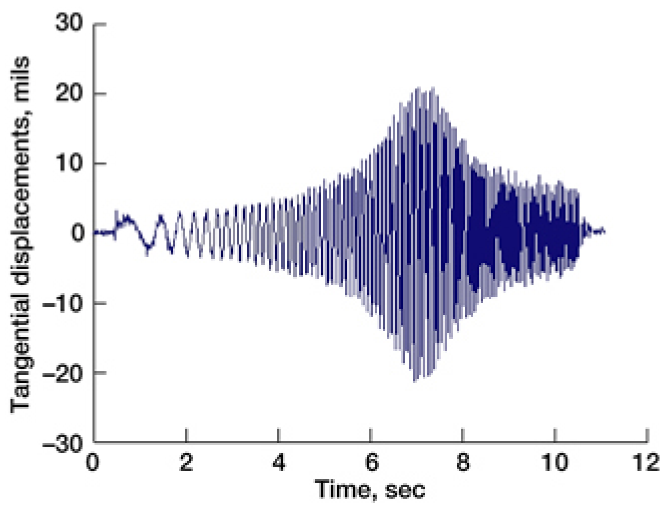
Method Developed for Noninterference Measurement of Blade Damping

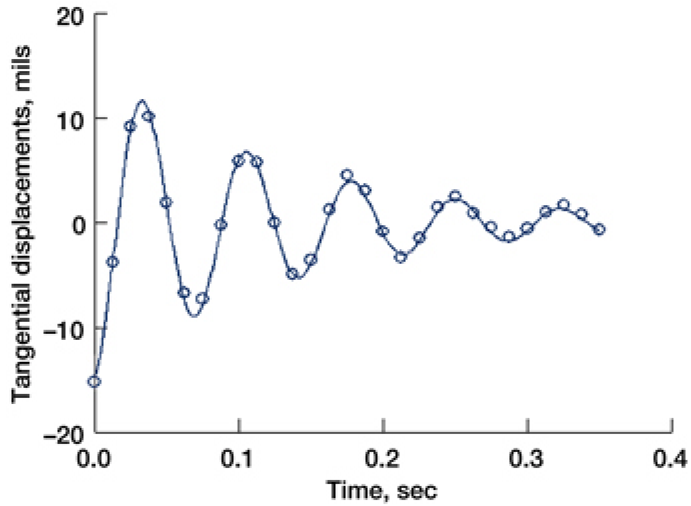
Although noninterference optical instrumentation has been previously used to monitor and measure rotor blade vibrations, it has not been used at the NASA Glenn Research Center for the determination of damping. This article describes such a measurement in Glenn's Spin Rig facility. The optical system was chosen because installation of the slip rig for this particular configuration was not feasible, ruling out strain gauge instrumentation. The shaft in this facility was suspended with two radial magnetic bearings, and the excitation was supplied to the bearings by a signal generator. For the first mode, the direction of excitation force was always perpendicular to the blade as described by Morrison (ref. 1).



Frequency sweep through the resonance.

The preceding graph shows blade displacements, as measured by an optical probe during a frequency sweep designed to locate the first mode resonance. The resonance determines the frequency at which the shaft is excited. Because the sampling rate was fixed to only once per revolution with these transducers, and the first mode frequency was much larger than the rotational frequency, the data in this figure were undersampled with an apparent frequency that was only 1 Hz at the beginning of the sweep, about 14 Hz at the maximum amplitude, and about 20 Hz at the end of the sweep. The true excitation frequency varied during the sweep from 320 to 340 Hz, and the resonance occurred at 334 Hz.

Damping is determined by applying a frequency burst to the shaft. Upon cessation of the burst, the blade undergoes free decay. The apparent damping is then obtained by a least-squares fit of the theoretical cosine decay function through the experimental points. The following graph illustrates this procedure. Because of frequency aliasing, the apparent measured damping must be divided by the ratio of the true resonant frequency to the apparent measured frequency to obtain the true damping. Note that the contribution of the shaft vibration to the blade vibration could be neglected because it was shown that it is an order of magnitude smaller and that its decay is an order of magnitude faster.



Least-squares fit of a decaying cosine function through experimental points.

The free decay method could not be applied for the higher torsional mode, because the displacements were smaller and frequency aliasing was higher, yielding an insufficient number of cycles for the decay fit. For this mode, damping was determined by the least-squares fitting of the theoretical forced frequency response function to the experimental data.

Reference

1. 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

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