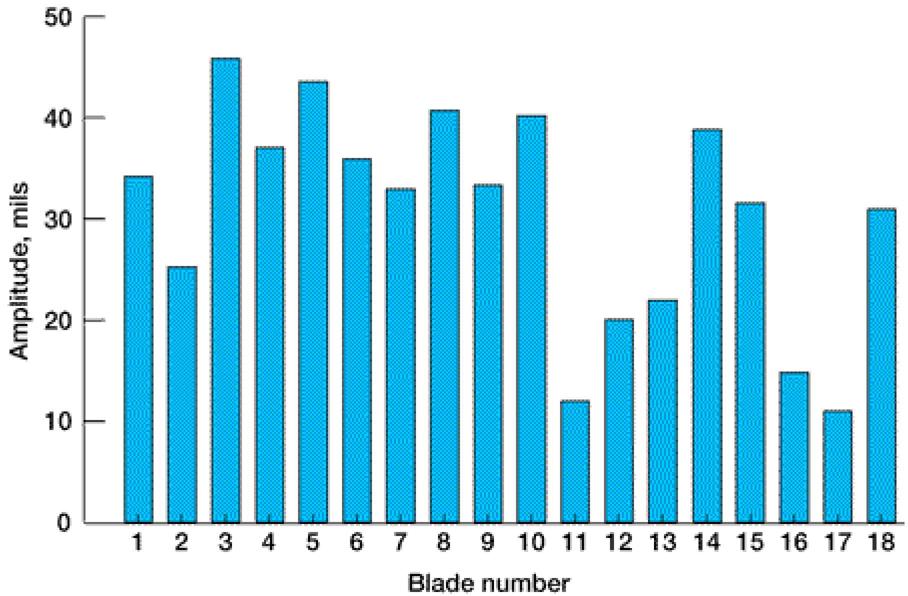
Noninterference Systems Developed for Measuring and Monitoring Rotor Blade Vibrations

In the noninterference measurement of blade vibrations, a laser light beam is transmitted to the rotor blade tips through a single optical fiber, and the reflected light from the blade tips is collected by a receiving fiber-optic bundle and conducted to a photodetector. Transmitting and receiving fibers are integrated in an optical probe that is enclosed in a metal tube which also houses a miniature lens that focuses light on the blade tips. Vibratory blade amplitudes can be deduced from the measurement of the instantaneous time of arrival of the blades and the knowledge of the rotor speed.

The in-house noninterference blade-vibration measurement system was developed in response to requirements to monitor blade vibrations in several tests where conventional strain gauges could not be installed or where there was a need to back up strain gauges should critical gauges fail during the test. These types of measurements are also performed in the aircraft engine industry using proprietary in-house technology.

Two methods of measurement were developed for vibrations that are synchronous with a rotor shaft. One method requires only one sensor; however, it is necessary to continuously record the data while the rotor is being swept through the resonance. In the other method, typically four sensors are employed and the vibratory amplitude is deduced from the data by performing a least square fit to a harmonic function. This method does not require continuous recording of data through the resonance and, therefore, is better suited for monitoring. The single-probe method was tested in the Carl facility at the Wright-Patterson Air Force Base, and the multiple-probe method was tested in NASA Glenn Research Center’s Spin Rig facility, which uses permanent magnets to excite synchronous vibrations. Representative results from this test are illustrated in the bar chart.



Blade-to-blade resonant amplitude variation for a fan rotor subject to a 5-engine-order excitation.

Nonsynchronous vibrations were measured online during testing of the Quiet High Speed Fan in Glenn's 9- by 15-Foot Low-Speed Wind Tunnel. Three sensors were employed, enabling a reconstruction of the vibratory patterns at the leading and trailing edges at the tip span, as well as a determination of vibratory amplitudes for every blade.

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