

Buildup and operating of data analysis platform “DS Cloud™”

～Efforts toward advanced O&M and products～

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Abstract

With the need to advance the operation and maintenance of plants growing every year, our company is accelerating the optimization of plants by launching the data analysis platform “DS Cloud™”. DS Cloud™ has useful functions, such as cooperation with edge computing (local advanced computers), cyber security, data backup, and utilization of analysis results. And it has started to be used, for example, in plant fields such as waste-to-energy, and in the electric power business field. In addition, we are trying to contribute to society by focusing on the development of data science human resources and the creation of value-added products and solutions.

1 Introduction

Recent years have seen dramatic progress in fields such as the Internet of Things (IoT) and artificial intelligence (AI), with a trend toward data analytics playing a core role in marketing and product development. This trend extends to plant engineering, with vendors offering data acquisition and analysis platforms and greater use being made of low-cost wireless sensors that can be installed in large quantities.

Nippon Steel & Sumikin Engineering has also devoted considerable effort to these technologies, having provided operation & maintenance (O&M) services that include supplying to the waste-to-energy and cogeneration industries, in particular, proprietary remote monitoring systems that have proven their effectiveness at getting the best out of equipment operation by allowing operating companies to undertake monitoring and support from their head office. The company has since gone on to develop its DS Cloud™ data analysis platform to provide further optimization. This article describes what DS Cloud™ has to offer.

2 Rising Demand for Advanced Data Analysis

Figure 1 shows the evolution of data analysis (advanced forms of operation and maintenance support) at Nippon Steel & Sumikin Engineering.

In applications such as waste-to-energy plants, the company has been providing operational support from the head office since the 1990s. As the communications infrastructure at the time was not as well developed as that available today, data from each site was forwarded to the head office once a day. Head office staff would then review and analyze the data, using it to advise on things like changes to operating practices.

As the 2000s brought growing demand for ways of achieving stable operation while minimizing the use of process inputs, Nippon Steel & Sumikin Engineering responded by developing the PlantPAD™ system that provided remote monitoring from portable devices as well as real-time data collection and analysis, and also by

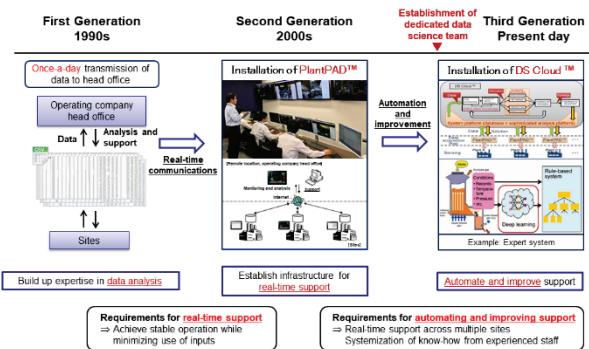


Figure 1 History of data analysis in this company



Figure 2 Monitoring at the operating company head office

establishing the capacity for remote monitoring and support from operating company head offices in real time, an application that entered service in 2011 (see Figure 2).

While use of these systems has already demonstrated significant benefits for maintaining reliable plant operation, putting remote monitoring and support in place for a large amount of equipment comes up against the limits of human ability to monitor all of this equipment at the same time and provide appropriate support. This in turn has led to demand for ways of utilizing advanced data analysis to automate and improve operation and maintenance support.

Nippon Steel & Sumikin Engineering already has experience with the development of operational guidance systems based on data analysis. The company responded to the requirements described above by establishing a new Data Science Solution Section (DS3) at its Engineering R&D Institute (which serves the entire company) in April 2017 to pick up the pace of this work. This included setting up the proprietary DS Cloud™ data analysis platform and commencing its operation (see

Figure 3).

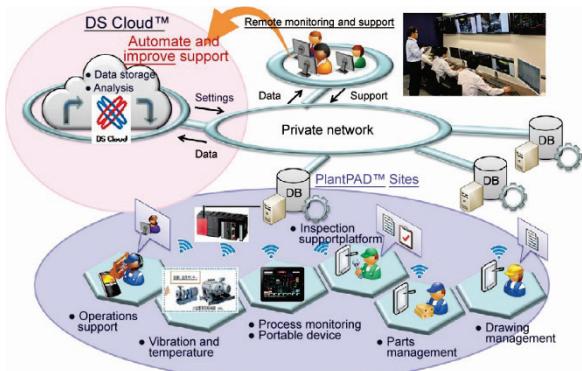


Figure 3 O&M with DS Cloud™

3 Features of DS Cloud™

DS Cloud™ is a data analysis platform that supports the use of data throughout the company. Developed in collaboration with group company, NS Solutions, the platform incorporates leading-edge IT and data analysis systems.

Whereas past practice was based on data being stored and analyzed separately for each item of equipment using edge computing (enhanced computers that have been customized to suit particular equipment, including PlantPAD™), the adoption of DS Cloud™ satisfies the requirement in O&M for an efficient way to consolidate operational data from across a range of different equipment, to store it for long periods of time, and to perform advanced data analyses. It can also be utilized for different equipment or products.

The following sections describe the features of DS Cloud™ in more detail.

3.1 Basic Concepts

Data acquired from different equipment is sent via the edge computing systems to the large-scale storage that forms part of the DS Cloud™ system platform. To allow for the integration of various different types of equipment, a low-cost DS Cloud™ adaptor has been developed to provide a simple way for those items of equipment that do not have their own edge computing systems to send data to DS Cloud™ (see Figure 4).

Once consolidated and stored on DS Cloud™, the data

is analyzed for different purposes. The DS3 plays a leading role in this work, which includes taking data made up solely of tables of figures and subjecting it to pre-processing (things like identifying useful data and eliminating missing values) and feature value extraction (the calculation of indicators to which significance can be attributed with respect to particular outcomes), thereby extracting meaningful information to which data analysis techniques can be applied to transform it into knowledge that can help with equipment operation. The associated sequence of steps involves execution in real time, with the resulting knowledge being sent back to the equipment after being incorporated into applications.

As various analysis techniques have been published in the literature and as source code libraries over recent years, the process is one in which IT and other companies find it difficult to differentiate themselves. This means that the associated steps of pre-processing and feature value extraction and also of evaluation and interpretation are of particular importance when it comes to making a success of data analysis. Nippon Steel & Sumikin Engineering works in the field of plant construction and O&M as well as its electric power and other businesses and delivers practical benefits by undertaking improvements on the basis of an understanding of the plant as well as of data analysis, with operations, control system, and data science staff working together.

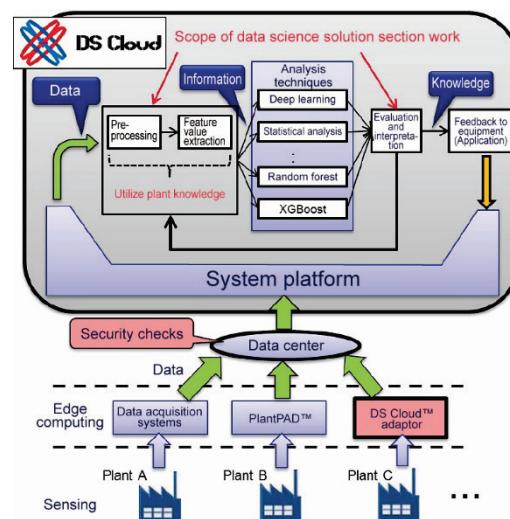


Figure 4 Data analysis with DS Cloud™

3.2 Security Measures

The collection of operational data from different sites faces limitations imposed by the customer network configuration and differences between edge computing systems from different vendors, making it difficult to maintain the same high level of security across all points of connection. Accordingly, all connections to DS Cloud™ are routed through a single data center (shown in the middle of Figure 4) where security checks are performed to ensure that data can be sent to DS Cloud™ securely regardless of the security levels at the different plants. Figure 5 shows the various security checks performed at the data center.

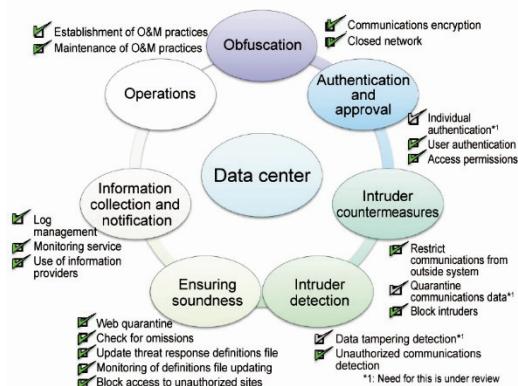


Figure 5 Security measures at the data center

3.3 Data Backup

DS Cloud™ is equipped with both hard disk drives for rapid access to frequently used data and magnetic tape drives for long-term backup of decades worth of uncompressed data. Improvements to the information storage density of modern magnetic tape mean that a single reel can now hold around 15 TB of data, with a likelihood of this being further improved in the future. Other advantages of magnetic tape are that it does not require a power supply for storage and that it lasts longer than DVD. It is also useful in terms of business continuity planning (BCP) because tapes can be held at a number of different geographically separate locations.

3.4 Making Use of Analysis Results

In broad terms, applications developed on DS Cloud™ can be used in two different ways (see Figure 6).

The first is to run the application on DS Cloud™ itself. This is done when the aim is to perform comparisons and manage activities across a number of similar plants or when high-volume data analysis is required.

The second is to run the application on an edge computing system. This is done when the requirement is to perform an analysis frequently or for a particular site only. By taking advantage of these two different configurations, DS Cloud™ can provide an analysis platform able to handle a variety of different requirements within a company.

The following sections describe examples of how these features are used in practice.

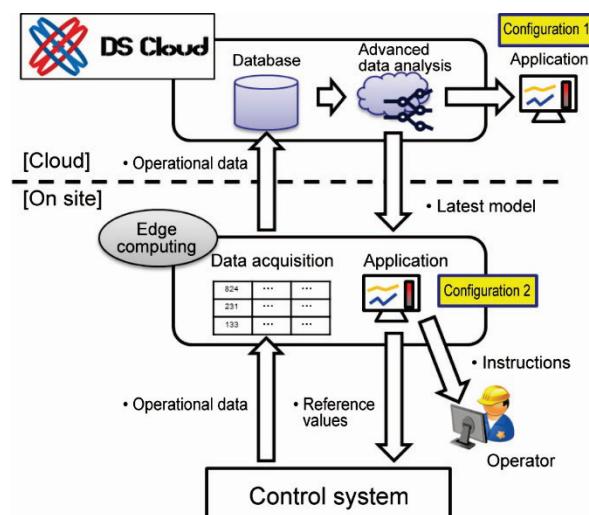


Figure 6 Application usage

4 Practical Examples

4.1 Waste-to-Energy Plant

This section presents an example of how DS Cloud™ is used at a waste-to-energy plant.

4.1.1 Operational Improvements at Low-Carbon Shaft Furnace

A low-carbon shaft furnace is a type of waste-to-energy plant with an improved design that uses significantly less coke as a heat source than a conventional shaft-furnace-type gasification and melting furnace thanks to modifications to the blower for the upper tuyere that improve the efficiency of waste drying and pyrolysis and thereby utilize as much of the energy in the waste as possible (see Figure 7)¹⁾.

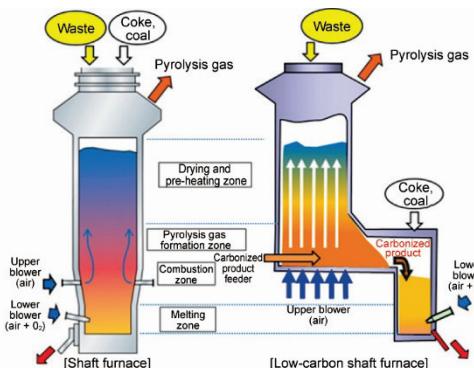


Figure 7 Shaft furnace and Low-carbon type shaft furnace

The amount of pyrolysis gas generated by a low-carbon shaft furnace can be stabilized by: 1) Blowing throughout the bottom of the shaft to maintain a uniform gas flow, and 2) Providing the ability to adjust the amount of blowing and rate at which waste is fed in at the bottom of the furnace based on the nature of the waste.

In the case of adjusting the amount of blowing and the waste feed rate based on the nature of the waste, there is a potential (especially for the waste feed rate) for automating and improving the process by using advanced data analysis to determine what adjustments to make. Accordingly, Nippon Steel & Sumikin Engineering set about automating and improving the support provided for operation by installing an expert system (see Figure 8).

The system first uses the rule-based system to

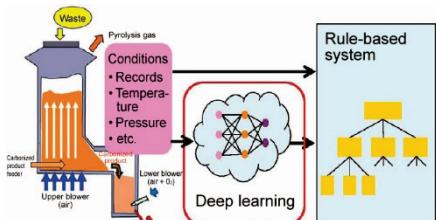


Figure 8 Expert system

establish and replicate the operating practices of the operators, then uses deep learning in DS Cloud™ to perform machine learning on the interrelationships between operations and furnace conditions. This results in a system that utilizes collected data and is capable of more advanced operation.

Installation of the system has improved operation of the low-carbon shaft furnace, reducing ε , the percentage variation in boiler steam output (an indicator of the extent to which fluctuation in pyrolysis gas generation has been reduced), from 3.3% to 2.0% (see Figure 9).

The percentage variation, ε , is calculated using the following formula.

$$\varepsilon = \frac{2 \times \sigma}{\bar{q}} \times 100$$

ε : Percentage variation in boiler steam output (%)
 σ : Standard deviation of boiler steam output (t/h)
 \bar{q} : Mean boiler steam output (t/h)

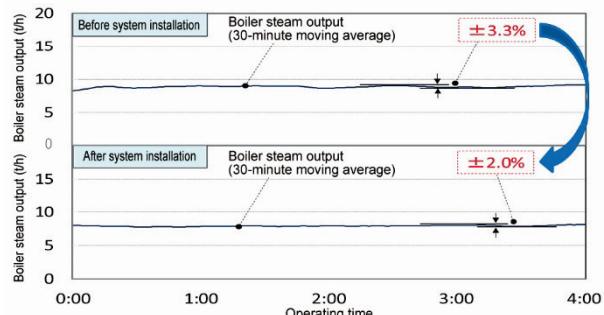


Figure 9 Benefits of expert system

4.1.2 Prediction of Lifespan of Key Equipment

Vibration analysis is an important technique in condition-based maintenance (CBM) for identifying deterioration or problems with equipment and so that maintenance can be done when needed.

Nippon Steel & Sumikin Engineering fits vibration sensors (IoT sensors that communicate wirelessly) to particularly important equipment to enable the continuous measurement of vibration, especially in bearings. The vibration measurements are sent to DS Cloud™ via the Internet where the data is stored as well as being subjected to spectral analysis and used to monitor trends in vibration so as to identify signs of deterioration by highlighting any deviations from the interrelationships between data present during normal

operation. If signs of deterioration are detected, a detailed analysis of the vibration is performed together with an analysis of the causes of deterioration and a prediction of how long the equipment will last. The results of analysis are then sent to the head office, the plant, and other equipment to facilitate appropriate maintenance management and to share information from different equipment (see Figure 10).

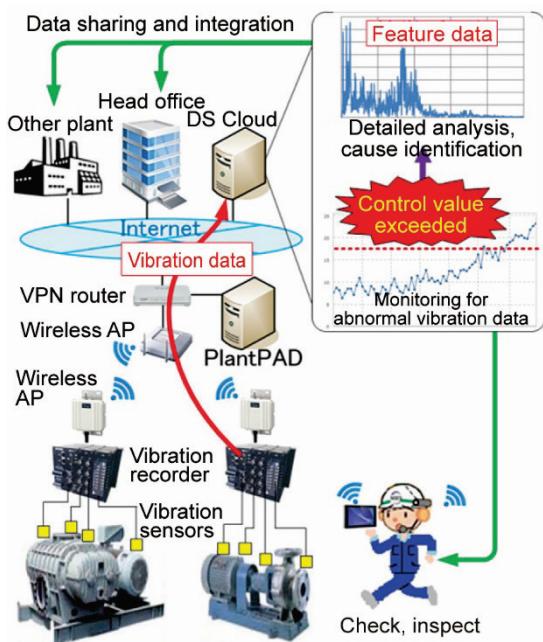


Figure 10 System to diagnose vibrations

4.1.3 Support for Optimal Control Tuning

Factors such as seasonal variations in the quality of the waste or changes in equipment over time mean that waste-to-energy plants do not always operate in an optimal manner. In response, long-term data collected from different plants by DS Cloud™ was used to identify performance deterioration by conducting an analysis and evaluation of the performance of key control loops compared against operating standards and data from other plants.

This maintained control performance by retuning the control systems based on modeling using the latest data in the event of deterioration being detected (see Figure 11).

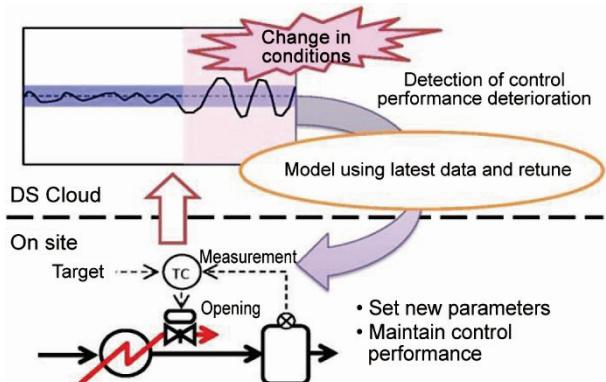


Figure 11 Maintain optimal control tuning

4.2 Application to Electric Power Business

The next two examples from the electric power business are applications of DS Cloud™ that do not involve an industrial plant.

4.2.1 Electricity Demand Forecasting

Nippon Steel & Sumikin Engineering has an electricity retail business that on-sells the electric power it purchases to users. In order to balance supply and demand across entire regions (such as Tokyo or Kyushu), industry participants submit their forecasts for how much electric power they will generate and consume during the following day (next-day plans in 30-minute increments) to the Organization for Cross-regional Coordination of Transmission Operators, and are obliged to match these to actual outcomes as far as possible. This means that reducing the amount of work involved in producing these predictions and improving their accuracy are among the key business objectives of these organizations.

To enable electricity demand forecasts to be made, learning was performed on approximately three years' worth of actual data, including data on actual power use, weather, and the industries in which customers operate. The two analysis techniques used were random forests (a decision tree ensemble learning technique) and deep learning. These were compared to assess how much their accuracies differ.

Figure 12 shows the electricity demand prediction results for one month of actual data that was not part of the learning data set. Both random forests and deep

learning track the actual demand, indicating that they are sufficiently accurate.

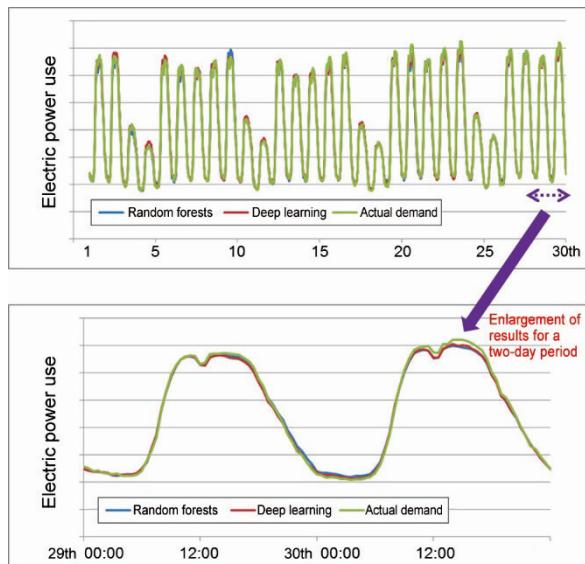


Figure 12 Result of power demand forecast

4.2.2 Grouping of Electricity Customers

To incorporate factors such as the contracted electric power or proportion of electric power used overnight when offering customers a choice of low-cost electricity rates, electricity retailers need an understanding of patterns of usage from past data. This is why it is standard practice to initially offer the default options only to customers in newly constructed buildings, with discounts only being offered from the second year onwards after reviewing a year of actual usage. Nippon Steel & Sumikin Engineering, in contrast, is now able to offer an advantageous choice of rates from year one by predicting the patterns of electric power use at the new building based on information about existing customers.

The first step in this analysis was to group the electricity usage patterns of more than a hundred office building customers that have contracts with Nippon Steel & Sumikin Engineering into categories based on their usage over a 24-hour period (factors such as peaks and troughs during the course of a day) and over a one-year period (factors such as seasonal highs and lows). This resulted in the customers being split into nine groups, as shown in Figure 14. After analyzing what each of these groups have in common based on information about each

customer, such as their total floor space or number of branches, it was found that grouping could be performed using a particular logic. This meant that customers with new buildings could be placed in one of these nine groups based on their responses to a simple questionnaire, and therefore that an advantageous choice of rates could be offered from year one (see Figure 13).

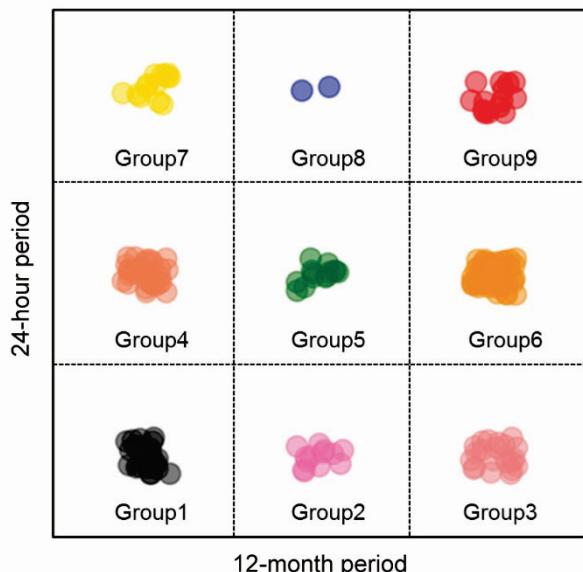


Figure 13 Grouping power customers

5 Further Uses for DS Cloud™

As described above, DS Cloud™ has useful applications that extend beyond making operational improvements at plants. Making it more useful still, however, will require the fostering of “citizen data scientists” who can expand the scope of data included in analysis and participate actively in the generation of new ideas. Meanwhile, the DS3 has been holding regular hands-on seminars for DS Cloud™ with the aim of getting more engineers to learn about simple data analysis procedures and how to use DS Cloud™ (see Figure 14), prompting engineers working in the field to look to data as a way of solving problems.

The DS3 also offers “rapid trial analyses” whereby they can respond to data analysis requests in approximately two weeks, providing a means by which ideas can quickly be deployed in practice, including those that have been put forward by people who have

attended the hands-on seminars. A lot of activity is taking place around improvements that utilize this program, and it is anticipated that good progress will be made in the future on enhancements to operation, maintenance, and plant products.



Figure 14 Hands-on seminar

6 Conclusions

This article has described the concepts and functions of the DS Cloud™ data analysis platform for putting data to use throughout the company, together with examples of how it is being used to make improvements to operation and maintenance at plants and farther afield in the electricity business.

The article has also described what is being done to expand its use through initiatives such as hands-on seminars and trial analyses.

Meanwhile, along with the use of DS Cloud™ for the automation and improvement of plant O&M, considerable scope still remains for utilizing the associated knowledge to enhance products or in sales and management.

Nippon Steel & Sumikin Engineering intends to contribute to society by developing products and solutions with added value, putting a lot of effort into training data scientists and fostering an organizational culture that encourages a vigorous and diverse exchange of ideas.

References

- 1) Naoko Yoshimoto, et al., Nippon Steel & Sumikin Engineering Vol. 8, p. 26 (2017)