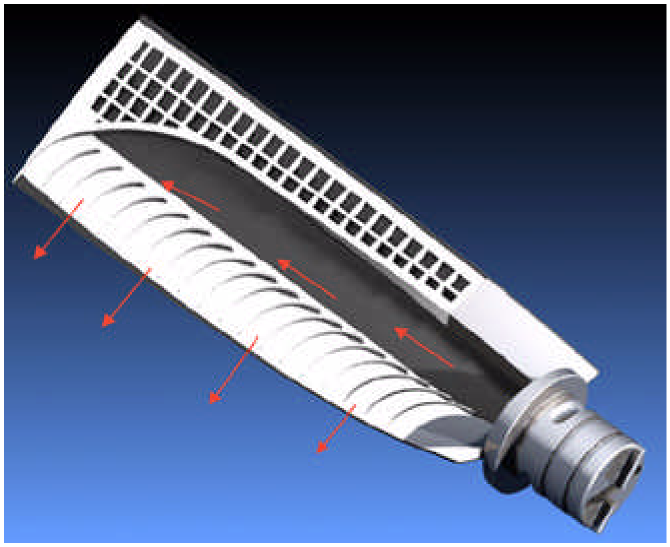
New Fan Engine Noise-Reduction Concept Using Trailing Edge Blowing of Fan Blades Demonstrated



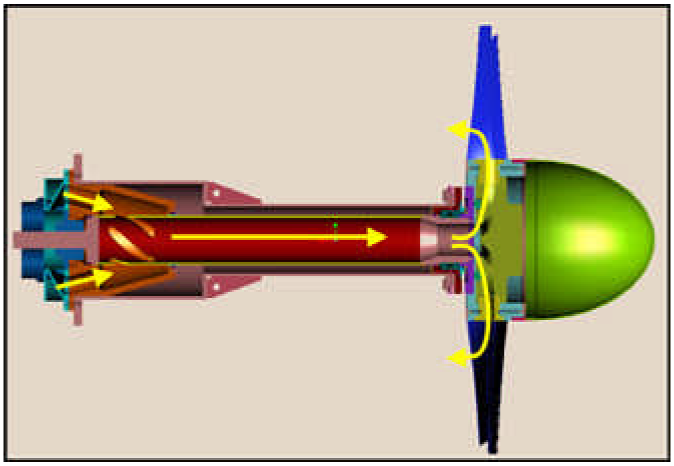
Flow path through blade with outer skin removed.

Long description Hollow fan blade shown with its outer skin removed to reveal the flow path of the blowing air. The air enters the blade at its base and flows in the radial direction where many small turning vanes change the flow to the axial direction where it exits through a narrow slot at the trailing edge.

A major source of noise in commercial turbofan engines is the interaction of the fan blade wakes with the fan exit vanes (stators). These wakes can be greatly reduced by filling them with air blown out of the blade trailing edge. Extensive testing of this concept has demonstrated significant noise reductions. These tests were conducted on a low-speed, 4-ft-diameter fan using hollow blades at NASA Glenn Research Center's Aeroacoustic Propulsion Laboratory (AAPL).

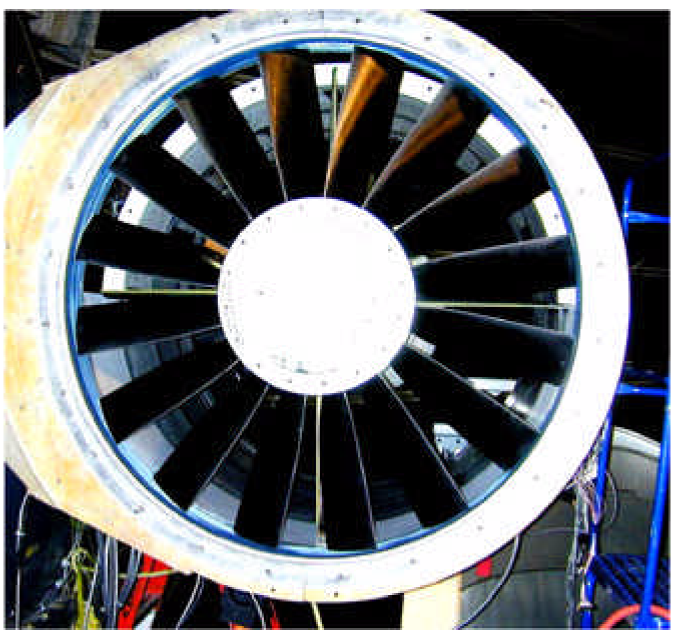
The fan was designed and fabricated using new techniques and concepts developed to support design goals. The fabrication made use of considerable rapid prototyping hardware and composites. During operation, air was injected into the hollow fan shaft and flowed into the blade though radial passages that extend to the trailing edge. The blades have composite skins with internal turning vanes and a narrow slot at the trailing edge. Up to 2 percent of the fan total flow can be injected into the slots to fill the wake.

These tests measured the internal and external (far-field) noise, the steady and unsteady velocity behind the fan blades (using hotwire anemometry), the unsteady vane surface pressures, and overall performance. The blowing flow rate was varied as well as the radial extent of the slot. Early results of these tests show that the tone noise was significantly reduced especially at harmonics above the fundamental blade passing frequency. Although this was primarily a noise test, there is evidence that much of the energy in the blowing airstream was recovered, as indicated by reductions in the fan shaft torque. There were also indications from the vane unsteady pressures that broadband noise might also be reduced. We hope that future tests and further analysis of the data will lead to still greater noise reductions.



Flow path through the shaft and hub.

Long description Cutaway view of the hollow fan shaft, hub, and rotor blades shows the blowing air path through this assembly. Air enters the rear of the assembly through an injection manifold where it flows into the hollow shaft by way of helical slots in the shaft wall. At the far end of the shaft, the flow is turned to the radial direction and divided into 16 channels for distribution to the base of each blade.



Fan installed in duct.

Long description Photograph of a 4-ft-diameter fan installed in its duct. This front view shows the 16 blades radiating from a central hub. The hub is 18 in. in diameter and the blades are 15 in. long by 5.2 in. wide.

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