RESEARCH NEWS

Studies on aircraft cabin air quality

Simulator Helps Characterizing Air Pollution in Aircraft Cabins

“Fume events” occur when fluids such as engine oil or hydraulic fluid contaminate the air inside an airplane cabin via the “bleed air” used for air supply and conditioning. Measurements taken in flight do not allow for determination of whether the air quality on board is negatively affected as a result. With the Bleed Air Contamination Simulator (BACS), researchers at the Fraunhofer Institute for Building Physics IBP can artificially simulate fume events on the ground, deliberately contaminating the air inside the testing unit with oils and deicing fluids and then studying the polluted air. The results can be used to make inferences about potential health risks.

Most aircraft draw “bleed air” for air conditioning and pressurization in the passenger cabin directly from the engine. Under rare and unfavorable conditions, this air may contain traces of engine oil, hydraulic fluid or deicing agents, which can enter the aircraft cabins, negatively affect cabin air quality and cause unusual odors. These occurrences are called fume and smell events. What levels of byproducts accumulate in the cabin air as these substances break down? What steps can be taken to reduce potential health risks? So far, these questions have gone unanswered. This is because fume events are rare and cannot be predicted in advance, so it is not possible to identify and quantify the relevant contaminants in the cabin air on regular flights.

Researchers at Fraunhofer IBP are investigating whether cabin air contaminated with engine oil could harm the health of cabin crew and passengers, how this can be prevented and how to detect risks in time to take action. Their Bleed Air Contamination Simulator (BACS) allows them to simulate pressure and temperature conditions in the air supply and deliberately contaminate the air with oil and deicing fluids. Defined amounts of engine oil are added to hot compressed air to replicate the degradation processes that take place in bleed air. This permits detailed analysis of the products of these reactions, which can enter the cabin and cockpit if conditions are unfavorable. “Fume events are rare and unexpected, so they cannot be captured using a predefined number of test flights. Our testing unit lets us perform these important studies on the ground and repeat them as often as desired. That saves jet fuel and eliminates unnecessary emissions and costs,” says Dr. Christian Scherer, Head of the Environment, Hygiene and Sensor Technology department at Fraunhofer IBP. The simulator measures 20 meters in length, 2 meters in width and 2 meters in height. There are 40 connecting

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ports where samples can be taken for online analysis and lab tests. The air flow rate is up to 300 kg/h, one-fifth of the air flow found on a long-haul aircraft.

The researchers at Fraunhofer IBP are studying whether the products of the thermal degradation of engine oil have toxic effects, in collaboration with colleagues at the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM, in the CAQ III project initiated by EASA, the European Union Aviation Safety Agency. ("CAQ" stands for "cabin/cockpit air quality.") The goal is to gather scientifically sound data on fume events to lay a foundation for broader and more detailed assessment of health risks and support the development of aviation standards in this area. "So far, our tests have not confirmed the suspicion that substances produced during the breakdown of engine oil, which include organic acids like valeric acid and traces of organophosphates such as tricresyl phosphate, could have neurotoxic effects," says Dr. Florian Mayer, a colleague of Scherer's. The amounts of PM10 and PM2.5 particulates generated are negligible as well. However, there is a sharp rise in ultrafine particulates with diameters of less than 0.1 µm. The researchers have also not found any increase in either CO or CO_2. Detailed results are still pending, though. They are expected at some point in 2025.

A unique testing unit

To perform the analyses, ambient air is first suctioned into a compressor. An air heater heats the air to a temperature as high as 590 °C, depending on the requirements. Then different concentrations of liquid contaminants are fed into the hot air, which has been compressed to as much as 8 bar. Once the mixture of oil and air has gone through a mixer, decompressed to 3 bar, and cooled down in the first of two heat exchangers, the researchers can take first samples. The air then flows into the second heat exchanger, where it is cooled down even more, and decompressed to ambient conditions until the air is at room temperature. Samples, such as for particulate matter PM, can be taken at this stage. A 300-liter vessel at the end of the line simulates the aircraft cabin.

"Our system is the only one of its kind, and it has a broad range of applications. We do not only simulate the breakdown of aircraft operating fluids. Instead, the simulator gives us and potential customers a way to test the effectiveness of different air treatment technologies used in airplanes," Scherer says. The contaminated air can also be used to study the effectiveness of air purification systems such as filters, catalysts and converters. Sensors can additionally be studied to see how well they respond to the pollutants. "Our measurements are accurate and close to reality, as we have demonstrated in various ways," Mayer says.

Fig. 1 Dr. Florian Mayer prepares to take measurements on the Bleed Air Contamination Simulator.

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