STABILITY OF BOUNDARY FILM ON METALS AND METAL OXIDES IN PISTON RING-LINER LUBRICATION

by

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CERTIFICATE

This is to certify that the thesis entitled, "Stability of Boundary Film on Metals and Metal Oxides in Piston Ring-Liner Lubrication" being submitted by Narinder Kumar to the Indian Institute of Technology, Delhi, for the award of 'Doctor of Philosophy' is a record of bonafide research work carried out by him. Narinder Kumar has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to our knowledge, has reached the required standard.

The results obtained in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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(NARINDER KUMAR)

ABSTRACT

The theoretical and experimental investigation of the stability of boundary lubricant film on metal oxides (e.g. iron oxide, chromium oxide, aluminium oxide, copper oxide) in terms of frictional behaviour and transition temperature have been conducted. With a view to have a better understanding of the mechanism of stability, metals such as cast iron, aluminium, chromium, copper and nickel have also been studied. Experimental investigations have been carried out keeping in mind the application to reciprocating machinery like internal combustion engines. The results reported have been obtained on a newly developed test rig which is essentially a high speed, high frequency, short stroke machine simulating the actual piston ring - liner contact conditions.

A theoretical model based on the vibrations of adsorbed lubricant molecules normal to the surface has been proposed. This model predicts transition temperature and heat of adsorption of boundary lubricant molecules on metals and metal oxide surfaces reasonably well.

From friction traces till transition for various metals as well as their oxides for different

lubricants and additive concentrations, heat of adsorption and transition temperatures have been obtained. The transition temperatures for metals obtained in the present study are in general higher, as compared to the reported values due to difference in the specimen geometry and the contact conditions. Transition temperature appears to be better criterion than heat of adsorption to decide the stability of boundary film. It has been found that presence of metallic oxide film alters the stability of boundary film. Thermodynamic Gibbs free energy concept valid for metals, has been found to be applicable to the metallic oxide surfaces as well.

From the present study the general view that oxides forming protective layer should give low friction and are always better under boundary lubricated conditions is not found to be true. Stronger the adsorption on metal or metal oxide the more would be stability. Cast iron and chromium are better compared to their oxides from the point of view of stability as the transition temperatures are found to be very high for them. The behaviour of copper and its oxide is dependent on the lubricant. With hexadecylamine copper shows better stability, but

with stearic acid copper oxide shows higher transition temperature and higher heat of adsorption. Pure aluminium does not appear to be suitable as liner material because of its stick-slip frictional behaviour and lower stability.

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