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Simcenter Nastran – Rotor Dynamics

Predict the dynamic response of rotating systems such as shafts, turbines and propellers

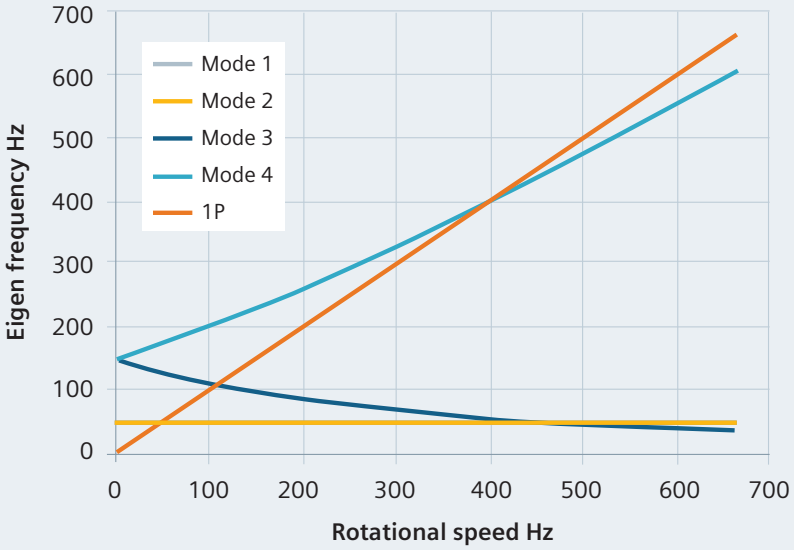
Benefits

- Rapidly evaluate and improve the dynamic performance of rotating systems prior to physical prototyping and production commit
- Troubleshoot dynamics-related noise and vibration problems in previous designs as well as current in-production rotating equipment systems
- Evaluate and develop optimal in-service design modifications to increase production process throughput of rotating equipment systems
- Evaluate rotor imbalance and study general excitation response
- Compute critical speeds and whirl frequencies from Campbell diagrams
- Evaluate in-flight maneuvering loads on an engine rotor and simulate engine blade-out conditions
- Perform multidisciplinary structural design analysis and optimization within the unified Simcenter 3D environment

Summary

Rotating systems are subject to gyroscopic forces such as Coriolis and centrifugal forces that are not present in stationary systems. Simcenter™ Nastran® Rotor Dynamics software provides the capability to predict the dynamic behavior of rotating systems. With the Rotor Dynamics functionality now integrated into Simcenter Nastran, users can now more easily simulate rotating system loads, perform synchronous and asynchronous analysis to generate Campbell Diagram data, predict whirl frequencies and critical speeds and detect instability in rotating components.

In a rotor dynamics analysis, the system's critical speed is particularly important. The critical speed corresponds to a rotation speed that is equal to the modal frequency. Because the critical speed is the speed at which the system can become unstable, engineers must be able to accurately predict those speeds as well as detect possible resonance problems in an analysis.



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Applications
The following is a list of common industry-specific problems that can be analyzed using the Simcenter Nastran Rotor Dynamics application:

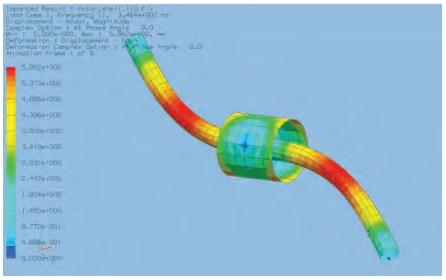
Rotating shafts
This type of a rotating structure can be analyzed using two cases – the symmetric case and the unsymmetric case. Internal damping and viscous damping are considered and the critical speeds corresponding to the different eigen frequencies of the rotor shaft as well as bending are evaluated in each case.

Propellers
For propellers, wind turbines and helicopter rotors, the blades are elastic and the shaft is relatively rigid. Structural analysis of these rotating systems can be performed with the Rotor Dynamics capability. Future enhancements could enable structural coupling with aero effects.

Electrical generators
The structure can be analyzed in the rotating reference system and critical speeds and system instability detected. Complex mode shapes can be plotted and displayed using any postprocessor capable of plotting complex modes and interfaces with Simcenter Nastran.

Simcenter Nastran Rotor Dynamics combines the versatility of Simcenter Nastran with the ability to analyze structures with rotating components:

- Perform a rotor dynamics modal analysis using solution sequence 110 (complex modal). Gives synchronous results (rotational speed that is coincident with rotor critical modes) and asynchronous results (rotor modes as a function of varying rotor speed)
- Compute the response of a rotating system in frequency domain using solution sequence 111 (modal frequency response analysis). Done as either an asynchronous solution in which the rotor speed is independent of the applied excitation, or as a synchronous solution in which the external excitation is dependent on the rotor speed – for example a mass unbalance
- Include differential stiffness to compute centrifugal softening effects
- Include geometric stiffening and centrifugal softening in the analysis
- Solve the model in the fixed or rotating coordinate reference system
- Use modal solutions (as opposed to direct solutions) in the analysis
- Support general models (analysis does not have to be restricted to a line model). This is more flexible than other programs that are limited to line models. Line models work fine for shafts with rigid rotor disks but not for elastic parts with complicated cross sections or blades
- Analyze symmetric as well as unsymmetric rotor models



- Include dynamic load scenarios such as mass and force imbalance and any generic Nastran dynamic loads
- Include damping as internal damping acting on the rotating part of the structure and/or external damping acting on the fixed part of the structure and in the bearings. The internal damping has a destabilizing effect. The external damping has a stabilizing effect
- Calculate the complex eigenvalues for each selected rotor speed, along with the damping and the whirl direction. The software determines the whirl direction from the complex eigenvectors; for example, see the complex mode illustrated in the figure above
- Calculate the whirl modes (system modal frequencies that vary with rotational speed) and critical speeds
- Calculate complex mode shapes
- View results in Simcenter 3D software for visualization of complex modes
- Create Campbell diagrams of the eigen frequencies leveraging software tools such as Excel. (See Campbell figure on the

Capability	Simcenter Nastran Rotor Dynamics
Synchronous and asynchronous excitation	Yes
Symmetric rotors	Yes
Unsymmetric rotors	Yes
Multiple rotors	Multiple speeds
Inline models	Yes
Non-inline models	Yes
Stationary reference frame	Yes
Rotating reference frame	Yes
Frequency simulation	Yes

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- Use Simcenter Nastran to write the results of a rotor dynamics analysis to the F06 or OP2 file for postprocessing. You can also use parameters (ROTCSV, ROTGPF) in the input file to have the software generate additional types of ASCII output files (CSV and GPF files) which contain data that is specially formatted for postprocessing results with other tools
- Use the CSV file data to plot the damping as a function of rotor speed to help detect resonance points and regions of instability

Prerequisites
The Simcenter Nastran Rotor Dynamics application is available as an add-on module and requires a license of either Simcenter Nastran Basic with Simcenter Nastran Dynamic Response or the Simcenter Nastran Advanced Bundle as a prerequisite.

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