

Technology Innovation

Industry, Distribution, Water



1 Screen for reviewing sales, profit, and inventory levels at factories, warehouses, retailers, and other points along the SC

1 Smart Factory Solution

A response is needed to the larger scale of supply chains (SCs) and the trend toward producing a wider range of products in variable production runs that has come with the globalization of production and shorter product cycles due to changing customer needs. To do so, Hitachi has developed solution technology for maintaining efficient operations by using a cyberspace model of the SC to make dynamic adjustments to production plans and SC strategies in a changing commercial environment.

The main features of this technology are as follows.

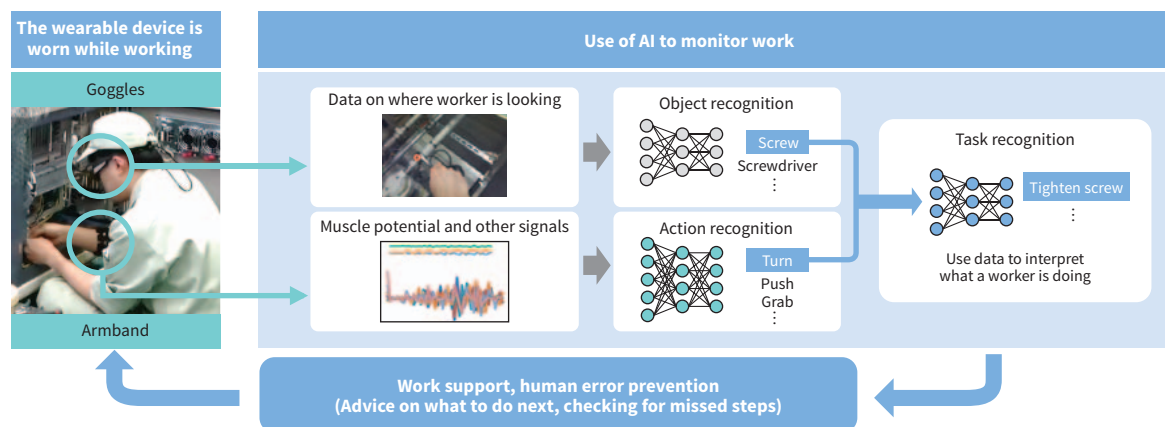
(1) Automatic operation for SCs that span thousands of sites, with stock movement instructions being issued based on current conditions, and automatic learning of optimal inventory level combinations for different supply and demand conditions.

(2) Dynamic production planning for production lines based on highly accurate production forecasting with automatic learning of work times from Internet of Things (IoT) data on things like production conditions and past performance.

The use of this technology for assembly operations and logistics has demonstrated its ability to reduce inventory levels and improve on-time delivery rates. Hitachi intends to proceed with the commercial roll-out of smart factory solutions that utilize its Lumada IoT platform.

2 Task Analysis Technology for Work Support Applications using AR/VR

Given the expectation that manual work will continue to be needed at workplaces that: (1) produce a wide range of products in small volumes, and (2) handle inspection and



2 AI-based task analysis technique

maintenance work, there is a need for ways to prevent human error. Meanwhile, by displaying information via virtual reality (VR) or augmented reality (AR), attempts are being made to extend the use of wearable devices such as head-mounted displays (HMDs) beyond the entertainment sector. One such field in which wearable devices may be able to shine is for industrial uses, such as work support or worker training. Advances in AR/VR display technology, as well as sensor quality make these possibilities increasingly practical.

Along with developing small and lightweight HMDs with high image quality, Hitachi is also looking into their uses for work support in areas such as factories, logistics, and railways. This has instigated joint development with Deutsche Forschungszentrum für Künstliche Intelligenz (DFKI: German Research Center for Artificial Intelligence), in which Hitachi aims to develop a task analysis technique that predicts work recognition and completion. This technology is used to improve the use of AR and VR for work support.

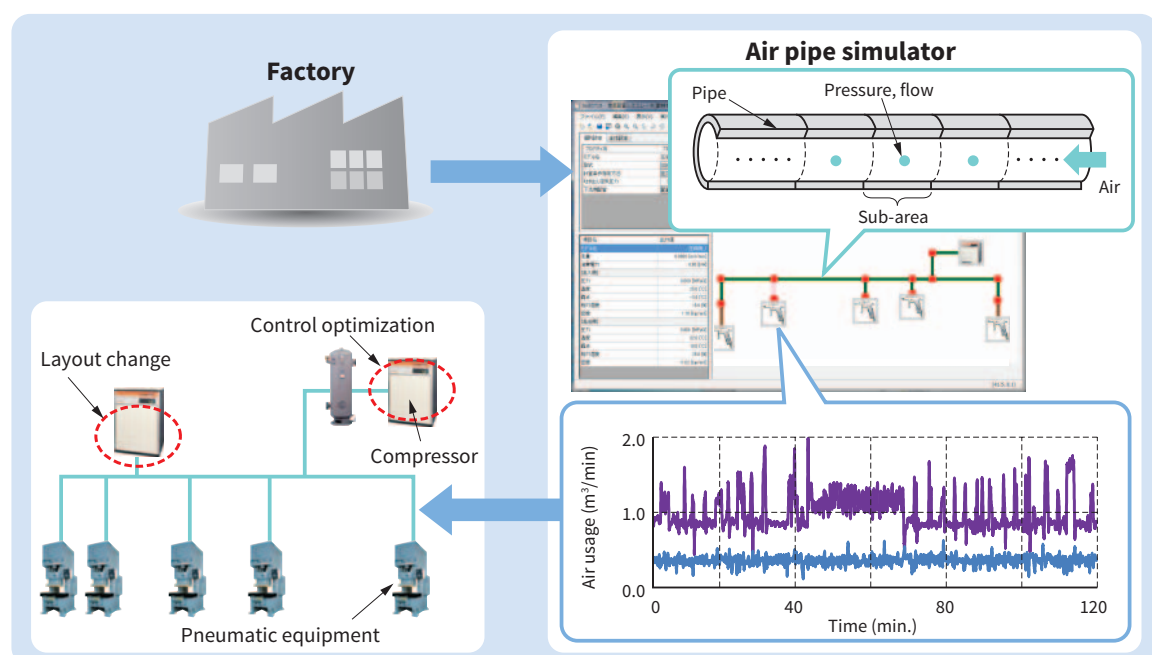
The work support system equips workers with wearable sensors and utilizes artificial intelligence (AI) that analyzes performance, detects errors, and improves productivity. It combines the use of goggles and an armband to collect

data, then applies deep learning to identify the object the worker is looking at, and the actions they are performing, providing the ability to monitor complex tasks in real time, required in many workplaces. Hitachi expects that this work support system will provide safer and more reassuring work support.

3 Air Pipe Simulator for Industrial Plants

Recognizing the demand for reducing electric power use by air compressors used to drive pneumatic equipment, something that accounts for 20 to 30% of power consumption in factories, Hitachi has developed an air pipe simulator that can be used to offer energy efficiency solutions by providing information on energy use by factory infrastructure.

In addition to using physical laws to model friction and thermal losses in the pipes, the simulator is able to analyze the flow of air through pipes with a high level of accuracy by also incorporating these models into calculations of pressure and flow rate for sub-areas that divide up the pipes based on the direction of flow. The simulator has demonstrated its ability to provide information on air usage by the pneumatic equipment at a factory, and



3 Use of air pipe simulator to provide energy efficiency solutions for pneumatic factory equipment

to reduce air compressor power consumption by optimizing the piping layout and air compressor control practices. Because the simulator runs on a mobile environment, Hitachi staff are able to provide quick information on things like air usage and pressure losses and offer energy efficiency solutions as they map out the factory piping layout.

The scope of the simulator is currently being expanded to include steam and water with the aim of using it to reduce both installation and running costs across the factory.

4 Use of Automated Guided Vehicle Group Control for Logistics Automation

As distribution warehouses face growing labor shortages, there is strong demand for the automation of materials handling and sorting work. Having already automated the materials handling work by commercializing its automated guided vehicles that bring shelves to the sorting staff, Hitachi built a prototype system that extends automation to the sorting process by coordinating the operation of the vehicles with that of newly developed picking robots.

Sorting involves the handling of a wide variety of items. Accordingly, the constraints on which items the robots are able to pick up means that the work is shared between human workers and robots. Unfortunately, adhering strictly to this shared work method leads to a major loss of productivity because of the inability to adapt to fluctuations in volume or the expansion of the

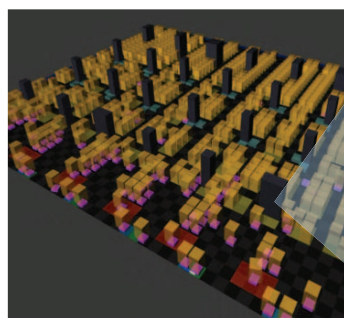
range of products handled. In response, Hitachi has developed a group control technique that can adaptively assign tasks and issue materials handling instructions for multiple vehicles and robots by predicting things like congestion and waiting times based on the capabilities of the robots and human workers, fluctuations in the volume of goods, and working conditions. Simulation using dispatch data from a working warehouse indicated that the technique could maintain the same throughput as before using approximately 13% less labor.

Hitachi plans to work with Hitachi Transport System, Ltd. to trial the technique in practice and commercialize it in the near future.

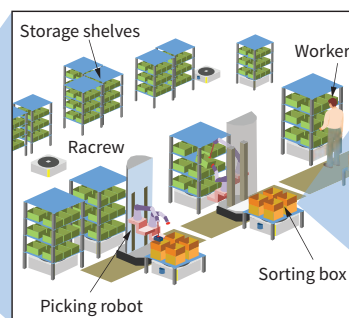
5 Data Analysis Technique for Expediting Drug Development

The pharmaceutical industry has been facing difficult conditions over recent years, including a lack of new drugs being brought to market and falling sales due to the rise of generics. In the case of the lack of new drugs in particular, this is in a large part due to a shift in the targets of drug development toward conditions such as cancer or the central nervous system where the mechanisms are not easy to elucidate. What are needed to overcome these difficulties are innovations in the current value chain for drug development.

Recognizing this state of affairs, Hitachi has focused on clinical development in particular and developed an AI that supports the formulation of clinical trial designs with the aim of improving trial efficiency. This AI automatically collects information from the medical literature



Simulation

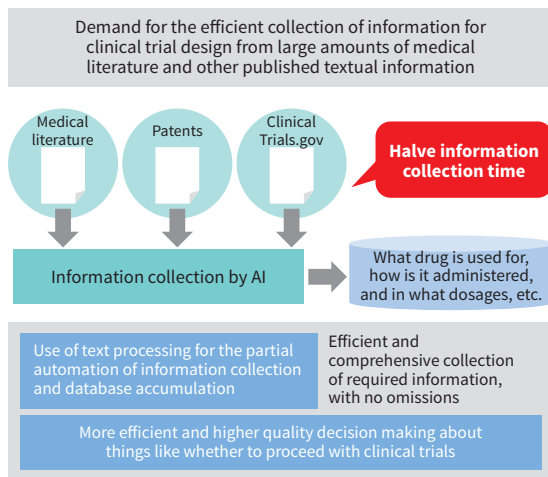


Picking and sorting



Prototype system

4 Automation of sorting by coordinating operation of automated guided vehicles and picking robots



5 Efficient information collection for formulating clinical trial designs

or open data published by regulatory agencies and accumulates it in a database, including data such as the number of trial subjects or the sample groups used for comparison to establish the efficacy of the drug being trialed. Compared to current practice, it is anticipated that the use of this AI will halve the amount of information collection work associated with clinical trial design.

Through collaborative creation with pharmaceutical companies, universities, and others, Hitachi intends to continue helping improve the sophistication and efficiency of an even wider variety of activities.

6 Small Scroll Air Compressor

Rising societal concerns about environmental problems such as global warming in recent

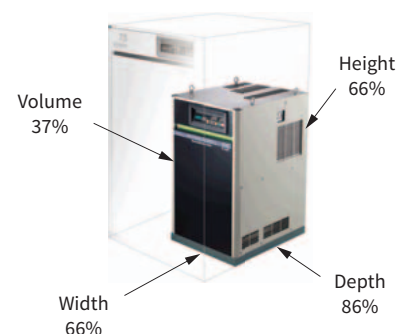
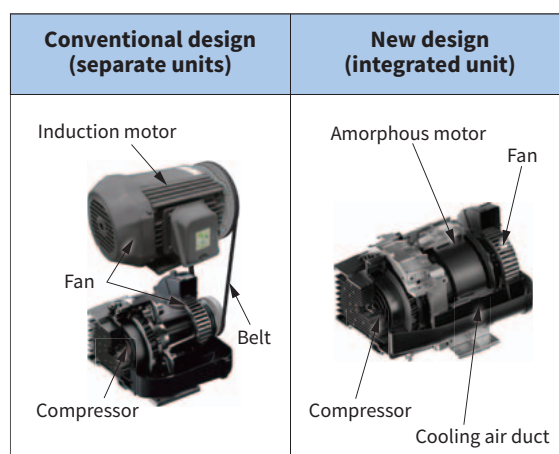
years has focused attention on ways of improving the efficiency of electrical machinery and minimizing energy use. After developing the core technology for amorphous motors (which use amorphous metal cores for higher efficiency) in 2008*, Hitachi went on to develop technology for higher capacities (from 0.2 kW to 11 kW) and higher efficiency (from 92% to 96% for a 11-kW motor) with the aim of commercializing the motors.

Now, Hitachi has developed technology for built-in amorphous motors and utilized it in scroll air compressors (from 3.7 kW to 7.5 kW), a product category where there is demand for smaller sizes and higher energy efficiency. Along with shortening the motor shaft by 40%, this has also cut motor losses by 40% such that the reduced heat generation makes it possible to house the motor and compressor in the same unit. This eliminates the need for a drive belt (to transfer torque) and reduces the size to 37% of the previous model.

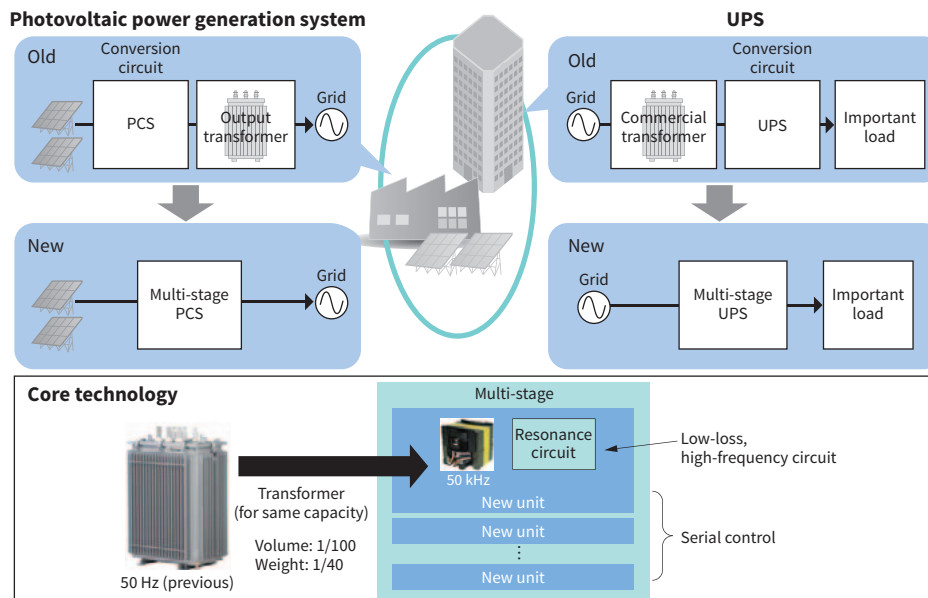
In the future, Hitachi intends to contribute to making electrical machinery smaller and more efficient by utilizing the technology in other industrial machinery such as pumps and fans, and in other applications such as vehicles or home appliances.

(Hitachi Industrial Equipment Systems Co., Ltd.)

* Some of the technology for amorphous motors was part of a project for encouraging the practical development of technologies for replacing or reducing use of rare metals funded by the New Energy and Industrial Technology Development Organization (NEDO)



6 Technology for using amorphous motors in other products



UPS: uninterruptible power supply

7 Comparison of new and old power supply systems

7 Multi-stage Power Conversion Technique

Hitachi has developed a technique for high-frequency insulated power conversion that significantly reduces the size of power supply systems to help make effective use of space in factories and other buildings. The purpose of power supply systems is to sit between the grid and the equipment being supplied, optimizing voltage, current, and frequency. Past practice was to use a transformer for voltage conversion between the high-voltage grid and conversion circuit, but the associated equipment was large because the power through the transformer was at a low frequency (50 or 60 Hz).

As transformers can be smaller the higher the frequency they operate at, Hitachi has responded to this problem by using a high-frequency circuit to increase the frequency 1,000-fold to 50 kHz, thereby reducing the volume of the transformer by a factor of 100 compared to the previous model, and its weight by a factor of 40. Moreover, a resonance technique with low losses was adopted for the high-frequency circuit to reduce heat generation. In addition to its being supplied as an integrated unit that contains both the high-frequency transformer and resonance circuit, the system can also make the power conversion equipment between the

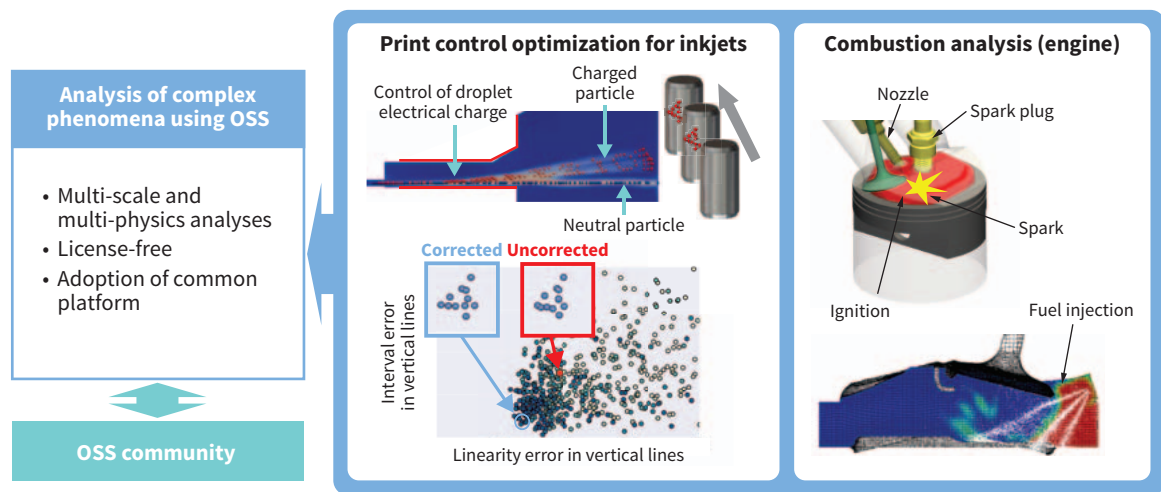
high- and low-voltage sides more compact by enabling a number of units to be connected in series. The construction of a prototype indicated that it should be possible to reduce both the volume and weight of a 300-kW-class power conditioning system (PCS) by 50%.

Hitachi intends to utilize the new technology in a variety of products in the future.

8 Technique for Analyzing Complex Phenomena in Industrial Equipment Using OSS

The phenomena that need to be dealt with in the development of industrial equipment are becoming more complex and diverse, creating a need to combine the individual analysis models developed in the past for various phenomena on a common platform so as to improve development efficiency. Also needed are lower computational costs for things like large parallel analyses or optimization design.

In response to these challenges, Hitachi has developed a technique for the analysis of complex phenomena in thermal fluids that uses open source software (OSS). The OSS development community works in an open manner and the software is available free of charge. Another advantage is that the source code is made available and can be freely customized, making it



8 Complex phenomena analysis using OSS

easy to integrate with analysis models previously developed in-house. The new analysis technique is being used for multi-scale and multi-physics analyses such as print control optimization design for industrial inkjet printers and integrated analysis of what happens in an engine from fuel injection to combustion.

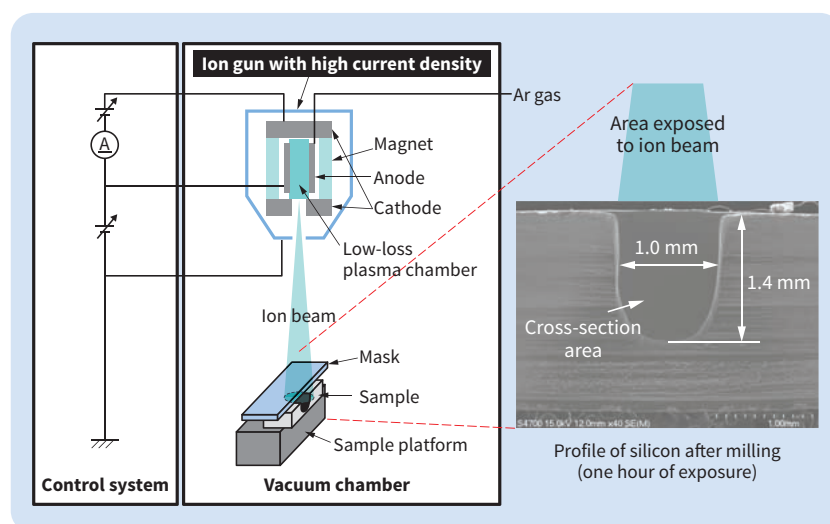
In the future, Hitachi intends to expand use of the technique to other industrial machinery and to draw on the advantages of OSS to deploy it at development sites around the world.

9 Ion Gun with High Current Density for Ion Milling Systems

The use of electron microscopes for structure analysis plays a vital role in the development of the devices that underpin the IoT and the

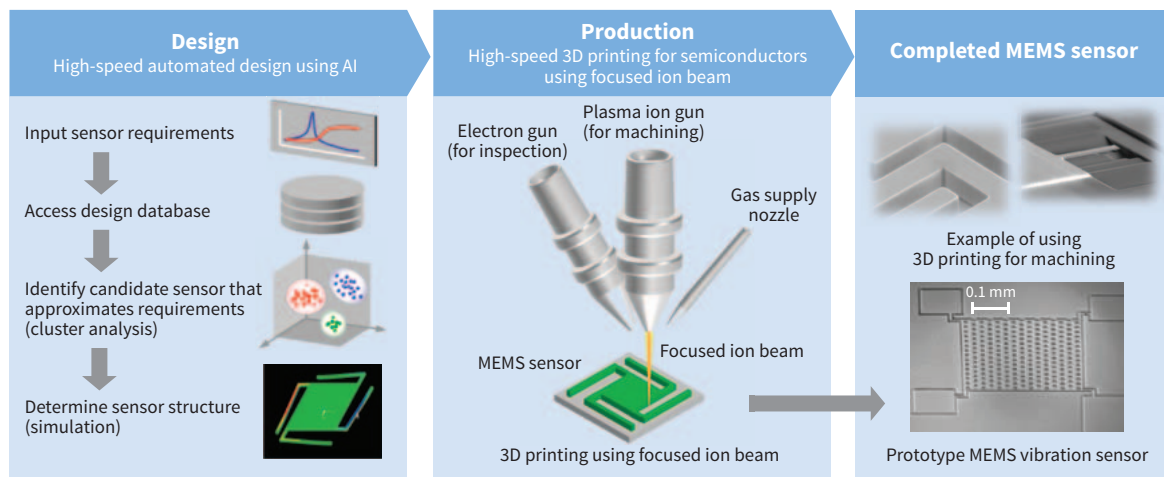
materials needed for a low-carbon society. As samples need to be smoothed before they can be viewed using an electron microscope, Hitachi supplies ion milling systems that use an ion beam to prepare samples in this way. To satisfy demand for higher throughput even as samples become smaller, with multiple layers and higher circuit densities, Hitachi has now developed an ion gun that significantly shortens ion milling times.

To investigate ion loss in the plasma chamber, a coupled analysis of plasma generation conditions and ion trajectory control was performed. As a result, Hitachi succeeded in producing ion beams with higher current density thanks to a plasma chamber design that minimizes ion loss and the ability to generate a highly efficient plasma by adopting a magnet layout that



Ar: Argon

9 Diagram of ion milling system and machined profile after cross-section milling



10 Flowchart of MEMS sensor design and production using 3D printing for semiconductors

optimizes electron behavior. New ion milling systems that use this ion gun were the first in the industry* to achieve a high throughput of 1 mm/hour or more (for the cross-section milling of silicon), double that of previous models.

In the future, Hitachi intends to develop machining techniques that minimize thermal degradation during ion beam exposure, and to extend their use to soft materials such as rubbers and other polymers.

(Hitachi High-Technologies Corporation)

* As of December 2017, for ion milling systems (based on research by Hitachi High-Technologies Corporation)

10 3D Printing for Semiconductors

As the IoT is adopted more widely by society, there is a need for a greater range of sensors able to measure such parameters as vibration, acceleration, temperature, and humidity for the sensing of things like equipment, people, and the environment. In most cases these are a type of miniature sensors called microelectromechanical systems (MEMS). However, because they are designed and produced using semiconductor technologies that are suited to mass production, it is difficult to supply them in small volumes and wide variety with short lead times.

In response, Hitachi has developed a three-dimensional (3D) printing technique for semiconductors that can design and manufacture MEMS sensors quickly. The technique uses AI to design the shape of the MEMS sensors

automatically. On the basis of this design, it then uses a high-output plasma ion beam focused to less than one thousandth of a millimeter to perform high-speed machining of the semiconductor that serves as the sensor's substrate. In the case of a prototype MEMS vibration sensor, the design and production time, which would previously have taken about a year, was shortened to approximately one month.

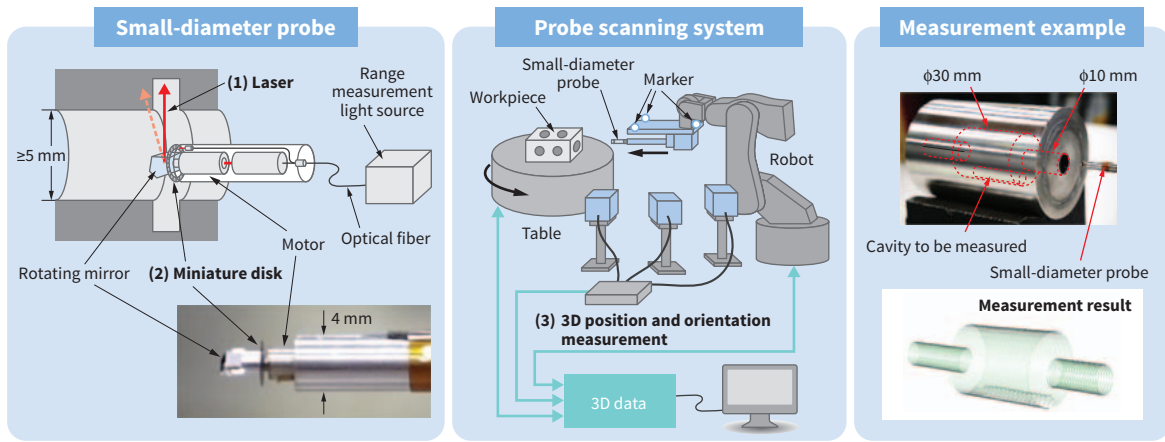
In the future, Hitachi intends to lead the adoption of the IoT through the rapid delivery of MEMS sensors to suit a wide variety of practical applications.

11 3D Shape Measurement of Confined Spaces in Parts

The shapes of confined spaces in the key parts of products used in social infrastructure, such as hydraulic and other fluid equipment, often have an impact on their performance. Accordingly, the in-line measurement of these shapes is becoming increasingly important to improve performance. In response, Hitachi has developed a system that can perform simple measurements of confined spaces inside these parts. It works by using a robot to insert a small-diameter probe into the confined space, and scanning the space to obtain its 3D shape.

The main features are as follows.

(1) A small-diameter probe with a miniature mirror that rotates at high speed to scan a range measurement laser around the circumference and obtain its cross-sectional shape



11 3D shape measurement system for confined spaces

- (2) A miniature disk marked with angle gradations that is used to simultaneously detect and correct the rotation of the scanning mirror
- (3) A technique to correct for probe position error due to the robot that uses optical measurement to determine the 3D position and orientation of the probe from the outside

The system can measure internal shapes as small as 5 mm with an accuracy of 50 μm . Hitachi is currently deploying the technique within its own operations.

12 Cooling Technique for Reducing Size of High-voltage Industrial Induction Motors

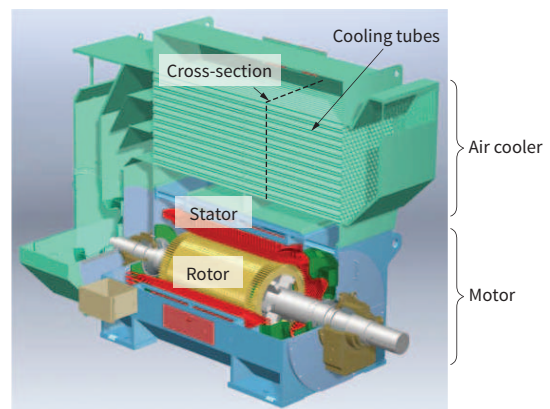
As high-voltage industrial induction motors are in widespread use, there is demand for making them smaller and lighter. While Hitachi already supplies a series of induction motors with four or more poles to meet this customer demand, it has now developed a small air cooler for use with its latest two-pole motors.

The higher speed of two-pole motors compared to motors with four or more poles means that they have higher output density, making cooling performance important. While the motors themselves have been designed for small size, including by reducing losses, the challenge when reducing the size of the overall motor system is to also miniaturize the cooling system, which is similar in size to the motor.

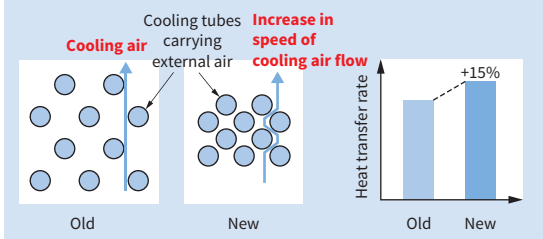
As is standard practice on high-voltage industrial motors, the new cooler uses air

cooling, with heat transfer being achieved by the cooling air in the motor flowing around a large number of cooling tubes through which external air flows. The air cooler increases the flow rate of the cooling air by having it follow a non-linear path around the cooling tubes, the result of which is a 15% increase in heat transfer rate. This allows the equipment volume to be shrunk by 30% compared to the previous model.

In the future, Hitachi intends to supply high-voltage industrial induction motors that are smaller and lighter by deploying the new air cooler across the product series.



Enlargement of cooler cross-section



12 High-voltage industrial induction motor equipped with air cooler