

Featured Articles

Cloud-based Equipment Maintenance and Facility Management Service Platform

Hiroshi Yoshikawa
Tetsuya Tsubokura
Shigeru Toida
Yuuji Kawai
Fumio Hatori

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.

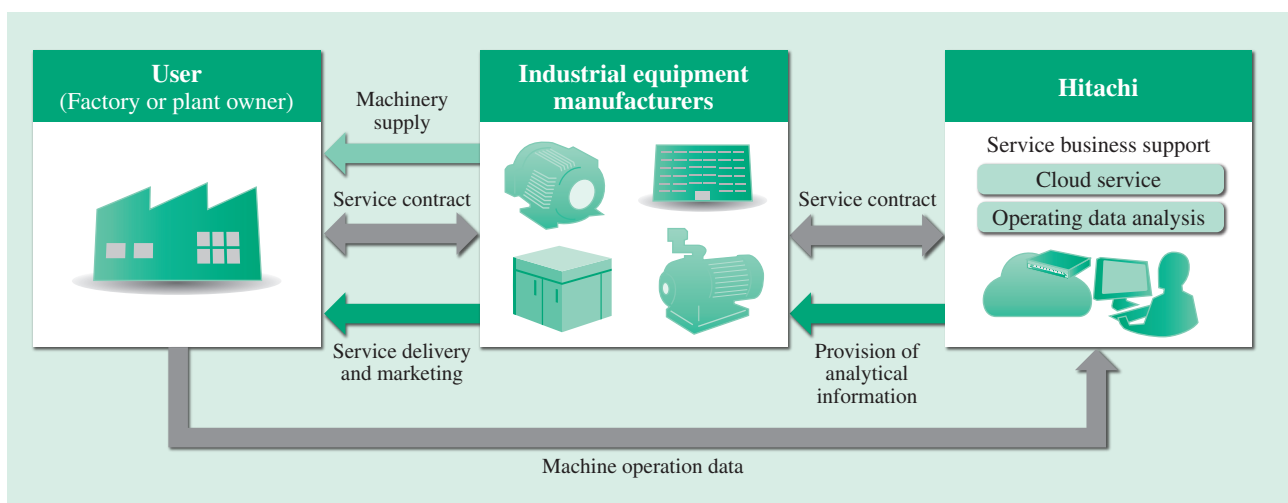


Fig. 1—Overview of Hitachi Cloud-based Equipment Maintenance and Facility Management Service. This provides cloud and operational data analysis services to industrial equipment manufacturers.

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

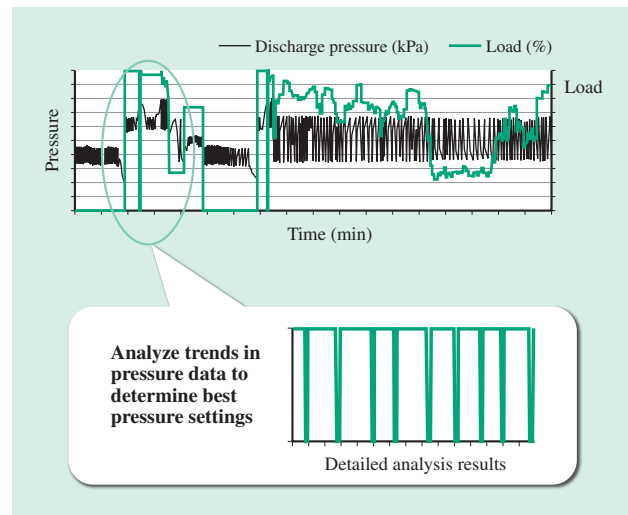


Fig. 2—Results of Analysis of Best Pressure Settings for Air Compressors.

This example involved analyzing trends in pressure data to determine the best pressure settings.

an air compressor to enable a faster initial response, the service can also predict appropriate maintenance timings by analyzing trends in various data.

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-

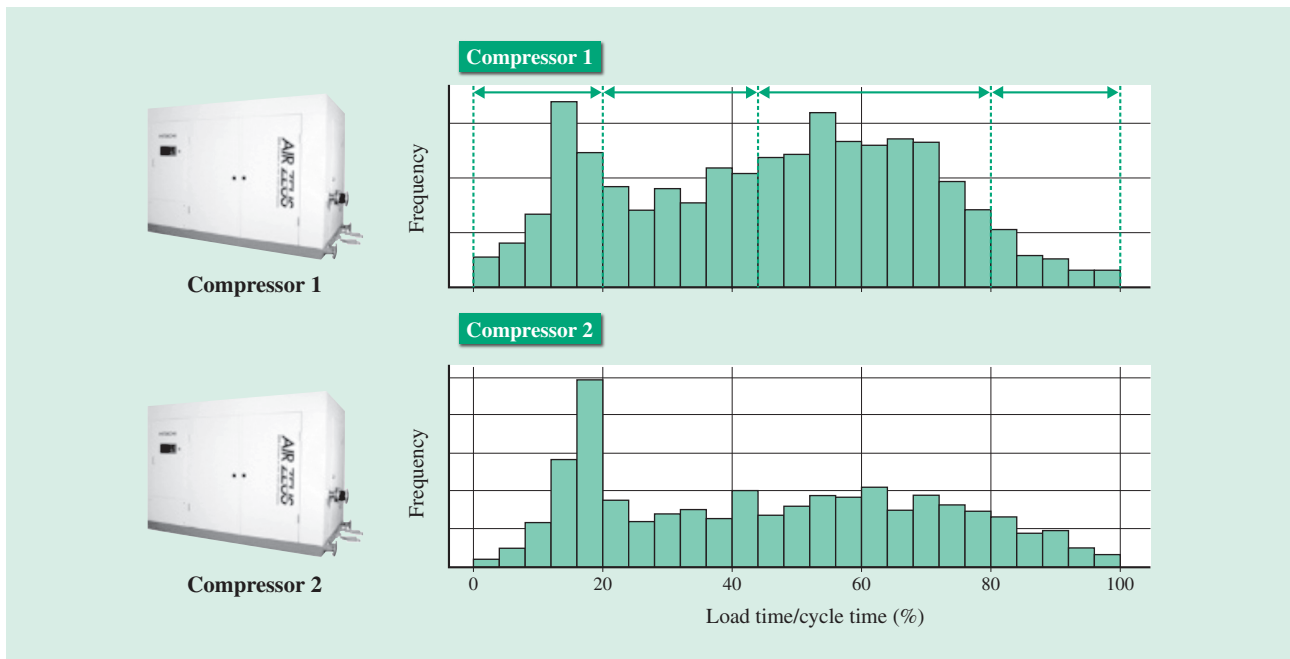


Fig. 3—Analysis of Operating Patterns.

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.

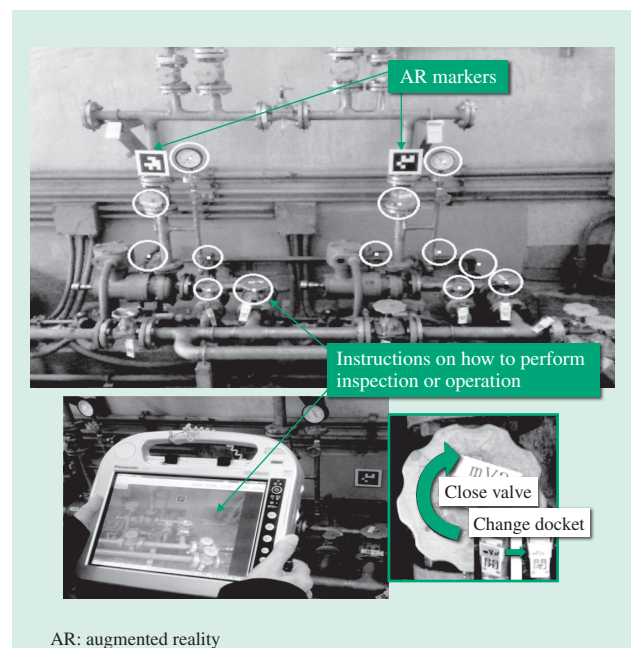


Fig. 4—Overview of AR Navigation System for Plant Operations. AR is used to provide visual instructions on how to perform inspection or operation.

(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.

REFERENCES

- (1) Industrie 4.0 Working Group: Recommendations for implementing the strategic initiative INDUSTRIE 4.0 (Apr. 2014)
- (2) GE, Industrial Internet, <http://www.ge.com/stories/industrial-internet>
- (3) S. Toida, F. Hatori, and M. Takemoto, "Plant Maintenance Services and Application of ICT," *Hitachi Review* **62**, pp. 276-281 (May 2013).

ABOUT THE AUTHORS



Hiroshi Yoshikawa
Energy Systems Department, Matsudo Research Center, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of information technologies for EPC and services. Mr. Yoshikawa is a member of the Information Processing Society of Japan (IPSJ).



Tetsuya Tsubokura
Energy Systems Department, Matsudo Research Center, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of information technologies for EPC and services. Mr. Tsubokura is a member of the IPSJ and The Japan Society of Mechanical Engineers (JSME).



Shigeru Toida
Solution Service Promotion Office, Infrastructure Systems Strategic Planning Division, Infrastructure Systems Group, Hitachi, Ltd. He is currently engaged in planning for service business magnification. Mr. Toida is a member of the JSME.



Yuuji Kawai
Solution Service Promotion Office, Infrastructure Systems Strategic Planning Division, Infrastructure Systems Group, Hitachi, Ltd. He is currently engaged in the development of cloud computing applications for factory and plant services.



Fumio Hatori
R&D Division, Hitachi Infrastructure Systems (Asia) Pte. Ltd. He is currently engaged in the development of global service business. Mr. Hatori is a member of the Japan Society of Civil Engineers (JSCE).