Smart aircraft wings and new lightweight construction materials

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At the JEC Composites Show 2008 to be held in Paris from April 1 to 3, Fraunhofer researchers will be exhibiting an aircraft wing that immediately detects any material damage. Another showcased development is a novel fiber-composite material with a fiber content that can extend to 50 or 60 percent by volume.

Nowadays it's easy to hop on a plane and fly to London or spend a romantic weekend in Paris for just a few euros – if the volume of air traffic is increasing, one of the main reasons is the low tariffs. From an environmental point of view, however, this frequent and spontaneous use of air travel is a controversial issue.

A European consortium consisting of 86 industrial firms and research partners from 16 nations has therefore formed the "Clean Sky" Joint Technology Initiative (JTI) with the aim of minimizing the amount of air pollution caused by aircraft.

Through a number of research and development projects to be conducted over the next seven years, this initiative intends to help to reduce CO2 emissions by 50 percent, NOx emissions by 80 percent, and cut perceived noise by half. The researchers also intend to develop more environmentally compatible methods, processes and materials for the design, manufacture, operation and end-of-life disposal of aircraft. Six Fraunhofer Institutes are currently members of the consortium, and the Fraunhofer-Gesellschaft is one of the twelve organizations that make up the program's Governing Board.

At the JEC Composites Show 2008 to be held in Paris from April 1 to 3, scientists from the Fraunhofer Institute for Structural Durability and System Reliability will be presenting a demonstrator of a structural health monitoring system based on the use of piezoelectric materials.

“We will be demonstrating an aircraft wing made of a fiber composite material incorporating a number of piezoelectric sensors and actuators,” says Dr. Ursula Eul, strategic manager of Fraunhofer LBF. “This system enables damage to the material, caused by impact for instance, to be detected at a very early stage – practically as it arises.”

Piezoelectric actuators in the structure emit acoustic signals which generate a specific pattern of structure-borne noise on the wing. The resulting vibrations are recorded by piezoelectric sensors. Any incipient damage to the material, such as the first signs of delamination, causes changes in the wave pattern of the structure-borne noise. A major challenge here is that the sensors integrated in the structure must not have any negative effect on the fatigue strength of the component or, worse still, on the normal performance of the wing. Reliable structural health monitoring systems that can operate continuously without affecting structural durability are one of the thematic areas of the Clean Sky Joint Technology Initiative.

Another of the exhibits to be featured at the JEC show stems from research at the Fraunhofer Institute for Chemical Technology ICT: A novel high-performance fiber composite material that demonstrates excellent crash behavior in addition to possessing high strength and stiffness, and is therefore particularly suitable for use in the automotive and aerospace industries.

Fiber-reinforced plastics generally consist of a matrix material into which reinforcement fibers – commonly glass or carbon – are embedded. “The most important requirement when producing high-

performance fiber composite materials is that the fibers should be laid down in the direction subject to the highest stresses and that they should be adequately wetted by the matrix material. Our process enables us to achieve a high fiber content of between 50 and 60 percent by volume – a far higher ratio than that obtainable using other thermoplastic techniques," declares Jan Kuppinger of the ICT.

The traditional method of producing thermoplastic fiber composites involves melting a plastic granulate to form the matrix and then mixing the viscous material with the selected type of fiber. "By contrast, in our process we start with the basic constituents of the polymer material, which have the same fluid properties as water and therefore wet the individual fibers much more efficiently. The ensuing polymerization process takes place very rapidly inside the tool," explains Kuppinger. An added advantage is that polymerization occurs at a maximum temperature of 160°C, which is well below the melting point of the final polymerized thermoplastic. This considerably improves the energy efficiency of the process.

This innovative process for the manufacture of new high-performance fiber composites was developed by the Karlsruhe-based innovation cluster "KITe HyLite – Technologies for Lightweight Vehicle Construction". The key research focus of this innovation cluster is technologies for function-integrated hybrid lightweight construction. Emphasis is placed on a holistic approach to fiber composite technologies, encompassing everything from basic methods and the design of new materials to manufacturing technologies.

Source: Fraunhofer-Gesellschaft