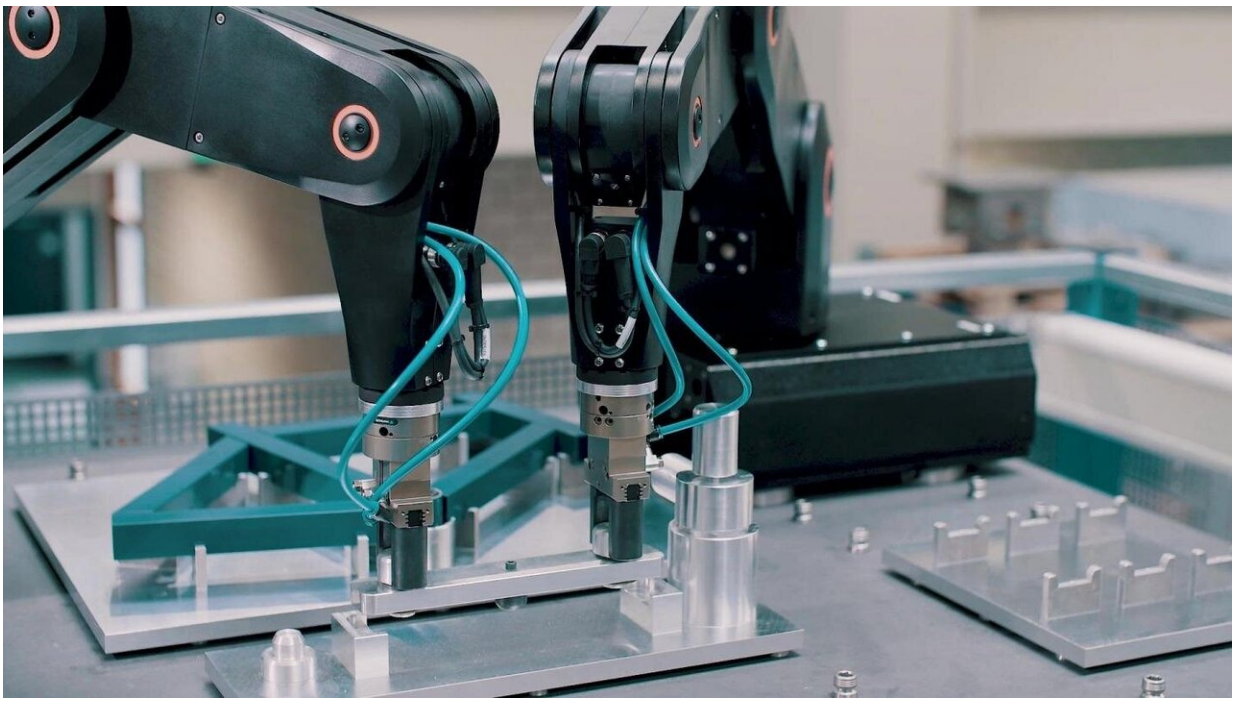
Flexible production system enables variety of variants

August 24 2020



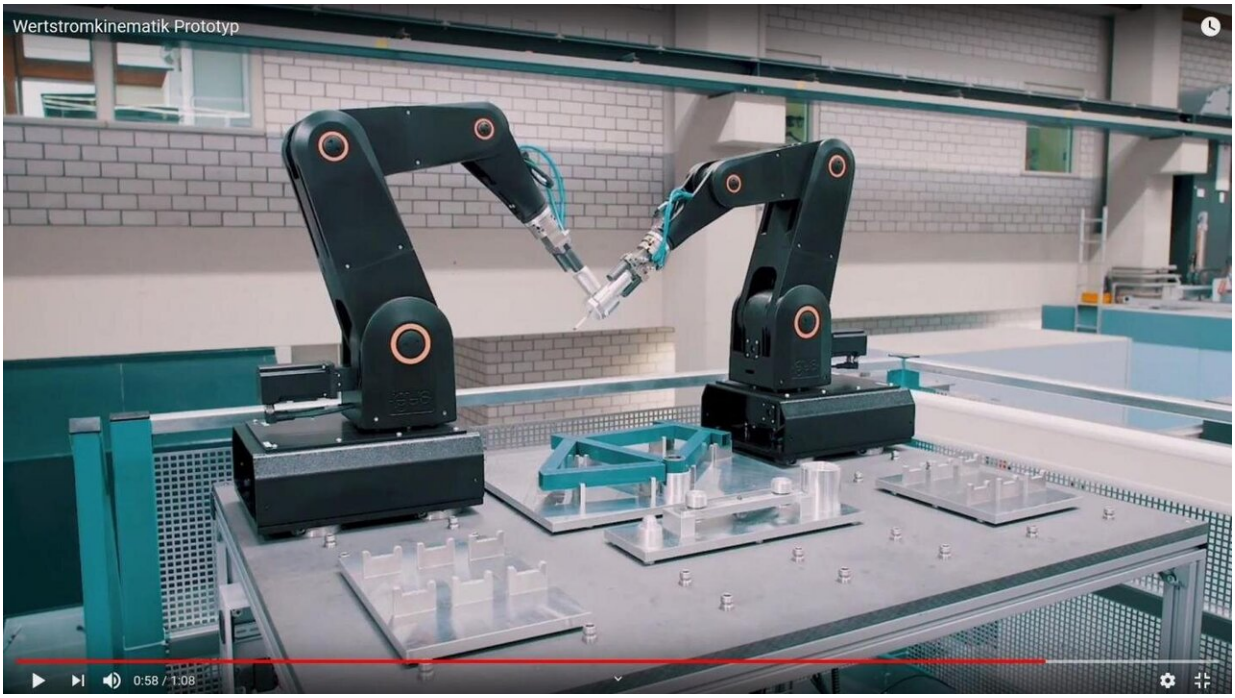
Flexible production system: Higher force and precision, for example when assembling a bicycle frame. Credit: wbk, KIT

From sports shoes to car accessories—there is an increasing demand for individualized products. The economic and competitive production of industrial and consumer goods with a high degree of individualization and improved quality standards in correspondingly smaller quantities requires suitable production processes. Together with some industrial

partners, researchers at KIT (Karlsruhe Institute of Technology) are developing a novel, user-friendly production planning system that combines the high productivity and accuracy of special machines with the flexibility and versatility of industrial robots.

Companies that respond to the growing demand for greater product variety have a competitive advantage, but their prices often have to match those of competing products from highly efficient, automated, and rigid production systems. They then have the choice between rigid production lines with high productivity or a flexible production with low efficiency. Removing this conflict of objectives and combining high flexibility with high productivity is the goal of the "Wertstromkinematik" (value-stream kinematics) research project. This is a completely new production approach. "Suitable production systems, which are characterized equally by great flexibility and a high degree of automation, have not existed until now, or only in rudimentary form. Our approach is going to close this gap," says Edgar Mühlbeier from the wbk Institute of Production Science at KIT. As a mechanical engineer who is specialized in control technology, he coordinates the development of this innovative production system, which combines the high productivity and precision of special machines with the flexibility of industrial robots.

"Value-stream kinematics have the potential to revolutionize today's production landscape," says Professor Jürgen Fleischer, head of the wbk institute and initiator of the novel production approach. It could obviate the need for large halls and avoid long supply chains or production losses due to supply bottlenecks. The current crisis caused by the pandemic has shown how quickly the lines can come to a standstill if supplies from abroad required for production are not available in time. "If our flexible systems were in use, regional companies in the immediate vicinity could step in and manufacture the missing parts. The reduction of transport distances would also be environmentally friendly and resource-saving," Fleischer emphasizes.



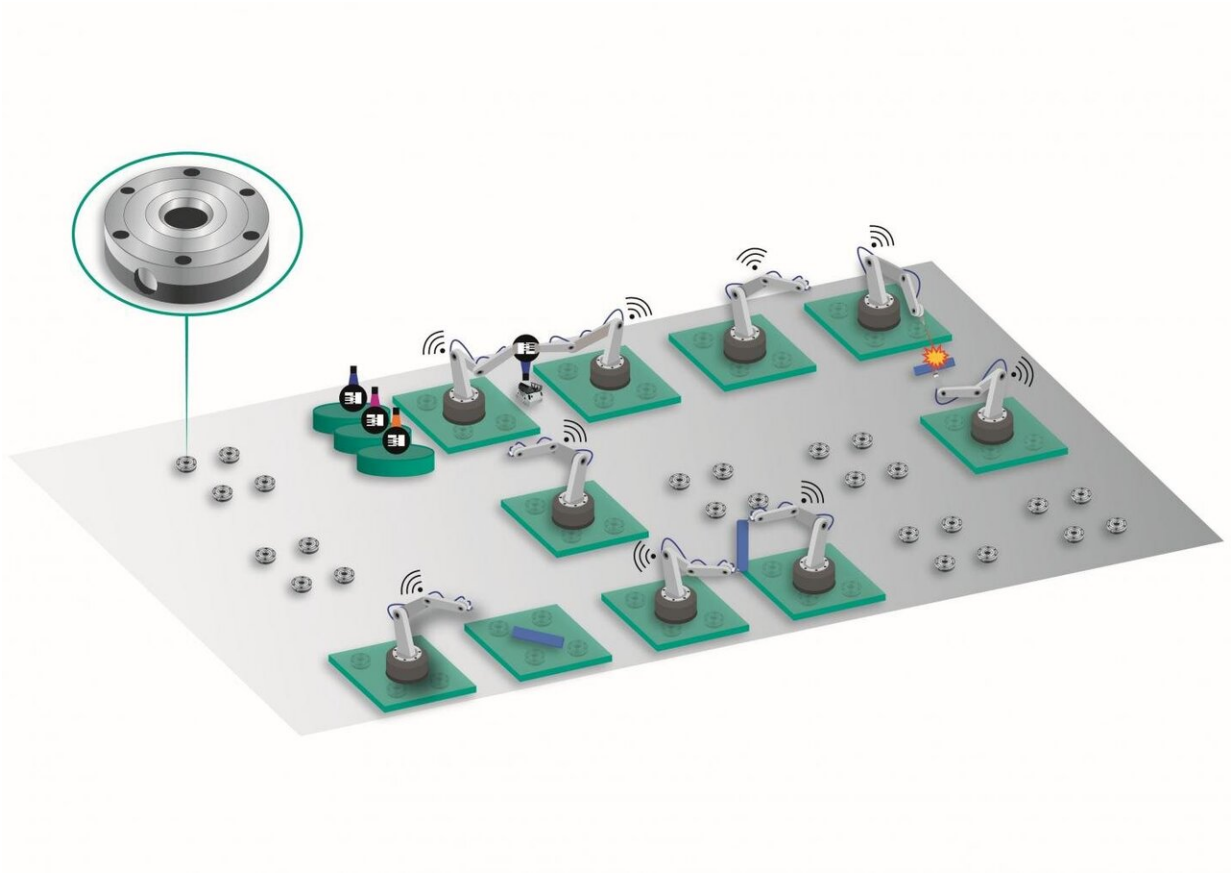
The prototype at work. Credit: wbk, KIT

Flexible design allows frequent and flexible rearrangement

The system consists of several uniform and freely configurable individual units (kinematics). They autonomously perform common robotics handling tasks and are capable of docking various production tools in order to carry out processes such as assembly, additive manufacturing, cutting and joining processes as well as machining tasks and quality assurance—fully automated and within a multi-layered production flow. "This design allows for frequent and flexible rearrangements of the production system without the need to purchase costly additional equipment," Mühlbeier states. In order to solve these demanding tasks, the new system needs to be optimized in various ways compared to conventional vertical articulated arm robots, especially with

regard to its stiffness.

Relying on innovative gear technologies and software support, the researchers want to achieve, for example, a milling path that is accurate to a few hundredths of a millimeter. The individual process parameters, such as cutting speeds and the use of force must be planned precisely. "The special feature of our production system is that the individual units can be coupled to cooperate and thus replace today's special machines for certain tasks and processes," explains Mühlbeier. After completion of the task, they can be decoupled again and used separately. This is a way for companies to reduce the number of production machines, which are often very expensive.



The flexible production system makes manufacturers independent from individual machines. For example, productivity increases can be achieved by coupling and decoupling units as required. Credit: wbk, KIT

Fast assembly, shorter planning and commissioning times

The fast, simple and exact spatial positioning of the flexible value-stream kinematics allows to establish a grid that extends across the entire production area "comparable to a Lego board on which the bricks can be pinned as desired," says Mühlbeier. The preparation of the production system can thus be accelerated considerably. In order to significantly reduce the planning and commissioning time, an intuitive and easy-to-use engineering platform will additionally provide web-based and thus platform-independent support for engineers also in medium-sized companies: This spans the design of a product in CAD, planning the number, arrangement and coupling of the kinematics, as well as simulation and fine-tuning of the production system.

KIT scientists are driving their development in cooperation with industrial partners: Siemens contributes in the field of control technology and the machine tool manufacturer GROB-Werke as hardware developer and integrator. "Production technologies have to satisfy the changing conditions of the market and meet the constantly increasing technological requirements. Our goal is to identify and develop innovative solutions for new processes and requirements," says Fleischer.

More information: Data Sheet: www.sek.kit.edu/downloads/Date … tromkinematik-en.pdf

Provided by Karlsruhe Institute of Technology

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https://techxplore.com/news/2020-08-flexible-production-enables-variety-variants.html

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