Texas A&M HPRC Use in the Vibration Control and Electromechanics Lab

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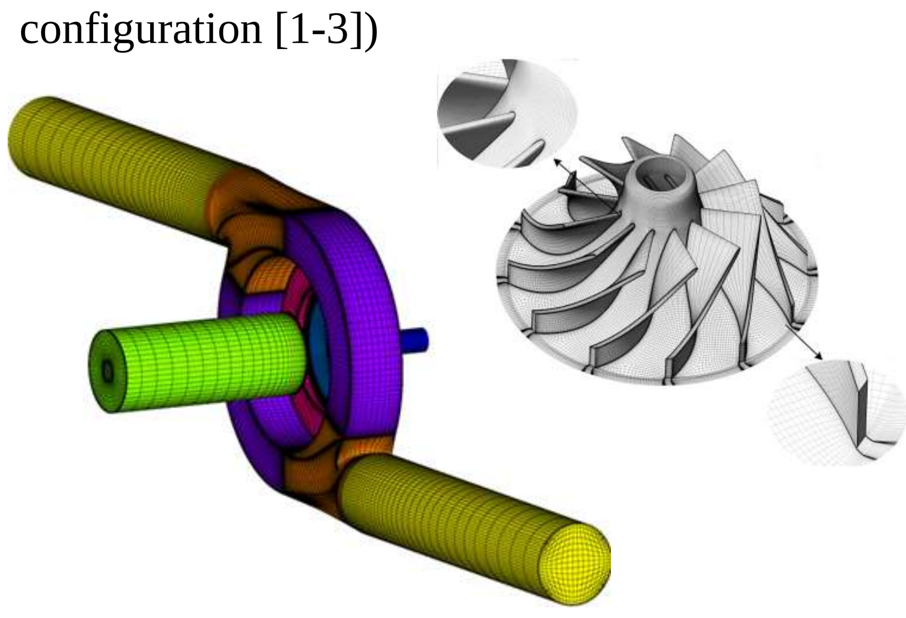
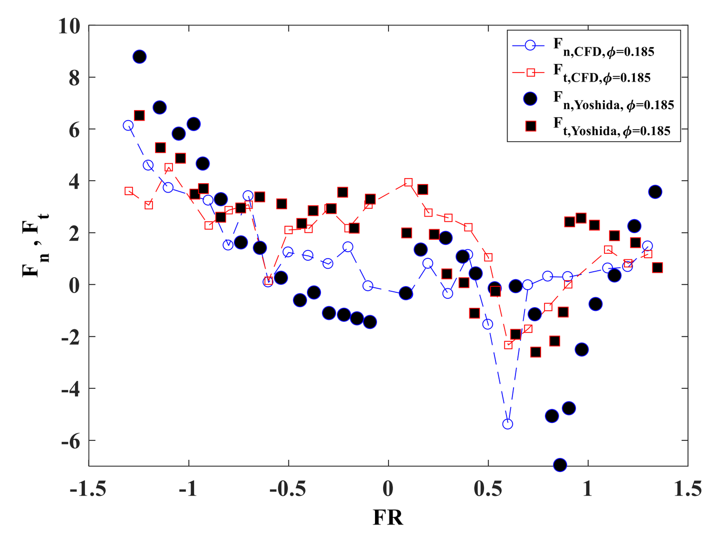
CFD-Based Impeller and Seal Rotordynamic Force Coefficients

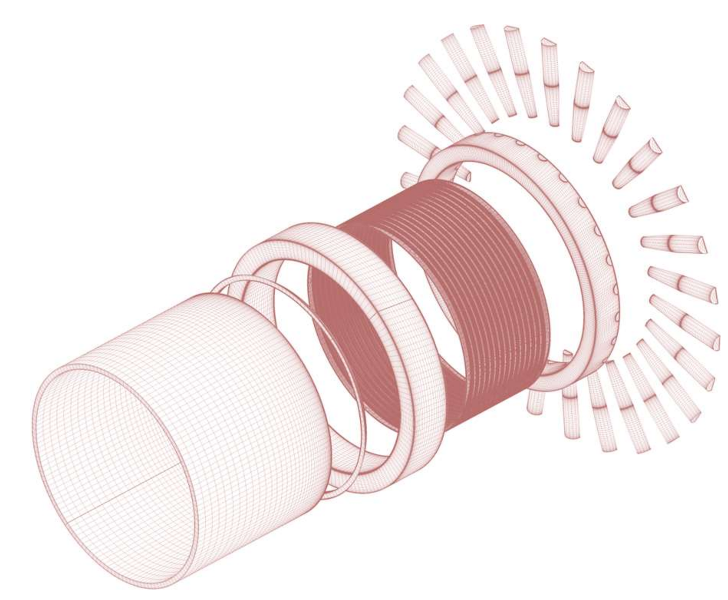
API 617 level-II analysis requires detailed computed rotordynamic coefficients for each component of the flow path if level-I criteria fails. Thus, calculating more accurate rotordynamic dynamic forces and coefficients are crucial to satisfy the API standards. This work includes use of the widely used, commercial CFD code CFX to calculate impedance curve, stiffness, damping and mass for entire flow paths of pumps/compressors including impeller, seal, diffuser and volute in presence of labyrinth seal swirl brakes and cavitation. A systematic approach has been developed to include non-axisymmetric components such as volutes and diffusers in the impeller model. Shrouded impeller, open impeller and grooved seal has modeled to extract rotordynamic coefficients. (Ada and Terra cluster, ANSYS CFX, up to 80 cores, 14 days running times for each geometry and/or flow configuration [1-3])



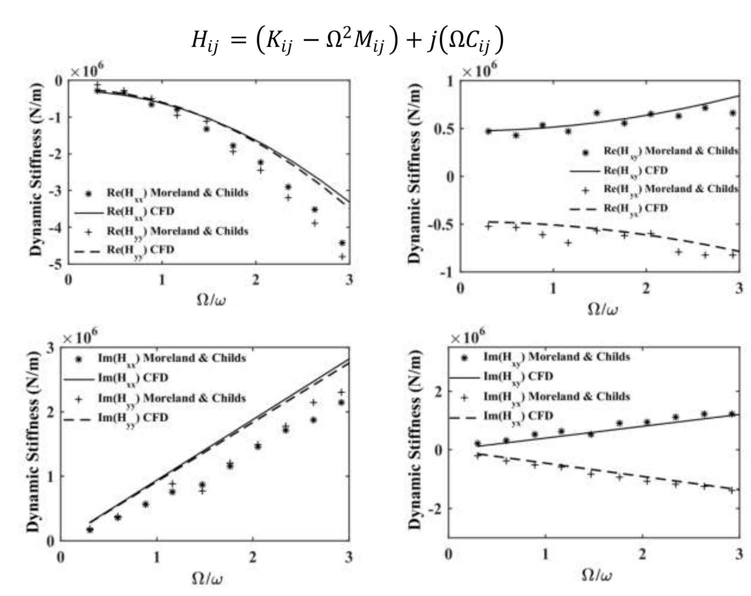
Open Impeller CFD Model (4,354,860 elements)



Rotordynamic Forces



Grooved Seal CFD Model (4,196,000 elements)



Dynamic Coefficients

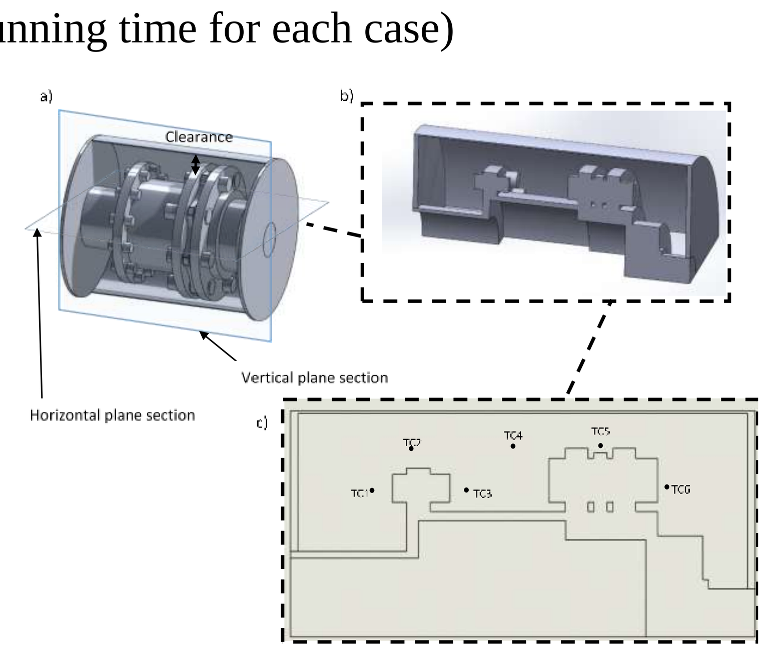
Publication: [1] Mortazavi, F. Palazzolo, A., "Rotordynamic Force Coefficients of Volutes and Diffusers for Improved Prediction of Turbomachinery Vibration", ASME J. of Vibrations and Acoustics., 2018. [2] Mortazavi, F., and Palazzolo, A., "Prediction of Rotordynamic Performance of Smooth Stator-Grooved Rotor Liquid Annular Seals Utilizing Computational Fluid Dynamics", ASME J. of Vibrations and Acoustics, 2018. [3] Mortazavi, F., Palazzolo, A., "A Transient Computational Fluid Dynamics, Phase Modulated, Multi-Frequency Approach for Impeller Rotordynamic Forces", ASME J. of Fluid Engineering, J. Fluids Eng 141(7), 071110.

Coupling guard power loss and heating

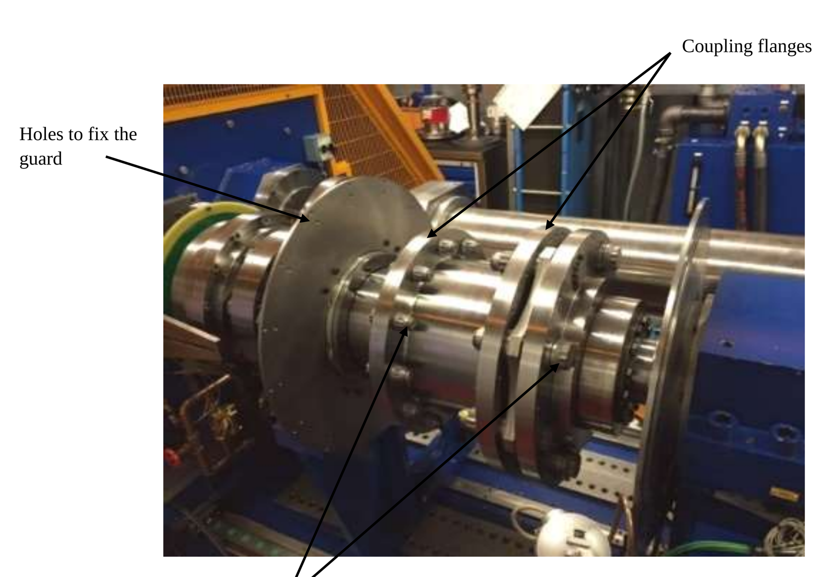
A coupling guard is a piece of equipment that encloses the coupling to protect industrial workers from the rotating coupling. Overheating of coupling guards characterizes a major safety and machine stop problem. Coupling guards may reach a very high temperature due to the windage power loss caused by the high rotating speed of the coupling. Based on the last version of API 671, the peak temperature for the coupling guard should not exceed 60℃.

This project proposes a machine learning model and an empirical formula to predict the maximum guard temperature and power loss. Machine learning models used a database from simulated CFD cases for different coupling guards under various conditions. Also, the project provides validation for the CFD models with experimental tests for different cases.

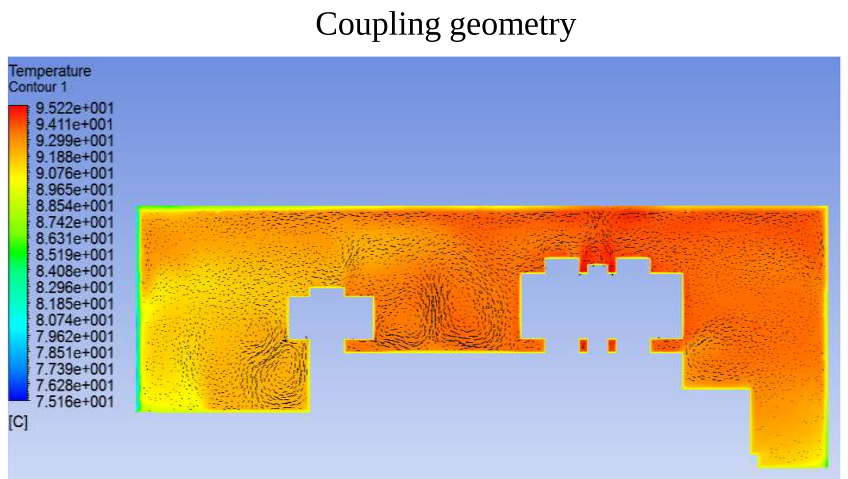
The suggested machine learning model uses eight different input parameters to predict temperature and power loss. HPRC support this project by high computational resources. For this project the simulation used .(Ada and Terra cluster, ANSYS CFX, 8 cores, 32 hours running time for each case)



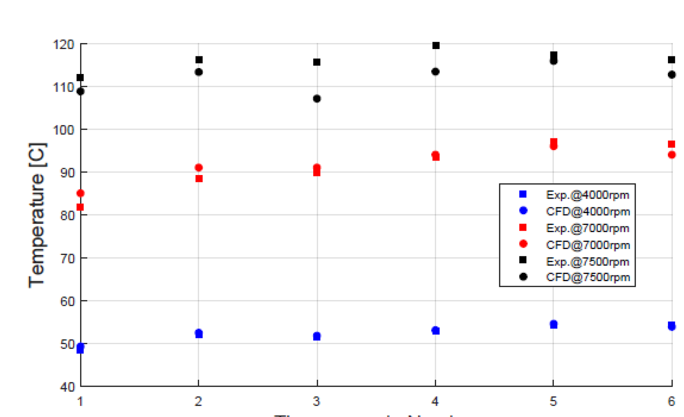
Coupling geometry



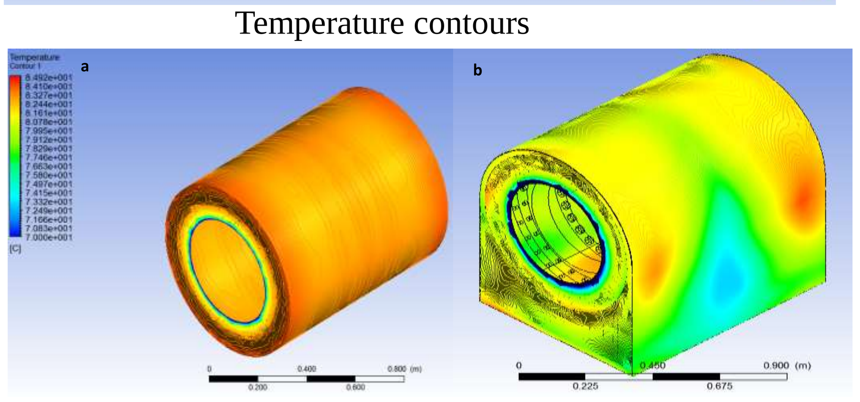
Test rig



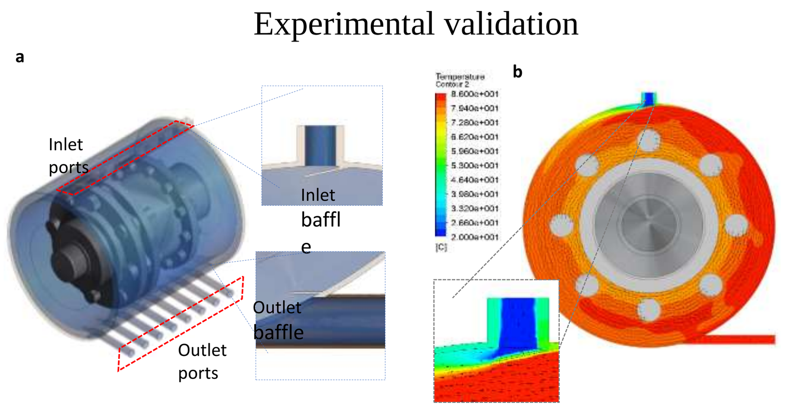
Temperature contours



Experimental validation



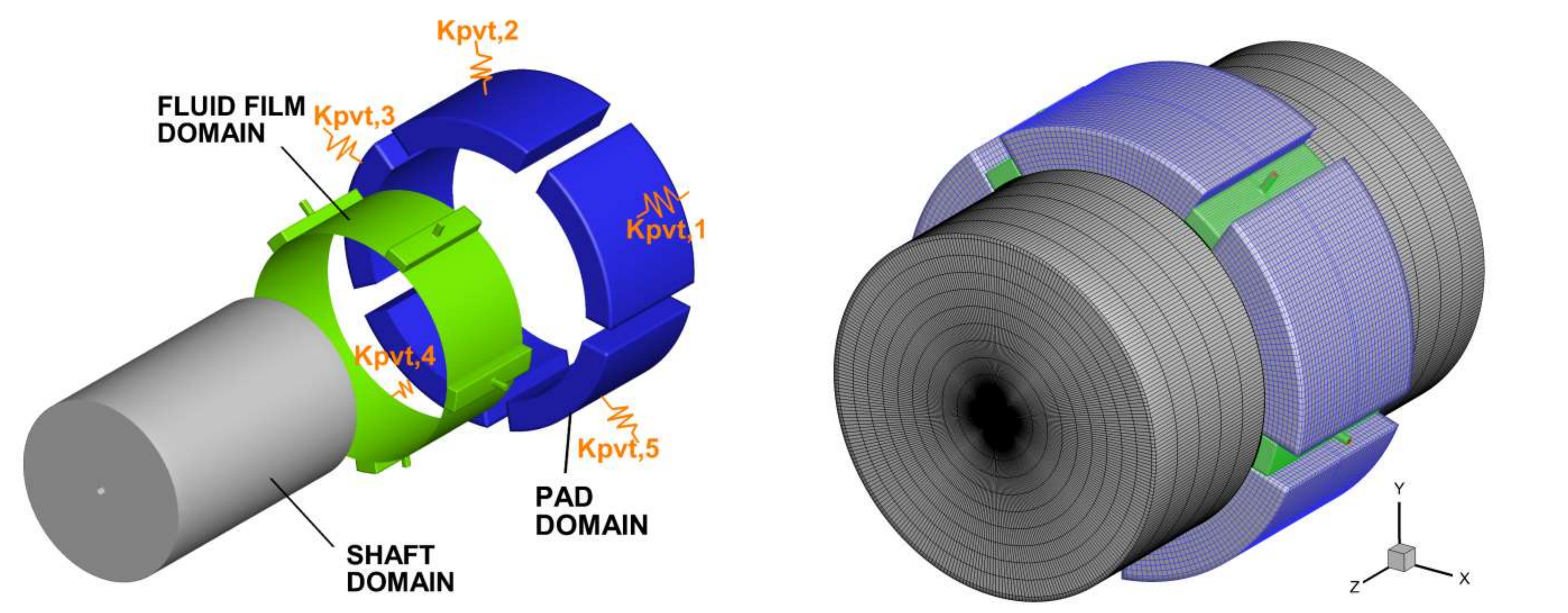
Effect of guard shape on the peak temperature



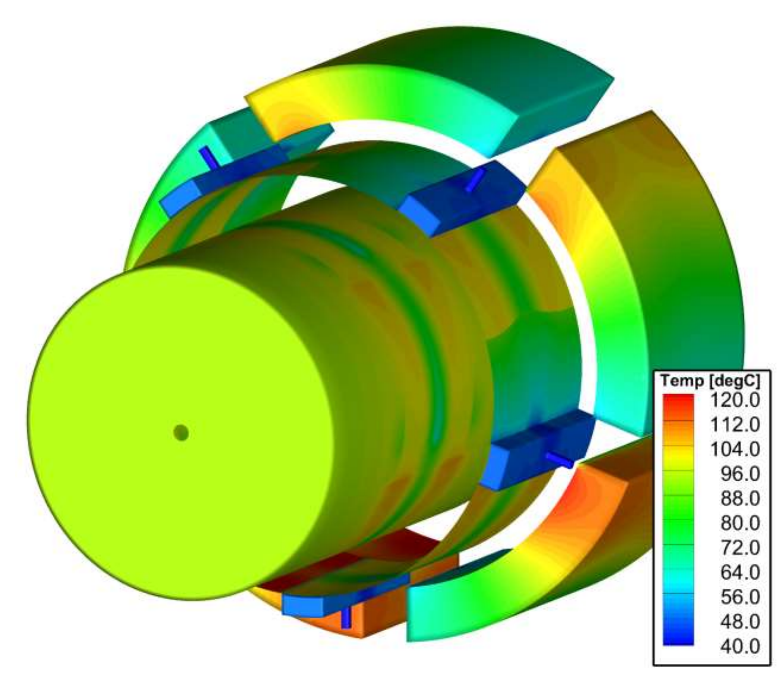
Coupling guard cooling

3D Thermo-Elasto-Hydrodynamic CFD Model of a Tilting Pad Journal Bearing

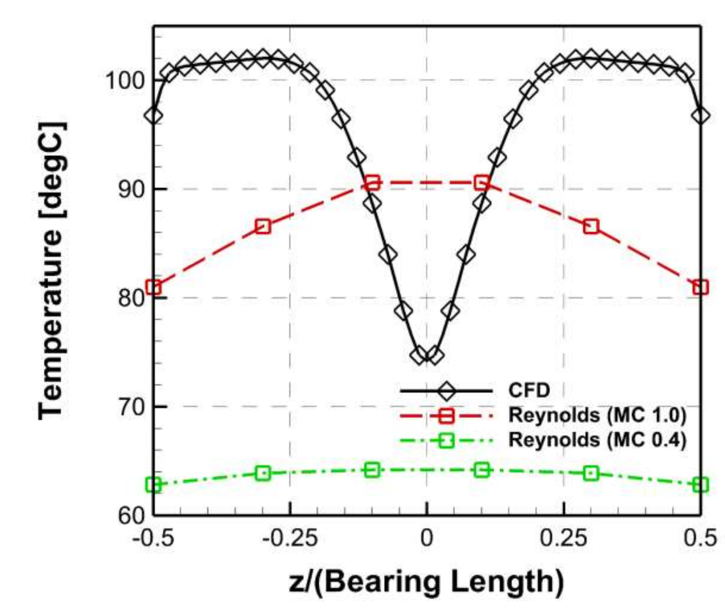
The conventional Reynolds model employs an oversimplified mixing coefficient MC representation of the 3-dimensional mixing effect of the BP (between pads) flow near oil inlet and heat transfer. On the contrary, the CFD model can be generalized by removing these fictitious boundary conditions on pad inlets and outlets and instead models the flow and temperature between pads. This study showed that the conventional MC approach could lead to a significant drawback when comparing to the CFD model, including detailed flow and thermal modeling between pads. Thus, this research provided increased reliability of predictions. The CFD analysis for a tilting pad journal bearing is executed by HPRC computational resources.(Ada cluster, ANSYS CFX, 8 cores, 10 days running times for one operating condition[1-2])



Geometry and mesh of example TPJB: (a) Overview (420,108 elements)



Temperature at Shaft Surface



Circumferentially Averaged Temperature distribution

Publication: [1] Yang, J., and Palazzolo, A., 2019, "3D Thermo-Elasto-Hydrodynamic CFD Model of a Tilting Pad Journal Bearing-Part I: Static Response," ASME J. Tribol., 141(6), 061702. [2] Yang, J., and Palazzolo, A., 2019, "3D Thermo-Elasto-Hydrodynamic CFD Model of a Tilting Pad Journal Bearing-Part II: Dynamic Response," ASME J. Tribol., 141(6), 061703.

Stability of Non-Axisymmetric Rotor and Bearing Systems Modeled with 3D-Solid Finite Elements

Although rotors have been usually assumed to be axisymmetric in rotordynamic analysis, in reality, they are non-axisymmetric. In order to model non-axisymmetric rotors, 3D finite element method can be used. When both the rotor and the bearings are non-axisymmetric, the rotor bearing systems are parametrically excited. The Floquet theory can be utilized to determine the stability of solutions. To improve the computational efficiency, discretization and parallelization are used by taking advantage of Hsu's method. A stability analysis for an asymmetric Root's blower is performed with computational resources of Texas A&M High Performance Research Computing (Terra cluster, Matlab, 12 cores, 10 hours running times for 500 speed ranges).[1]

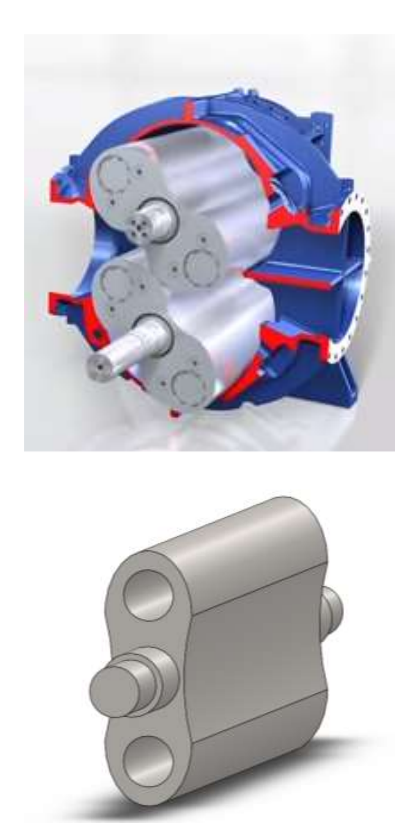


Fig. Root blower

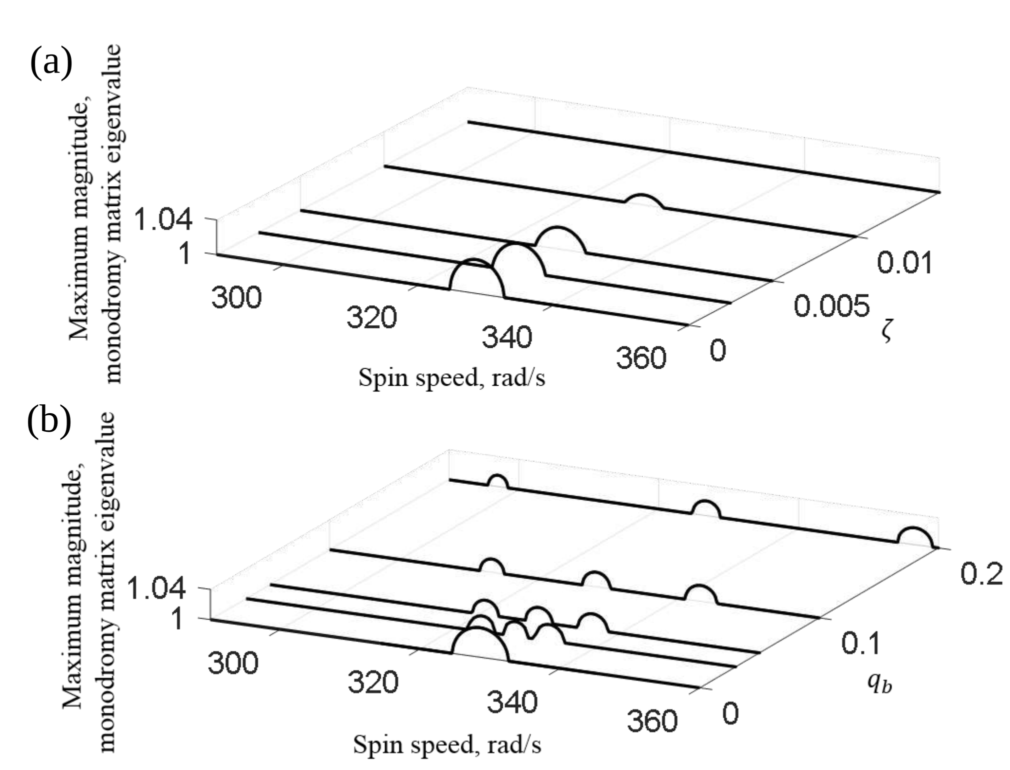


Fig. Stability waterfall plots of the root blower
(a) Instability vs. spin speed vs. damping ratio
(b) Instability vs. spin speed vs. bearing asymmetry

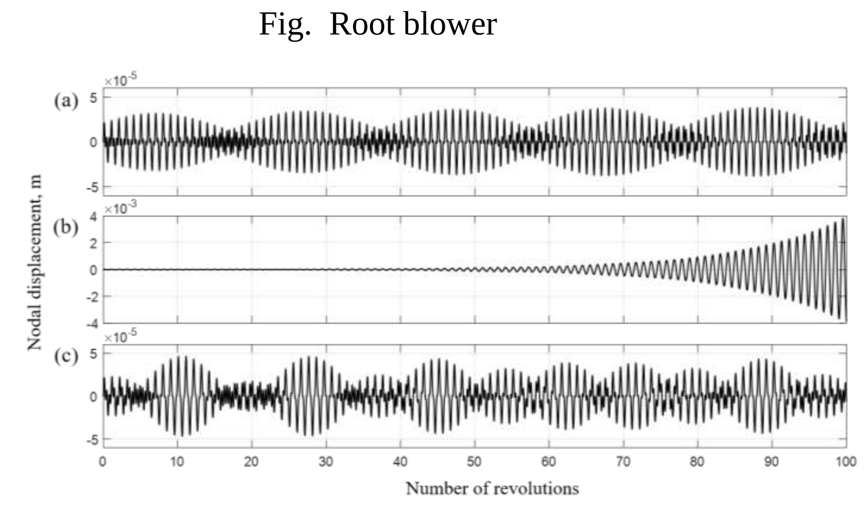


Fig. Time transient, numerical integration of the root blower

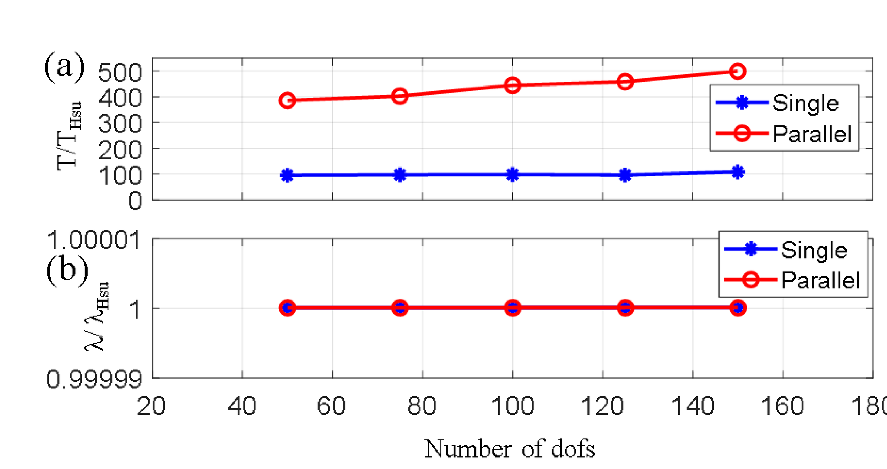


Fig. Computational efficiency improvement with parallelization

Publication: [1] Oh, J, Palazzolo, A. B., Hu, L., 2019, "Stability of Non-Axisymmetric Rotor and Bearing Systems Modeled with 3D-Solid Finite Elements," Journal of Vibration and Acoustics