New software for increasingly flexible factory processes

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The smart manufacturing network serves as an enabler for connected, adaptive production processes. Credit: Fraunhofer IPT

Industrial manufacturing usually follows rigidly programmed processes, in which individual work steps and machines are tightly scheduled. This makes production inflexible and causes problems if devices fail or unscheduled com- ponents need to be processed at short notice. At the Hannover Messe Preview on February 9, 2017, Fraunhofer developers will be presenting new software that allows each individual component to tell the machine what has to be done. By breaking away from central production planning, factories can achieve unprecedented agility and flexibility, very much in the spirit of Industrie 4.0.

In today's factories, components such as engine blocks or blanks for a turbine blade are processed in linked processes by multiple machines. The systems turn and mill each component and repeatedly measure it automatically as they do so. A timetable precisely defines the sequence of work steps and the machines and devices required to carry them out. However, such timetables work through the individual steps in rigid sequences. If machines fail or other components have to be prioritized because of customer requests, the manufacturer has to laboriously reschedule production or retool the machines. This costs time and money.

The component knows

Everything would go much faster if production and the requisite machines were not rigidly set by a control program, but if every component itself knew the best way for it to be moved quickly through the process chain. This is similar to a car's navigation system, which is able to calculate the fastest route with the latest real-time data. Impossible? Not at all, as developers at the Fraunhofer Institute for Production Technology IPT in Aachen intend to demonstrate: The institute's engineers are developing a production system in which every workpiece itself carries the necessary information about concrete manufacturing steps it needs to complete. This is what the engineers call "service-oriented architecture for adaptive and connected manufacturing," and they will be presenting their new development with a special exhibit at the Hannover Messe Preview. The basic idea is this: The component behaves like an individual. First, the information outlining which production steps each component should pass through is stored. Here, it is deliberately left open just which machine should carry out a specific processing step. Only once a processing step is pending, the system does choose one of the various machines with suitable capabilities one that is available immediately or, failing that, the soonest available one.

The decisive point is that a record is kept for each production step, detailing what task was carried out and what each component has been put through: "Hole drilled with machine parameter A and tool X", "edge ground with machine parameter B and tool Y," "surface milled with machine parameter C and tool Z". IHence, the software chronicles the

manufacturing history of each individual component, creating what is known as a digital twin. The components bear a QR code so that they can be individually recognized.

One-of-a-kind production thanks to digital twins and a smart manufacturing network

The goal is to use the software to create a digital twin for every component. This way, manufacturers will always know how each component was processed, which machine or tool was used and which step is coming up next. This strategy is important for companies, for example, whose production machinery handles batches of different components. In conventional manufacturing setups, it is necessary to repeatedly stop, reprogram and retool systems when switching to the new product. However, with the service-oriented approach, it's the product itself that tells the devices what needs to be done. "By connecting components and machines in the future, companies will be able to successively manufacture one-of-a-kind pieces, in other words even batches of one," says Michael Kulik, who is helping develop the new software as a project manager at Fraunhofer. To this end, a component's entire process data should be made available in the form of its digital twin in a smart manufacturing network. Subsequently, data sets can be analyzed and reused, thus increasing process robustness and product quality. At the Hannover Messe Preview, Fraunhofer researchers will be using a small, representative production line to demonstrate the features of the digital twin, the service-oriented software and connection to the smart manufacturing network.

Service-oriented software leads to flexible production

What is unique about the service-oriented software is that the production process sequence can be easily configured using a menu: By means of drag and drop, users select individual work steps from a list of all services derived from the production environment – and ultimately from the manufacturing machines – and add them into the relevant process chain. They then line these work steps up in a row. In case a machine fails, a top-down, centrally controlled manufacturing setup can – at worst – lead to a full production downtime. With service-oriented software, this should no longer occur: Since the next step for each component is stored in detail in its digital twin concept, users can flexibly redirect the component to another machine that offers the next work step. "Many machines can fulfill multiple tasks in a production line", says Kulik. "A technically sophisticated 5-axis milling machine, for example, can also do the job of a simpler 3-axis milling machine." With central production planning, however, there is usually no provision for such switches, because the whole manufacturing process is set up for defined work steps and machines. "Within the smart manufacturing network, the service-oriented software will have the flexibility to decide whether or not to send the job to the 5-axis machine that is free at that moment."

Plug and produce

Another important prerequisite for flexible manufacturing is the ability to integrate machines from different manufacturers easily into the smart manufacturing network. Consequently, Fraunhofer IPT is working together with partners from science and industry in the Fraunhofer High Performance Center for Connected, Adaptive Production, focusing on the integration of the various manufacturer systems into a shared superordinate software and data platform. "As of yet, there is no equivalent for the sort of plug-and-play approach that we're so familiar with from everyday technology," says Dr. Thomas Bobek, coordinator of the Fraunhofer High Performance Center. "Our goal is to pave the way for 'plug and produce'."

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