TRC CONTINUATION PROPOSAL 2022-2023

Morton Effect Experimental – 00128

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INTRODUCTION AND JUSTIFICATION

(a) ***Newly Acquired Assets***: A new tilting pad bearing (TPB) was donated by SIEMENS, which will replace the previous TPB by Hunan SUND. 26 channels slip ring for temperature measurement is acquired that will be used to collect accurate temperature data from 26 RTDs in the journal. These main parts allow the construction of Morton Effect (ME) test rig that will exhibit consistent and repeatable data.

(b) ***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***: Our prior Morton rig (version 2) was able to produce evident ME at the designed speed; however, it could not replicate the occurrence of the ME due to unknown parameters. The current proposal is for continuing work on version 2 to reliably produce Morton synchronous instability (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 3.0) that reliably exhibits ME, 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 it allows for variations of rotor/bearing/support configuration or other operating conditions to investigate their influence on Morton effect.

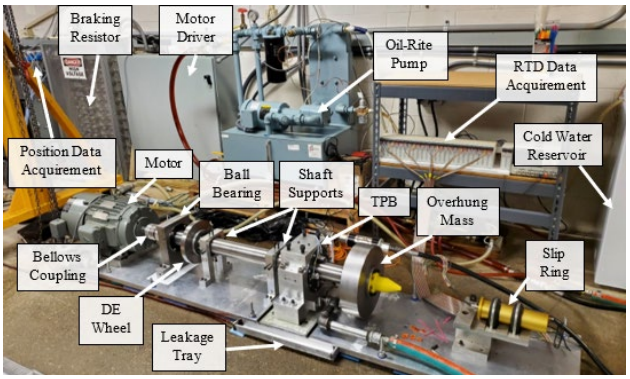
Experiment report including (a) transient journal temperature in both circumferential and axial direction at various operating conditions (b) steady state analysis of journal vibration and temperature difference (c) detailed description of changes in vibration profiles for each ME occurrences (d) summary of parametric recommendations related to suppressing the ME, one being the incorporation of automatic ball balancer.

COST ($50,000)

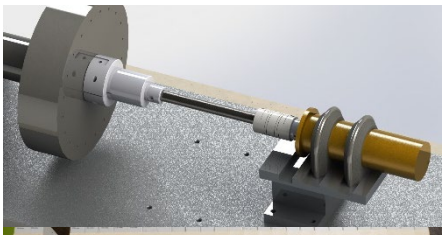
1 Graduate Student, 12 months $2,250/mo. Salary, $200/mo. Insurance, 2.5% fringe on salary, approximately $13,000 tuition and fees, $9,000 for material and machining cost for SIEMENS TPB housing, installation of new concrete slab, pressure dam bearing or squeeze film damper, enhanced instrumentation for bearing and shaft temperature measurement, and for anticipated modifications for suppressing ME.

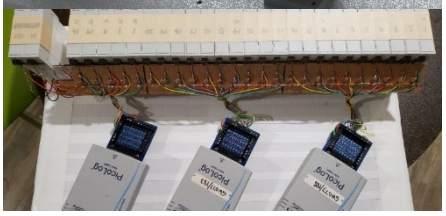
STATUS OF CURRENT WORK

1. Construction of the ME test rig – mechanical and measurement systems – to the designed specification is complete and validated.
2. Measurement systems are calibrated and its low noise output with high sampling rate is established.
3. Real-time monitoring system and data processing system is developed using MATLAB and LabVIEW.

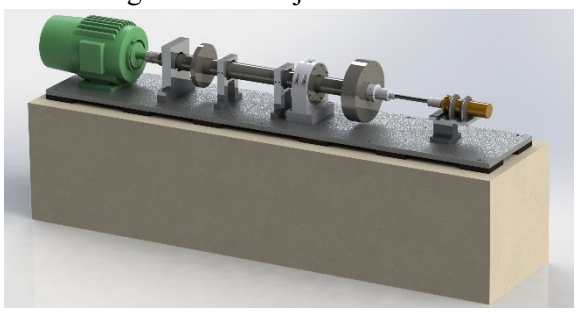


4. Observed ME with its major symptoms (large vibration, continuous amplitude and phase angle changes, hysteresis for run-up and cost-down processes) near designed ME speed.
5. NDE wheel is removed in order to show profound ME observation.
6. Oil leakage issue from the bearing housing from the start-up to shut-down is completely solved.
7. Metal shims inserted in between the TPB and its housing to create metal to metal contact; vibration from base plate to ground is isolated using absorber pads and rubber washers; motor shaft is aligned with the main rotor well below coupling specification limit; ball bearing and TPB is aligned, and the eccentricity path shows proper operation of the rig.
8. Defective RTD slip ring is replaced with a new slip ring, and its quality is checked; intermediate shaft for RTD slip ring is redesigned and machined.
9. RTD transmitters and Pico data loggers are rewired, relabeled, and reorganized for proper connection. The new transmitter and data logger panels show improved shaft temperature measurement.





10. Obtained SIEMENS TPB and designed its housing for test rig installation (Bearing crush: H7/k6).
11. Steady state simulation data for SIEMENS TPB show ME instability occurring past 4200 rpm.
12. A real-time journal alignment code is being built to monitor alignment in the journal real-time.



PROPOSED WORK 2022-2023

1. Complete the construction of housing for SIEMENS TPB.
2. Complete the installation of the new concrete slab.
3. Demonstrate real-time journal alignment code for real-time monitoring of the alignment in 3D.
4. Advance Morton effect software utilizing test data.
5. Install oil supply temperature monitoring system to set the supply oil temperature.
6. Vary operating conditions including supply oil temperature, oil viscosity, bearing clearance, etc., for parametric study. Develop optimum operating parameters recommendation for ME suppression.
7. Test various fluid film bearings including tilting pad bearings with different pad numbers, nozzle type lubrication & loading direction, pressure dam bearings, partial arc bearings, etc.
8. Incorporate automatic ball balancer to the test rig (on overhung mass) and investigate the instability suppression.
9. Incorporate a Squeeze Film Damper (SFD) to test rig and investigate the instability suppression.
10. 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 3.0 is designed to produce the Morton effect repeatably, 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 3.0 were generously donated by SIEMENS, Hunan SUND and Dr. Wenbiao Sun completely free of charge.