Estimation of Oil Quantity in Porous Bearing

Hajime kohno[1,a]

[1] Mitsubishi Materials Corporation,central resuerch institute
1002-14 Mukohyama,Naka-shi,Ibaraki-ken,311-0102, Japan
[a]h-kohno@mmc.co.jp

Abstract

Porous bearings are lubricated the oil that is contained in porous metal. Then they are always used with no oil supply, because of that, widly used electric motors. But, if oil flow out less than the limit, troubles often happen. This report shows that attmpt of estimating oil quantity in porous bearing by using calculation that based Reynols' equation and Darcy's law, aimed of developing long life bearing. And comparing with experimental and calculation result, we show possibility of estimating rest oil quantity in porous bearing at steadry state by calculation.

Keywords : bearing, porous, oil quantity, oil pressure

1. Introduction

Porous bearings are composed of porous sintered materials made from powder metal and lubricant oil in the pores. Because of lubrication by oil pumping from the pores, the porous bearings are always used without oil supply, and widely used in electric motors.

Pores in a new porous bearing is filled with oil, and at beginning, the excess oil is flow out from bearing clearance and pores on surface, and the oil is blow out by axis rotation or droped out form housing. After that, oil in the bearing is reduced slowly by evaporation. When oil are reduced below about 75% of initial quantity, troubles often happen.

There are many studies[1),2)] about porous bearing, some of them deal about oil pressure, but oil quantity always deal from experimental data. Then, we attempt to estimate oil quantity in the bearing by calculation.

At this study, we attempt to estimate oil quantity in porous bearing with some assumptions. In porous metal, oil flow by oil pressure, and at bearing surface, oil is absorbed by capillary force. Then we made calculation model that approximated capillary force as boundary conditions on metal surface, and this model is assumed that capillary force is in proportion to air/oil ratio in the pores. And on the metal surface at low pressure that is below the capillary force, oil is absorbed. Pressure distribution is calculated using Reynolds' equation on sliding surface and Darcy's law in porous metal. We report that calculation and experimental results, and show that our model are effective in estimation of oil quantity in porous bearing.

2. Calculation Method

At first, oil pressure is calculated with simultaneous equations Reynolds' equation and Darcy's law[2)]. Reynolds' equation is used to get oil pressure on bearing surface. And Darcy's law is apllied to obtain oil pressure in porous metal. Then pressure on bearing clearance and bearing surface are determined from surface tension of oil in pores and capillary force, as boundary conditions. And then, those boundary conditions are show below and Fig.1.

$$\begin{cases} p_{surf} = p_{st}(p_{pore} > p_{st}) \\ p_{surf} = p_{pore}(p_{cf} < p_{pore} < p_{st}) \\ p_{surf} = p_{cf}(p_{pore} < p_{cf}) \end{cases} \quad (1)$$

(P*surf*: pressure on bearing surface, P*st*: surface tension, P*pore*: pressure in pore, P*cf*: capirary force)

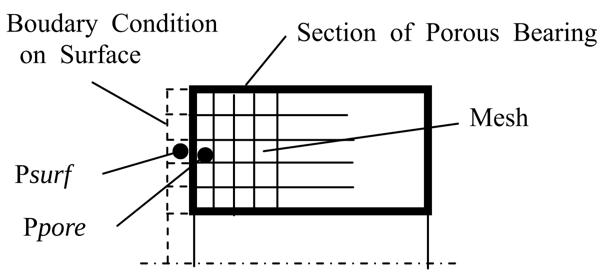

Fig. 1. Boudary conditions for calculation

According to estimate oil quantity in bearing, we assumed that capirary force is in proportion to air/oil ratio in the pores.

$$p_{cf} = p_{cf0} \times R_{air/oil} \quad (2)$$

(P*cf0*: capirary force on oil empty bearing, R*air/oil*: air/oil ratio in pores)

As air in pores is increased, capirariy force is increased. We can find the condition that flow out oil and absorbed oil are blanced by changing R*air/oil*. And obtained R*air/oil* is equal to rest/initial oil quantity ratio.

And, we assume that when oil pressure is greater than surface tension, oil flow out from bearing surface, and smaller than capillary force, oil is absorbed near the surface. But, bearing surface is not covered with oil, some place is touch the air. And we determine absorption coefficient by experiment.

3. Experimental and Calculation result

Fig.2 is shown observation of flow out oil on bearing surface and oil pressure distribution on bearing surface by calculation. This calculation result is corresponded with observation on oil flow out aria. This is indicated that oil pressure calculation is certain.

We measured oil quantity in porous bearing and friction coefficient. At first, a new bearing is prepared, the dimensions are outer diameter is 18mm, inner diameter is 8mm, width is 8mm, and porous metal is made by Cu-Fe powder. Secondary, this bearing is put in the housing, and motor axis is inserted the bearing hole. And, start the motor and measure friction force and the bearing weight, at two hours period. Finally, oil in bearing quantity is obtained at each time. The rest oil quantity per at initial time and friction coefficient show Fig.3. It shows that time is gone, gradually reduced to constant value.

Then, we fitted absorption coefficient form experimental data at low load (about 3N), and calculate oil quantity with changing load. Fig.4 shows experimental and calculation result of rest/initial oil quantity dependence of load. This calculation result is corresponded with experimental data qualitatively.

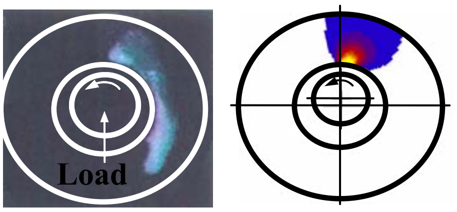

Fig. 2. Observation of Flow out oil and oil pressure calculation on bearing.

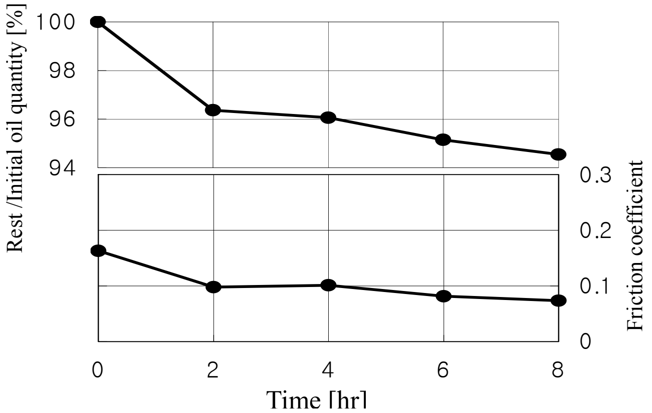

Fig. 3. Result of rest oil and friction coefficient

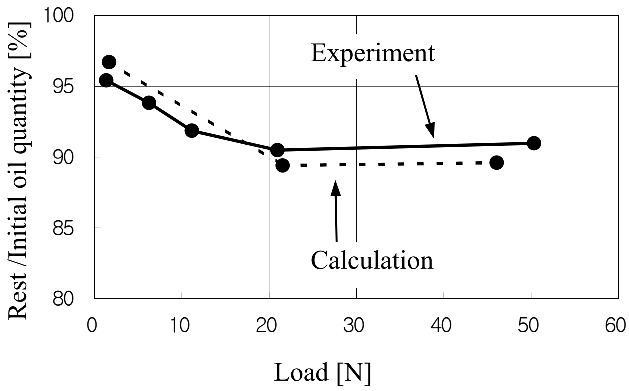

Fig. 4.Experimental and calculation results of rest/initial oil quantity.

4. Summary

We attempted to estimate oil quantity in porous bearing, and assumed oil flow by oil pressure and oil absorption by capillary force. At this case, calculation results are corresponded with experimental data qualitatively.

5. Reference

1. V.T.Morgan and A.Cameron: Proc. Conf. on Lubrication and Wear, London, (1957) 151.
2. V.T.Morgan: Conf. on Lubrication and Wear, Inst. of Mech. Eng., Londn,(1957) 405.
3. S.kaneko and Y.Ohkawa: Transactions of the Japan Society of Mechanical Engineering,series C, vol. 58, No.554(1992)188-194