATION" being submitted by Mr. Mange Ram to the Indian Institute of Technology, Delhi for the award of degree of 'Doctor of Philosophy' is a record of the bonafide research work carried out by him. Mr Mange Ram has worked under my guidance for the submission of this thesis which to my knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted in part or full to any other university or institution for the award of any degree or diploma.

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ABSTRACT

Elastohydrodynamic (EHD) lubrication is now a well understood regime and the available theory can be used with confidence. The established theory mainly governs the situations where there is no asperity contact. The situation where asperity contact occurs through EHD films, is yet poorly understood. The tribological problems of wear, fatigue and scuffing are governed by the extent of asperity contact and hence this area is of practical relevance. Traditionally, contact through films has been modeled assuming random contact and taking into account the ratio of film thickness to r.m.s roughness. Such an approach is valid where contact occurs at the high spots. In some tribological situations the wear process can generate matching at asperity level. In such situations the assessment of the contact is different than that of a random contact. The present investigation is concerned with the generation of such conformity and its influence on EHD lubrication.

An experimental evidence of conformity has been provided. Experiments were conducted in a disc machine operated under high slide/roll ratios using Cast Iron and Aluminium disc pairs. Two different lubricants were used in the study. Examination of surface profiles formed the basis to evaluate conformity. Investigation of friction, wear and temperature during these experiments indicated that matching

at asperity level improves the lubrication. Experiments were also conducted in FZG gear rig with an EP lubricant and asperity level conformity was observed under the experimental conditions employed , indicating that such conformity can occur in real situations also.

Characterization of conformity was also attempted. In this, various surface roughness parameters were examined for characterization of conformity and it is concluded that such parameters are inadequate, as they are also based on statistical analysis of random surfaces. An approach based on cross-correlation analysis of the contacting surface profiles was developed. The cross-correlation coefficients were calculated between the contacting profiles. The disposition of the surfaces that correspond to the maximum cross-correlation is considered to be the contact situation. With this matched condition as reference, composite roughness profile is obtained on the basis of point to point difference in heights and then the profile generated by computer. This composite profile formed the basis of further analysis. Limited examination of two extreme cases, one of a good matching and another of a fresh surface, by power spectral density function was also done. It is considered that perhaps the Fourier analysis of the surface profiles can be a good approach for evaluation of asperity level conformity.

Additional experimental work was done to study the influence of roughness on lubrication in light of surface conformity. It is shown that the contact severity is a function of the ratio of film thickness and rms value of the composite profile generated on the basis of cross-correlation in case of conformity. A substantial difference is brought out if the roughness is characterized on the basis of random contact in case of conformity. Such verification for high slide/roll ratios was approximate. Hence experiments were also conducted with the conforming surfaces at low slide/roll ratios and this provided better verification as film thickness calculations in such cases are more reliable. Another aspect that needed consideration was the possibility that roughness itself can modify the film thickness. With the available information in the literature, these implications are also discussed.

The thesis concludes with the observation that in partial EHD lubrication asperity level conformity is beneficial. It is suggested that the conformity may be a more general phenomenon and the studies on thin film lubrication should include this aspect for better appreciation of lubrication mechanism and failure in this regime of lubrication.

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