PRESS RELEASE

automatica 2025 – New type of machining robot closes the gap between classic industrial robots and machine tools

For resource-efficient, flexible and automated production – Newly developed milling kinematics enable versatile, efficient and high-precision machining of fiber composites to aluminum up to tempered steel with a manufacturing tolerance of up to 0.1 millimeters

The globally unique new development will be presented at automatica, the leading exhibition for smart automation and robotics (June 24-27, 2025, Munich, Germany), by Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Stade, together with autonox Robotics GmbH and Siemens AG in hall A4 at the autonox Robotics booth A4-329 and hall B6 at the Siemens booth 303.

New type of machining robot – maximum precision and dynamics in production

The Fraunhofer IFAM in Stade has developed a pioneering technology to improve the dynamics and precision of industrial robots, combining intelligent, model-based control strategies with innovative drive technologies and an optimized mechanical structure of the robot. This development enables dynamic errors to be compensated for and vibrations to be effectively damped. That significantly improves path accuracy, even at high feed rates and complex path movements.

A particular advantage is the optimized disturbance rejection which ensures constant precision even with highly dynamic process forces. This drive concept therefore enables machining with higher material removal rates as well as the ability to operate with higher jerk settings, both of which lead to a significant increase in productivity.

Thanks to these properties, this "Machine Tool Robot" (MTR) closes the gap between classic industrial robots and machine tools. It is particularly suitable for demanding manufacturing processes, e.g. in the machining of harder materials, and open up new possibilities for automation technology as well as smart industry.

Alternative machine concept

Industrial robots enable an alternative machine concept, especially if they are used together with a workspace extension by means of a surface-moving platform or additional translatory axes, such as linear axes, or in combination with other robots.

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Compared to gantry systems or machine tools, this machine concept is much more space-saving and not economically tied to individual large components. In addition, there is no need for special foundations which makes it easier to adapt production lines in future.

Wide range of applications thanks to the combination of linear axis and robot

The combination of serial articulated arm kinematics with a linear axis provides many advantages over large gantry and special machines for processing. The smaller mounting space and the modular design of the linear axis make the system highly flexible. The use of two preloaded rack and pinion drives compensates for reversal effects and achieves a sufficiently high drive stiffness of the linear axis carriage for path-accurate robot processes. Due to the high structural rigidity of the linear axis, the influences on the robot accuracy are low despite the large lever arms to the load application point.

Further potential for increasing precision: "CaliRob" – Model-based calibration of industrial robots and linear axes

A software application for model-based calibration developed at Fraunhofer IFAM in Stade – "CaliRob" – opens up a complementary technology for increasing precision: Due to unavoidable manufacturing tolerances, industrial robots exhibit individual deviations from the ideal system. These deviations can result in errors of up to several millimeters when approaching target positions in robot systems without knowledge of these deviations. In order to achieve the highest possible accuracies, industrial robots must therefore be calibrated according to requirements, for example with "CaliRob". A key element of this application is a very extensive mathematical model that includes over 200 parameters to describe robot kinematics on a linear axis.

Perspectives

In the next step, the experts at Fraunhofer IFAM will test the new robot system together with their R&D partners autonox Robotics GmbH as well as Siemens AG in demanding industrial applications in order to further advance the potential of the technologies.

Machine Tool Robots can be used for a wide range of applications: In combination with a linear axis, the spectrum ranges from machining tasks from the aerospace industry, such as lighter fiber composite structures and aluminum alloys, to the machining of harder materials, such as steel or titanium which are used, for example, in rail, commercial vehicle and shipbuilding as well as in the energy sector. Until now, it has not been possible to machine such components and materials in an industrially robust manner using industrial robots. In

particular, the machining of harder materials using Machine Tool Robots appears to have a promising future.

Project funding

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Niedersächsisches Ministerium für Wirtschaft, Verkehr, Bauen und Digitalisierung

NBank

Projektträger DLR Luftfahrtforschung

Further information

- **Trade fair**
  Find out more – visit us from June 24 to 27 at automatica 2025 in Munich, Germany, in hall A4 at the autonox Robotics booth A4-329 and hall B6 at the Siemens booth B6-303

- **Industrial robots with high path accuracy**
  www.ifam.fraunhofer.de/en/technologies/hybrid-drive-for-robots.html

- **Press release from October 24, 2024**
  www.ifam.fraunhofer.de/en/Press_Releases/high-precision_processing_robot_innovative_drive_train.html

- **Linear axis for industrial robots**
  www.ifam.fraunhofer.de/en/technologies/linear-axis-industrial-robot.html

- **Model-based calibration of industrial robots l “CaliRob”**
  www.ifam.fraunhofer.de/en/technologies/calibration-industrial-robots.html

- **Fraunhofer IFAM l Stade branch**
  Automation and Production Technology
  www.ifam.fraunhofer.de/en/stade

- **autonox Robotics GmbH**
  www.autonox.com/en

- **Siemens AG**
  www.siemens.com/en

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Figure 1 l Caption
The newly developed flexible milling kinematics on a linear axis machines a CFRP vertical tail plane of an aircraft on a 1:1 scale with high precision (© Fraunhofer IFAM).

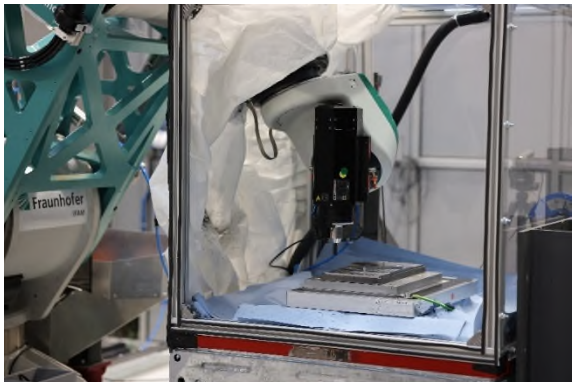

Figure 2 l Caption
The successful high-precision machining of a steel part shows that the machining robot on the linear axis is able to close the gap between industrial robots and machine tools (© Fraunhofer IFAM).

Figure 3 l Caption
Technology transfer to industrial applications: In the background the flexible milling kinematics developed at Fraunhofer IFAM, in the foreground the jointly developed product solution from autonox Robotics (© Fraunhofer IFAM).