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ACTIVE CONTROL AND SYSTEM IDENTIFICATION OF ROTORDYNAMIC STRUCTURE

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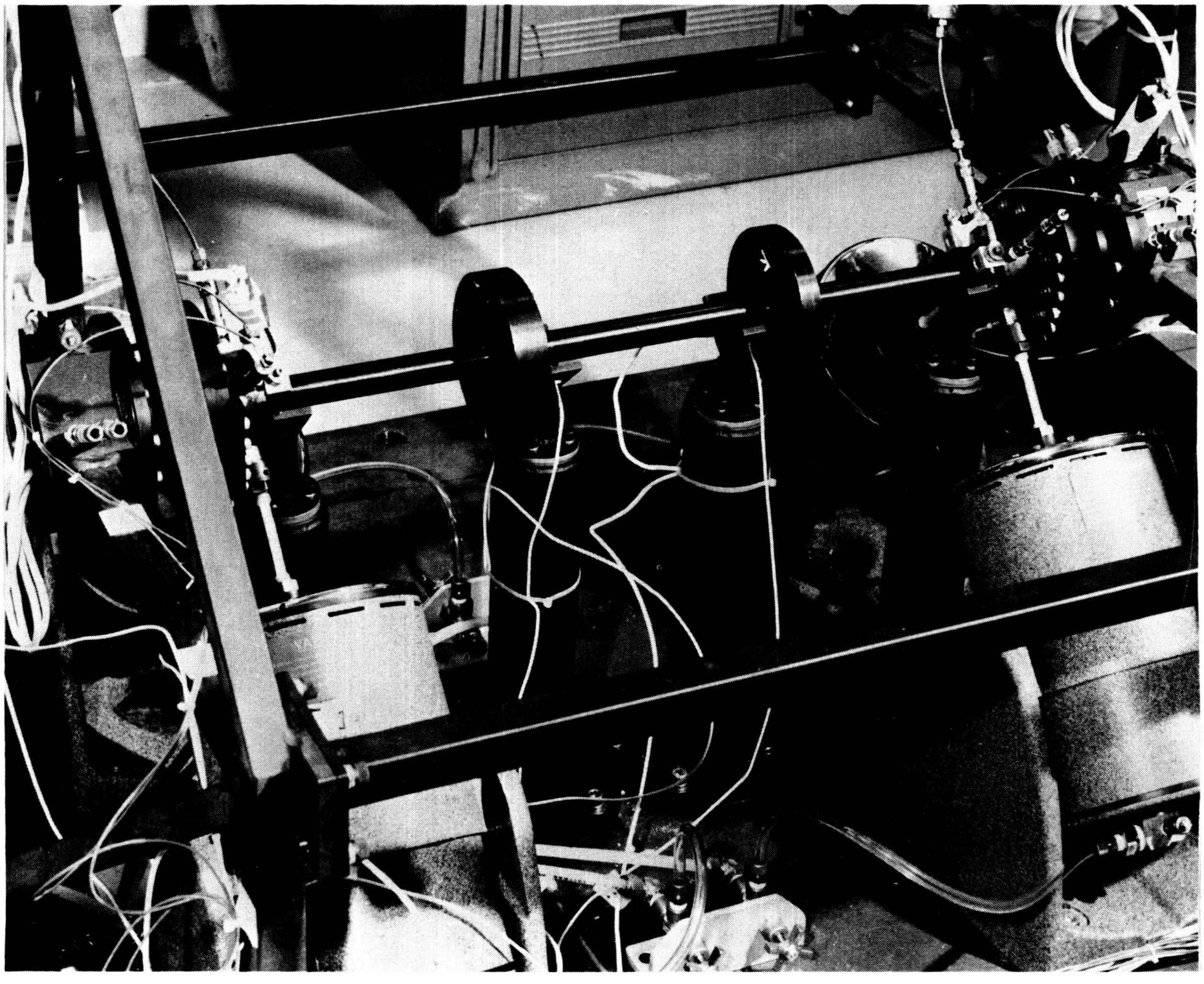
ABSTRACT

Two general topics are currently at the forefront of investigations by presently active researchers working on problems in the dynamics of rotating machinery. These two topics are Active Control and System Identification, both of which are being actively researched at Case Western Reserve University (CWRU). Four current CWRU research projects are summarized in this paper: (1) Active control of rotor system dynamics, this work being performed on site at NASA Lewis by the CWRU rotordynamics research team, (2) Attenuation of rotor vibration using controlled-pressure hydrostatic bearings, (3) A new seal test facility at CWRU for measuring isotropic and anisotropic linear rotordynamic characteristics, and (4) The use of rotordynamic instability thresholds to accurately measure bearing rotordynamic characteristics.

ACTIVE CONTROL RIG

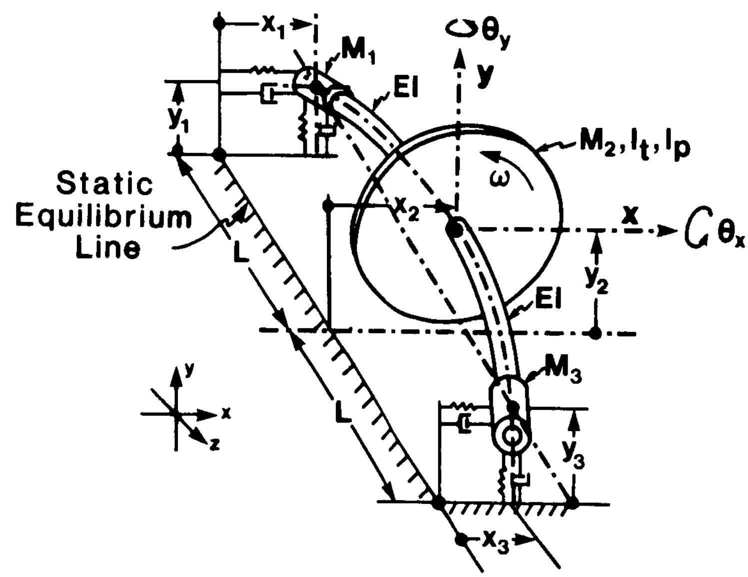
This test rig has been recently installed at NASA Lewis Research Center to perform a wide variety of experimental studies on techniques for actively controlling rotor system dynamics. The rig is shown here with four independently controllable electromagnetic shakers. Other types of servomechanisms are also presently being designed for use in this rig, including a magnetic bearing. This test facility is fully operational except for establishing the best type of servomechanism for delivering the controlled input forces.

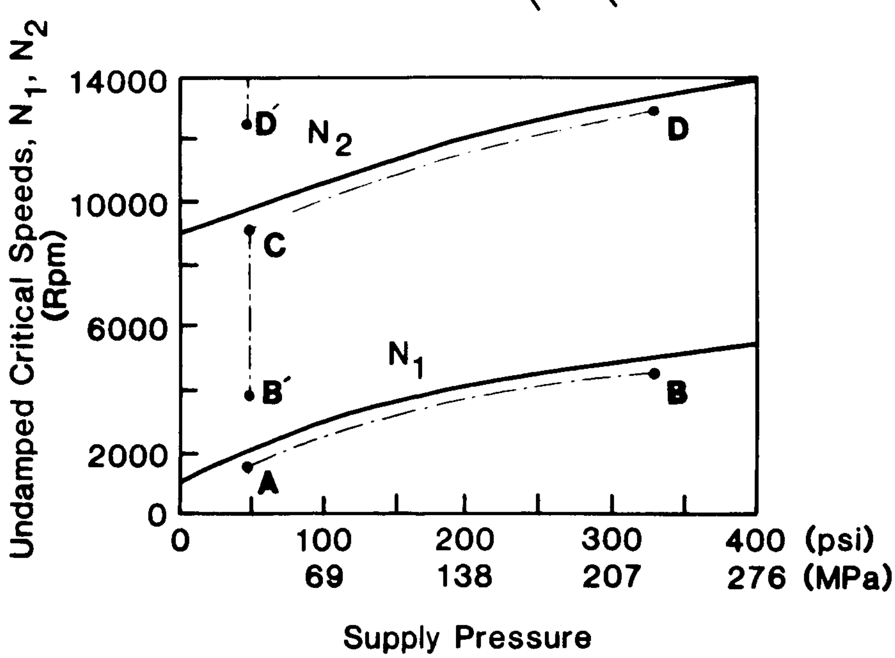
In parallel with perfecting this general purpose test facility, we are also developing mathematical and conputational approaches for the controller. Published work in recent years have focused on control approaches based upon detailed a priori dynamic characteristics of the rotor system and these approaches has been successfully demonstrated in laboratory test setups. The approaches being researched at CWRU are focused on optimization (i.e., minimization) methods, not requiring a priori dynamic characteristics and thus are potentially much more robust and automatically adaptable to system changes and uncertainties in applications outside the laboratory.



ATTENUATION OF ROTOR VIBRATION USING CONTROLLED-PRESSURE HYDROSTATIC SQUEEZE-FILM DAMPERS

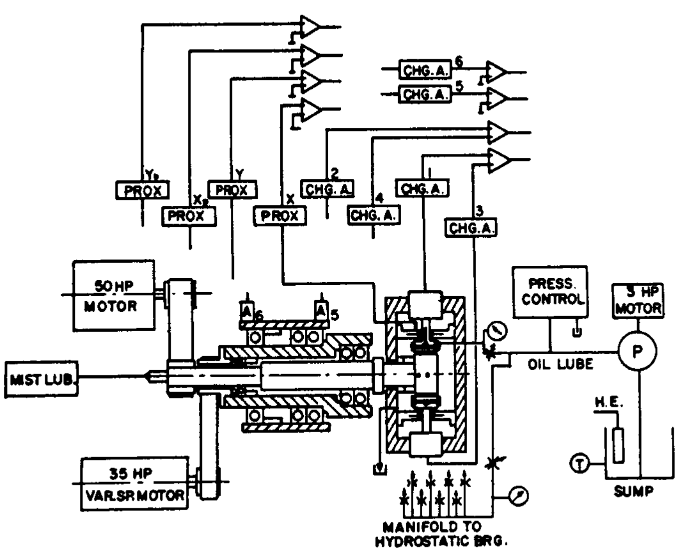
The use of fluid-film hydrostatic bearings to minimize flexible rotor vibration is a practical design approach with potential advantages. Computational results of the first phase of this work has been recently published by Adams and Zahloul (1987) and are summarized in the illustrations here. Essentially, the results demonstrate the degree of system controlled variability which could typically be provided on a variety of rotating machinery through the use of controlled-pressure hydrostatic bearings. The case shown below is based on a single controlled supply pressure, common to all hydrostatic bearing pockets. More elaborate scenarios would provide even more controllability.

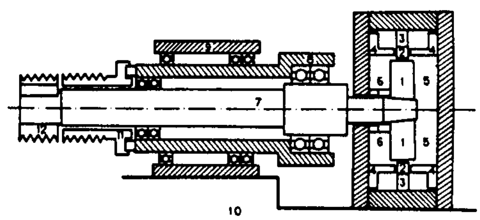




NEW GENERAL PURPOSE TEST FACILITY AT CWRU FOR MEASURING SEAL AND BEARING ROTORDYNAMIC CHARACTERISTICS

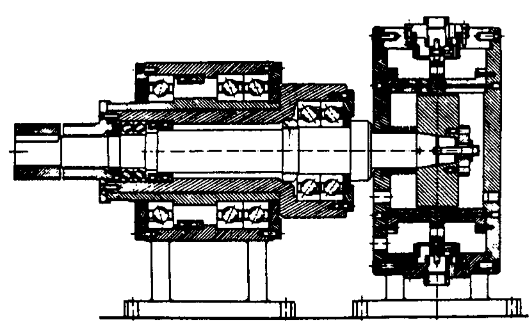
The illustration below is a schematic of a new test facility at CWRU for system identification research pertaining to both seals and bearings. The design of the apparatus is quite unique and the most advanced in its field, see Adams and Makay (1983). A controlled rotor vibration circular orbit is provided using the double-spool shaft configuration shown. The spindle is designed with an adjustable eccentricity (0-60 mils) between the inner and outer spindle centerlines. This provides independent control over spin speed and vibration orbit using two variable speed drives, and permits experimental studies in both linear and nonlinear regimes of any seal or bearing tested. This facility also contains an eighteen stage centrifugal pump with a design output of 50 gpm at 450 psi. This pump is used to subject tested seals to actual pressure/flow conditions of the intended application.





1 - Test rotating element
2 - Test annulus ring
3 - Piezoelectric load cells
4 - Hydrostatic axial ring supports
5 - High-pressure compartment
6 - Low-pressure compartment
7 - Inner spindle rotor
8 - Outer spindle rotor
9 - Spindle housing
10 - Support base
11 - V-belt pulley
12 - V-belt pulley

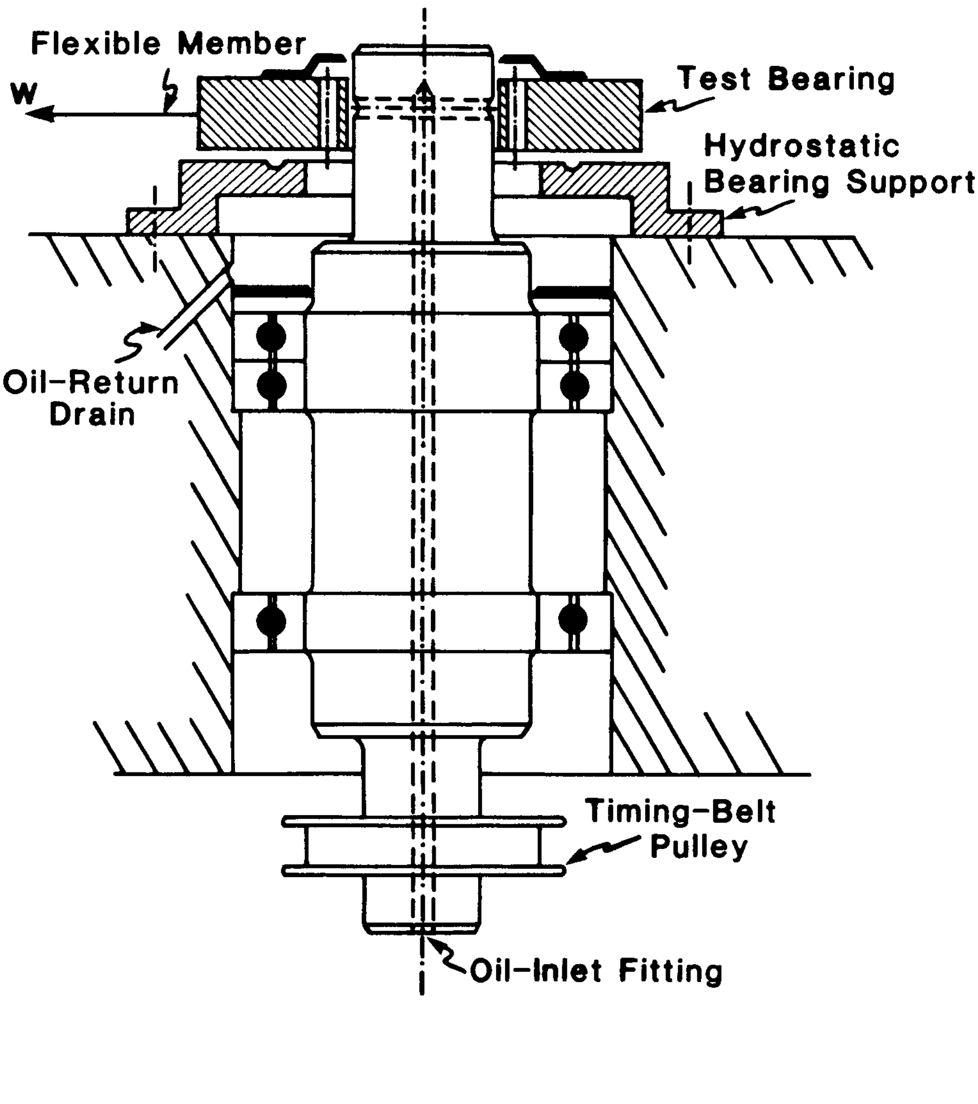
Conceptual Sketch of Rotor Support Component Test Apparatus



Assembly Layout of Rotor Support Component Test Apparatus

THE USE OF ROTORDYNAMIC INSTABILITY THRESHOLDS TO ACCURATELY MEASURE BEARING ROTORDYNAMIC CHARACTERISTICS

A re-examination of rotor-bearing dynanic instability has led to a fresh approach that has been shown to significantly improve the measurement accuracy of journal bearing rotordynamic coefficients. The approach uses a two-degree-of-freedom system and has two major parts. First, bearing stiffness coefficients are measured using static loading. Second, measured orbital motion at an adjustable threshold speed is used to extract the bearing damping coefficients by inverting the associated Eigen problem. Below is shown the test rig design for this new experimental method. Detailed treatment is given by Adams and Rashidi (1985) and Rashidi and Adams (1988).



REFERENCES

Adams, M.L., and Makay, E., 1983, "Development of Advanced Rotor-Bearing Systems for Feedwater Pumps - Phase 3: Hardware Design and Fabrication," Electric Power Research Institute, EPRI-CS-3203.

Adams, M.L., and Rashidi, M., 1985, "On the Use of Rotor-Bearing Instability Thresholds to Accurately Measure Bearing Rotordynamic Properties," Trans. ASME, Journal of Vibration, Stress and Reliability in Design, Vol. 107 (4).

Adams, M.L., and Zahloul, 1987, "Attenuation of Rotor Vibration Using Controlled Pressure Hydrostatic Squeeze-Film Dampers," Proceedings of Rotor Dynamics Papers, ASME Vibration Conference, Boston

Rashidi, M., and Adams, M.L., 1988, "Accurate Prediction of Rotordynamic Stability Limits Using Bearing Dynamic Properties Extracted From a Controlled Instability Threshold Experiment," submitted for publication, 4th International Conference on Vibrations in Rotating Machinery,