TRC CONTINUATION PROPOSAL 2016-2017

Solid Modeler Implemented Rotordynamics Software for Rotating Machinery with Flexible Casing and Support Structure

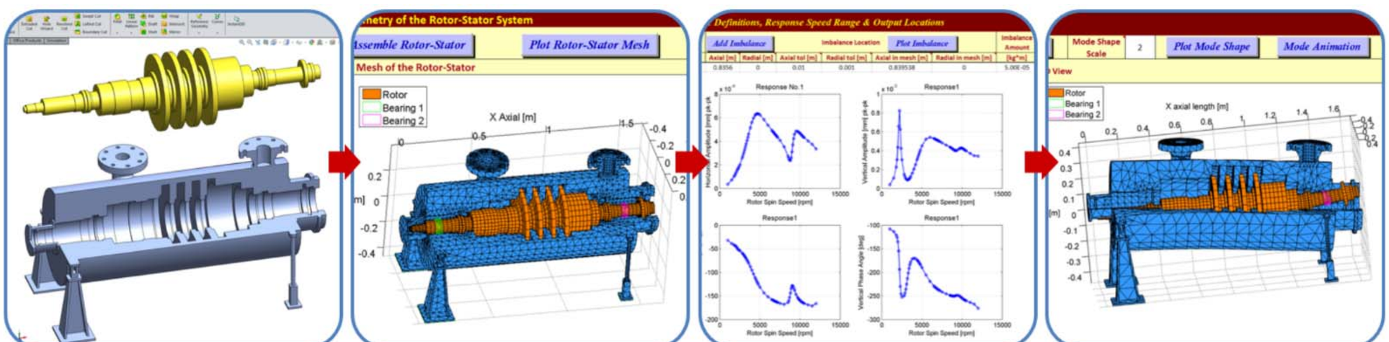
by Dr. Palazzolo a-palazzolo@tamu.edu and Mr. Lingnan Hu

INTRODUCTION AND JUSTIFICATION

The strict requirements of API, MIL, ISO and other standards require that rotating machinery predictions at the design stage closely match those measured on the test stand or actual installation. This is specifically important for predicting critical speeds and instability onset speeds.

Rotors and supporting structures are becoming lighter weight to reduce material costs, payload costs, power requirements, etc. The reduced weights of rotors translate into thinner walled, thinner disk rotors that may deform in non-beam like ways resulting in the measured natural frequencies departing significantly from beam model predicted values. The lighter weight supports become more flexible and may shift critical speeds of the combined rotor-support system. Composite shafts, shrink-fitted disks and coupling spool pieces may be destabilized by internal damping at rotating.

In these instances a solid element model is required to produce reliable predictions of critical speed, log dec, imbalance response, etc. Solid rotor and stator models are developed in CAD software, such as Pro/E, CATIA, NX, etc. Then, the CAD models are automatically imported into TRC software for rotordynamic analysis (figure below).



Solid Model in CAD Software | Solid Element Mesh Model in TRC Software | Rotordynamic Analysis in TRC Software | Pro-Process in TRC Software

DELIVERABLES AND PROPOSED WORK

- Stand-alone Solid Model Based TRC Software
  - Stand-alone solid model based rotordynamics software (compiled in C code) which runs under the new EXCEL system umbrella **without any other software** (Matlab, Fortran…, etc.) **installation**
  - Extend the current solid finite element (FE) model of metal (isotropic) rotors with internal damping to composite (orthortropic) rotors
  - Extend the current 3-D beam frame FE model of foundation/platform/ support structures by adding plate elements for flooring
  - Develop code for dynamic analysis of non-axisymmetric rotor with non-symmetric bearings, such as generator rotor or rotors with large blades
  - Develop code for blade-loss dynamic analysis of Turbomachinery
  - Use interface elements for modelling destabilizing micro-slip induced internal friction damping at pressed fit wheel locations

- Convert the current code to Python/C++ code for computational speed enhancement
- Integrate XLTRC functions in this Solid Modeler software will be integrated into XLTRC^2, e.g., generation of transfer-function casing/foundation/support model
- User's manual update and illustrative examples for the new features

➢ Field Verification Study

- Work with TRC member company to model rotating machines and compare simulation results with test

BUDGET FOR 2016-2017

1 PhD Student, (\$2,250/mo. Salary + \$197/mo. Insurance) × 12 months
Tuition and Fees \$9260
Supplies and Conference \$3,000
Total Cost: \$ 41,800

STATUS OF CURRENT WORK

(1) Stand-alone Solid Model Based TRC Software

- Features
  - Include gyroscopic moments, non-beam type deformation, disk flexibility, bending stiffness, translational and rotatory inertias, shear deformation, centrifugal stress stiffening effect, viscoelastic effects, internal damping, strain energy, axial load and torque
  - Include asymmetric stiffness and damping coefficients of bearings, seals, impellers and aerodynamic loads
  - Include coupling of rotating and stationary components like rotor and flexible casing/support
  - Use Guyan reduction method and modal synthesis to enhance computational speed
  - Adapted for most types of bearings, seals, impellers and aerodynamic loads in XLTRC^2
  - Provide greater flexibility than commercial rotordynamics software for upgrading code with new capabilities requested by TRC members, such as attaching force and moment dynamic coefficients to shaft, squeeze film dampers and magnetic bearings
- Capabilities
  - Accept solid model in CAD software, such as Pro/E, CATIA, Siemens NX, SolidWorks, Solid Edge, Autodesk Inventor, etc., and also enable user to define beam model
  - Generate MIMO (multiple-input and multiple-output) transfer-function casing/support model from solid CAD model or measured forced response data
  - Conduct rotordynamic analyses, such as predictions of critical speed, log dec, imbalance response, onset speed of instability, 3-D mode shape, etc.

(2) Investigation of Viscoelastic Rotor and Internal damping

- Both material and geometry of the rotor have an impact on rotor stability

(3) Validation of the MIMO Transfer-Function Casing/Support Model with Solid Element Model

(4) Development of 3-D Beam Frame Foundation/Support Structure

- Include flexible Timoshenko beam, rigid beam, and bearing