3:15

2pNSa6. Quiet, efficient fans for space flight: An overview of NASA's technology development plan. Danielle Koch (NASA Glenn Res. Ctr., 21000 Brookpark Rd., MS 54-3, Cleveland, OH 44135, l.danielle.koch@nasa.gov)

NASA has developed a Technology Development Plan for improving the aerodynamic and acoustic performance of spaceflight fans. The intent is to make broader use of the technology developed at NASA Glenn to improve the efficiency and reduce the noise of aircraft engine fans. The goal is to develop a set of well-characterized government-owned fans nominally suited for spacecraft ventilation and cooling systems. NASA's Exploration Life Support community will identify design point conditions for the fans in this study. Computational Fluid Dynamics codes will be used in the design and analysis process. The fans will be built and used in a series of tests. Data from aerodynamic and acoustic performance tests will be used to validate performance predictions. These performance maps will also be entered into a database to help spaceflight fan system developers make informed design choices. Velocity measurements downstream of fan rotor blades and stator vanes will also be collected and used for code validation. Details of the fan design, analysis, and testing will be publicly reported. With access to fan geometry and test data, the small fan industry can independently evaluate design and analysis methods and work toward improvement.

3:30

2pNSa7. Aerodynamic design and computational analysis of a space flight vehicle cabin ventilation fan. Daniel L. Tweedt (AP Solutions, Inc., 22526 Tammy Circle, Council Bluffs, IA 51503, daniel.tweedt@ap-solutions.com)

Quieter working environments for astronauts are needed if future long-duration space exploration missions are to be safe and productive. Ventilation and payload cooling fans are known to be dominant sources of noise, with the International Space Station being an important case in point. To address this issue in a cost effective way, early attention to fan design, selection, and installation has been recommended. Toward that end, NASA has begun to investigate the potential for small-fan noise reduction through improvements in fan aerodynamic design. Using tools and methodologies similar to those employed by the aircraft engine industry, the aerodynamic design of a new cabin ventilation fan has been developed, and its aerodynamic performance predicted using computational fluid dynamics (CFD) codes. The design, intended to serve as a baseline for future work, is discussed along with selected CFD results.

3:45

2pNSa8. Surface integration method used on semi-solid surface for fan noise prediction. Yoon-Shik Shin and J. Stuart Bolton (Ray W. Herrick Labs., Purdue Univ., 140 S. Martin Jischke Dr., West Lafayette, IN 47907-2031, shin31@purdue.edu)

As a continuation of previous work, the Ffowc-Williams and Hawkings model was applied to an axial fan that was operated under unfavorable inflow condition. A thin aluminum foam screen that is used as a treatment for disturbed inflow condition was included as a noise source in computational aeroacoustic simulation. The incompressible URANS model was used for the CFD simulation and the inflow foam was modeled as a homogeneous porous zone with permeability and inertial resistance factors found experimentally. Since the homogeneous porous zone defined in this way does not have a solid structure that could be used as a dipole noise source, the control surface integration method was applied to the surface of the homogeneous porous zone: i.e., to a surface right between the normal fluid zone and the porous zone. The unsteady pressure data on the control surface under the incompressible assumption was treated as representing pressure fluctuations on a semi-solid surface rather than as a representation of acoustic sources within the volume surrounded by the control surface.

4:00

2pNSa9. Cooling fan noise reduction by optimizing spacing of blades. John Wang (Volvo Construction Equip., 312 Volvo Way, Shippensburg, PA 17257, john.wang@volvo.com)

Cooling fan noise theories are briefly reviewed. A simplified model is derived from a rotating point source theory. Optimization was done using the simplified model. A fan with unevenly spaced blades was prototyped, tested, and compared with a fan with evenly spaced blades. Noise reduction data are presented.

4:15

2pNSa10. Suppression of ducted dipole noise by an expanded segment around the source. Lixi Huang (Dept. of Mech. Eng., Univ. of Hong Kong, Hong Kong, lixi@hku.hk)

Low-speed fan noise mainly features dipole sound radiation. For such a fan operating in a duct, the low- to medium-frequency radiation derives mainly from the unsteady, axial forces acting on the rotating blades. Recently, we have found, both theoretically and experimentally, that self-cancellation of sound can be achieved by placing the dipole in an expanded segment of the duct which provides a reverberating environment with a reduced radiation impedance. The insertion loss spectrum shows a very broadband appearance similar to but is better than the transmission loss spectrum of an expansion chamber silencers used for reflecting an incident plane wave. Parametric analysis reveals that the expansion ratio controls the peak insertion loss, while the chamber length controls the single-lobe bandwidth. Simple plane wave analysis implies that short chamber would give wider stopband with a chamber of vanishing length yielding the best result. It is shown here that such analysis fails when the chamber is too short. For a given finite frequency band, there exists an optimal chamber length. Spectral element analysis reveals details of such optimal length and the result is explained in terms of the known fundamentals of dipole radiation and duct acoustics.

4:30

2pNSa11. Active control of axial fan noise using a multiple-input multiple-output feedback controller. Cole V. Duke, Scott D. Sommerfeldt, and Kent L. Gee (Dept. of Phys. and Astron., Brigham Young Univ., N283 ESC, Provo, UT 84602, coleduke@gmail.com)

In the past, significant progress has been made in actively controlling the tonal noise of axial cooling fans using a digital, feed-forward controller. Progress has also been made in controlling broadband fan noise using an analog feedback controller due to the nondeterministic nature of the noise. Current work focuses on the control of broadband noise with a multiple-input multiple-output (MIMO) feedback controller using four control sources and four error sensors. To ensure stability of the closed-loop control system, the phase and magnitude characteristics of the controller must be chosen to produce attenuation in the target frequency band without augmenting the noise outside the band. A practical analog feedback controller will be presented, and performance results will be compared between a single-input single-output controller and a MIMO controller.