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PRESSURE MEASUREMENTS OF A THREE WAVE JOURNAL AIR BEARING

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ABSTRACT:

In order to validate theoretical predictions of a wave journal bearing concept, a bench test rig was assembled at NASA lewis Research Center to measure the steady-state performance of a journal air bearing. The tester can run up to 30,000 RPM and the spindle has a run out of less than 1 micron. A three wave journal bearing (50 mm diameter and 58 mm length) has been machined at NASA Lewis. The pressures at 16 ports along the bearing circumference at the middle of the bearing length were measured and compared to the theoretical prediction. The bearing ran at speeds up to 15,000 RPM and certain loads. Good agreement was found between the measured and calculated pressures.

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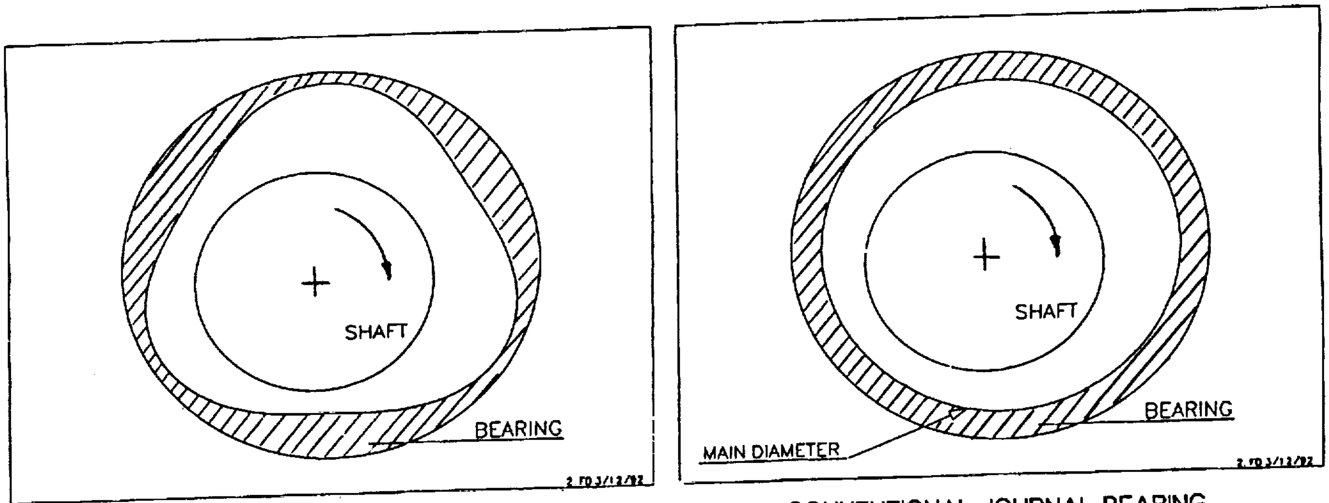


WAVED JOURNAL BEARING

CONVENTIONAL JOURNAL BEARING

FIGURE 1. WAVED JOURNAL BEARING CONCEPT (Wave height and clearance greatly exaggerated)

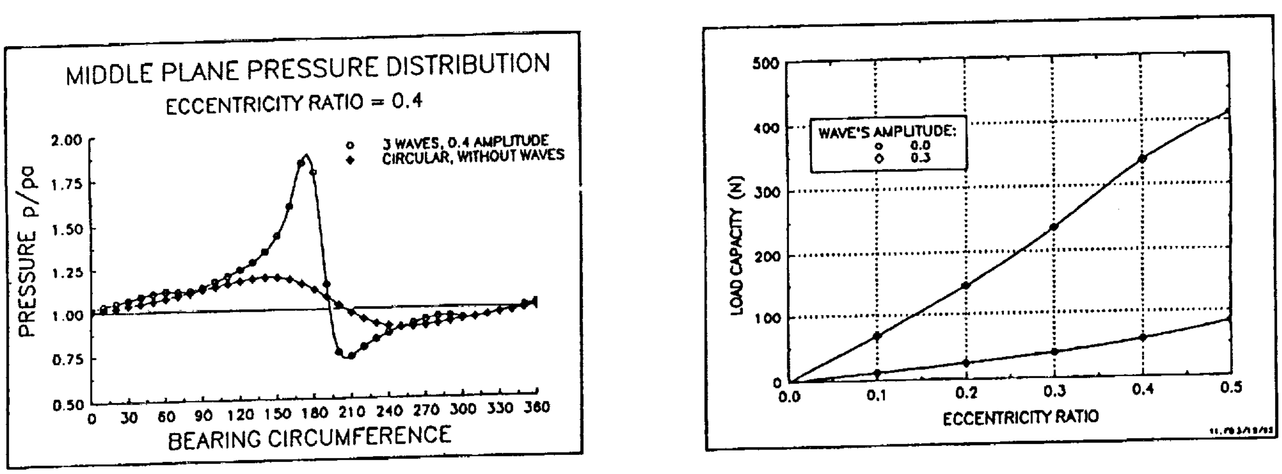


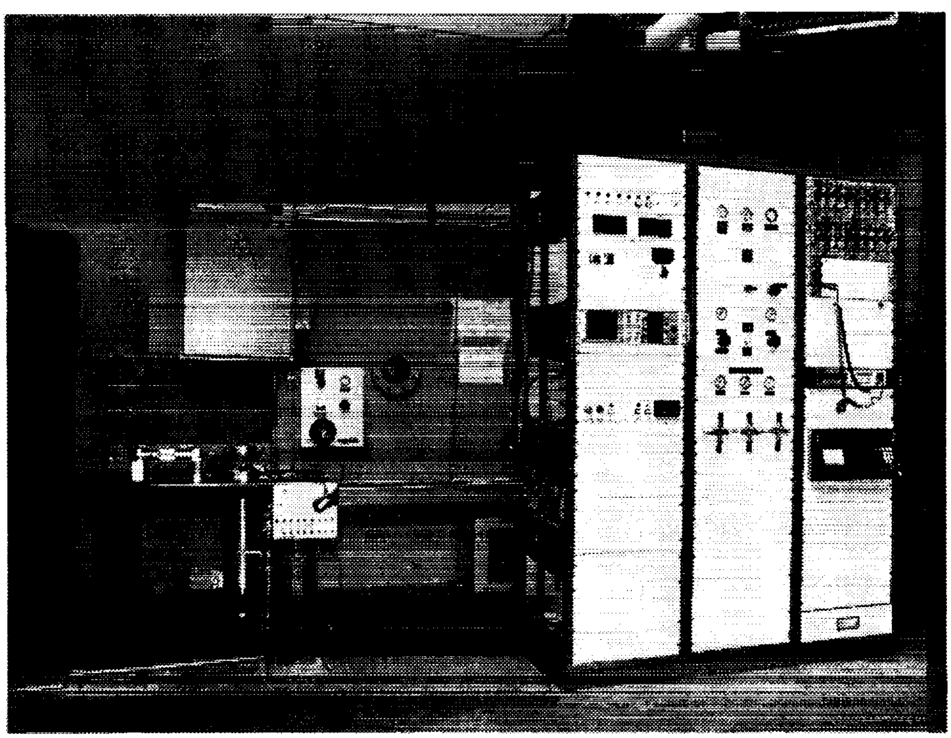
FIGURE 1A. WAVED/CONVENTIONAL BEARING PRESSURE DISTRIBUTION AND LOAD CAPACITY COMPARISON

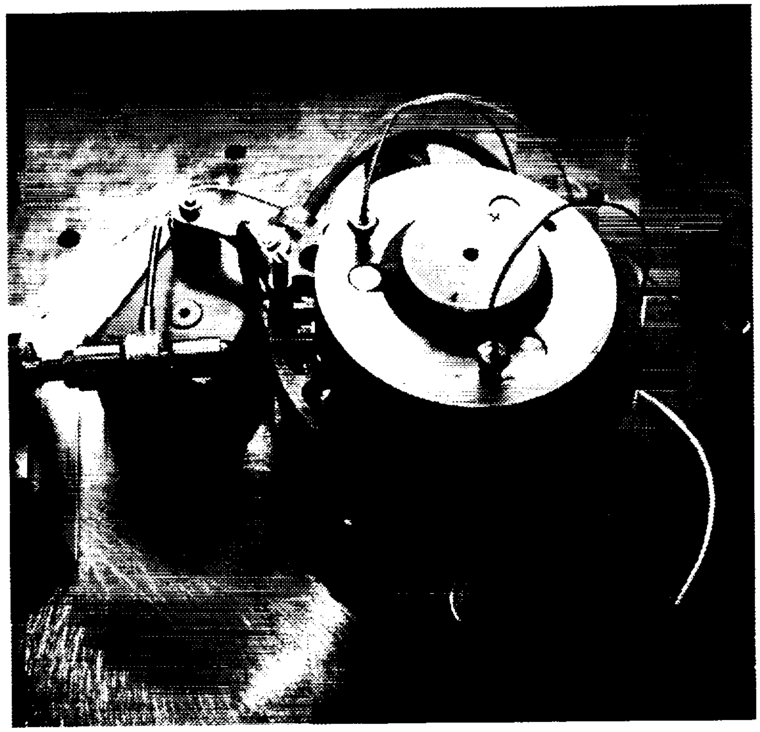
Wave Bearing Advantages:

* The wave journal bearing has increased load (stiffness) compared to the truly circular journal bearing.

* The wave journal bearing offers better stability than the truly circular journal bearing under all operating conditions.

* The wave journal bearing's performance is dependent upon the wave amplitude and increase significantly as the wave amplitude increases.





The Journal Bearing Bench Tester

* Lubricant: air

* Spindle: Air Bearing Spindle:

  - Speed: up to 30000 RPM,

  - Run-out less than 1 micron.

* Levitation Thrust Air Bearing Plate with three sectors.

* Instrumentation:

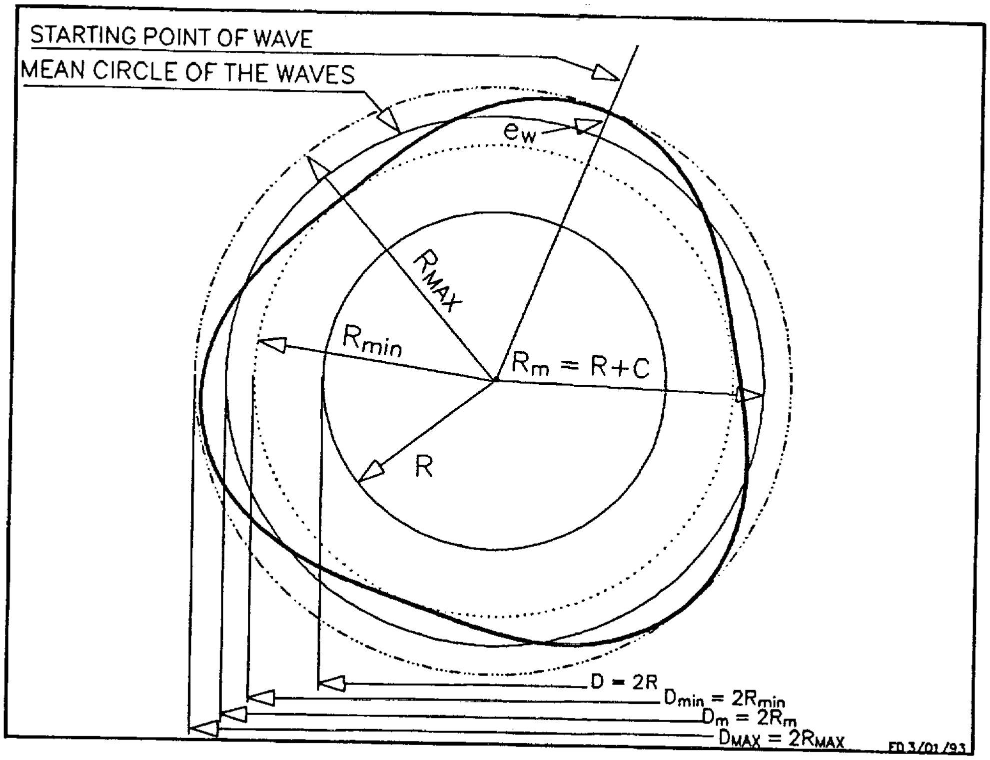
  - Turning Speed Read Out,

  - SOTEC Precision Miniature Load Cell 100 lbs.,

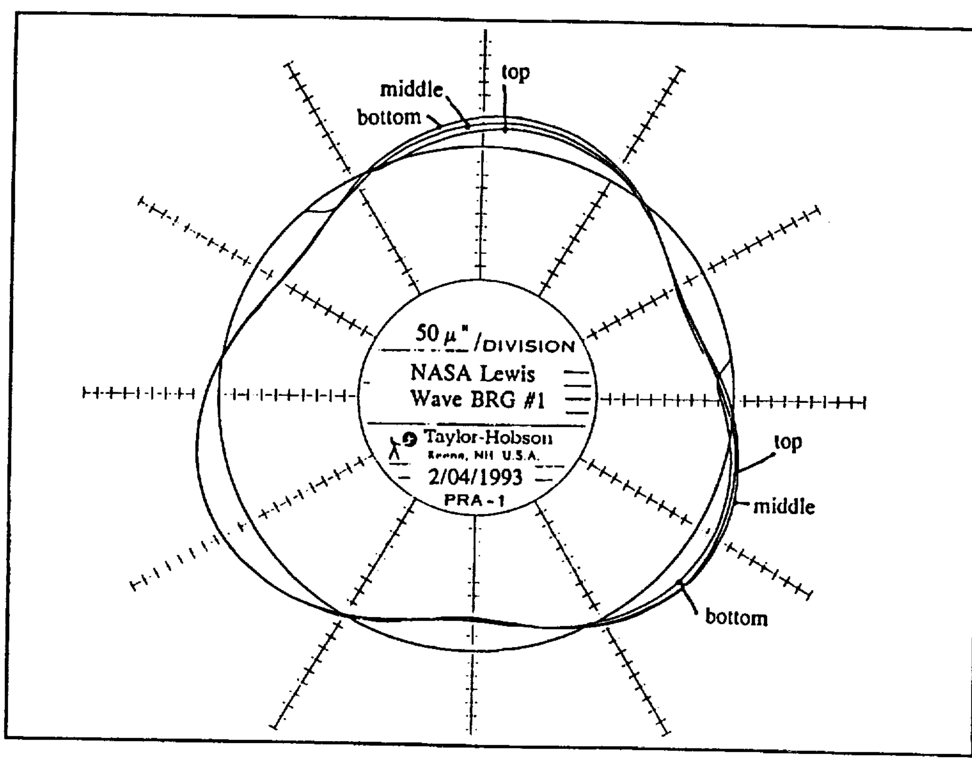
  - Kaman Instrumentation Displacement Sensors,

  - ENDEVCO Piezo-resistive Pressure Transducers,

  - Thermo-couples.



a. Theoretical three wave bearing profile.



b. NASA Lewis Three Wave Bearing Measured Profile.

THREE WAVE TEST BEARING No. 1

Date: 2/04/93 Machine Shope 71° F

Bearing:	D_{min}	D_{MAX} [inchs]	ϵ_w & C [μm]		Shaft: D =2R [inchs]	
Top:	2.0118	2.013	7.62	12.7	2.0114	2.0114
Middle	2.0119	2.0129	6.35	12.065	2.0114	2.0115
Bottom	2.0121	2.0133	7.62	15.24	2.0115	2.0115
	2.011933	2.013067	7.2	13.335	2.01145	

****
$D_m = 2R_m = 2.0125"$
****

Error: 0.0003"/D =3.8 μm /R   Error: .0001"/D =1.2 μm /R

Metric: [mm]
$D_{MAX} = 51.132$ $D_{min} = 51.103$ $D_m = 51.1175$ $D = 51.091$
$R_{MAX} = 25.566$ $R_{min} = 25.5515$ $R_m = 25.55875$ $R = 25.5455$

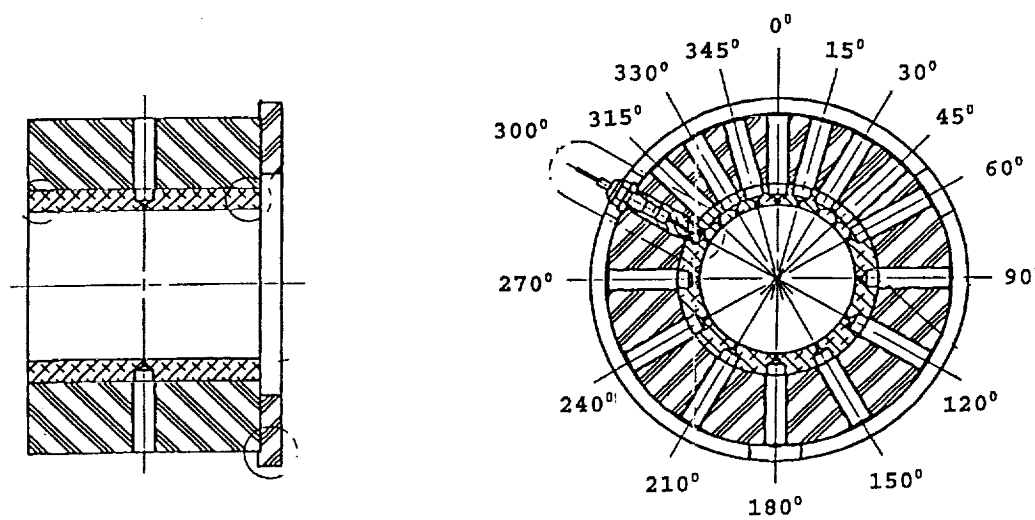
Radial Clearance: $C = (D_m - D)/2 = (R_m - R) = 0.01325$mm $= 13.25\ \mu$m

Wave Amplitude $e_w = (D_{MAX} - D_{min})/4 = (R_{MAX} - R_{min})/2 = 0.00725$mm $= 7.25\ \mu$m

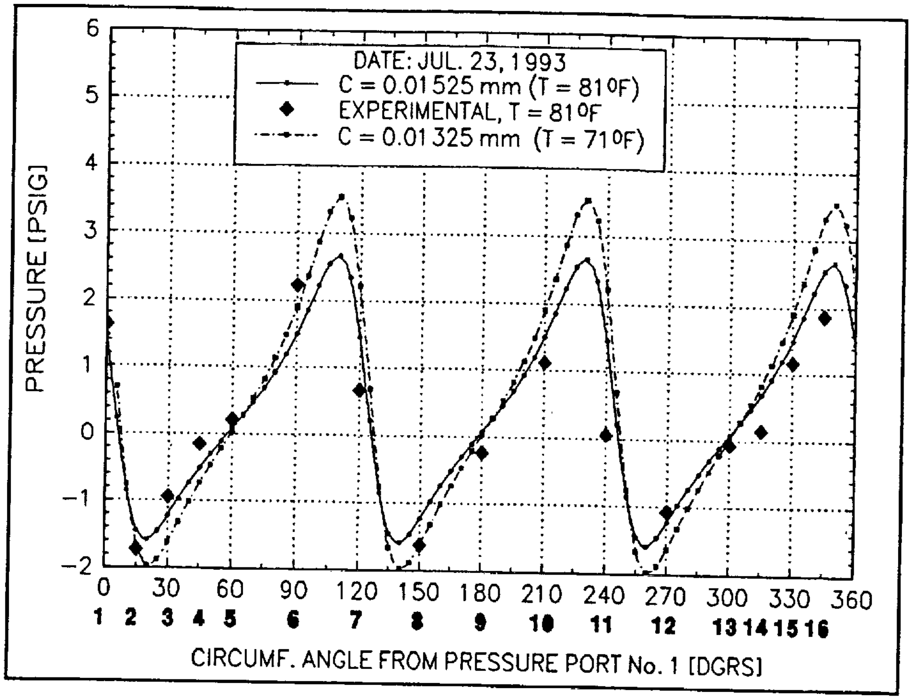
Wave Amplitude Ratio $\epsilon_w = e_w/C = .54717$

Bearing Length: L =58mm   Bearing Mass: M =2.966 Kg

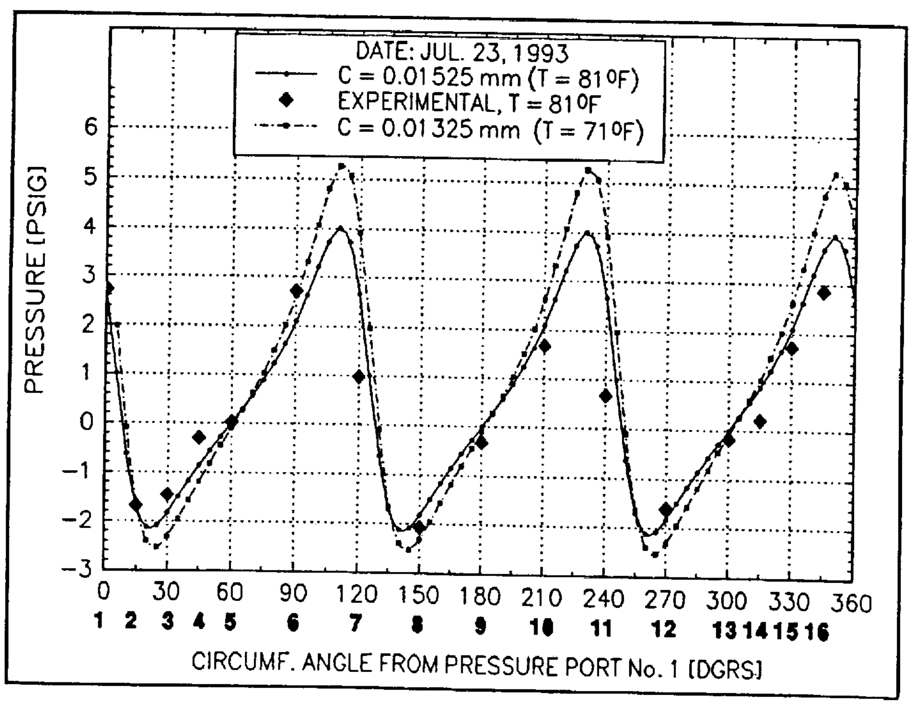
NASA THREE WAVE JOURNAL TEST BEARING



PRESSURE PORT LOCATIONS

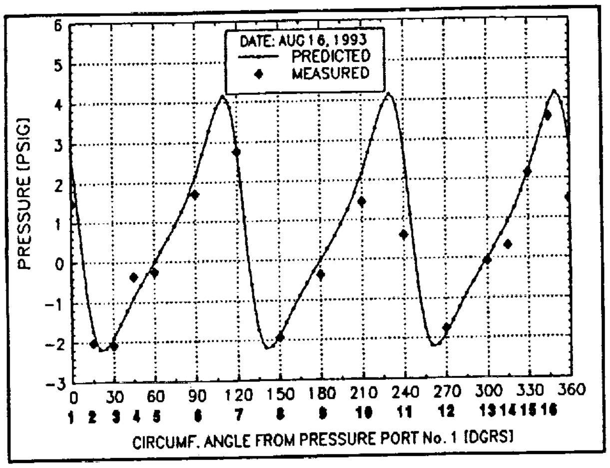


a. Speed 2000 RPM, Load 0..

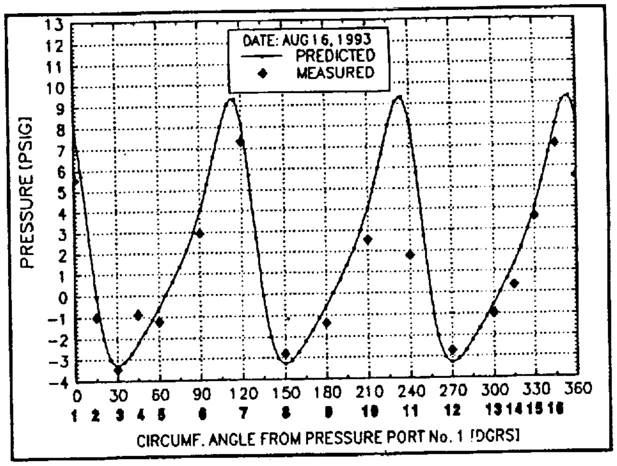


b. Speed 3000 RPM, Load 0..

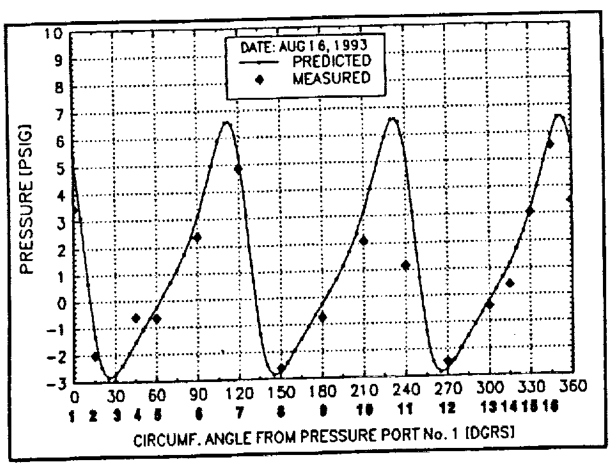
NASA Test Wave Bearing #1, Predicted and measured pressures in the bearing middle plane. The influence of the bearing temperature over the bearing radial clearance and bearing pressures.



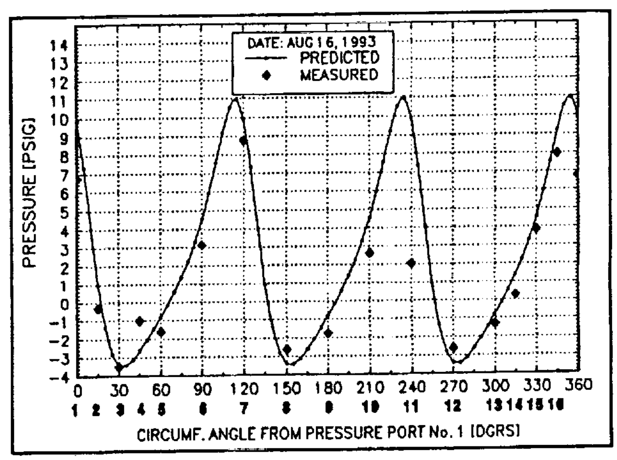
a. 3000 RPM, C=15.0μm, (t=80°F)



c. 8000 RPM, C=15.8μm, (t=84°F)

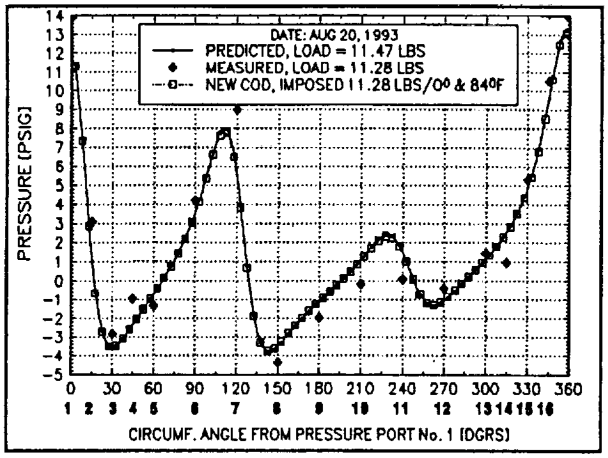


b. 5000 RPM, C=15.1μm, (t=81°F)

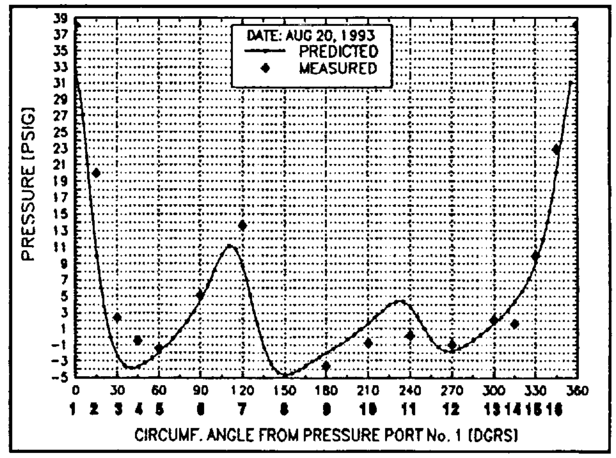


d. 10000 RPM, C=15.9μm, (t=85°F)

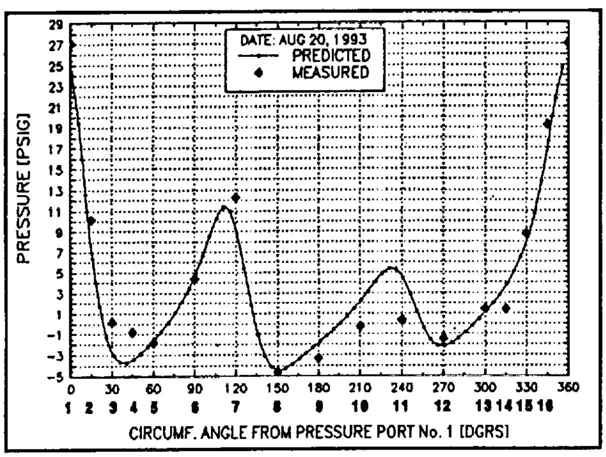
NASA LEWIS Test Wave Bearing #1, Predicted and measured pressures in the bearing middle plane at zero load and certain speeds.



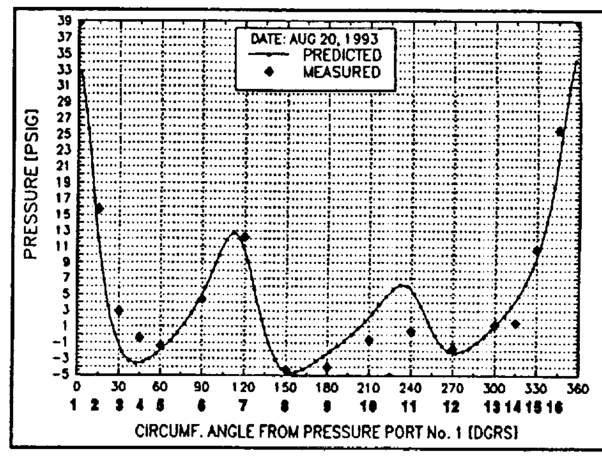
a. 5000 RPM, C=15.8μm, (t=83°F).



c. 10475 RPM, Load 22.0 lbs., C=15.9μm.



b. 10475 RPM, Load 22.0 lbs., C=15.9μm.



d. 15069 RPM, Load 31.8 lbs., C=19.0μm.

NASA LEWIS Test Wave Bearing #1, Predicted and measured pressures in the bearing middle plane at certain loads and speeds.

CONCLUSIONS:

* Good agreement was found between the measured and calculated pressures. A correction of the bearing clearance due to actual bearing running temperature is necessary.

* The three wave test bearing # 1 can run stable without load up to 6000 RPM when the half frequency whirl instability phenomena occurs. However, the bearing running speed can be increased up to 10000 RPM without any damage of the bearing. The wave bearing can keep the half frequency whirl instability orbit inside its clearance and the bearing runs safely. A small amount of load such as 10 lbs. makes the bearing to run stably without any half frequency whirl phenomena.