Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

How to Improve the Availability of Geothermal Power Plants with IoT-Based O&M Support

FUKUDA Norihiro, KAWADA Masanori, TSUJII Kazunori, HAYASHI Ryutaro and SAITO Shojiro

Norihiro_fukuda@mhps.com

Keywords: geothermal power generation, operation and maintenance, O&M, IoT, cloud, edge, simulator, deterioration, diagnosis, performance

ABSTRACT

Compared to fuel-fired power plants with high steam conditions, the operation of geothermal power plants is less complicated because no boiler is included and deterioration due to high temperature creep is not an issue. However, they are more prone to trouble or long-term deterioration due to corrosive impurities and gases contained in geothermal fluid (steam and brine) -impurities such as sulfur, chloride, silica and hydrogen sulfide, among others. Usually a lot of resources are invested in monitoring these problems and over long periods of operation the costs are significant.

Consequently, MHPS has released an IoT-based cloud service tool for optimizing operation, maintenance and performance. This tool includes (1) Dash Board (a system to assist operation), (2) Fault Diagnosis, (3) Performance Diagnosis and (4) Operation Optimization. The Performance Diagnosis evaluates historical trends of a power plant by comparing actual performance to an predicted performance, which is calculated by a virtual plant model, thus revealing any deterioration in the plant. The service tool provides operators instructions on how to operate plants and maximize net output (kW) under various conditions, such as geothermal resources, atmospheric conditions and demand from the grid. The effectiveness of the service tool and a sample calculation are discussed in this paper.

1. INTRODUCTION

Mitsubishi Hitachi Power Systems, Ltd. (MHPS) was established in February 2014, integrating the thermal power plant business of Mitsubishi Heavy Industries, Ltd. (MHI) and Hitachi, Ltd. Our geothermal power plant business was inherited mainly from MHI and dates back to the 12.5MW Otake Geothermal Power Plant (Kyushu Electric Power Co., Inc.) project. Operation commenced in 1967 and this was Japan's first geothermal power plant with water-dominated production wells. In this project, a lot of material tests were conducted and the experience gained from these provided foundational knowledge of material selection. Additionally, the basis for the design was developed through analysis of characteristics and verification tests regarding major equipment components such as the steam turbine, the separator, the direct contact condenser and the gas extractor. MHPS has now supplied 107 units (3,249MW) in 13 countries around the world. At present, MHPS is developing an IoT-based O&M support system for our digital solution architecture platform, MHPS-TOMONI®.

2. THE DIGITAL SOLUTION ARCHITECTURE, MHPS-TOMONI®

MHPS-TOMONI® was developed as a comprehensive digital solution, consisting of a variety of hardware, software and services to provide solutions to all parties involved in power plant operations (Ishigaki et al., 2018). MHPS-TOMONI® has two components: a cloud service and an Edge service. Figure 1 shows a conceptual diagram of the system configuration. An advanced and stable cloud service is achieved with major global technologies including Microsoft Azure and the PI system of OSIsoft. Various services, such as visualization and data analysis can be accessed via the internet through the virtual desktop built into the system. Regarding the Edge service, an Edge device "Secure Gateway (data diode)" is installed inside the power plant. This device ensures secure data transmission and enables one-way access from the power plant to the cloud server.

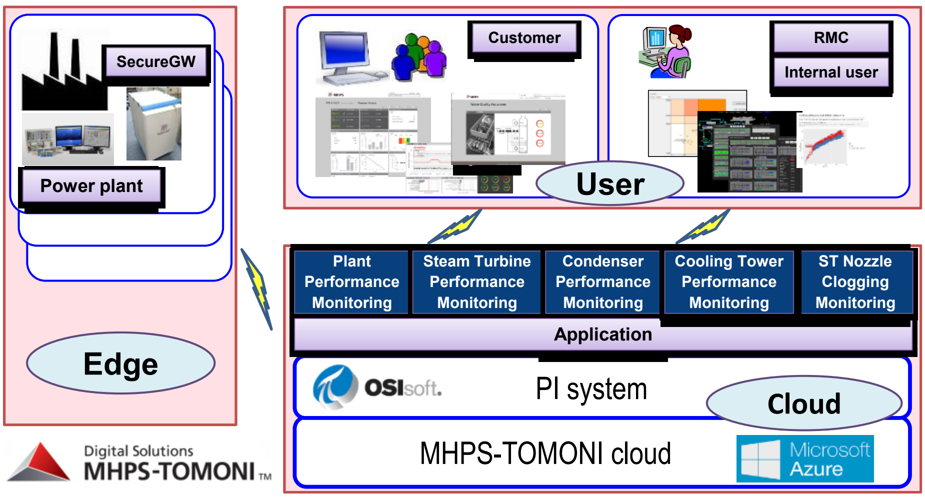

Fig. 1: Conceptual diagram of MHPS-TOMONI® system configuration

3. REMOTE MONITORING SERVICE UTILIZING MHPS-TOMONI®

MHPS is now developing a remote monitoring service offering worldwide coverage with four Remote Monitoring Centers (RMCs), illustrated in Figure 2. The first two RMCs to be established were the Takasago RMC (Japan) in 1999 and the Orlando RMC (USA) in 2001. These RMCs, with specialized staff, provide 24-hour monitoring services for GTCC (Gas Turbine Combined Cycle) power plants. Two more RMCs, the Alabang RMC (The Philippines) and the Nagasaki (Japan) RMC followed, starting operation in 2016 and 2019 respectively. These four RMCs provide remote monitoring services for various power facilities.

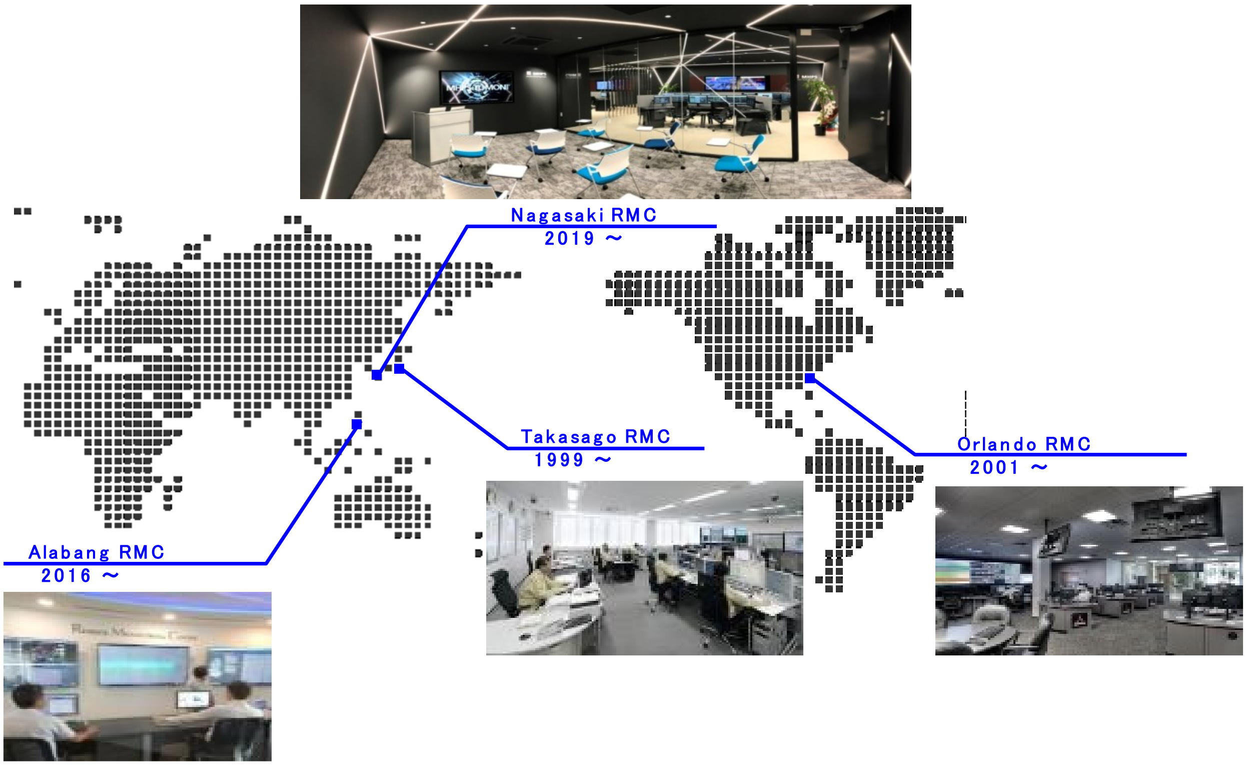

Fig. 2: Worldwide expansion of Remote Monitoring Center network

4. PERFORMANCE DIAGNOSIS FOR GEOTHERMAL POWER PLANT

The configuration of geothermal power plants is relatively simple compared to that of other types of thermal power plants. The latter require different kinds of control elements in order to achieve stable power generation, such as combustion control according to the type of fuel, feed water flow control, main steam temperature control and water-steam quality control, etc. There are fewer elements that can be controlled by operators in geothermal power facilities because the steam generation process depends on geothermal reservoirs lying deep underground. However, compared to clean boiler water, the quality of geothermal water is poor from the perspective of high content of impurities and non-condensable gas. Therefore trouble and deterioration due to poor water and steam quality are specific to geothermal power facilities. It is therefore important to monitor these phenomena during operation and maintenance work of the geothermal power plant.

MHPS has developed a plant performance simulator which simulates operational status, including internal process values, using measured data transferred from power plants. Figure 3 shows the conceptual diagram of the simulator which consists of complete plant model with four major facilities; the turbine and generator (STG), the condenser (CD), the cooling tower (CT) and the gas extraction system (GES). The first step of the performance diagnosis is to calculate the predicted generator output under boundary conditions, such as the meteorological conditions (ambient pressure and temperature) and steam conditions (pressure, temperature, flow rate and gas content) and compare this to measured values. If the actual overall performance is lower than the predicted performance, then, individual evaluations of the abovementioned four facilities are conducted in conjunction with performance diagnosis of entire plant. As a result, the root cause can be identified. If, for example, the cooling water temperature measured is higher than predicted, the root cause can be discovered as a deterioration of the cooling tower performance (for reasons such as fill clogging or a water distribution failure) and recommend inspecting and cleaning the cooling water system as a countermeasure. In actual operations, it is considered normal that multiple phenomena cause plant performance deterioration. Our performance diagnosis module determines the contribution of each cause of such deterioration so that operators can plan and schedule a maintenance work in advance.

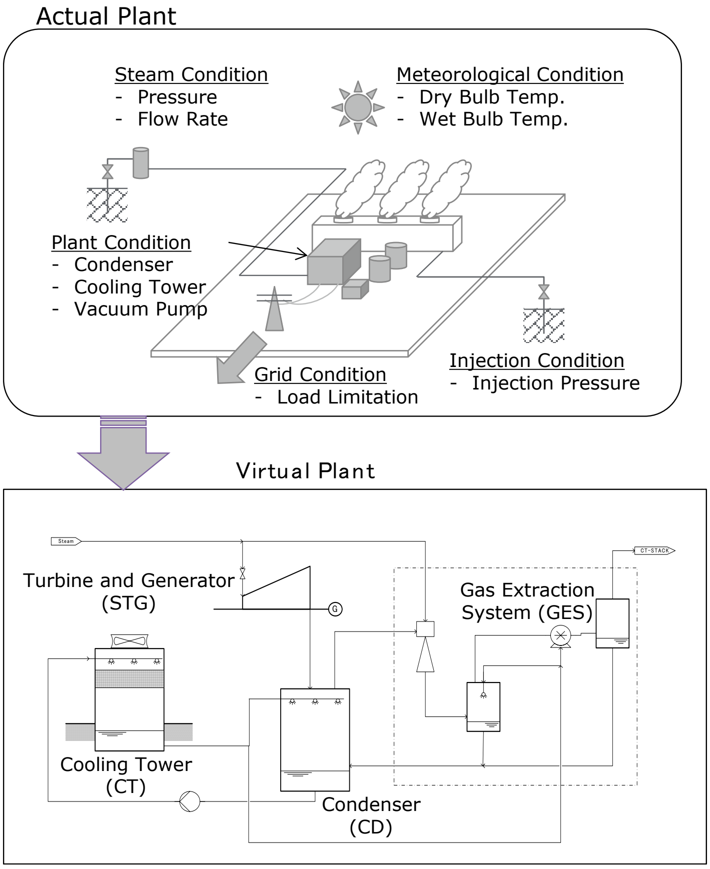

Fig. 3: Conceptual diagram of the geothermal power plant simulator

5. CONCLUSION

Our recent activities for improving the availability of geothermal power plants with IoT-based O&M support were introduced. As a geothermal power plant supplier, MHPS considers that it is our mission to make continuous improvements and offer better products. Furthermore, MHPS also thinks it is important, now more than ever, to make efforts in maintaining and improving the performance of the geothermal power plants MHPS has supplied, working on this together with our customers. MHPS will make every effort to enhance customer value through the chain of processes (R&D, design, manufacturing, delivery and operation) and supply higher quality products with knowledge acquired from the operation of power plants back to our product design.

REFERENCES

Ishigaki, H., Mouri, S. Goto, D. and Nagafuchi, N.: MHPS-TOMONI: Thermal Power Generation Digitalization Platform Cloud/Edge Service and System Architecture, *Mitsubishi Heavy Industries Technical Review,* (2018).