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Smart Maintenance: Machines report their working condition in real time to trigger maintenance before breakdowns occur.

SMART MAINTENANCE – FROM ISOLATED APPLICATIONS TO HOLISTIC CONCEPTS

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Modern industrial production is precision work in more than one respect. Products are manufactured to exacting standards, requiring machine tools' mechanics to operate reliably and with uncompromising accuracy – unwanted vibrations for example can cause flaws in the required product geometry and lead to expensive waste. Similarly, manufacturing processes usually follow a tight schedule. Disruptions or machine breakdowns mean lost time and, potentially, incur contractual penalties when delivery deadlines are missed.

Smart and predictive maintenance is meant to recognize any signs of damage or wear and tear in machine components at the earliest possible time in order to avoid unplanned and unexpected failures. Sensors fitted to machines keep track of active operations and measure temperature, vibration, energy consumption, and many other parameters. Whenever there are deviations from the norm or signs of potentially problematic trends, the system triggers an alarm so that operators can start countermeasures. However, most commercially available monitoring systems remain isolated proprietary solutions that only track the condition of individual components.

Holistic Smart Maintenance

Fraunhofer IPK pursues solutions that integrate machine monitoring into holistic fleet maintenance concepts. A comprehensive approach of this type reaches from sensors capturing the condition of components and pinpointing even tiny signs of wear or damage, to predicting critical conditions with virtual machine twins, and supporting service technicians on site with the maintenance and repair work that may be required.

Demonstrator with two ball screws and dashboard

The holistic principle has been put into practice in a demonstrator unit with ball screws fitted with sensors to monitor vibration along the linear axis. Ball screws are a common component of machines tasked with moving tools and products with extreme precision. As screw shafts wear over time, vibration may occur and cause flaws in the finished product. Tracking this type of vibration is, however, only one of many possible applications, as the solution can be adapted to many other types of sensor data.

Retrofitting Add-on Sensor Capabilities

The right choice of sensors is the base of any effective condition monitoring. The necessary components do not have to be original parts of the machine they are meant to track. Retrofitting is easy and cost-efficient, allowing modern smart maintenance capabilities to be added even to older machines. Fraunhofer IPK uses sensor technology based on Micro Electro Mechanical Systems (MEMS), as already popular in automotive use or consumer smartphones. The sensors are combined with microcomputers that process the reported data immediately at the place where it is collected. This distributed data processing helps reduce the amount of data that needs to be transmitted through the network.

Machine Learning with Sensor Data

The information retrieved from the sensors is first used to classify the condition of machine components. The demonstrator system for example distinguishes between different vibration patterns, some of which might correlate with wear and damage. The categories help define which machine behavior can be considered acceptable and at which point an intervention might be indicated. Machine learning, using the sensor data from actual operations, can help to continuously improve the accuracy of the damage class identification.

Cloud-based Predictive Maintenance

By recording monitoring reports on an Industrial Internet of Things (IIoT) platform, the data continuously builds up to form a complete history of a machine. This data helps level up the capabilities of supervised machine learning: By following trends in the sensor data over a longer period of time, predictions can be made about component wear and damage. This enables genuine predictive maintenance and more: The history can reveal whether certain process parameters favor certain types of wear – and allows manufacturers to tweak and optimize their processes accordingly.

All machines suffer a unique and characteristic pattern of wear and tear over their lives. To account for this, a virtual twin is created for each machine that records the relevant parameters and keeps a historical log of its condition and any spare parts. Whenever a component is replaced, the replacement is recorded to make sure that the virtual twin stays fully synchronized with the physical machine.

Support for Servicing on Site

If servicing or repairs are indicated, the service technicians on site can get invaluable support for their maintenance work through the cloud. They can use mobile devices to scan special unique identifier markers, like QR codes, to find the right machine and the part that needs to be replaced – an indispensable precaution and great relief for technicians working in large factories. The assistance system can also provide instructions for the planned works and can be configured and readily updated, using a responsive process model that can adapt to new procedural insights or revised processes. The required documents, media, and information are fed into the process model and provided at the point of need.

Target Users

Fraunhofer IPK's smart maintenance concepts are addressing machine tool manufacturers as well as plant operators. They enable factory operators to integrate even older facilities into a comprehensive and holistic maintenance system with a cost-efficient retrofit solution. Machine tool manufacturers can get access to real-life operating data to optimize their designs and introduce new add-on services, such as condition-responsive maintenance services.