Hitachi Review

Volume 64 Number 4 March 2015

HITACHI
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Industrial Solutions

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Volume 64 Number 4 April 2015

From the Editor

Infrastructure Systems Company of Hitachi, Ltd. operates four businesses, which deal with the urban development and electrical machinery, water, industrial plant, and component sectors respectively, with a vision of being the "best solution partner" for overcoming the management challenges that global customers face. This issue of Hitachi Review focuses on the industrial plant sector, including examples of the company's work in applications such as manufacturing execution systems, plant security systems, utility operation systems, and maintenance service systems.

In this issue's Message, the President of the Infrastructure Systems Company describes its solutions for the industrial sector, including where it plans to take these in the future.

In Technotalk, the CTOs of the Infrastructure Systems Company and Information & Telecommunication Systems Company join the General Manager of the Business and Engineering Solutions Division of the Social Innovation Business Project Division to discuss their respective perspectives on how to gain a closer appreciation of the challenges faced by customers and what sort of approaches will be needed in the future to confront customers' management challenges.

The issue also includes articles that cover a variety of technologies and solutions supplied by Hitachi that are essential to customers' business operations. These include descriptions of manufacturing execution systems and intelligent logistics systems that play a role in achieving efficient production, and examples of the approach Hitachi has adopted to food and regenerative medicine. One article uses the example of food processing plants to profile plant security, a risk mitigation measure that, in recent times, companies can no longer afford to ignore. Utility equipment has an essential role in business activity and one of this issue's articles explains the operation of a cloud-based service and the control techniques it incorporates for optimizing energy efficiency. Another article describes solutions that provide total support for production, including a service system that helps reduce things like industrial equipment downtime and life cycle costs.

I hope that the work on problem-solving solutions for the industrial sector described in this issue will prove useful to readers by providing you with a better understanding of the activities of Hitachi as it pursues its Social Innovation Business.

Editorial Coordinator,
Industrial Solutions Issue

Takumi Sugiura
Deputy General Manager
Corporate Technology Division
Infrastructure Systems Company
Hitachi, Ltd.

Industrial Solutions

Society progresses in step with advances in the wide range of industries that underpin its existence, including steel, chemicals, automobiles, food, pharmaceuticals, energy, and electronics.
Meanwhile, the progress of society drives major changes in the environment in which industry operates, bringing new challenges in the form of ongoing globalization, structural changes in society, measures for dealing with global environmental problems, and ensuring safety and security in the face of a diverse range of risks.
Hitachi supplies numerous different solutions to a wide range of industries, helping overcome an increasing number of challenges.
Through activities that include manufacturing optimization, logistics rationalization, and energy management, Hitachi is contributing to corporate business improvement and innovation.

Solutions for automotive manufacturing

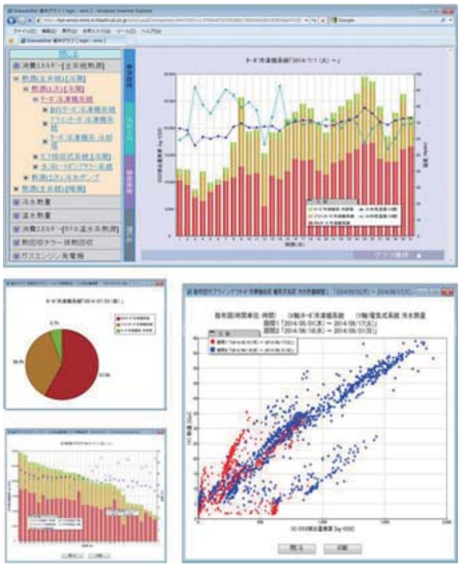
Solutions for pharmaceutical manufacturing

Solutions for food and beverage plants

Solutions for plant security

Screen from manufacturing execution system for process industries

Screen from factory management cockpit solution



Web screen from energy management system for heating and cooling equipment

Service solutions for utility equipment

Layout of cell processing center (top) and cell processing equipment (biohazard safety cabinet) (bottom) for regenerative medicine solution

Equipment maintenance and facility management services

Use of augmented reality (AR) to provide instructions for equipment operation and maintenance work

Message

Industrial Solutions Issue of Hitachi Review

Kunizo Sakai

Vice President and Executive Officer of Hitachi, Ltd.
President & CEO of Infrastructure Systems Company

Joined Hitachi, Ltd. in 1975. Appointed General Manager of the Command Control Systems Division of the Defense Systems Group in 2003, President of the Defense Systems Company in 2009, and Vice President and Executive Officer and CEO of Plant System Division at the Infrastructure Systems Company in 2013 prior to taking up his current position in April 2014.

The environment in which corporations operate is undergoing rapid changes, influenced by factors such as ongoing globalization, changing social trends and economic conditions in Japan and elsewhere, and technological innovation. There are also active moves toward the delivery of new value in the industrial sector by utilizing information and communication technology (ICT) in such forms as the Internet of things (IoT), machine to machine (M2M) communications, big data, and the cloud, including, for example, the Industrie 4.0 concept being pursued in Germany with the aim of creating a more advanced manufacturing industry. With companies being faced by these major changes and new business environment, Hitachi believes in the importance of growing in tandem with customers as they strive to make a success of their businesses, collaborating with them on everything from sharing a vision and working together on challenges to proposing, testing, operating, and maintaining solutions.

Hitachi supplies a wide range of solutions, from plant construction to products and systems, and is working on the development of leading-edge technologies that can help make these solutions more advanced.

In the past, while we have supplied customers with an extensive range of goods, we are also aware that we have had a tendency to view the job as being finished once the product is delivered. From now on, we intend to put an effort into providing support across the customer's entire business life cycle, covering the manufacturing process in the factory or elsewhere as well as throughout the product life cycle, including maintenance. To achieve this, it is important to have a detailed understanding of the customer's challenges to jointly identify their key goal indicators (KGIs). If we are able not just to look at where customers are at present, but also to share ideas on where they should be going in the future and what their own customers are looking for, we should be able to make a major contribution by being a one-stop provider of timely solutions combining the information technology such as "Big data" and "Cloud computing" with components, manufacturing technologies and systems and engineering, procurement and construction (EPC) capabilities associated with plant construction that Hitachi has supplied to customers in a variety of industries in the past.

Our aim is to continue providing customers with new value by combining the latest technology from the IT sector with knowledge built up in a variety of industries; including steel, automobiles, robotics, electronics, pharmaceuticals, chemicals, and food. In doing so, we will implement the concept of symbiotic autonomous decentralized systems, which, rather than being limited to the optimization of individual systems, seek to achieve overall optimization while adapting to constant change by having systems work in mutual harmony, with system-wide coordination and interoperation.

In operating our business, which takes a "market-in" approach based on customer needs and deals with life cycles, our aim is to contribute to all of society through the supply of solutions to industry to promote innovation.

This issue of *Hitachi Review* describes a number of systems and services that supply solutions to customers in the industrial sector. I hope that this will prove useful to you in your own business and in the public arena.

Technotalk

Problem-solving Approach to Improving Competitiveness of Industry

Jun Abe Corporate Officer & General Manager, Business and Engineering Solutions Division, Social Innovation Business Project Division, Hitachi, Ltd.

Yoshiaki Kinoshita Chief Technology Officer, Information & Telecommunication Systems Company, Hitachi Ltd.

Koichi Tsuzuki, Dr. Eng. Chief Technology Officer and General Manager, Corporate Technology, Infrastructure Systems Company, Hitachi Ltd.

Along with the ongoing globalization of industrial activity in recent years, major changes are taking place in the services demanded by the solutions market. In supplying solution services, Hitachi places an emphasis on adopting a customer's perspective. By being quick to pick up on changes in the market, and utilizing its extensive business know-how and advanced information and control technology to work with customers to identify challenges, Hitachi helps customers maximize their corporate value through the supply of solution services in the form of innovative solutions tailored to the customer's business challenges and value chain.

CHANGING INDUSTRIAL ENVIRONMENT

Tsuzuki: Hitachi has supplied solutions to numerous customers in the industrial sector. This can be seen as the culmination of how we work alongside customers to confront and overcome challenges. Accordingly, we are seeking to strengthen our capabilities across the group, with our front office businesses being actively engaged in finding out from customers about the issues they face and providing this as feedback to the technology development divisions for use in the development of new products, systems, and services that can be delivered in the form of solutions. This is because, with economies becoming more globalized, it is becoming even more important to enhance competitiveness through innovations in value creation across all different industrial sectors. Initiatives at the national level that are aimed at enhancing industrial competitiveness and involve the public and private sectors working together are also starting to appear, driven by an awareness that advances in fields such as information and communication technology (ICT) and robotics in particular are bringing about fundamental changes in manufacturing. Major examples of these include the Industrie 4.0 project in Germany; the National Network for Manufacturing Innovation (NNMI) in the USA; the Engineering and Physical Sciences Research Council (EPSRC) in the UK; and the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST), Cross-ministerial Strategic Innovation Promotion Program (SIP), and the Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT) in Japan.

Could you please tell me about the changes you have noticed while supplying solutions in your respective fields?

Jun Abe

Corporate Officer & General Manager, Business and Engineering Solutions Division, Social Innovation Business Project Division, Hitachi, Ltd.

Joined Hitachi, Ltd. in 1984. After roles that included Manager of the DB Design Group of the Software Business Division, Senior Vice President of Hitachi Data Systems Corporation, and General Manager of the Software Business Division, he took up his current appointment in 2013.
Mr. Abe is a member of the Information Processing Society of Japan (IPSJ).

Yoshiaki Kinoshita

Chief Technology Officer, Information & Telecommunication Systems Company, Hitachi Ltd.

Joined Hitachi, Ltd. in 1982. After roles that included heading the Enterprise Server Division, Deputy Manager of the Management Strategy Office, and General Manager of the Hardware Monozukuri Division, he took up his current appointment in 2014.
Mr. Kinoshita is a director of the Research Organization for Information Science & Technology (RIST) and the Information Technology Security Center (ITSC).

Abe: At the Business and Engineering Solutions Division where we strive to envisage the issues as we interact with customers and devise solutions from a sales engineering perspective, I have become aware of changes in customers' value chains in recent times.

A need has arisen to present the challenges and solutions associated with changes in the value chain that result from manufacturing customers whose business was previously based on the production and sale of goods shifting to a service-based business model. Hitachi itself is going through this change and we have already embarked on measures aimed at becoming a service business.

Also, customers who operate globally are increasingly outsourcing some of their business processes to external specialists on an ongoing basis in order to enhance their ability to generate cash to compete in global markets. A trend is evident in which companies are seeking to improve operational efficiency in terms of overall optimization, with the scope of activities being outsourced having expanded to even include some aspects of the production process, such as information technology (IT) management, equipment management, procurement, logistics, and packaging.

The Industrie 4.0 project in Germany aims to cut manufacturing costs dramatically by using IT to make production facilities smarter while also creating new services that take goods as their starting point by linking the factory via communication networks to external value chain activities. National initiatives like this can be thought of as enabling a paradigm shift in the world's manufacturing industry.

The first step in supplying solutions under these circumstances is to be able to see the true objectives toward which changes are directed. What is needed is to eliminate "front-side" vagueness to make sense of what the goal actually is.

Kinoshita: The activities of the Information & Telecommunication Systems Company extend from the supply of highly reliable IT platforms to IT service solutions such as consulting and system integration. From this perspective, the question recently has been how IT can contribute to the customer's products or other aspects of their business through the consolidation and collation of information, including big data analytics. When IT is used to see what is happening in a business from a variety of perspectives, the quantity of information tends to increase significantly and the quality to vary more widely. How to make use of this information has a significant influence on corporate value. This calls for high-impact IT solutions that incorporate knowledge about how to make the most of big data, and that can help management identify goals.

As a manufacturer, Hitachi is also working on improvements at production workplaces, achieving efficiency gains and optimization through the sophisticated use of IT to coordinate different sites with each other from a global perspective. Examples include work on establishing practices for improving our own management and operations by analyzing large amounts of big data, including operational information from equipment and other plant systems collected using sensing technology.

I believe that presenting Hitachi's in-house experience with establishing such practices can help resolve customer issues.

COMBINING COMPREHENSIVE CAPABILITIES OF HITACHI TO SUPPLY SOLUTIONS

Tsuzuki: Certainly, the Infrastructure Systems Company has many customers who want to use

Koichi Tsuzuki, Dr. Eng.

Chief Technology Officer and General Manager, Corporate Technology, Infrastructure Systems Company, Hitachi Ltd.

Joined Hitachi, Ltd. in 1978. After roles that included working at the Central Research Laboratory, CTO of Hitachi Europe, and Executive Officer of Hitachi Plant Technologies, Ltd., he took up his current appointment in 2013.
Dr. Tsuzuki is a member of The Japan Society of Mechanical Engineers (JSME) and the Turbomachinery Society of Japan.

systems and other technologies that we have developed for our own use. Examples include technology that uses tablet computers at the workplace to provide a clear view of work progress by displaying images created using four-dimensional computer-aided design (CAD) (which adds a time dimension to the three spatial dimensions) to shorten delivery times while still maintaining high quality at the site when bringing together resources from inside and outside the company to build factories or equipment.

On the other hand, when it comes to supplying solutions that look to the true objectives and other challenges at which changes are directed, I believe it involves finding solutions that suit the customer's business sector and value chain. In this regard, what things are most important to you?

Abe: The first is to identify changes in the markets in which customers operate at an early stage. To achieve this, it is important to place a high value on interaction with customers in order to share information about the nature of their business, such as the challenges they routinely face, and also to keep up with the latest developments among customers' customers, partner companies, and others.

Hitachi operates in a wide range of businesses, with a large number of customers and partner companies. I believe one of our strengths is that we can draw on knowledge from across different sectors to keep up with the markets in which customers operate from a variety of perspectives.

Transforming manufacturing into a service business requires a different sort of value chain management than has been used in the past. This requires company-wide reforms that go beyond individual factories, sales offices, and other operations. Along with setting a large number of key performance indicators (KPIs) that are optimal in company-wide terms, what is required is to work through the plan, do, check, and act (PDCA) cycle by utilizing IT to provide a more timely overview of the global supply chain as well as inventory management and quality management.

For solutions that support this company-wide reform, what is important I believe is to package these as services, including specific methods such as the four-dimensional CAD technology, and to prioritize how they are combined, without losing sight of the customer's ultimate objectives and goals.

Kinoshita: We have already discussed the Industrie 4.0 project, and Hitachi already designs control systems for its plants based on the autonomous decentralized concept. Nowadays, we are moving into the era of "symbiotic autonomous decentralized" systems that provide optimal solutions including the exchange of data, handling coordination not only within our own plants but also with those of customers and the partners who supply us with parts. In simple terms, we are establishing the capability to minimize inventory, delivery times, and so on by having production systems and machines communicate with each other on an autonomous basis.

Hitachi has also been engaged in an active program of strategic investments aimed at expanding its businesses in leading-edge IT, as epitomized by cloud computing and big data analytics. We have established extensive global infrastructure for our consulting business, strengthened our storage solutions business, developed Hitachi Advanced Data Binder*1 (a high-speed data access platform), and set up a big data laboratory in North America.

I believe that presenting these leading-edge initiatives to customers in a timely manner will also strengthen Hitachi.

Abe: That's right. The deployment of smart logistics in China has attracted attention from customers. Part of the Hitachi Smart Transformation Project for restructuring the Hitachi Group, this involves establishing and operating a service for transporting goods without waste in both the outbound and inbound directions by combining the "milk run" (in which a single vehicle visits a number of suppliers to pick up goods) of Hitachi Transport System, Ltd. with the global procurement service of Hitachi High-Technologies Corporation and the TWX-21*2 business media service built by our Information & Telecommunication Systems Company. We have had requests from customers for the service to also transport their parts and materials in China, which is recognized as somewhere that suffers from poor logistics efficiency.

This can be seen as an example of the high-level integration of services derived from the diverse forms of knowledge possessed by Hitachi for dealing with an issue that could not be resolved by individual measures, and that is distinctive of Hitachi.

Kinoshita: There is another example in which Hitachi Construction Machinery Co., Ltd. has achieved significant results. Maintenance services are important for construction machinery, with higher utilization

*1 Utilizes the results of "Development of the Fastest Database Engine for the Era of Very Large Database and Experiment and Evaluation of Strategic Social Services Enabled by the Database Engine" (Principal Investigator: Prof. Masaru Kitsuregawa, The University of Tokyo/Director General, National Institute of Informatics), which was supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).

*2 TWX-21 is a trademark of Hitachi, Ltd.

meaning more value for customers. For more than 10 years, Hitachi Construction Machinery has been operating the Global e-Service, which it developed to use sensor data for realtime monitoring of the operation of machines that it has sold to optimize the procurement of the required maintenance parts. Since 2012, Global e-Service has been available as a cloud service on TWX-21. In addition to the life cycle management of equipment, it offers a broad range of other useful services that include use at sales offices for things like inventory management and tracking the status of deliveries. As Hitachi Construction Machinery operates throughout the world, other features include multilingual support and reliable service operation and maintenance.

MAXIMIZING CORPORATE VALUE OF CUSTOMERS THROUGH CO-CREATION

Tsuzuki: From what we have been saying, it seems that the approach to business whereby we determine the customer's requirements and then take responsibility for building and delivering the product is a thing of the past. This reinforces the impression that we now live in an era in which we seek to create value jointly by creating a forum in which Hitachi and the customer can exchange information and consult on issues.

Kinoshita: In the case of IT system development, whereas in the past it was assumed that we would perform the design, including the hardware, the style now increasingly includes using an open cloud to combine systems together with the use of existing IT assets. For ourselves, what we supply to customers is not so much IT systems as corporate value itself, which is created together with customers through the functions of those IT systems.

Abe: Our job does not end with the delivery of a product or other system. The products that underpin industry and other parts of society remain in use for a decade or more, and the markets in which customers operate can change considerably during that time. What matters is being able to remain in touch with customers after delivery so that we can offer them after-sales services and provide ongoing suggestions tailored to changes in their circumstances, and I believe that our ability to this at Hitachi is part of the value we provide.

Kinoshita: In the case of IT platforms, while difficulties can arise when it comes to being able to assess things that change over time, such as the customer's values and the state of their business, and to design the scale, we supply the highly reliable Hitachi Cloud platform and our flexibility encompasses both short-term and long-term scale out (provision of additional resources). It is also important to establish practices that enable dynamic changes to things like the system design and specifications, including for the customer's on-premises systems. As greater use is made of the cloud, we are moving more and more into a software-defined world that virtualizes server, storage, and network IT resources. Nowadays, differentiation depends more on applications than on hardware, and we are steadfastly seeking to catch up with these changes.

Abe: In this time of rapid change, solving the business challenges that customers face requires in-depth analysis and understanding of the current situation from their perspective. First of all, this requires a process that involves obtaining a global overview of the customer's business value chain and sharing information about issues at each phase. It is important to adopt an approach whereby the value in the customer's business is created jointly by combining the technologies and solution services from Hitachi, its partner companies, and others to strengthen capabilities, categorizing the various elements required for the solution in terms of equipment, IT, energy, and logistics.

Kinoshita: IT has created value by linking various different things together, and facilities such as manufacturing execution systems (MESs) that perform optimization by linking core business systems to manufacturing plants in realtime are rapidly growing in importance in the industrial sector and elsewhere. By drawing on experience and technical capabilities gained through our work on IT system implementation, we will help customers solve problems by collecting and analyzing information and by using it in business decision making to achieve company-wide optimization.

Tsuzuki: What you have been saying reconfirms for me that there are many things that only Hitachi can achieve. It is fair to say that the key to industrial solutions lies in the "symbiotic autonomous decentralized" concept of solving problems by seeking to achieve overall optimization. This involves the sharing of information about customer issues while keeping up with changes in the market, and is achieved through the combining and linking of a variety of individual services, systems, and data so that they can interoperate while also functioning autonomously. We will continue striving to utilize Hitachi's extensive business experience to help achieve innovation and growth in customers' businesses.

Overview

Industrial Solution Technologies for Overcoming Customer Challenges

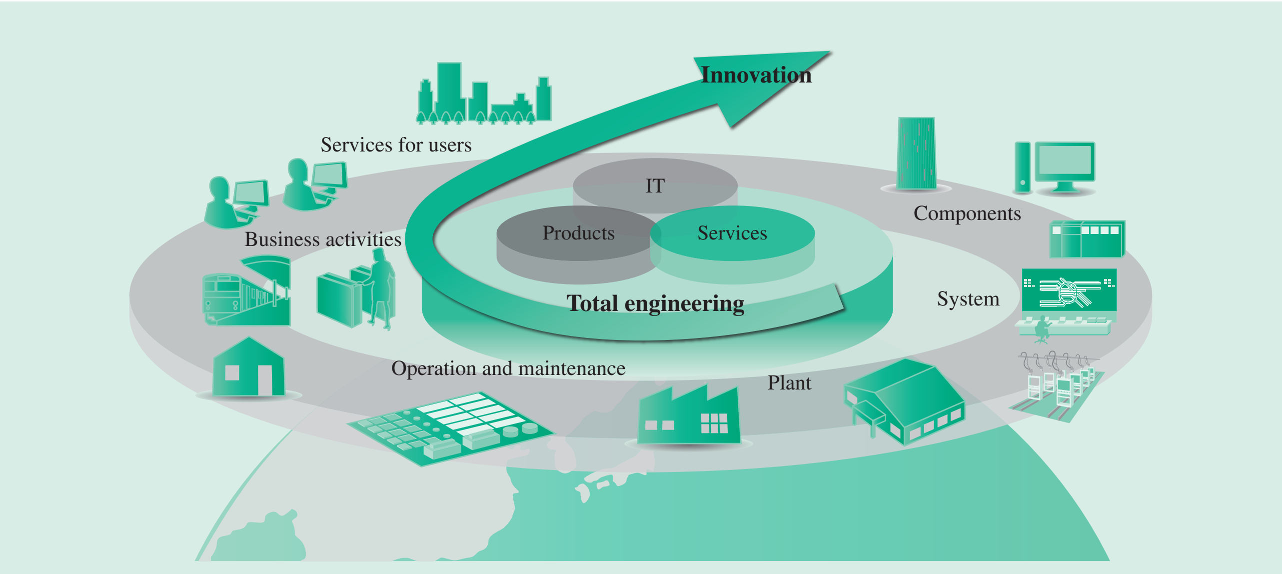
Takumi Sugiura, PE.Jp
Takaki Taniguchi
Shinsuke Kanai
Masatoshi Furuya
Hiroshi Yoshikawa

ENVIRONMENT SURROUNDING CORPORATE ACTIVITY

WITH the growing complexity and pace of change in the environment in which corporations operate, it has become extremely difficult to see what is ahead. In addition to a borderless economy and increasingly intense international competition, worsening resource and environmental problems, more diverse market needs, rapid technical innovation in information and communication technology (ICT) and other fields, and countermeasures to risks that have arisen in recent years, such as measures for dealing with disasters and security, these changes also have a synergistic interaction with the measures that companies are adopting as they globalize their own businesses, such as those for dealing with the regions in which they operate, and will inevitably accelerate further in the future.

Companies need to deal with this ever-changing business environment without falling behind, facing an era in which only those that adapt to change will survive.

What companies require in this situation is the ability to identify the signs of change at an early stage and to respond promptly.



IT: information technology

Fig. 1—Innovations Created by Total Engineering.
Hitachi products, services, and IT, and the new value created through the total engineering capabilities of Hitachi's Infrastructure Systems Company, accelerate innovations that solve the problems faced by customers and society.

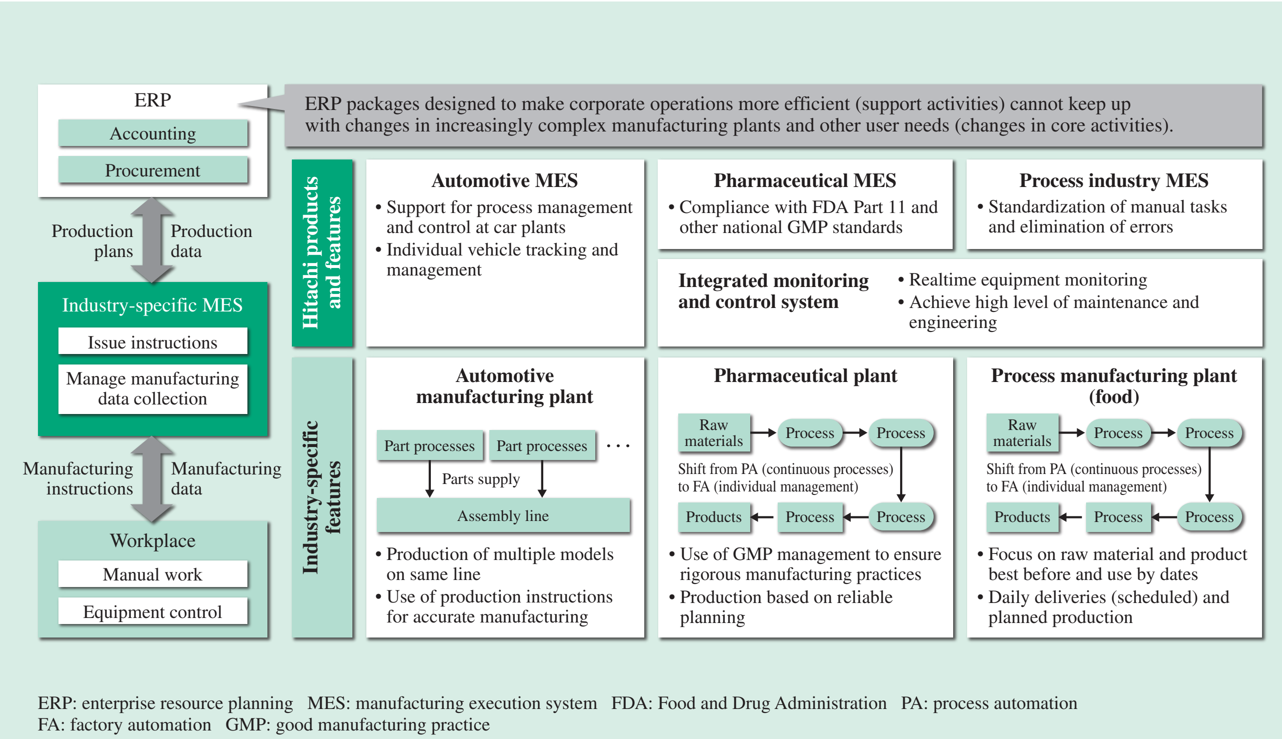


Fig. 2—Industry Features and MES Products for Different Industries.
The philosophies behind the MESs for manufacturing plants in specific industries depend on factors such as the regulatory environment and manufacturing processes required to produce the end product.

SOLUTIONS FOR OVERCOMING CUSTOMER CHALLENGES

Hitachi has been strengthening its ability to act as a one-stop supplier of a wide range of products, services, and "information technology (IT) × operation technology (OT)" in a variety of fields (see Fig. 1). In factories, the manufacturing process is underpinned by production management systems, heating and other utility equipment, parts supply logistics, and equipment maintenance practices, with corporate security also having grown in importance in recent years, food defense[(a)] being a notable example. By supplying companies with functions in a variety of situations that fulfill their need to see what was previously invisible, and that can respond flexibly and quickly, Hitachi believes it can maximize operational efficiency and reduce risk.

The following sections describe the solutions profiled in this issue of *Hitachi Review*.

(a) Food defense
The prevention of the deliberate contamination of food by external parties at all stages, from ingredients procurement to production and sales, and measures for achieving this. Food defense is conceptually different from food safety and security, in the sense that these terms have been used in the past, and is a subject that has attracted growing interest in Japan and elsewhere due to an ongoing series of incidents involving the poisoning of food in recent years.

MEASURES THAT CONTRIBUTE TO HIGHLY EFFICIENT PRODUCTION

Efficient manufacturing requires the use of an MES[(b)] that acts as an intermediary between core business systems and the automation systems used at production facilities, performing realtime monitoring of production equipment, raw materials, inventory levels for work in progress and similar, and other status information, and providing things like work schedules based on production plans and information on operating procedures. Hitachi supplies MESs to a number of different industries (see Fig. 2). This issue includes an article that focuses on an MES package for process industries (food and chemicals), which have a particular need for workplace improvement, and that proposes ways of expediting the plan, do, check, and act (PDCA) cycle and providing seamless coordination with service businesses based on customer needs.

(b) MES
An abbreviation of "manufacturing execution system." A realtime system for production facilities in the manufacturing industry with functions that include production monitoring, schedule management, and providing instructions to staff. In addition to making information from production facilities available by linking plant systems and equipment to the enterprise resource planning (ERP) system, the MES also helps ensure that manufacturing is performed in an optimal manner in accordance with the production plan.

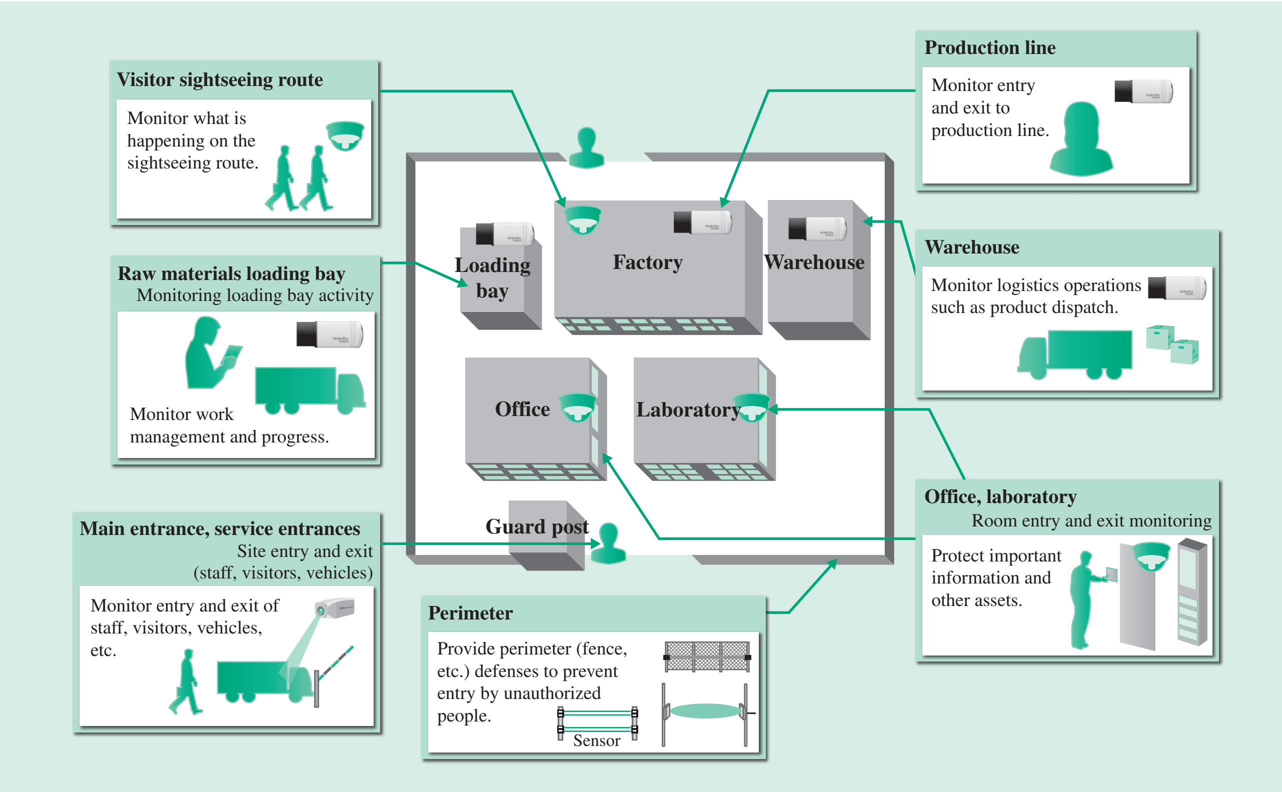


Fig. 3—Overview of Physical Security at Food Processing Plant.
Entry and exit checks on goods, people, and vehicles are important, as are reliable monitoring and recording.

Articles also describe examples of solutions for food processing plants; a solution for regenerative medicine, a field that is expected to achieve an industrial scale; and a newly developed logistics system that supports production systems.

SECURITY SYSTEMS THAT UNDERPIN PRODUCT SAFETY

Earthquakes, eruptions, storms, and other acts of nature are not the only events that can force companies into business interruptions or operational shutdowns. In addition to information leaks, false labeling, and inadequate food hygiene management, malicious acts by staff or acts of corporate terrorism are also serious threats. Hitachi supplies solutions that provide the "adaptivity," "responsivity," and "cooperativity" required for social infrastructure security, and that extend from cybersecurity (anti-virus measures, etc.) to physical security (including premises access control and monitoring). In particular, food security is at the top of the priority list of things that need to be ensured if people are to enjoy a healthy way of life, because the level of damage that can be inflicted on companies is incalculable. This issue includes an article on plant security using the latest Hitachi technology based on case studies of food defense. It describes the operation of security policies, surveillance camera systems with ultra-high-resolution and a high level of data compression for the long-term recording of high-quality video that provide useful methods for reliable recording and checking of historical records, and hands-free systems with detection capabilities that include determining the direction of movement and the presence of large numbers of people (see Fig. 3).

OPTIMAL OPERATION OF ENTIRE UTILITY SYSTEMS

In addition to the monitoring of energy usage, equipment operating status, faults, and other parameters for the utility equipment that supports corporate activity, there is also a need to make ongoing improvements in areas like work efficiency and energy efficiency. To achieve this, Hitachi markets a cloud service based on the mall model that enables participation by a range of stakeholders, from consumers to equipment suppliers, energy suppliers, and national and local government or other agencies to which reports need to be submitted.

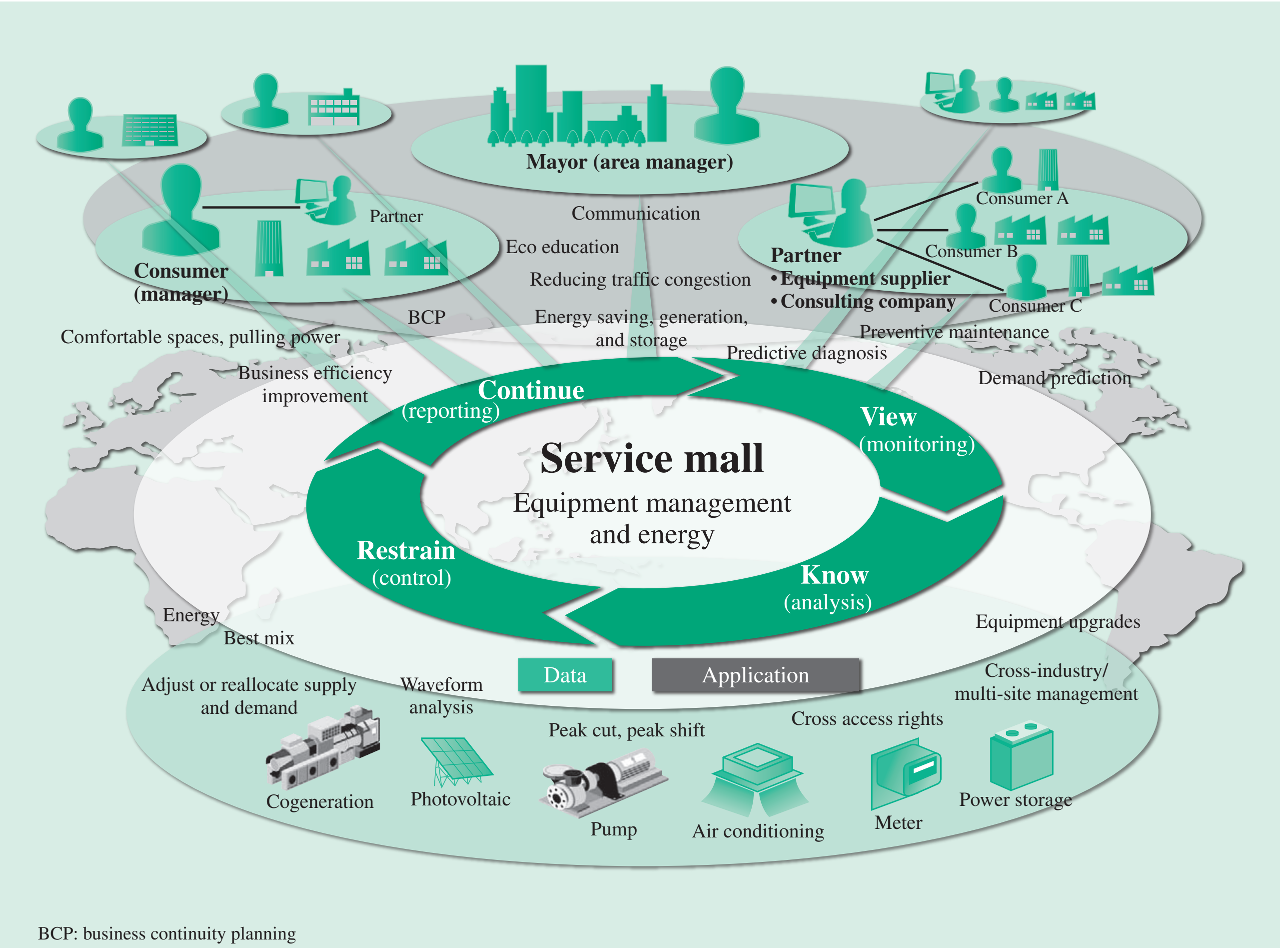


Fig. 4—Service Concept.
By performing integrated management of energy and other operational data from equipment and machinery installed at sites such as factories or retail stores, the service delivers total support that extends from providing and analyzing information to optimal operation, reporting, and maintenance.

Hitachi supplies a service for corporate consumers, incorporating equipment and energy management functions. Stakeholders who have been granted access rights can access the service mall via the Internet and make suitable use of information, including equipment operating data, energy usage, and fault records, in accordance with these rights. By using the functions, which are categorized in terms of "view" → "know" → "restrain" → "continue," it is possible to coordinate the shifting of peaks in electric power consumption with production plans, and to formulate equipment upgrade plans (see Fig. 4).

In an example of the functions bundled with the integrated energy and equipment management service(c), this issue also contains an article about a system that performs optimal control of different types of heating and refrigeration equipment in the heating and refrigeration system in the ABENO HARUKAS building, Japan's tallest mixed-use skyscraper.

SERVICE SYSTEM THAT HELPS ACHIEVE EFFICIENT OPERATION OF INDUSTRIAL MACHINERY AND REDUCE COST OF OPERATION AND MAINTENANCE

The requirements for reducing downtime in industrial machinery that has an important supporting role in factories and other plants include using preventive maintenance to minimize the incidence of problems and providing a rapid recovery response when a problem does occur. The difficulties with this, however, are that, because the practice in the past has

(c) Integrated energy and equipment management service
Supplied by Hitachi to corporate consumers, the service enables integrated management of energy and equipment information for various facilities, equipment, and machinery spread across multiple sites in a single energy management system (EMS), and provides benefits such as optimal company-wide use of energy and operational efficiency improvements through a service that supports the adoption of energy efficiency measures based on the analysis and utilization of integrated management data.

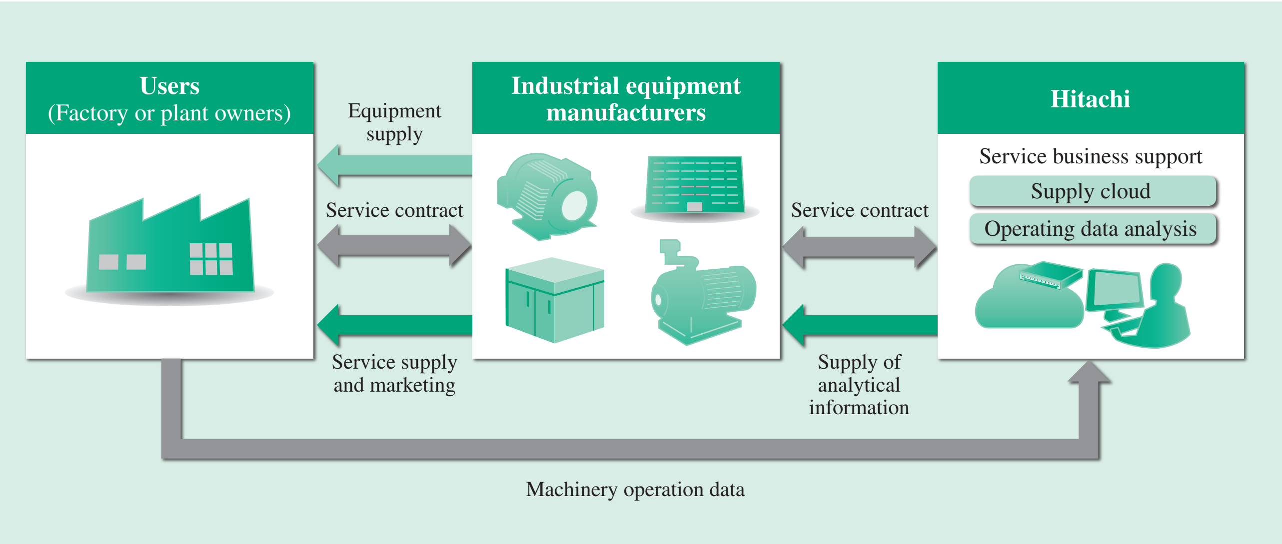


Fig. 5—Overview of Hitachi Cloud-based Equipment Maintenance and Facility Management Service.
Hitachi supplies cloud and operational data analysis services to industrial equipment manufacturers.

mainly involved performing status checks by making routine visits to the user or starting recovery work only after receiving notification of a problem, it has been difficult to perform preventive maintenance at the best time, and restoring operation has taken a long time. To solve these problems, Hitachi supplies an equipment maintenance and facility management service platform that it developed itself using cloud computing. By collecting and analyzing operational data, the service platform can be used to provide information that is useful to users, such as suggesting energy-efficient operating practices (see Fig. 5). When utilized for air compressors, the service was able to identify energy-efficient ways of operating equipment through the collection and analysis of operational data. When used to guide workers through operating procedures by using AR[(d)] for operation and maintenance work at various plants, it has also achieved benefits such as preventing steps from being missed as well as other operational errors.

WORK AIMED AT DELIVERING NEW VALUE AND OVERALL OPTIMIZATION

While the environment in which corporations operate continues to undergo major changes, this article has described Hitachi solutions that respond to customer issues in a variety of fields. All of these are examples of solutions that Hitachi's Infrastructure Systems Company has supplied to the industrial sector by combining equipment, systems, and information and control technology.

By supplying new value to customers through the sharing and analysis of the data collected by each of these systems, and also by performing optimization across multiple systems, Hitachi will continue to operate its Social Innovation Business in the future, not only in industry but also in a variety of other fields.

(d) AR
An abbreviation of "augmented reality." A technology that uses computer processing to overlay information on a view of the real world, or that presents it in modified form, and the environment presented by the technology. One example of AR use is to display operating procedures over images of a plant that have been captured by a camera.

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Featured Articles

Current Activities and Future Prospects for Industry-specific MESs

—Recommendations for Operational Optimization and Service Businesses—

Takaki Taniguchi
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OVERVIEW: The role of industrial MESs has been changing in recent years due to a variety of factors such as rapid advances in IT and greater operational diversity at manufacturing sites. Hitachi supplies MESs tailored to specific industries, such as the automotive and pharmaceutical manufacturing industries, and has been further developing MES functions to keep pace with user needs. One of these is the MES package for process industries (such as food and chemicals), which have a particular need for workplace improvements. Hitachi MES package provides solutions that can be adapted flexibly to workplace changes, including management functions based on SOPs. Recognizing the demand from users for operational optimization, environmental and equipment maintenance, and other workplace management tasks that are expanding in scope, Hitachi is also investigating the future potential for implementing systems that can expedite the PDCA cycle and provide seamless coordination with service businesses.

INTRODUCTION

INDUSTRIE 4.0 is an advanced technology strategy introduced by the German government in 2011. The concept is based on a joint industry-academia-government project, with the release of a final report in Germany in 2013 being a recent development. In the information technology (IT) field, meanwhile, it is evident to everyone that cloud technologies such as software as a service (SaaS), platform as a service (PaaS), and big data are making a place for themselves in the wider world.

Manufacturing execution systems (MESs), too, are becoming widely used, particularly in factory automation (FA) applications such as the automotive and semiconductor industries, and in process industries such as chemicals, pharmaceuticals, foods, and cosmetics. However, the functions required of MESs are changing in various ways as greater operational diversity at manufacturing sites and shorter lead times for activities such as product development cause manufacturing plants and user needs to become more complex across a range of industries. Taking note of this background, Hitachi supplies a variety of packages to suit different customer activities (see Fig. 1).

This article describes Hitachi's current activities and the future prospects for industry-specific MESs.

BACKGROUND TO ADOPTION OF IT SYSTEMS AND EXPECTATIONS FOR MESs

The process of adopting IT systems in many industries has started with the automation of manufacturing plants, followed by the installation of core business systems with functions such as accounting, procurement, and warehousing. For these core business systems to function adequately, however, there is a need to use a variety of manufacturing workplace data as information in an organic way, including the results of work performed manually and by automation systems. To make good use of this information, MESs have been installed in various industries over the last dozen or so years to act as intermediaries. Many users have come to recognize the worth of MESs, whose benefits include improving productivity and maintaining quality.

In recent years, however, the number of issues related to workplace and management has risen, including how to deal with operational optimization at plants that produce a wide range of products with variable production runs, environmental and

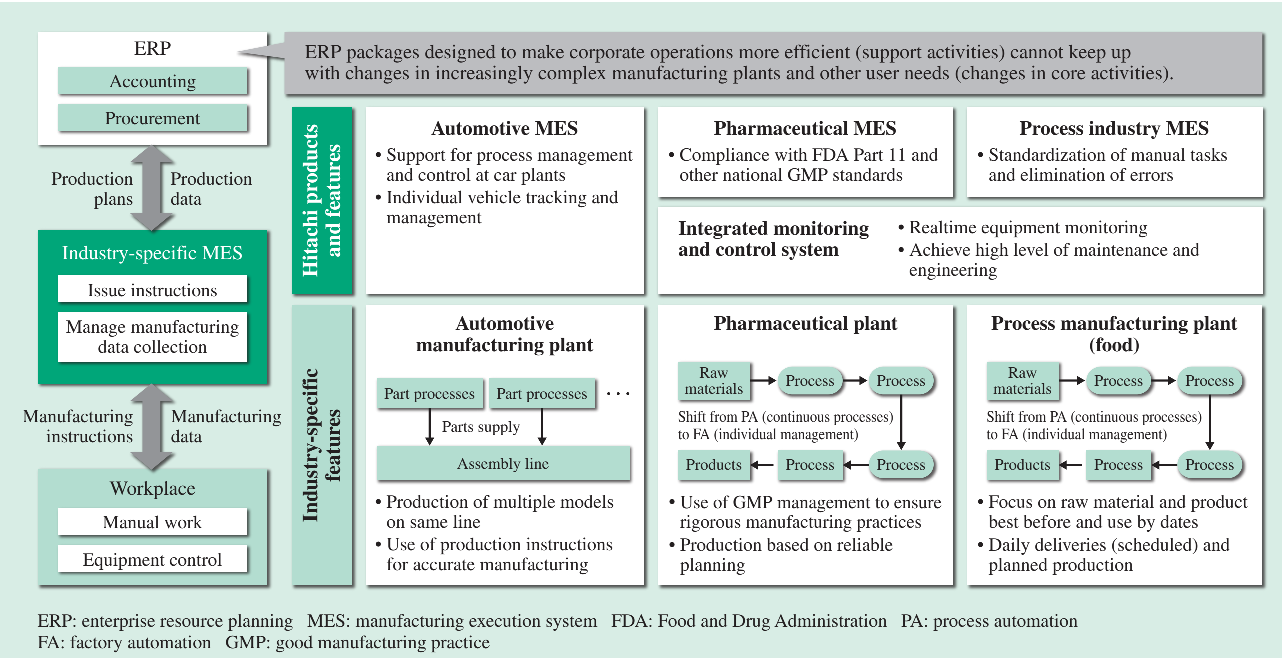


Fig. 1—Industry Features and MES Products for Different Industries.
The philosophies behind the MESs for manufacturing plants in specific industries depend on factors such as the regulatory environment and manufacturing processes required to produce the end product.

equipment maintenance, and other workplace management tasks that are expanding in scope. Growing expectations have been placed on MESs in recent years to resolve these issues.

MESs DESIGNED FOR SPECIFIC INDUSTRIES

MES for Automotive Manufacturing Featuring Realtime Processing and Data Collection Management

The MES for automotive manufacturing was developed by consolidating Hitachi's experience of more than 30 years in implementing process management systems for automotive manufacturing, and provides fine-grained process management for automotive manufacturing plants. Its functions extend to support for equipment control, primarily manufacturing management functions that provide realtime delivery of production information from core business systems to the continuously changing vehicle production process.

In the future, Hitachi will enable the system to be expanded progressively and supplied in stages by breaking the management of parts manufacturing processes down into individual modules based on the assembly line. With the aim of satisfying user needs for expediting overseas deployment, Hitachi is also focusing on improving the expandability of the system and adding multilingual capabilities to enable its use throughout the world by unifying the architecture, which in the past has been set up separately in different countries.

Hitachi Pharmaceutical Manufacturing Execution System Featuring Compliance with Regulations and Strict Quality Standards

To ensure that quality standards are maintained, the pharmaceuticals industry needs to comply with strict rules such as good manufacturing practice (GMP), which is a set of standards for manufacturing and quality management for pharmaceuticals and other products of a similar nature.

A major feature of systems designed for pharmaceutical manufacturing is that they must support "validation," which means documenting how to ensure that the equipment, procedures, processes, and so on required for pharmaceutical production, quality management, and other tasks deliver the expected outcomes. As an MES designed specifically to comply with the regulatory requirements of the pharmaceuticals industry, Hitachi for pharmaceutical manufacturing can reliably execute complex procedures, provide efficient record-keeping, and support reliable production. To satisfy the requirement that has arisen in recent years for MESs for the pharmaceutical, food, and other process industries to support control integration with

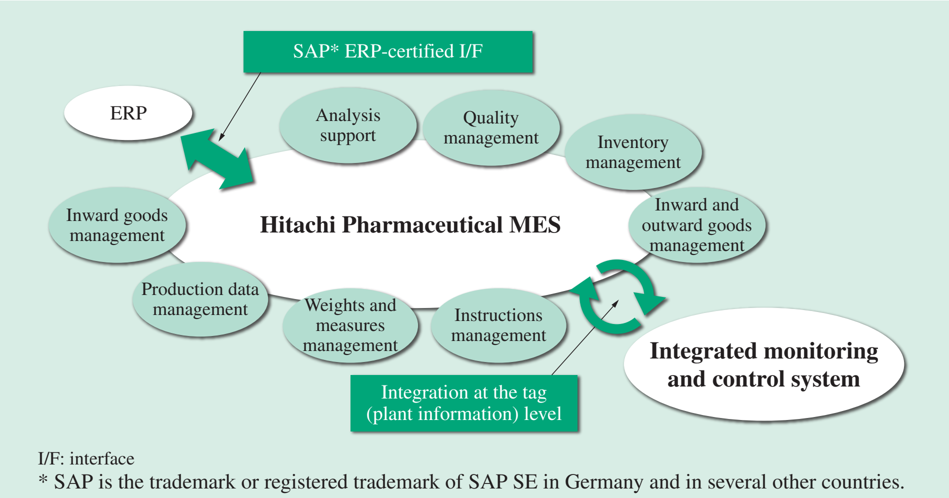


Fig. 2—Overview of Hitachi Pharmaceutical MES.
Ease of global deployment, including compliance with various national GMPs, is one of the MES's features.

on-site equipment, Hitachi Pharmaceutical MES can interoperate closely with the integrated monitoring and control system (see Fig. 2). Hitachi has also anticipated global deployment by adapting the product to the Chinese and Indian markets.

MES FOR PROCESS INDUSTRIES FEATURING ENHANCEMENT OF WORK QUALITY AT MANUFACTURING PLANTS

MES for Process Industries

The MES for process industries has undergone ongoing development in response to ever-changing user needs based on Hitachi's experience in implementing food industry MESs since the 1990s. It was released in FY2009 as a simple MES for standardizing work practices, preventing errors, and so on by using standard operation procedures (SOPs) for workplace tasks to manage manual activities such as measurement and mixing processes. Further growth has taken the form of solutions that can more flexibly keep up with changes in the workplace, including the provision of tools that Hitachi developed in FY2013 to enable customers to perform their own engineering work after system installation.

Distinctive Functions for Efficient Operation

(1) Using SOPs to prevent errors

Hitachi's approach to the use of SOPs for things like standardizing operations and preventing errors is to treat as a design prerequisite the provision of displays simple enough that all workers at the site can understand how to perform operations. In relation to work instructions that in the past involved the use of paper and other checklists, Hitachi MES for process industries enables the provision of clear guidance to workers by displaying appropriate screens for each step of the work instructions. Workers can avoid making mistakes or missing steps by consulting the next SOP screen after completing each task. This also helps reduce the strain on workers by ensuring they can do the work regardless of how proficient they are (see Fig. 3).

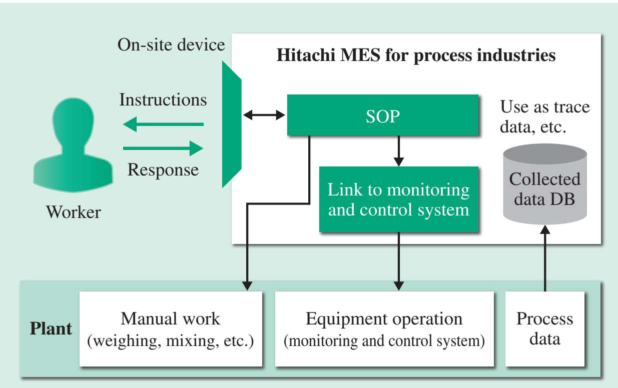
(2) Centralized management of information through interoperation with the monitoring and control system

The MES can automate instructions and data collection from production equipment through interoperation with the monitoring and control system supplied by Hitachi. As a result, it can provide centralized management of work instructions and data collection by covering entire processes that combine both manual and automatically controlled steps. Specifically, issuing instructions to equipment (such as to add ingredients automatically) and instructions to workers (such as to add ingredients manually) can be performed seamlessly from the SOP screen without dividing operations between separate systems. Also, because process information (automatic and manual) is managed centrally, the MES helps supervisors reduce the amount of investigation time required for tasks such as responding to inquiries about quality (see Fig. 4).

(3) Provision of self-engineering tools

Hitachi MES for process industries enables the provision of engineering tools that can visually edit or modify SOP master copies to reflect user requirements using spreadsheet software that has easy-to-use editing functions for maintaining master data records (see Fig. 5). By enabling supervisors to update work instructions as appropriate to match

Fig. 3—SOP Screens.
The screens show standard operation procedures (SOPs) displayed by Hitachi MES for process industries. Features include multilingual support and the ability to use text, images, video, and audio.



DB: database

Fig. 4—Overview of Coordination between Manual Work and Equipment.
An SOP can include instructions for people or equipment and data collection.

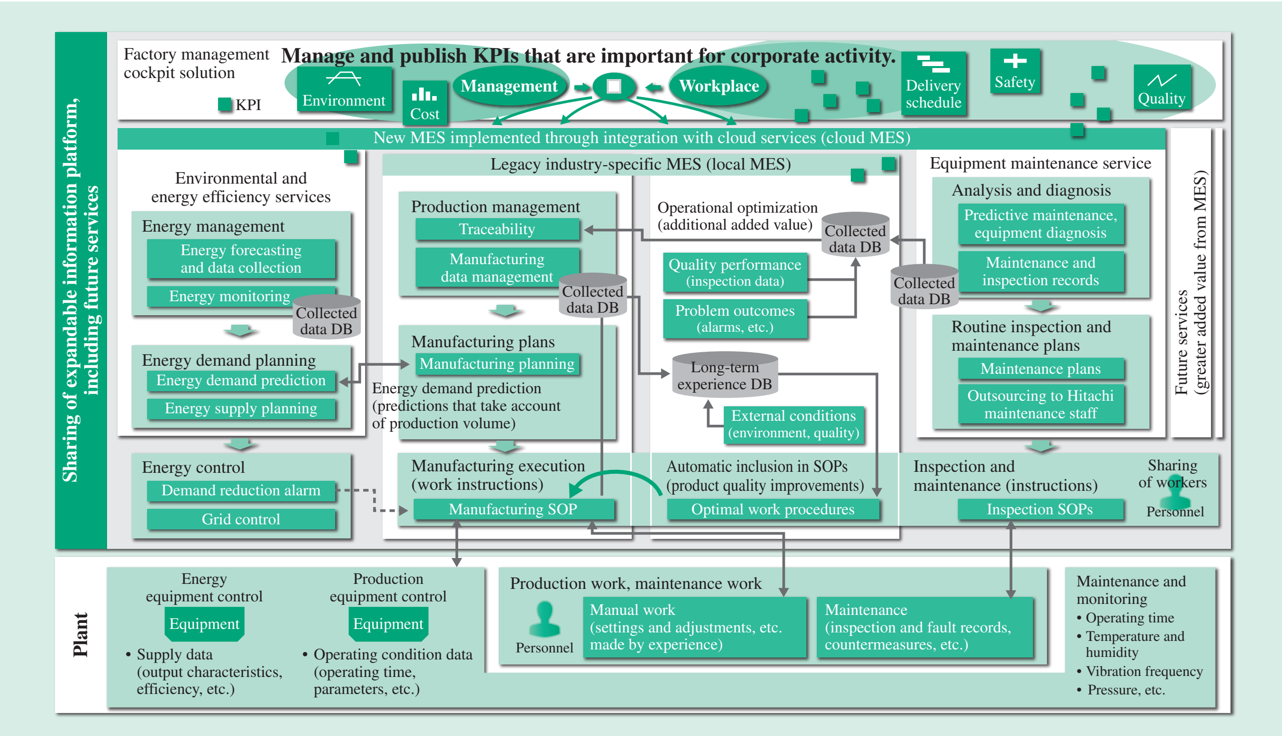
Fig. 5—Self-engineering Screen.
The screens, text, and other information to be used (right) can be assigned to work procedures (left).

workplace operation, this keeps the MES up to date with the workplace. Using these tools, users can also generate and edit reports based on information in the database.

CONFIGURATION REVIEW AND FUTURE PROSPECTS FOR NEW MESs

Issues and Countermeasures Required in MESs

Along with the industry trends and advances in IT described earlier in this article, industry-specific MESs need to continue resolving a growing number of issues. One such issue is the search for ways to establish efficient work practices in the workplace that can ensure consistent lot-by-lot quality for variable-length production runs of a wide range of products. Managers and supervisors, meanwhile, need to look at how to handle compliance with environmental and energy efficiency regulations as well as things like life cycle management of equipment and efficient maintenance. Hitachi deals with issues that cannot be resolved by either the workplace or management in isolation through integration with solutions and other services based around its industry-specific MESs. To achieve this, Hitachi believes there is an urgent need to adopt standardized information platforms, such as methods for integrating master records and other data across its industry-specific MESs and other solutions and services (see Fig. 6).



KPI: key performance indicator

Fig. 6—Future Outcomes Made Possible by New MESs.
The scope of industry-specific MESs includes production management, and this along with other MES functions associated with manufacturing plants will be implemented through integration with services.

Future Outcomes Made Possible by New MESs

(1) Operational optimization by collating know-how from skilled workers

With conventional SOPs, it is difficult to provide appropriate guidance from an IT system for manual tasks performed by skilled workers in accordance with workplace rules of thumb. However, through the long-term collection of the process data described above together with correlations to the factors that skilled workers use to make judgments (quality of upstream processes, external environment, etc.), it is possible to obtain approximations from accumulated information by using the factors that are relevant during actual work as search values. Hitachi believes it can implement this approach by using technologies developed in its laboratories, such as memory-based reasoning (MBR)[*1] and warning sign modeling[*2].

As a result, this can contribute to things like productivity and product quality by enabling even inexperienced workers to do the work using standardized guidance based on operational know-how that enables skilled workers to take appropriate steps in response to factors such as an external environment, which varies in realtime, and the unreliable quality of upstream processes.

(2) Factory management cockpit solution for increasing work activity

Defining the key performance indicators (KPIs) required to manage a factory and providing a realtime view of the manufacturing workplace are good ways to keep up with workplace information. Factory management cockpit solutions provide realtime monitoring of factory KPIs relating to production (yield and output, etc.), quality (defect rate, etc.), equipment (equipment utilization, alarms, maintenance schedules and records, etc.), and environmental performance (basic unit energy consumption, etc.) so that appropriate and timely decisions can be made based on an understanding of the situation in the workplace. When a problem arises, for example, a quick response can be achieved at all levels by making details available to everyone from workers to factory managers, allowing the production manager to obtain an early resolution by focusing on dealing with the problem; the logistics manager to

*1 A prediction technique for calculating approximations from a base of collected data

*2 A modeling technique for identifying unusual behavior and predicting outcomes

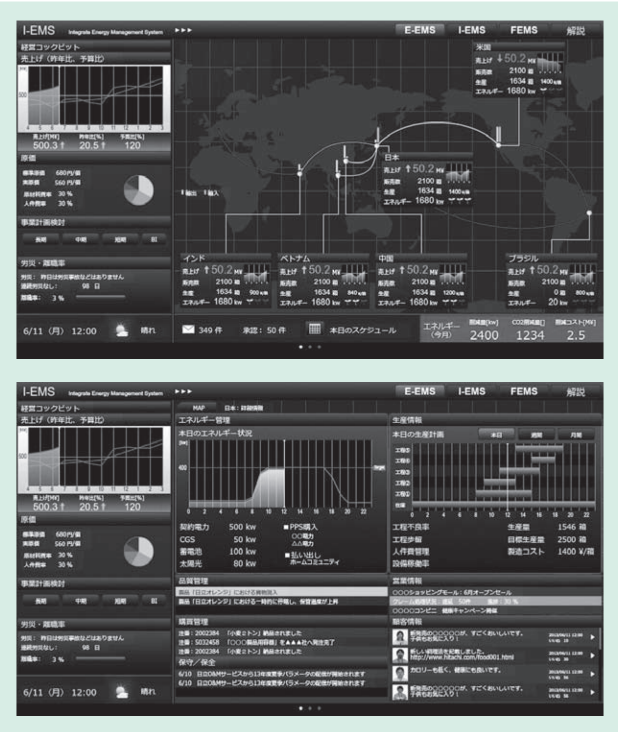


Fig. 7—Factory Management Cockpit Solution Screens.
The screens show KPIs for each level from a global management perspective (top) down to a factory perspective (bottom), and also workplace information.

quickly adjust finished product delivery schedules; and the factory manager to quickly determine what impact the problem will have on factory operation. By clearly identifying who is responsible for KPIs at each level, this helps the workplace's ability to make improvements by individually working through the plan-do-check-act (PDCA) cycle, and aids the early detection of hidden problems (see Fig. 7).

(3) Use of the cloud to supply MES functions as a service

Based on cloud technology, Hitachi supplies cross-industry services that provide simulation and other analyses for the energy management and equipment maintenance functions that are within the scope of an MES.

For example, Hitachi plans to develop and supply cloud-based energy management services for environmental and energy management, which has arisen as a new way for companies to look at their business since the Great East Japan Earthquake. In one example involving interoperation with an MES, Hitachi has implemented a function that seeks to reduce peak electric power demand by simulating the energy requirements of production plans. Other examples include a service that supports timely maintenance by identifying and analyzing warning signs of equipment faults, and that enables the proactive provision of maintenance and maintenance infrastructure by sharing operational know-how with Hitachi maintenance personnel. In this way, diverse user needs can be satisfied without imposing a burden on the workplace by taking advantage of services supplied by Hitachi, as required, rather than implementing all MES functions on a single system.

Hitachi's Next Generation of MES Solutions

In the future, Hitachi will achieve seamless integration between the MES functions that customers require by establishing the capability to provide industry-specific MESs and other functions and services that utilize cloud technology. Specifically, this will enable appropriate workplace operation by having local MESs take account of the results of simulations performed on a cloud MES based on information collected from multiple sites, where these simulations include risk assessment and other complex analyses, such as warning signs of equipment faults, process modeling, and production capacity allocation. Because work can be performed based on standardized work instruction screens, workers can be assigned without being split into departments that each have a separate responsibility, such as production or maintenance. By becoming deeply integrated into the company's operations rather than just its manufacturing plants, this can improve service levels above what has been

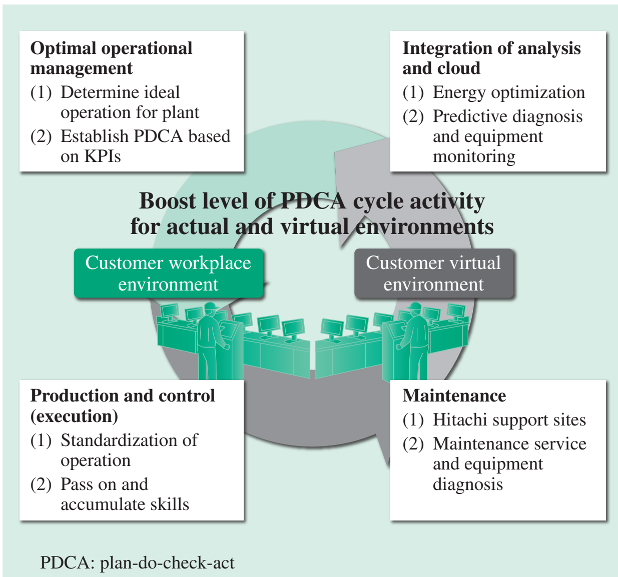


Fig. 8—Hitachi's Next Generation of MES Solutions.
The solutions are intended to boost the level of PDCA cycle activity for actual and virtual environments in accordance with the customer's workplace.

provided by local MESs in the past, further expediting the PDCA cycle and delivering more efficient workplace improvement and flexible management (see Fig. 8).

CONCLUSIONS

This article has described Hitachi's work on industry-specific MESs and their future prospects, including giving an overview of the MES for process industries.

Along with changes in social and other environmental factors, it is anticipated that workers and managers will be called on to deal with a growing number of issues in the future. Hitachi intends to continue contributing to manufacturing sites and other corporate workplaces through the ongoing delivery of additional value in the field of MESs in ways that suit these changing user needs.

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Featured Articles

Solution for Food and Beverage Plants Based on High-concentration Ozonated Water Production System

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Kazuhiro Hata
Shuichi Mori

OVERVIEW: Hitachi supplies total solutions for the construction of manufacturing plants for the food and beverage industry, which is experiencing an expansion in global markets. Hitachi has developed technology for the production of strongly oxidizing high-concentration ozonated water, a key component of these plants, and is using it for cleaning and disinfecting. Cleaning times influence plant productivity, and having confirmed its ability to shorten cleaning times in beverage plants, Hitachi is also investigating rapid disinfection techniques that can act as a substitute for chlorine-based disinfectants in fresh-cut produce plants. In these cases, Hitachi anticipates that systems that utilize the properties of ozonated water produced at a high concentration can help shorten production times, reduce utility use, and deliver safe and secure products. Use in a wider range of applications is planned.

INTRODUCTION

FOOD manufacturing is expected to experience an almost doubling of market size over the next decade due to global population growth and rising incomes. Hitachi has a track record of taking on turnkey contracts for food and beverage plants that include construction, supplying solutions that deal not only with concerns about energy efficiency and the environment, but also the concerns about food safety and security that are growing year by year. The use of new technology to rationalize the manufacturing functions of plants in this industry is particularly important, and Hitachi is now working on the development of cleaning and disinfecting techniques that use high-concentration ozonated water, seeing these as key components of such plants (see Fig. 1).

Cleaning and disinfecting are among the most important processes for ensuring quality and safety in the food manufacturing industry, and they often consume a lot of time, energy, water, and chemicals. Given this situation, Hitachi wants to help rationalize plants by adopting technology for high-concentration ozonated water.

This article describes studies focusing on the use of high-concentration ozonated water for cleaning in place (CIP)[(1)] on beverage production lines that need to be made more efficient to produce a variety of

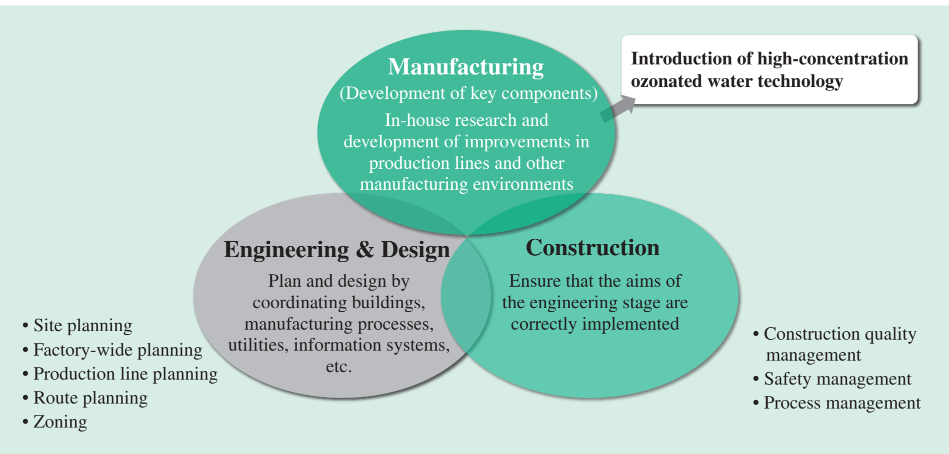

Fig. 1—Total Solution for Food Processing Plants and Introduction of High-concentration Ozonated Water Technology.
Hitachi has developed technology for the production of strongly oxidizing high-concentration ozonated water as a key component of its total solution.

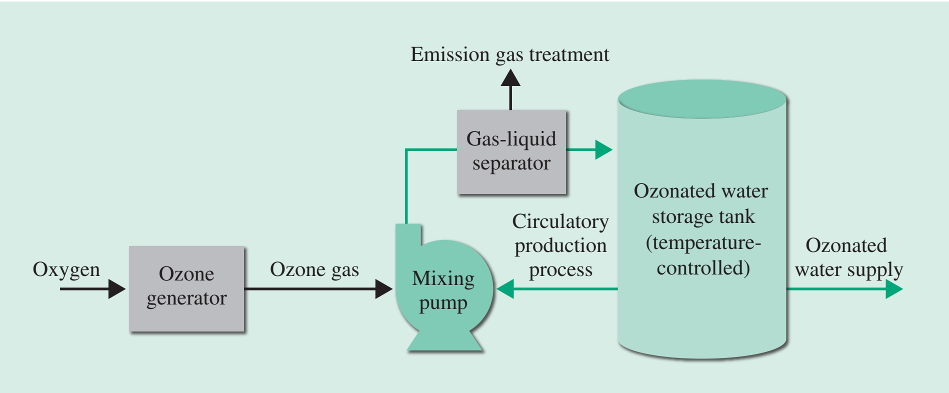

Fig. 2—Block Diagram of Ozonated Water Production System.
Higher concentration is achieved by using a circulatory production process that efficiently mixes high-concentration ozone gas with water.

different products, and for chlorine-free processes on disinfecting and cleaning lines for fresh-cut produce, a sector that is enjoying rapid growth.

PROPERTIES OF OZONATED WATER AND EQUIPMENT FOR ITS PRODUCTION AT HIGH CONCENTRATION

Properties of Ozonated Water

The properties of ozone include (1) strong oxidizing power, (2) it can be produced from air using only electricity, and (3) it does not leave a residue in food, rapidly self-decomposing into harmless oxygen. Accordingly, ozone has been used in food manufacturing for a comparatively long time, primarily for disinfecting and deodorizing. It is already recognized as an additive in Japan's food hygiene regulations and approved by the U.S. Food and Drug Administration. Although gaseous ozone, which is harmful to people, requires measures to prevent direct exposure, ozonated water (ozone dissolved in water) is comparatively safe for human use, such as its use in dental treatments, for example. Also, because the reactivity of ozonated water is higher than gaseous ozone, it is increasingly being used as a safe and reliable method for cleaning and disinfecting that does not use chemical agents or leave a residue in the product (food or beverage). However, because ozone gas is not very soluble in water and therefore tends to volatilize from ozonated water, the use of ozonated water on production lines presents challenges, because it is difficult to handle and difficult to produce and store at high concentrations.

Ozonated Water Production System

Common ways of producing ozonated water include the gas liquid mixing dissolution method, membrane dissolution method, and direct electrolytical (ozonation) method. For the solution described in this article, Hitachi has developed a high-concentration ozonated water production system based on a technique that combines circulation with gas liquid mixing dissolution using fine bubbles.

Fig. 2 shows a block diagram of Hitachi's ozonated water production system that uses this gas liquid mixing dissolution method. The main elements include the ozone generator, a mixer for mixing the ozone into the water (including a mixing pump and gas-liquid separator), a tank for storing and circulating the ozonated water, and a chiller for controlling water temperature (not shown in figure).

Parameters that control the concentration of ozonated water include the concentration of ozone gas mixed into the water, the water temperature, the gas-liquid ratio (mixing ratio for ozone gas and water), and the mixing pressure. Also important is water quality management (including pH) to reduce the decomposition of ozone while stored in the tank. While the concentration of ozonated water produced by gas and liquid mixing is fundamentally determined by Henry's Law, Hitachi also recognizes the importance of optimizing the ozonated water production system with consideration for the total efficiency of a particular application. Accordingly, Hitachi has developed a method for predicting the ozonated water concentration from the relevant control parameters and is seeking to optimize operation across the entire high-concentration ozonated water production system.

STUDIES ON THE USE OF HIGH-CONCENTRATION OZONATED WATER

Use for Piping CIP at Beverage Plant

The production line at a beverage plant consists of mixing (combining raw materials in a tank),

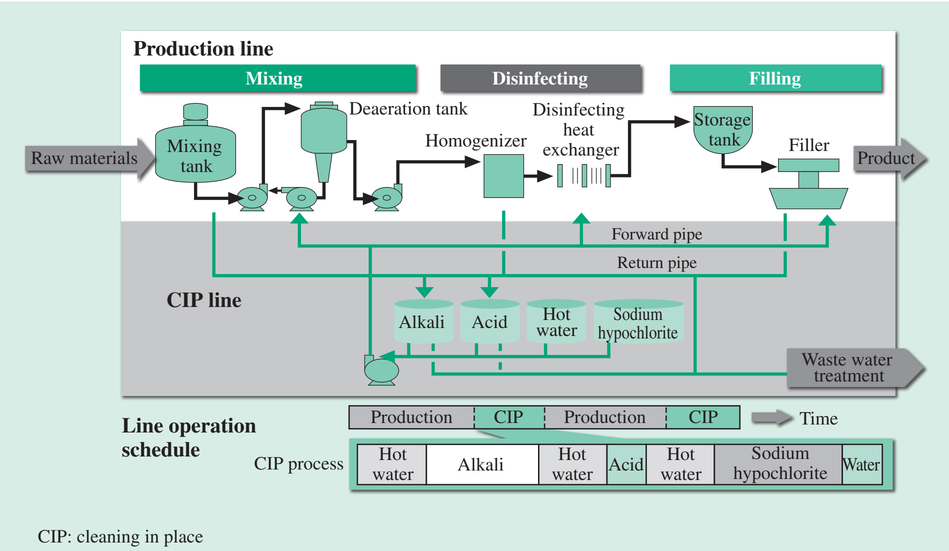

Fig. 3—Overview of a Beverage Plant.
A beverage plant consists of a production line (for mixing, disinfecting, and filling) and a CIP line for cleaning the interior of the production line. CIP is performed each time production switches to a new product.

disinfecting (heat sterilization of the product), and filling (sealing the beverage in a container) processes. Also part of the plant is an ancillary CIP line for cleaning the production line (see Fig. 3).

Since the operating schedule consists of alternating between production and CIP, and because production lines that produce a variety of different products perform CIP after each product run, increasing line utilization by shortening the time taken for CIP is an important challenge. Since the conventional practice for CIP involves the use of alkaline cleaning agents based on caustic soda, acidic cleaning agents based on nitric acid, and sodium hypochlorite to remove organic and inorganic material and sterilize the equipment, it involves problems such as the time taken for cleaning and the large quantities of highly concentrated chemical liquids and rinse water that is used.

To verify the cleaning performance of CIP using high-concentration ozonated water, Hitachi conducted testing using a model cleaning line and test samples (see Fig. 4). Transparent piping was installed along parts of the model cleaning line, and test samples were coated with model soil to be cleaned. The cleaning performance was assessed from the degree of residue left on the test samples after the cleaning fluid had been flowing through the model line for a fixed period of time. The cleaning fluids used for testing were an alkaline cleaning agent (caustic soda at a concentration of 3% and 80°C), sodium hypochlorite solution (300 ppm concentration, 23°C), and the high-concentration ozonated water (50 ppm, 30°C). The flow rate was 0.5 m/s.

Fig. 5 shows the test results. Conventional cleaning using an alkaline cleaning agent and

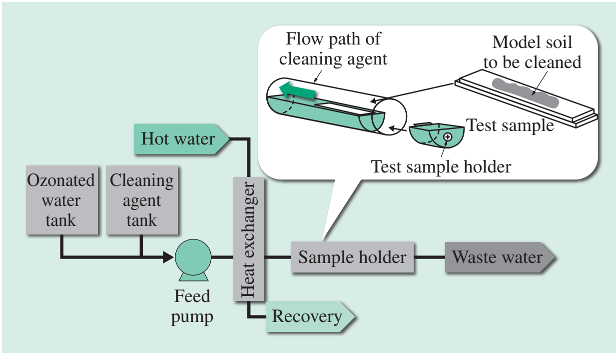

Fig. 4—Model Line for Testing CIP Cleaning Performance.
The model soil to be cleaned was baked onto stainless steel test samples and cleaning performance was assessed from the extent to which these samples were cleaned.

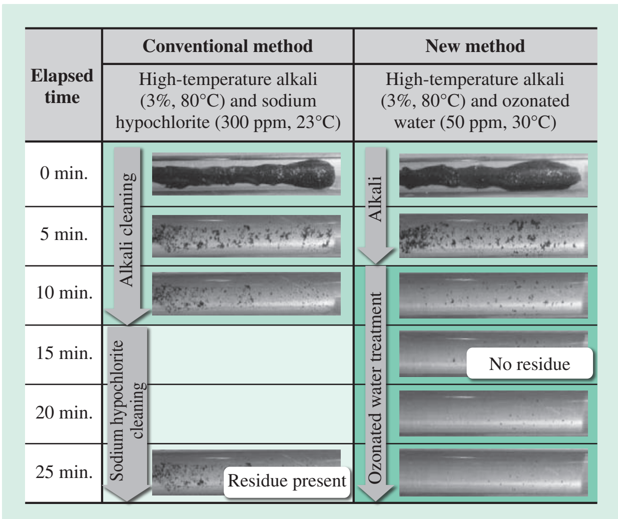

Fig. 5—Comparison of Cleaning Performance.
Cleaning efficiency was improved by replacing the conventional method with a cleaning procedure that also used ozonated water.

sodium hypochlorite solution failed to adequately clean the line, with considerable residue remaining after 25 minutes. Cleaning with high-concentration ozonated water was preceded by five minutes of alkali cleaning. It succeeded in completely removing all residue after a total time of only 15 minutes. This shows that the new technique can halve CIP time, and can increase production line capacity as well as reducing water and chemical use (see Fig. 6). However, because cleaning performance depends on the material to be cleaned, there is a need to optimize CIP conditions for each production line.

Use for Disinfecting Fresh-cut Produce

Demand for fresh-cut produce is growing along with changing lifestyles, such as the increase in the number of elderly and two-income households. Because cutting vegetables causes rapid growth in the number of bacteria attached to the vegetable surface, disinfecting is required to maintain product quality and prevent food poisoning. While sodium hypochlorite has been widely used for this purpose, the problems with this include vegetables being left with a distinctive smell of bleach, the inherent risk of leaving a residue of organic chlorine compounds, and a tendency for vegetables such as iceberg lettuce to brown* even when kept in cold storage after disinfection.

The use of ozonated water for disinfecting vegetables has been studied for the last 10 years or so, and in some cases has been implemented in practice(2). The highly oxidizing nature of ozone means that, along with disinfecting bacteria from the vegetable surface, it may also damage the vegetable. For this and other reasons, such as competition from low-cost sodium hypochlorite disinfection, it has failed to enter wider use.

Fig. 7 shows the typical processing sequence for the production of fresh-cut produce. Fresh-cut produce needs to be kept at a low temperature at the processing plant to maintain its quality. Unlike sodium hypochlorite, ozonated water can disinfect at low temperature. A cleaning system that uses less energy for cooling can be achieved by supplying high-concentration ozonated water at a low temperature based on the rate at which ozone is consumed during the cleaning process.

This article describes a study focusing on the use of a technique for cut iceberg lettuce, one of the main types of fresh-cut produce and one that is difficult to keep in good condition because it is so easily damaged. By making a number of improvements to the methods used for disinfecting, washing, packaging, and storage, Hitachi developed a cleaning technique that combines ozonated water cleaning with a heat shock (HS) treatment(3) that uses hot water.

Fig. 8 shows the procedure used to test the cleaning performance of the technique together with the test results. Commercial iceberg lettuce was cut into

* The browning of vegetables such as iceberg lettuce at the parts where they have been cut or damaged.

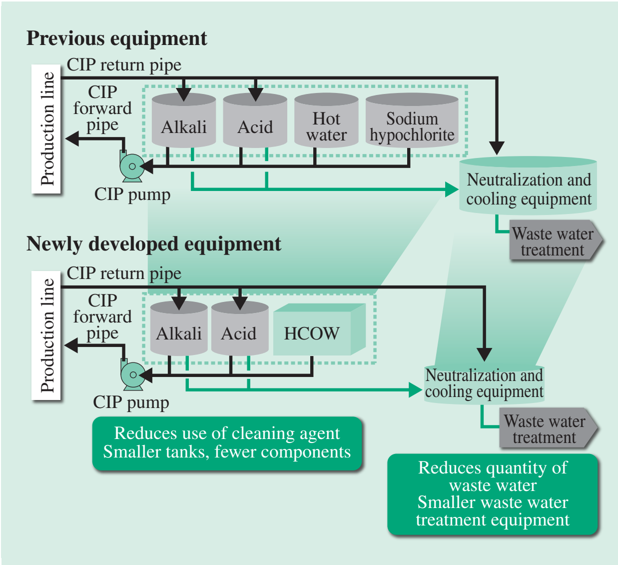

Fig. 6—Use of High-concentration Ozonated Water (HCOW) to Rationalize CIP.
Using ozonated water reduces the use of cleaning agent and rinse water and shortens the time taken for cleaning.

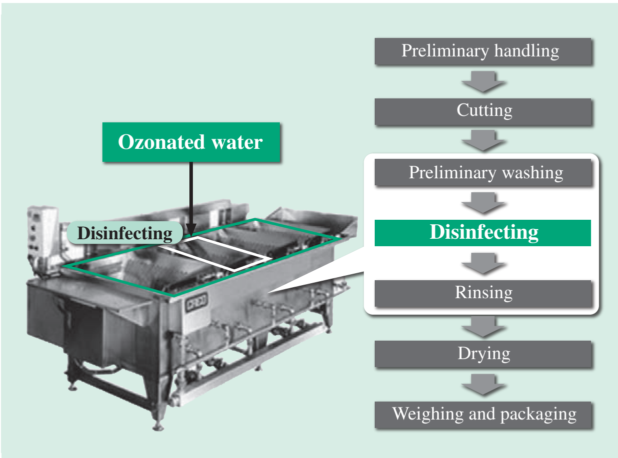

Fig. 7—Fresh-cut Produce Production Process and Cleaning and Disinfecting System.
Switching from the conventional sodium hypochlorite cleaning method to ozonated water makes cleaning and disinfecting more efficient.

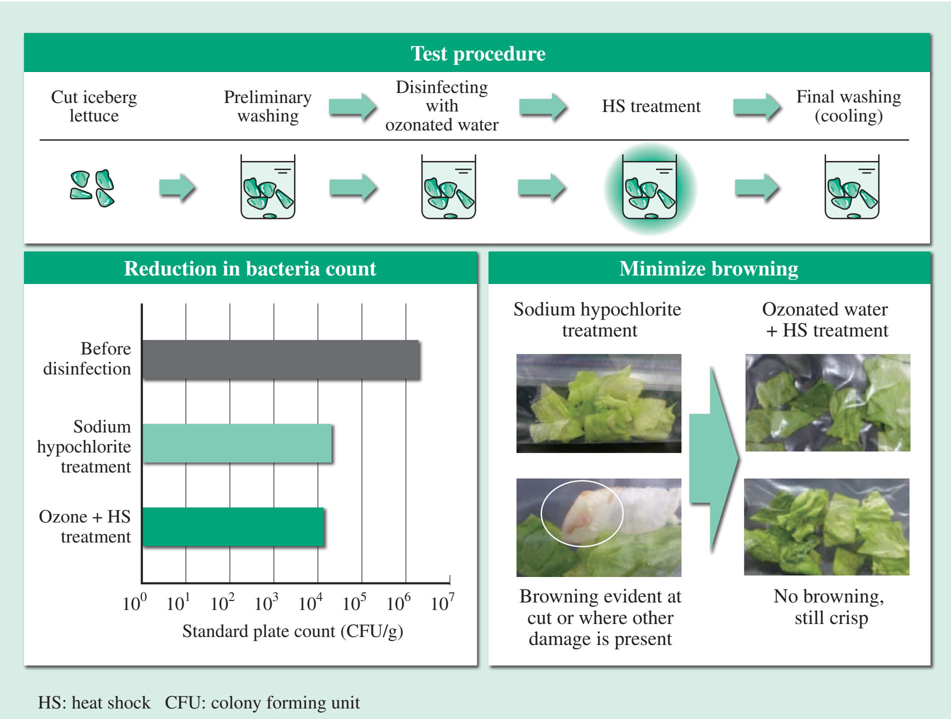

Fig. 8—Procedure and Results of Testing Cleaning and Disinfecting Performance of Ozonated Water.
Using ozonated water achieved a similar reduction in bacteria count to the conventional method using sodium hypochlorite, and also improved product quality.

3- to 5-cm squares, washed and disinfected with ozonated water, and then HS-treated with hot water. The high-concentration ozonated water was diluted to a concentration of 5 ppm. The combined ozonated water and HS treatment achieved a similar level of disinfection to sodium hypochlorite while also keeping the vegetables crisp with no browning.

Other major advantages of the new cleaning and disinfecting method are that it requires only about one minute to disinfect and is easy to rinse off (also about one minute). This means it uses less energy and water than the previous sodium hypochlorite technique, in which disinfecting takes five to 10 minutes and rinsing about 10 minutes, requiring a large amount of water. Running costs can be cut by 40% or more compared to existing sodium hypochlorite disinfecting methods. Hitachi believes the overall system can deliver new value, with sensory evaluation results indicating that using ozonated water instead of sodium hypochlorite can also keep vegetables fresh, which is what consumers want.

DEPLOYMENT OF HIGH-CONCENTRATION OZONATED WATER TECHNOLOGY AND ASSOCIATED CHALLENGES

Other than the applications discussed here, the use of ozonated water at high concentration can also help decompose chemicals that are otherwise difficult to remove and improve the elimination of microorganisms that are tolerant of heat and chemicals. One example is a system that has been developed specifically for a food processing plant to deodorize exhaust air. Because ozone can break down odor-causing substances such as lower fatty acids and sulfur or nitrogen compounds, high-concentration ozonated water is used as the spray water in a wet scrubber. The work also indicates that the system can kill heat-resistant spores in liquids (something that past techniques have found difficult) under low-temperature conditions of around 5°C. Other possibilities include building systems that can produce ozonated water centrally at high concentration and supply it as required at the point of use, and systems that can reuse used low-concentration ozonated water for wastewater treatment or for the sanitation of factories (floor, wall, surface of machines, etc.).

While this indicates the excellent potential of ozone at high concentrations for cleaning and disinfecting in the food and beverage industry, one requirement for doing so is that gaskets and similar parts be made of ozone-resistant materials.

Also, the maximum concentration of gaseous ozone allowed in the workplace in Japan and many other countries is around 0.1 ppm (exposure limit). It is necessary for systems that use ozonated water to incorporate safety measures such as ventilation at locations where there is the potential for ozone to escape into the work environment in highly concentrated gaseous or other forms. Hitachi uses simulations based on computational fluid dynamics to provide suitable countermeasures.

CONCLUSIONS

While high-concentration ozonated water is already used in semiconductor cleaning applications, this has involved high-cost systems that use high-purity oxygen gas and ultra-pure water as inputs. Now Hitachi has enabled its use in the food and beverage industry by adopting a low-cost circulation-based production technique that uses ambient air and tap water as its raw materials.

Food and beverage manufacturing requires highly reliable production processes in relation to risks such as large-scale product recalls caused by incidents such as food poisoning or product accidents. In the future, Hitachi intends to continue testing with producers of beverages and fresh-cut produce, and to make a broad contribution to the food manufacturing industry, including through plant construction, by adopting the new system as a key technology. Hitachi also plans to expand its applications beyond food manufacturing into a wide range of fields encompassing chemicals, pharmaceuticals, and biotech.

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Featured Articles

Regenerative Medicine Solutions

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OVERVIEW: There are growing expectations throughout the world for the practical commercialization of regenerative medicine, a new field of medical technology that can cure or restore function to diseased parts of the body by transplanting tissue or cells processed using advanced cell culture techniques that use cells as raw materials. Encouragement for commercialization is also anticipated in Japan where regulations on regenerative medicine came into force in November 2014. Hitachi already offers a wide range of in-house resources for cell production, including equipment and facilities, information systems, and services. In the future, in addition to the marketing of resources from within the group, Hitachi will also consider joint development with customers or collaborating with other companies if needed, aiming to adopt a "One Hitachi" approach to deploying a wide range of regenerative medicine solutions that can take on the challenges faced by customers. Hitachi also plans to play a part in the development of the regenerative medicine industry through extensive collaboration with industry organizations, companies, and other groups associated with the field.

INTRODUCTION

CELLS are the basic units of the human body. Regenerative medicine is a new field of medical technology that makes it possible to restore function to diseased parts of the body by transplanting tissue or cells processed using advanced cell culture techniques that use cells as raw materials. There are growing expectations around the world for the commercialization of regenerative medicine, which can fully cure, at the cellular level, disease sites that have proven difficult to treat in the past, with numerous researchers having reported its highly therapeutic effects[1]. In Japan, cultured skin and cultured cartilage are already commercially available, being marketed as "regenerative medicine products," with extensive use of cancer immuno-therapy being led by doctors. Close to 90 regenerative medicine projects have reached the clinical research or clinical trial stage, and Japan is leading the world in establishing a legal framework that encourages commercialization.

The importance of cell culturing and other cell processing techniques will grow in the future as regenerative medicine enters wider clinical use. Hitachi is already involved in research, development, and manufacturing of equipment, facilities, and systems for cell culturing, utilizing technologies built up through its work in fields such as manufacturing equipment for medicine or semiconductors. This article describes the regenerative medicine solutions supplied by Hitachi, beginning with an overview of the field.

CHANGES IN CIRCUMSTANCES SURROUNDING REGENERATIVE MEDICINE

Act to Ensure Safety in Regenerative Medicine and Revised Japanese Pharmaceutical Affairs Law

Under the previous legal framework for regenerative medicine in Japan, clinical research and elective treatment were dealt with by the Medical Practitioners Law and Medical Service Law (human stem cell guidelines where applicable[2]), and regenerative medicine products by the Pharmaceutical Affairs Law[3] (use of medical devices). Since November 2014, this has changed such that clinical research and elective treatment are now regulated by the Act to Ensure Safety in Regenerative Medicine[4] and regenerative medicine products are now regulated by the Revised Japanese Pharmaceutical Affairs Law[5]. The changes give Japan a legal framework that is at the forefront globally (see Fig. 1).

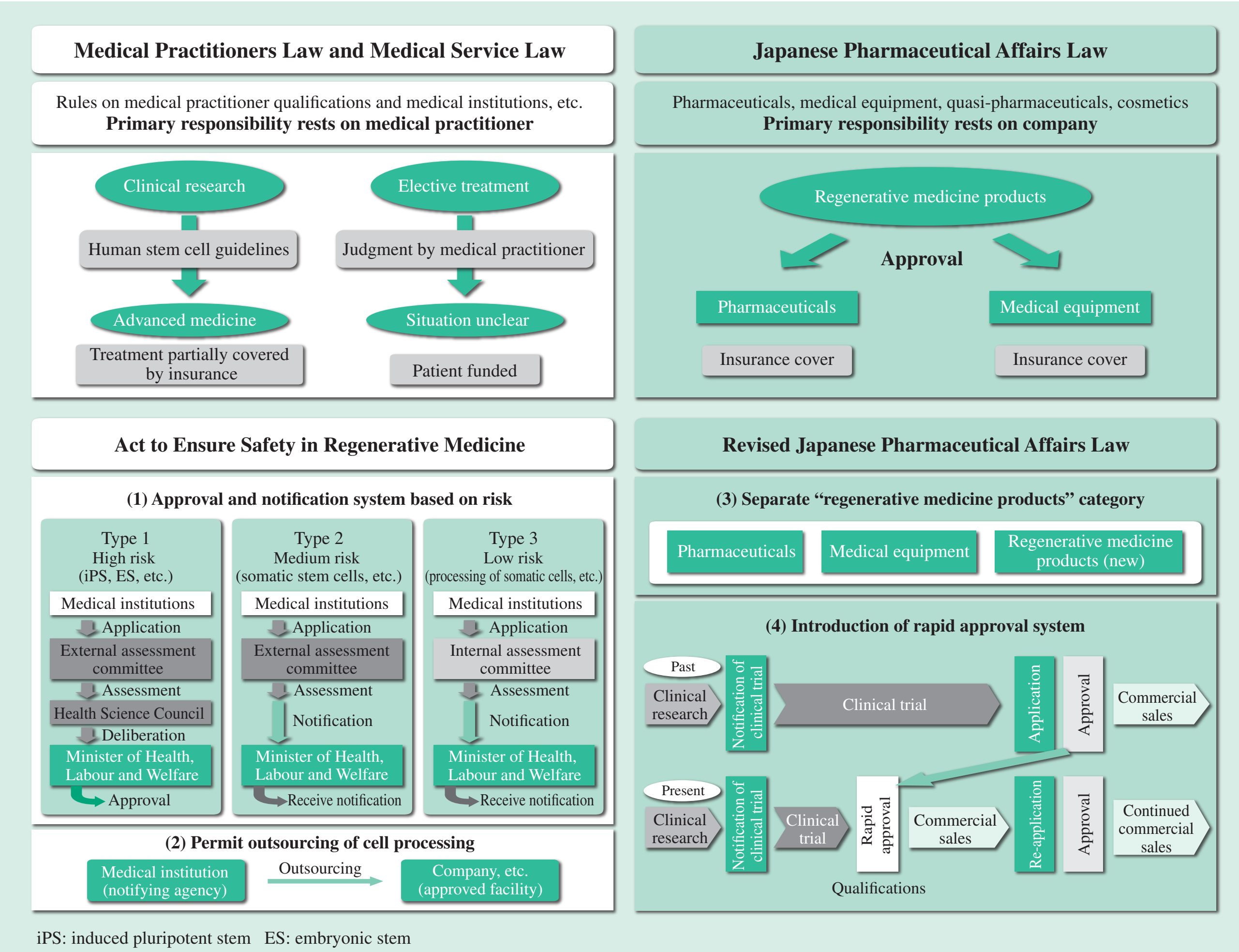


Fig. 1—Act to Ensure Safety in Regenerative Medicine and Revised Japanese Pharmaceutical Affairs Law.
The law on regenerative medicine in Japan came into force in November 2014. The key differences from the previous legal framework are: (1) steps to deal with risks, (2) outsourcing of cell processing, (3) a new "regenerative medicine products" category, and (4) a conditional approval system for clinical trials.

Major features of the Act to Ensure Safety in Regenerative Medicine include the following two provisions aimed at ensuring the safety of regenerative medicine in clinical research and elective treatment.
(1) An obligation to take steps to deal with the risks associated with the material (cells, tissue, etc.) used in transplants
(2) The ability to outsource cell processing

Similarly, the following two provisions are major features of the Revised Japanese Pharmaceutical Affairs Law.
(3) The addition of a "regenerative medicine products" category to the existing pharmaceuticals and medical equipment categories
(4) The creation of a conditional approval system for clinical trials

The first, third, and fourth of these provisions relate to the commercialization of regenerative medicine products. The second provision relates to the efficiency of cell processing, and because it allows medical institutions to outsource cell culturing, it is anticipated that the construction of a seamless infrastructure encompassing equipment and instruments, transportation, and information systems will become important in the future in order to ensure that medical institutions can obtain a reliable supply of cells, tissue, and other material produced for use in regenerative medicine.

Forum for Innovative Regenerative Medicine

The Forum for Innovative Regenerative Medicine (FIRM)[6] was formed in 2011 to get the regenerative medicine industry established. Interest in regenerative medicine within the Japanese industry is high, with the number of FIRM member companies growing rapidly to more than 100 companies (as of November

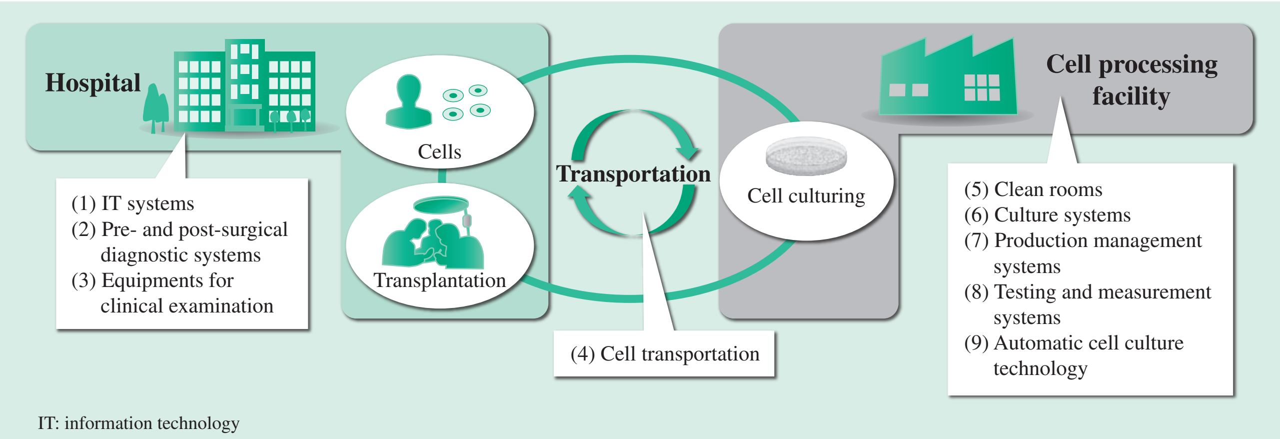


Fig. 2—Hitachi's Existing Involvement in Regenerative Medicine.
Hitachi has been engaged in a wide variety of businesses that relate to cell processing for regenerative medicine in the fields indicated by (1) to (9) in the figure. These activities have not included medical practices such as cell harvesting and transplantation.

2014). FIRM is divided into a Regulatory Committee, a Medical Economics Committee, a Public Relations Committee, a Business Planning Committee, a Standardization Committee, and a Supporting Industries Committee. As yet, regenerative medicine has few common standards (or guidelines), so the current practice is for each company to adopt its own. Accordingly, the Supporting Industries Committee has set up five working groups (equipment and instruments, automated cell culture systems, materials and samples, reagents and culture medium, and transportation), which are working toward equipment standardization. Hitachi is helping provide leadership to the regenerative medicine industry with a deputy chairmanship role at FIRM (as of November 2014).

PAST WORK BY HITACHI ON REGENERATIVE MEDICINE

Drawing on the capabilities of its group companies, Hitachi has been involved in work on regenerative medicine in a wide variety of areas (see Fig. 2).

Regenerative medical treatments typically involve the transportation of cells harvested from a patient or donor from the hospital to a cell processing facility (CPF)[*1]. At the CPF, the cells are cultured and processed by specialist technicians or automated cell culture systems in accordance with the legal requirements for cell processing, and subjected to the tests required for transplantation. The necessary cell processing equipment is used for this cell culturing and processing. The cells are then transported back to the hospital for transplanting into the waiting patient. After transplanting, the effect on the diseased body part is monitored using in vitro diagnostic systems.

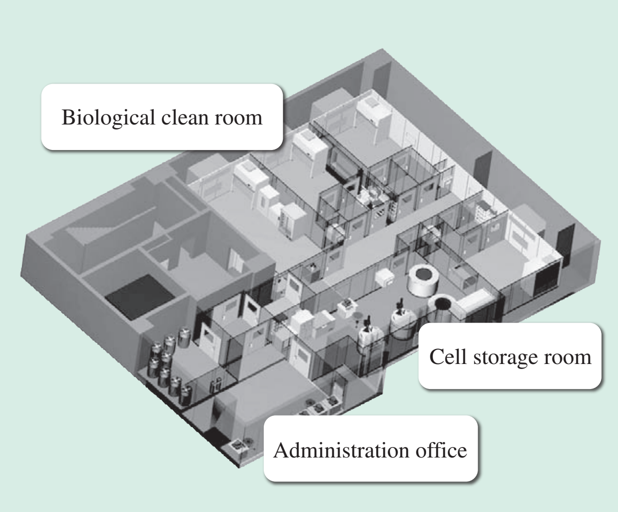
Hitachi operates businesses that are associated with this sequence of steps, and conducts research and development into the required technology[(7)–(9)]. The following sections describe details of the CPF, equipment used at the CPF, a process management system for cell culturing, and cell transportation.

Cell Processing Facility (CPF)

Because cells, tissue, or other material processed at a CPF are inserted or transplanted directly into a patient's body, the products must be sterile. The regulations stipulate numerous requirements, including that facilities have the necessary mechanisms and equipment to supply clean air and maintain pressure differences where appropriate. There are also many regulations relating to operation and maintenance management. It is necessary to provide facilities that can comply with these requirements while also operating smoothly and controlling costs[(10), (11)].

The CPF includes rooms for cell preparation that enable work to be done aseptically, cell culturing, cell frozen storage, gowning rooms, instrument sterilization, and administration, and also utilities for supplying things like carbon dioxide gas and liquid nitrogen (see Fig. 3). At CPFs that handle cells that potentially contain pathogenic material, biosafety rooms are provided that are kept at negative pressure to prevent any escape of hazardous material. In addition to appropriate control of pressures in each of these many rooms to maintain cleanliness, it is also necessary to prevent the dispersal of contaminants.

*1 Also called a cell processing facility (CPF).



CPF: cell processing facility

Fig. 3—Example Layout of CPF.
Efficient operation is combined with cost control and compliance with regulations.

With over 40 years of experience in the design and construction of medical and other facilities that require a high level of cleanliness, such as pharmaceutical and semiconductor plants, Hitachi Plant Services Co., Ltd. has a variety of technologies that are suitable for CPFs that possess the characteristics described above. For example, it provides reliable control of room air pressure using low air flow volumes thanks to the development of a simulator that accurately predicts fluctuations in the air pressure inside rooms resulting from factors such as changes in atmospheric pressure (such as during low-pressure weather systems) or the opening and closing of doors[12]. In the field of regenerative medicine, the company has further developed these technologies since supplying a CPF to the Donated Blood Distribution Foundation in 2004, during which time it has also supplied CPFs to numerous universities, organizations, private-sector companies, and medical institutions (see Fig. 4).

It also supplies solutions across the CPF life cycle, covering assistance with the preparation of documents for submission to regulatory agencies, equipment maintenance, and performance testing performed by conducting periodic re-validation.

Equipment for Cell Processing

Cell manipulation (seeding, processing, passage, culture medium replacement, and so on) is an important process when culturing cells for regenerative medicine and must be performed in an environment that has an appropriate level of sterility (a "sterile environment"). Typically, regenerative medicine requires an environment that satisfies the International Organization for Standardization (ISO) class 5 level of sterility. The main items of equipment used to achieve this level of sterile environment at cell culture facilities are biohazard safety cabinets (see Fig. 5) and isolators.

Fig. 4—CPF Interior.
This scene from the Yotsugi CPF of the Donated Blood Distribution Foundation shows preparation work, which is performed in a safety cabinet in an environment-controlled room with 10 or fewer airborne microbes per cubic meter.

Fig. 5—Equipment for Cell Processing.
Biohazard safety cabinets like this are used at cell processing facilities to support regenerative medicine.

A feature of both types of equipment is that they are designed to prevent air inside the equipment from leaking into the external environment while also maintaining a sterile environment to perform manual cell manipulation. Biohazard safety cabinets are open at the front and use an air barrier to keep the work environment sterile, while preventing cells, culture medium, and other material from leaking out of the cabinet. Hitachi Industrial Equipment Systems Co., Ltd. jointly developed the first biohazard safety cabinets in Japan with the National Institute of Infectious Diseases (previously the National Institute of Health), and currently supplies products that incorporate this technology according to customer needs for use in regenerative medicine. Isolators, on the other hand, enable cell manipulation to be performed in a sealed environment, using a clean air supply and disinfection (including decontamination) to maintain a sterile work environment and to prevent leaks into the surroundings.

Cell manipulation often involves using a centrifuge to separate and purify particular cells. Hitachi Koki Co., Ltd. produces centrifuges for use in regenerative medicine. It also supplies other cell processing equipment, including air conditioning systems such as pass boxes and air showers, and various testing equipment.

The Central Research Laboratory, Hitachi, Ltd. has developed an automated cell culture system for corneal and esophagus regeneration and a large-capacity culture system for heart muscle regeneration to automate the process of cell culturing, which is currently performed manually, and boost productivity by enabling 24-hour operation[(13)–(20)]. A feature of these automated cell culture systems is their advanced design that minimizes the risk of contamination or cross-contamination by unwanted microorganisms and enables cell culturing to be performed safely by using single-use closed designs for the culture vessels, flow paths, and other places where cell culturing takes place. The automated cell culture system for corneal and esophagus regeneration can produce cell sheets. The large-capacity culture system for heart muscle regeneration has a culture area of roughly 2.4 m^2 and a passage function (for sub-culturing cells to increase their number) that can achieve 1,000-fold growth in the number of cells. Utilizing the technologies developed through this research, Hitachi aims to achieve safe and reliable automated culturing that operates in tandem with CPF, cell processing management, and other systems.

Process Management System for Cell Culturing

Regenerative medicine facilities require production and quality management at a similar level to that provided by manufacturing management systems for pharmaceuticals. Most pharmaceutical manufacturers today make extensive use of manufacturing execution systems (MESs) to achieve rigor and efficiency in their production processes.

Hitachi Pharmaceutical Manufacturing Execution System (HITPHAMS), Hitachi's MES designed specifically for pharmaceutical manufacturing, has been installed at numerous sites since it was first released in 1995[(21), (22)]. Intended to improve the efficiency of manufacturing management and the reliability of product quality at pharmaceutical manufacturers, the HITPHAMS system complies with not only current pharmaceutical regulations but also new regulations on regenerative medicine, companies involved in regenerative medicine have started to look at installing it. The following are some of the functions it provides (see Fig. 6).

The main functions of HITPHAMS are the management of manufacturing instructions and record-keeping. Other manufacturing-related functions include inventory management of cells and reagents, tracking and tracing, and storage management. Intended for a specific recipient only, regenerative medicine products require strict inventory management. Efficient record-keeping and the prevention of errors during production are achieved by providing interactive devices at the workplace to perform reliable on-the-spot checks during production.

The system is built on the Microsoft[*2] .NET Framework and is not tied to any particular version of Windows[*2]. To satisfy customer needs, it can also be used from tablet computers and other portable devices. This means that it can adapt flexibly to processes that are specific to regenerative medicine by, for example, displaying detailed operating procedures and enabling the efficient on-site entry and recording of work records.

Cell Transportation

Hitachi has developed and trialed a constant-temperature cell transportation container for use in regenerative medicine[(23)–(26)]. The development was undertaken primarily by its research laboratories in collaboration with Hitachi Transport System, Ltd. With the adoption of the new law, Hitachi anticipates rapid growth in

*2 Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

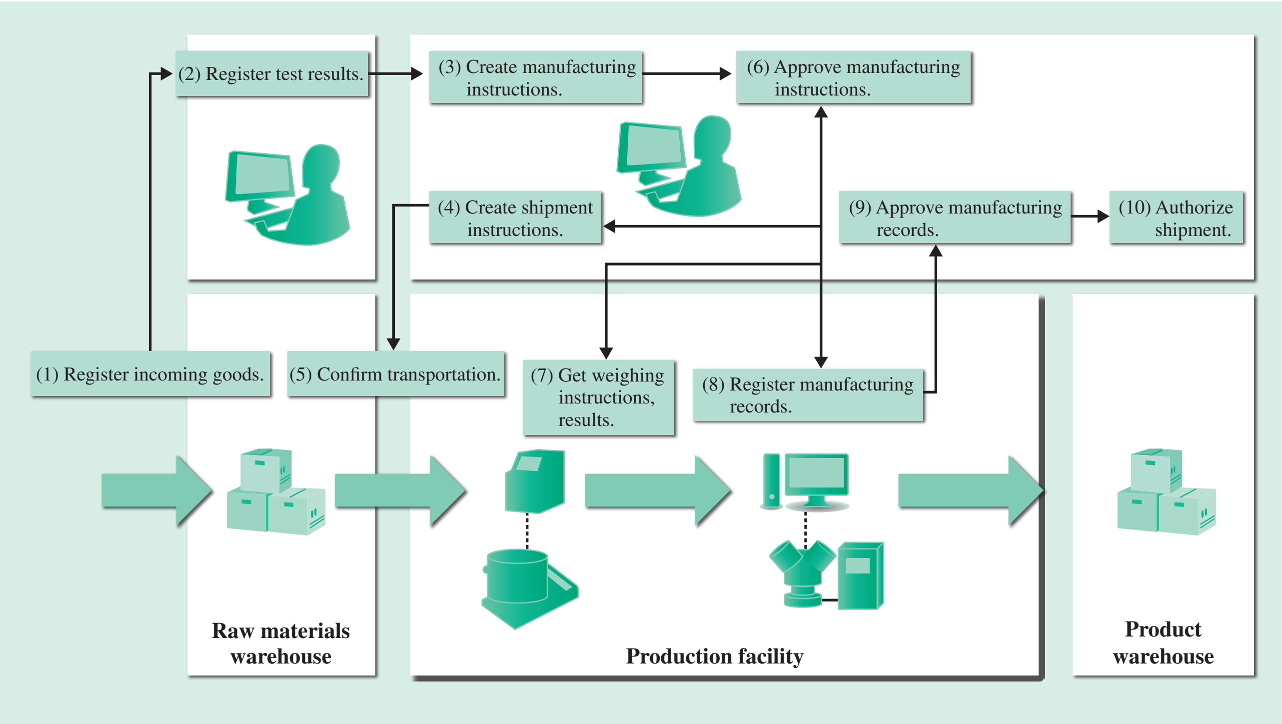


Fig. 6—Overview of HITPHAMS Functions.
Functions for managing incoming goods, manufacturing instructions, inventory, quality, test results, and shipment authorization ensure efficient production of regenerative medicine products with more reliable quality.

demand for reliable cell transportation from third party providers. However, because the transportation industry lacks standards (or guidelines) for cell transportation, each provider currently follows its own practices.

Hitachi plays a leadership role in the transportation working group of the Supporting Industries Committee of FIRM and is seeking to coordinate the formulation of guidelines by the transportation industry. Once in place, this should facilitate providing safer and less expensive cell transportation by enabling the resolution of issues of concern, such as quality assurance (minimizing changes in quality during transportation), preventing accidents (minimizing the risk of harm to transportation providers and others), and expanding the transportation market and the production of transportation goods (by ensuring consistent quality when activities are outsourced). Including these industry activities, Hitachi's aim is not just to supply its cell transportation containers, but also to establish a cell transportation service that suits customer needs.

REGENERATIVE MEDICINE SOLUTIONS THAT HITACHI AIMS TO SUPPLY

Hitachi's existing business consists primarily of equipment for the manufacturing of biopharmaceuticals (including antibody drugs and vaccines), equipment and instruments for regenerative medicine, and equipment for diagnosis, testing, and treatment at hospitals and other medical institutions. In the regenerative medicine sector in particular, Hitachi's past practice has been to market its equipment and instruments to customers as standalone products. Hitachi established its Healthcare Company in April 2014. In addition to taking a customer's perspective to marketing regenerative medicine resources from across the group (including equipment, systems, and services), Hitachi is also working on operation and maintenance services, joint development proposals, and collaborations with other companies. Based on its existing businesses, the company aims to take a "One Hitachi" approach to supplying pharmaceutical companies and others such as research institutions that work on regenerative medicine with a wide variety of regenerative medicine solutions designed to confront the issues customers face.

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Featured Articles

Case Studies of Food Defense in Relation to Plant Security Management

Shinsuke Kanai
Sunao Kakizaki, Dr. Eng.
Satoshi Matsutani
Hironari Nakata
Shinya Kaneko

OVERVIEW: In an era of information technology and globalization, major threats to business continuity at the companies that support the social infrastructure include not only issues that are inherent in the nature of business management, such as leaks of personal information, data fabrication, false advertising, or inadequate food hygiene, but also things like malicious acts by staff, malicious postings on the Internet, and corporate terrorism (deliberate contamination of food). Given this environment, establishing measures for food defense is a challenge for food processing plants, and Hitachi supplies a wide range of solutions that use the latest technology to facilitate the management of plant security. The ability to reliably review records and other historic data when an incident occurs is an important aspect of the formulation and implementation of security policies. Hitachi has developed a number of methods that are suitable for this purpose, including surveillance camera systems with ultra-high-resolution and a high level of data compression for long-term recording of high-quality video, and hands-free systems with detection capabilities that include determining the direction of movement and the presence of large numbers of people.

INTRODUCTION

WITH numerous reported cases of food safety issues, such as the incidents of mass food poisoning in Japan caused by milk in 2000 and another of poisoned frozen dumplings in 2007, food defense has been attracting attention since another incident in December 2013 of frozen food that was found to contain pesticide. Incidents like these make it difficult for the company concerned to continue trading, and can indirectly bring a halt to operations at some of the companies with which it deals. In recent times, this has gone beyond simply posing problems to specific companies, and instead poses a risk of a slowdown in overall economic activity.

Food defense, which primarily relates to safety measures for preventing deliberate contamination with poisons, etc., is a poorly understood issue in Japan and the concept has yet to penetrate into corporate thinking. Nevertheless, action by the food industry has picked up pace since the December 2013 incident. The social environment is such that, if an incident occurs, those companies that lack countermeasures face a further loss of trust together with business losses, while companies that do implement such countermeasures gain the respect and trust of their customers. Accordingly, there is a need for the dependable implementation of measures based on internal controls and management rules.

This article uses case studies of food defense to describe security management at food processing plants and the requirements for surveillance camera systems and facility access control systems (two effective ways of achieving this), and profiles distinctive Hitachi systems that are in strong demand, such as hands-free access control and high-compression/ultra-high-resolution video technologies. The article also describes future requirements.

FOOD DEFENSE IN THE PAST

Food Safety and Security Management

The requirements for ensuring food safety can be broadly divided into three elements: food security, food safety, and food defense[(1)] (see Fig. 1).

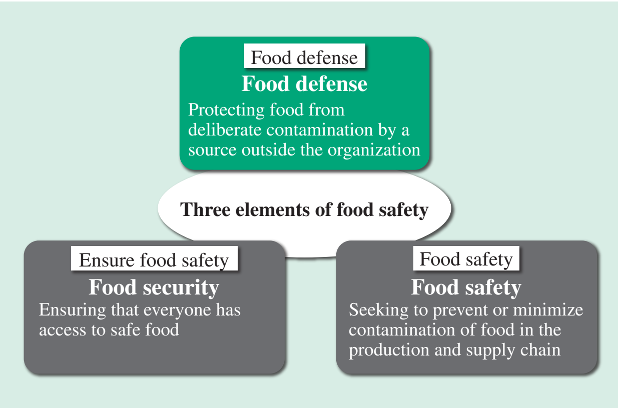


Fig. 1—Three Elements of Food Safety.
Food safety consists of food security and food safety, which are predicated on good intentions, and food defense, which assumes malicious intent.

The aim of food security is to ensure a secure supply of food in the face of international problems associated with things like population and resource depletion, so that everyone has access to safe and nutritious food when they need it. The aim of food safety, meanwhile is to protect against things like agricultural chemical residues or problems with food additives by preventing the sort of contamination that occurs unpredictably due to system failures. In other words, there is a need to ensure that food is kept safe by assessing and managing the risk of hazards in the food supply chain so as to prevent or minimize contamination. Security management that addresses these concerns is based on an assumption of people's good intentions. In contrast, food defense aims to prevent contamination resulting from deliberate attacks on the system. Accordingly, it needs to ensure that food is safe by protecting it from the deliberate introduction of contaminants.

While the concept of food defense existed before the incident described above of pesticide found in frozen food, the main aim of security measures had been to prevent intruders from outside.

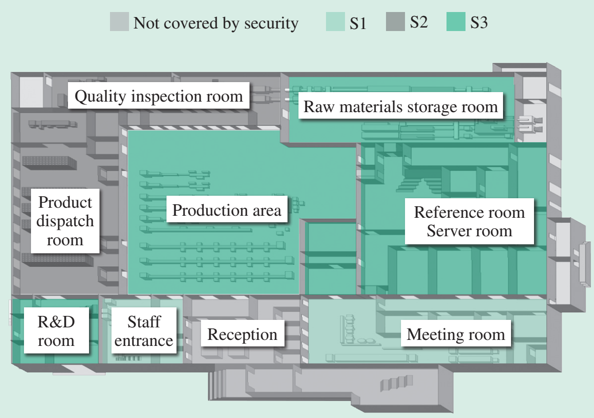
Security Management in the Context of Food Defense

Strengthening internal controls, that is, how to manage company staff, is a key aspect of food defense. And, because recent cases including deliberate food contamination indicate that this needs to include measures that assume malicious intent, the formulation and implementation of company security policies (including company-wide consistency and management rules) play an important role.

The first step is to define security levels for each area of the plant and to assign access permissions accordingly. In terms of food defense, the areas that need to be assigned the highest importance are those production and storage areas that require strict control because they provide an opportunity for direct contact with products or raw materials, or for actions that can adversely affect production. In keeping with this approach, surveillance points need to be located with consideration for the plant's layout, zoning, and access ways (see Fig. 2).

Setting up surveillance points and implementing appropriate access control enables incidents to be minimized. The monitoring of entering and exiting production areas and how staff go about their work is particularly important for preventing deliberate contamination with foreign material. It is also important to conduct a thorough review of work records (such as data and video) to minimize the damage if an incident does occur.

The following section describes trends in current security products and systems for food defense in light of these requirements.



Security level	Definition	Explanation
S1	Controlled area	Visitor access control is needed even though not a production area.
S2	Important controlled area	An area used for production or storage, with employee access control needed even though there is no direct contact with products.
S3	Most important controlled area	An area used for production or storage that requires strict access control because it provides opportunities for direct contact with products or raw materials, or for actions that can adversely affect production.

R&D: research and development

Fig. 2—Zoning of Food Processing Plants.
The security level for each zone is set based on the risk of contamination.

PRODUCTS AND SYSTEMS FOR FOOD DEFENSE

Use of Cameras for Production Line Quality Recording

Prompted by incidents at food company plants of contamination by agricultural chemicals, active steps are being taken to implement food defense measures against deliberate criminal acts from outside forces with malicious intent. Surveillance camera systems are one example of plant security equipment that can be installed quickly and at comparatively low cost.

Based on a relationship of trust with staff, past surveillance camera systems have in many cases only been installed at plant or building entrances and exits, and not inside the buildings themselves. Since the pesticide contamination case, however, surveillance cameras are increasingly being installed indoors on production lines and in other important locations. These are called "quality recording cameras," capturing video data showing staff activities such as entering and exiting areas. This video data is increasingly of high quality and is being kept for longer periods of time, a common requirement being to base the retention of video data on product use-by dates, meaning that for some products video needs to be kept for as long as several years. Satisfying this demand requires recorders with larger capacity. Another feature of cameras installed on production lines is that they need to be designed to withstand dust, water, and other harsh conditions.

Hands-free Access Control System

One of the security solutions Hitachi supplies for factories is a hands-free access control system. The system identifies (IDs) people by having them wear a radio frequency identification (RFID) tag with an omni-directional communications function that uses a proprietary built-in three-dimensional (3D) antenna, which avoids the need for them to pass a card over a reader as required by non-contact smartcard systems. Accordingly, a feature of the system is that staff can carry the RFID tag even when wearing sanitary uniforms with no external pockets. Eliminating the need to present a card makes the system highly practical for sites like food processing plants that use practices such as sanitary uniforms, air blowers, hand washing, and disinfection to rigorously control for dust, microbes, and other contaminants.

The role of the card reader in the system is taken by a transmitter and transmission antenna that activate the semi-active tags, and a receiver and reception antenna that detect radio signals from the tags. Unlike conventional active tags, semi-active tags normally remain dormant (non-transmitting) until they enter an ID area created by the presence of a transmission antenna. Three different ID areas are created in the vicinity of a gate, on the outside, in the middle, and inside respectively. The tags only activate on entering an area, at which point they transmit information indicating the ID area and the tag ID. Depending on the circumstances at the gate and the required security level, the system can be used to detect when people pass, the direction in which they are moving, and whether anyone else is entering with them ("tailgating").

The detection of tailgating in cases where a particularly high level of security is required involves installing a motion sensor in the middle ID area of the gate and only turning it off when the tag is present in this area. This detects tailgating because the motion sensor reacts to any unauthorized person who attempts to pass through the ID area (see Fig. 3). Because the ID areas overlap if placed too close together, it is not possible to determine the area in which the tag is located during these times. Since the system can prevent the tag from detecting when it is in such overlapping ID areas, and the size of the ID areas can be kept small, tailgating can be detected even when the gap between people is as little as about 1 m.

The main system features are as follows.

(1) Hands-free identification of up to about 10 tag-wearing users at a time. Also, because the direction of movement (entering or exiting) can also be determined from the sequence of ID areas and tag IDs, the system can keep track of how many people are present in a room.

(2) The system does not impose any constraints on the interior design of the building. Virtual gates can be set up, with no need to install physical gates such as automatic doors or electronic locks.

(3) Because the tags only transmit during the identification process, their button batteries can last for around three years (depending on frequency of use).

At food processing plants, the first feature is typically made use of on the production floor or at access points, and the second feature at access points. Other benefits include quickly being able to tell how many people are still inside in the event of an emergency.

Hitachi also markets and implements integrated security systems that combine surveillance camera and access control systems.

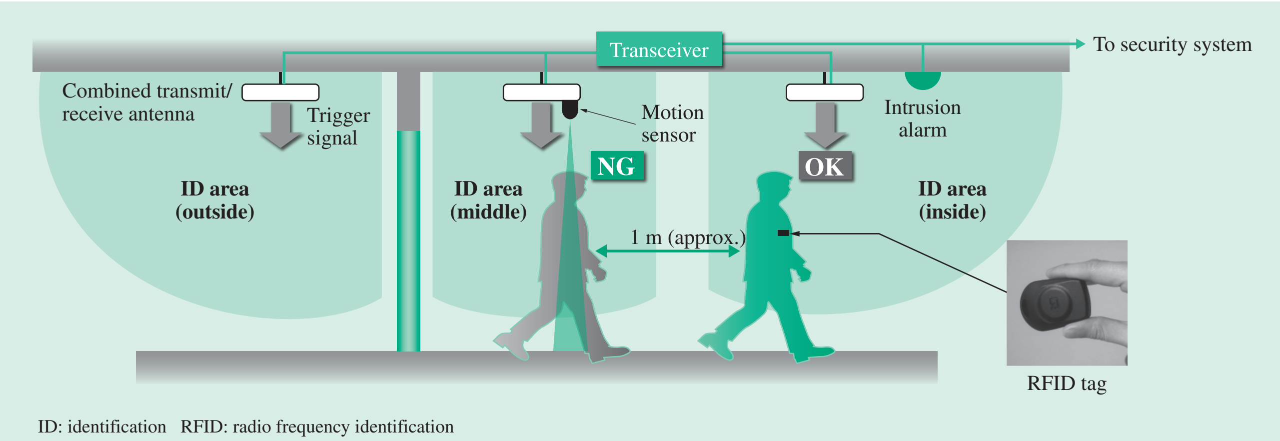


Fig. 3—Tailgating Detection.
Tailgating detection means detecting when an unauthorized person without a tag passes through the detection area immediately after someone who does have a tag.

PROPRIETARY HITACHI TECHNOLOGY

High-level Data Compression for Video

As described above, food processing plants need to keep data for long periods of time, depending on product use-by dates. Accordingly, Hitachi has developed surveillance camera systems that incorporate its own ultra-high-resolution technologies to provide long-term storage at low cost without using high-capacity recorders.

Network cameras with this ultra-high-resolution technology compress high-quality video at full high definition (HD) (1920 × 1080) down to D1 size (704 × 480). Because this video can be converted to HD quality (1280 × 720 resolution) on a personal computer (PC), high-resolution display can be achieved with a small data size. Recording data in D1 format increases storage capacity by around three to four times compared to the previous megapixel (1280 × 960) resolution, enabling the use of recorders with smaller hard disk drives (HDDs). Because data can also be transmitted in D1 format, it also reduces the load on the network by minimizing bandwidth requirements (see Fig. 4).

The system has demonstrated its capabilities and earned a good reputation at sites such as food processing plants that need to record high-quality video covering long periods of time with limited transmission bandwidth.

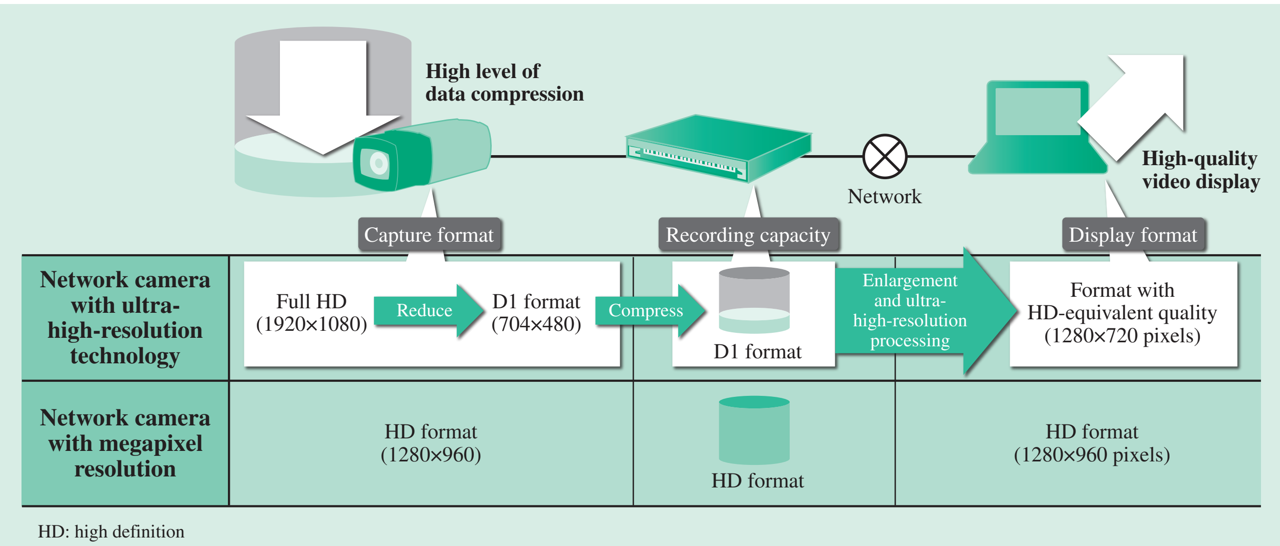


Fig. 4—Surveillance Camera System with Ultra-high-resolution Technology.
Proprietary Hitachi technology for high levels of compression and resolution enables a high level of data compression to be combined with high-quality video display.

Hands-free Applications

In its past installations at food processing plants, Hitachi has implemented measures for tracking in detail who is doing what, and when, by determining the direction in which people, vehicles, or goods pass a detection point. This utilizes the ability to perform high-speed communications and identify individuals even when there are a large number of tag-wearing people coming and going together. Hitachi systems act as reliable deterrents because they ensure that there are no flaws in security management, even in situations where a large number of people enter or exit at the same time, such as during lunch breaks at factories or other large facilities.

Also, even higher levels of security can be provided by combining systems with other surveillance equipment at various locations around a plant. Through integrated management with a surveillance camera system, for example, it is possible to implement a system that triggers a camera or alarm whenever a person passes who is not wearing a tag. The level of protection can also be raised by combining a wide variety of infrastructure based on the requirements, such as only zoning and installing surveillance cameras in work areas, and performing management based on the combinations. This is not necessarily limited to high-security areas, and given that every area can potentially have a need for the gathering of evidence from the scene in the event of something happening, it is possible to find smart ways to implement more robust food defense by operating in tandem with network cameras and recorders.

Numerous vehicles enter and exit a plant site and its various areas, including trucks, forklifts, and other vehicles used for materials handling. Using smartcards or similar techniques to manage such operations poses major challenges for food defense, such as card holder identification being all it takes to enter the site and the inability to identify forklift drivers. Because Hitachi's hands-free system can track the entry and exit of not only the vehicles themselves but also of all of the people riding on them, this tracking of vehicle entry and exit can be performed with greater sophistication than past security systems. The area zoning function of the hands-free system can also track the movements of workers and the forklifts and other vehicles used at a plant. When moving raw materials from a storage area into the factory, for example, for the forklift and driver to gain access, the driver needs to get off the forklift and press a button or use a smartcard or other mechanism to open the door each time they pass through one of the numerous gates, such as when opening or closing roller doors.

With the hands-free system, the driver only needs to wear the RFID tag to be identified, saving the trouble of having to get off the forklift each time.

FUTURE NEEDS

Since the 9/11 terrorist attacks in the USA in 2001, the US government and congress have thoroughly inspected the infrastructure that is important to industry, the public, and their way of life, and have implemented defensive measures in industries such as food and water, information, and finance. While measures against contamination by foreign material were already in place, there has been a growing awareness since the terrorist attacks of the need for actions to defend against such threats as toxins or toxic organisms that had not been within the scope of pre-9/11 measures, including taking a more demanding approach to implementing stricter measures for the manufacturing, processing, distribution, and other processes of food companies.

At the same time, the World Health Organization (WHO) has also been working on this issue in parallel and has published guidelines. It has emphasized the point that, with expanding global trade in agricultural products, a situation has arisen in which past ideas and measures are inadequate on their own, including in those sectors that deal with food safety and hygiene. It highlighted the fact that the threat of deliberate acts of contamination or terrorism in the food or agriculture sector is now a reality, and pointed out the need for people to be aware of the difficulty of dealing with this.

In terms of food defense in Japan, the fact that things like the structure of the economy, labor relations, and information channels are experiencing ongoing change means that Japan needs to initiate a comprehensive investigation. That is, there is a need to pay attention to all areas without exception, from the upstream to the downstream end of the supply chain, and from domestic and overseas production facilities and farms that produce raw materials to production plants, storage and distribution facilities, ready-made meal retailers, and logistics operations. It has also become necessary to flexibly adopt methods that will make routine communications proceed more smoothly, for example, because of the need to adapt to increasingly diverse considerations that encompass not only measures for preventing incidents at workplaces or processing plants, and concerns or dissatisfaction with working environments, but also things like the handling of whistle-blowing, deliberate obstructive actions targeted at external suppliers, or excessive complaints or requests for redress.

Meanwhile, the economic environment, international trade, environmental degradation, international disputes, income inequality, problems with overseas workers, and other factors associated with globalization are interlinked in a complex manner, such that the various risk factors that arise have more aspects than might be imagined. Furthermore, there is a risk of damage being greater, more widespread, and more devastating. Accordingly, the importance of conducting adequate risk assessments beforehand is growing to encompass the question of how to prevent unexpected events that exceed predictions based on risk analysis.

CONCLUSIONS

This article has used case studies about food defense to describe how plant security management is provided using Hitachi's latest technologies.

In Japan, the 2013 incident of pesticide in frozen food has led to progress on implementing security measures for food defense, with a requirement to comply with common standards such as Food Safety Systems Certification (FSSC) 22000* across all facilities, including those located overseas.

In addition to surveillance camera systems and hands-free access control systems, Hitachi is able to offer a wide range of security management solutions for factories that suit different security levels, including an access control system using finger vein authentication, a vehicle access control system using number plate recognition, and a cloud-based access control service. Hitachi intends to contribute to maintaining the safety and security of the food supply chain by supplying effective solutions for issues that food companies potentially face.

REFERENCE

(1) Food Defense, Food Analysis Technology Center (SUNATEC) in Japanese, http://www.mac.or.jp/mail/090701/02.shtml

* A benchmark approval standard published by the Global Food Safety Initiative (GFSI) that combines the International Organization for Standardization (ISO) 22000 standard for food safety management systems and its associated additional standard, ISO/TS 22002-1 (or ISO/TS 22002-4).

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Featured Articles

Service Mall with Support for Collaboration with Third Parties

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OVERVIEW: A feature of service malls is that they perform unified management on the cloud of equipment and energy data from multiple sites and make the data available for online use, not only by site managers but also by equipment manufacturers, maintenance companies, consultants, and others. Even at sites where it is difficult to station skilled engineers despite having a wide variety of different equipment, this makes it possible to maintain appropriate and timely collaborations with external experts over long periods of time while also making good use of data collected on the mall. This helps resolve issues on a variety of fronts, including equipment upgrade plans, rationalization and optimization of equipment operation, identification of wasteful operating practices, emergency response, and report preparation. The mall is also useful for equipment manufacturers who find it difficult to establish and maintain their own remote support infrastructure.

INTRODUCTION

THE operation and management of things like equipment and energy use involves more than just tracking the operational status of equipment or monitoring for faults, it should also include control operation with consideration for operational and energy efficiency, enabling continuity of operation in the event of a disaster, and ongoing improvements. Achieving this requires drawing on the diverse knowledge, experience, and know-how of the operations and equipment described below to establish the organization and infrastructure needed for ongoing improvement.

(1) Selecting various types of leading-edge equipment, installation and upgrade planning, and financing
(2) Tuning equipment to improve its capabilities, rationalization and optimization of equipment control
(3) Analyzing correlations between equipment operation and energy, and identifying waste and inefficiency
(4) Providing operation manuals for routine and emergency operations, training and drills

In practice, however, customers find it difficult both to recruit people with expertise in a wide variety of fields and to establish a labor-intensive organization divided into narrow specializations. Japan has been experiencing an aging population and falling birth rate in recent years. Appropriate operation and management is limited to a particular scope, with most areas being ignored. Maintaining a stable workforce is one of the critical issues facing companies that sell equipment, systems, or added-value services to customers.

Two effective ways of dealing with the problem of skills shortages are the centralized management of equipment spread over multiple sites and routine collaboration with experts on those elements that are highly specialized[(1), (2)]. Service malls play a part in this improved convenience.

This article describes Hitachi's view of the features and benefits of service malls that enable participation by multiple stakeholders and are suitable for corporate customers in a wide variety of fields, not just industry. A key aspect of a service mall is that access rights to the data entered into it and its applications are assigned according to the needs of each stakeholder.

The article also looks at how the use of time shifting offers a potential way of dealing with bottlenecks in actual equipment operation and maintenance workloads, regardless of whether a service mall is used.

TABLE 1. Categorization of Stakeholders in Equipment Operation and Management
This article categorizes stakeholders as follows.

Category	Description	Main stakeholders	Main sources of data
Customers	Organization that operates and manages equipment installed at a plant, and is directly involved in using the equipment	Factories and other plants, offices, shopping complexes, warehouses, railway stations, schools, hospitals, etc.	Equipment operation, equipment faults, equipment records, energy, measurement data
Equipment vendors	Organization that manufactures and sells equipment to customers	Equipment manufacturers, system manufacturers, etc.	Equipment specifications
Energy suppliers	Organization that supplies customers with the electric power, gas, or other energy needed to operate equipment	Power company, gas company, etc.	Energy supply price, energy saving requests
External data providers	Organization that supplies customers with the external data needed to operate the equipment	Weather information provider, traffic information provider, map company, etc.	Weather information, traffic information, maps
Support service provider	External organization that supports or facilitates installation and operation of equipment by customers	Trading companies, construction companies, system integrators, operation & management providers, maintenance companies, design offices, consultancies, equipment diagnosis organizations, financial institutions, etc.	
Organizations with which customers have to file reports	Organizations with which customers have to file reports relating to things like equipment, energy, or environmental impact to meet legal obligations or similar	National or local governments, fire departments, auditors, etc.	Report or submission formats, conversion constants

SERVICE MALLS

Definitions

Table 1 lists the different types of stakeholders considered in this article. Here, a service mall is defined as follows.

A service mall is a cloud service that collects and manages equipment and energy data from the customer's site and makes it available as required (subject to access rights) to not only the customer (factory or other workplace), but also equipment vendors (including manufacturers), energy suppliers (such as power companies), support service providers (such as consultancies), and organizations with which the customer has to file reports (such as local governments).

Two important concepts with service malls are the ability of numerous stakeholders to get online access via data networks to customer data stored in the cloud, and that the rights to view data granted to stakeholders are assigned at the discretion of the customer who owns the data. Limiting usage to the same internal stakeholders as in the case of an in-house network service significantly undermines the benefits of using a cloud service. A service mall also increases the added value for each stakeholder by keeping up to date with the latest data from such sources as equipment vendors, energy suppliers, and external data providers, and by providing applications for the further processing of this data in conjunction with customer data.

Comparison of Cloud Service Models

Fig. 1 shows the relationships between stakeholders in various cloud service models. This example omits the model in which the customer only outsources server management to a data center.

(1) Client-server model

This involves collecting and managing operational data from the customer and performing contracted services such as remote monitoring. The service is run by the equipment vendor. The client-server relationship in this model simply involves migrating server functions (such as applications and data management) to a cloud platform managed by the equipment vendor. The customer and equipment vendors have a 1:N (or M:1) relationship.

Because there is a different cloud service for each vendor, this limits the ability of customers with equipment from a number of different vendors to perform management and operation across all equipment. In this model, third parties (other than the customer and service provider) do not have online access to the data.

(2) Portal model

This involves collecting and managing operational data from the customer and performing contracted services such as remote monitoring. The service is run by a third party that acts as an intermediary between the customer and equipment vendor. The intermediary plays a hub-and-spoke role and links customers and equipment vendors with an M:N relationship. In terms of the relationship model, this is equivalent to web sites for things like web search, reservation services, and e-commerce sites that act as intermediaries.

Because everything is consolidated into a single cloud service, this enables customers with equipment from a number of different vendors to perform

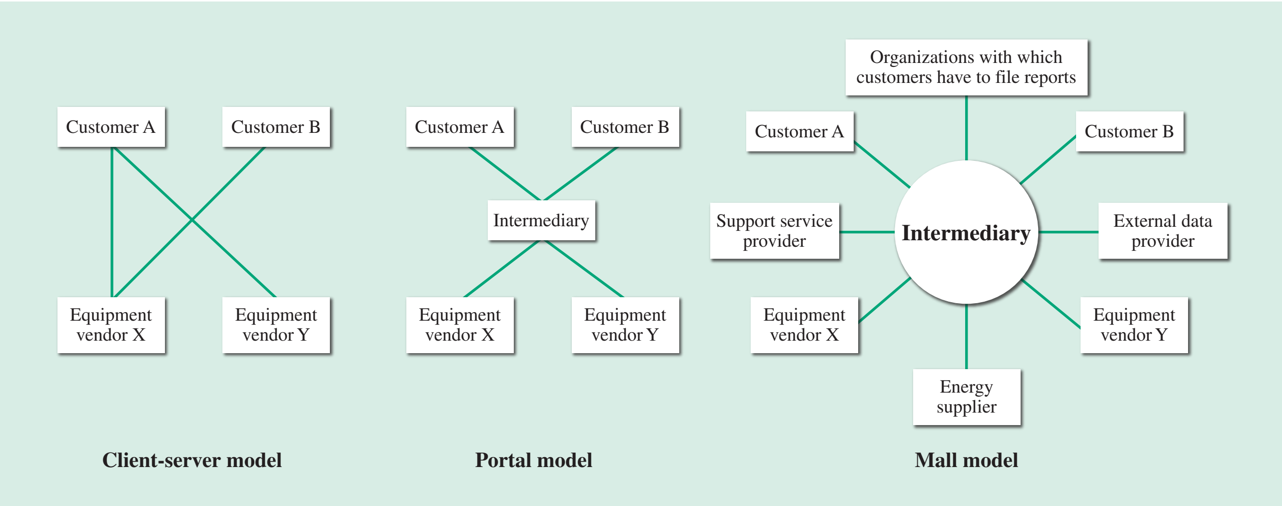

Fig. 1—Comparison of Cloud Services.
A feature of the mall model is that it can be used by a wide variety of stakeholders, not just customers.

management and operation across all equipment. In this model, third parties (other than the customer and service provider) do not have online access to the data.

(3) Mall model

This involves collecting and managing operational data from the customer and performing contracted services such as remote monitoring. The service is run by a third party that acts as an intermediary between the customer and equipment vendor. While this links customers and equipment vendors with an M:N relationship, the same as the portal model, it differs in enabling third parties such as support service providers and organizations with which the customer has to file reports to participate in the community, granting online access to the customers' data. It is equivalent to the relationships in a social media site around which a community group is formed that shares information.

Because everything is consolidated into a single cloud service, this enables customers with equipment from a number of different vendors to perform management and operation across all equipment while also facilitating collaboration involving numerous support service providers that extends beyond the cloud. This has benefits for customers concerned about maintaining their workforce, equipment vendors, and support service providers alike[3]. While current practice with reporting typically involves the customer submitting documents to the organization concerned, Hitachi envisages that the workload associated with preparing and submitting reports can be significantly reduced in the future by putting in place the ability for the recipient of the report to view the data itself.

Ideal Service Mall

Maintaining a stable workforce and eliminating waste and inefficiency are frequently quoted as issues in corporate management. Maintaining qualified personnel for equipment operation and management is a challenge even for large companies. The value of a service mall is that it can assist with rational and effective operation and maintenance through the use of personnel and services from both inside and outside the company.

The advantages to each stakeholder of using cloud services based on a service mall model are as follows.

(1) Customers

(a) Avoids the need to have people with highly specialized knowledge, experience, and know-how in a wide variety of fields stationed permanently at the workplace.

(b) Can unify diverse services from different equipment vendors.

(c) Provides centralized management of multiple dispersed sites. Simplify comparison of data from different sites.

(d) Provides the ability to share some equipment with neighboring organizations.

(e) Can receive remote notification from equipment vendors identifying equipment with minor faults, equipment operating less efficiently than normal, or idle equipment, and advice on what to do about it.

(f) Can call on locally based suppliers to provide on-site support when a major fault occurs.

(g) Can make use of the latest weather, maps, and other data.

(h) Enables automatic response to requests from the power company to reduce power consumption.

(i) Eliminates the need to visit the site, download data for analysis from equipment and other systems, and supply it to external support service providers.

(j) Reduces security concerns by giving external support service providers direct access to plant equipment and other systems.

(k) Enables planned equipment upgrades.

(l) Facilitates selection of best option from among those provided by the energy supplier, and switching between options.

(m) Reduces the workload associated with preparing and submitting reports to national and local governments or certification agencies.

(2) Equipment vendors

(a) Avoids the need for the company to establish, maintain, and manage its own cloud service.

(b) Minor faults or other performance degradation can be dealt with without visiting the site.

(c) Analysis and consulting can be delegated to the appropriate support service provider in the case of customers who also use equipment from other vendors.

(3) Support service providers

(a) Identify equipment that has deteriorated significantly over time and formulate upgrade plans for the customer at an appropriate time.

(b) Can handle system setup for customers remotely.

(c) Enables analysis and consulting based on statistical data from the workplace (big data).

(d) Provides access to equipment vendor expertise to obtain advanced knowledge and know-how about equipment.

(4) Service mall operator

(a) Can utilize large quantities of data from a large number of stakeholders (big data) to extract statistical knowledge, and use this as the basis for future innovation.

(b) Presence of a large number of stakeholders encourages third parties to join and to provide superior applications. Increases value to stakeholders.

Service Mall Requirements

(1) Stakeholder-specific access rights

The following describes typical situations encountered when considering the requirements for access rights.

Consider the case when company A (a customer) has company F install air conditioning manufactured by company D. Company B (another customer), meanwhile, has company F install air conditioning manufactured by company E, and contracts company G (a consultancy) to provide consulting and analysis. Companies A and B (the customers) both need to file regular reports with the local government (Z).

Table 2 shows an example of access right settings for each stakeholder. Note that “stakeholders” here means individuals, not the companies or other organizations to which they belong.

In this example, companies D and E are given view and modify rights to look at data on the air conditioners they have manufactured. Company F is given rights to view air conditioner data from the customers (A and B) and to perform system setup. Company G is given rights to view data and reports from customer B only. The local government (Z) is given the right to view reports. The customers (A and B) are not able to access each other’s data.

(2) Management of multiple sites at different locations

A company like Hitachi, for example, needs to manage and operate equipment appropriately, not only at its factories but also at a wide variety of other facilities, such as offices, research centers, hospitals, and warehouses. A service mall should provide ways

TABLE 2. Example Service Mall Access Rights Settings

Stakeholders do not necessarily have access to the full range of data and services.

Site	Data	Use	Customer A	Customer B	Vendor D	Vendor E	Company F	Consultancy G	Local government (Z)
Customer A	Vendor D air conditioner	View	○		○		○		
		Operate	○						
		Modify	○		○				
	Report	View	○						○
	System	Set	○				○		
Customer B	Vendor E air conditioner	View		○		○	○	○	
		Operate		○					
		Modify		○		○			
	Report	View		○				○	○
	System	Set		○			○		

to share experience and know-how and perform comparisons between sites through the centralized management of a variety of different types of sites.

(3) Simplicity of screen operation

Service malls are intended to be used not only by customers but also by service providers and others. Accordingly, screens need to be easy to understand and intuitive to operate.

(4) Anonymity of service data

Service malls collect data from a large number of customers and convert it into anonymized statistical data to make it available for analysis and consulting.

(5) Third-party provision and registration of applications

In addition to managing equipment operation and energy, equipment management and operation also includes things like community management, document management, equipment records management, environmental management, billing management, and security management. A large number of excellent third-party application services are available on the market, and service malls actively seek to incorporate these, while also maintaining neutrality, in order to provide greater benefits to stakeholders.

USING TIME SHIFTING TO AVOID CONCENTRATED WORKLOADS

Off-peak commuting is one way to reduce the congestion that occurs during city rush hours. Rolling shutdowns to deal with peak electric power demand in summer can be thought of as another example of time shifting. There are also cases in which the concept of time shifting can be utilized in equipment operation and management. The following describe a number of examples.

(1) Using time shifting in production planning

It is common practice at factories to operate each production line on the basis of detailed production schedules to ensure that products are produced efficiently and delivery is on time. In this case, it is possible to adjust production schedules to avoid bottlenecks and thereby shift peaks in electric power use (see Fig. 2).

(2) Using time shifting in power-sharing arrangements

Time shifting is also a useful technique for mutual power-sharing arrangements that are managed centrally by bringing together at the district level customers with different types of businesses, such as factories, shopping centers, hospitals, offices, condominiums, or event venues. For example, facilities such as factories, hospitals, and offices have high daytime power demand on weekdays, whereas demand from condominiums is high from evening through to night. Shopping centers and event venues, on the other hand, attract large numbers of people on non-working days. In other words, district-wide demand peaks can be smoothed by organizing mutual power-sharing arrangements designed to use time shifting together with batteries and other technology.

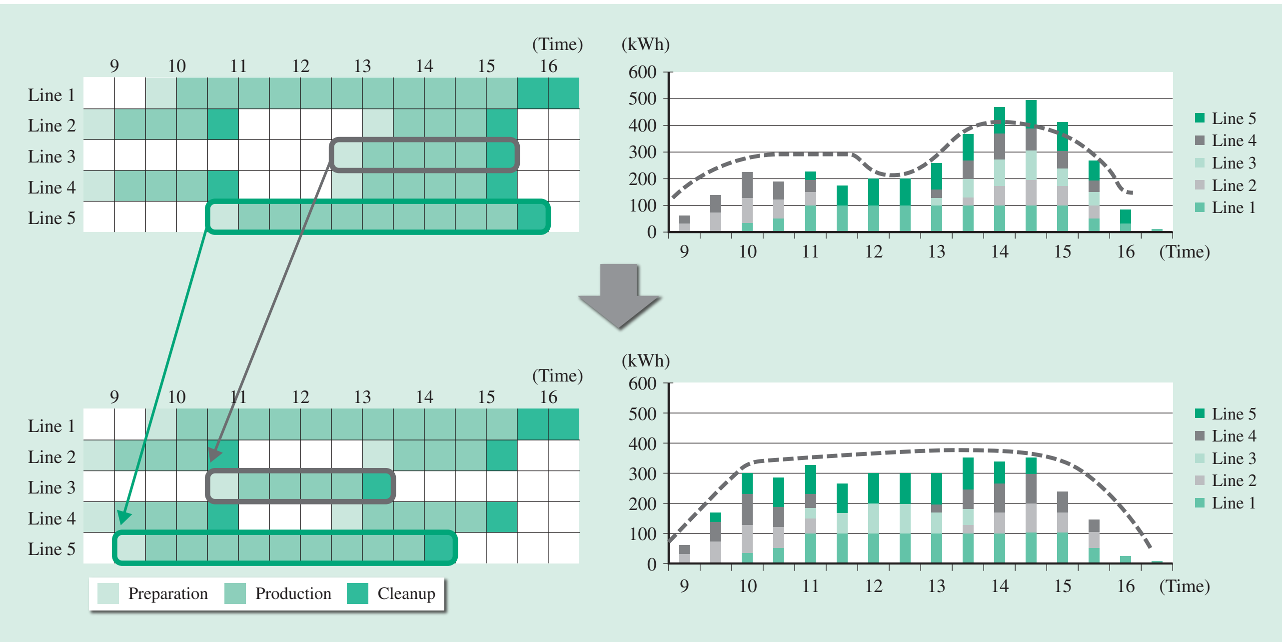

Fig. 2—Use of Time Shifting in Production Plans.
Power use can be smoothed by shifting production processes that overlap in time.

(3) Using time shifting with equipment start times

Many types of equipment such as air conditioning, etc. draw a large amount of power when starting up. Accordingly, rather than starting air conditioners all at once at the start of each working day or after the lunch break, automatic scheduling can use time shifting to smooth peak demand. Also, more reliable operation can be achieved when using emergency generators, such as during an outage in the commercial power supply, by offsetting equipment (load) restart times.

(4) Using time shifting in anticipation of equipment upgrades

Operating equipment in such a way that the timing of upgrades can be offset is a useful way to avoid having to fund upgrade costs all at once. In a case where multiple heat sources or batteries have similar performance and design life specifications, for example, this would mean deliberately controlling the number of units that are operating at any one time so that some are used more than others, rather than using all of the heat sources or batteries to the same extent. As a result, the operating hours and the number of times each unit is operated are different. This helps with investment planning because unit upgrades due to failure or performance degradation no longer occur all at once.

INTEGRATED ENERGY AND EQUIPMENT MANAGEMENT SERVICE DESIGNED BASED ON SERVICE MALL CONCEPT

System Configuration

Hitachi markets its integrated energy and equipment management service based on the service mall concept. The integrated energy and equipment management service is broadly divided into on-premise and center systems that are connected together via a controller (or server) that acts as a gateway (see Fig. 3). The service mall is on the center system and manages data and applications that include equipment operation data, energy use, and fault records from the site. Customers access the service mall via the Internet for equipment

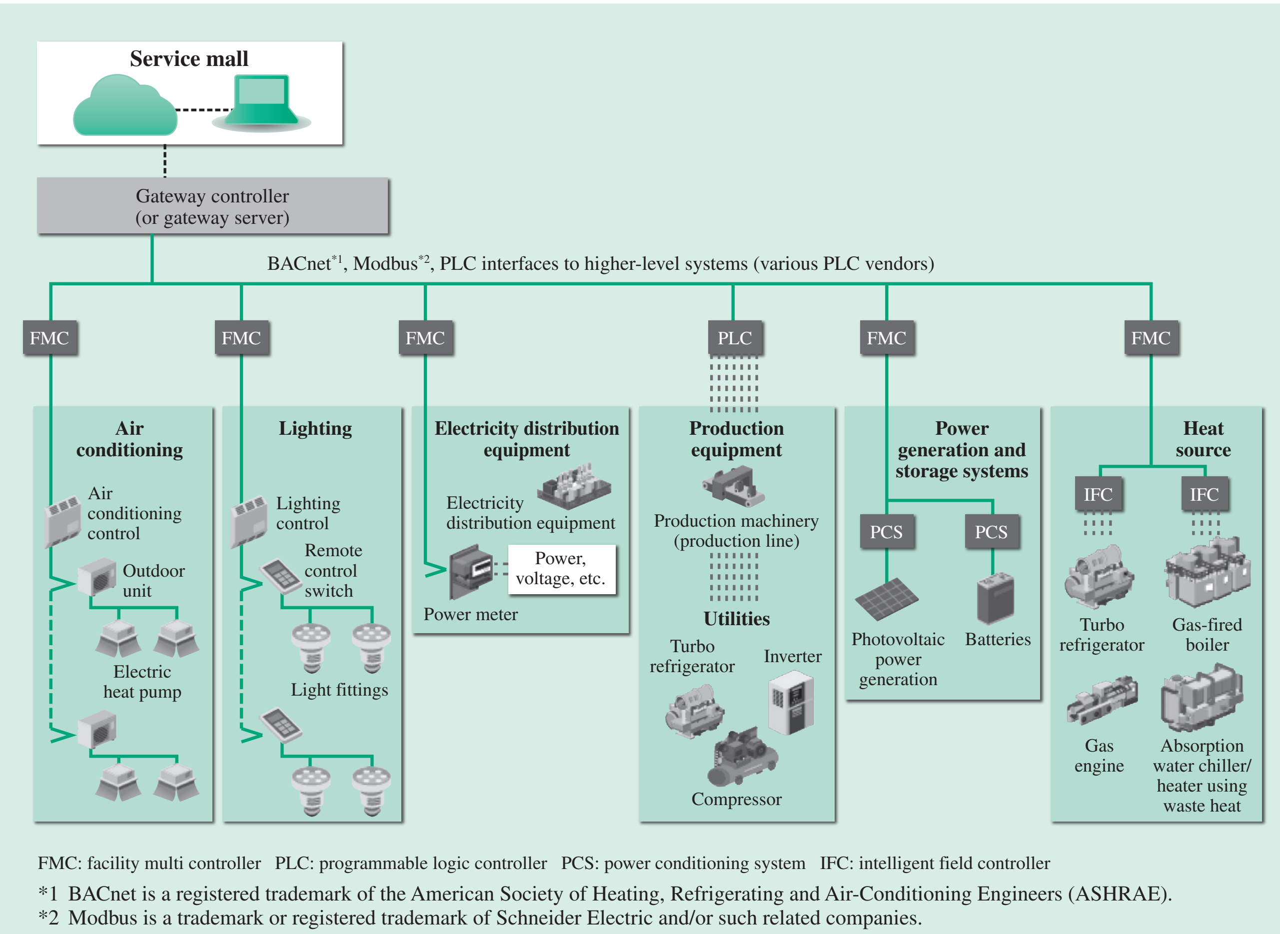

Fig. 3—System Configuration of Integrated Energy and Equipment Management Service.
The site systems are linked to the cloud-based service mall via gateways.

management and operation, while equipment vendors, support service providers, and others are able to use the system within the scope defined by their assigned access rights.

The on-premise system is connected using the BACnet, Modbus, and communication protocols used by common programmable logic controllers (PLCs) for communicating with higher-level systems, which are widely used in various markets and industries. The integrated energy and equipment management service can also be used in a closed configuration consisting of the on-premise system only, without a connection to the service mall. This configuration can be subsequently upgraded by adding a connection to the service mall.

Applications

The integrated energy and equipment management service is an application for commercial users. It provides functions for equipment and energy management. The available management screens are designed based on the business operation cycle of “view,” “know,” “restrain,” and “continue.” The screens are designed in such a way that, as far as possible, even people who do not use the system in their daily work can intuitively find the functions they need. Also, compared to sites such as office buildings in which air conditioning and lighting make up a large proportion of daily power use, production equipment accounts for a large proportion of power use at factories(4). Accordingly, the energy management functions for factories include a peak shift guidance function that uses production plan simulations. The on-premise system sends production schedule data from the production management system to the gateway server, which runs a simulation of power use to provide guidance on peak shifting. The service mall does not collect this production schedule data.

CONCLUSIONS

This article has described the features and benefits of cloud service malls, which enable participation by multiple stakeholders and operating practices that use time shifting to avoid bottlenecks, and the cloud service, which incorporates some of these concepts. Key points include the use of access rights to enable collaboration and the neutrality that enables participation by multiple stakeholders.

In the future, Hitachi anticipates that cloud services based on the service mall model will become a standard practice for social infrastructure, and that most equipment installed in plants will include a communication interface to higher-level systems as a standard feature.

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Featured Articles

System for Optimal Control of Heating and Cooling Equipment to Reduce CO_2 Emissions and Save Energy

Hiroshige Kikuchi
Yuji Miyajima
Fumihiro Ito
Akira Maeyama

OVERVIEW: Hitachi has commercialized a system for the optimal control of heating and cooling equipment to minimize system-wide energy consumption. This is an optimal control system for entire heating and cooling systems, including thermal sources, cooling towers, and pumps, that works by determining the optimal combination of control targets and number of machines to operate based on the outside air conditions and thermal load. The control system has been supplied to provide optimal control of the heating and cooling system in the ABENO HARUKAS, building, Japan's tallest mixed-use skyscraper, and is currently in operation. The control techniques developed for the system have also been incorporated as a function in an integrated energy and equipment management service.

INTRODUCTION

THE growing demand to reduce electricity, gas, and other running costs in factories and other buildings, and to prevent global warming, means that heating and cooling equipment is also being called on to become more energy efficient and to emit less carbon dioxide (CO_2). Hitachi deals with system solutions for energy efficiency, and has commercialized a system for the optimal control of heating and cooling equipment to minimize system-wide energy consumption. This is an optimal control system for the entire heating and cooling system, including thermal sources, cooling towers, and pumps. To determine the optimal combination of control targets and number of machines to operate, it uses a simulator that is tuned for high accuracy using sensor data.

This article provides an overview of the system for optimal control of heating and cooling equipment and describes an example application.

OVERVIEW OF SYSTEM FOR OPTIMAL CONTROL OF HEATING AND COOLING EQUIPMENT

Fig. 1 shows an overview of the system for optimal control of heating and cooling equipment. The system performs optimal control of equipment such as heater/chillers, cooling towers, and pumps. Based on inputs such as the load and outdoor sensor measurements, the system determines the parameters (control targets and number of machines to operate) that minimize the performance function and then outputs these to the equipment. The performance function criteria, such as primary energy, CO_2 emissions, or running costs, can be selected by the user. In the case of cogeneration systems such as those that utilize waste heat from gas engine generators, the system can obtain optimal values that take account of the amount by which use of waste heat reduces the gas consumption of the heating and cooling equipment.

Optimization of Control Targets

The control system obtains a set of control targets for the temperature and flow rate of chilled water and cooling water that has been optimized to minimize a performance function that considers factors such as primary energy, CO_2 emissions, or running costs based on the outside air conditions and thermal load, and then outputs these targets to the heating and cooling equipment.

Fig. 2 shows the principle of optimal control for an example in which the aim is to minimize primary energy use by individual machines. For example, reducing the flow of cooling water reduces the amount of primary energy used by the cooling water pump, but the reduced flow of cooling water to the chiller causes it to use more primary energy due to the fall in its coefficient of performance (COP). Similarly, setting a higher cooling water temperature reduces the amount

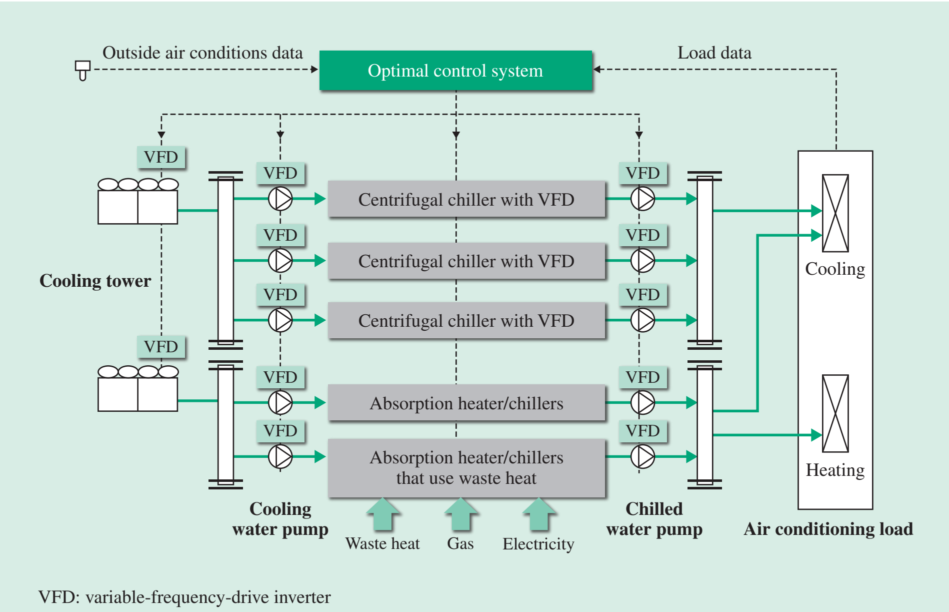


Fig. 1—Overview of System for Optimal Control of Heating and Cooling Equipment.
The system for optimal control of heating and cooling equipment, including heater/chillers, cooling towers, and pumps, works by using sensor measurements of the outside air conditions and thermal load to determine the optimal combination of control targets and number of machines to operate so as to minimize energy consumption across the entire system, and then outputting these settings to the equipment.

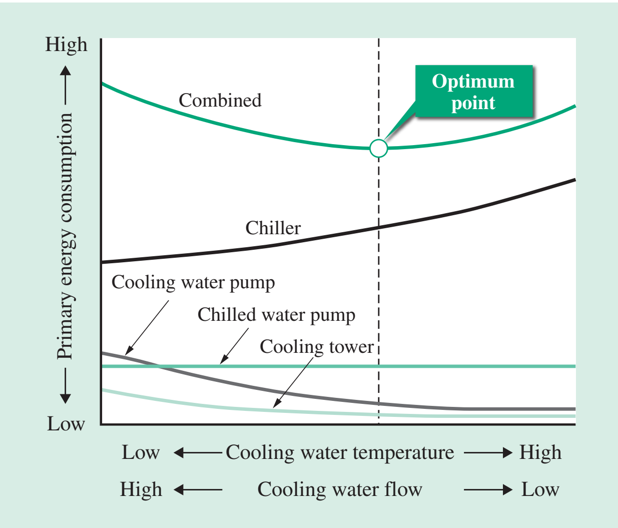


Fig. 2—Principle of Optimal Control.
Optimal control targets are obtained to minimize primary energy consumption across the entire system.

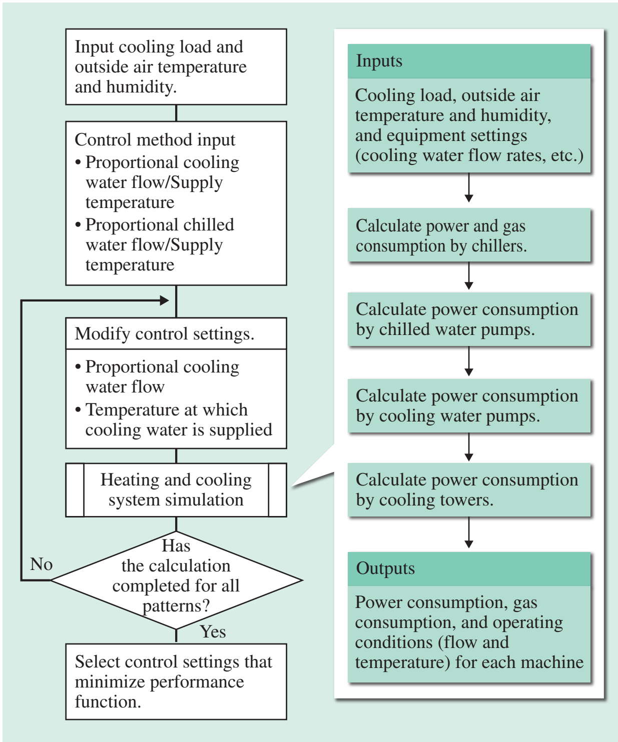


Fig. 3—Flow Chart of Optimal Control.
The system for optimal control of heating and cooling equipment uses simulation to obtain the optimal combination of control targets.

of primary energy used by the cooling tower but raises primary energy use by the chiller. These trade-offs are reflected in the parameters for the temperature and flow rate of chilled water and cooling water, and the optimal combination of values varies depending on the outside air conditions and thermal load.

Fig. 3 shows the flow chart of optimal control. The optimal control system determines the optimal combination of control targets by using an iterative calculation that incorporates simulation.

Fig. 4 shows the energy savings when operating in cooling mode for two absorption heater/chillers with a capacity of 240 tons (RTs). The figure indicates energy savings of about 24% compared to the previous system, which used a constant temperature and flow rate for chilled water and cooling water. While the energy savings provided by optimal control depend on the system configuration, thermal load, and outside air conditions, they are in the 10% to 30% range.

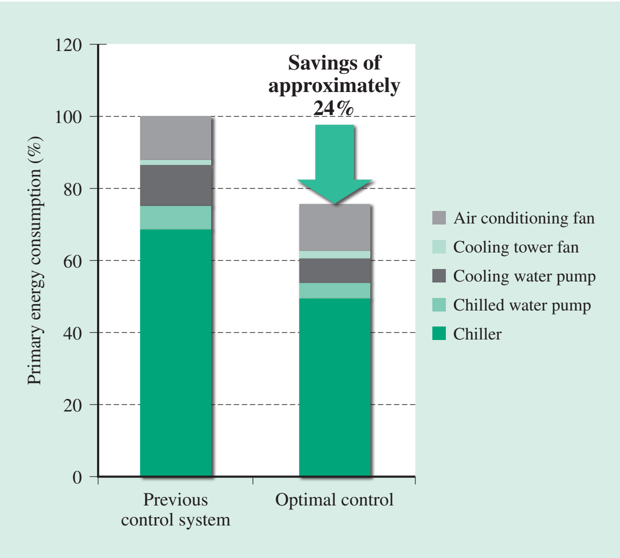
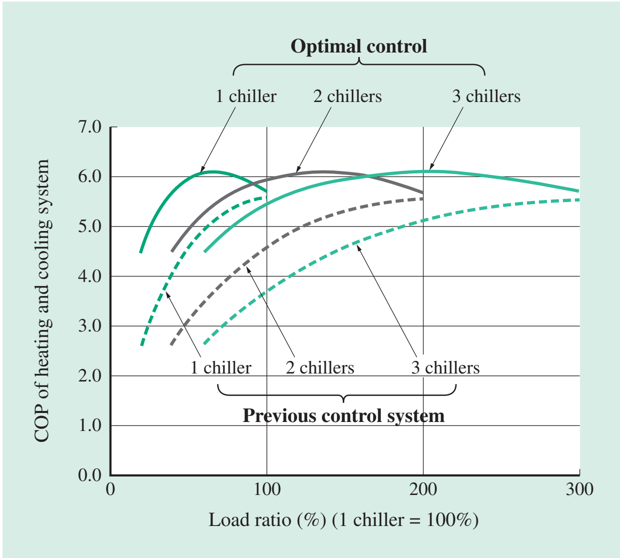


Fig. 4—Energy Savings Made by System for Optimal Control of Heating and Cooling Equipment (Cooling Mode).
The graph shows the energy savings, where 100% represents energy use by the previous system that used a constant temperature and flow rate for chilled water and cooling water. Optimal control reduced this energy use by approximately 24%.



COP: coefficient of performance

Fig. 5—Optimization of Number of Chillers to Run.
Whereas the COP of the heating and cooling system under the previous control system was highest when the fewest number of chillers were operating, this does not always apply in the case of optimal control. Optimal control of the number of chillers to operate works by using a simulation to determine the optimal load ratios that minimize energy consumption across the entire system.

Optimization of Number of Machines to Operate and Load Distribution

Fig. 5 shows the relationship between load and COP for three centrifugal chillers with VFDs. In the case of previous control systems that used a constant temperature and flow rate for chilled water and cooling water, the COP of the system tended to be highest when operating at full load. Accordingly, all such a control system needed to do was to run the minimum number of machines needed to cover the required load, thereby allowing each to operate at as high a cooling load as possible. In the case of equipment operated in accordance with optimized control targets, on the other hand, minimizing the number of machines being used does not necessarily maximize the COP of the heating and cooling system. Accordingly, the optimal control system developed by Hitachi optimizes the number of machines to operate by using a simulation to calculate the energy consumption and then determines the number of machines that minimizes the energy consumption across the entire heating and cooling system.

Fig. 6 shows the operating priorities for equipment when using a performance function that minimizes running costs. In the case of a system that combines a number of different types of heating and cooling equipment, such as cogeneration systems, centrifugal chillers with VFDs, or absorption heater/chillers, the operating priorities are determined so as to minimize the performance function used as an indicator. While Fig. 6 shows a case with a performance function that minimizes running costs, the performance function for this system could be changed to one that minimizes a different parameter, such as CO_2 emissions, in which case the operating priorities would change in accordance with the conversion coefficient used in the performance function calculation.

A function for optimizing the load distribution by adjusting the chilled water flow rate is also provided for the case when different types of heating and cooling equipment are operating at the same time.

EXAMPLE APPLICATION

System for Optimal Control of Heating and Cooling Equipment at ABENO HARUKAS Building

The optimal control system has been supplied to the ABENO HARUKAS building (location: Osaka, height: 300 m), Japan's tallest mixed-use skyscraper, and is currently in operation. ABENO HARUKAS is a mixed-use building that was fully opened in March 2014. Its numerous facilities include a railway station, department store, art gallery, offices, hotel,

Cooling						
	Summer (July to September)		Mid-season (May, June, October)		Winter	
Operating priorities	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
1	Absorption heater/ chiller that uses waste heat	Centrifugal chiller with VFD	Absorption heater/ chiller that uses waste heat	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD
2	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD
3	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD	Centrifugal chiller with VFD
4	Centrifugal chiller with VFD	Absorption heater/chiller	Centrifugal chiller with VFD	Absorption heater/chiller		
5	Absorption heater/chiller		Absorption heater/chiller			

Heating			
Operating priorities	Summer (July to September)	Mid-season (May, June, October)	Winter
1		Absorption heater/chiller	Absorption heater/ chiller that uses waste heat
2			Absorption heater/chiller

Fig. 6—Optimization of Equipment Operating Priorities.
This optimizes the priority order for equipment operation to minimize running costs. The priorities change depending on the electric power tariff, which varies by season and time of day.

and observation deck. As an advanced “vertical city” that hosts all of these facilities, the ABENO HARUKAS building incorporates a variety of leading environmental technologies that reduce its CO_2 emissions and energy use. The aim is to reduce its annual CO_2 emissions by approximately 5,000 t. Hitachi’s optimal control system is included among these “leading environmental technologies” (see Fig. 7).

The optimal control system supplied by Hitachi works by collecting operational information from the heating and cooling equipment in realtime, performing calculations to determine the combination of equipment and other control settings that will minimize CO_2 emissions, running costs, or whatever it is that is being targeted, and then automatically provides these to the equipment in the form of control targets. To ensure reliable and flexible operation, the heating and cooling equipment used in the ABENO HARUKAS building consists of a combination of electric and gas-powered machines, with the CO_2 emission coefficients and energy prices being different for each type. Accordingly, multiple calculations are required to perform optimal control of heating and cooling equipment, including determining which type of equipment to use first and what control settings to use. This can be achieved by using the system for optimal control of heating and cooling equipment.

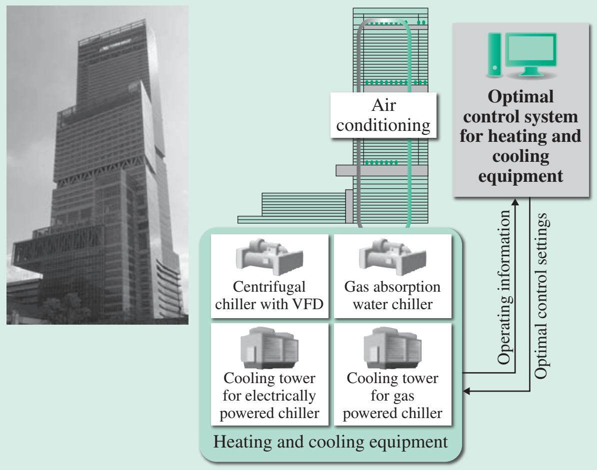


Fig. 7—ABENO HARUKAS Building.
The optimal control system for heating and cooling equipment has been supplied to the ABENO HARUKAS building, Japan’s tallest mixed-use skyscraper.

Hitachi has also supplied a system for centralized management and data presentation that utilizes energy data, such as data on the electric power and gas used by the heating and cooling equipment at the ABENO HARUKAS building, and heat quantity, temperature, flow rate, and other analog data collected from the equipment. This enables operational management based on efficiency data, such as that for energy use by individual items of heating and cooling plant or by

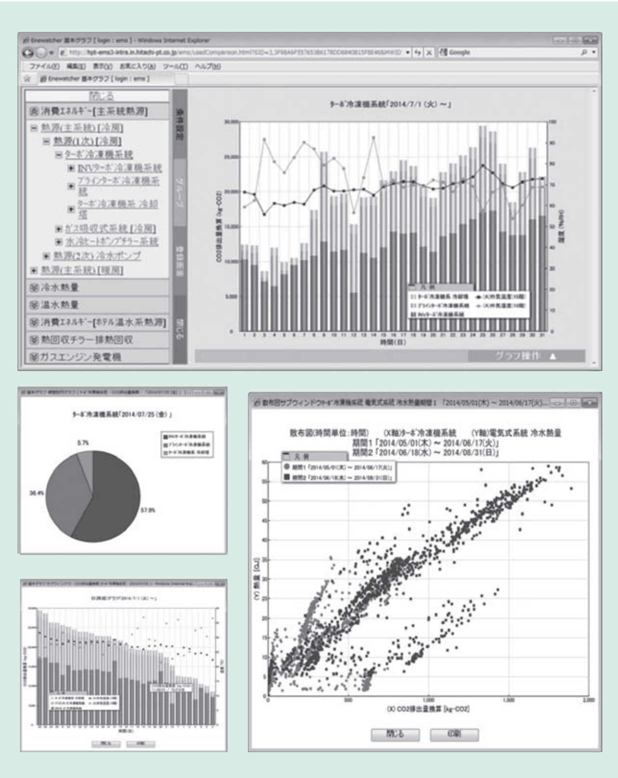


Fig. 8—Viewing Graphs in Web Browser.
Hitachi has also supplied an energy management system for centralized management and data presentation that utilizes energy data, such as data on the electric power and gas used by the heating and cooling equipment, and heat quantity, temperature, flow rate, and other analog data collected from the equipment.

the entire system, CO_2, and operating costs. Because this information can be viewed as graphs using a web browser on a personal computer (PC) connected to a dedicated network in the ABENO HARUKAS building, it enables sharing of information by everyone involved in facilities management (see Fig. 8)

CONCLUSIONS

This article has provided an overview of an optimal control system that minimizes energy consumption across an entire heating and cooling system, and has described an example application.

The optimal control technique has also been included as a function in a service for integrated energy and equipment management. This is a core product in Hitachi's energy management service business and the company intends to deploy it as a service for solving management problems that supports improvements in consumers' energy and business efficiencies, and also activities such as business continuity planning (BCP).

ACKNOWLEDGEMENTS

Hitachi received considerable advice and cooperation from KINTETSU CORPORATION and everyone else involved in the system for optimal control of heating and cooling equipment at the ABENO HARUKAS building used as an example in this article. The authors would like to take this opportunity to express their sincere gratitude for this assistance.

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Featured Articles

Cloud-based Equipment Maintenance and Facility Management Service Platform

Hiroshi Yoshikawa
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Yuuji Kawai
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OVERVIEW: The industrial equipment used in factories and other plants needs to operate efficiently. This is made difficult, however, by issues such as the rising maintenance costs of aging equipment and the shortage of operation and maintenance technicians. To solve these problems, Hitachi has developed an equipment maintenance and facility management service platform that uses cloud computing. The ability of the service platform to provide information that is valuable to users has been demonstrated by its use with air compressors, including the collection and analysis of operational data to suggest operating practices that will save energy. It has also been utilized for operation and maintenance work at a water purification plant, where the use of AR to guide users through operating procedures has achieved benefits that include preventing steps being missed out or other operational errors.

INTRODUCTION

THE information technologies for the Internet of things (IoT) and machine-to-machine (M2M) communications are attracting attention from industry. The German government, for example, is pursuing its Industrie 4.0 technology strategy that aims to connect machinery and cloud computing to achieve benefits such as improving productivity and reducing energy consumption in factories[1]. Similarly, General Electric Company has proposed its Industrial Internet concept for connecting machinery to the cloud and using big data analytics to improve productivity[2]. Both of these are seeking to achieve a dramatic boost to productivity at factories and other plants by creating a “connected world” in which machines are connected to other machines and to the cloud.

In particular, reducing downtime and achieving efficient operation of important industrial equipment used in factories and other plants are needed to ensure that the plants operate reliably. Meanwhile, the challenges include the rising maintenance costs of aging equipment and the shortage of skilled technicians with extensive expertise and experience in operation and maintenance.

Along with growing global demand for services that can solve the problems associated with the operation and maintenance of industrial equipment, work is proceeding on developing service solutions that use the cloud.

This article gives an overview of an equipment maintenance and facility management service that uses the cloud and describes its features, benefits, and outcomes.

CLOUD-BASED EQUIPMENT MAINTENANCE AND FACILITY MANAGEMENT SERVICE

Overview

Reducing downtime for industrial equipment requires the use of preventive maintenance to minimize abnormalities or to detect them at an early stage so that repairs can be made quickly. To date, however, conventional practice has been to conduct regular inspections of equipment condition and to only commence repair work after notification is received of an abnormality. Accordingly, the problems with this are that it is difficult to choose the ideal time to perform preventive maintenance and that it takes time to complete repairs after an abnormality occurs.

To overcome these problems, Hitachi has since 2011 been operating its M2M cloud-based equipment maintenance and facility management service for Hitachi-made industrial equipment[3]. Since 2014, Hitachi has also been marketing the service to industrial equipment manufacturers.

To operate and maintain industrial equipment more efficiently, the cloud-based equipment maintenance and facility management service performs the continuous and remote collection of operating data, and provides services that include monitoring, preventive maintenance, failure predictive diagnosis, energy efficiency diagnosis, and equipment maintenance management. Hitachi is able to draw on its experience with the design, manufacture, and maintenance of industrial equipment and the engineering, procurement and construction (EPC) of factories and other plants, and also on its know-how as an information technology (IT) vendor. By utilizing the know-how of data scientists and the engineers involved in the design, manufacture, and maintenance of industrial equipment to analyze the collected data and collate the results, Hitachi aims to supply information that is valuable to users.

Available Schemes and Benefits

Hitachi cloud-based equipment maintenance and facility management service can be used for individual items of industrial equipment or for entire factories or other plants. In the former case, Hitachi can supply the following schemes to industrial equipment manufacturers (see Fig. 1).

(1) Service contracts between Hitachi and the industrial equipment manufacturer and between the industrial equipment manufacturer and the user.

(2) Hitachi supplies the M2M cloud on behalf of the industrial equipment manufacturer to implement a system for collecting operating data from equipment that the manufacturer has supplied to users.

(3) Hitachi data scientists analyze the collected operating data and supply the results to the industrial equipment manufacturer. Hitachi can draw on its own experience to provide consulting on data analysis to meet the industrial equipment manufacturer's needs (such as the choice of data to collect and how to use it).

(4) The industrial equipment manufacturer supplies services to the user based on the analyses it receives from Hitachi.

This provides the following benefits to the industrial equipment manufacturer and user.

Firstly, the industrial equipment manufacturer can make business efficiency improvements, such as reducing the cost of equipment maintenance management by revising its spare parts inventory or predicting when and what sort of maintenance to perform, or establishing an efficient service infrastructure. Customer service can also be improved by having Hitachi analyze data and offer suggestions from a user's perspective.

Users, meanwhile, can minimize the upfront costs of installing the service because it uses the Hitachi cloud. The service also reduces downtime caused by abnormal situations because it allows industrial equipment manufacturers to monitor operational data remotely and thereby identify the causes of problems quickly and act promptly to resolve them. Furthermore, it can be used to reduce product life cycle costs by enabling industrial equipment manufacturers to provide comprehensive services for the equipment they have supplied, including using the results of Hitachi data analysis to assist with failure predictive diagnosis and preventive maintenance planning.

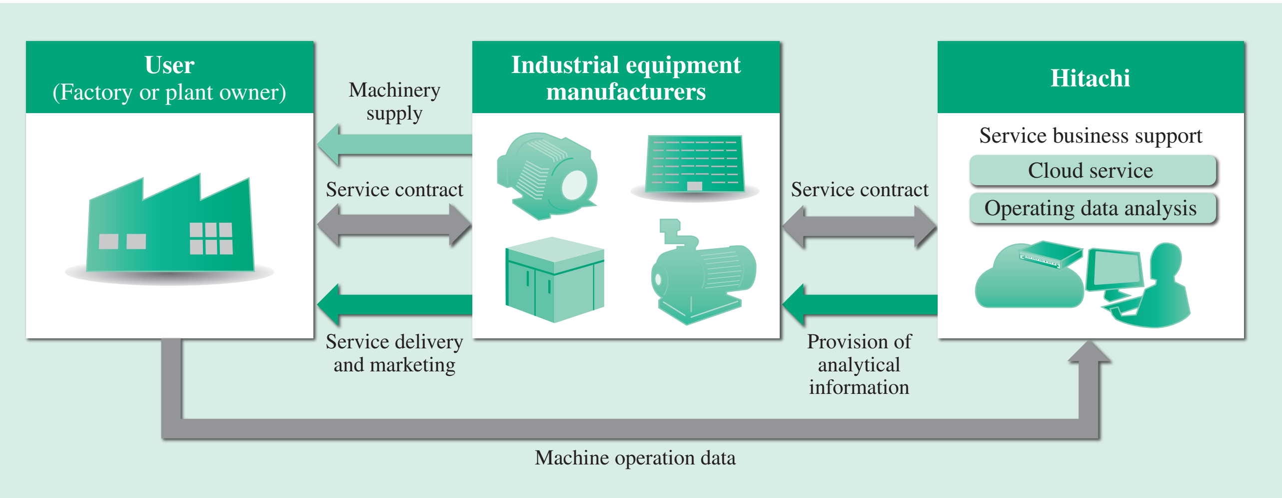

Fig. 1—Overview of Hitachi Cloud-based Equipment Maintenance and Facility Management Service.
This provides cloud and operational data analysis services to industrial equipment manufacturers.

TRIALS OF CLOUD-BASED SERVICE

The following sections describe the results of using the service for air compressors and for facility operation and maintenance management at a water purification plant. The former is an example involving individual items of industrial equipment while the latter applies to an entire plant.

Application to Air Compressors

The cloud-based service has been supplied for use with Hitachi air compressors, which are used at automobile, semiconductor, liquid crystal, and other factories. The compressed air these machines produce provides the driving force for air sprays and other equipment used in these plants, and they account for about 25% of plant power consumption. Because they are an important source of motive power, downtime needs to be kept to a minimum. Accordingly, Hitachi has conducted trials to assess how well the service supports energy-efficient operation and helps reduce downtime.

(1) Support for energy-efficient operation

The air compressors covered by the service include control functions for energy-efficient operation. However, to achieve the maximum energy savings from these control functions, it is necessary to specify appropriate pressure settings based on the conditions in which the compressors operate. Accordingly, Hitachi developed a function to facilitate energy-efficient operation by using operational data collected via the cloud in an analysis to determine the best pressure settings for different levels of air consumption (see Fig. 2). This achieved roughly the same level of energy savings as was expected for the control functions.

Operational data collected via the cloud can also be analyzed to determine the operating patterns for the compressors and suggest more energy-efficient ways of operating. For example, energy savings were made by analyzing the operating patterns at a plant that operates two air compressors in parallel and suggesting energy-efficient ways of operating with only one compressor at a time (see Fig. 3).

As this support for energy-efficient operation can help customers cut their power bills, it also has the potential for use in new service models in the future, such as profit sharing.

(2) Support for reducing downtime

This involves use of operational data collected via the cloud for a maintenance service. In addition to reducing downtime due to abnormalities by sending an e-mail notification whenever an alarm occurs on an air compressor to enable a faster initial response, the service can also predict appropriate maintenance timings by analyzing trends in various data.

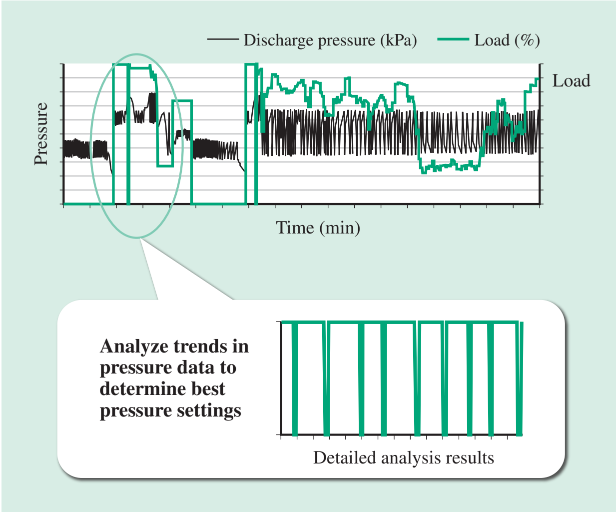

Fig. 2—Results of Analysis of Best Pressure Settings for Air Compressors.
This example involved analyzing trends in pressure data to determine the best pressure settings.

In the future, Hitachi plans to develop a predictive diagnosis function for analyzing collected data and assessing abnormality trends, and new information services that satisfy customer needs.

Application to Facility Operation and Maintenance Management

The operation and maintenance management of plant facilities includes formulating facility maintenance plans in conjunction with production schedules, arranging parts replacements, and preparations for dealing with issues identified in previous inspections. Recent years have seen an increase in the outsourcing to private sector suppliers of the operation and maintenance of public sector facilities. Hitachi is utilizing and supplying cloud-based support tools for operation and maintenance work because this enables the same operation and inspection practices to be used for facilities that operates under different conditions, and improvements in the quality of operation and maintenance achieved by collecting operational data from each site to obtain operational know-how.

Hitachi can undertake operation and maintenance work on plant facilities on behalf of customers. To improve the efficiency of contracted operation and maintenance work on facilities, including the collection and recording of operational data from a facility, Hitachi uses systems that combine the cloud-

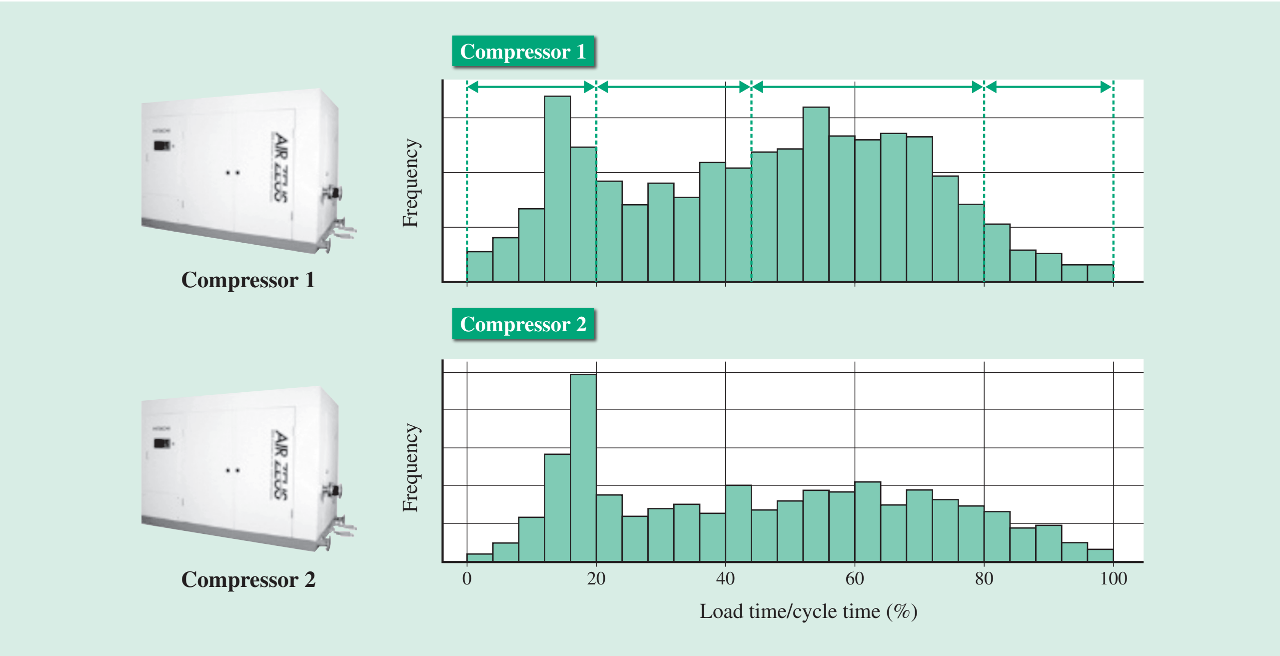

Fig. 3—Analysis of Operating Patterns.
An analysis of operating patterns at a plant that operates two air compressors in parallel identified energy-efficient ways of operating with only one compressor at a time.

based operation and maintenance management support service described above with technologies such as mobile devices and augmented reality (AR). AR is a technique for using a computer to overlay information on images of the actual scene. It has rapidly entered wider use in recent years thanks to the spread of things like M2M communications and camera-equipped mobile devices.

To assist with non-routine operations where there is a high risk of operational errors, Hitachi has developed an "AR navigation system for plant operations" that uses AR for operation and maintenance work. Non-routine operations are those for which it is difficult to build up skills because they are not performed often, and where there is considerable potential for error even if workers are skilled, such as a changeover of facility lines that is only performed once a month. Because it uses images, the "AR navigation system for plant operations" can also be used with facilities that are not equipped with sensors. It enables "skill-free" operation and maintenance by using visual display to guide workers through operating procedures.

Here, "navigation" means stepping workers through a facility operating procedure by developing scenarios for the procedure, such as checking meters or operating valves, and recording these on the cloud. This navigates workers through their work in the following way (see Fig. 4).

(1) The worker takes a photograph of the facility using the camera in their mobile device.
(2) On identifying a special-purpose marker, the system links the captured image to a pre-recorded scenario on the cloud.

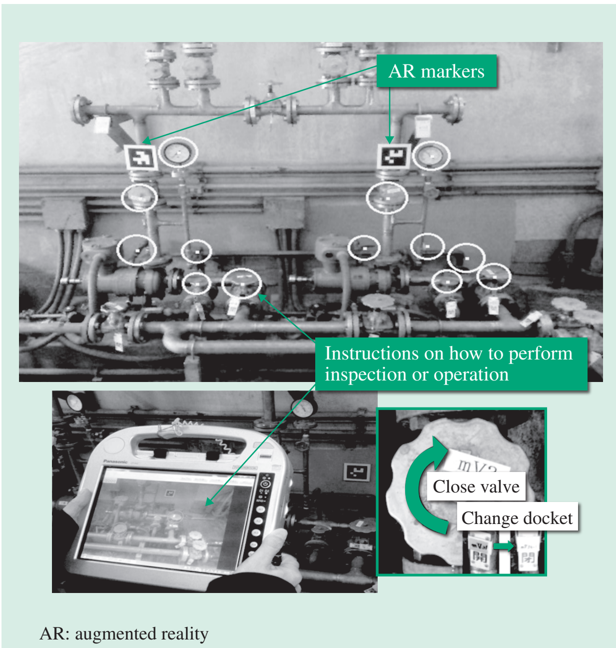

Fig. 4—Overview of AR Navigation System for Plant Operations.
AR is used to provide visual instructions on how to perform inspection or operation.

(3) The cloud provides assistance, such as input of operating procedures or operating information in the form of comments or video.
(4) The cloud links together and saves images, timestamps, and results.

Hitachi has demonstrated the benefits of using this navigation process for non-routine operations (monthly or similar) in which an error can potentially result in business losses. This succeeded in preventing operational errors and improving quality of work. Another benefit is more efficient reporting, such as work results reports, using the automatically recorded work results.

In the future, Hitachi intends to use the technique to provide instructions for complex tasks where the next step depends on the results of problem diagnosis, such as failure cause diagnosis when an abnormality occurs.

CONCLUSIONS

This article has given an overview of the cloud-based equipment maintenance and facility management service and described its features and benefits and the results of its use in practice. Used for individual items of industrial equipment or for entire plants, Hitachi has demonstrated that the service can boost the efficiency of operation and maintenance, such as by enabling energy-efficient operation, reducing downtime, or avoiding operating errors.

In the future, Hitachi intends to further reduce downtime and support the efficient operation of industrial equipment through innovations such as the use of head-mounted displays (HMDs) or other wearable devices, or more extensive analysis options.

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