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On the Temperature Difference between Inner and Outer Races of Rolling Bearings

By

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1. Introduction

The temperature difference between inner and outer races of rolling bearings is an important factor having a close connection with their slacknesses and it brings about a fundamental influence on designing of rolling bearings themselves. The value of it is generally accepted to be about 5°C higher in inner race than in outer race as shown by SKF[1], however, it needs yet to be clarified.

Therefore, the authors investigated its value experimentally on the several typical kinds of rolling bearings with rotating inner race under usual conditions by means of our own method and device. In this paper the experimental method applied is explained and the results obtained are reported.

2. Experimental Method

Fig. 1 shows the skeleton of our experimental method. The test bearing is fitted on the arbor of bearing testor and is loaded through its housing. The temperature of the stationary outer race is easily measured by the thermo-couple and the galvanometer as shown in this figure. As for the rotating inner race, the thermo-couple is separated to two parts which are connected at the points A and B in Fig. 1 with wires, slip-rings and brushes made of the same bronze material. By means of these special and simple connection, the temperature of the inner race can be measured as well as that of the outer race. But it is necessary to maintain the point A in room temperature (in Fig. 1, a cooling fin is used), and also to make the electric resistance of slip-ring system negligibly small (in the same figure, the large resistance of 50kΩ is used).

The testing conditions are as follows:

Test Bearings (Fig. 2)

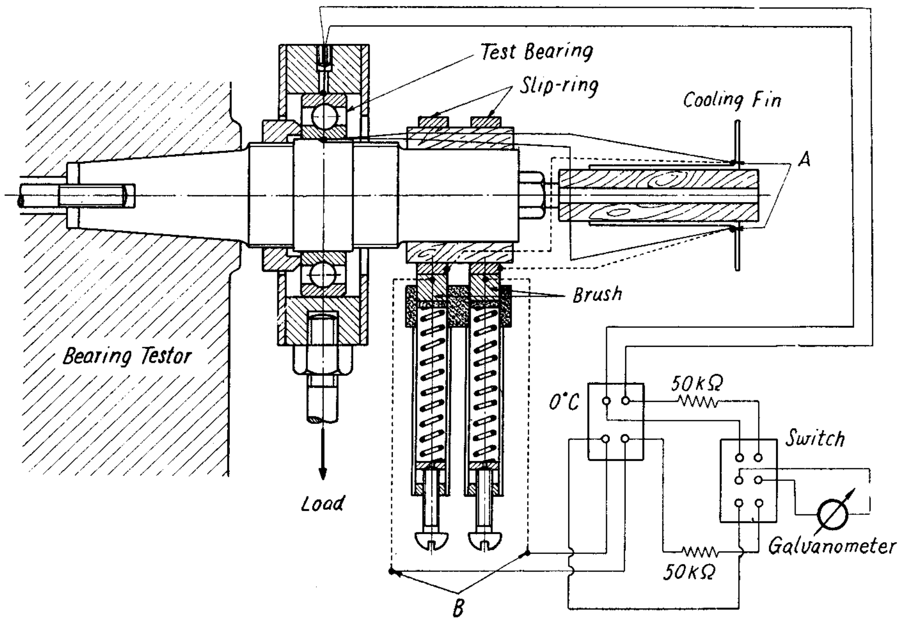

Fig. 1

Table 1

Test Bearing	Inner Diameter of Inner Race	Outer Diameter of Outer Race
	mm	mm
# 6212 (with P.C.)	60 − 0.003	110 − 0.011
# 6212 (with S.C.)	60 − 0.003	110 − 0.014
# 1212	60 − 0.001	110 − 0.015
# N212	60 − 0.001	110 − 0.014

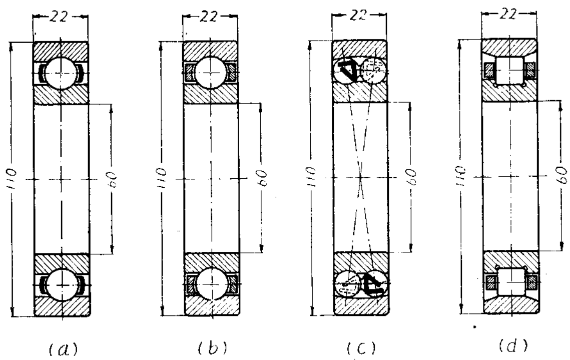

Fig. 2

(a) Single-Row, Deep-Grooved Ball Bearing # 6212 (with Pressed Cage)

(b) „ „ „ „ # 6212 (with Solid Cage)

(c) Double-Row, Self-Aligning Ball Bearing # 1212

(d) Single-Row, Cylindrical Roller Bearing # N212

Loads 215, 400, 615, 815 kg

Speeds 500, 1000, 1800, 2500, 3600 r. p. m.

Lubricants Grease, Spindle Oil, Mobiloil

The values of measurement of the inner and outer diameters of test bearings are as shown in Table 1, and the measured values of corresponding diameters of arbor

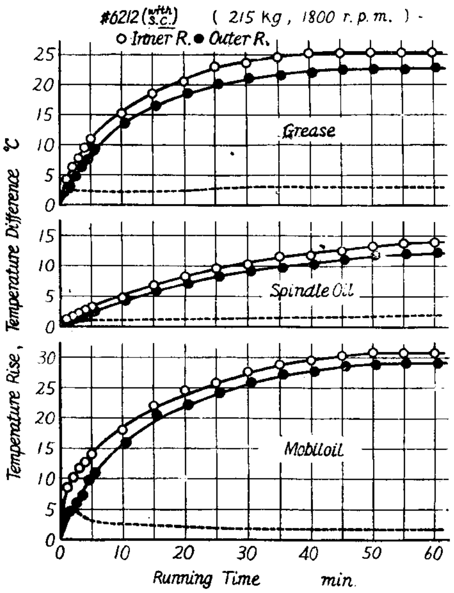

Fig. 3

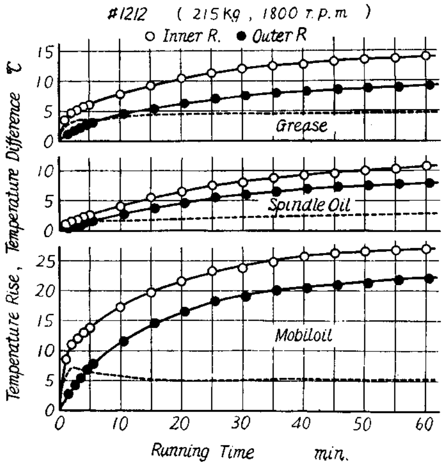

Fig. 5

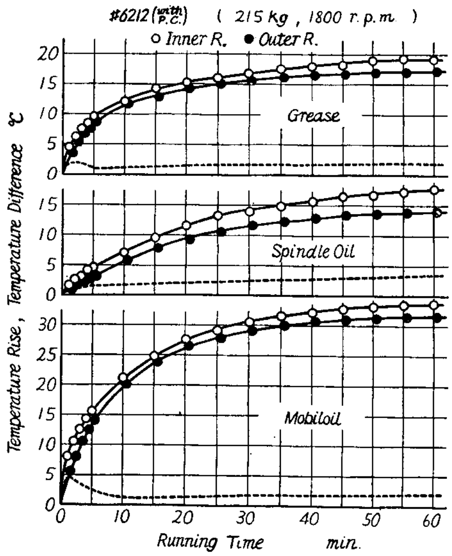

Fig. 4

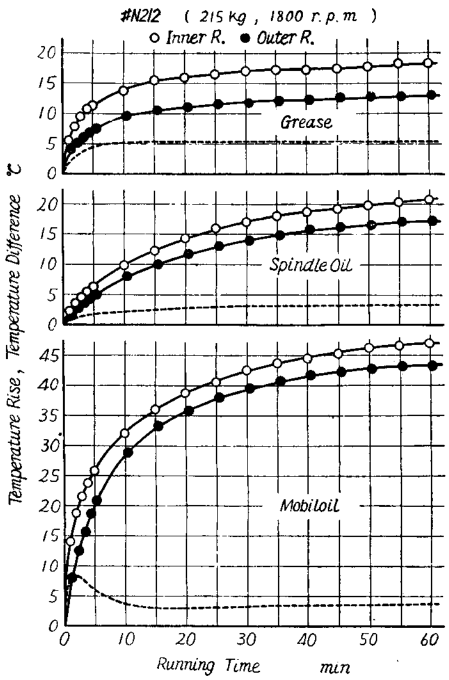

Fig. 6

and housing are shown in Table 2. As it is clear from these tables, the conditions of fitness of bearing are found to be nearly ISA k_5 and K_6 respectively in the inner and the outer races.

Table 2

Diameter of Arbor	Inner Diameter of Housing
60 +0.010 mm	110 − 0.019 mm

Conditions of loads and speeds are selected from the above-mentioned values within the allowable carrying capacity noted in the catalogues of each test bearing. As for lubricants, the most usual oil-bath lubrication is applied, and the quantity of lubricant, grease or oil, is determined by the common usage.

3. Experimental Results

Some examples of experimental results are shown in Fig. 3~6, in which the temperature rise is the difference between the temperature of both the inner and outer races and that of the room. The results obtained of other experiments are the same. As it is obvious from these figures, it is found that the temperature of the inner race (indicated by ○) is higher than that of the outer race (indicated by ●) during the whole period of operation, and that, as the full lines in these figures show, these values become almost constant within 30~60 minutes after starting the operation. Consequently, we can say that the temperature difference between both races also becomes steady at certain value. This tendency is shown by the dotted lines in Fig. 3~6.

Assuming that the value at which the temperature difference become constant is most important in designing rolling bearings themselves (that is: the so-called initial slackness of rolling bearing can be determined on this basis), the summary of these values obtained is shown in Fig. 7 and Fig. 8. From the former figure, the effects of loads on these values at a few cases of varying speeds can be found; and from the latter, the effects of speeds

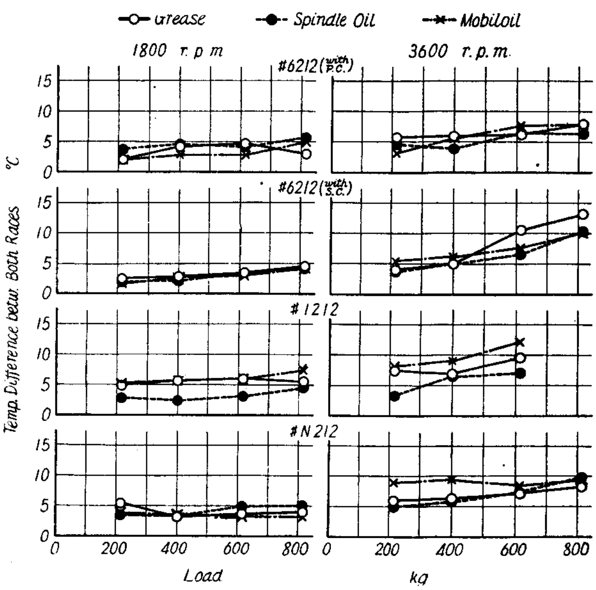

Fig. 7

at a few cases of loads can be learned. That is: the severer the condition of load or speed, the greater the temperature difference in general. It is found, however, that the effect of speed seems to be greater than that of load, but, in both of these two figures, the effect of the type of bearing or the kind of lubricant is negligible. It is very interesting, mereover, that the values of temperature difference between both races of rolling bearings obtained in the moderate running conditions of this research are about 5°C as have generally been acknowledged in this country up to this time.

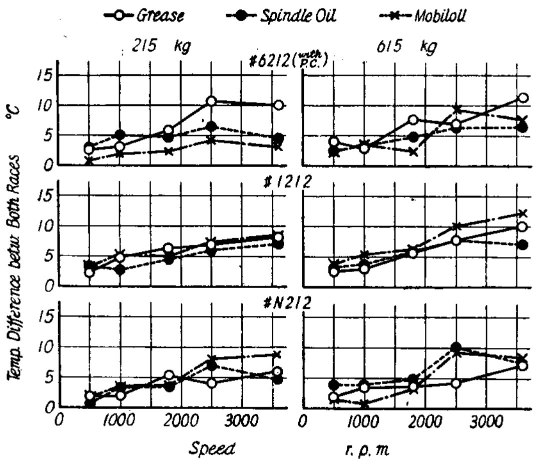

Fig. 8

A few differences of values under the same condition shown in Fig. 7 and Fig. 8 are probably due to the difference of bearing lubrication of the testor.

4. Concluding Remarks

The following conclusions are reached by this experimental research on the temperature difference between inner and outer races of rolling bearings used under the ordinary conditions:

(1) In these typical rolling bearings which are popularly used, the temperature of rotating inner race is always higher than that of stationary outer race, and the changing state of temperature while in rotation (that is: its value becomes almost constant within 30∼60 minutes after starting) is in both races similar.

(2) The temperature difference between both races increases at a considerable rate for several minutes after starting and then gradually becomes steady within 30∼60 minutes. This tendency, however, differs more or less in each case.

(3) The value of temperature difference in the steady state is generally greater when the condition of load or speed becomes severer, however, the effect of speed on it seems to be greater than that of load. And it can be said that the type of bearing or the kind of lubricant as almost no significant influence on it.

(4) The steady values of temperature difference which occur in the moderate running conditions are about 5°C, and this value of temperature difference, which has heretofore been believed generally, has been approved by this experimental research.

Reference

1) SKF: The Ball Bearing Journal, Vol. 6 No. 1, 1931.