MITSUBISHI ELECTRIC CORPORATION
PUBLIC RELATIONS DIVISION
7-3, Marunouchi 2-chome, Chiyoda-ku, Tokyo, 100-8310 Japan

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Customer Inquiries   *Media Inquiries*

Advanced Technology R&D Center   Public Relations Division
Mitsubishi Electric Corporation   Mitsubishi Electric Corporation
Fax: +81-6-6497-7285
www.MitsubishiElectric.com/ssl/contact/company/rd/form.html   prd.gnews@nk.MitsubishiElectric.co.jp
www.MitsubishiElectric.com/en/about/rd/   www.MitsubishiElectric.com/en/pr/

Mitsubishi Electric Develops Edge Digital Twin Technology for Real-time Compensation of Errors in CNC Machine Tools

Reduces machining errors by up to 50% for improved productivity and reduced environmental impact
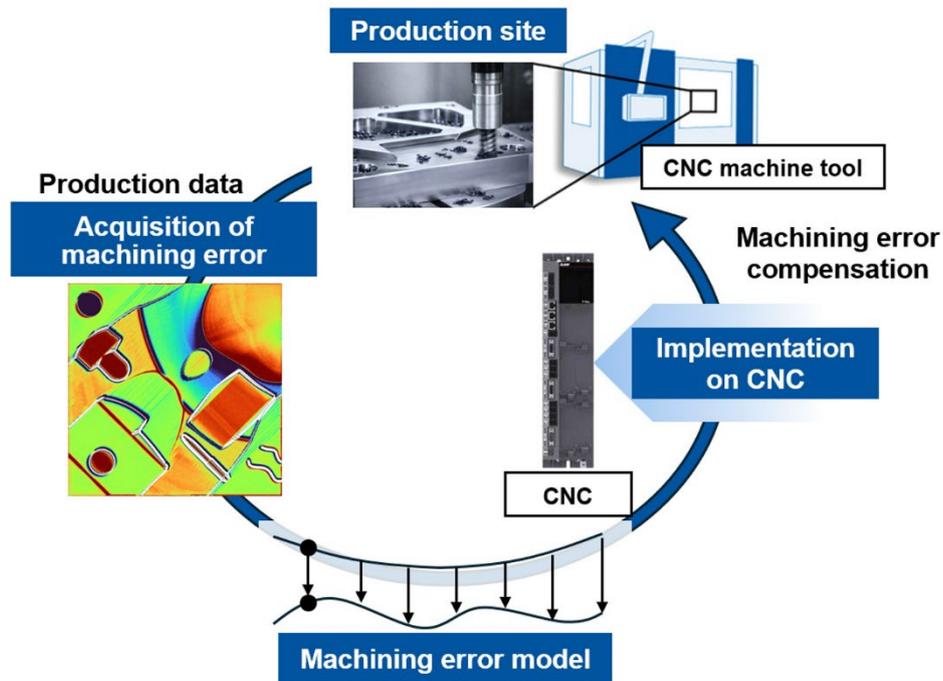
Overview of edge digital twin implementation

TOKYO, March 25, 2026 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that in collaboration with RWTH Aachen University in Germany, it has developed a technology that uses a digital twin to correct machine-tool errors in real time on machine tools equipped with computer numerical control (CNC[1]). Tests showed that the technology can reduce errors caused by slight deformation of machined parts due to the force of a cutting tool by up to 50%.[2] This results in fewer mistakes during the cutting process, thereby lowering the number of defective parts for improved productivity and reduced environmental impact.

From April 2023 to March 2026, Mitsubishi Electric and RWTH Aachen University, which is renowned for

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[1] A device that uses a computer to numerically control the operation of a machine tool.
[2] Using a test machine equipped with a Mitsubishi Electric CNC device owned by RWTH Aachen University.

its digital twin expertise, conducted joint research on online edge computing with a high-speed processing unit. As a result, they developed digital twin technology for CNC machine tools that can accurately estimate machining errors and feed the results back into the control system in real time. The digital twin's proprietary compact physical model, which is composed of a minimum number of equations, was created using large amounts of data, including axis positions, currents and cutting forces. The data are acquired at a high sampling rate,[3] and only information necessary for estimating machining errors is extracted. Real-time testing on a CNC machine tool confirmed that errors in machining due to a tool inadvertently deforming the part being cut can be reduced by up to 50%. By reducing defective parts and stabilizing surface quality, the technology improves productivity while reducing environmental impact.

Product Features

1) ***High-precision, compact digital twin that operates on CNC equipment***

- A high-speed processing unit[4] was installed on a CNC machine tool to rapidly acquire control information (e.g., machine-tool axis positions and motor currents) and sensor information (e.g., cutting forces) at a high sampling rate with time synchronization. This allows for the precise extraction of only the necessary data for estimating machining errors.

- The extracted data was then used to develop physical models of the machine tool and the cutting process. These compact models require minimal sets of equations and achieve high-precision, real-time operation on the high-speed processing unit

2) ***50% reduction of machining errors by estimating and correcting them in real time***

- The digital twin was used to create an algorithm for real-time estimation and compensation for machining errors caused by cutting forces that deform the workpiece or the machine-tool structure.

- The system calculates compensation values for the CNC machine based on the estimated errors and issues commands in real time to reflect the digital twin's simulated corrections to the CNC control.

- In shaker (vibration) tests, it was confirmed that using this compensation reduces machining errors by up to 50% compared to not using compensation. Consequently, applying this technology to CNC machine tools can reduce defective parts and stabilize the quality of the cutting process, thereby improving productivity and reducing environmental impact.
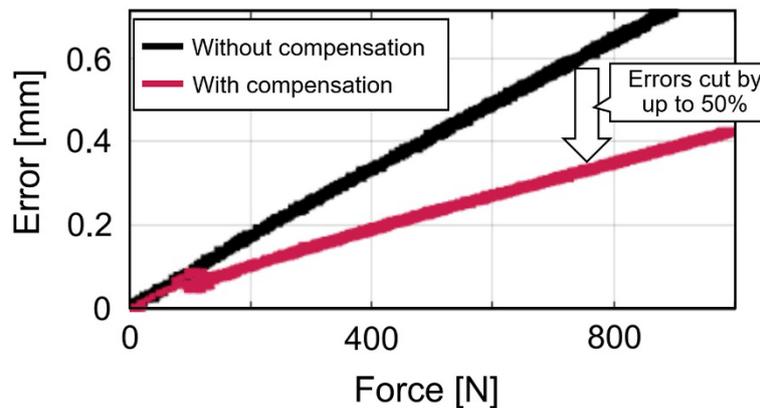
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[3] A value of how many times per second a sensor or measurement device acquires data.
[4] Mitsubishi Electric's original edge device allows end-users to implement custom functions they develop.
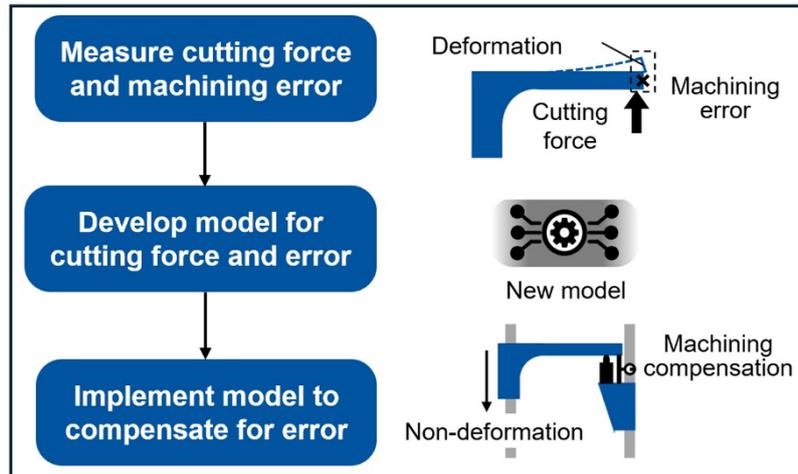
Method for constructing the edge digital twin

Comparison of machining errors with and without compensation by the digital twin

Responsibilities

Organization	Responsibilities
Mitsubishi Electric	- Setting up the verification CNC environment - Implementing and evaluating the digital twin on the high-speed processing unit
RWTH Aachen University	- Developing algorithms to rapidly estimate machining errors - Constructing the digital twin and performing on-machine verification

Manufacturers are developing increasingly accurate and efficient production systems due to diversifying market demands and other factors. In machining fields such as metal cutting, for example, processing accuracy may decrease due to workpieces being inadvertently deformed by a machine tool's cutting force, tool wear, temperature changes, or variations in workpieces. The result is defective parts and reduced production efficiency. These issues have drawn attention to digital twin technology, which combines on-site data with physical models of machine tools and cutting processes to reproduce and estimate machining conditions in real time on a computer. However, achieving real-time control based on digital twin estimations requires three simultaneous actions: acquiring large volumes of data from machine tool sensors and controllers, constructing a high-precision machining error estimation model, and correcting errors through real-time control. But limits

in the processing capabilities and memory capacity of CNC systems built into machine tools make it difficult to build a high-precision model that incorporates data selection and other necessary functions. This presents challenges to achieving real-time control using a digital twin.

Future Plans

Going forward, Mitsubishi Electric will promote the real-world deployment of digital twin technology for machine tools through co-creation with research institutions and other partners. In addition, the company aims to contribute to sustainable production systems that support carbon neutrality and the circular economy.

About Mitsubishi Electric Corporation
With more than 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Mitsubishi Electric enriches society with technology in the spirit of its "Changes for the Better." The company recorded a revenue of 5,521.7 billion yen (U.S.$ 36.8 billion*) in the fiscal year ended March 31, 2025. For more information, please visit www.MitsubishiElectric.com
*U.S. dollar amounts are translated from yen at the rate of ¥150=U.S.$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2025