TRC CONTINUATION PROPOSAL 2020-2021

High Fidelity, Shaft Dynamics, Stress and Thermal Modeling

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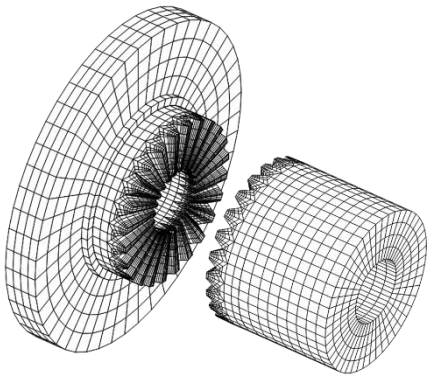


INTRODUCTION AND JUSTIFICATION

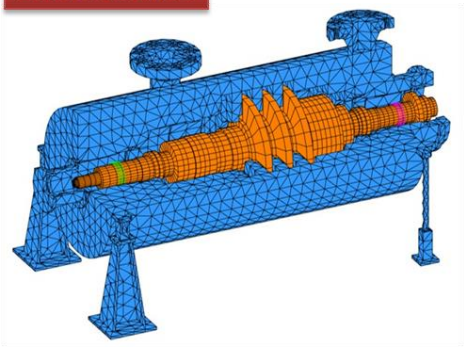
API, MIL, ISO and other standards help insure that predicted rotordynamic response coincide with those in the actual operating machinery, and are at acceptable levels. This requires high accuracy in predicting critical and instability onset speeds, with consideration of the rotor not being a single body, but instead an assembly of a shaft, disks, sleeves, thin blades, impellers, etc. with connections via fastening rods, Hirth/Curvic couplings and so on. This may cause predicted natural frequencies and responses to significantly deviate from their measured counterparts, if a beam-type finite element model FEM is employed for predictions. In these instances, a 3D solid finite element model with accompanying rotordynamic analyses is recommended to produce reliable predictions of critical speed, log dec, unbalance response, etc. This may also be done indirectly using equivalent beam properties obtained from the 3D FEM.

DELIVERABLES

Standalone 3D Solid Modeler TRC Software

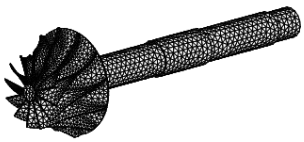
- Standalone 3D Solid Finite Element Rotordynamics software which runs under the EXCEL system umbrella without any other software (MATLAB, Fortran, ANSYS, …) required.
- Geometric input obtained from any solid model software outputs (SolidWorks, Catia, …)
- Multiphysics solid finite element analysis (thermal/structural/rotordynamics) with arbitrary shape geometries (thin blades and etc.) with multiple materials and connections (coupling/press fits).

Basic features

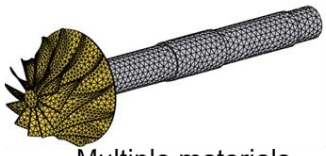


Axisymmetric rotor with Stator (TF)

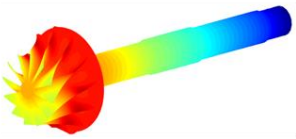
Arbitrary geometry rotor (.STL) from Solidworks, NX, etc.



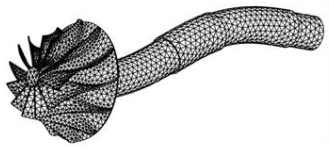
Automatic mesh generation



Multiple materials

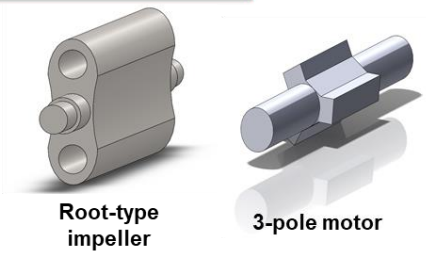


Thermal & stress analysis



Rotordynamics analysis

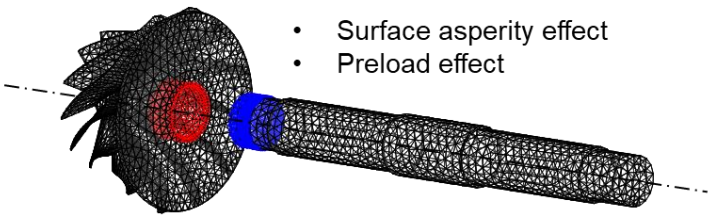
Advanced features



Root-type impeller

3-pole motor

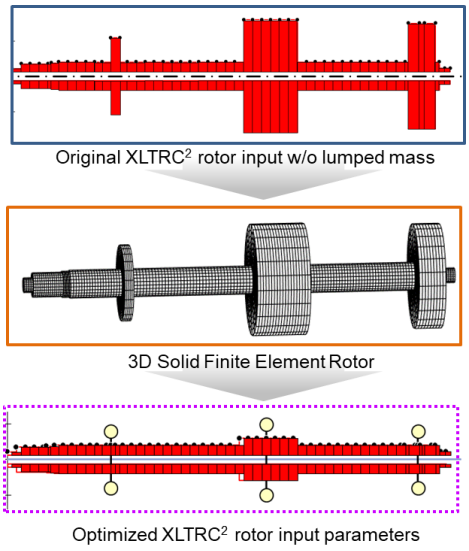
Parametric instabilities



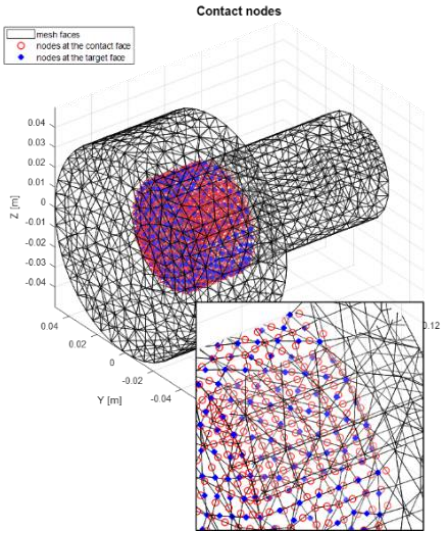
- Surface asperity effect
- Preload effect

Contact analysis for rotor assemblies

PROPOSED WORK



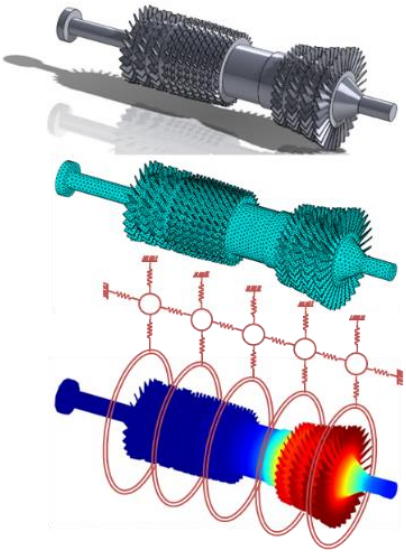
1) **Rotordynamics for preloaded rotor assemblies with Hirth/Curvic couplings**
    a. Improve mesh generation algorithm and Excel user interface of mesher
    b. Experimental tests for Hirth couplings
    c. Curvic couplings modeling capability (curved teeth face)
    d. Experimental tests for Curvic couplings
2) **Tuned/calibrated beam rotor model by using 3D solid finite element rotor model with butt-joint/Hirth/Curvic couplings**
    a. Develop a stand-alone preprocessing tool for generating tuned/calibrated general beam FE rotor models
    b. Develop an optimization algorithm for tuning/calibrating beam FE rotor model parameters by using 3D solid finite element rotor as a reference model
    c. Develop a user interface for interacting with XLTRC^2 rotor input
3) **Contact algorithm for non-conformal interface mesh**
4) **Advanced thermal analysis including working flows**
    a. Thermal/centrifugal stressed bladed vibration analysis
    b. Customized input/setting capabilities from TRC recommendations
5) **Improve SW computational efficiency and Excel user interface**



STATUS OF CURRENT WORK

Standalone Solid Modeler TRC Software

- A user-friendly EXCEL User Interface based simulation environment
- Axisymmetric 2D element/10-node quadratic tetrahedron/8-node hexahedron finite element rotor modeling capability
- Multiphysics analysis for thermal/structural/high-fidelity-rotordynamic analysis (natural frequencies, log dec, Campbell diagram, parametric instability and etc.)
- Parametric instability evaluation algorithm
- Butt-joint modeling capability with different levels of surface roughness and preload
- Butt-joint experimental test data
- Hirth coupling modeling capability with different levels of surface roughness and preload



BUDGET FOR 2020-2021

1 PhD student ($2,200/mo. Salary + $300 insurance) × 12 months, tuition and fees $18,000, machining cost and supplies $2,000,
Total Cost: $ 50,000