ON THE OCCURRENCE OF NEGATIVE GROOVE FLOW RATE IN TWIN GROOVE HYDRODYNAMIC JOURNAL BEARINGS

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ABSTRACT

This paper describes the phenomenon of negative flow rate (hot oil reflux) occurring in one of the grooves of twin axial groove hydrodynamic journal bearings. This rarely described phenomenon, which can occur under severe operating conditions, increases the risk of bearing seizure. Existing codes for predicting bearing behaviour do not seem to be suitably incorporating this phenomenon into the analysis. The present work reports some experimental observations of the phenomenon and the way it can be taken into account in theoretical modelling.

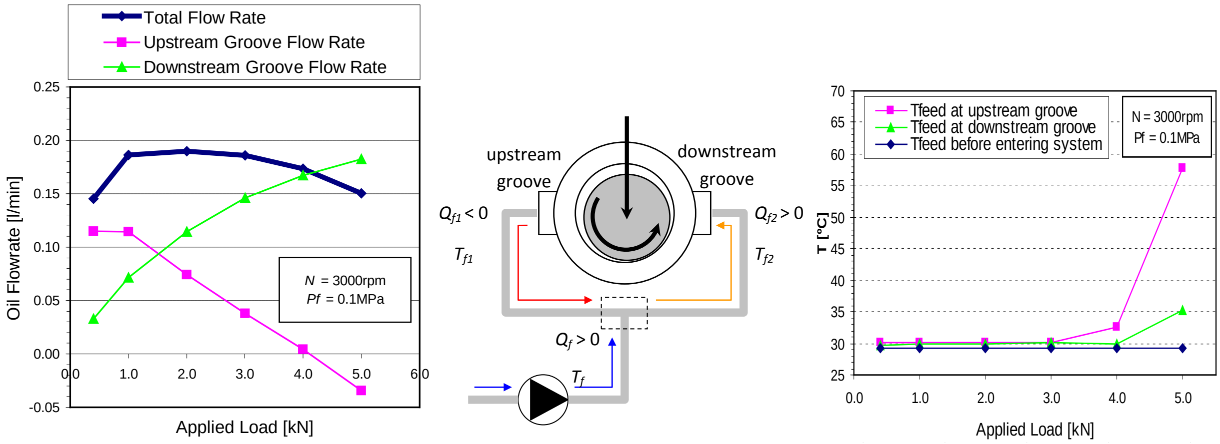
INTRODUCTION

Frequently, the lubricant supplied to hydrodynamic journal bearings is fed at a prescribed pressure through two diametrically opposed axial grooves located at ±90º to the load line. Under certain combinations of speed and load the hydrodynamic pressure building up in the vicinity of a groove might be sufficiently strong to reverse the direction of the flux of lubricant that was feeding the bearing (Brito et al, 2011). Under these conditions, a portion of the lubricant flowing along the bearing gap will flow out of the bearing through the groove, which means that the lubricant flow rate at that groove will be negative.

As far as the authors know, this phenomenon has never been studied in research literature, although some works vaguely refer to this issue (Basri and Neal, 1990). Moreover, it is not normally detected in industrial applications because only total flow rate is monitored, at best. Most models for the prediction of bearing behaviour also fail to predict this phenomenon due to the over-simplified way under which the lubricant feed conditions are treated. In the present work, a series of experiments in which the flow rate has been recorded at each groove is analyzed. In addition, several novel theoretical procedures which allow the incorporation of this phenomenon into the thermohydrodynamic analysis of the bearing are proposed.

RESULTS AND CONCLUSIONS

Results concerning total lubricant flow rate as well as flow rate through each groove are presented in Fig. 1a) for varying applied load. It may be seen that for loads in excess of 4kN the flow rate at the upstream groove (the groove located upstream of the active land of the bearing, as depicted in Fig. 1b) was negligible or even negative. A curious phenomenon occurred under these conditions, observed in Fig. 1c) which depicts the global feeding temperature and the temperature of the lubricant at the entry of each groove: For the 5kN test, the reflux of lubricant out of the bearing through the upstream groove (with a temperature, T_f, around 58ºC) mixed with the fresh lubricant (T_f = 30ºC) at the junction of the pipes serving each groove, and was fed to the opposite groove with a higher resulting T_f (35ºC). These phenomena were accompanied by a dangerous rise of the bearing eccentricity.



(a) (b) (c)

Fig.1 (a) Total and partial lubricant flow rates in each groove as a function of applied load; (b) outline of the bearing; (c) lubricant feeding temperature in main lubricant supply pipe (upstream of the bearing system) and temperatures at the pipes serving each groove. diam. 50mm ; length/diam=0.5 ; diametral clearance at 20ºC: 54µm; Lubricant: ISO VG32.

The aforementioned phenomena can be incorporated into a bearing performance prediction tool if the net feeding flow rate at each groove is estimated through a rigorous mass balance across the borders of the groove regions. The flow rates crossing each border will be a function of the local pressure gradients. If the resulting groove flow rate in both grooves is positive, then T_f in both grooves will be equal to the nominal T_f. However, if negative flow rate occurs in one of the grooves, the temperature of this lubricant flowing out of the bearing will correspond to that of the inner groove temperature, while the temperature of the oil reaching the opposite groove will result from the mixing between the oil reflux and the fresh oil, easily obtained through an energy balance involving the relevant flow rates and temperatures.

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