Thermal modeling of a grease lubricated thrust ball bearing

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1. Abstract

Grease lubricated rolling element bearings are widely used in several applications. Most of the time they allow low friction, a large lifetime at low cost, and an easily grease retention. Their lifetime hardly depends on the grease temperature [1] which acts on the lubricant rheology and has also a large influence on how grease bleeds oil [2]. Therefore to have a good estimation of bearing's lifetime, an accurate prediction of internal temperature distribution is required.

A literature survey indicates that thermal model for greased bearings, doesn't exist. In case of oil lubrication, some studies [3-4] showed that it is possible to elaborate bearings thermo-mechanical model. In case of grease lubricated bearings, some additional questions about the lubricant reparation can be issued. In the first's moment of use, grease, which is initially between balls and on the raceway, is pushed away and ejected on the sides. During operation grease can have two different behaviors:

– On the one hand, grease can be stuck on bearing rings and constitute lanyard directly next the raceways.

– On the other hand, grease can move and travel between the two rings and create some additional convection between them.

The aim of this study is to investigate the influence of the above-mentioned assumptions on the thermal behaviour of grease lubricated bearing. The system under consideration in this study is a clutch thrust bearing and more precisely a sealed single row angular contact ball bearing. In order to investigate on the influence of grease surmise, two models have been developed using the thermal network method one for each hypothesis.

In order to simulate the temperature distribution in a clutch thrust ball bearing, the thermal network method has been used [5], which consists in dividing the system into isothermal elements connected by thermal resistances. The studied bearing has been divided in 13 elements. The thermal resistance value depends on the heat transfer mechanism, i.e., conduction, free or forced convection and radiation. This thermal model is coupled to heat sources determination. The following power losses have been taken into account: dissipation at ball-race contacts, lubricant shearing between the balls and cage pockets, seal's friction.

A number of temperature measurements have been carried out on a given thrust ball bearing thanks to the NTN-SNR facility. Comparisons between calculations and experimental findings show that the thermal network method gives an accurate prediction of temperature distribution, whatever the assumption is made concerning the grease repartition. It is demonstrated that the grease influence on heat flow inside the thrust ball bearing is limited: heat is mainly exchanged by conduction between balls and raceways.

2. References

[1] Cann P. M. and Lubrecht A. A., "An analysis of the mechanisms of grease lubrication in rolling element bearings," Lubrication Science, 11, 3, 1999, 227–245.
[2] Cann P. M.," Grease lubrication of rolling element bearings — role of the grease thickener," Lubrication Science, 19, 3, 2007, 183–196.
[3] Harris, T. A., "Rolling bearing analysis," 3th ed. Wiley Interscience, 1990
[4] Pouly F., "Modélisation thermo mécanique d'un roulement à billes grande vitesse," Thesis, INSA Lyon, 2010
[5] Changenet C., Oviedo-Marlot X., Velex P., "Power loss predictions in geared transmissions using thermal networks applications to a six speed manual gear box," Journal of Mechanical Design, Transaction of the ASME, 126, 2006, 618 - 625.