Nervous system for structures

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Technical structures will soon have their own nervous system. Developers and users expect this to bring greater safety, maintenance activities only when required, and a more efficient use of material and energy. Researchers will present a demonstrator for monitoring wind turbines at the Hannover-Messe from April 21 to 25.

On average, a single square centimeter of human skin contains over 300 receptors that register pain, pressure, heat or cold. Twenty-four hours a day, these tiny sensors receive and transmit vital information about the condition of our outermost covering via a widely ramified network to the brain. An electronic network modeled on this nervous system will in future protect technical structures, from aircraft and pipelines to the rotor blades of wind turbines.

The ambitious concept bears the name of ‘Structural Health Monitoring (SHM)’. Sophisticated systems of sensors, actuators and signal processing devices detect cracks, rust and other defects at an early stage in order to prevent damage – especially in critical places that are difficult to reach. In structural status monitoring, unlike conventional test methods, the sensors are firmly attached to the structure and can monitor it constantly – even during day-to-day operation.

Several Fraunhofer institutes and various industrial partners are currently working on an SHM system that will use ultrasound to detect any damage to the technical structures of aircraft, pipelines or wind turbines. The core of the sensors used is made up of ceramic piezo fibers that convert mechanical energy into electrical impulses and vice-versa. Any piezo element can be used as either a transmitter or a receiver. It can excite the structure to produce vibrations, and it can record vibrations in the structure.

The ultrasound waves spread out in certain patterns depending on the type of structure. Cracks and other flaws alter this wave pattern in the same way as a rock changes the pattern of waves in a lake. Even a group of four piezo elements is sufficient to locate flaws accurately to the nearest centimeter – flaws that are often no more than a few millimeters in size.

“Our system is intended to supplement the checks used up to now,” says Bernhard Brunner of the Fraunhofer Institute for Silicate Research ISC, Würzburg. But that is only the first step. If the SHM systems prove successful, the researchers can envisage a status-dependent maintenance and repair system: “to save inspections and therefore time,” adds Brunner’s project partner Bernd Frankenstein of the Fraunhofer Institute for Non-Destructive Testing IZFP in Dresden. He is in no doubt that SHM systems will eventually replace conventional test methods, at least in part. The task of the Fraunhofer Institute for Structural Durability and System Reliability LBF is to create deliberate flaws in structures, which can then be detected during tests.

There are even more reasons for teaching structures to ‘feel’. It helps to make better use of valuable resources, both materials and energy. This is particularly noticeable in the aviation industry, where each gram less in the weight of the aircraft increases its potential payload as well as reducing exhaust fumes.

Continuous monitoring by SHM systems is also expected to yield greater safety, particularly for equipment such as offshore wind farms that are not readily accessible. The artificial nervous system fulfills a dual task in such cases: It monitors the structure and at the same time delivers data about occurrences in the structure during day-to-day operation. Data of this kind, which hardly existed until now, will help to optimize the next generations of components.

Source: Fraunhofer-Gesellschaft