Mechanics/Machinery

Wireless Inductive Power Device Suppresses Blade Vibrations

The aerospace and electric power generation industries could benefit from this technology.

John H. Glenn Research Center, Cleveland, Ohio

Vibration in turbomachinery can cause blade failures and leads to the use of heavier, thicker blades that result in lower aerodynamic efficiency and increased noise. Metal and/or composite fatigue in the blades of jet engines has resulted in blade destruction and loss of lives. Techniques for suppressing low-frequency blade vibration, such as "tuned circuit resistive dissipation of vibratory energy," or simply "passive damping," can require electronics incorporating coils of unwieldy dimensions and adding unwanted weight to the rotor. Other approaches, using vibration-dampening devices or damping material, could add undesirable weight to the blades or hub, making them less efficient.

A wireless inductive power device (WIPD) was designed, fabricated, and developed for use in the NASA Glenn's "Dynamic Spin Rig" (DSR) facility. The DSR is used to simulate the functionality of turbomachinery. The relatively small and lightweight device [10 lb (≈4.5 kg)] replaces the existing venerable and bulky slip-ring. The goal is the eventual integration of this technology into actual turbomachinery such as jet engines or electric power generators, wherein the device will facilitate the suppression of potentially destructive vibrations in fan blades. This technology obviates slip rings, which require cooling and can prove unreliable or be problematic over time.

The WIPD consists of two parts: a remote element, which is positioned on the rotor and provides up to 100 W of electrical power to thin, lightweight piezoelectric patches strategically placed on/in fan blades; and a stationary base unit that wirelessly communicates with the remote unit. The base unit supplies inductive power, and also acts as an input and output corridor for wireless measurement, and active control command to the remote unit.

Efficient engine operation necessitates minimal disturbance to the gas flow across the turbine blades in any effort to moderate blade vibration. This innovation makes it possible to moderate vibration on or in turbomachinery blades by providing 100 W of wireless electrical power and actuation control to thin, lightweight vibration-suppressing piezoelectric patches (eight actuation and eight sensor patches in this prototype, for a total of 16 channels) positioned strategically on the surface of, or within, titanium fan blades, or embedded in composite fan blades. This approach moves significantly closer to the ultimate integration of "active" vibration suppression technology into jet engines and other turbomachinery devices such as turbine electrical generators used in the power industry.

The novel feature of this device is in its utilization of wireless technology to simultaneously sense and actively control vibration in rotating or stationary turbomachinery blades using piezoelectric patches. In the past, wireless technology was used solely for sensing and diagnostics. This technology, however, will accomplish much more, in terms of simultaneously sensing, suppressing blade vibration, and making it possible for detailed study of vibration impact in turbomachinery blades.

This work was done by Carlos R. Morrison, Andrew J. Provenza, Benjamin B. Choi, Milind A. Bakhle, James B. Min, George L. Stefko, Kirsten P. Duffy of Glenn Research Center and John Kussmann of MESA Systems Co. and Alan J. Fougers of D-2 Inc. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18601-1.

Safe, Advanced, Adaptable Isolation System Eliminates the Need for Critical Lifts

Inflatable isolators are integrated into an aircraft jacking system.

Dryden Flight Research Center, Edwards, California

The Starr Soft Support isolation system incorporates an automatically reconfigurable aircraft jack into NASA's existing 1-Hertz isolators. This enables an aircraft to float in mid-air without the need for a critical lift during ground vibration testing (GVT), significantly reducing testing risk, time, and costs. Currently incorporating the most advanced technology available, the 60,000-pound-capacity (27-metric-ton) isolation system is used for weight and measurement tests, control-surface free-play tests, and structural mode interaction tests without the need for any major reconfiguration, often saving days of time and significantly reducing labor costs.

The Starr Soft Support isolation system consists of an aircraft-jacking device with three jacking points, each of which has an individual motor and accommodates up to 20,000 pounds (9 metric tons) for a total 60,000-pound (27-metric-ton) capacity. The system can be transported to the aircraft by forklift and placed at its jacking points using a pallet jack. The motors power the electric actuators, raising the aircraft above the ground until the landing gear can retract.

Inflatable isolators then deploy, enabling the aircraft to float in mid-air, simulating a 1-Hertz free-free boundary condition. Inflatable isolators have been in