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HIGH STRENGTH CERAMICS BEARINGS

INTERIM REPORT
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13. ABSTRACT *(Maximum 200 words)*

Rotordynamics-Seal Research is currently performing on a 6 month contract to develop high strength ceramic bearings using a new low cost process. This effort consists of development of a ceramic bearing design, fabrication, and testing of the bearing in an existing test rig. This is the first monthly progress report.

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Monthly Report for N00014-97-C-0375

Progress During Reporting Period

The focus of the effort during the first contract month was design of the angular contact ball bearing. The complete effort consisted of the following:

- completed subcontract with JHU
- design adapter hardware for motor test
- analyze ball bearing for preload and tolerances
- revise bearing race drawings

JHU Subcontract

The subcontract for Johns Hopkins University was completed this month. The negotiations took much longer than anticipated due to a major disagreement over the publication of research results. JHU expected to publish at will without regard for patent issues, trade secrets, or government approvals. This position is typical of universities. All matters have been resolved and the subcontract is in place.

Test Hardware

The final task in this effort will be a simple test of the ball bearing. To accomplish this, the bearing will be mounted on the shaft of a small high speed motor. The conceptual design for this adapter hardware is shown in Figure 1. The bearing will be compliantly mounted on the end of the motor shaft. This will be done to limit stress on the inner race of the bearing and to avoid rotordynamic problems associated with a three bearing rotor. Manufacturing drawings are being completed for the adapter hardware and will be sent out for bids.

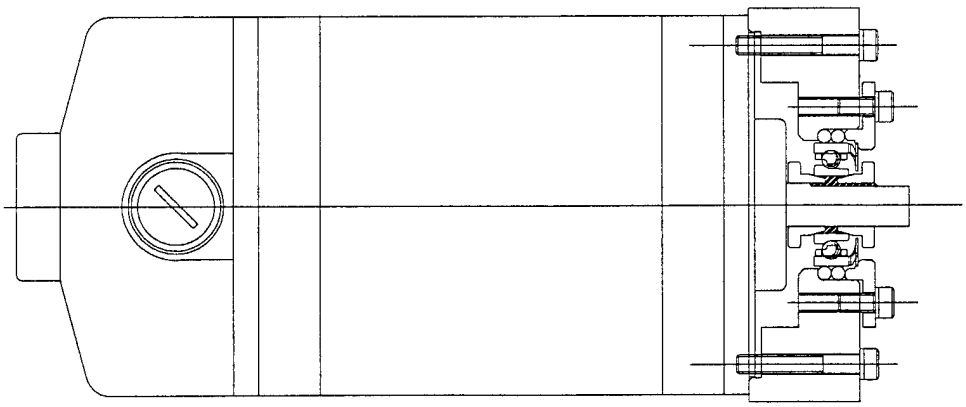

Figure 1. Test set up

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Ball Bearing Analysis

RSR's ball bearing analysis code MBZIP was used to analyze the bearing to determine the operating characteristics of the bearing up to 10,000 rpm for 4.448 N (1 lbf) and 22.24 N (5 lbf) axial preload. The bearing operating at a preload of 22.24 N will have a positive axial displacement at speeds up to 10,000 cpm while for the 4.448 N preload the bearing operates at a negative axial displacement at speeds above 9500 cpm.

Table 1 shows the geometry and materials of the bearing to be tested. The outer race is fixed, and the inner race rotates. The bearing will be mounted compliantly; therefore, the stress on the inner race will primarily due to rotational effects. At 10,000 cpm, the stress on the ceramic inner ring will be 0.31 MPa (45 psi). Figure 2 and Figure 3 show the axial displacement and radial stiffness, respectively, for preloads of 4.448 N and 22.24 N. The negative axial displacement and radial stiffness at a preload of 4.448 N precludes using that preload at speeds above 5000 cpm.

Table 1. Geometry and Materials of Ball Bearing

Number of balls	11
Ball diameter, mm (in)	4.7625 (0.1875)
Inner race curvature, %	54.03
Outer race curvature, %	54.03
Pitch diameter, mm (in)	23.48 (0.9246)
Contact Angle, degrees	15.0
Ball material	Silicon Nitride
Ball elastic modulus, GPa (psi)	310 (45E6)
Ball density, g/cm^3 (lb/in^3)	3.2 (0.116)
Race material	Silicon Carbide
Race elastic modulus, GPa (psi)	393 (57E6)

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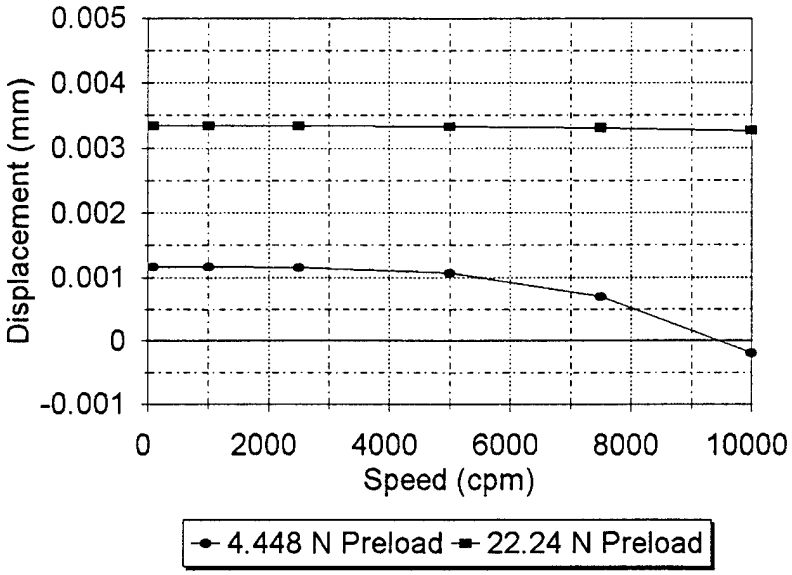

Figure 2. Axial displacement versus rotational speed

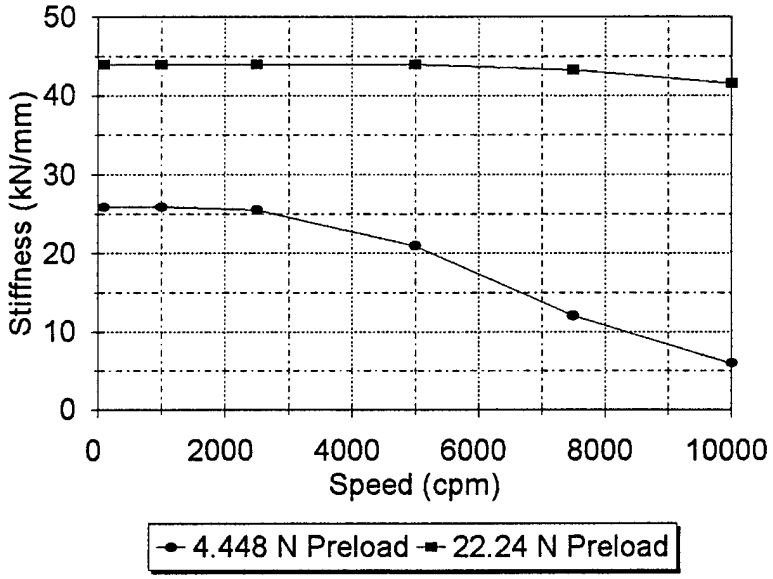

Figure 3. Radial stiffness versus rotational speed

Bearing Race Drawings

Bearing race drawings were obtained from the Barden Company for a hybrid ceramic ball/metallic race bearing. Based on the aforementioned analysis, the drawings were revised to fit the test set up and to ease some tolerances (mainly axial length). The final drawings are shown in Figures 4 and 5.

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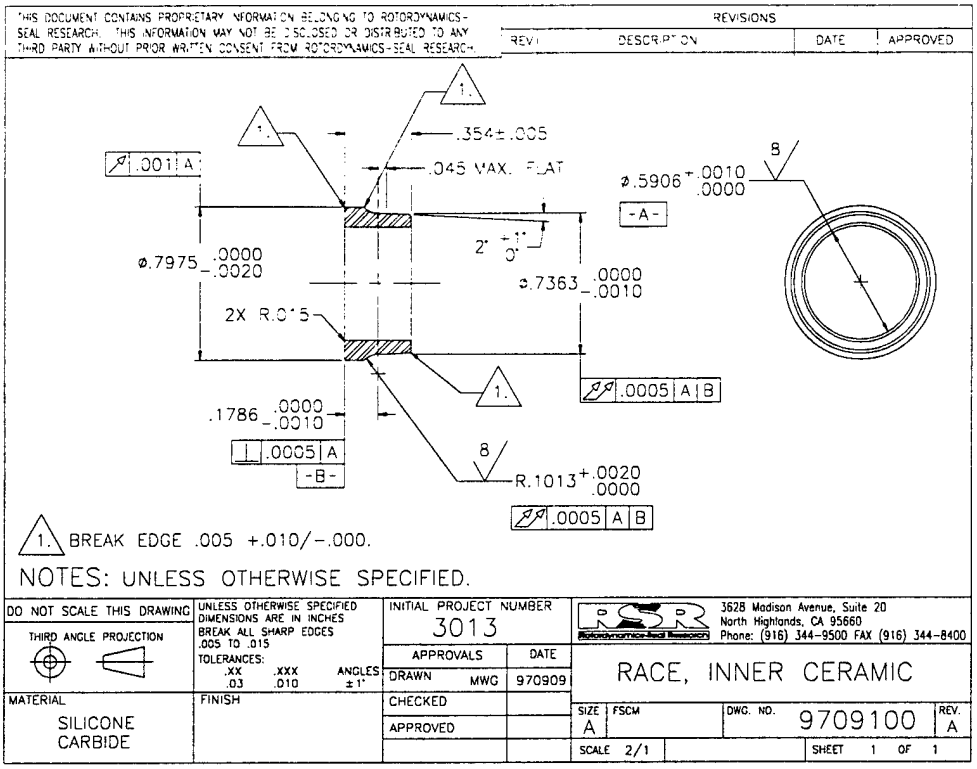

Figure 4. Inner race drawing

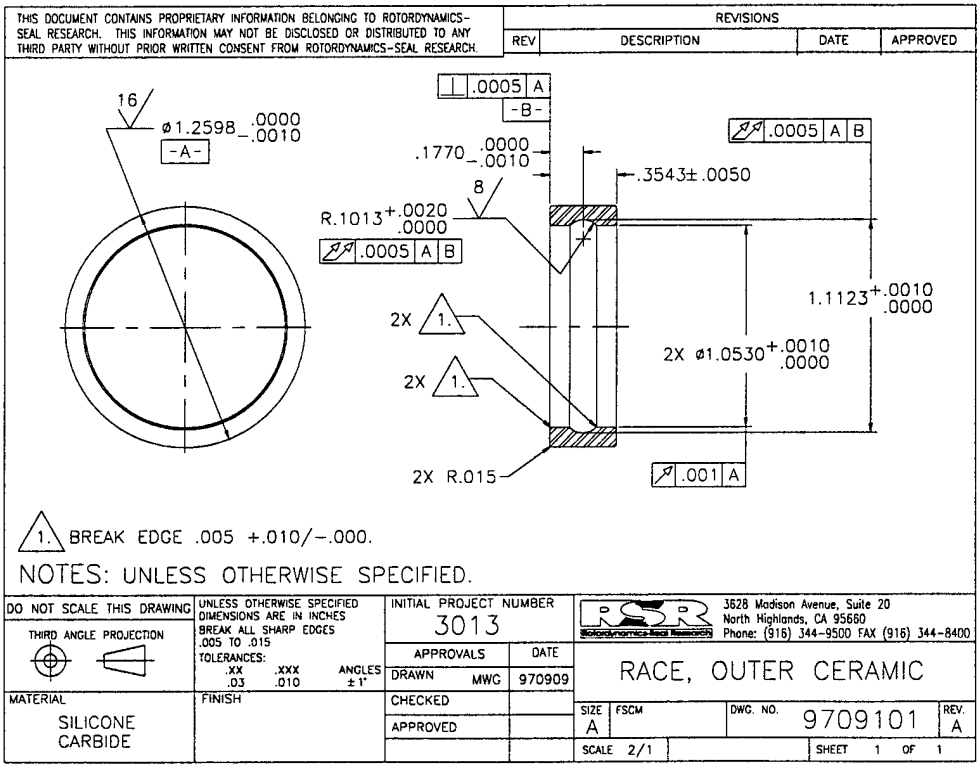

Figure 5. Outer race drawing

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Work To Be Performed For The Next Reporting Period

The following effort will be reported on for the next reporting period:

- initiate fabrication of adapter hardware
- begin development of ceramic races at JHU

Cost And Schedule Status

During the first month of the contract effort $6,132.60 was expended for labor $53,812.40 will be required for completion. Approximately 19.13% of the labor has been completed.

TASK	Month from Go-ahead					
	1	2	3	4	5	6
Bearing Design						
Bearing Fabrication						
Bearing Test						
Reporting						

Potential Problem:

No problems at this time.

Please feel free to contact me if you have any questions concerning this report.

Sincerely,

Joseph K. Scharrer, Ph.D.
President

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