

Implementation of Sensor-Intelligence Devices (SIDs) for Condition Monitoring Applications in the Sense of Smart Predictive Maintenance

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Summary:

A condition monitoring and predictive maintenance testing system, called **M**odular **A**utarkic **S**ensor platform (MAUS), is presented. Various applications are demonstrated and an outlook is given into further developments.

Keywords: Condition Monitoring, Predictive Maintenance, Sensor-Intelligent Device, EMAT, MAUS

Background, Motivation an Objective

Non-destructive approaches for the continuous monitoring of structures and components provide important information about their condition, service life and safety during operation. Especially in the area of critical infrastructure, exceptional situations in the form of impact events and dynamic processes - which cannot always be absorbed constructively - also influence the operating status of technical systems, which consequently require an as-built examination at regular intervals as part of Smart Predictive Maintenance models. Additional overlapping external influences such as extreme weather conditions, which can lead to age-related damage such as corrosion, or dynamic alternating loads, which can lead to material changes due to fatigue, require the recording and evaluation of relevant condition data in order to derive a damage assessment so that systems can be proactively monitored and subjected to preventive maintenance.

Description of the System

To address this challenge, an innovative solution known as the Modular Autarkic Sensor Platform (MAUS) has been developed. This modular, energy-efficient, and intelligent monitoring system utilizes state-of-the-art microelectronics to provide a platform for many different sensor types, one of which utilizes couplant-free ElectroMagnetic Acoustic Transducers (EMATs) to enable ultrasound ndt testing. MAUS is specifically designed for long-term monitoring of critical infrastructure components, primarily within the industrial and civil engineering sectors.

In order to enable combined monitoring system applications, the platform concept of the MAUS is split into different functional modules. These includes the base module, power supply module for tethered or autarkic supply, communication module for Wifi, LoRaWAN etc., up to different sensor modules for environmental data, position and vibration sensors as well as for different non-destructive sensors including ultrasound or eddy current testing.

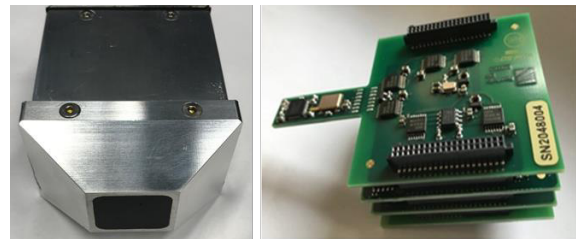


Fig. 1. Developed EMAT (left) and stacked functional blocks of the MAUS platform

The developed EMAT-based system was primarily designed for the local (see Fig. 2) and the mobile (see Fig. 3) ultrasound-based inspection of hard-to-access critical structures, such as wind turbines in the onshore and offshore sector or storage tanks including their in- and outlets, within the framework of operational monitoring in order to ensure the operating condition through permanent quality monitoring.

Results

Appropriate laboratory tests were carried out to investigate and evaluate the resolution and accuracy of the ultrasound-based wall thickness measurement of the system. For this purpose,

several reference specimens of steel have been manufactured, covering a wall thickness range of 2.5 mm up to 20 mm. In other applications similar test results were gathered through lab experiments and field validation. A long term experiment monitoring overhead line anchors on building walls shows the reliability of an energy-constrained system.

Finally a high-performance multi-sensor approach is shown using fast vibration sensors that monitor automotive loads on driving surfaces. A field test setup is shown that demonstrates multiple systems acquiring data at high speeds, which are capable of evaluating the data at real time to reduce data throughput to the acquisition site.

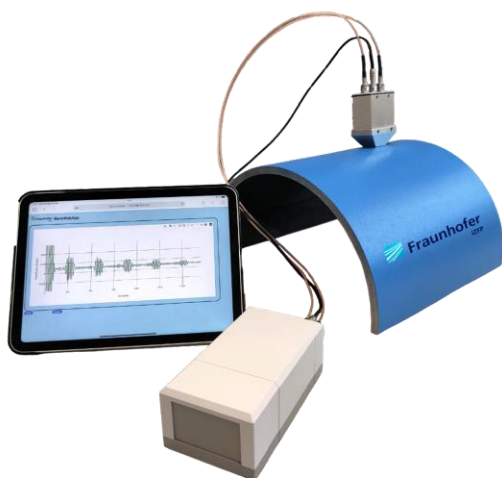


Fig. 2. Developed EMAT-SID concept applied to a half shell test specimen for stationary use including the wireless result display



Fig. 3. Developed MAUS-SID applied to line angle monitoring of wall anchors with constrained power

Conclusion

The system developed in this work excels to a:

- Scalable toolbox of hardware and software components
- High adaptability of the topology of the monitoring system
- Parameterization of the sensors to the test object geometry and damage mechanisms
- Sensor-related data reduction, -fusion and adapted signal evaluation directly in hardware

This system enables further use cases for the modular sensor platform combined with EMAT, covering applications in monitoring of critical infrastructure components and enhancing the detection of structural anomalies, assessing material integrity, and facilitating predictive maintenance to prevent catastrophic failures.

In addition, the MAUS platform as part of recently installed monitoring systems have been successfully implemented in different industrial projects, such as for the investigation of load and the motion of wall anchors via accurate position- and distance measurements [1]. Results in research projects for the determination of the humidity of concrete at bridges leading to structural damages like corrosion at the reinforcement or spalling due to volume increase [2][3] are not yet available but look very promising.

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