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POST OFFICE BOX P
OAK RIDGE, TENNESSEE **ORNL**
CENTRAL FILES NUMBERCF-57-5-45

DATE: May 3, 1957

External Transmittal
AuthorizedSUBJECT: Evaluation of Coated Al₂O₃ and Tungsten
Carbide Bearing-Journal Assemblies in
Westinghouse 100A Pump (Summary of Runs
S-96A and S-97)

Copy No. 15

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Summary

Preliminary results of tests with the Westinghouse 100A pump indicate that Al_2O_3 and tungsten carbide coated bearing-journal assemblies prepared by the Linde process are not promising as substitutes for the graphitar-stellite combination. The front Al_2O_3 assembly failed at start-up with water and both front and rear tungsten carbide assemblies failed after 121 hours with water at 245°C .

Introduction

Performance of the front graphitar bearing in the Westinghouse 100A pump is poor when the pump is used to circulate thorium oxide slurries at elevated temperatures. The average life of the bearing is approximately 300 hours.¹ To prolong the life of this component, two bearing-journal combinations of known wear resistant qualities were tested, one consisted of sprayed Al_2O_3 and the other of sprayed tungsten carbide.

This report summarizes the results of water runs, S-96A and S-97, conducted in February 1957 with these two combinations. Runs S-96A was with the Al_2O_3 components and S-97 was with tungsten carbide.

Description of Bearing-Journal Combinations and Test Procedure

Stainless steel, type 347, prototypes of the standard Westinghouse 100A pump front and rear bearing-journal assemblies were coated with Al_2O_3 and tungsten carbide prepared by the Linde process to a maximum thickness of 3 mils. Both the Al_2O_3 and tungsten carbide journals were fitted to solid shaft rotors with an 0.0002 inch interference fit by chilling the stub ends in a mixture of dry ice and acetone. The Al_2O_3

bearings were fitted according to the REED standard procedure of inserting the bearings into the heated (800° - 900° F) holders to give an 0.0002 inch interference fit when cooled. The tungsten carbide bearings were installed differently; the bearings were inserted into the holders with approximately zero clearance and then pinned radially with 4 pins spaced 90° apart to prevent rotation.

The motor end of the pump was assembled with the test components to check alignment and ease of rotation before installation into the loop. In assembling the Al_2O_3 components, the front journal was found to be tapered 0.0007 inch and required lapping with diamond dust to obtain the desired fit with the bearing. No adjustments were needed with the tungsten carbide assemblies; the rotor rotated easily and freely. Dimensional data for both bearing-journal assemblies are shown in Table I.

Results

A. Al_2O_3 Coated Bearings

The condition of the Al_2O_3 bearings and front journal is shown in Fig. 1 through Fig. 3. The front journal-bearing assembly failed on the start-up with water at room temperature due to siezing which resulted in the spinning of the front bearing holder (note in Fig. 1 the scored marks on external surface) and removal of the coating in the damaged areas shown in Figs. 1 and 2. The rear assembly was not damaged; the condition of the rear bearing is shown in Fig. 3.

Prior to the failure, the pump was started six times with water while checking and adjusting the thrust balance of the rotor.

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TABLE I

DIMENSIONAL DATA FOR JOURNAL-BEARING ASSEMBLIES

Component	Before Run	After Run	Wear	Material
Front Bearing Diameter	1.499 in.	1.499 in. except where damaged	--	Al_2O_3
Bearing Rear Diameter	1.499 in.	1.499 in.	0	Al_2O_3
Front Journal Diameter	1.498 in.	1.498 in. except where damaged	--	Al_2O_3
Rear Journal Diameter	1.498 in.	1.498 in.	0	Al_2O_3
Front Bearing Diameter	1.498 in.	1.517 in.	+ 0.019 in.	Tungsten Carbide
Rear Bearing Diameter	1.499 in.	1.512 in.	+ 0.013 in.	Tungsten Carbide
Front Journal Diameter	1.497 in.	1.476 in.	- 0.021 in.	Tungsten Carbide
Rear Journal Diameter	1.497 in.	1.479 in.	- 0.018 in.	Tungsten Carbide

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SPECIAL BEARING AND JOURNAL TEST

Fig. 1 Damaged Front Al_2O_3 - Coated Bearing (Run S-96A)

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Fig. 2 Damaged Front Al_2O_3 - Coated Journal

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SPECIAL BEARING AND JOURNAL TEST

Fig. 3 Undamaged Rear Al_2O_3 - Coated Bearing (S-96A)

B. Tungsten Carbide Coated Bearings

Both the front and rear tungsten carbide coated assemblies failed after 121 hours of operation at 245°C with oxygenated water. During the course of the run, samples were taken for gas analyses to determine the resistance of the carbide to oxidation. The carbon dioxide content of the water was used as the index of the chemical stability of the coating. Results of these analyses are shown in Table II. Referring to Table II, it can be seen that the CO_2 content of the water increased with continued circulation at 245°C . Based on the data for sample S-97-2 and assuming a total water volume of 12 liters at room temperature, three grams of CO_2 were found in the water after 75.6 hours of circulation. If the assumption is also made that the tungsten carbide coating was WC, 2 mils thick with a density of 16, then it is possible to find a total of 4.5 grams of CO_2 in the water if all the coatings were completely oxidized. Since only 3 grams of CO_2 were found, part of the coating still remained on the stainless steel bearing when failure occurred. Subsequent visual inspection confirmed the conclusion that the failure of the carbide coatings was due primarily to oxidation. Most of the coating was removed from the bearings and journals and the remaining patches appeared porous and powdery as seen in Fig. 4 through Fig. 7.

The effect of temperature in causing these failures was not established. It would appear, however, that temperature is not important since both the front and rear assemblies failed even though the rear assembly was exposed only to cold water and the front one to approximately 200°C water.

TABLE II

GAS ANALYSIS DATA FOR WATER CIRCULATING AT 245°C USING
TUNGSTEN CARBIDE ASSEMBLIES AS PUMP COMPONENTS

Sample Number	Circulating Time Hours	O ₂ cc	O ₂ ppm	CO ₂ cc	CO ₂ ppm	Total Gas Volume (cc)
S-97-0	4.3	23.9	545	0.4	13	37.0
S-97-1	28.9	38.3	875	6.1	192	75.0
S-97-2	75.6	27.8	634	7.7	243	61.1

Total length of run - 121 hours

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Fig. 4 Tungsten Carbide Coated Front Bearing Showing Damage to Thrust Face and Radial Surface (Run S-97)

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Fig. 5 Tungsten Carbide Coated Front Bearing Showing Porous and Powdery Condition of Surface (Run S-97)

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Fig. 6 Damaged Tungsten Carbide Coated Rear Bearing (S-97)

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Fig. 7 Condition of Front and Rear Tungsten Carbide Coated Journals (S-97)

REFERENCES

1. R. B. Korsmeyer et al., HRP Quar. Prog. Rep. Oct. 31, 1956, ORNL-2222, p 66.