Interview with Dr. Olaf Sauer

About Big Data and the optimization of production plants using condition monitoring and intelligent data analysis.

In dialogue with Dr. Olaf Sauer of Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB)

The key factors indicating the productivity of a manufacturing system are the output of good quality parts and/or lots and the availability of production equipment. To improve availability, new maintenance and repair strategies for machinery and equipment based on condition monitoring are receiving more and more attention. Instead of simple, corrective maintenance, there is a trend towards systems that make proactive proposals for maintenance and other services. At the same time, an overall perspective will be taken on production systems in the future, rather than considering individual machines or aggregates, as has been the case so far. The challenge is to collect data spanning the entire factory or disparate production systems and to evaluate and interpret them in a meaningful way.

Where do you think could decision-supporting maintenance be applied specifically?

Olaf Sauer: In the last few years, industry has defined various application scenarios for these kinds of new approaches. Software systems can record the behavior of production systems, draw abstract conclusions on normal behavior and, on this basis, detect non-conformance events such as wear and tear or defects and analyze the root causes. Sensor and actuator data from production equipment can be used for the automated identification of potential improvement of technical processes with regard to the consumption of water, energy or other resources. The machine-assisted interpretation and indication of relevant data can help reduce the workload on equipment operators in the future, using appropriate human/machine interfaces.

What are the basic requirements to leverage these productivity potentials?

Olaf Sauer: What is needed is data about the processes which are captured by field devices. The increasing availability of intelligent field devices results in a trend towards more and more instrumented processes. By means of intelligent diagnostic and forecasting methods, this data can then be converted into information about the condition of the equipment and its components and gradual changes in process parameters or the risk of component failures. This helps avoid unplanned downtime of machinery and improve the availability of production systems.

What process technologies make use of these applications?

Olaf Sauer: They can specifically be applied in continuous processes in the chemical industry and in batch processes in pharmaceutical production, for instance. These processes are very complex; in addition, they are described by a wide variety of system variables and it is difficult to model their behavior in analytic terms. Owing to the comparatively long life cycles of continuous processes, it is, above all, gradual changes in the system behavior or wear and tear that need to be detected. In view of the dimensions of the plants and the complexity of the processes, equipment operators and maintenance staff also need detailed information to be able to track the detected malfunctions accurately. Batch processes, by contrast, are marked by process phases which the ongoing process has to pass. In order to supervise them, monitoring procedures have to find these process phases, monitor their sequence and check whether the processing times are adhered to during the respective process phases. For both types of processes, we have developed data mining methods...
that are able to learn. They are also called ‘self-organizing maps’, which have been tailored to the specific needs of process technology.

**In what way do your applications in discrete manufacturing differ from continuous or batch processes?**

Olaf Sauer: Unlike continuous or batch processes, discrete manufacturing requires the storage and evaluation of discrete events in the system, such as switching states. The increasing automation of manufacturing processes and the extensive use of sensors result in ever larger volumes of data captured at shorter and shorter intervals. However, users are overloaded by these quantities of data, which is why they do not use them sufficiently. In addition, there are not enough intelligent analytical tools. They draw abstract conclusions from the data and support users in applying them to plant intelligence and optimization. The basic idea is to leverage methods of data mining and statistics.

For these industries, we use the same approach, which consists in deriving models of plant behavior from the data, rather than creating them manually. To this end, we use hybrid, timed automata. They have proved appropriate and robust to various sectors of the manufacturing industry for learning the conditions and modelling the behavior of machinery and equipment.

**Are your applications also suited for capturing and analyzing energy data in manufacturing?**

Olaf Sauer: Our methods enable us to generate models that deliver reliable forecasting information on the energy consumption of production plants, allowing the most energy-efficient production methods to be chosen. Using the example of drives of a material-handling system we could prove that the energy consumption could be reduced by modifying monitoring and control and the control algorithm. In parallel to the evident basic features of receiving and shipping, operations are supposed achieve optimum energy
efficiency. To this end, a computer model of the system is required, which shows the energy and automation related aspects. This model can be created using our machine learning procedure, for example. On the basis of this model, algorithms of self-organization perform the tasks of the PLC programmer, repeatedly and in real time, by adjusting the workflow behavior of the drive axes continuously in a way that, for one thing, ensures the basic functions and, for another, helps meet the energy targets. These kinds of assistant functions are examples of intelligent technical systems that provide additional forecasting data.

Your institute also has considerable expertise in innovative data logging, analysis and evaluation. What are the main fields of application of this know-how?

Olaf Sauer: First of all, there are the hybrid processes. The clear distinction between continuous process and discrete manufacturing technology is vanishing more and more in practice. Hybrid processes that include components from both fields of application can increasingly be found in industry today. For this reason, our methods can be combined as needed in the specific case and can precisely be tailored to the requirements of our customers.

In addition to the aforementioned procedures we are also working on other methods and components. We have universal, real-time-compliant data loggers in place which are able to capture analogous and digital process information in a heterogeneous networked automation system at the precise time and to store it in a database for later analyses.

To monitor complex systems, their behavior can be understood using machine learning procedures. This saves process engineers the efforts of creating the model. New technologies of unsupervised machine learning capture the normal behavior of equipment without having to include equipment know-how right from the start, for example during start-up. On the basis of the models they have learned it is possible to monitor the equipment online and to detect non-conformities quickly, to track them accurately and ultimately to eliminate them effectively. Hence, the availability of costly production plants will increase significantly. The subsequent visualization of the results of condition monitoring, for example in a web portal, is another component we can provide in a custom-made way. These systems, in turn, have to be linked to maintenance management systems, allowing for consistent system support ranging from the sensor to the database.

For which of your applications do you offer live demonstrations in your test factory?

Olaf Sauer: In cooperation with inIT – Institute of Industrial IT – of the OWL University of Applied Sciences we use our smart factories to study, test and demonstrate future information and communication technology solutions in the field of automation. At our Karlsruhe, Lemgo and Ilmenau sites we run a distributed Industrie 4.0 production system that serves as a test environment for Industrie 4.0 technologies. For example, we test and demonstrate condition monitoring across all locations including visualization in a genuine control room. In addition, it is also possible, even today, to demonstrate the reliable remote control and maintenance of distributed systems using internet and mobile communication in a comprehensible way.

Thank you very much for your time.

The interview was conducted by Rudolf Müller.