# Health screening for industrial machines

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Trained workers at Gorenje install sensors in the tool components of a press used to produce parts for household appliances. Credit: Gorenje Group

Germany's Industry 4.0 initiative aims to develop industrial machinery with built-in intelligence based on smart self-monitoring functions. Researchers have now come a step closer to the ideal of a self-maintaining machine. A technology developed as part of the iMAIN project provides real-time online monitoring of unprecedented quality.

Metal forming machines have to withstand considerable forces and yet

remain in operation for a long time. When cold forming parts for automobiles, washing machines, refrigerators and the like, the exerted pressure can easily amount to several thousand metric tons. This operation has to be repeated hundreds of thousands of times in the complete lifetime of a machine. If the machine fails, it can cause substantial damage. Worse still, because the machine is usually integrated in a series of production steps, the failure can cause the entire production process to come to a stand-still. Depending on the extent of the damage, the repairs could take up to a month – accompanied by a loss of revenues in the six-digit region. If it were possible to predict such failures, either of the entire machine or a single component, companies would know precisely when they ought to maintain the machine or replace specific components, preferably in coordination with the production schedule.

## Virtual sensors render real sensors almost obsolete

Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz aim to change this situation. In the future, the machines themselves will be capable of detecting problems and predicting failures. As part of the EU-sponsored iMAIN project (www.imain-project.eu), the scientists have developed a prototype of an information-based predictive maintenance system that enables operators to determine when a component or entire plant is likely to fail. The distinctive feature of this technology is its use of virtual sensors. These receive input both from computer-simulated models of the machine and from real sensors that provide information on the strain occurring in individual components. "Using mathematical models and a minimum of actually installed, real sensors, it is possible to realistically simulate strain scenarios for the entire machine in real time. This in turn provides the basis for an entirely new and innovative approach to predictive maintenance," says Markus Wabner of Fraunhofer IWU.

Until now, it has been customary to carry out plant maintenance according to a fixed schedule or on an ad-hoc basis in response to failures. Certain manufacturers already equip their machines with (real) sensors, but solutions that rely exclusively on these devices are not ideal: they are expensive and complicated to implement, require their own error monitoring system, and measure stress and strain only at the points where they are installed – and nowhere else. "In our option, the use of virtual sensors is the only conceivable and economical way to obtain a complete picture of the forces acting on the material," says Wabner. While algorithms, simulations and mathematical models can often provide a reasonably good image of reality, even the most precise calculations are subject to errors. This is why the researchers constantly compare the virtual data with real measurements recorded while the machine is in operation. "If there is a wide discrepancy between them, we modify the model accordingly," says Wabner.

A cloud site accessible to internal users via a wide range of interfaces – including smartphones, tablets and laptops – serves as storage of information on the stress history of different manufacturing plants. "The more data we collect, the easier it is to know the right time to implement preventive measures. We develop algorithms that enable machines to learn from experience, and decide on the right time to replace components or determine when they have reached their optimum stress loading. The real data are compared with a simulated model that can be used to calculate the breaking point of the material," explains Wabner.

The EU-sponsored iMAIN project was launched in September 2012 and brings together manufacturers, industrial users, computer scientists and engineers in a concerted effort to develop new, advanced technologies for the maintenance of industrial machines. "The virtual sensors have long since passed the proof-of-concept stage and are already being successfully used in real-life applications. And the private cloud solution for data sharing has reached the test stage," reports Wabner. A prototype

version of the system is being used by a project partner in Slovenia - the Gorenje Group, which manufactures home appliances – for the condition monitoring of a universal press supplied by Litostroj Ravne, another project partner. This factory forms metal panels used in the construction of washing machines, refrigerators and other appliances. "Since this system was introduced, Gorenje has better information enabling it to predict possible outages in advance, and also facilitate and optimize press operations by monitoring the stress and strain on the machines. We regularly compare the recorded data with the results of tests conducted at our facility at Fraunhofer IWU," says Wabner. The ultimate aim is to be able to produce a system capable of predicting the stress-related failure of components in practice by the time the project ends next summer.

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