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An artificial intelligence emerges

Kistler is supporting tepcon with the development of a model for predictive maintenance

Listening in to the plant: accelerometers from Kistler examine critical components such as this chemical module pump to identify structure-borne sound patterns.

tepcon's software experts have launched a partnership with the new Kistler Digital Solutions Lab. The goal: to integrate predictive maintenance capability into the wet process systems developed by AP&S, tepcon's sister company. This development project in the semiconductor production sector takes machine learning as the basis for creating intelligence with predictive ability, independently of the individual plant.

The semiconductor sector is one of the most complex of all industries: circuits and microstructures such as MEMS are becoming more compact and more powerful, while production technology is also evolving at a relentless pace. Nowadays, 400 to 1,000 individual steps are needed to manufacture just one single chip – resulting in complex value chains that span the globe and are difficult to understand and manage.

One of the pieces in this intricate jigsaw puzzle is AP&S, a company based at Donaueschingen in the extreme south-west of Germany. They specialize in manufacturing wet process systems that are used for cleaning and surface processing (etching, stripping and plating) of wafers and substrates. 160 employees across the globe develop and manufacture equipment here in two segments: Single Wafer Processing and Batch Processing. The AP&S portfolio also includes services such as system repairs and complete overhauls.

Smart software – the key to productive added value

The market sets demanding requirements: maximum machine availability, high plant process quality with modular, flexible machinery design, and rapid response times in case of faults. AP&S does its utmost to meet these challenges, so continuous development of products and systems is a critical success factor for the company. Innovative Industry 4.0 solutions play a key part here. This is why AP&S acquired a participating interest in tepcon, the software company. By taking this step, AP&S broadened its know-how in areas such as software, connectivity and IoT that are increasingly important factors in mechanical engineering, machine maintenance and control.

AP&S's entire IoT strategy is based on solutions from its subsidiary tepcon. But the software experts also remain active on the market as an independent B2B provider. Its offering includes IIoT applications such as condition monitoring, machine learning (ML) and augmented reality – opening the way to more efficient processes for end customers from a variety of industries. Christoph Kluge, tepcon's Managing Director, describes the synergy effects of this structure: "The decisive factor for us – as IT specialists – is our physical proximity to AP&S, the special-purpose machinery manufacturer. We work together on every software project right from the outset, so we know exactly what matters most in the development work. Process optimization, competitive edge and cost savings for end customers – we always focus on achieving those goals. Thanks to augmented reality (AR), for example, we make it possible for a service technician to project the current machine data onto the machine with AR glasses. That cuts out complicated manipulations on the HMI (human-machine interface). The AR glasses also allow the technicians to call up step-by-step instructions telling them exactly where they need to intervene."

How is it possible to predict outages on complex plants?

A project is currently under way to develop a new functionality for predictive maintenance. Machine outages can cost end customers a lot of money: depending on the processing stage and the types of substrate, the value of a batch of wafers in a plant can easily run into six digits. Stefan Wolf, a software developer at tepcon, explains: "The interaction among different components in these plants is often so complex that the cause of a machine outage isn't immediately clear, so the first step is to locate it." Since completing his master's thesis in 2017, Wolf has focused on machine learning and in October 2018, he took on the management of the predictive maintenance project. "This meant that we had to find a way of getting meaningful feedback from the machine, evaluating it in the appropriate way and using this data as the basis for predictions."

Project Manager Stefan Wolf of tepcon (center) with Head of Kistler Digital Solutions Lab Marco Angliker (right) and Solution Architect Rolf Lussi of Kistler (left) in the inhouse laboratory at AP&S.

tepcon invited the new Kistler Digital Solutions Lab to come on board as its development partner for sensor technology and data acquisition. The new unit is headed by Marco Angliker, Head of Kistler Digital Solutions Lab. He takes up the story: "We've assembled a powerful team that combines measurement technology know-how with software and development expertise. The main focus here is not on products or technologies, but on gaining a precise understanding of the customer's objectives, bringing the right people together and working jointly to find the key to solving problems that are often very complex."

Listening in to the machine directly

Central components such as pumps, rotary plates and filter fan units (FFUs) on a total of four AP&S machines have been equipped with uniaxial and triaxial accelerometers from Kistler, as well as distance sensors from a third-party supplier. The volume of data recorded per plant and per day is about 120 gigabytes. "The Kistler sensors actually enable us to listen in to the machine. They record structure-borne sound and position data that tell us when the plant is getting into the abnormal range and is soon likely to fail," Wolf explains.

The challenge now is to develop intelligence that can predict outages with a specific degree of probability, but without being limited to one particular type of plant. tepcon is deploying machine learning to achieve this: the vast quantities of data are stored locally on an industrial PC (IPC); later on, they are transferred to a cloud backend where the artificial intelligence (AI) is trained. Based on the machine learning concept, this AI is trained with the data recorded continuously from various systems. This gradually improves its ability to understand the differences between normal and critical operating conditions.

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Measurement technology and software from a single source

"The Kistler Digital Solutions Lab is a very valuable partner in this long-term, open-ended development process," Wolf emphasizes. "The fact is that every type of system is different, so each one has to be individually equipped with suitable measurement technology. Bearing that in mind, the new KIDAQ data acquisition system from Kistler meets our needs excellently – it's flexible, it can operate with many different sensors, and it features efficient setup and configuration. The option of simply recording raw data without direct evaluation is also very helpful." KiDAQ is one of the elements in the extensive technology toolkit that the Kistler Digital Solutions Lab uses to offer its customers efficient solutions tailored precisely to their needs.

Continuous data recording and vast quantities of data called for special attention to the details of the KIDAQ setup in conjunction with the IPC for data storage. There was a requirement to specify sensor configuration, channel assignment, sampling rate, storage intervals and other parameters. To meet these needs, Kistler offered the option of controlling the KiDAQ directly from the IPC via the command line. "We're highly satisfied with the support we receive from the Kistler Digital Solutions Lab – from commissioning and integration all the way through to programming. That's not something you can find anywhere else on the market," Wolf notes. "Kistler's combination of advice, development partnership and groundbreaking technologies is unique. When you're confronted with a complex, open-ended challenge, you're glad if someone is just prepared to listen to you – but thanks to the Kistler Digital Solutions Lab, we also had access to the know-how needed to master the details of the steps that led to the solution."

The KiDAQ data acquisition system from Kistler (front left) is connected to an IPC (front right) that initially provides temporary local storage for data from the plant.

Moving towards a higher level of artificial intelligence

One example of these challenges was the fact that some of the systems are located in a clean room environment – meaning that programming also has to be carried out there. "We reserved one full week in the clean room to set up and program the entire data acquisition on the system, including the measurement technology. Thanks to the efficient setup on the KiDAQ from Kistler, we'd already completed this step by the Wednesday of that week. Anyone who has ever carried out system programming in full kit in a clean room can judge how much easier that made our work," Wolf points out.

tepcon has already obtained Proof of Concept for individual systems – outages on them can now be predicted with a very high degree of probability. But more still remains to be achieved. Christoph Kluge describes his vision: "If we can succeed in developing an 'intelligence above the intelligence' that can predict imminent outages with high probability – let's say 80 percent, because machine learning is always probabilistic – and if the predictions are not plant-specific – well, that would be something that many industrial customers would want." Kluge continues: "So – we're on a journey. At a later stage, this evolving intelligence could be integrated directly into the KiDAQ or the systems – not only at AP&S, but also for other providers beyond the semiconductor industry."

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Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland
Tel. +41 52 224 11 11

Find your local contact at
www.kistler.com

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