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Abstract

This report presents the results to date of the hydrodynamic journal type bearing phase of the salt-lubricated bearing development program at Oak Ridge National Laboratory. One test each of two hydrodynamic journal type bearings constructed of INOR-8 versus INOR-8 was performed with molten salt #130 (62 LiF, 37BeF, 1 UF_4 Mole %) at 1200°F as the lubricant. The first bearing operated for twenty minutes and the test was terminated due to seizure of the bearing and journal. The second bearing operated for 500 hours during which fifty-seven stop-start tests were performed and hydrodynamic lubrication was attained for extended periods at 1200 rpm and 200 lb_f radial load. Termination of the test was as scheduled at the completion of 500 hours of operation. Plans are also included for further testing.

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DISCLAIMER

SALT-LUBRICATED HYDRODYNAMIC JOURNAL BEARING TEST

Introduction

This report summarizes the results of the first two salt-lubricated hydrodynamic journal bearing tests conducted by the Experimental Engineering Department of the Reactor Projects Division at Oak Ridge National Laboratory. These tests are a part of the salt-lubricated bearing program which was evolved during the last half of FY 1958 under the auspices of the Molten Salt Reactor Program.

This report will cover the purpose of the tests, description of the test equipment, selection of bearing materials, summary of tests, results, and plans for future tests.

Purpose of Tests

The purpose of the tests is to investigate the performance and the reliability of a hydrodynamic type journal bearing lubricated with molten salt at elevated temperatures. If successfully developed, such a bearing should be an extremely useful element in the design of a salt pump for a molten salt reactor. It could be used to expand the usefulness and to increase the flexibility of design for the overhung type of sump pump. When a high-temperature, radiation-resistant motor becomes available, the salt-lubricated bearing would permit the design and construction of a completely submerged pump, requiring no auxiliary oil-lubrication circuits with their attendant complexities.

Description of the Test Equipment

The test apparatus (see Fig. 1) used for the salt-lubricated hydrodynamic journal bearing test consists of a PK pump tank and a PK rotary assembly without an impeller. The impeller region has been modified to accommodate the test bearing with provisions for mechanically varying the radial load on the bearing. The bearing design (see Fig. 2) which was chosen for initial investigation consists of a sleeve with axial feed grooves located 120° apart, running the complete length of the bearing. These grooves provide lubricant feed to the bearing and they also serve as an anti-whirl device.

It was decided to investigate a bearing for a three-inch diameter shaft, suitable for carrying a radial load of 200 pounds, since design studies had shown that such a bearing would be suitable for use in a 5000 g.p.m., 70 foot head pump for a molten salt reactor. From a study of the relationships between bearing clearance, minimum film thickness, journal speed, load-carrying capacity, viscosity of the molten salt, and journal power requirements, it was decided that the bearing should be three inches long, and have a radial clearance of 0.005 inches.

Selection of Bearing Materials

A literature survey revealed that compatibility studies of bearing materials with molten salt (ORNL, CF 58-1-5, dated January 2, 1958) had been performed at Oak Ridge National Laboratory and Battelle Memorial Institute, and valve tests and salt-lubricated bearing tests had been performed at Oak Ridge National Laboratory and Battelle Memorial Institute, respectively.

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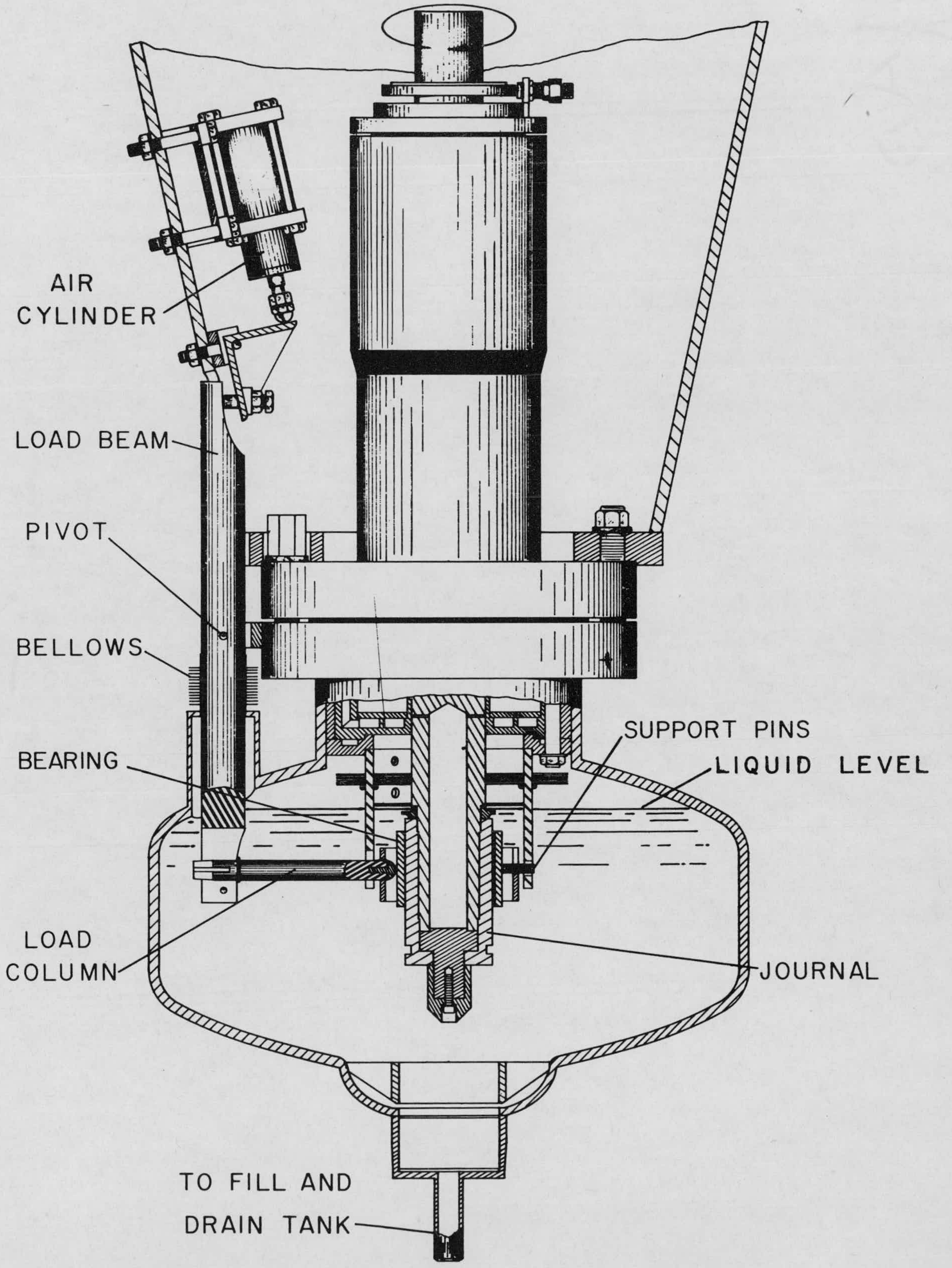

Hydrodynamic Bearing Tester , Section

- Fig. 1 -

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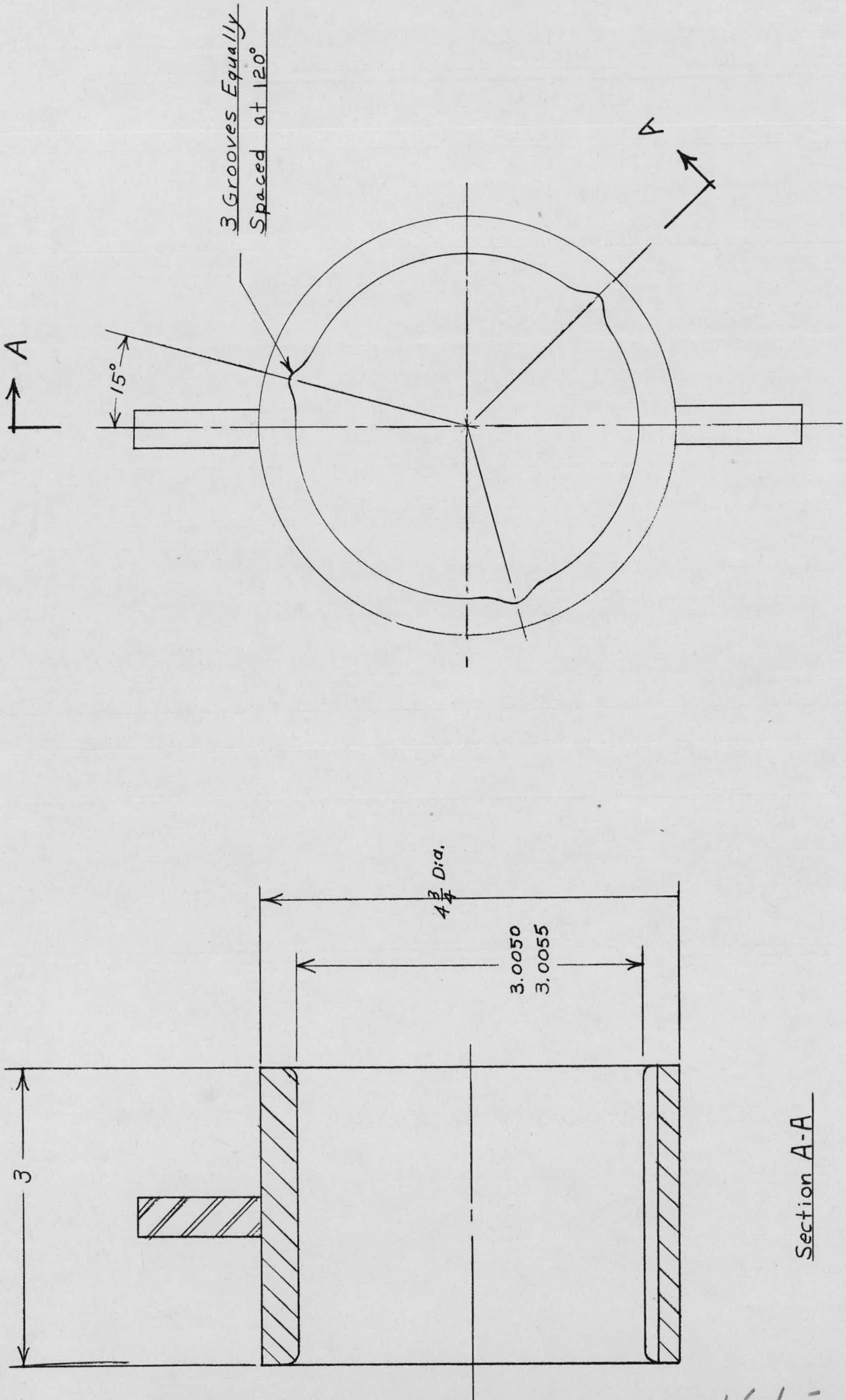

Fig. 2

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From this survey it was decided to investigate experimentally a bearing combination of molybdenum versus tungsten carbide with 12% cobalt. However, since it was anticipated that there would be a delay in obtaining a bearing fabricated from these materials, it was decided to construct and experimentally investigate a bearing combination of INOR-8 versus INOR-8. A satisfactory and reliable bearing and journal of INOR-8 would eliminate the problems associated with the use of molybdenum and tungsten carbide in a pump constructed of INOR-8. The coefficient of thermal expansion of INOR-8 is approximately three times that of molybdenum and tungsten carbide, so the development of special bearing mounts capable of accommodating the differential expansion and yet preserving concentricity is required.

Summary of Tests

The first two tests were conducted with molten salt #130 (62 LiF, 37BeF, 1 UF_4 Mole %) at 1200°F, and the bearings and journals were fabricated of INOR-8. The INOR-8 journal used in the first test was spray-coated with INOR-8 and ground to a bearing finish of 10 microinches rms.

The first test was of twenty minutes duration and was terminated as a result of seizure between the bearing and journal at 1200°F, 1200 rpm, and 100 lb_f radial load.

The second test was of 500 hours duration with the molten salt at 1200°F. The journal used in this test was not spray-coated but was finished to 10 microinches rms. The axial feed grooves of the bearing were enlarged, and their transition radii into the bearing surface were increased, as compared to the bearing used in the first test. Bearing operation during the second test consisted of fifty-seven stop-start tests which consumed about fifty-four hours. The remainder of the operating time was consumed in operation at constant conditions, mainly at 1200 rpm, and 200 lb_f radial load. The stop-start tests were performed as follows:

1. Fifty-five tests were made wherein the stops were accomplished by gradually decreasing the speed and load from 1200 rpm, and 200 lb_f radial load, to zero speed and load. The test was held stationary for about one minute and then restarted by gradually increasing the speed load up to 1200 rpm, and 200 lb_f radial load.
2. One stop was made wherein rotation was abruptly stopped under 200 lb_f radial load. The journal remained stopped for nine hours under the load and could not be rotated by hand. However, when the load was removed, the journal was free to rotate. The test was restarted by gradually increasing the speed and load to 1200 rpm and 200 lb_f.
3. One other stop was made wherein the load system failed and the bearing unloaded automatically. The journal rotation was halted until repairs could be made to the load system. The journal remained stationary with no load for about seventeen hours.

Each of the stop-start tests in (1) above consumed about thirty minutes time. About five minutes were consumed for stopping, about one minute consumed while stopped, about five minutes consumed for getting back to 1200 rpm and 200 lb_f radial load, and about 20 minutes were consumed for steady state operation.

During operation at constant conditions, power data were obtained at various combinations of speed and load. The maximum speed to which the bearing was ever subjected was 2000 rpm and the maximum load was 200 lb_f radial load. These maximum conditions were not imposed simultaneously. The method of power measurement was not accurate nor precise enough to permit determination of the journal power.

Results

The first test was of twenty-minutes duration at 1200°F and was terminated at a load of 100 lb_f radial load (22.5 psi on the journal effective projected area) at 1200 rpm. The bearing surface was found to contain thin sheets of metal which came from the journal surface. The thickness of these thin sheets of metal was much less than the thickness of the journal spray-coat. Post-run examination also revealed that the bond between the INOR-8 spray coat and the INOR-8 parent metal failed, which could have resulted in a loss of bearing clearance. This is believed to be the major cause of seizure. There are two other possible causes of failure; namely, there may have been insufficient feed to the bearing through the feed grooves, and the bearing was not installed in the tester as intended.

The second bearing performed satisfactorily. Hydrodynamic lubrication was attained at 1200°F with molten salt #130 for 500 hours during which time fifty-seven stop-start tests were made without encountering any observable difficulties, and operation for extended periods was achieved at constant conditions. The conditions of constant operation were at 1200°F and, mainly, at 1200 rpm, and at a bearing radial load of 200 lb_f (45 psi on the journal effective projected area). At 1200 rpm and 200 lb_f, the journal power was quite low and it is believed that the friction coefficient was less than 0.013. The bearing surface roughness was 10 microinches rms, both before and after the test, and the bearing was very clean when removed from the tester at the conclusion of the test. Diametral measurements of the bearing revealed no change in its diameter.

Plans for Future Tests

The bearing and journal used in the second test will be replaced in the tester to investigate repeatability of test results with the same bearing. For this test, the 15 H.P. drive motor used in the first two tests will be replaced with a 2 H.P. drive motor to obtain more accurate power measurements. About one week of operation is anticipated for this test.

A duplicate of the bearing used in the second test is being fabricated and will be tested under more strenuous stop-start conditions, with greater loads, and simulating situations one might expect to encounter in a reactor salt pump application.

In another area of investigation, the bearing will be operated at steady state conditions for an extended length of time to determine whether or not dynamic corrosion conditions may be encountered.

Should future tests show that the INOR-8 versus INOR-8 journal and bearing combination is unsatisfactory for any reason, a combination of molybdenum and tungsten carbide with 12% cobalt will be investigated experimentally (studies of the problem of mounting these materials to INOR-8 are now in progress).

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