TRC CONTINUATION PROPOSAL 2022-2023

CFD-Machine Learning Tilt Pad Bearing Software for Dynamic Coefficients and Mortan Effect-00147

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INTRODUCTION

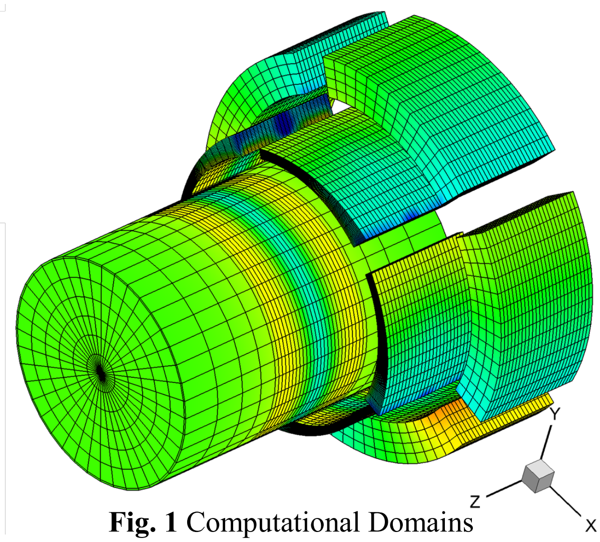

Fig. 1 Computational Domains (New Software)

When running high fidelity simulations for dynamic coefficients it is necessary to choose a mixing coefficient, however it is often unclear what should be chosen. The Mixing Coefficient (MC) is an uncertain and assumed parameter to determine the pad leading-edge temperature for a Tilt Pad Journal Bearing (TPJB, **Fig. 1**). Previous software employing the MC has shown limitations for calculating the rotor-dynamic coefficients because of its uncertainty and ignoration of a 2D-MC distribution. Our investigations have also shown that the classical Finite-Element-Method (FEM) causes an irregular temperature discontinuity problem near the shaft surface. Such problems lessen the accuracy of the predicted rotor-dynamic coefficients. Therefore, this research proposes a new "*CFD-Machine Learning (ML) Tilt Pad Bearing Software*" coupled with a CFD-based machine learning (deep autoencoder neural network) to consider the 2D MC effect at the leading-edge of a fluid-film. Furthermore, Finite-Volume-Method (FVM) based solvers for fluid domains are included in the new software to follow the local energy conservation rule instead of the FEM. It has been verified that the accuracy of the suggested software is equivalent to that of the verified and highly detailed CFD model and has a much faster computational speed.

COSTS $2,200 monthly salary for a graduate student, $5,000 for insurance and fringe benefits, $17,000 for tuition and fees, and $1,600 for travel and supplies. The total cost is $50,000

DELIVERABLES

(a) New High-Fidelity and Fast CFD-ML Tilt Pad Bearing Software with following benefits:
- ✓ Excellent 2D MC Prediction by Deep Convolutional Autoencoder Neural Networks (**Fig. 2**)
- ✓ High Accuracy Dynamic Coefficient Prediction without MC assumption (**Fig. 3**)
- ✓ Verified Ability for Dynamic Coefficient and Static Analysis
- ✓ Rotordynamic Coefficient and Static Analysis for Various Oil Injection Types
- ✓ Reliable 3D Temperature Distribution (**Fig. 1**) for Various Oil Injections
- ✓ Efficient Direct Solver with Significant Computational Speed Acceleration

(b) TRC Report including Detailed Modeling Methodology Employed in the Proposed Software
(c) Easy Set-up and User-friendly Excel-GUI with User Manuals
(d) Output as a stand – alone code and integrated in XLTRC2

STATUS OF CURRENT WORK

- New Lynix based mass batch traning software to enable the traning of exponentialy larger DOEs for increased ANN accuracy

- Regex based monotering software to ensure simulation accuracy
- Extream CFD simulation speed
- UI and output upgrades for ANN Dynamic Coeficient Software
- Develop New High-Fidelity and Fast CFD-ML Tilt Pad Bearing Software with following features:
  - ✓ 3D Thermal-Elasto-Hydrodynamic (TEHD) Model including Pivot and Pad flexibility
  - ✓ Application of 3D FVM to Fluid-Film Modeling to solve Local Energy Non-conservation Problem
  - ✓ Development of a Surrogate Groove Model via Deep Convolutional Autoencoder Neural Network
  - ✓ Combination of Surrogate Groove Models and TEHD Rotor-Bearing Model
  - ✓ Pre-trained Convolutional Neural Networks (CNNs) for 5 Lubricant Injection Cases
  - ✓ Significant Computational Speed Acceleration over full CFD approach

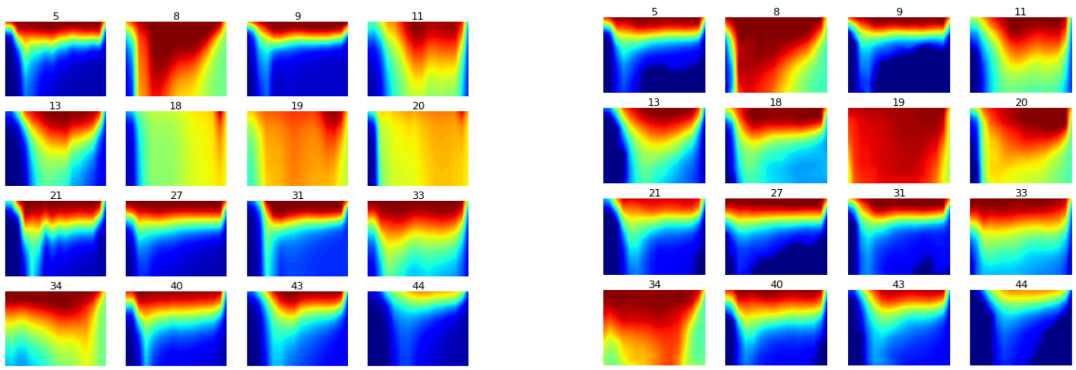

Figure: CFD predicted mixing coefficients on the left with ANN predictions on the right

PROPOSED WORK 2021-2022

(a) Continue to Improve the High-Fidelity Bearing Software (MATLAB code with Excel-GUI)
  - ✓ Add More Pre-trained CNNs for 2D-MC on Other Injection Types (Spray bar, etc.) and Investigate the Effect of the Bearing Performance (Dynamic Coefficients)
  - ✓ Expand Training Sets with Additional Data Generated by new software

(b) Development of TEHD-CFD Model for Various Bearing Types (Pressure Dam, Flexure Pivot, etc.)

(c) Application 2D-Mixing Coefficient to Morton Effect Software

(d) Expanding DOE's for existing ANNs to account for supply temperature, pad thickness, and between pad region size

(e) Residual Network Deep Convolutional ANNs to allow for increased accuracy and to allow for deeper neural networks, test other neural network designs to save on training requirements.

(f) Add XLTRC2 compatibility to ANN software

(g) Increase 2D temperature precision from 16x16 to 32x32

(h) Upgrade Simulation Management software further.

The ANN is only effective over the parameter ranges it was trained on. Thus, it is possible that a TRC member may have a case outside these ranges. In this case please simply contact me at my email with the ranges that are desired, and a custom neural network can be trained for your needs.