TRC NEW PROPOSAL 2020-2021

SCO2 Bearing Stiffness and Damping Test

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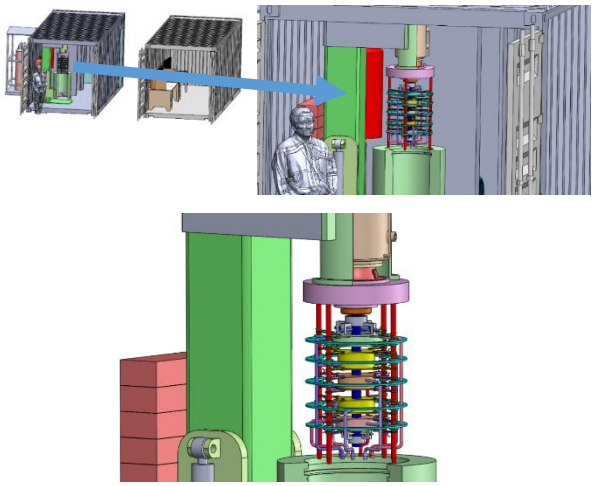
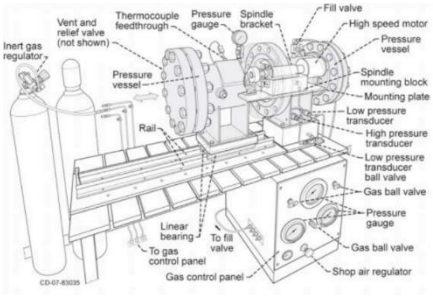
INTRODUCTION AND JUSTIFICATION

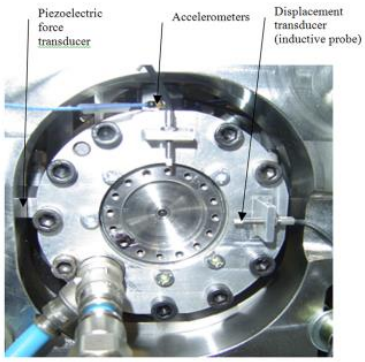
Power cycles based on Super-critical CO2 (SCO2) as an operating fluid promise improved thermal efficiencies, low cost, and environmentally-friendly features. Some SCO2 power cycle research has been reported [1-3], but the focus is solely on the performances of components such as compressor, turbine, and heat exchanger, not the supporting bearing. NASA Glenn research center published a research paper [4], which experimentally investigated the performance of the SCO2 bearing, but its results are limited to the static performance of its bearing. Based on the literature survey, it is clear that the experimental tests on the static and dynamic characteristics of SCO2 lubricated bearing have not been fully conducted yet. This new proposal aims at measuring both the static (load capacity) and dynamic characteristics (stiffness, damping, and mass coefficients) of the SCO2 bearing employing the bearing test rig*, which is currently being designed by Professor Alan Palazzolo's research lab for Department of Energy funded research. Among various types of gas bearings, the hybrid gas bearing type will be specifically tested in this proposal. Compared to solely hydrodynamic or hydrostatic bearings, the hybrid bearing type takes advantage of both hydrodynamic and hydrostatic forces. Therefore, hybrid gas bearings show much improved static load capacity and damping characteristics compared to other bearing types. Prediction software for SCO2 bearings will also be developed based on CFD program and MATLAB/C++ based software. This software will have linear rotordynamic analysis (generating damping ratio, Campbell diagrams, and log decrement of a rotor-bearing system) with linearized dynamics coefficients of the SCO2 bearing, in addition to nonlinear transient simulation capability. The accuracy of the prediction software will be calibrated with the measured data from the rig. A high-fidelity CFD-based bearing model will also be developed, and its results will be incorporated into the MATLAB/C++ based software for further improved accuracy. The software will be provided to TRC companies with a user-friendly interface, user manual, and technical support.



*Current SCO2 test rig (design in progress)



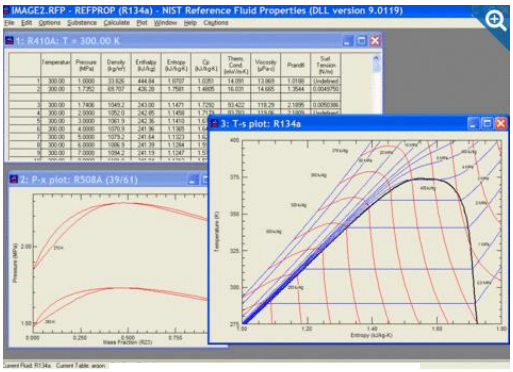
SCO2 test rig from NASA [4]



Hybrid gas bearing and instrumentation [6]

DELIVERABLES

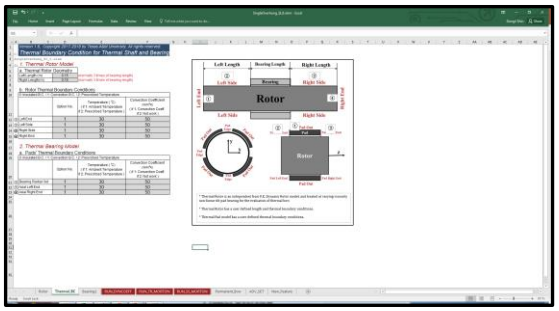
- SCO2 bearing test data of measured static and dynamic performances (load capacity, stiffness and damping coefficient, etc.)
- Test data for various hybrid gas bearings (Flexure pivot, spiral groove, herringbone groove, etc.)
- Provide TRC companies with static and dynamic performance test data
- SCO2 bearing performance prediction software
- Linear and nonlinear rotordynamic prediction software for a rotor supported by SCO2 bearing
- CFD analysis and machine learning-based codes for SCO2 bearing



Refprop program [5]

STATUS OF CURRENT WORK

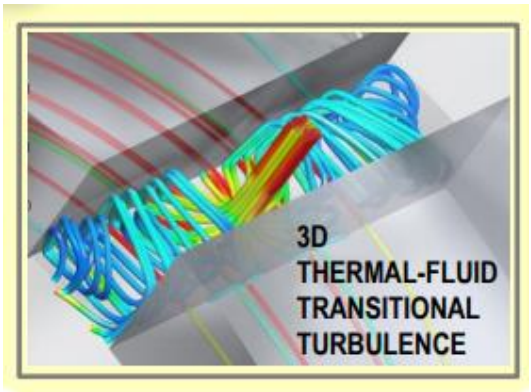
NEW PROPOSAL



Excel-based prediction software

HOW WILL THE WORK BE ACCOMPLISHED

- Use SCO2 bearing test rig currently being designed for Department of Energy funded project
- Test various types of hybrid gas bearings
- Model thermodynamic properties of super-critical CO2 fluid based on Refprop [5].
- Calibrate the accuracy of SCO2 bearing's mathematical models based on measured test data



CFD analysis of bearing

Budget for 2020-2021

1 PhD Student, Salary $2000/mo×12 months; $2500 for insurance and fringe benefits; $15000 tuitions and fees; $8500 for experiment. The total cost amount is $50,000.

References

1) Wright SA, Radel RF, Vernon ME, Rochau GE, Pickard PS. Operation and analysis of a supercritical CO2 Brayton cycle. 2010. Sandia Report No. SAND2010-0171.

2) Muto Y, Kato Y. Optimal cycle scheme of direct cycle supercritical CO2 gas turbine for nuclear power generation systems. J. Power Energy Syst. 2007;2(3):1060–73.

3) Ahn Y, Lee J, Kim SG, Lee J, Cha JE. The design study of supercritical carbon dioxide integral experiment loop. In: Proceedings of ASME turbo expo 2013: turbomachinery technical conference and exposition, san antonio, Texas; 2013.

4) Bruckner, R. J., 2009, "Windage Power Loss in Gas Foil Bearings and the Rotor-Stator Clearance of High Speed Generators Operating in High Pressure Environments," NASA Glenn Research Center, Technical Report No. NASA/ TM-2009-215826.

5) Rudloff, Laurent, Mihai Arghir, Olivier Bonneau, Sébastien Guingo, Guillaume Chemla, and Emelyne Renard. "Experimental analysis of the dynamic characteristics of a hybrid aerostatic bearing." Journal of Engineering for Gas Turbines and Power 134, no. 8 (2012).

6) Lemmon EW, Huber ML, McLinden MO. NIST reference fluid thermodynamic and transport properties—REFPROP v9.0," user's guide, NIST standard reference database 23. 2010.