Technology Innovation

Industry, Distribution, Water

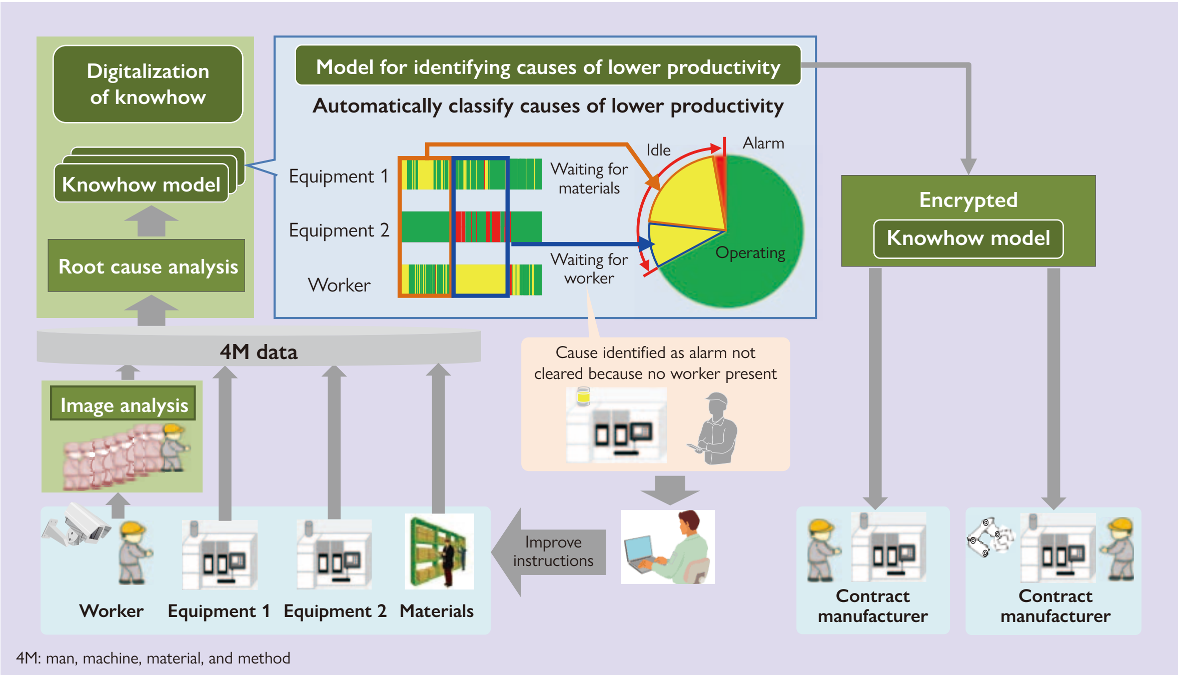
1 Digital Encapsulation of Manufacturing Knowhow

While the manufacturing industry has relied on the extensive knowhow possessed by experienced staff to maintain high levels of quality and productivity, the aging of this workforce over recent years has raised concerns about how this knowledge will be passed on to others.

In response, Hitachi has developed a technique for the digital encapsulation of manufacturing knowhow so that it can be reused. This involves transforming knowhow into digital form by collecting and analyzing "man, machine, material, and method" (4M) data from the workplace.

Knowhow such as how to identify the causes of lower productivity or adjust equipment operating parameters is modeled by analyzing the causal relationships between 4M data, including worker actions and stances extracted from image data, logs and other operational information and alarms collected from equipment, and details of the materials being worked on. The modeled knowhow is available for use not only by the users who provided it but also by other users such as contract manufacturers, depending on the scope stipulated by those who provided the knowhow. In this latter case, the knowhow can be provided without the risk of it being leaked because the information contained in the model is encrypted inside the capsule.

Hitachi has developed a productivity analysis service that provides an example of how such a knowhow model is used. The service helps people to come up with improvement ideas by using the knowhow model to classify and highlight the causes of lower productivity. The service was trialed on the production line of Okuma Corporation, who partnered in the collaborative creation project, and will contribute to improving productivity across the manufacturing industry by supplying the resulting knowhow to corporate users of Okuma machine tools.

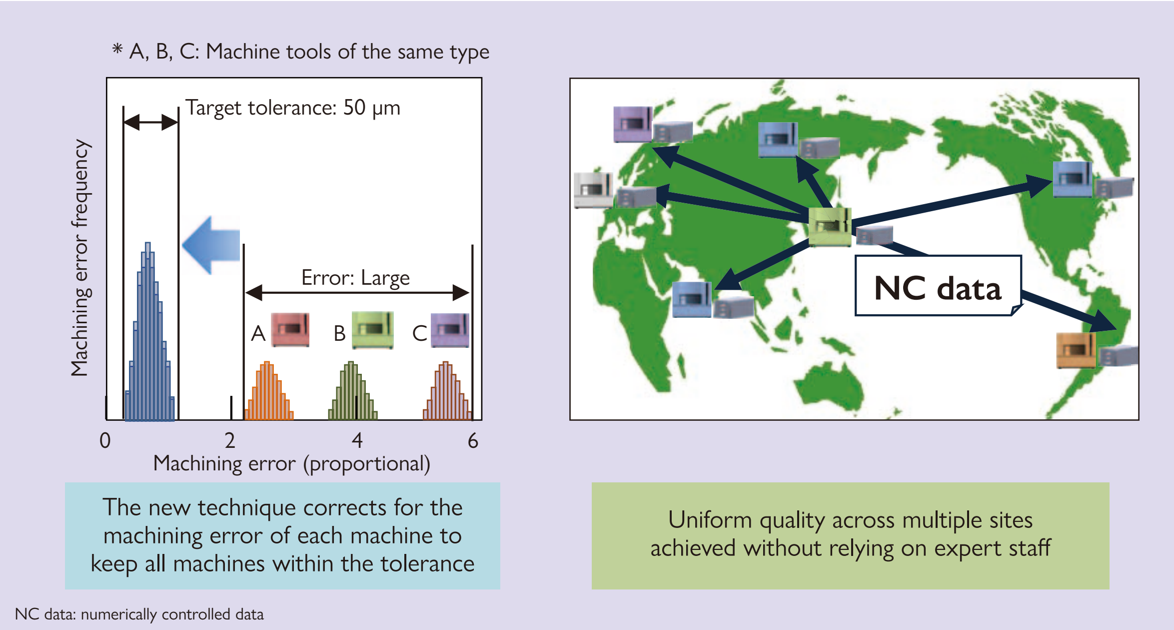


1 Functional architecture of digital encapsulation technique

2 Cutting Error Correction Technology Able to Achieve Same Quality as Expert Machinists

In a first for numerically controlled (NC) machine tools, Hitachi has developed a cutting error correction technology that takes account of the individual differences between machines. The technology improves cutting quality by representing the knowledge of expert machinists in digital form and automatically adjusting the control program (NC data) based on factors such as the machine and tool being used and the shape of the material being machined. In high-volume production in which machine tools from a number of different plants are used, this improves cutting accuracy by four to six times compared to when no correction is performed, delivering uniform quality without relying on expert machinists.

The key technical feature is that it can correct for error by creating a physical model of the cutting error mechanisms, one that takes account of the stiffness of the machine's spindle and cutting tool, and using it to calculate the target position for the cutting tool tip. The stiffness of the machine's spindle is one of the physical model constants and it is obtained by individually measuring each machine to determine how the amount of deflection varies depending on the level of force applied to the spindle. This can then be used to make precise predictions of cutting errors. NC data for precise cutting is output automatically using inputs that include the NC data (uncorrected), machine tool stiffness, and cutting tool shape.



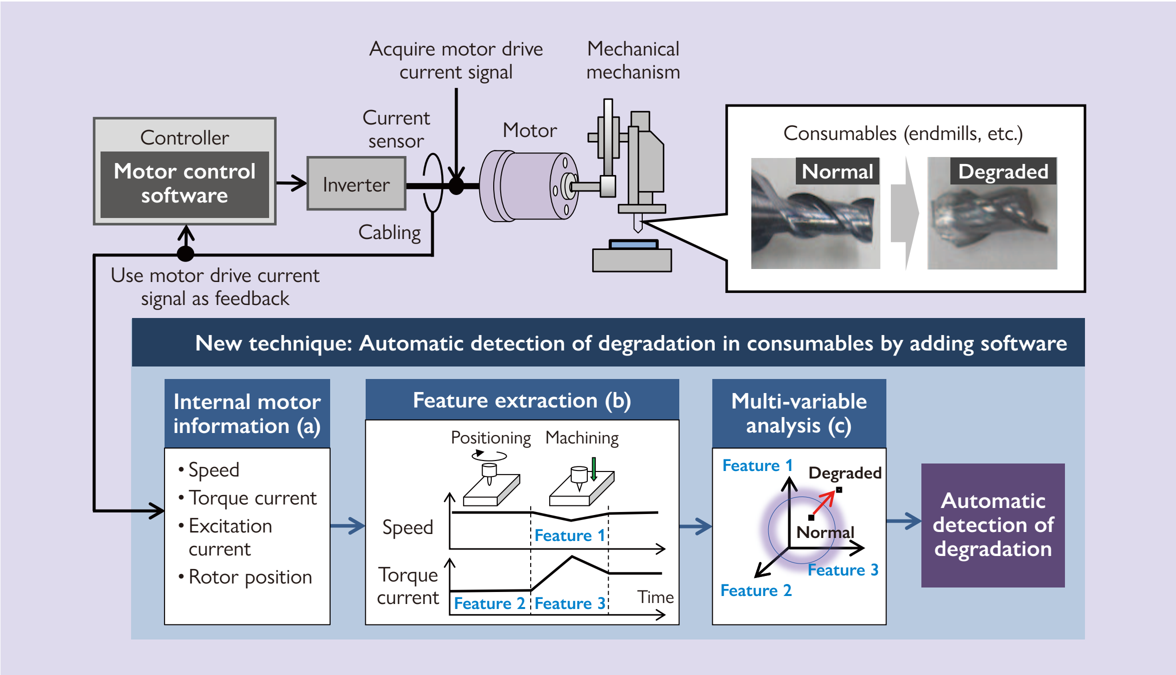
2 Overview of how the knowhow of expert machinists is transformed into digital form

3 Technique for Reducing Cost of Machine Tool Maintenance

The progress of the Internet of Things (IoT) is driving growing interest in the use of information collected from machinery to improve factory productivity and work efficiency. While one practice used with machine tools is to fit them with imaging, vibration, and other sensors and to monitor for degradation of consumables such as end mills, it results in higher installation and maintenance costs.

In response, Hitachi has developed a technique that estimates the extent of degradation in machine tool consumables by looking at the detailed internal information handled by the motor control software, including motor speed and torque current. In the case of milling machines, for example, the positioning torque current and the speed and torque current during machining have both been identified as feature values that vary with end mill wear, and a multi-variable analysis was performed to enable degradation to be detected with high accuracy. As trials have also demonstrated that the technique can be used to detect die wear on a servo press, it can be used to reduce operating costs for various types of other machine tools as well as milling machines.

In the future, Hitachi intends to contribute to reducing operating costs in a variety of sectors by utilizing the technique on various different types of equipment fitted with electric motors that are used in social infrastructure, including cars and trains as well as industrial machinery.



3 System for detecting degradation in machine tool consumables

4 Plant Condition Monitoring System for Industry

Industrial plants need to maintain safe and reliable operation while also coping with changes such as raw material lot changes and the deterioration of equipment over time. Hitachi has developed a plant condition monitoring system that provides early detection of abnormal operation or other problems in equipment.

Plant condition monitoring in the past has relied on the judgement of skilled operators acquired through experience. The shrinking workforce, however, has led to demand for systems that can take the place of such operators. The new system uses adaptive resonance theory (ART), a technique for classifying data that incorporates learning. After first being trained on operational data from equipment that is functioning normally, the system is then used to assess operational data of many different types. An operator uses plant operation as a basis for deciding whether a problem is present, and learning takes place from the causes of the various problems that occur. This means that decisions become more accurate if the problem recurs and the problem's causes can be identified. By building up an archive of decisions by skilled operators, the system becomes smarter the more it is used.

Hitachi plans to trial the system at plants operated by customers.

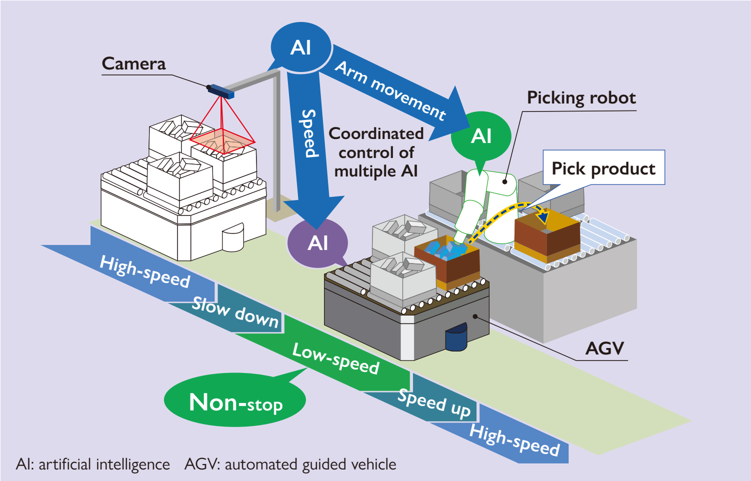
4 Plant condition monitoring system using adaptive resonance theory (ART) data classification

5 Multiple AI Coordination Control to Improve Efficiency of Automatic Picking System

Hitachi has developed a system for automating picking at warehouses that hold a wide range of products. The system works by loading cases containing a large number of products onto automated guided vehicles (AGVs) from which the required items can be picked by robot.

As the products are placed randomly in the cases, a problem with the technology used in the past was that it was difficult to ensure that all of the items were correctly picked without first bringing the AGV to a halt. In response, Hitachi has developed a technique for picking items without stopping the AGV that incorporates a new artificial intelligence (AI) for instructing the AGVs and picking robots on how to operate, using these instructions to coordinate the AGV and robot actions. The AI acquires a camera image of the case contents and, using deep learning, estimates which items should be picked and how much the AGV needs to slow down to ensure that those items can be picked. It has estimated that the system can improve work efficiency by 38% by sending this information to the AGV and robot in advance so that the robot is able to pick out the items correctly while still allowing the AGV to move as fast as possible.

Hitachi is targeting commercialization in the near future, with plans to trial the technique on systems that use large numbers of AGVs.



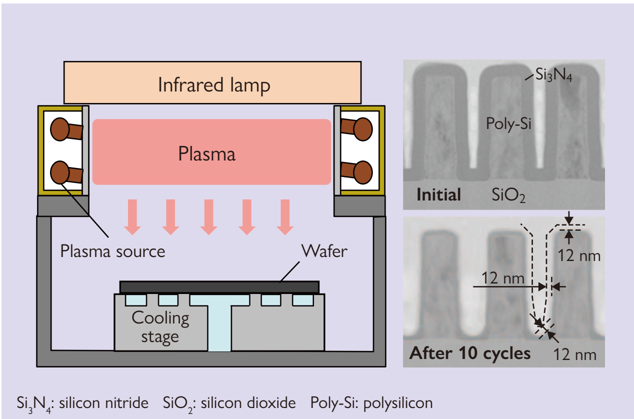
5 Overview of multiple AI coordination control

6 Microfabrication Technique for 3D Devices Able to Operate at the Level of Atomic Layers

With the spread of the IoT, it is anticipated that more than 50 billion devices will be connected to a network by 2020, home appliances and vehicles among them. Given the accompanying demand for performance improvements and greater capacity in the semiconductor devices used to process data, there is a need for microfabrication techniques able to operate at the level of atomic layers for use in producing the next generation of devices with fine-scale three-dimensional (3D) structures.

In response, Hitachi, working on joint research with Nagoya University, has developed an etching technique that can be controlled at the level of atomic layers and applied to the materials such as titanium nitride and silicon nitride that are used in device gate electrodes and hard masks. The technique uses a proprietary method involving repeated cycles of a process in which a reaction layer is formed by exposing the surface of the nitride film to a fluorocarbon plasma followed by the thermodesorption of the reaction layer by exposure to infrared light. The technique makes it possible to manufacture the next generation of devices with a 3D structure.

Hitachi intends to contribute to the progress of IoT adoption by commercializing this technique for etching at the level of atomic layers in semiconductor manufacturing equipment.



6 Design of etching equipment and silicon nitride film after microfabrication

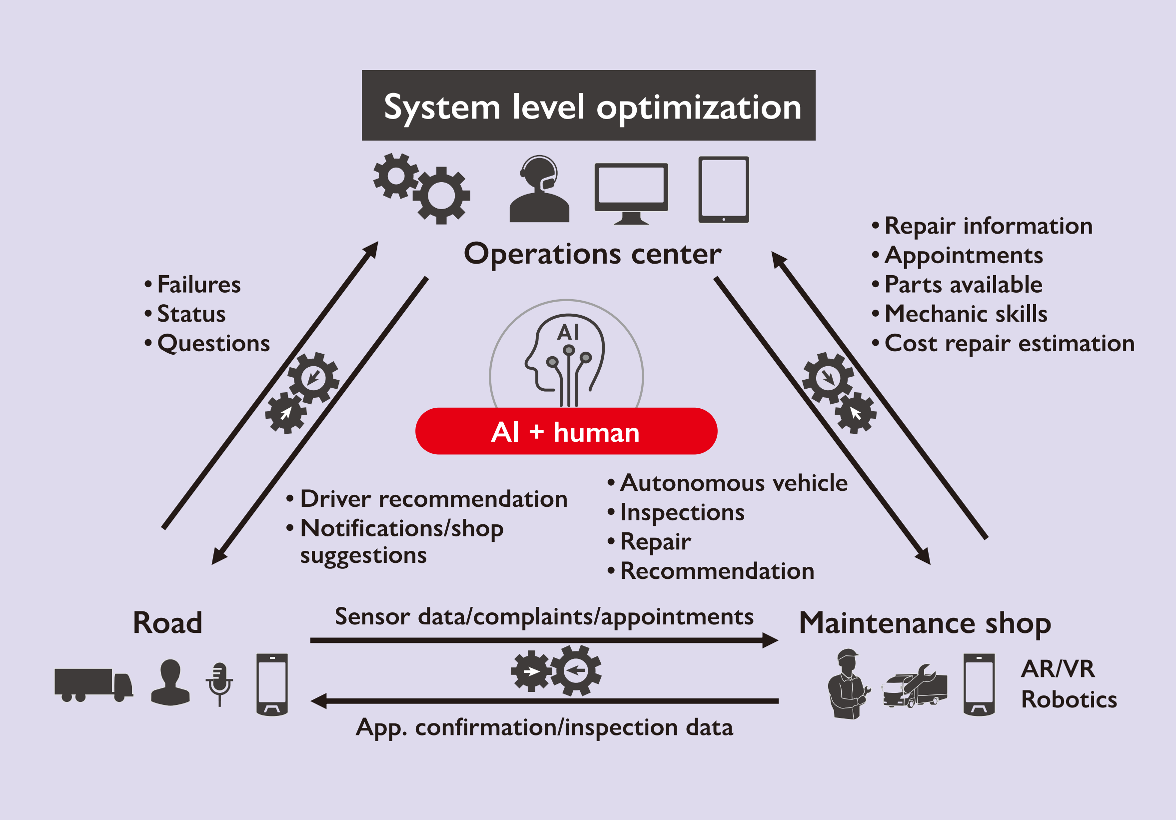
7 Fleet Maintenance and Repair Solution with Advanced Analytics

The economy and society run on fleets, from trucking and automotive to rail and mining. Over the years in its interaction with fleet managers Hitachi has learned that they often face similar challenges while maintaining their fleets. Some things that are important to fleet managers are to reduce unexpected downtime, to reduce the time to repair and repair mistakes, to deal with the shortage of skilled labor, and to improve the customer and operator experience.

Hitachi's Global Center for Social Innovation–North America is developing solutions for fleet maintenance and repair that address these challenges using AI, machine learning, and advanced analytics. Some of the key technologies powering its solutions are:
(1) Performance analytics to model the performance of the equipment and perform tasks such as performance degradation detection, failure prediction, and remaining useful life estimation;
(2) Maintenance analytics to quantify the impact of maintenance and for better maintenance planning;
(3) Operation analytics to extend the useful life of the equipment and overall maintenance process optimization;
(4) Repair analytics for recommending repairs when breakdowns happen.

In repair analytics, currently Hitachi is working with customers to recommend the right course of action when equipment comes in need of repair. This recommendation is learned by training an advanced machine learning model over historical repair data, which includes factors such as the make and model of the vehicle, event/sensor data from the vehicle, and the natural language complaints of the operator.

As a next step, Hitachi is integrating these technologies into an end-to-end solution for overall optimization for fleet maintenance and repair. This solution integrates information across silos, incorporates new technologies for data collection via robotics and video, integrates AI for decision making and end-to-end optimization, and incorporates design thinking to convey the results of AI results. At the heart of its solution is a powerful



AR: augmented reality VR: virtual reality

7 Fleet Maintenance and Repair Solution Utilizing Advanced Analytics

AI-based recommendation engine that recommends the best action for different personas involved in maintenance and repair: the operator, the operations manager, the service manager, and the technician.

In conclusion, Hitachi is changing the future of fleet maintenance and repair using AI and advanced analytics.

8 Technique for Estimating Remaining Useful Lifetime of Air Compressor Consumable Parts Using Industrial IoT

It is absolutely required to create value by utilizing IoT and data analytics. Hitachi has developed a remaining useful lifetime diagnostic technique for air compressor consumable parts by using industrial IoT solutions to predict when best to replace them.

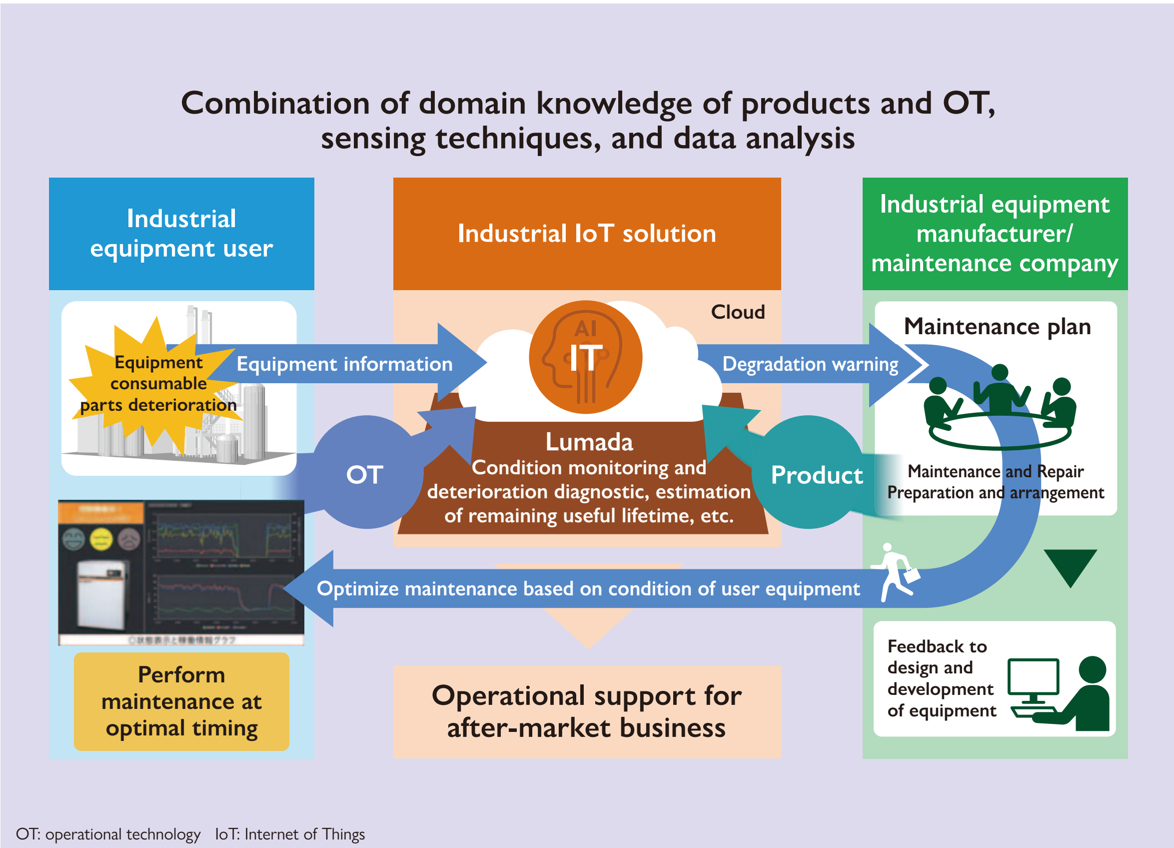
The main features are as follows:

(1) A method of directly detecting the degree of wear on consumable parts by clarifying the wearing mechanisms with knowledge of material properties based on the functions of the consumable parts required by air compressors

(2) A method of directly detecting the degree of wear on consumable parts with limited sensors by fully utilizing knowledge of equipment design and simulation and data analysis even in the poor environment of a remote monitoring system with limited data communications capacity

(3) A remaining useful lifetime diagnostic model of consumable parts that was built using AI from operational data and data for detecting the degree of wear acquired via the IoT, and also from maintenance and repair management data that contains diagnostic knowledge accumulated from practical maintenance work

Hitachi aims to create even more value in the future by embarking on measures to solve challenges across all steps from product planning and design to operation and maintenance.



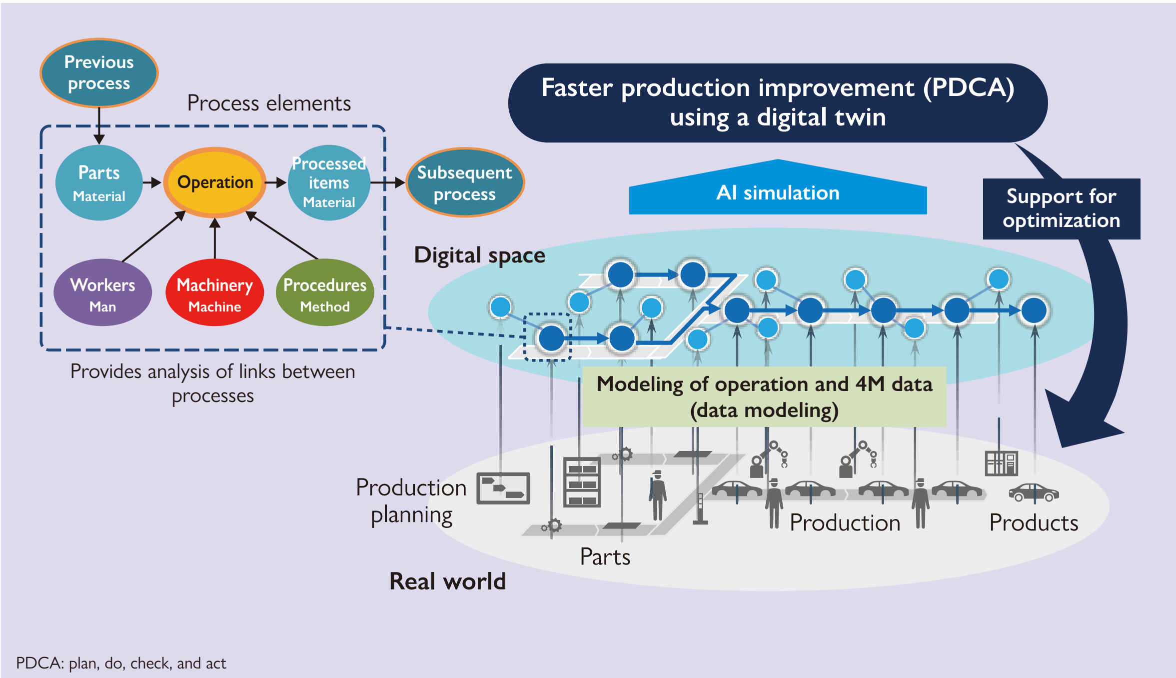
8 Overview of operational support for after-market business utilizing estimation of the remaining useful lifetime of consumable parts

9 Data Modeling Technique for Creating "Digital Twins" in Manufacturing

The manufacturing industry has been looking with interest at the development of production systems that are based on the concept of a "digital twin" in which the entire manufacturing process can be replicated, made transparent, and analyzed in digital space by consolidating the diverse range of operational data scattered across the different factory processes. Hitachi, meanwhile, is working on building platforms for using data that facilitate the collation and consolidation of OT and IT data collected from a variety of different processes to support ongoing productivity improvements involving the use of AI analysis and simulation.

Now, Hitachi has also developed a proprietary data modeling technique that represents objects and their interconnections in abstract form and presents them in graph format to facilitate the linking together and making available of data of different types, such as operational data and 4M data from the workplace.

The technique can highlight the interconnections between various tasks and data across the entire production process. Even staff without specialized knowledge such as production coordinators can easily extract and combine the required data as needed, thereby shortening the plan, do, check, and act (PDCA) cycle of data analysis.



9 Continuous productivity improvement solution for supporting optimization across the entire manufacturing process