

Torsional/Lateral Rotordynamics Software with Variable Frequency Drives and Motor Eccentric Force Prediction – Project #: 258124-00089

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INTRODUCTION AND JUSTIFICATION

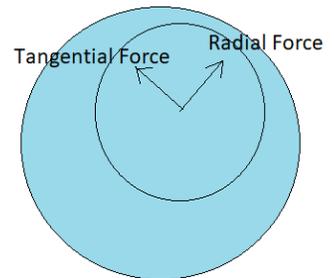
VFD-Motor Machinery Train Software:

- VFD-motor drive may cause shear failure of rotating machinery.
- Primary reason for failure is rich harmonic spectrum of the motor torque.
- VFD-Motor Machinery Train Software (VFD Torsional) provides the feature of simultaneously solving VFDs, motors, and mechanical gear trains with various open and closed loop control techniques using an easy to use Excel UI.



VFD Test Rig

- The VFD Torsional Software contains several key features not found in other industry standard software.
- The VFD Test Rig allows for unique features to be benchmarked in house. The features include, dynamic torque and torsional vibration predictions

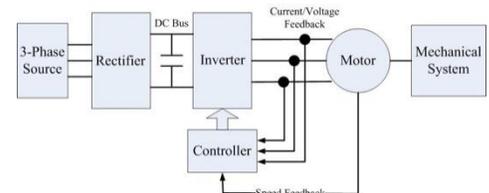


Motor FEM Software:

- Electric motors may have static eccentricity due to operating conditions.
- Static eccentricity results in unbalanced eccentric shaft forces in the radial and tangential directions.
- Eccentric shaft forces may result in an instability problem.
- Motor-FEM Software provides the feature of electromagnetic FEA of motors to calculate eccentric shaft forces.

Deliverables

The included deliverables for the project involve three software packages: VFD Torsional, Motor FEM, and Motor MEC. The software (programed in MATLAB) utilizes an easy to use, Excel based, user interface to input the various required parameters for the VFD, mechanical system, motor, etc. Another deliverable for this year is the VFD test rig to further benchmark the innovative features of the VFD Torsional software. Finally, a report which details the benchmarking data and results along along with the explanation of all software improvements and changes throughout the year, will be delivered.



STATUS OF CURRENT WORK

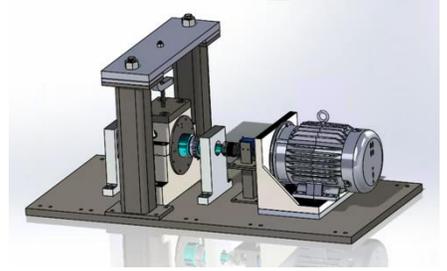
Excel GUI based software. Does not need MATLAB/ANSYS etc.

VFD Software

- Synchronous/Induction Motor Open/Closed Loop Simulations.
- Both steady-state and transient life-prediction and vibration response of mechanical systems with the pure torsional/coupled lateral-torsional model with user-defined/motor torque. Mechanical train may consist of shafts, couplings, gears, etc. Gears could be rigid/flexible with/without backlash and impact damping.

VFD Test Rig

- Complete test rig design including part drawings with necessary tolerances
- Designed to create dynamic torques and torsional vibration as predicted by VFD Torsion Software and measure response through a variety of embedded sensors



Motor MEC Software

- Radial and tangential magnetic forces and stiffness calculated using Maxwell stress tensor method.
- Bounded limit cycle with mass unbalance included. Combination of the synchronous whirling due to mass unbalance and the whirling limit cycle due to the motor radial and tangential forces.

Motor FEM Software

- Linear and Non-linear Electromagnetic FEM of induction and synchronous motors to calculate motor force.
- Simulate motor eccentric fault condition to calculate radial and tangential force.

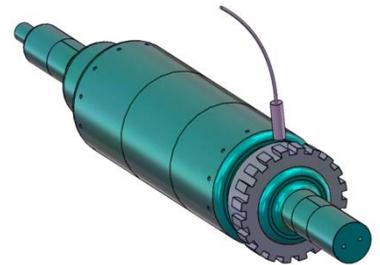
Case Study: Southwest Research Institute Motor-Compressor Model

- Theoretical validation of mode shapes and natural frequencies.
- Verification of presence of torque and shear stress harmonic around fundamental natural frequency during open loop control.

PROPOSED WORK

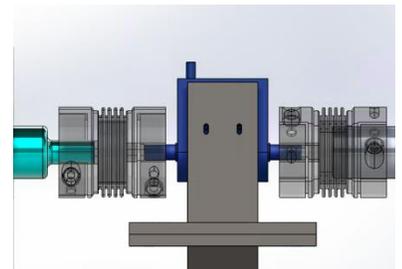
VFD Test Rig

- Fabricate and construct the VFD test rig based on current design
- Continue to generate industry level confidence in the VFD Torsion Software by benchmarking the dynamic torque and torsional vibration predictions to a wide variety of test rig experiments.



VFD Software:

- Formulas based transient torque input
 - Oscillating torque with defined average and pulsating components, which can be function of time (e.g. $\sin \omega t$) or function of speed (e.g. $k\theta^2$).
- Life prediction update
 - Strain-based life prediction as provided in XLRotor
 - Provide feature so that VFD Software predicts the weakest element in the system and calculates fatigue life
- Nonlinear torsional coupling model
- Include Sensor-less vector Control for Motors
- User defined initial condition for both electrical and mechanical system
- Add FFT option for any plot in the Output sheet of VFD Software



Motor FEM Software

- Evaluate motor equivalent circuit parameter
- Extend Source Options: Line-Line Voltage Source; Current Source and External Circuit.
- Extend windings types: multiple layers with delta connection/star with neutral connection.
- Add other types of motors: reluctance/hysteresis synchronous motor and wound rotor induction motor.
- Develop 3D FEM magnetic field modeler with option to import CAD file.

BUDGET FOR 2020-2021

- 1 MS student - \$2,000/mo. Salary × 12 months, \$3,000 insurance and fringe benefits, Tuition and fees \$16,000, equipment and supplies \$7,000. Total Cost: \$ 50,000