Integrated monitoring for durable lightweight vehicle modules

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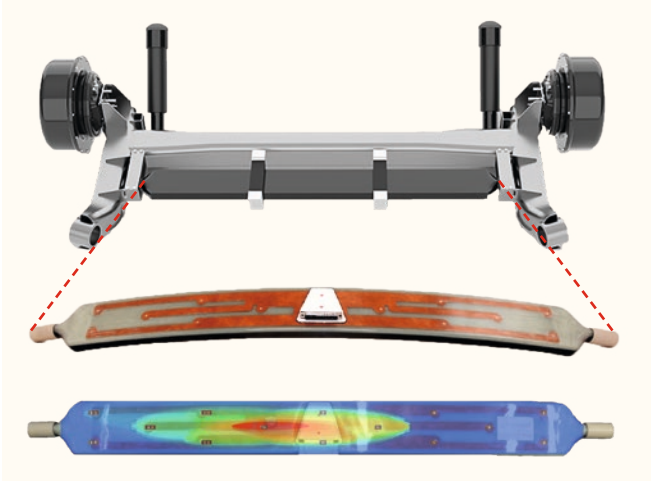

Figure 1: Leaf spring made of fiber composite material with integrated, innovative sensor network.
Top: Schematic representation of the installation state (source: EDAG Engineering Group AG).
Middle: Image of a leaf spring with integrated sensor network.
Bottom: Visualization of damage detection on a leaf spring in a laboratory test.

Closed-loop vehicle components

Vehicles currently produce up to 20 % of CO_2 emissions during their manufacturing process. This is due to the linear, industrial fabrication processes (raw material supply – production – use – disposal). The energy demand results primarily from a short vehicle service life of about 15 years. The basic prerequisite for reducing the energy demand is to retain the value of the raw materials and components used for as long as possible, e.g. through reusable parts.

Durable components made from carbon fiber-reinforced compounds

Durable materials, such as carbon fiber-reinforced plastics, are highly resilient and therefore very well suited for multiple reuse. This is achievable with a circular value chain, in which individual components are tested after the first life cycle and, if necessary, reworked.

In a first step toward realizing this, Fraunhofer IKTS, together with INVENT GmbH, has developed an exemplary innovative fiber composite leaf spring with a novel connection and sensor concept. A sensor network integrated into the material compound (Figure 1, middle) continuously collects data. In this way, the condition of the spring can be holistically described both during operation and at the end of life.

Integrated sensor network

The data collected with the sensor network is evaluated with a corresponding diagnostics system which was developed at Fraunhofer IKTS. The measuring method itself is an established procedure in Structural Health Monitoring (SHM) based on the active Acousto-Ultrasonic method, whereby elastic waves in the range of ultrasound are introduced into the component, and also detected, by piezoelectric transducers. A comparison of the measurement data with a previously recorded reference condition makes it possible to identify the sensor paths on which a change occurred. If the signal deviations are visualized, a graphical interpretation of the measurement signals can be obtained (Figure 1, bottom).

Using this structural monitoring, the component integrity of the spring can be evaluated during its entire service life. An undamaged leaf spring can be used safely and sustainably, even beyond its intended lifetime.

The cycle-oriented concept can be transferred to other automotive components and can trigger further developments in the automotive and aviation sectors. The ultimate goal is a circular-ready e-vehicle platform, which will in future reduce development costs and risks.

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