New Vapor-Particle Separator Improves Understanding of Aircraft Engine Combustion and Particulate Emissions

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Technology Summary

A new apparatus has been developed by ORNL researchers to efficiently separate volatile particles from condensible vapors in aircraft engine emissions. The technology enables high-precision emissions research, generating insightful data that helps improve the scientific understanding of the combustion process of modern jet engines and the formation process of secondary particulate matter in the atmosphere.

Sampling jet aircraft exhaust is a daunting task. The exhaust is high-temperature and high-pressure—not only posing severe technical challenges, but also environmental safety and health constraints to workers. The main difficulty lies in how to capture the phase-partition dynamics of volatile particles, as they travel downstream from the engine exhaust nozzle, and to obtain representative data as secondary particles formed at a downstream location.

The unique ORNL lightweight, rugged volatile particle separator (VPS) has an engineered metallic membrane to enable removal of condensible vapors and detection of non-volatile particles, simultaneously. The VPS apparatus, which weighs about 12 kg, consists of a front-end section that has an immersed ceramic heater that radiantly heats the flow and a subsequent section that has a microporous metallic membrane. The membrane section separates the non-volatile engine particles from the condensible vapors by employing the principle of cross-flow filtration. The ability to perform phase separation in real-time simultaneously with phase collection is a feature unavailable in any current commercial thermodenuder and catalytic stripping technologies.

Advantages

- Microporous metallic membrane is field-rugged, lightweight, and fully enables simultaneous collection of particles in both the vapor and particulate phases
- Composition of both vapor and particulate phases can be determined to a full extent to improve understanding of the combustion vapor-particle partition processes
- Very high particle transmission efficiency faithfully portrait the dynamics of the engine emission
- Membrane can be regenerated in the field condition, eliminating the need to replace adsorbent and reducing the weight and size for field deployment

Potential Applications

- Study of the volatility and hygroscopicity of engine particles
- Investigation of particle thermogram on-line
- Characterization of secondary particle formation in engine emissions and ambient atmosphere

Patent

Meng-Dawn Cheng and Steve L. Allman. *A Membrane-based Apparatus for Measurement of Volatile Particles*, U.S. Provisional Patent Application 61/496,632, filed June 14, 2011.

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