Towards Rotordynamic Analysis with COMSOL Multiphysics

Martin Karlsson

Innovation by experience

Excerpt from the Proceedings of the 2012 COMSOL Conference in Boston.

Background

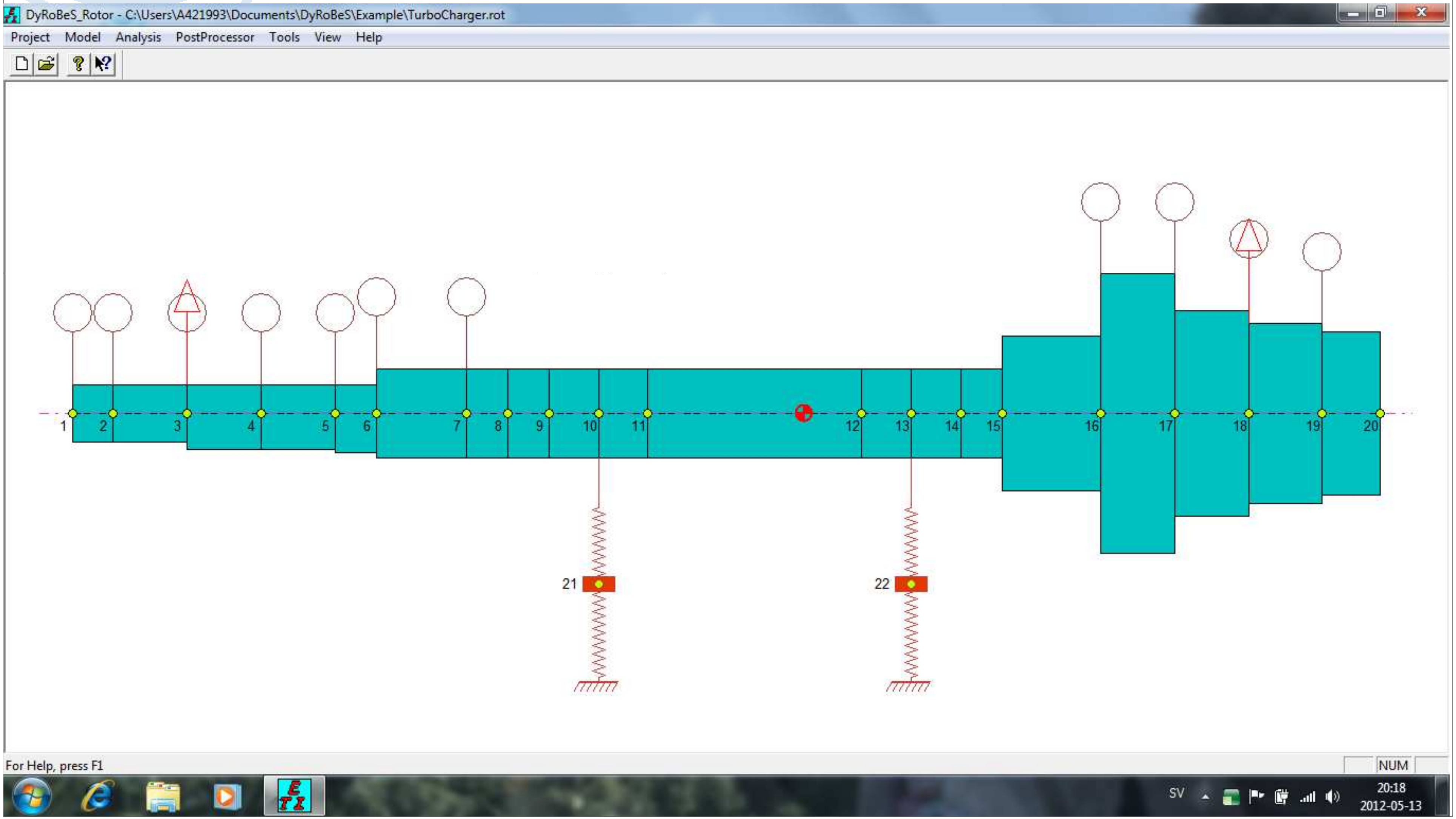
- Rotordynamic analysis are carried out with special purpose rotordynamic codes
- Rotating equipment is supported by a structure and is physically coupled with it
- In special cases – a combined analysis might be needed
- Simulation driven design

Innovation by experience

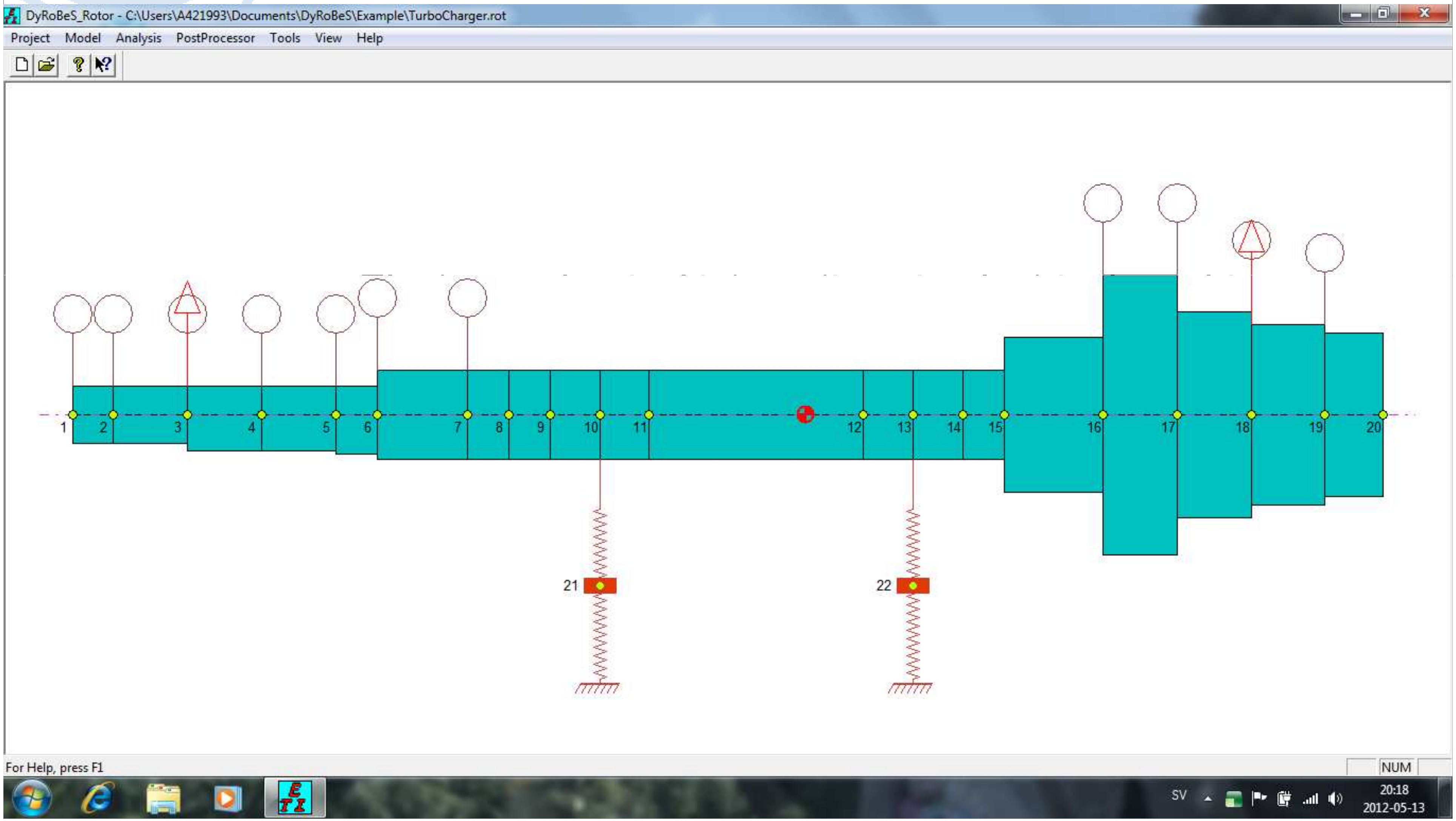
Objective

- What is needed to perform separate as well as combined rotordynamical and structural analysis of rotating equipment?

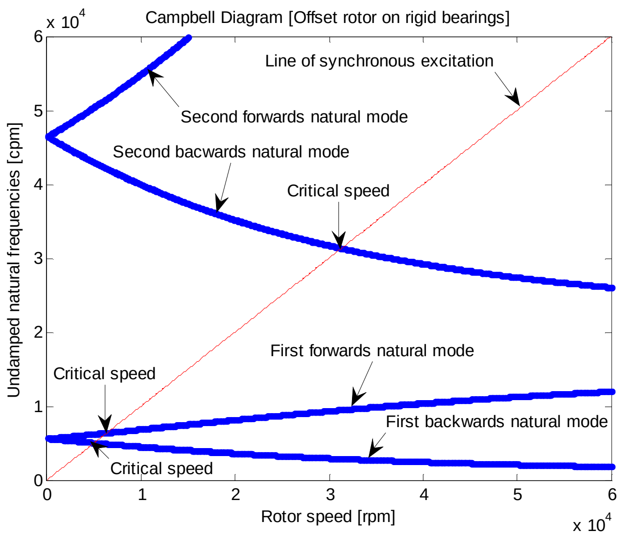
Rotordynamical modelling

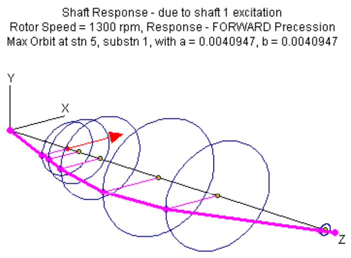


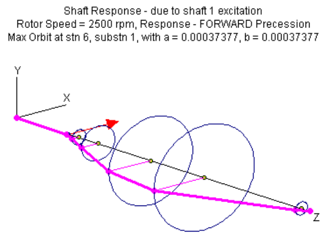
Multiphysical interactions

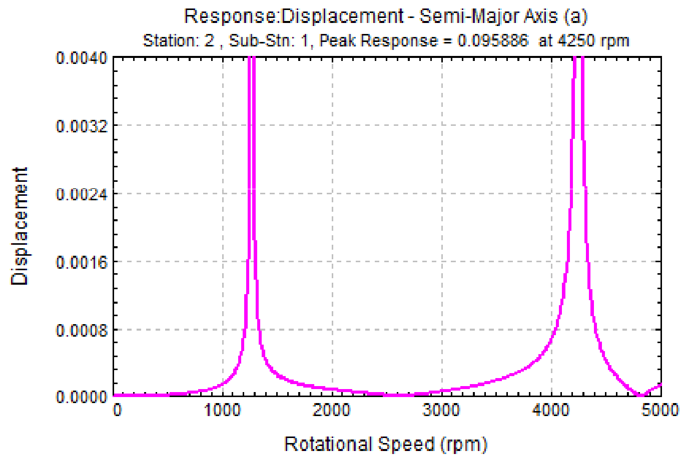


Typical analysis









Possible codes for combined analysis

- ABAQUS
- ANSYS
- NASTRAN
- COMSOL Multiphysics

COMSOL Multiphysics

COMSOL Multiphysics®

ELECTRICAL
- AC/DC Module
- RF Module
- MEMS Module
- Plasma Module

MECHANICAL
- Heat Transfer Module
- Structural Mechanics Module
- Nonlinear Structural Materials Module (New)
- Geomechanics Module
- Acoustics Module

FLUID
- CFD Module
- Microfluidics Module
- Subsurface Flow Module
- Pipe Flow Module (New)

CHEMICAL
- Chemical Reaction Engineering Module
- Batteries & Fuel Cells Module
- Electrodeposition Module
- Corrosion Module (New)

MULTIPURPOSE
- Optimization Module
- Material Library
- Particle Tracing Module

INTERFACING
- LiveLink™ *for* MATLAB®
- CAD Import Module
- LiveLink™ *for* SolidWorks®
- LiveLink™ *for* SpaceClaim®
- LiveLink™ *for* Pro/ENGINEER®
- LiveLink™ *for* Creo™ Parametric
- LiveLink™ *for* Inventor®
- LiveLink™ *for* AutoCAD®
- File Import *for* CATIA® V5

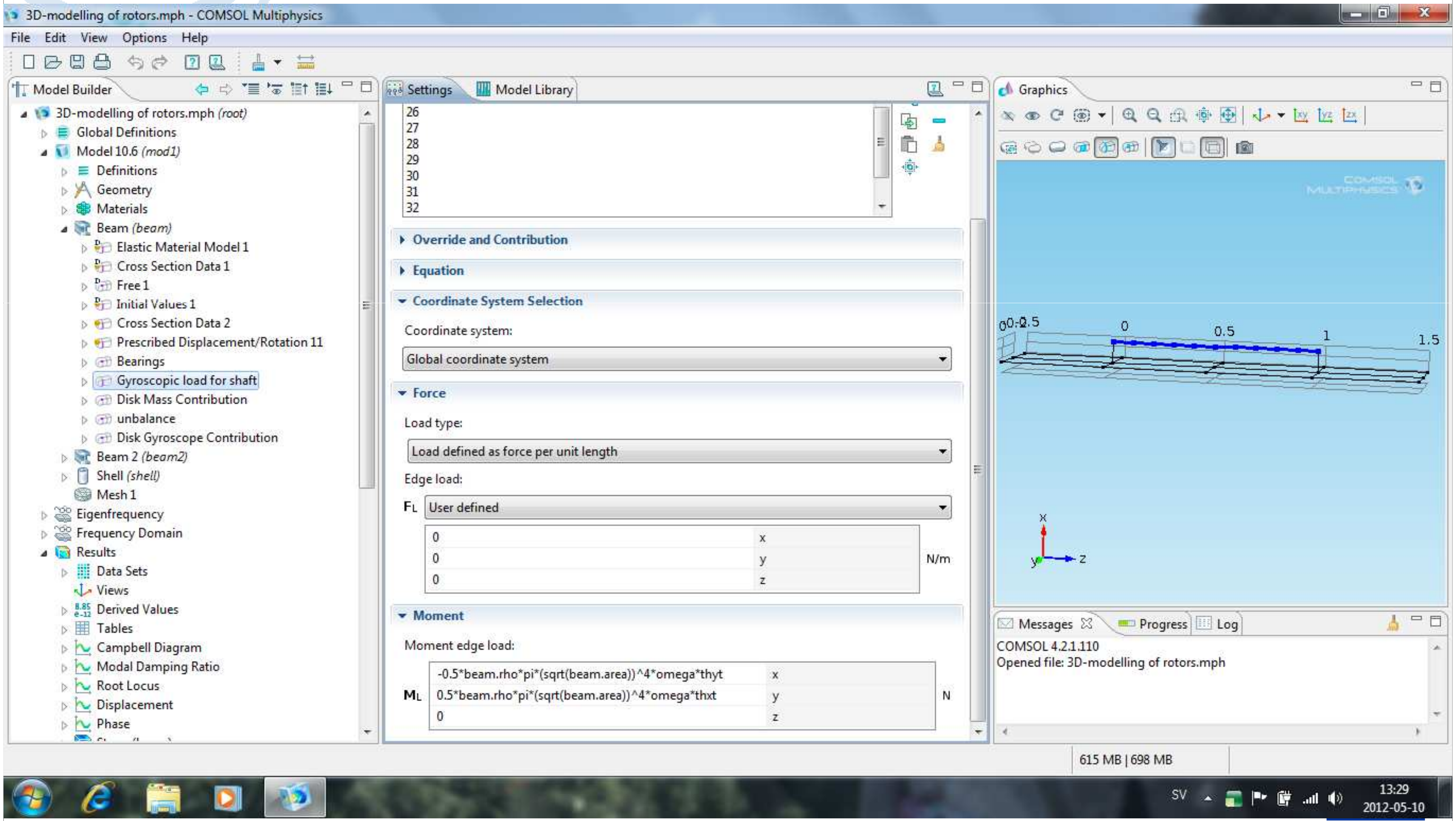
Implementation of rotordynamics

- Gyroscopic effect
- Rotordynamical coefficients
- Rotordynamical analysis by parametric sweep
- Calculations of rotordynamical coefficients

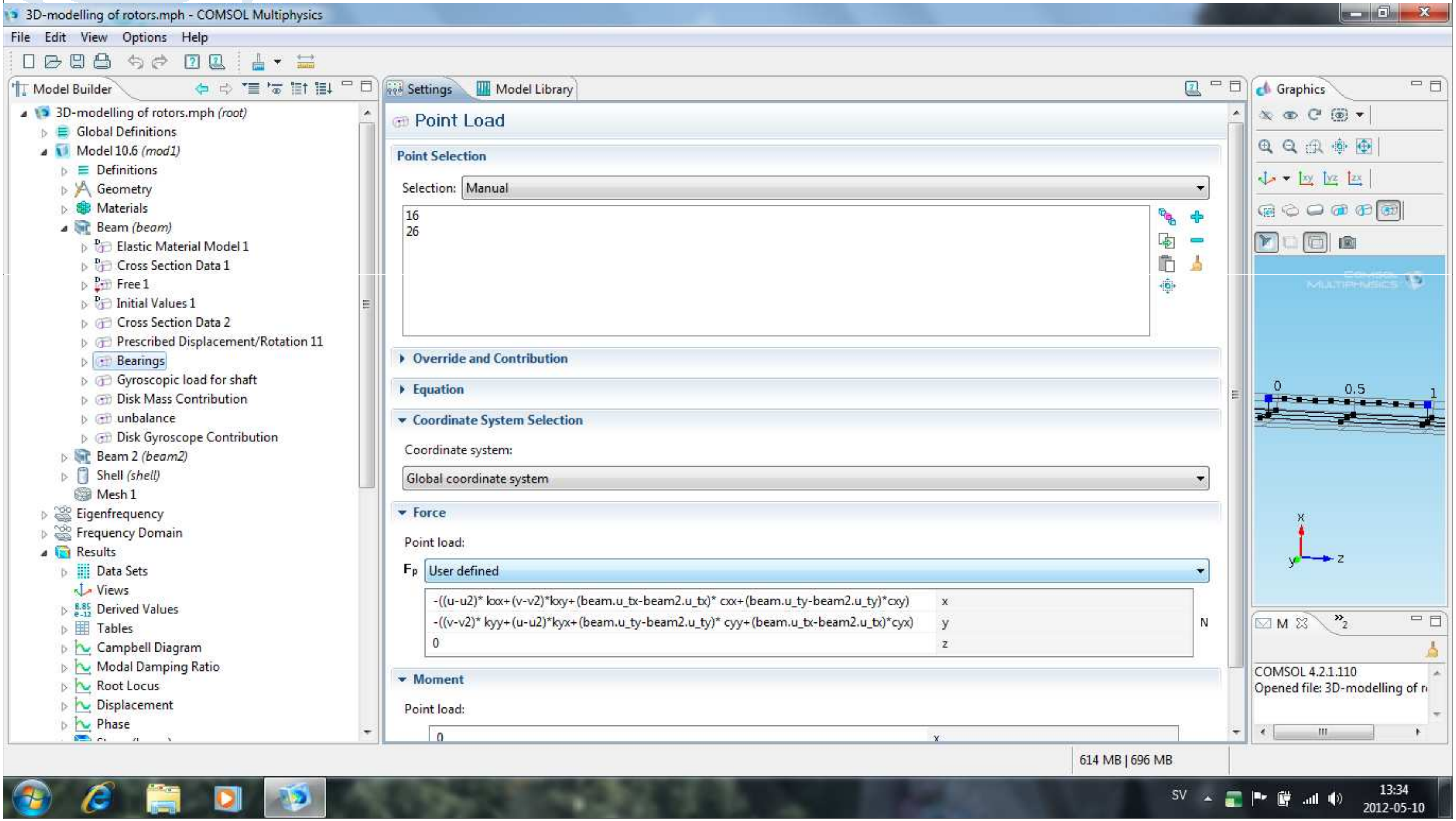
$$\bar{M}\ddot{\vec{x}} + \left(\bar{C} + \Omega\overline{\mathrm{G}}\right)\dot{\vec{x}} + \bar{K}\vec{x} = \vec{F}(t)$$

Innovation by experience

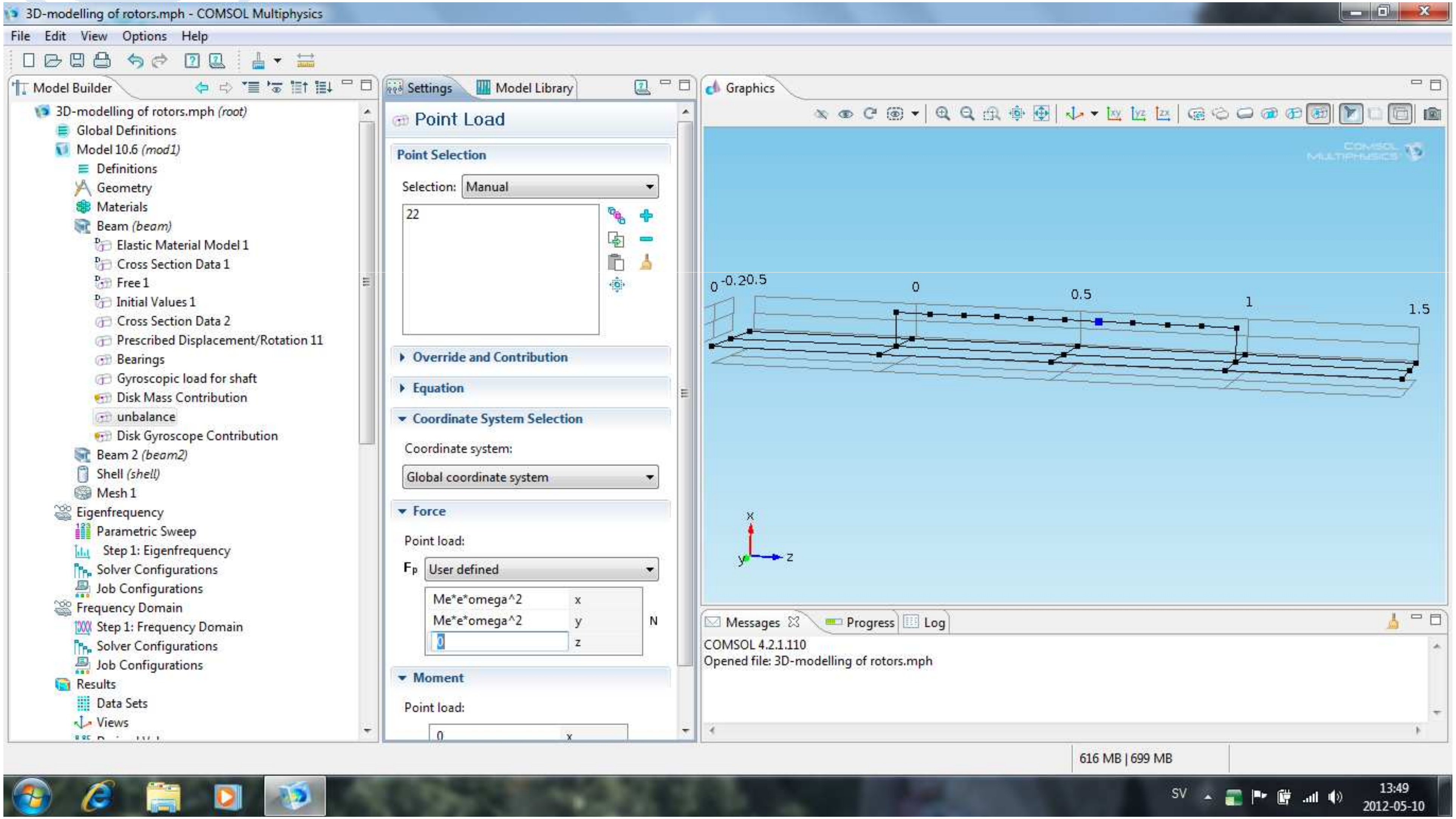
Gyroscopic effect



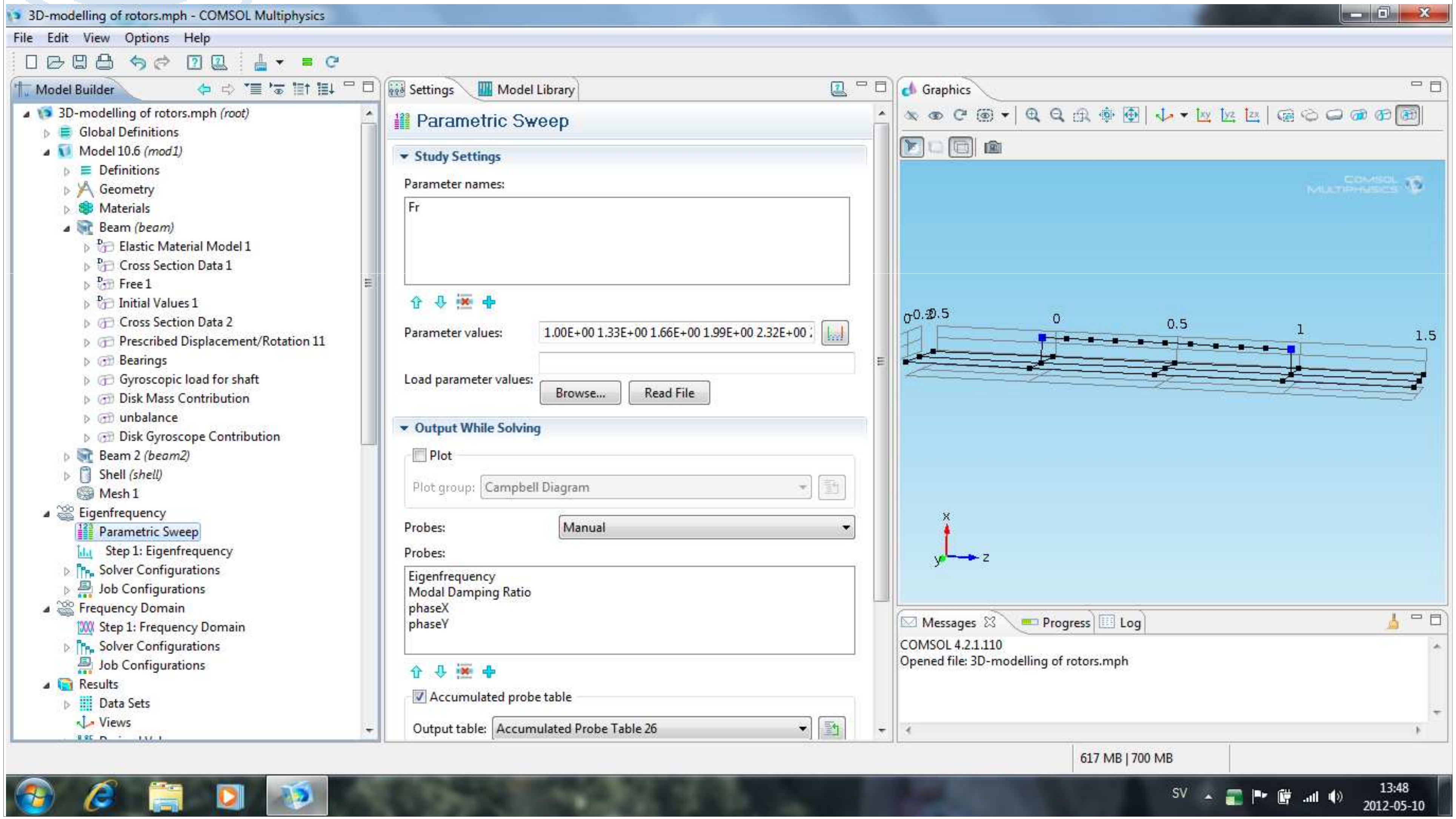
Rotordynamic coefficients



Excitations

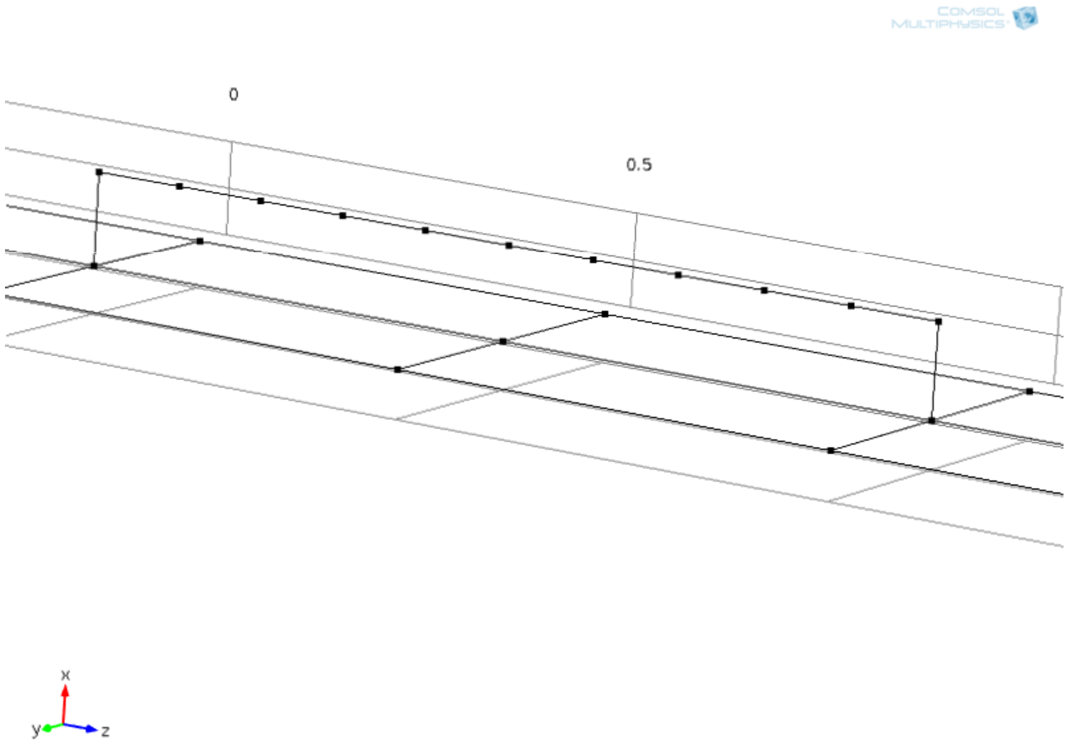


Solvers



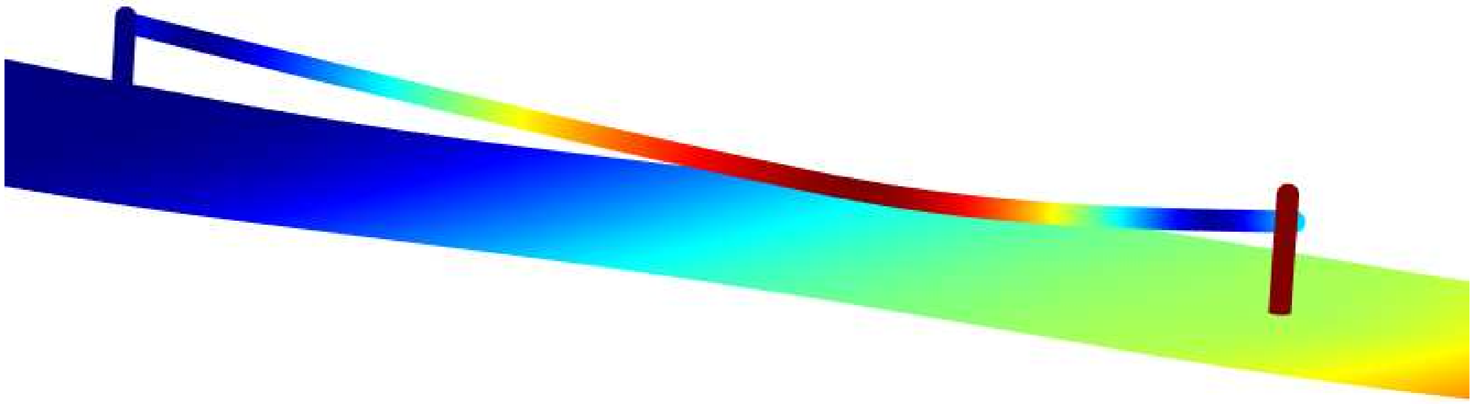
3D-modelling of rotors.mph - COMSOL Multiphysics
File Edit View Options Help
Model Builder
3D-modelling of rotors.mph (root)
Global Definitions
Model 10.6 (mod1)
Definitions
Geometry
Materials
Beam (beam)
Elastic Material Model 1
Cross Section Data 1
Free 1
Initial Values 1
Cross Section Data 2
Prescribed Displacement/Rotation 11
Bearings
Gyroscopic load for shaft
Disk Mass Contribution
unbalance
Disk Gyroscope Contribution
Beam 2 (beam2)
Shell (shell)
Mesh 1
Eigenfrequency
Parametric Sweep
Step 1: Eigenfrequency
Solver Configurations
Job Configurations
Frequency Domain
Step 1: Frequency Domain
Solver Configurations
Job Configurations
Results
Data Sets
Views
Settings
Model Library
Parametric Sweep
Study Settings
Parameter names:
Fr
Parameter values:
1.00E+00 1.33E+00 1.66E+00 1.99E+00 2.32E+00
Load parameter values:
Browse...
Read File
Output While Solving
Plot
Plot group: Campbell Diagram
Probes: Manual
Probes:
Eigenfrequency
Modal Damping Ratio
phaseX
phaseY
Accumulated probe table
Output table: Accumulated Probe Table 26
Graphics
0
0.5
1
1.5
x
y
z
Messages
Progress
Log
COMSOL 4.2.1.110
Opened file: 3D-modelling of rotors.mph
617 MB | 700 MB
SV
13:48
2012-05-10

Couple a rotor model to a structural model

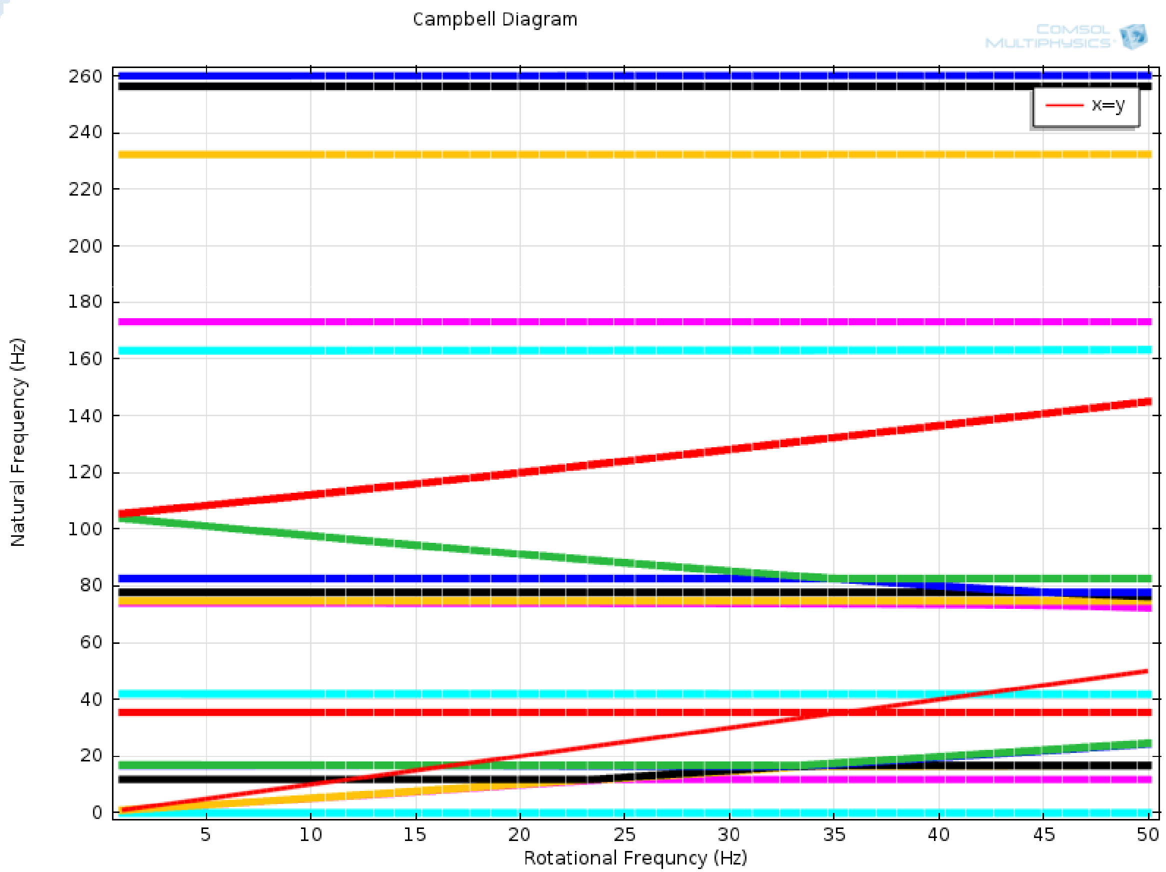


Innovation by experience

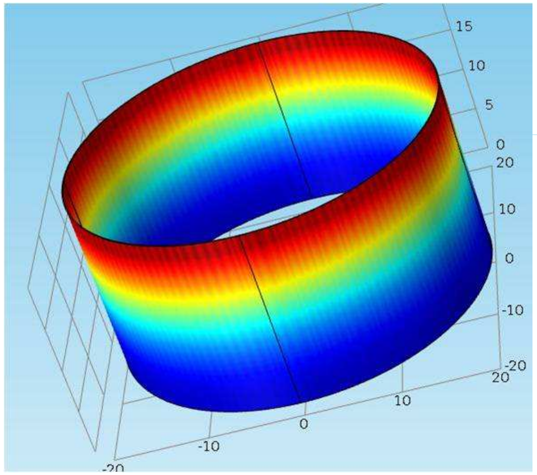
Example of results – foundation – support – rotor mode shape

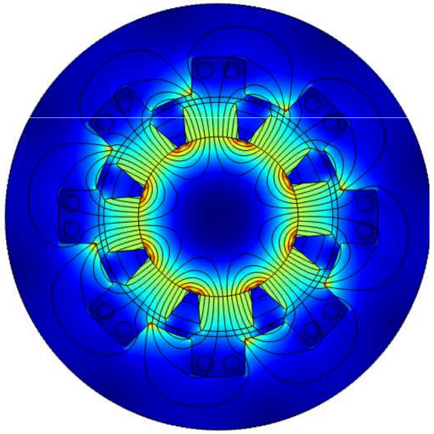


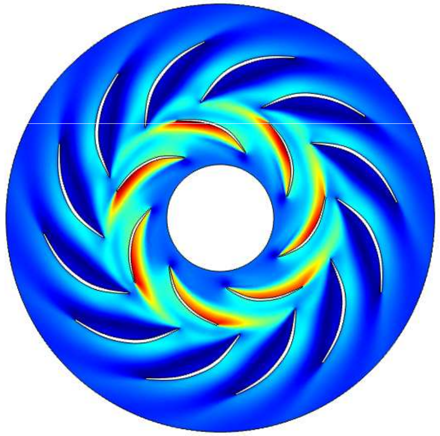
Example of results - Campbell plot



Calculation of rotordynamical coefficients







Conclusions

- Possible to design an engineering tool in order to carry out coupled rotordynamical and structural analysis
- Possible to identify rotordynamical coefficients using numerical methods
- Further implementation needed for a complete 3D-rotordynamical analysis