Penn State participates in new alternative jet fuels tests launched by NASA

Amidst the new and lasting reality of higher oil prices and shrinking supplies, the search is heating up across the globe for viable alternative fuels. And there's no sector of business more eager to make a breakthrough on that front than those in the aviation industry, whose highest cost is fuel. That is why NASA, together with research groups from three other government agencies, five companies, and three universities, recently conducted a series of tests on two non-petroleum-based jet fuels. The research project is part of the organization's Alternative Aviation Fuel Experiment (AAFEX), with the ultimate goal being to find an alternative fuel capable of powering commercial jet aircraft.

Dr. Randy Vander Wal

Right in the middle of the action representing Penn State is Randy Vander Wal, associate professor of energy and mineral engineering. Dr. Vander Wal is using his extensive background in carbon structure, chemistry and their characterization to collect and characterize the test fuels' carbonaceous particulate emissions from jet engines.

"Several groups, from the United Technologies Research Center, the Environmental Protection Agency, Aerodyne, NASA, and Missouri-Rolla measured aerodynamic particle sizes and gas compositions," Vander Wal said. "We, however, are the only group examining the structure and chemistry of the carbonaceous particulate."

The first round of tests took place in late January and early February at NASA's Dryden Flight Research Center in California. They were carried out on a grounded DC-8 aircraft by using sampling probes placed downstream of the jet's right inboard engines.The purpose of the tests was to measure the engine performance and aircraft emissions of two synthetic fuels derived from coal and natural gas using the Fischer-Tropsch (FT) process.

The FT process is a chemical reaction in which a synthesis gas – a mixture of carbon monoxide and hydrogen – is converted into liquid hydrocarbons of various forms. The process produces synthetic petroleum for various uses, but primarily for fuel.

Both 100 percent synthetic fuel and 50-50 blends with JP-8 were tested and compared to pure JP-8, the current, petroleum-derived, aviation fuel. The two fuels were chosen because they have the energy necessary for commercial flight. With samples back from the tarmac, it is now Vander Wal's task to analyze the samples for differences related to the different fuel sources and compositions.

"We are presently in the midst of using high resolution transmission electron microscopy and X-ray photoelectron spectroscopy to characterize the nanostructure and chemistry of the emissions," Vander Wal said. "We anticipate differences in both categories to reflect the different fuels used in the tests, a high-sulfur JP-8, a natural gas derived Fischer-Tropsch fuel or a coal-derived Fischer-Tropsch fuel."

Test instrumentation was set up behind the inboard engines of NASA's DC-8 airborne science laboratory during alternative fuels emissions and performance testing at NASA's Dryden Aircraft Operations Facility in Palmdale, CA.
Photo Credit: NASA Dryden

As explained by Vander Wal, both the physical and chemical properties of engine emissions have environmental and health implications. The emission of particulate matter (PM) from aircraft gas turbine engines is a unique pollutant source according to the Clean Air Act. Until recently PM emissions from jet engines have not been well characterized. To understand the evolution and fate of aircraft engine generated PM, especially for current/advanced technology engines, fundamental physical and chemical parameters are required.

Sampling 100% pure fuels along with blends should help to prove or disprove the current theory that synthetic fuels create fewer particles and other harmful emissions than standard jet fuel. If proven true, the use of synthetic fuels could improve the air quality around airports. Almost all previous testing has considered only blends.

From here, the research team will finish the analyses of the initial tests and load the findings into a database. According to Vander Wal, they then will move on to take additional emissions measurements.

"We anticipate another field campaign with other aircraft, engine types, and fuel. Results will then be compared to particulate emissions from laboratory-scale flames and combustors, to be conducted in both my lab here at Penn State and at the NASA-Glenn Research Center in Cleveland," he added.

Prior field campaigns, such as Aircraft Particle Emissions Experiment (APEX) III, studied emissions from a variety of jet aircraft including a Boeing 757, 737, Learjet and an Airbus A300 at a variety of power settings. Results showed significant differences between the different engines and selected conditions. According to Vander Wal, although models are being developed for soot formation from such combustors, the experimental particulate signatures are quite different compared to those from laboratory scale systems upon which such models are based.

This article was compiled with information obtained from a NASA press release.