A Solution to Streamlining Water Quality Management via IoT

Hiroshi KANDA
Hirotaka EGUCHI
Hisato TAKIGUCHI
Hideaki TANAKA
Kazuhiro IRIE

"HAKARU EXpress" is a solution-based business aimed at streamlining water quality management, offering to solve the problems that Japan as a society is currently facing, including the issues of how to pass on technical know-how to other workers, as well as reducing manpower required for management in order to make operations more efficient. HAKARU EXpress differs from conventional business models in that it offers the value inherent in the water quality "values" measured by these instruments. This system is used to remotely monitor the condition of water quality measuring devices to optimize inspections and rapidly respond in the case of a malfunction as the manufacturer performs all tasks from data analysis to preventive maintenance. In this paper, we describe the results of using HAKARU EXpress with our Automatic Total Nitrogen/Phosphorus Monitoring System, a water quality measuring device used in the field of factory wastewater management, as our first line of business, and explain the objectives and future prospects of this system.

Explanation: What is "HAKARU"?
"HAKARU" is a Japanese word that carries many different meanings. We have strong feelings regarding the word "HAKARU," which we would like to explain here. There are many kinds of "units" in the world. For instance, there are units of length such as meters and yards, units of weight such as kilograms and pounds, units of temperature such as Celsius, Kelvin and Fahrenheit, and many more. The act of "HAKARU" helps us to visualize things. We define our "HAKARU technology" as the technology that is necessary for visualizing, which includes monitoring and analysis.

Introduction

Japan's population is currently declining, with the ratio of older people growing rapidly. It is predicted that Japan's population will fall below 100 million by the year 2053[1]. The labor workforce of the manufacturing industry is also decreasing more rapidly than before. More than 94% of small-to-medium and large-scale businesses are experiencing significant labor shortages, and 32% of businesses replied that these shortages are having an effect on their business. One of the management issues that small-to-medium businesses are now facing is a notable lack of skilled human resources (human resources who can do knowledge-related work or work that uses some kind of know-how)[2].

The water and sewer pipe business is no exception. We need to solve the issue of a lack of skilled human resources, paving the way towards a solution through streamlined facility maintenance and management.

Owing to this situation, we have aimed to solve the lack of skilled human resources by streamlining the maintenance and management of water quality measuring instruments, and we have been involved in product systems and converting our efforts into services. We would like to introduce and show you the details of what we have accomplished.

Our Efforts towards Creating "HAKARU EXpress"

"H-1 Link" Maintenance and management application (objective: making on-site maintenance and management easier and more convenient)

HORIBA has developed a wide variety of water quality measuring instruments in order to contribute to the environment and the society. Driven by the purpose that our customers could easily use water quality measuring instruments, we developed the "H-1 Link" (**Figure 1**), a maintenance and management system for water quality measuring instruments that uses wireless communication—a management system for water quality measuring instruments that uses wireless communication—a first in the water quality measurement instrument industry in Japan (according to our 2012 survey). In addition to water treatment and quality management, the H-1 Link system is used to wirelessly maintain the water quality measurements necessary for waste regulations and manage time-based changes in the inspection data (calibrated values) of water quality measuring instruments and so on. Our system is therefore able to accumulate knowledge related to maintenance and management carried out by workers on-site, as well as technical information.

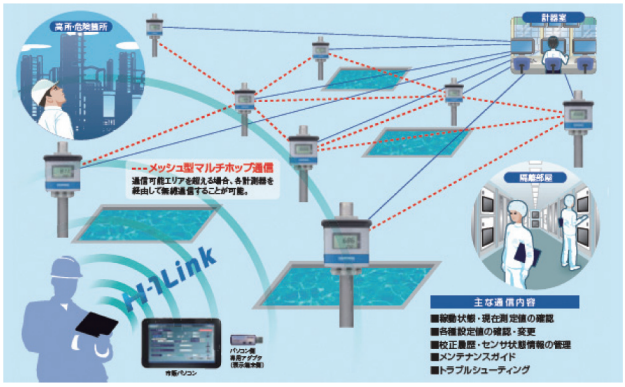


Figure 1 H-1 Link (conceptual diagram)

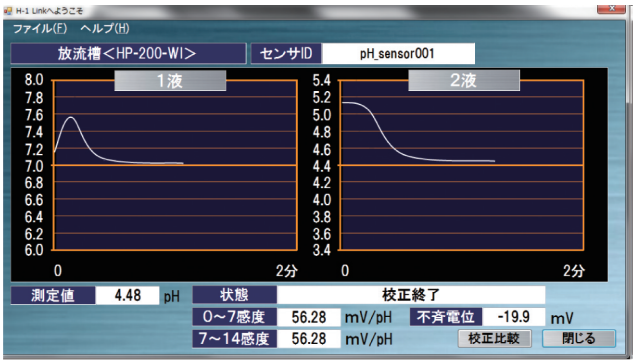


Figure 2 H-1 Link (determination of calibration validity)

Figure 3 H-1 Link (calibration history)

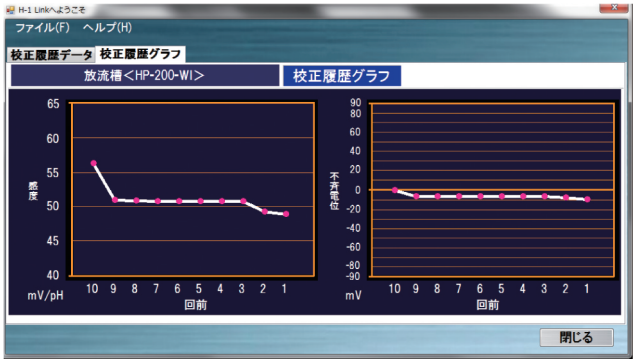


Figure 4 H-1 Link (calibration history)

Our goals with the H-1 Link are to increase the work efficiency of workers on-site, to support their ongoing training and to solve the problem of technical know-how inheritance to other workers. The H-1 Link offers a function for users to input inspection items for unsupported products and directive values for non- HORIBA products, following easy steps to maintain and manage those products as well. Through wireless communication, the system reduces the burden required when trying to read measured values in places that are dangerous to enter or in high places; and a different water quality measuring instrument can be used to inspect multiple instruments from one location, in the case where radio waves cannot be directly received.

This system can also be used for training newly hired workers. Collecting the experience and the knowledge that was previously kept by each worker onto a personal computer can contribute to a wiser use when determining the validity of a calibration (by looking at how a sensor currently calibrated will act (**Figure 2**)) or for predicting the lifespan of a product from the calibration results log. (**Figure 3**, **Figure 4**) [3]

We recommended to our customers the implementation of the H-1 Link for increasing their work efficiency in regard to maintenance and management. However, there remains the issue of how to share information between the customer and the manufacturer in the event that this maintenance and management system detects a malfunction in a water quality measuring instrument, since the customer needs to send manufacturer the data from the instruments in order for us to check their condition. For this reason, it is essential that the system makes it possible for the manufacturer to independently check on the condition of the instruments, so that they can proactively handle any issues.

The "HORIBA AQUA LINKAGE" cloud-based after-sales service solution (objective: optimizing maintenance and management on-site)

"HORIBA AQUA LINKAGE" is our after-sales service solution integrating the predictive maintenance function of "H-1 Link", introduced in the previous section, with an advance state monitoring. This solution has evolved into an active system for real-time monitoring by means of it ability for the data transmission. Remote monitoring of the status of water quality measuring instruments permit a quick recover in the case of a failure, as well as ensuring system integrity by evaluating warning signs. Maintenance and management logs as well as work procedure manuals can be centrally managed via the cloud, making it easier and more convenient to pass work on to other workers, and making it possible to accumulate technical know-how.

We have done a test run using the TPNA-500 Automatic Total Nitrogen/Phosphorus Monitoring System, to confirm the effectiveness of this after-sales service solution. When a water quality measuring instrument malfunctions, the new system made it possible for the manufacturer to actively handle the issue by contacting the customer, rather than the customer taking the first action (with the manufacturer playing a passive role) to handle the problem. The HORIBA AQUA LINKAGE leads to an improved after-sales service and received favorable reviews from

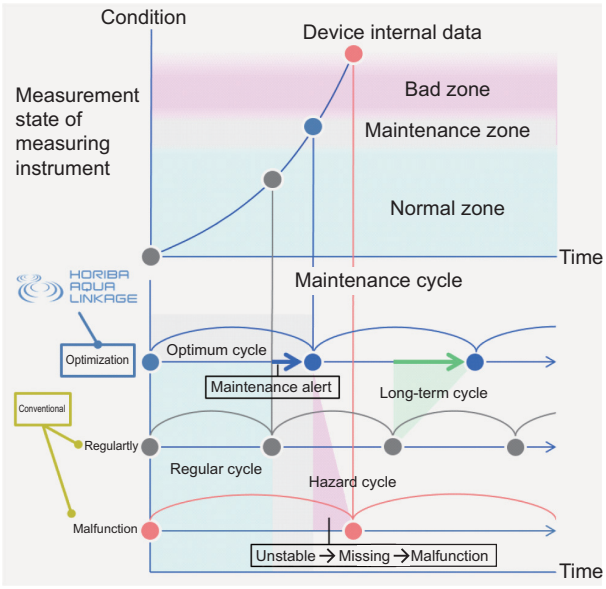


Figure 5 Condition Based Maintenance

customers for its ability to generate and submit reports as-is to administrative offices[4].

The parts used in water quality measuring instruments tend to degrade with use, and consumable parts become insufficient. Information about the regular maintenance (which has so far been left to the customers) is indispensable, in order to verify the required maintenance cycles or validity of content. By accumulating and qualifying maintenance data, we can establish a range of tolerance from normal operations to malfunctioning conditions. Further, by accumulating overall data that includes the measuring environment of the water quality measuring instrument, we are able to recommend the optimum maintenance cycle and content for the measuring environment.

In the case that a water quality measuring instrument malfunctions, twe can perform a general evaluation by comparison with the accumulated data and by checking the relationship with the measuring environment, making it possible to accurately detect the malfunction.

The previous method of maintenance is called "TBM" (Time-Based Maintenance). The TBM method is a method of performing appropriate maintenance when used under the environment specified by the manufacturer. When the instrument is used in an environment that is determined to put a high load on the instrument, there is a possibility that the parts will degrade more quickly than expected, or that the device may malfunction. On the other hand, if the instrument is used in an environment with a low load, replacing parts that do not need to be replaced right away results in excessive costs. As a proposal to improve this, we aim for the CBM (Condition-Based Maintenance) method. (**Figure 5**) With the CBM method, the condition of the water quality measuring instrument is compared with the maintenance history, making it possible to carry out maintenance according to the condition of the instrument. A minimum number of parts need to be replaced, lowering running costs.

We have firmly established the technology to continually monitor the condition of water quality measuring instrument by using active maintenance and management systems. This also allows manufacturers to offer a more advanced level of support to

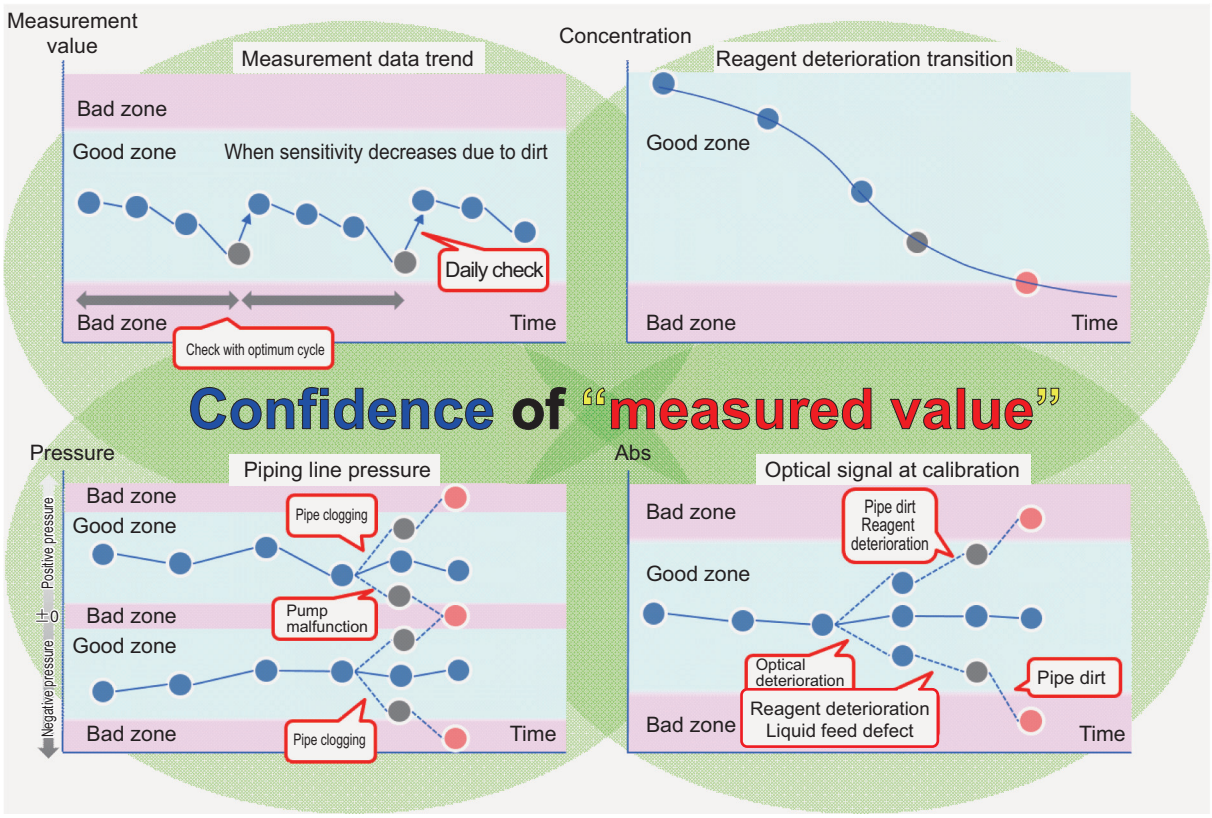


Figure 6 Measurement values ensured by HORIBA technology

workers, the customers. However, the social issue regarding the lack of skilled human resources still leaves us with the problem of how we deal with basic needs of our customers for more streamlined maintenance and management operations of the water quality measuring instrument.

Proposing Further Solutions

HORIBA's solution for streamlining water quality management: "HAKARU EXpress" (objective: stress-free maintenance and management at the site)

"HAKARU EXpress" is a new service begun by HORIBA in 2018 that is a more streamlined version of HORIBA AQUA LINKAGE. This is a solution for minimizing the problems faced by customers in regard to water quality measurement. HAKARU EXpress differs from conventional business models, largely in that customers do not purchase water quality measuring instruments—they purchase the "values" measured by these instruments.

Under this new service, management tasks necessary for the stable operation of water quality measuring instrument such as regular maintenance and malfunction handling are taken care of by the manufacturer, resulting in a significant reduction in hours spent on maintenance and management by the customer.

The customer installs manufacturer-owned water quality measuring instruments in their measuring environment, and the manufacturer provides maintenance while remotely managing the instruments. This allows us to determine a method of maintenance and appropriate maintenance cycle that would normally be different for each particular installation environment. We can stabilize operations by providing the maintenance that is appropriate for each installation environment.

Also, an automatic water sampler that can save samples of water in eight-hour intervals is always in operation, which provides data that might not have been measured due to regular or yearly inspections.

The accuracy of values measured

As previously mentioned, acquiring the know-how that allows us to make decisions based on a data analysis of the water quality measuring instrument's condition gives us a clearer picture of the relationship between the instrument's condition and the values it measures.

The general data that includes the measuring environment of the water quality measuring instrument is extremely important when checking the accuracy of values measured (**Figure 6**), serving as evidence as to whether the instrument is working properly. With HAKARU EXpress, the manufacturer takes care of the maintenance and management, and the status of operations can be checked. This makes it possible to collect more accurate data on the condition of the water quality measuring instrument.

In this way, general data is accumulated not only to prove the accuracy of the measured values, but to make it possible to enhance the quality of the measured results.

HAKARU EXpress makes stress-free maintenance of water quality measuring instruments a reality for our customers. Also, since the water quality measuring instrument manufacturer manages the instrument's maintenance, reliable measurements can be performed. We continue to work in pursuit of advancing our HAKARU technologies, as we work in partnership with our customers to help solve their problems regarding measurement.

Our Perspective on the Future

Big data analysis

The business environment in which the HORIBA Group works features a wide variety of fields around the world from which data can be obtained. Some of these fields include automotive measurement systems; measuring instruments used in environmental regulations for air, water and soil; blood testing equipment in the field of medicine; fluid flow control devices for the gas used in semiconductor manufacturing; spectroscopic analysis devices used in state-of-the-art science technology and more. Being able to acquire a large amount of product data in real time will enable us to offer a new kind of added value.

The reliability of a data is in the knowledge of both the type of data and the combination method according to the purpose to be used. There are different data types such as data that has momentary value, data that has continuous value, and wide-ranging data acquired over a single time series. We combine this data by type according to the application in order to derive added value; and we expand the scope of the proofs we can arrive at by adding new data. We can say that big data offers a treasure trove of potential value in this regard.

That said, in order to effectively use this treasure trove, we need to organize the data with an awareness of the five elements (5V) of big data: volume, velocity, variety, value and veracity. The result of this is that we can perform data matching, offering new opportunities for business development.

To discover these opportunities, we need to review our data from multiple angles in cooperation with companies in other industries, research institutes and municipalities, proactively developing huge value from a singular result.

The relationship to data science

Data science is indispensable in the analysis of big data. What we mean here by data science is data accumulation, analysis, structural examination and problem solving, with all of these elements working together to form a science. One of the objectives of using data science for water quality measuring instruments includes enhancing the added value that stems from transforming results into big data, CBM and so on.

To transform results into big data, we need to use data science to guide us to certain proofs from the accumulated data, thereby turning the accumulated data into a reliable source (offering value). Combining reliable data with other data further leads us to new proofs. The proofs we derive are added to big data; and by combining this with many diverse kinds of data, these proofs carry the potential of adding even greater value.

With CBM, more of the content is proved through data science, which allows us to understand the condition of water quality measuring instruments in greater detail, establishing a method of detection. We believe that establishing many different methods of detection will eventually lead us to create a new kind of value, such as the introduction of artificial intelligence (AI) into products.

Summary

In the current water and sewer pipe business environment, we are facing many issues such as a lack of human resources, problems in passing on technical know-how to other workers, streamlining our operations, and maintaining stable operations at our facilities. Among these, procuring human resources has become a serious challenge.

HAKARU EXpress is a solution-based service that streamlines the water quality management process, which contributes to the problems of labor shortage and the issue of a lack of manpower for management that is required to make operations for efficient, which Japan is now facing. We want to expand our solution-based business aimed at an overall streamlining of water quality management by expanding the devices supported beyond our Automatic Total Nitrogen/Phosphorus Monitoring System.

References

[1] Population Projections for Japan (2017): 2016-2065, National Institute of Population and Social Security Research (Ministry of Health, Labour and Welfare), http://www.ipss.go.jp/pp-zenkoku/e/zenkoku_e2017/pp29_summary.pdf (accessed Dec. 19, 2018)

[2] Ministry of Economy, Trade, and Industry, Current Situation Regarding Labor Shortage in the Manufacturing Industries and Making Use of Foreign-Sourced Human Resources, July 2018 ; Explanatory meeting for the Foreign Employee Acceptance Program for Manufacturing Industry http://www.meti.go.jp/press/2018/07/20180712005/20180712005-2.pdf (Japanese, accessed Dec. 19, 2018) Manufacturing Industries Bureau, Ministry of Economy, Trade, and Industry

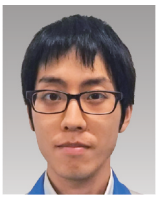
[3] H. Kanda, "Establishment of the Application Business for Maintenances with a Cloud Network", *Readout*, No. 43, p.29 (2014)

[4] H. Tanaka, H. Kanda, "Water Quality Measurement Solutions Using IoT", *Journal of EICA*, Vol. 22, Issue 2/3, p.32 (2017)

Hiroshi KANDA
New Business Promotion Office
HORIBA Advanced Techno, Co., Ltd.

Hirotaka EGUCHI
New Business Promotion Office
HORIBA Advanced Techno, Co., Ltd.

Hisato TAKIGUCHI
New Business Promotion Office
HORIBA Advanced Techno, Co., Ltd.



Hideaki TANAKA
Research & Development Division New Product Development Department 1
HORIBA Advanced Techno, Co., Ltd.

Kazuhiro IRIE
Research & Development Division New Product Development Department 1
HORIBA Advanced Techno, Co., Ltd.