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THERMAL FRICTION TORQUE CHARACTERISTICS OF STAINLESS BALL BEARINGS

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Stainless steel ball bearings are used in the control element drive mechanism and driving mechanisms such as step motor and gear boxes for the integral nuclear reactor, SMART. The bearings operate in pressurized pure water (primary coolant) at high temperature and should be lubricated with only this water because it is impossible to supply greases or any additional lubricant since the whole nuclear rector system should be perfectly sealed and the coolant cannot contain ingredients for bearing lubrication. Temperature of water changes from room temperature to about 120 degree Celsius and pressure rises up to 15MPa in the nuclear reactor. It can be anticipated that the frictional characteristics of the ball bearings changes according to the operating conditions, however little data are available in the literature. It is found that friction coefficient of 440C stainless steel itself does not change sharply according to temperature variation from the former research, and the friction coefficient is about 0.45 at low speed range. In this research frictional characteristics of the assembled ball bearings are investigated. A special tribometer is used to simulate the axial loading and the bearing operating conditions, temperature and pressure in the driving mechanism in the nuclear reactor. Highly purified water is used as lubricant, and the water is heated up to 120 degree Celsius and pressurized to 15MPa. Friction force is monitored by the torque transducer.

Keywords : Ball Bearing, Friction Torque, Rotational Tribometer, Water Lubricated

1. INTRODUCTION

Generally stainless steel bearings are resistant to water, water vapor, alkaline solutions, photographic developers, and acids. Especially 440C stainless steel can be used in radiation or vacuum environment because of low emission gas. So this steel can be considered to be used in the new type nuclear reactor as a support bearing material. In the nuclear reactor bearings may be lubricated with high temperature and highly pressurized water, and then viscosity of lubricant goes down to very low level just about 10 times of air. Lubrication condition becomes severe and friction force would be increased, and finally the load capacity of the bearing is drastically reduced. The frictional characteristics of the stainless steel may be affected by operating temperature, however information of frictional characteristics according to temperature variation is not sufficient to refer for estimating the system friction force or torque. Many researches focused on the surface coating effect or the effect of low viscosity of oil or solid lubricant with composite or ceramic materials[1-4]. Some studies considered water-lubricated effects with other materials[5].

In this paper, frictional torque characteristics of 440C stainless steel ball bearing at high temperature is studied with a special tribometer on the basis of the research result with stainless steel itself[6]. The photograph of the tribometer is shown in Figure 1. The tribometer consists of the water chemistry panel and electrical control panel (A), the autoclave (B) and rotational tribometer(C). Temperature can be elevated up to 350 and pressure applied up to 17MPa adjustably. It has two types of tribometer, one is for rotational bearings (Figure 2) and the other is for evaluation of friction force of materials themselves with reciprocating motion[6]. The test results with the rotational tribometer are introduced and analysed.

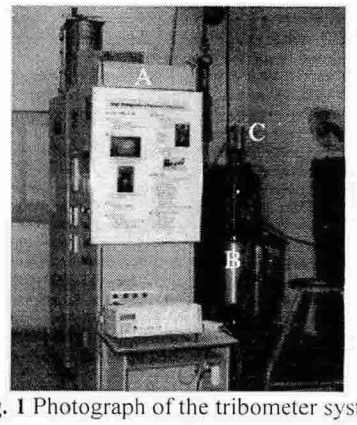

Fig. 1 Photograph of the tribometer system

2. TEST METHOD

For the rotational test, 6208 stainless steel ball bearings made by FAG are used (Figure 3). The specially machined plastic retainers are made by the Research center of FAG Hanwha bearing Co., and installed instead of the general steel retainer. Bearing installation layout and loading method are shown in Figure 4. The bearing specification and test condition are as below.

Bearing dimension : 40 x 80 x 18mm (ID x OD x Width)
Thrust load : 10kg (by the 4 coil springs)
Rotational speed : 500rpm

Lubricant : Pure water (chemically controlled)
Pressure : 15MPa

Light thrust load is applied to define thermal characteristic of the material itself. Heavy loading tests will be performed.

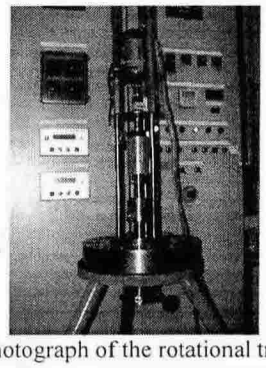

Fig. 2 Photograph of the rotational tribometer

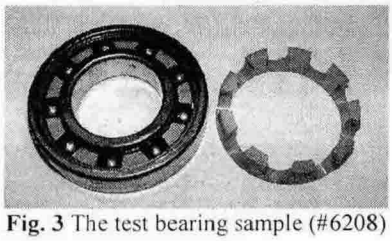

Fig. 3 The test bearing sample (#6208)

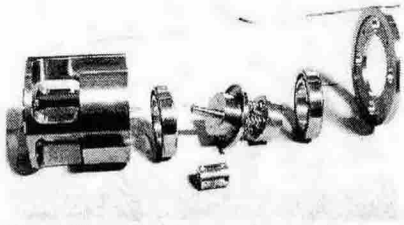

Fig. 4 Thrust loading method and layout

3. TEST RESULTS

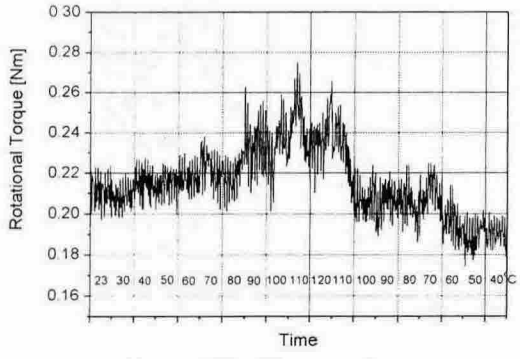

Figure 5 The 1st test results

Figure 5 and 6 show the friction torque data from the torque transducer and the data acquisition equipment (T20WN/2NM and MGCplus by HBM). The figures along the x-axis mean operating temperature. The test started at room temperature and water heated to 120 , and finally cooled. There is the system inherent torque, so the value must be subtracted from the measured results. It is confirmed that this inherent system torque is not affected by operating temperature, rotational speed and system pressure, and the value is 0.13Nm

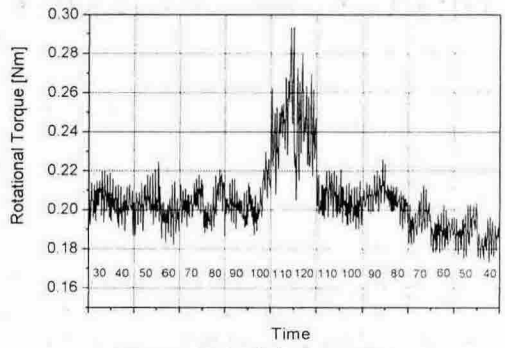

Figure 6 The 2nd test results

Frictional torque variation according to temperature is small and the range about from 0.07 to 0.11Nm. The trend of thermal friction characteristic is same as the result of the 440C stainless steel itself[7]

4. CONCLUSION

1. Water-lubricated bearing friction torque change according to temperature is not severely variable as the thermal characteristics of the 440C stainless steel.

2. Water-lubricated friction force at the contact of the ball to the raceway and the ball to the retainer is much greater than that with general lubrication method. So the new-type retainer would be designed for the bearings to operate properly at heavy loading. This research result will be reported.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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