National Aeronautics and Space Administration

Aeronautics

Tip Vortex Noise Reduction Technology

Open structure design reduces turbulent flow noise generated at surface boundaries by delaying and preventing vortex formation

NASA's Langley Research Center has developed aircraft flap tip modifications that reduce noise produced during approach and landing. The modifications are rigid open lattice (honeycomb-like) and fin structures (closely packed columns) that delay the formation of a noise-generating vortex at the flap side edge. The designs are low-profile, with control action limited to the steady and fluctuating fields in a very small region at the flap edge. By limiting the control action to a very small region, aerodynamic characteristics of the structure remain nearly unchanged. The noise-reducing structures may be used in a variety of applications where tip vortices produce undesirable noise. These applications may include helicopter or wind turbine rotors. The technology has been validated using computational fluid dynamics analysis and wind tunnel testing. NASA is seeking partners who are interested in co-development or licensure of the technology for a variety of applications.

BENEFITS

- The invention is a simple and low profile design
- The concepts are effective over the entire audible frequency range, reducing noise by 3-5 dB.
- Associated lift, drag, and weight penalties are minimal
- The treatment concept has minimal effect on flight control surfaces
- Existing flaps may be retrofitted to incorporate the technology

APPLICATIONS

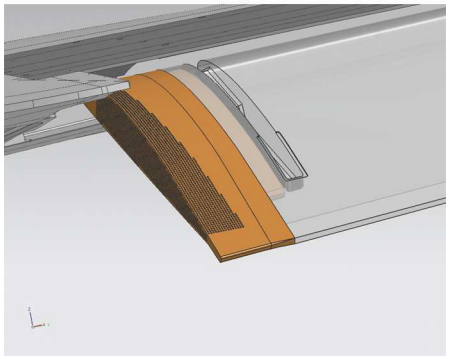
- Aerospace
  -- Aircraft flap side edges
  -- Helicopter blade tips
  -- Jet turbine fan blade tips
- Wind energy
  -- Wind turbine airfoils tips or trailing edges

technology solution

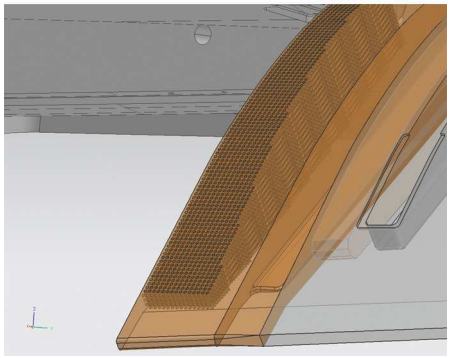
THE TECHNOLOGY

The open-structure of the flap modifications allows the aeroacoustic environment outside the flap to communicate with the perforations or gaps within the flap. The openings embedded within the volume of the flap change the boundary condition at the surface of the flap, significantly reducing the steady pressure differential experienced by the edge. These modifications reduce turbulent fluctuations and delay vortex formation that causes noise during aircraft landing and approach. Comparisons of fluctuating surface pressures between untreated and treated flaps showed an order of magnitude reduction of pressure fluctuation amplitude. Each concept is effective over the entire auditory frequency range, reducing noise amplitude by 3-5 decibels, up to a 50% reduction. Computer simulations have been corroborated by 18% scale wind tunnel testing at NASA Langley.

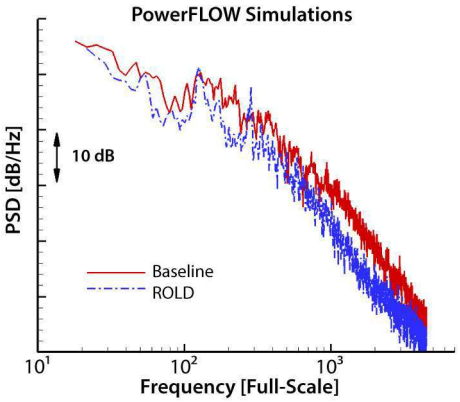
Although the aerodynamic penalties associated with the concepts are predicted to be very small, minimizing them to negligible levels will require further optimization of the invention. Further considerations of cost, manufacturability, and maintainability are forthcoming.



Top view of a typical flap side-edge showing surface extent of rigid open lattice treatment.



Translucent view of rigid open lattice flap side-edge showing the internal lattice structured holes.



Comparison of far field noise in flyover direction between baseline (untreated) and treated flap.

PUBLICATIONS

Patent Pending

More Information

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