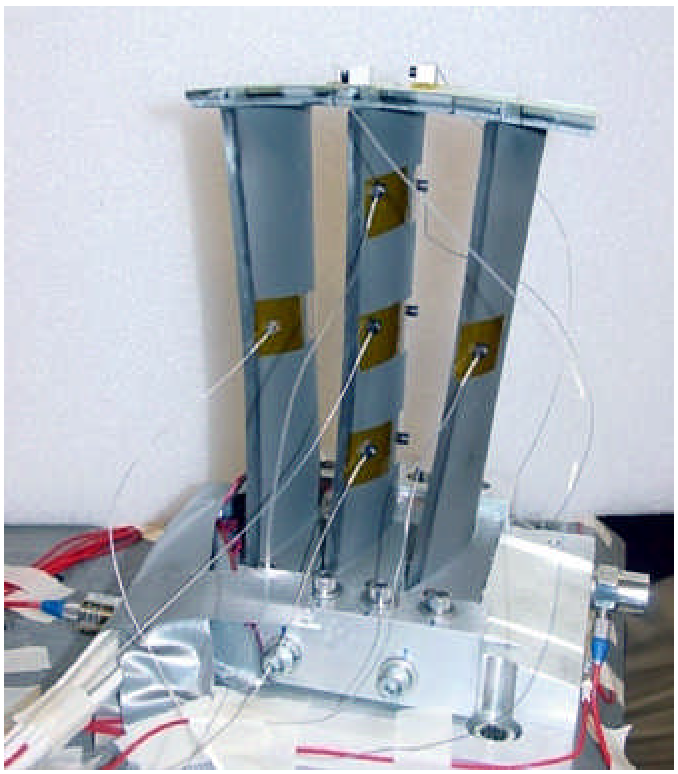
Testing of Composite Fan Vanes With Erosion-Resistant Coating Accelerated

The high-cycle fatigue of composite stator vanes provided an accelerated life-state prior to insertion in a test stand engine. The accelerated testing was performed in the Structural Dynamics Laboratory at the NASA Glenn Research Center under the guidance of Structural Mechanics and Dynamics Branch personnel. Previous research on fixturing and test procedures developed at Glenn determined that engine vibratory conditions could be simulated for polymer matrix composite vanes by using the excitation of a combined slip table and electrodynamic shaker in Glenn's Structural Dynamics Laboratory. Bench-top testing gave researchers the confidence to test the coated vanes in a full-scale engine test.

Coated stator vane on the shaker slip table. Total vane height is approximately 15 cm (6 in.).

Bypass fan stator vanes from the AE3007 (Rolls-Royce Corporation, Indianapolis, IN) gas turbine engine were coated by Engelhard (Windsor, CT) with compliant bond coatings and hard ceramic coatings. The coatings were developed collaboratively by Glenn and Allison Advanced Development Company (AADC)/Rolls-Royce Corporation (Indianapolis, IN) through research sponsored by the Advanced High-Temperature Engine Materials Technology Program (HITEMP) and the Higher Operating Temperature Propulsion Components (HOTPC) Project. High-cycle fatigue was performed through high-frequency vibratory testing on a shaker table.

At the request of Rolls Royce engineers, four stator vane segments were preconditioned by high-cycle fatigue using Glenn's facilities. The bypass stator vanes for the AE3007 engine were assembled as segments consisting of three vanes. Two of the vane segments were cycled for 30 million cycles at a maximum strain amplitude of 300 to 400 microstrain. This fatigue condition is comparable to the loading on the vanes during nominal engine conditions. The other two vane segments were tested for 5 million cycles at a maximum strain amplitude of 600 to 700 microstrain--a level estimated to correspond to an aerodynamic engine overload condition. The vanes were instrumented with both lightweight accelerometers and strain gauges to establish resonant frequencies, deflection mode shape, and strain amplitudes. Inspection with a fluorescent-dye penetrant indicated that at the higher strain amplitude the bench-top fatigue had initiated small cracks in the vanes from one of the segments tested. No obvious damage was found on the vanes from the other three vane segments.



Bypass fan vane segment instrumented for accelerated life testing via high-cycle fatigue.

The four preconditioned vane segments were inserted into a test-stand, AE3007 engine at Rolls Royce America in Indianapolis, Indiana. Also in the engine were vane segments that had not experienced accelerated testing, as well as baseline, uncoated production vanes. The coated vanes were successfully engine tested for 4750 engine cycles (1663 hr). The coating remained intact (did not spall or come off the vanes) even though some cracking occurred. The segments that had been preconditioned to the higher-than-normal strain amplitudes were the first to show damage or coating crack growth when inspected during interruptions in the engine testing. The damage on the preconditioned vanes was similar to that on the vanes that were not reconditioned. Therefore, bench-top testing is a useful means for developing accelerated life history on the vanes.

Find out more about this research:
Glenn's Structural Mechanics and Dynamics Branch at
http://structures.grc.nasa.gov/5930/

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