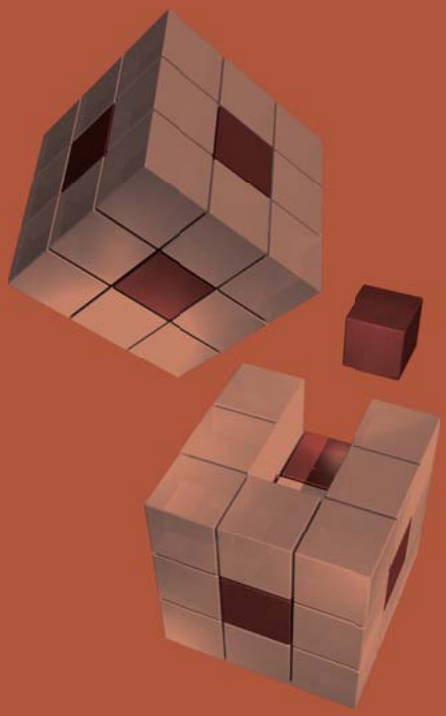


Research & Development

Research & Development

Human Cell Sheet-based Automated Cell Culture Equipment that Greatly Contributes to Regenerative Medicine of the Cornea and Esophagus

Although "regenerative medicine," which involves culturing cells to regenerate tissue that can be transplanted into lesions or areas where body parts have become dysfunctional, has been attracting attention and raising hopes as a way to fundamentally revolutionize medical treatment, for the technique to spread significantly, the efficient production of regenerated tissue is seen as holding the key. In order to resolve this issue, Hitachi, Ltd. has been working with Tokyo Women's Medical University on a joint project to develop an automated cell culture equipment for cell sheets, which are a type of regenerated tissue. A prototype has already been built in order to verify the quality of cultured sheets.

Challenges in Efficiently Culturing Cell Sheets

Expectations are high for regenerative medicine as a next-generation medical treatment that can fundamentally regenerate cells, tissues, or organs. Regenerative medicine uses regenerated tissue such as living cells from humans that have been cultured in a sheet arrangement. At present this culturing procedure is performed manually, and therefore requires a great deal of time and effort. In addition to the extremely clean environment that is required in order to prevent contamination, a culture technician can only work on one person's cell culture in a single room at any one time, in order to avoid cross-contamination whereby materials from another person's cells are inadvertently mixed in with a culture. Also, a culture technician must have sufficient experience and skill in order to be able to culture a high-quality cell sheet. This is why for the practice of regenerative medicine to spread significantly, the major challenges of increasing efficiency and training more culture technicians must be met.

In order to meet these challenges, Hitachi and the Institute of Advanced BioMedical Engineering and Science at Tokyo Women's Medical University (TWMU) have been participating in Japan's New Energy and Industrial Technology Development Organization (NEDO)'s "Development of Nano-bio Interface Technologies for Tissue Regeneration Transplant" project since 2002, and have been engaged in joint development work on equipment that can automatically culture cell sheets from rabbit cells. Starting in 2009, Hitachi and TWMU have been participating in development work as part of the Ministry of Education, Culture, Sports, Science and Technology's "Formation of Centers for the Creation of Innovative Mergers of Leading Edge Technologies."

Compliance with GMP and Compact, Space-saving Design

Automated cell culture equipment requires a clean environment that can completely protect against contamination by foreign material from the outside. To this end, we have been developing a completely closed culturing environment as part of an automated cell culture equipment, and successfully built a prototype in 2012.

The developed device applies technology established by TWMU that can recover cell sheets without the need for an enzymatic process, and can be used to automatically culture human cell sheets for regenerative treatment of cornea and esophagus tissue. Also, the device is designed to be compact and space-saving, and can be installed within approximately the same amount of floor space as the incubators that are currently used for cell culturing. In addition, it complies with Good Manufacturing Practice (GMP) for safety and quality in the manufacturing of medicines and medical devices.

Achievement of Completely Closed System that Was Seen as Difficult

The achievement of this completely closed system was actually extremely difficult. Adoption of a closed system makes the movement of culture solution inside flow channels problematic. Also, in order to protect against cross-contamination, it must be possible to swap everything including flow channels after each culture. For this reason, we modularized the spaces used to culture cells, and adopted a structure such that everything can be attached and detached. The pumps and other mechanisms for transporting the culture solution are located outside the modules, so this allows for the achievement of a completely closed system.

Cell sheets cultured by this prototype are of the same quality as those manufactured manually. Also, it has been verified that when they are used in medical treatment, manually cultured cell sheets are effective in regenerating corneal epithelial cells and preventing the constriction of the throat that can occur after the excision of esophageal cancer. We are collaborating with TWMU in improving the automated cell culture equipment with the goal of starting clinical research with cell sheets cultured using the equipment in 2015.

This automated cell culture equipment has the potential for applications in the automated culturing of human cells from a variety of different parts of the body, and will be indispensable to regenerative medicine. It is with these applications in mind that the Hitachi will continue working to contribute to the full-scale spread of regenerative medicine by pooling its comprehensive knowledge in the medical treatment and bio fields, and by promoting the development of equipment and systems that reach an even higher level of excellence.

Shizu Takeda (left), Manager; Toyoshige Kobayashi (right), Researcher; Advanced Research Department, Central Research Laboratory, Hitachi, Ltd.

Human-oriented Big Data Revolutionizing Business and Society

Hitachi draws on its strengths in information and telecommunications technology to supply a variety of solutions for utilizing big data. One leading-edge example is the human-oriented big-data cloud that helps improve business performance by combining business data with data on human behavior acquired using the name tag sensor and then analyzing it using proprietary technology. In this article, key people involved in the development and evolution of the product describe the latest results and future possibilities.

Linking Data on Behavior with Real Corporate Data

We developed the name tag sensor in 2007 and collected ten trillion items of "big data" information over a million days covering things like human behavior and face-to-face interactions. We then demonstrated that this information could be represented visually to measure things that in the past could only be determined qualitatively, such as people's initiative and empathy for the organization.

Even greater value is created when this large quantity of data on people's behavior and the associated analysis techniques are linked to corporate performance data. We have now gone on to develop the human-oriented big-data cloud that performs automatic computer analyses of business improvement proposals by combining data on people's behavior with big data relating to business operation and performance, such as financial data or system logs. This work has already been tested on actual business activities where it has produced interesting results.

Trialing Use of Proprietary Big Data Analysis Techniques for Business Performance Improvement

One of these examples involved improving the performance of a call center. In collaboration with MOSHI MOSHI HOTLINE, INC., we collated data on the working behavior of call center sales representatives and their success in gaining orders, aggregated it on a cloud system, and then conducted analyses on the acquired data. This identified a positive correlation between the level of communication during breaks and the number of successful telephone sales. To test this conclusion, the teams were reorganized into groups of similar age to increase their interaction, resulting in a 13% improvement in the ratio of calls resulting in sales.

Similarly, the human-oriented big-data cloud was used at a large retail store to collect point-of-sale (POS) data on sales together with data on the movements of staff and customers. The computer then used this information to generate automatic proposals for improving store sales. The results of the study found that sales-per-customer was increased by 15% by adopting a policy of preferentially stationing staff at locations within the store that the computer had identified as having a strong influence on sales. This demonstrates how computers can do better than people at identifying business performance improvements when large quantities of data are available. In the analysis, the computer generated more than 6,000 indices from the big data and then automatically identified which of these were important for corporate performance. Significant improvements in business performance can be anticipated from the utilization of big data and computers without relying on the limited experience of individuals or hypotheses.

Potential for Transforming Work Practices and Nature of Society

The human-oriented big-data cloud is currently being used to reform a design and development project. The aim is to establish project management methods based on data on projects that did not experience delays or quality problems. This is done by collecting data on things such as the working methods or forms of organization common to successful projects.

In the call center example, providing suitable break times led to an improvement in the ratio of successful sales. In other words, the analysis demonstrated quantitatively that economic considerations and worker satisfaction, things that in the past had been believed to be in conflict, were in fact mutually reinforcing. If more results of this nature are identified in the future, it may well have the potential to transform work practices and the nature of society. We hope that the human-oriented big-data cloud can contribute both to smarter business and to the creation of a better society.

(Left to right) Kazuo Yano, Senior Chief Researcher, Central Research Laboratory; Norihiko Moriwaki, Senior Researcher; Nobuo Sato, Senior Researcher; Satomi Tsuji, Researcher, Social Information Systems Research Department, Central Research Laboratory, Hitachi, Ltd.

MBD Technology Using Virtual CPUs to Revolutionize Automotive Embedded System Development

MBD is being applied to the development of increasingly advanced and complex automotive embedded systems as a way to meet challenges such as efficiency improvement, quality improvement, and cost reduction. Automotive Products Research Laboratory at Hitachi America, Ltd. and Central Research Laboratory at Hitachi, Ltd. are working on MBD based on virtual CPUs in advance of other companies, and are pursuing efficient design in a virtual environment as well as shared design connecting research centers around the globe. As a part of these efforts, the use of a virtual CPU-based method was demonstrated in order to verify effectiveness in the development of a fuel pump control system for gasoline engines. Based on this example, the people in charge were interviewed regarding the benefits and future prospects of virtual CPU-based MBD.

MBD Drawing Attention in Development of Embedded Systems

Automotive embedded systems are growing increasingly complex as the use of electronic systems in automobiles is progressing. Since, due to the configuration with 10 or more electronic control units (ECUs), the scale of the software must also be large, the number of software test items has also increased, as has the work involved in validation. Also, there are potential problems such as how when a fundamental flaw is discovered in hardware during the development validation phase, reworking is required, leading to major losses in terms of both time and cost.

In response to these challenges, model-based development (MBD) is drawing attention as a method for improving efficiency in the development of embedded systems. Since the design is optimized based on projections of overall system behavior, it is possible to improve both development efficiency and quality. As it simulates using models instead of actual physical systems, MBD is one example of a cyber-physical system.

Virtual CPU-based MBD Applying Hitachi's Strengths

Automotive Products Research Laboratory (APL) at Hitachi America, Ltd. and Central Research Laboratory (CRL) at Hitachi, Ltd. have been taking the lead in MBD efforts as a new approach for applying new technologies. Popular forms of MBD at present are based on MATLAB*/Simulink*, which can be used to validate designed control algorithms, but the MBD method developed by APL and CRL creates an environment whereby the actual binary code (control software) designed for real ECU can be executed on the model. This method, which uses a virtual CPU, coordinates a microcontroller model with a physical system's operational model in order to evaluate and validate actual system behavior. Also, in addition to control software development, another benefit is that validation can also be carried out in parallel.

As part of the development of a fuel pump control system for gasoline engines, APL conducted demonstrations in order to consider the validity of the virtual CPU-based method. These demonstrations showed that the results of both Simulink-based and virtual CPU-based methods for analyzing pump behavior matched up extremely closely, thereby providing evidence for the validity of this method. With the virtual CPU-based method, when the actual software is run, an external environment other than the microcontroller is created, and technology is also necessary to integrate the two. We would like to take advantage of the Hitachi's comprehensive strengths in order to conduct further research and development in this area.

Simultaneously Meeting Needs of Advancement and Greater Complexity as well as Safety and High Quality

Not only are automotive embedded systems expected to continue growing more advanced and complex in the future, they also need to comply with the functional safety standard ISO 26262, which was established in 2011. This is why even higher levels of safety, quality, and design and validation efficiency are necessary, and virtual CPU-based MBD greatly contributes to achieving this. In particular, when it comes to compliance with ISO 26262, the ability to validate Failure Mode and Effect Analysis (FMEA) provides major benefits.

APL is also conducting distributed implementation experiments on gasoline fuel pump control systems, and has demonstrated that it is possible to implement a multiphysics design method between bases of operation overseas. Furthermore, Hitachi is also working on research and development in the area of massively parallel processing in a cloud computing environment in order to handle increasingly large amounts of data and test items. We would like to continue developing these types of new methods in order to contribute to the achievement of manufacturing that is safe, high-quality, and efficient.

* See "Trademarks" on page 91.

(From left to right) Yasuo Sugure, Senior Researcher, Platform Systems Research Department, Central Research Laboratory, Hitachi, Ltd.; Sujit S. Phatak, Researcher; DJ McCune, Group Leader/Senior Researcher; George Saikalis, Vice President, Research & Development Division, Automotive Products Research Laboratory, Hitachi America, Ltd.

Boarding Gate with Built-in Explosives Detection for Detecting Explosive Compounds Adhered to Boarding Passes

To ensure the safety and security of transportation services, there has been a need in recent years to improve security in order to prevent people carrying explosive devices onto airplanes or other forms of transportation. One way to make a significant improvement in flight safety would be to inspect all passengers for explosives as they pass though the boarding gate. The problem with this has been that the time required for X-ray or other conventional detection methods has been too long for scanning the large numbers of passengers (several hundreds) who need to pass through the gate for each flight.

In response, to meet the need, Hitachi has been working with Nippon Signal Co., Ltd. and the University of Yamanashi to develop a prototype boarding gate that employs mass spectrometry to detect the presence or absence of explosive compounds within one or two seconds. As a result, it is now possible to inspect all passengers for explosive compounds at the same time as checking their boarding passes, without affecting the flow of passengers passing through the gate.

The features of the prototype boarding gate with built-in explosives detection are as follows.

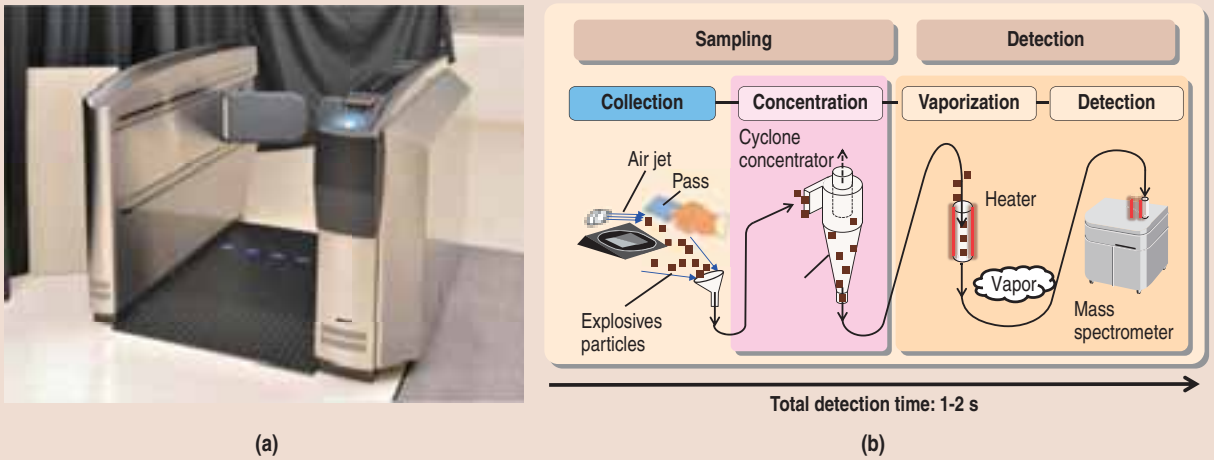
(1) High-speed collection of minute particles adhering to smartcards or portable devices when the device is read

When reading a smartcard or other portable device used as a boarding pass, a jet of high-speed air is used to collect minute particles that have adhered to the device. The development optimized the speed and timing of the air jet, and the positioning of the pass (smartcard or device), to extract and collect the minute particles efficiently and in a short period of time.

(2) High-speed concentration of collected particles and high-sensitivity mass spectrometry analysis

Because the particles are collected together with a large volume of air, a cyclone centrifuge technique is employed to separate and collect the particles from the gas efficiently and quickly. The unwanted gas is expelled from the system. The resulting increase in the concentration of particles means that mass spectrometry can be performed with greater sensitivity. This enables the particles fed into the mass spectrometer to be collected and concentrated in a short time, thus achieving high sensitivity mass spectrometry.

The prototype boarding gate can efficiently collect minute particles that have adhered to smartcards or portable devices used as boarding passes, and its internal equipment can detect the presence of explosive compounds within one or two seconds. The system can inspect 1,200 passengers per hour. Because inspections are performed immediately prior to boarding without disrupting the flow of passengers, the technology is expected to contribute to the prevention and containment of carry-on explosives, while providing increased security without affecting convenience. As this equipment also has the potential for use in entrance security equipment for train stations, stadiums, event halls, and other venues in the future, it is seen as having the role of a platform technology for ensuring safety and security in public places. This research and development was supported by funds for integrated promotion of social system reform and research and development of the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT).



Prototype boarding gate with built-in explosives detection (a) and detection process of explosives detector (b)

Semi-perpetual Digital Data Archive

The rise of our information-based society has brought with it a rapid shift from paper to digital media for the storage of records, and this in turn has created a need for long-term storage technologies. Specifically, public documents and other aspects of our cultural heritage require a means of semi-perpetual storage that is immune to degradation due to factors such as heat or humidity, and that can retain an ability to be read across generations.

Microscopic image of 4-layer sample (layer 3)

To meet this need, Hitachi has developed a digital data storage technique based on fused silica, which is thermally and chemically stable. The data is recorded using a femtosecond laser, and can be read using an optical microscope. The femtosecond laser beam forms tiny regions (dots) of altered structure on the fused silica, and this can be used to record digital data by using each dot site to represent the binary bit "1" if a dot is present, or "0" if absent. A high recording density is achieved by creating multiple recording layers within the fused silica. This is done by changing the focal point of the laser. A recording density comparable to that of a compact disc was achieved using four layers. Testing also confirmed that the data could still be read without degradation even after the fused silica underwent a two-hour accelerated temperature test at 1,000°C. This corresponds to data storage for more than three hundred million years.

In the future, Hitachi plans to increase the recording density to the same level as a digital versatile disc by increasing the number of the recording layers.

920-MHz/250-mW Wireless Transceiver for Long-range Communications

Hitachi has developed a 920-MHz-band wireless transceiver capable of long-range communications (several kilometers) for use in remote control and monitoring systems in industrial energy management and smart grid applications in smart cities. The transceiver supports long-range wireless communications between industrial instruments in applications such as these that increasingly use wireless data collection and control because of its superior cost-performance and ease of configuration. The 920-MHz band is a universal frequency band used by common international wireless standards such as IEEE802.15.4g.

To comply with Japan's strict radio regulations, the transceiver uses a new high-performance surface acoustic wave (SAW) filtering technology with very steep frequency dependence to suppress the spurious emissions that can be generated as a by-product of 250-mW high-power carrier signals. The new filter helps the transceiver achieve certification under the Association of Radio Industries and Businesses (ARIB) T-108 standard. The transceiver also features a software-selectable power output that can be switched between 1, 20, or 250 mW, allowing the appropriate power level to be selected for the communication range and power consumption requirements of specific applications, such as automotive and railway systems.

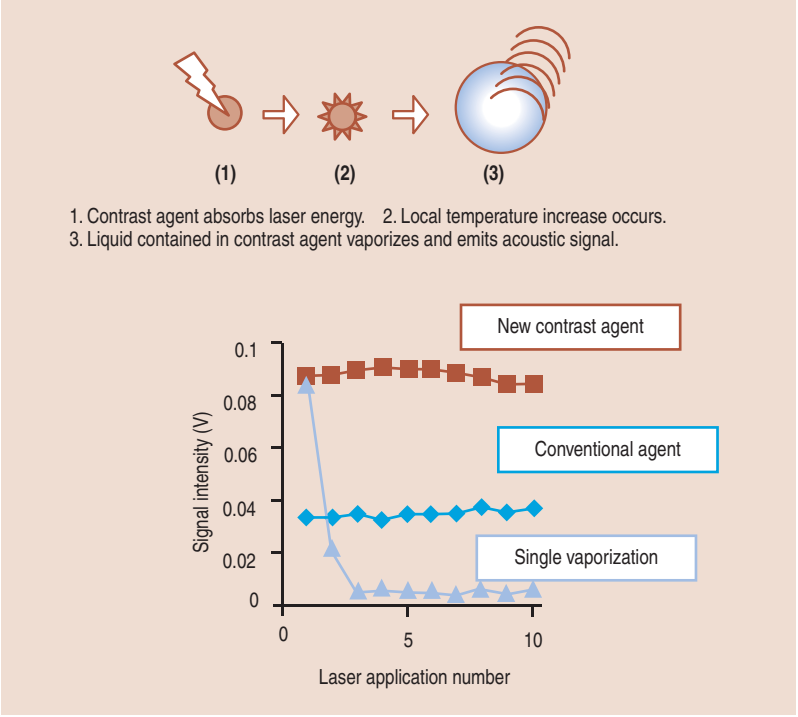
920-MHz/250-mW wireless transceiver

Development of Highly Sensitive Photoacoustic Contrast Agent for Early Detection of Cancer

Hitachi has developed a highly sensitive photoacoustic contrast agent for use in the early detection of cancer. Photoacoustic contrast imaging can visualize targets such as cancer by transmitting laser pulses and detecting the acoustic signals that these pulses generate. Our new contrast agent aims to provide a much stronger signal by using a fundamentally different signal emission process to that of conventional photoacoustic contrast agents.

When a droplet of contrast agent absorbs the energy from an applied laser pulse, the liquid contained in the droplet vaporizes instantly and in the process emits a strong acoustic signal. Experiments have confirmed that vaporization of the new contrast agent generates photoacoustic signals that are three times higher than before. Testing also confirmed that changing the liquid component contained in the contrast agent allows vaporization to occur repeatedly. This suggests that even stronger contrast enhancement could be achieved by using multiple laser pulses.

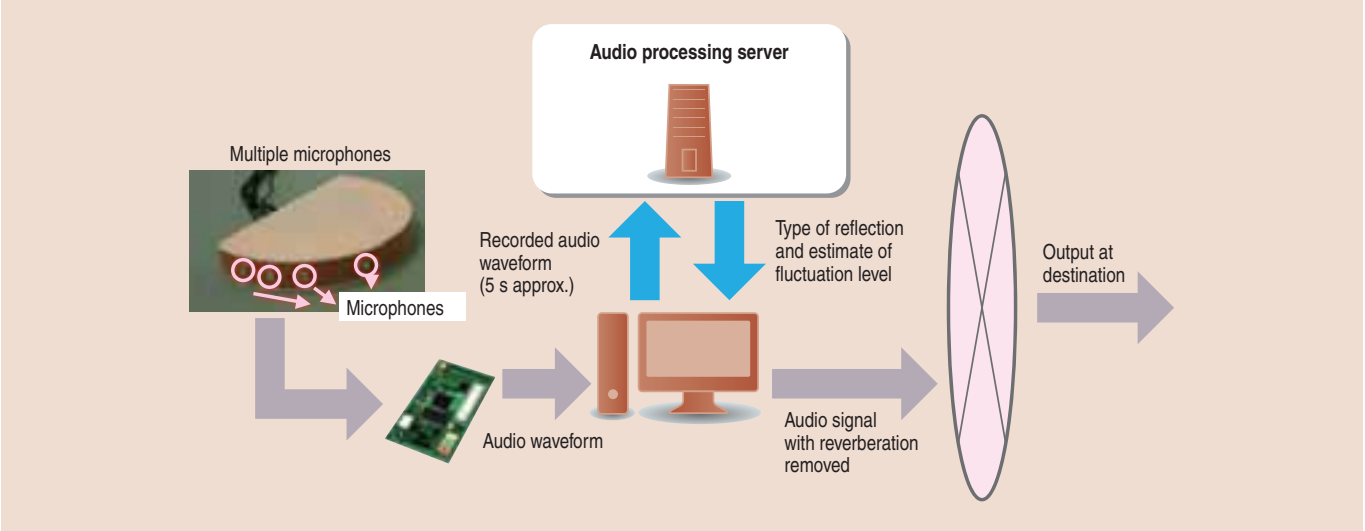
If linked to an appropriate cancer-indicating molecule, this new technique has the potential to facilitate detection of even smaller cancers at an early stage of progression.



Vaporization of contrast agent (upper) and photoacoustic signal intensity (lower)

Dereverberation Technique for Teleconferencing Systems

Teleconferencing systems need to provide smooth and efficient communication between people in distant places. Unlike teleconferencing in a small room with only a few people, teleconferencing in a large venue holding several dozen people suffers from reverberation from the ceilings and walls. In response, Hitachi has devised a novel dereverberation technique that can reduce reverberation accurately even in the presence of head or body movement. When tested in practice, the new technique reduced reverberation to one-ninth its previous level.



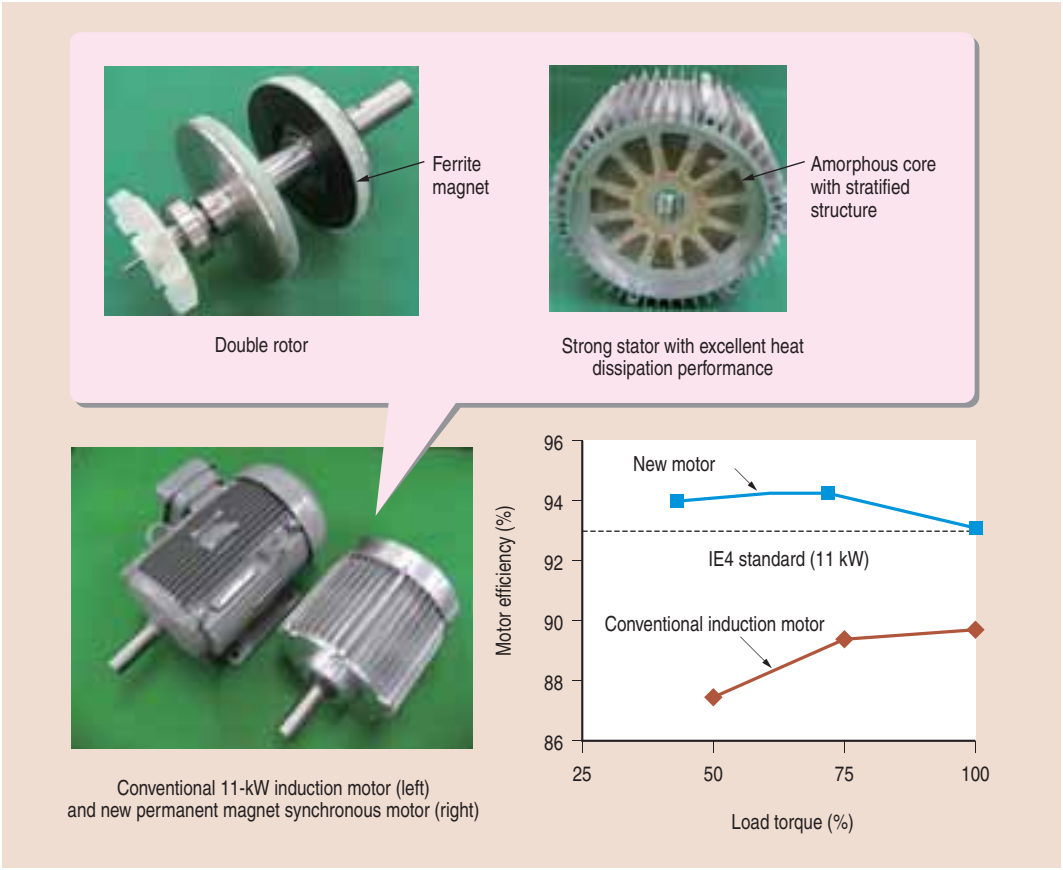
Structure of teleconferencing system with new dereverberation technique

Highly Efficient 11-kW Permanent Magnet Synchronous Motor for Industrial Applications with no Rare Earth Magnets

Hitachi Research Laboratory of Hitachi, Ltd. and Hitachi Industrial Equipment Systems Co., Ltd. have jointly developed a highly efficient 11-kW permanent magnet synchronous motor that does not use magnets that contain rare earth metals (neodymium and dysprosium).

The motor is able to make effective use of low-magnetic ferrite material by using a double rotor, axial gap design with an increased volume of magnetic material, and an iron-based amorphous metal with significantly lower core loss. This configuration was achieved through the development of a stator design that combines heat dissipation performance with the strength to handle high torque loads, a stratified core structure that takes advantage of material characteristics, and three-dimensional magnetic field and thermal analysis technologies that were used to optimize the design. Despite being smaller than existing motors, the 93% energy efficiency of the new motor complies with IE4, the highest efficiency guideline of the International Electrotechnical Commission (IEC). Hitachi plans to commercialize the motor for industrial applications.

A part of this work was supported by the New Energy and Industrial Technology Development Organization (NEDO), Japan as part of its support program for the development of practical technology to substitute or reduce rare metals.



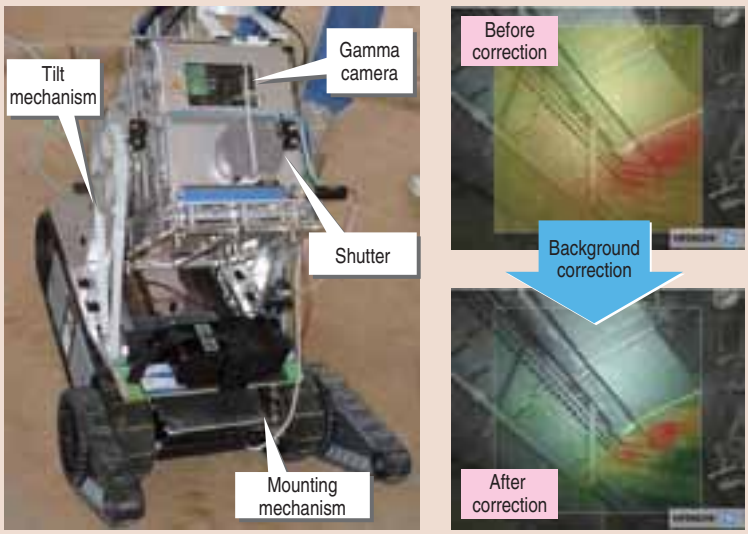
Comparison of structures of new and old motors

Dose Distribution Measurement Technique in High Dose Rate Environments

Hitachi has developed a dose distribution measurement technique that can remotely measure the distribution of gamma ray intensities in high dose rate environments inside nuclear reactor buildings.

The technique uses optimized gamma camera shielding and collimators together with a background correction function based on the shutter mechanism to perform measurements under high dose rate environments (80 mSv/h). Realtime, remote measurement is achieved by a combination of wire and wireless communications. The technique is being used to help with surveys at Units 1 to 3 of the Fukushima Daiichi Nuclear Power Station.

In the future, Hitachi intends to upgrade the technique to operate under even higher dose rate environments, and to enhance its accuracy by incorporating a three-dimensional distance measurement function, with the aim of utilizing it in long-term reactor decommissioning projects in situations with a high level of radioactive contamination.



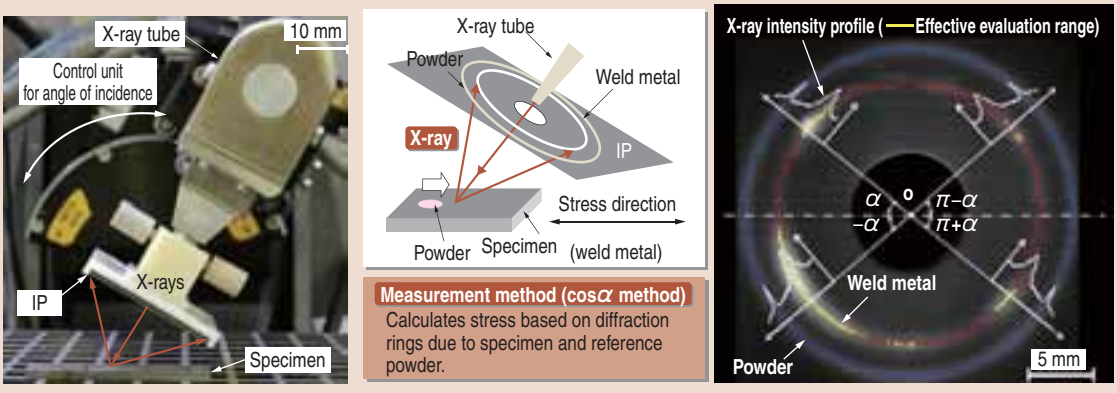
Gamma camera for sites with a high dose rate, and an example measurement images

Residual Stress Measurement Technique Using 2D X-ray Diffraction

While X-ray diffraction can be used to measure residual stress from lattice strain in a crystal, the one-dimensional (1D) diffraction patterns used in the past had difficulty performing measurements on weld metal, which is characterized as coarse crystals and texture.

Hitachi has incorporated an imaging plate (IP) into an existing X-ray diffraction instrument (the iXRD Combo from Proto Manufacturing Ltd. of Canada) to develop a technique for performing measurements from two-dimensional (2D) diffraction patterns. Due to its microscopic characters, weld metal usually shows incomplete diffraction patterns on IP. The new technique works by using an algorithm to select the effective range from these patterns for evaluating residual stress of weld metal.

In the future, Hitachi intends to make further improvements in measurement accuracy and utilize the technique for in-service measurement of welds.



2D X-ray diffraction instrument (left), diagram of measurement process (center), and image processing of diffraction patterns (right)

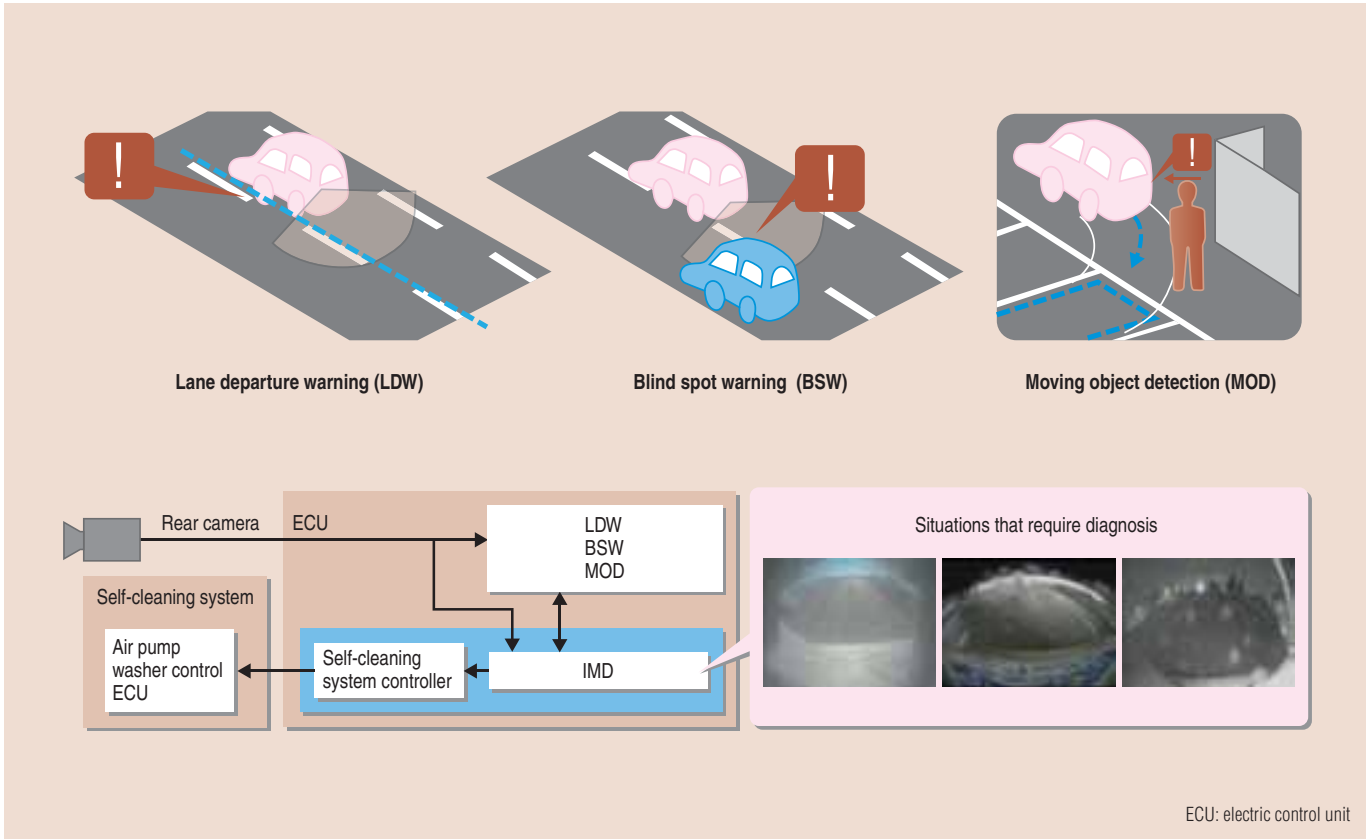
Self-cleaning Driving Safety Support System Using Rear Camera

In collaboration with Clarion Co., Ltd. and automotive manufacturers, Hitachi, Ltd. has commercialized a preventive safety system that uses image recognition from a monocular rear camera.

The system uses the rear-mounted fisheye-lens camera provided for parking assistance to implement blind spot warning (BSW), lane departure warning (LDW), and moving object detection (MOD) functions. A major feature of the BSW function, which detects when another vehicle is present in the driver's blind spot, is that it can achieve this using the rear camera only.

Because the rear camera is mounted on the vehicle exterior, the lens can become dirty due to splashes of water and mud when driving on a wet road surface after rain. Deposits of this material can build up on the lens surface over time resulting in cloudy images. The loss of image quality that results from a dirty lens surface can make image recognition performance unreliable. To ensure reliable operation even when image quality is degraded, the system incorporates an image diagnosis (IMD) function that assesses the road surface, lighting, and lens condition from the camera images. This has succeeded in making image recognition performance more robust by making appropriate use of an algorithm for improving the performance of the BSW, LDW, and other image recognition functions based on the assessment of the IMD function. The system can also spray air and washing fluid when needed to keep the lens surface in good condition.

The numerous common difficulties faced when using image recognition from vehicle-mounted cameras include camera movement, changes in the ambient environment (due to factors such as weather, time of day, and backlight), and the various different aspect of the object to be detected. In the future, Hitachi intends to produce image recognition systems, which can recognize objects more robustly under various environments.



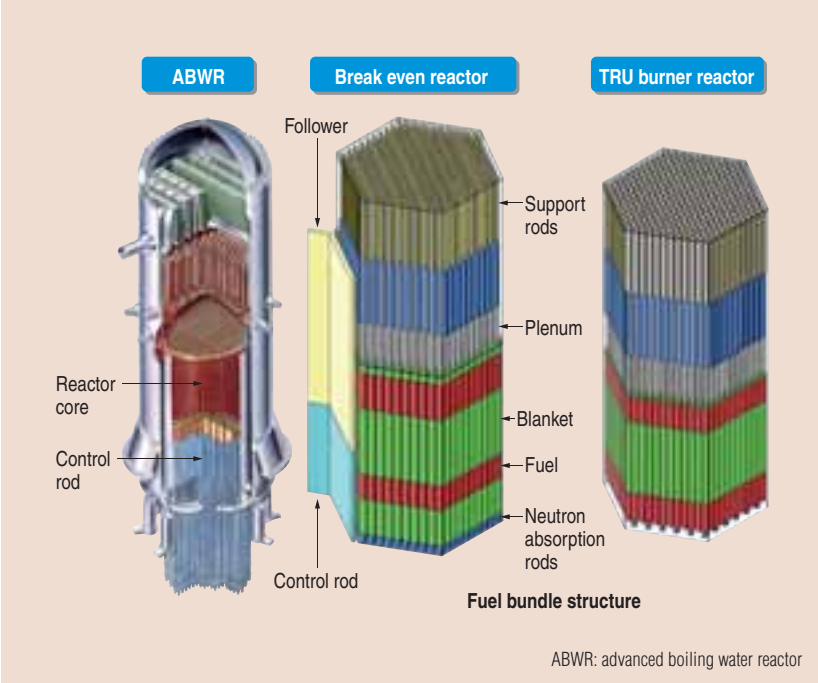
Self-cleaning driving safety support system using rear camera

RBWR System

Hitachi has proposed a new resource-renewable boiling water reactor (RBWR) that is capable of achieving nuclear fission of uranium 238 (U-238) (which makes up more than 99% of mined uranium) without increasing the amount of trans-uranium elements (TRUs), and also of achieving the nuclear fission of almost all of the TRUs produced in light water reactors.

By using existing technology from light water reactors to increase the utilization of uranium and eliminate the need for external storage of TRUs, the new reactor design can significantly reduce the load that nuclear power generation places on the environment. Electric Power Research Institute, Inc. (EPRI) is currently completing an evaluation of the RBWR.

In the future, Hitachi plans to use an experimental reactor to verify whether nuclear fission of TRUs produced by operating light water reactors can be performed safely at rates that are two or more times faster, with the aim of removing one of the obstacles to the construction of new light water reactors by overcoming concerns that TRUs will end up as long-term radioactive waste.



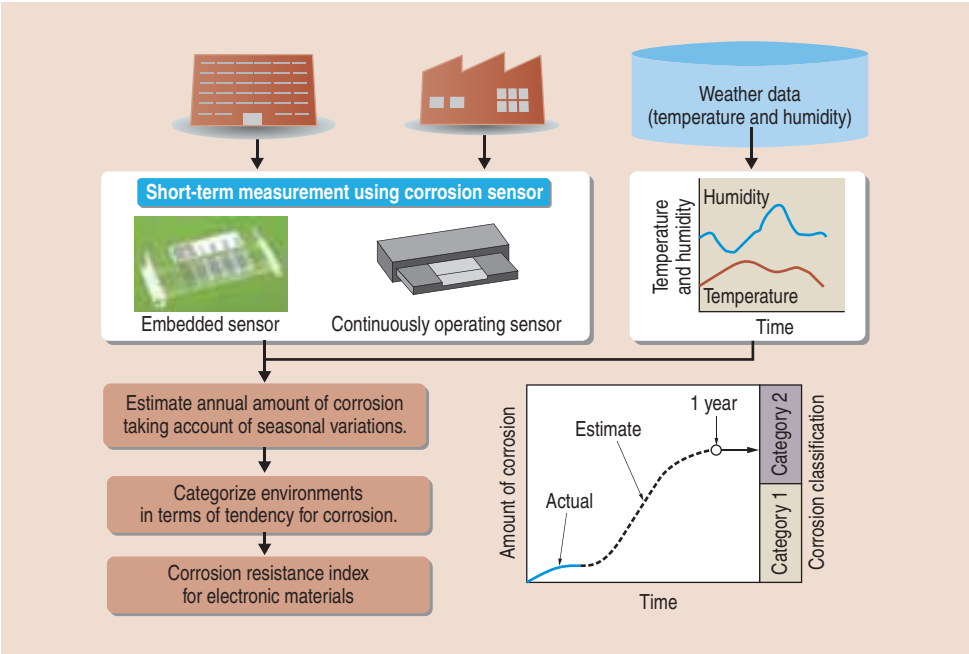
RBWR system and fuel bundles

Technique for Assessing Corrosion of Electronic Materials

Hitachi has developed a technique for assessing the corrosion of electronic materials that can quickly and accurately determine the tendency for corrosion to occur in environments where electronic equipment is installed.

It is possible to produce accurate estimates for the amount of corrosion that will occur over a year from data collected over a short period (one to three months) from sources such as corrosion sensors for electronic materials together with publically available weather data (temperature and humidity) that is used to take account of seasonal variations. This information can help cut the costs associated with the corrosion of electronic equipment by using it to assess the tendency for corrosion to occur at installation sites, and to implement appropriate countermeasures.

In the future, Hitachi intends to deploy this technique for quickly assessing the tendency for corrosion to occur in specific environments by utilizing it for corrosion assessments in emerging nations.

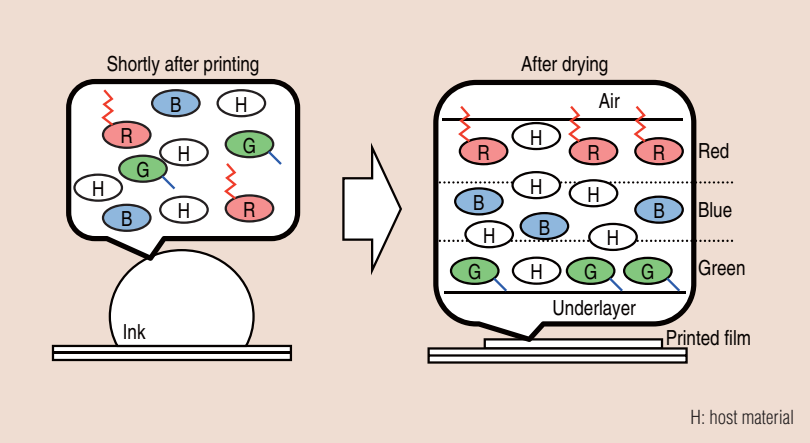


Technique for assessing corrosion of electronic materials

Printable White Organic Light-emitting Diode for Environmentally Conscious Lighting

A highly efficient white organic light-emitting diode (OLED) fabricated by solution processes has been developed to achieve a next-generation light source with low cost and low-power consumption that is mercury-free. The emitting layer is fabricated in a one-step solution coating process using a self-layered technique that was developed to reduce the cost and improve the efficiency of OLED. In this technique, a multi-layered structure is formed by controlling the concentration of dopants in the cross-sectional direction. To localize the dopants, a special substituent was added to the dopants. The dopants with the substituent move to the surface (or bottom) of the emitting layer during drying. A maximum power efficiency of 70 lm/W was obtained by applying high photoluminescent quantum yield dopants and improving light-extraction efficiency. The photoluminescent quantum yield of the dopants was enhanced by a molecular design that confines the excited states on a radiative moiety of the dopants. An efficient molecular orbital calculation method based on the density functional formalism was used for molecular design of the dopants. The light-extraction efficiency was also improved by reducing a non-radiative mode using a thick electron transport layer and placing a light-outcoupling layer on the OLED.

In the future, Hitachi intends to continue improving the efficiency and lifetime of printable white OLEDs.



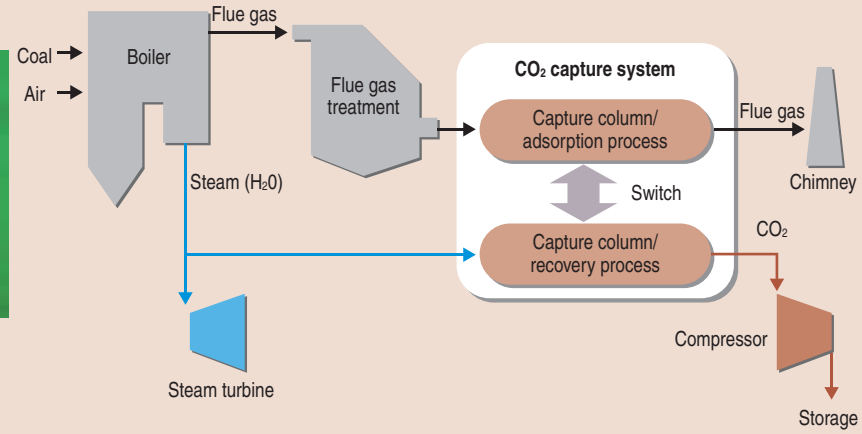
Conceptual illustration of self-layered technique

Solid CO_2 Adsorbent for Thermal Power Plants

Hitachi is developing a solid material capable of adsorbing the carbon dioxide (CO_2) emitted from thermal power generation systems.

A problem that has obstructed the use of existing solid adsorbents for CO_2 separation is that they preferentially adsorb the moisture in the flue gas. Recognizing that cerium oxide is able to adsorb CO_2 even under moist conditions, work by Hitachi has succeeded in increasing the quantity of CO_2 adsorbed by a factor of approximately 13, both by increasing the number of sites for CO_2 adsorption and by increasing the likelihood of contact between the adsorption sites and CO_2 gas. Laboratory-scale testing has indicated that the new material should be able to reduce the energy requirements for CO_2 capture down to roughly the same level as amine solvents.

In the future, Hitachi intends to reduce energy requirements further through material, system, and other enhancements.



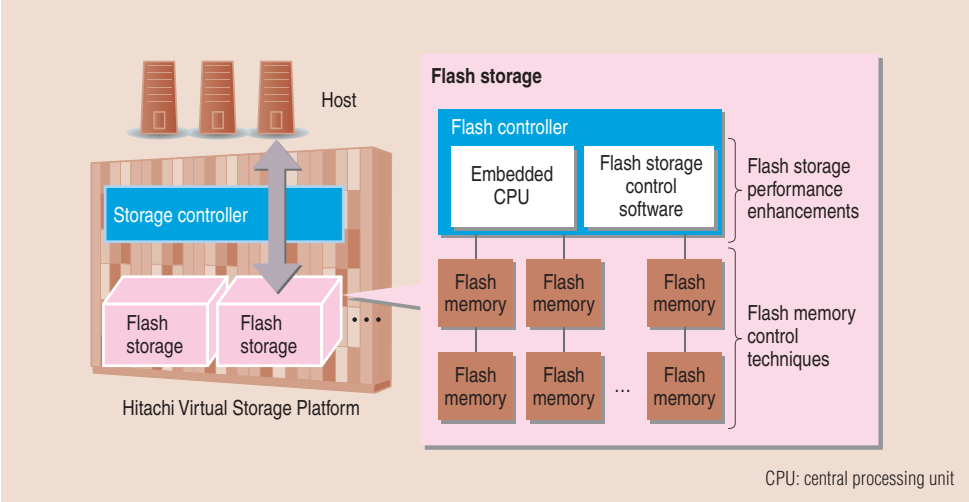
CO_2 adsorbent and block diagram of CO_2 capture system

Technology for Enhancing Performance of Flash Storage

The falling price of solid-state drives (SSDs) made using NAND flash memory in recent years has meant that storage systems, which in the past have primarily used hard disk drives (HDDs), are in an increasing number of cases now also incorporating SSDs.

Now, Hitachi has developed a flash memory control technique that can operate large flash memories at higher speeds than conventional SSDs. Hitachi has also developed technology for enhancing the performance of flash storages by coordinating the operation of a storage controller and the flash storages, taking advantage of its position as a manufacturer of both components.

The flash storages that incorporate this technology have been commercialized in Hitachi storage systems, and Hitachi intends to continue developing technologies for further enhancing the performance of flash storages.



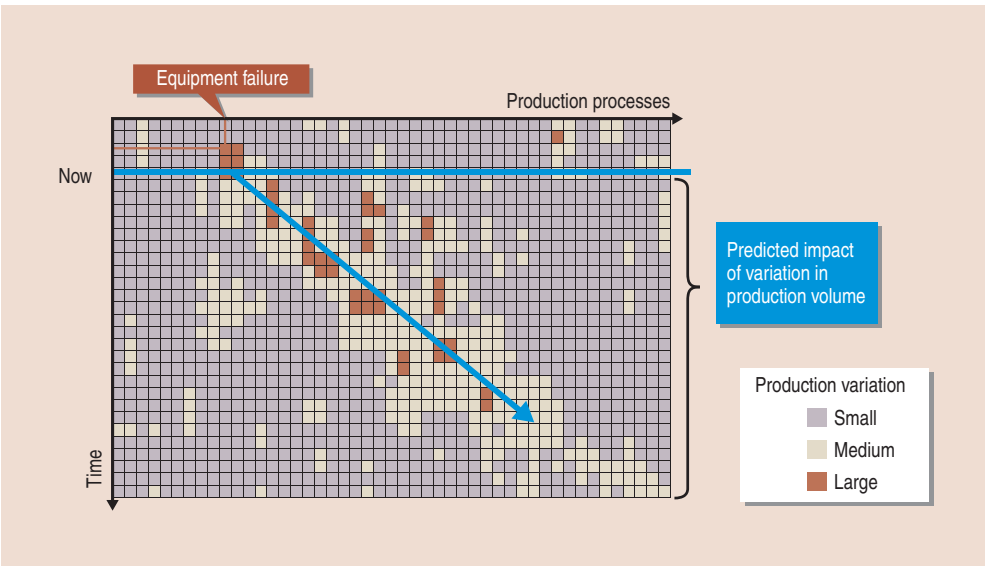
Technology for enhancing the performance of flash storage

Technique for Predicting Impact of Variations in Production Volume

With production facilities expanding globally in recent years against a background of business globalization, there is a need for production control techniques that can minimize the impact of disruptions caused by unexpected events.

In response, Hitachi has developed a production control technique that can make accurate predictions of future changes in the output of production processes using a new visualized coefficient of variation analysis (VCVA) statistical model for quantifying the variations in production volume that arise from events such as unexpected parts supply shortages or the failure of production machinery. VCVA uses a matrix with production processes on the horizontal axis and the time schedule on the vertical axis to present numeric values for the status of each production process on each day, and color-coding to represent the size of fluctuations in production volume. This presentation makes it easy to take an overview of the entire production process and see how a delay in a specific process can propagate to downstream processes with time. It can also be used as a way to consider what actions should be taken to minimize delivery delays or falls in production volume.

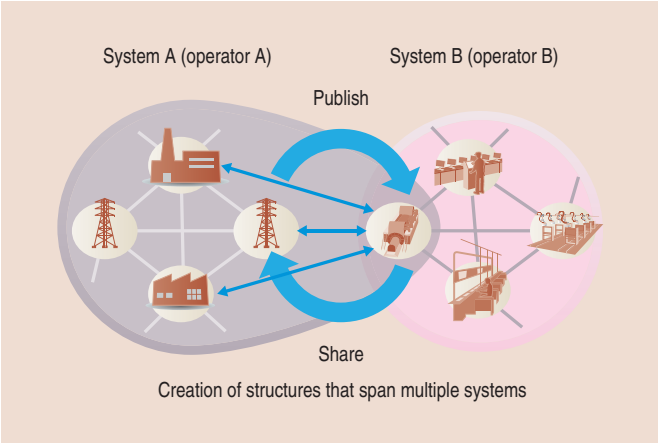
In the future, Hitachi intends to use this new development technology as a base for expanding its application to a wider range of processes within the group, and for establishing a production control consulting services for external customers.



Technique for predicting impact of variations in production volume

Symbiosis-autonomous Decentralized Concept

The symbiosis-autonomous decentralized concept refers to systems that are individually autonomous and yet also designed to work together to respond to changing circumstances or requirements. The aim of this approach is to create sustainable and efficient social infrastructure systems. Individual systems publish and share their own internal information so that their status to be determined by other systems. In this way, when a shortage of resources occurs, systems can respond altruistically by freeing up and sharing their own resources, thereby smoothing over peaks and troughs in resource use.



Symbiosis-autonomous decentralized concept

In the case of electric power management systems and production management systems, these systems can publish and share information on electric power supply as well as on factors that influence supply and demand such as production schedules. For example, if a shortage of electric power is predicted, a production management system can free up excess power by adjusting its own production schedules to the extent that it is able to do so without compromising its production targets. This minimizes the total cost to society by eliminating the need for standby power generation or storage capacity.

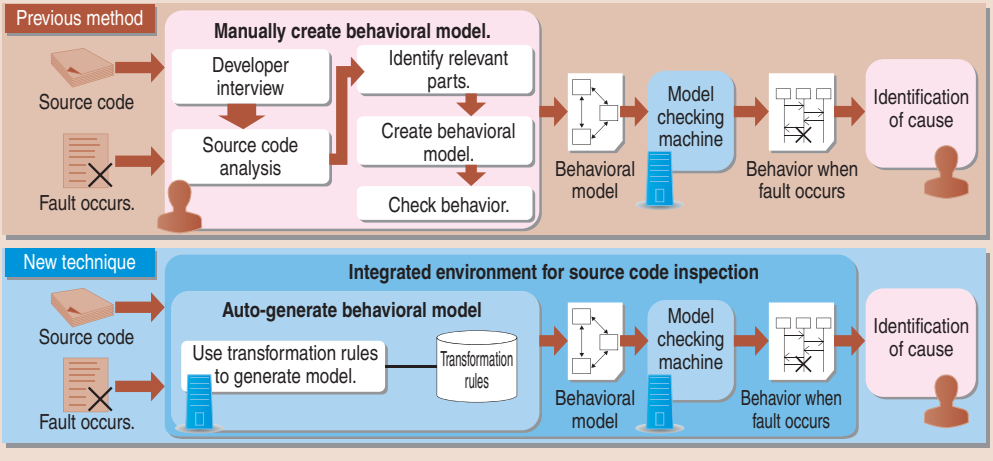
In the future, Hitachi intends to deploy this concept in activities such as its smart city business in Japan and elsewhere to contribute to the creation of inherently sustainable societal systems.

Technique for Generating Models from Software

Many of the social infrastructure systems that underpin modern society are controlled by software. Referred to as embedded software, these programs have a major influence on our way of life and require a high level of quality. However, as embedded software becomes larger and more complex, it becomes more difficult to identify the causes of faults, which may occur only rarely in live systems and be dependent on factors such as timing.

To ensure high-quality software development under these circumstances, Hitachi has developed a technique for generating behavioral models that are abstracted from the software's source code. The causes of faults that may lie hidden inside the software's source code can then be identified through a comprehensive checking of the resulting behavioral model. When the technique was used during in-house product development, the amount of time spent of identifying the causes of faults was cut by 65% compared to the previous method.

In the future, Hitachi intends to make the technique easier to use and to develop it further to produce tools suitable for use with a wide range of different products.

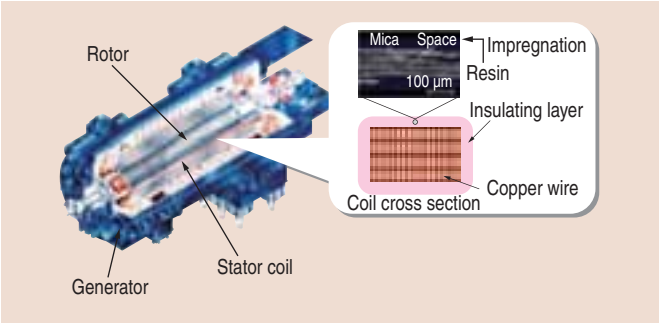


Fault cause identification based on generation of a behavioral model

3D Simulation Technology for Resin Impregnation of a Stator Coil

Resin-impregnated molding involves the infusion of resin into the spaces in a base material, such as pulverized mineral, that is bonded to carbon fiber or other reinforcing material. Because the sizes of the spaces in the base material are in the micron range, the computational requirements for performing resin flow analysis of large structures with a size in the range of meters are very large, and therefore difficult to carry out in practice.

In response, Hitachi has developed a technique for analyzing resin impregnation that is suitable for use with large structures. The technique uses an impregnation model that considers the macroscopic changes in resin pressure as it passes through the spaces in the base material, but without modeling the base material shape, and combines this model with the use of a visualization instrument able to identify the impregnated region experimentally so as to determine the flow properties of the impregnation model. When applied to the insulating layer of the stator coil for a large turbine-generator with a total length of about 10 m, the technique succeeded in predicting the variation in resin filling time, and it is estimated that the resulting adjustments to the impregnation time will cut this time by up to about 50%.



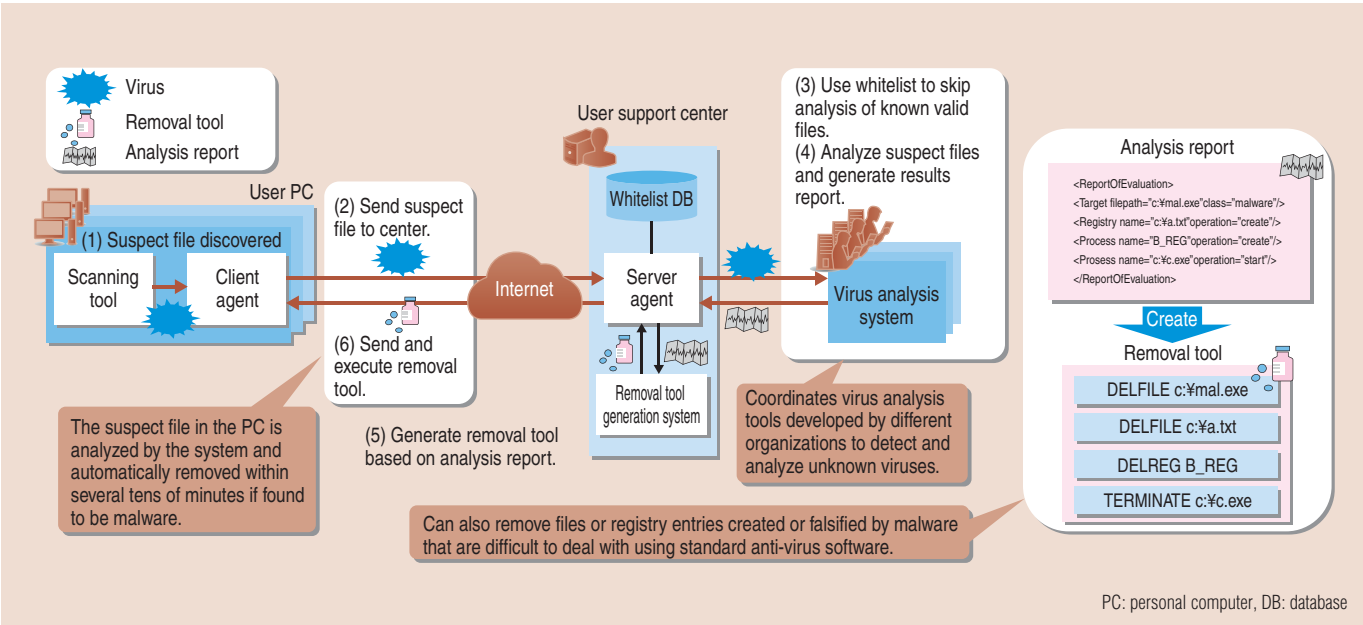
Structure of insulating layer of the generator stator coil

Countermeasures against Targeted Attacks

Targeted attacks aimed at acquiring confidential information from specific companies or causing damage to public infrastructure systems have become a major issue in recent times. What is needed to deal with this threat is multi-level protection that can provide multiple layers of measures that cover entire systems.

Hitachi is developing a range of different countermeasures in response to this situation. These include systems that analyze the behavior of suspect files and automatically remove them if they are deemed to be infected with a virus, analysis techniques that scan logs to detect traces left by communication between viruses and attackers, and risk-based authentication techniques that re-authenticate devices that communicate with suspect parties. Incidents such as information theft or system damage can be prevented by implementing these techniques on systems.

Some of the technologies described in this article were supported by a consignment research from National Institute of Information and Communications Technology (NICT), Japan.



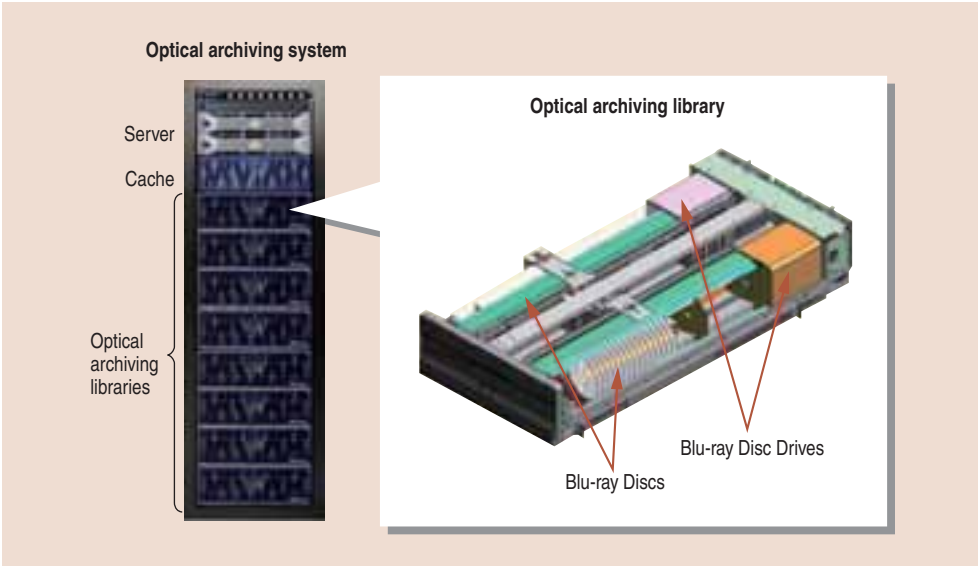
Automatic virus detection and removal system

Development of Optical Archiving System for Long-term Storage of Large Quantities of Data

As the quantity of data built up by companies and individuals continues its explosive growth, demand is increasing for storage systems capable of the long-term archiving of large quantities of data. Hitachi is currently developing an optical archiving system to meet this need.

The optical archiving system consists of a server, cache, and multiple optical archive libraries. Data is transferred from the server to the libraries where it is archived on a storage medium. The storage medium chosen for the system is a special archiving Blu-ray Disc* designed for high reliability and long life to ensure that the system is capable of long-term storage and is able to protect data in the event of a disaster. Each library unit contains 500 disks (100 Gbyte each) and 12 drives for the efficient archiving of large quantities of data.

Development of the basic functions is already complete and sample systems are being supplied to customers.



Example configuration of optical archiving system and internal structure of optical archiving unit

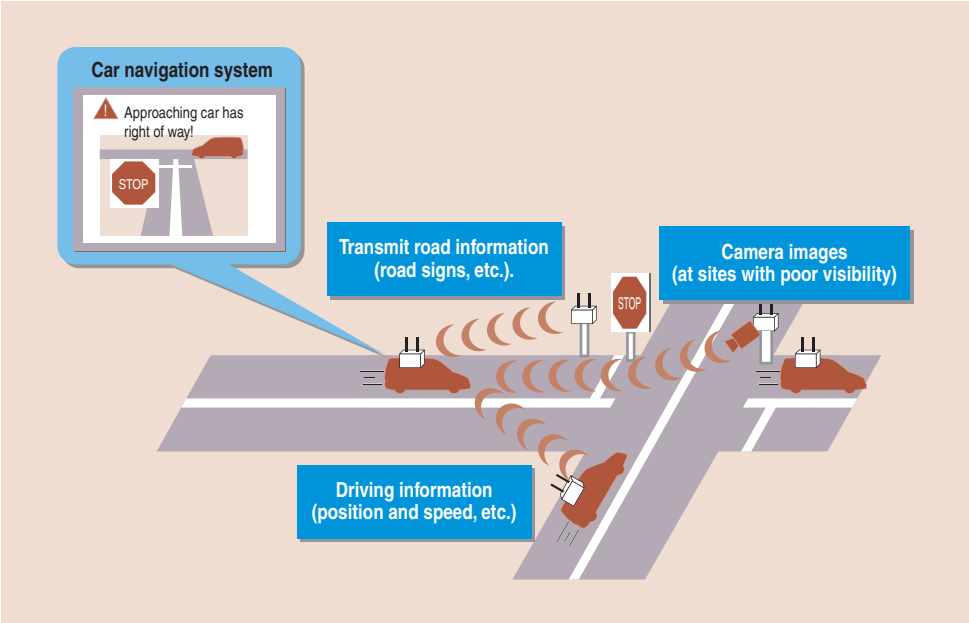
* See "Trademarks" on page 91.

Cooperative Driving Safety Support System

Initiatives are being undertaken in Japan, the USA, and Europe aimed at using wireless communications between vehicles and between vehicles and road infrastructure to achieve more advanced road traffic behavior. Called "cooperative driving safety support systems," these systems exchange vehicle movement and other information to detect potential accidents and warn the driver.

Hitachi has developed technology for detecting potential accidents based on information obtained from the vehicle's own control systems and information about the movements of other vehicles obtained via wireless communications. The work included standardizing the communications specifications and trialing the operation of a prototype system.

In the future, Hitachi intends to continue improving the accuracy of the technology, and to deploy it in its vehicle-mounted information systems business and infrastructure systems business.



Cooperative driving safety support system