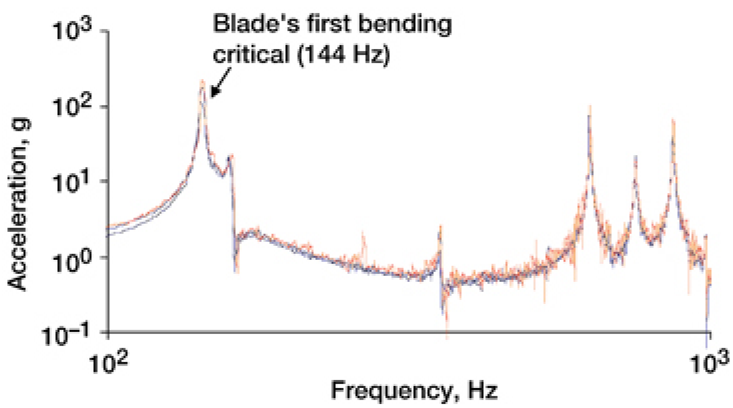
New Dynamic Spin Rig Capabilities Used to Determine Rotating Blade Dynamics

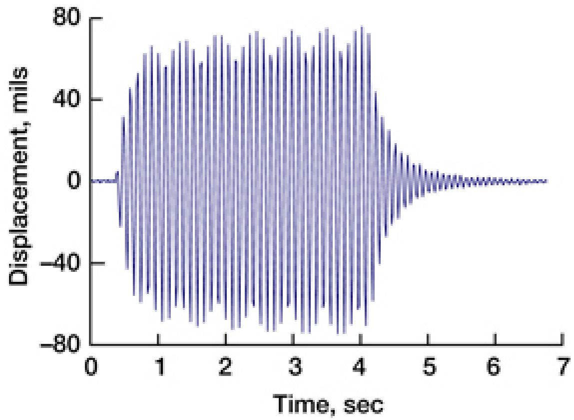
The Dynamic Spin Rig Facility at the NASA Glenn Research Center is used to determine the structural response of rotating engine components without the effects of aerodynamic loading. Recently, this rig's capabilities were enhanced through the replacement of grease-lubricated ball bearings with magnetic bearings (see ref. 1). Magnetic bearings offer a number of advantages--the most important here being that they not only fully support the rotor system, but excite it as well. Three magnetic bearings support the rotor and provide five axes of controlled motion: an *x*- and *y*-axis translation at each of two radial bearings and a *z*-axis translation in the vertical or axial direction. Sinusoidal excitation (most commonly used) can be imparted on the rotor through the radial magnetic bearings in either a fixed or rotating frame of reference. This excitation is added directly to the magnetic bearing control output. Since the rotor is fully levitated, large translations and rotations of the rotor system can be achieved.



Titanium flat plate blade-tip acceleration magnitude versus frequency using swept sine excitations of 0.25, 0.5, and 1.0 A at 0 rpm.

Some of the capabilities of this excitation system were determined and reported in ref. 2. The preceding graph shows the accelerations obtained at the tip of a titanium flat plate test article versus the swept sine excitation sent to both radial bearings in phase and perpendicular to the plane containing the two blades. Recent tests required the excitation of fundamental bending and torsional blade resonances at rotor speeds up to 10,000 rpm. Successful fixed synchronous rotation of the excitation signal provided the best detectable blade resonant vibrations at excitation frequencies up to 1100 Hz for the particular blades of interest.

A noncontacting laser measurement system was used to collect blade-tip motions. From these data, the amplitude and frequency of the motion could be determined as well as the blade damping properties. Damping could be determined using two methods: (1) free decay and (2) curve fitting the vibration amplitude as a function of frequency in and around the resonance of interest and using the half-power method. The following graph shows the free decay of a composite blade vibrating at its first bending resonance while rotating at 3000 rpm.



Blade excitation and free vibration decay at 3000 rpm.

This new system is currently being used to support the Efficient Low-Noise Fan project at Glenn. The damping properties of prototype hollow composite blades specially designed to reduce fan noise are currently being determined.

References

1. Morrison, Carlos R.; and Mehmed, Oral: Dynamic Spin Rig Upgraded With a Five-Axis-Controlled Three-Magnetic-Bearing Support System With Forward Excitation. Research and Technology 2002, NASA/TM--2003-211990, 2003, p. 168. http://www.grc.nasa.gov/WWW/RT2002/5000/5930morrison.html
2. Morrison, Carlos R., et al.: Fully Suspended, Five-Axis, Three-Magnetic-Bearing Dynamic Spin Rig With Forced Excitation. NASA/TP--2004-212694, 2004. http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2004/TP-2004-212694.html

Glenn contacts: Andrew J. Provenza, 216-433-6025, Andrew.J.Provenza@nasa.gov; Carlos R. Morrison, 216-433-8447, Carlos.R.Morrison@nasa.gov; and Dr. Tony Kurkov, 216-433-5695, Anatole.P.Kurkov@nasa.gov
Author: Andrew J. Provenza
Headquarters program office: OAT
Programs/Projects: SEC, QAT, UEET, ELNF