National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Aerospace

Anti-Phase Noise Suppression Rotor Technologies

Acoustic Optimization for Anti-Phase Asymmetric Rotor

All rotorcraft experience rotor noise and vibration that present operational challenges due to the unsteady forces that result from blade vortex shedding. Rotor noise is often a nuisance, and excessive rotor vibration can be hazardous. Several methods exist to deal with the noise and vibration from rotor blades, though many designs either aim to reduce vibration and do not address noise, or vice versa. NASA Ames Research Center has developed a novel patent-pending design and method for reducing rotor blade vibration and acoustic signatures in rotor systems using anti-phase blade vortex suppression design concepts. The design objective is to maximize reduction of noise perceived by the community while maintaining the aerodynamic thrust. These designs could be applicable in any system that uses rotor blades.

BENEFITS

- Reduces noise from rotor blades: reduces the acoustic signatures made by rotorcraft during operation, providing noise reduction both for passengers inside the vehicle and community noise reduction for people on the ground
- Reduces vibrations in systems with rotor blades: allows for more stable aircraft operation and improved performance of rotor systems
- Increases thrust: creates more thrust than the standard baseline rotor blade design at the same RPM, thereby allowing rotors to operate at lower RPMs for noise reduction
- The designs could be applicable in any system that uses rotor blades

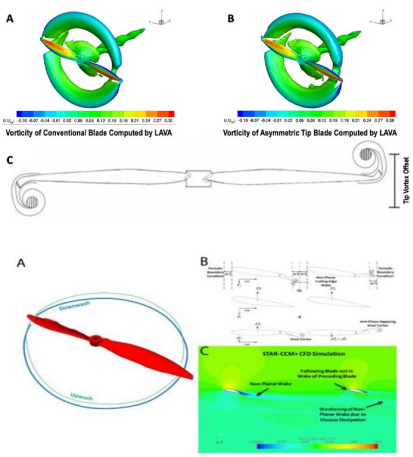
APPLICATIONS

The technology has several potential applications:

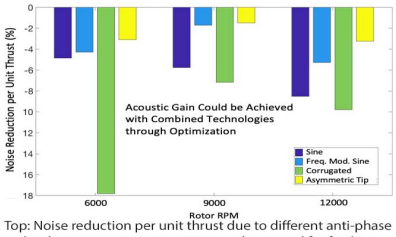
- Rotorcraft like helicopters
- Drones/Unmanned Aerial Vehicles (UAVs)
- Military/commercial/passenger aircraft
- Urban Air Mobility Vehicles (UAMV)
- Gas turbine engines; Wind turbines
- Power plants
- Industrial systems that uses rotor blades

THE TECHNOLOGY

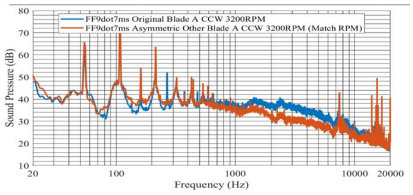
Rotor noise and vibration are two sources of operational challenges for all aircraft operating with open rotors such as helicopters, unmanned aerial vehicles (UAVs), urban air mobility personal air vehicles, drones, and aircraft operating with ducted fans such as passenger aircraft. One disadvantage of convention rotor design is the noise due to noise-induced shed vortices generated by rotor blades. The unique problem with rotor noise and vibration is the periodic blade passage that causes a harmonic reinforcement and causes the rotor blades to vibrate and generate noise sources. This technology from NASA Ames seeks to optimize the implementation of anti-phase trailing edge designs and asymmetric blade tip treatments for rotor noise suppression and integrated aircraft noise solutions by incorporating the anti-phase rotor design concepts into an aircraft flight control system to reduce noise footprint. There are several embodiments of the invention, which include the following: (1) an anti-phase trailing edge design whereby the trailing edge pattern of the leading rotor blade is offset by a phase shift from the trailing edge pattern of the following blade; (2) an anti-phase rotor design implementing asymmetric blade tips with inverted airfoil; and (3) other anti-phase enabled concepts such as unequal blade length, ducted rotors with non-radial unequally spaced struts, and multi-axis tilt rotor design incorporating the anti-phase rotor design.



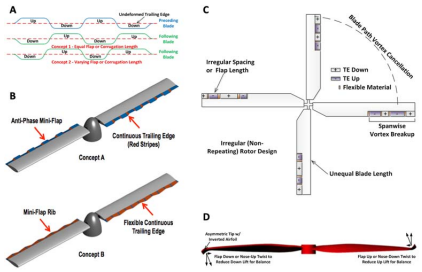
Possible Mechanism of Noise Reduction of Anti-Phase Asymmetric Tip Rotor Concept

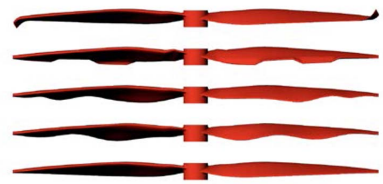


Top: Noise reduction per unit thrust due to different anti-phase technologies at various rotor RPMs and potential for further acoustic gain through optimization



Bottom: Sound pressure level spectra of baseline blade (in blue) and anti-phase trailing edge design (in red) showing broadband noise reduction of anti-phase rotor technology





Top: Anti-Phase Rotor Concept
Bottom: The bottom rotor blade is the conventional rotor blade that the others above it are modified from to incorporate anti-phase designs. The anti-phase trailing edge configurations going from next to bottom to top are frequency modulated sinusoidal waveform, sinusoidal waveform, corrugated waveform, and asymmetric blade tips.

PUBLICATIONS

Patent Pending

https://arc.aiaa.org/doi/abs/10.2514/6.2020-1496

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