TRC CONTINUATION PROPOSAL 2020-2021

Morton Experimental – 00128

by Jongin Yang jiyang@tamu.edu, Dongil Shin davshin@tamu.edu,
and Dr. Palazzolo a-palazzolo@tamu.edu

"The Lab was mandated to close for 3 months due to the Covid Pandemic. Consequently, the Morton tests were delayed. The lab is now reopened and testing is resuming"

INTRODUCTION AND JUSTIFICATION

(a) ***Morton Effect**:* Synchronous rotor instability phenomenon, known as the Morton Effect (ME) is caused by the temperature circumferential differential (ΔT) across the journal in fluid film bearings. The temperature difference bends the rotor and causes increased vibrations, which will continue to grow and drive the system unstable in certain conditions.

(b) ***Experimental Morton Effect***: The ME experiment involves measuring vibrations and the detailed journal circumferential temperature distribution with embedded RTD's and a slip ring at high speed. The ME experiment utilizes dozens of RTD sensors slightly beneath the journal surface to accurately measure the high spot to hot spot angle and ΔT across the journal. Our prior Morton rig (version 1.0) was designed only to measure the asymmetric temperature distribution around the journal due to an imposed synchronous orbit resulting from an eccentrically machined shaft. It could not produce the Morton synchronous instability (MSI). The current proposal is for continuing work on rig version 2.0 which was designed to produce MSI, and will be utilized for benchmarking the companion prediction software, and for providing possible remedies for the ME.

DELIVERABLES

Morton effect test rig (version 2.0) with measurement capability of (a) both journal circumferential and axial temperature (b) operating with various journal orbits, supply oil temperatures, supply oil flowrates, bearing lubrication methods, bearing clearance, rotor overhung configuration, etc. The rig is designed to produce the Morton effect, and allow for variations of rotor/bearing/support configuration or other operating conditions to investigate their influence on Morton effect.

Experiment report including (a) transient journal temperature in both circumferential and axial direction at various operating conditions (b) steady state analysis of journal vibration and temperature difference (c) summary of parametric recommendations related to suppressing the ME.

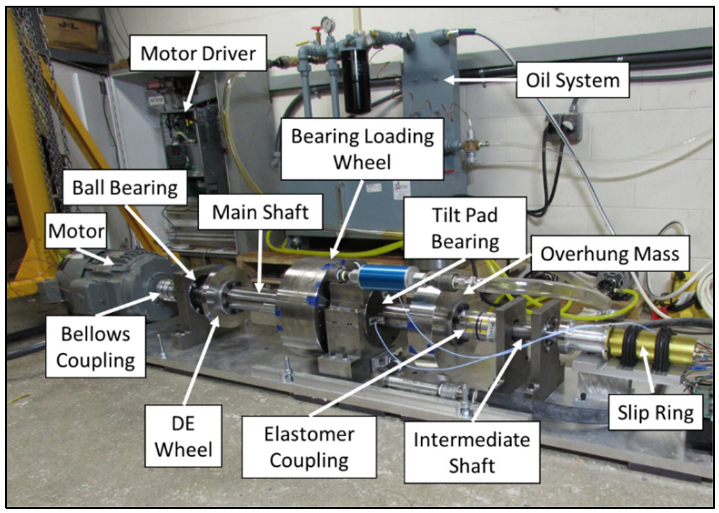
COST ($50,000)

1 Graduate Student, 12 months $2,200/mo. Salary, $200/mo. Insurance, 2.5% fringe on salary, approximately $13,000 tuition and fees, $9,000 for pressure dam bearing or squeeze film damper, enhanced instrumentation for bearing and shaft temperature measurement, and for anticipated shaft/rotor mod for controlling ME.

STATUS OF CURRENT WORK

(a) The TRC Morton software predicted rotor temperatures similar to test data for rig ver.1.0.
(b) Morton software used to design the shaft and system parameters for MSI in test rig ver. 2.0.
(c) Detailed design of ME test rig ver. 2.0, including both shafts and all bearing housings.
(d) Purchased and machined all parts and components for ver. 2.0 of the test rig. (Total cost $60,000).
(e) Installed test rig baseplate, including stiffness and frequency testing.
(f) Assembled main shaft and intermediate shaft subassemblies.
(g) Conducted free-free mode testing on the shaft with and without the wheels mounted to validate the model. Measured frequencies and mode shapes agreed with predictions.

(h) Cemented and tested all RTDs. Determined correction values for each RTD for improved accuracy.
(i) Installed electronics cabinet for safe and reliable control of the motor and pumps.
(j) Test rig assembled with oil and electrical lines connected.
(k) Conducted balancing and commissioning version 2.0 of the test rig to the speed of 4,500 rpm.
(l) With the rotor balanced up to 4500 RPM, the lift-off of the rotor was checked with increased speed.
(m) All probes for measuring vibration were installed with linearity checks.
(n) The rotor vibration and temperature effect were experimentally measured vs. supply oil temperature and unbalance variations at 4,200 RPM.
(o) All devices (ferrite rings, line filter, transmitters, and brush) for temperature noise reduction were purchased and installed. Ultimately, significant temperature noise reduction was achieved.
(p) The RTDs were installed, positioned, and epoxied into place in the pads.
(q) A temperature measurement system with a high sampling rate and low noise was established.
(r) Calibration coefficients for each temperature transmitter were experimentally and reasonably obtained.
(s) The temperature monitoring system was established to monitor supply and discharged oil temperatures, shaft and pad temperatures, and ΔT during tests.
(t) Developed MATLAB and LabVIEW codes for the post-processing of the measured data.
(u) Cameras were purchased and installed to monitor TPJB, slip ring, and oil gage during experiments.
(v) Measurement and simulation results showed good agreement at 3,000 and 4,200 RPM.



PROPOSED WORK 2020-2021

(1) Operate test rig with parameters at design values. If ME is evident, compare to predictions for validation. If not, vary the parameters to find configuration that produces ME then compare.
(2) Vary operating conditions including supply oil temperature, oil viscosity, bearing clearance, etc., for parametric study. Develop optimum operating parameters recommendation for ME suppression.
(3) Test various fluid film bearings including tilting pad bearings with different pads, nozzle type lubrication & loading direction, pressure dam bearings, partial arc bearings, etc.
(4) Test misaligned bearings by tilting the TPB housing.
(5) Incorporate a Squeeze Film Damper (SFD) to test rig and investigate the instability suppression.
(6) Add additional proximity sensors to measure pivot deflection and pad angles to compare with tilt pad software model results. Add proximity sensors along shaft to measure shaft bow.

The test rig version 2.0 is designed to produce the Morton effect, i.e., display large rotor vibration due to rotor thermal bow. The rig configuration (rotor, bearing, support) and operating conditions can be changed, aiming to seek for the most effective measures to mitigate the Morton effect. The Tilt Pad Bearings for version 2.0 were generously donated by Hunan SUND and Dr. Wenbiao Sun completely free of charge.

Our Related Publications

[1] Tong, Xiaomeng, Palazzolo, Alan and Suh, Junho, 2016, "Rotordynamic Morton Effect Simulation with Transient, Thermal Shaft Bow." *ASME Journal of Tribology*, 138(3), 031705. 2016 Best Paper Award, Journal of Tribology.

[2] Tong, Xiaomeng, Palazzolo, Alan and Suh, Junho, 2017, "A Review of the Rotordynamic Thermally Induced Synchronous Instability (Morton) Effect," *ASME Applied Mechanics Reviews*. Review Paper Invited by Editor.