Service Technology for Improving Product Reliability

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In order to provide long-term product value to clients, the responsibility of Mitsubishi Heavy Industries, Ltd. (MHI), as a manufacturer, is understood to mean taking all possible steps to ensure not only fundamental performance but also high reliability. Building on its extensive product knowledge, MHI has been engaged in the development of a variety of service-related technologies to improve the operating rates at client facilities. This article details a number of MHI service technologies via product case studies.

1. Introduction

MHI offers a broad product range that includes custom-designed products such as large-scale power plants, medium-lot machinery such as forklift trucks and paper converting machinery, as well as mass-produced items such as residential air conditioners. While the production scale of these products may vary significantly, it is important for each product to continuously provide not only performance essentials but also high post-sale reliability. By making the best use of its extensive knowledge of product life cycles (e.g., design, manufacturing, testing and maintenance), MHI has been developing service technologies that achieve client-specific equipment availability and improve product performance.

This article describes some of these service technologies, using key case studies.

2. Operational Support System with Service Visits (Paper Converting Machinery)

Recently, there has been increasing interest among MHI clients in preventive maintenance and product quality stability related to existing client facilities. In order to meet this demand, MHI has been expanding its service activities via service personnel visits, offering site machinery diagnoses and consultations for improved equipment availability and facility performance. In this chapter, an example involving paper converting machinery (**Figure 1**) is used to illustrate the main features of MHI's operational support system with service visits that offer a prompt response to client needs.

2.1 Features of the operational support system with service visits

(1) Centralized management of client information (client database)

Client information that was formerly managed using multiple systems spanning different divisions, including machinery specifications, production data and service history, is now being centrally controlled with a newly developed client database system. All service data are made instantly available by running a client name search query. Furthermore, MHI uses this comprehensive client data in combination with diagnostic results described below to develop

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demand forecasts for replacement and spare parts, and offers service solutions for optimal machinery operation by proactively addressing client needs.

(2) Diagnostic system with mobile terminal

Service visits are conducted using a mobile terminal, which carries client machinery information extracted from the database prior to the visit. Thus, by simply following on-screen instructions to enter diagnostic results for each listed item as on-site tests are performed, service personnel can arrive at an overall diagnosis in a short time.

(3) Report generation

A diagnostic report can be automatically generated from the data entered by service personnel. Based on diagnostic results, the system also creates a list of necessary replacement parts and corresponding price estimates while still on site. Traditionally, it has taken longer to produce such a list. The results are also entered in the client database for future consultation.

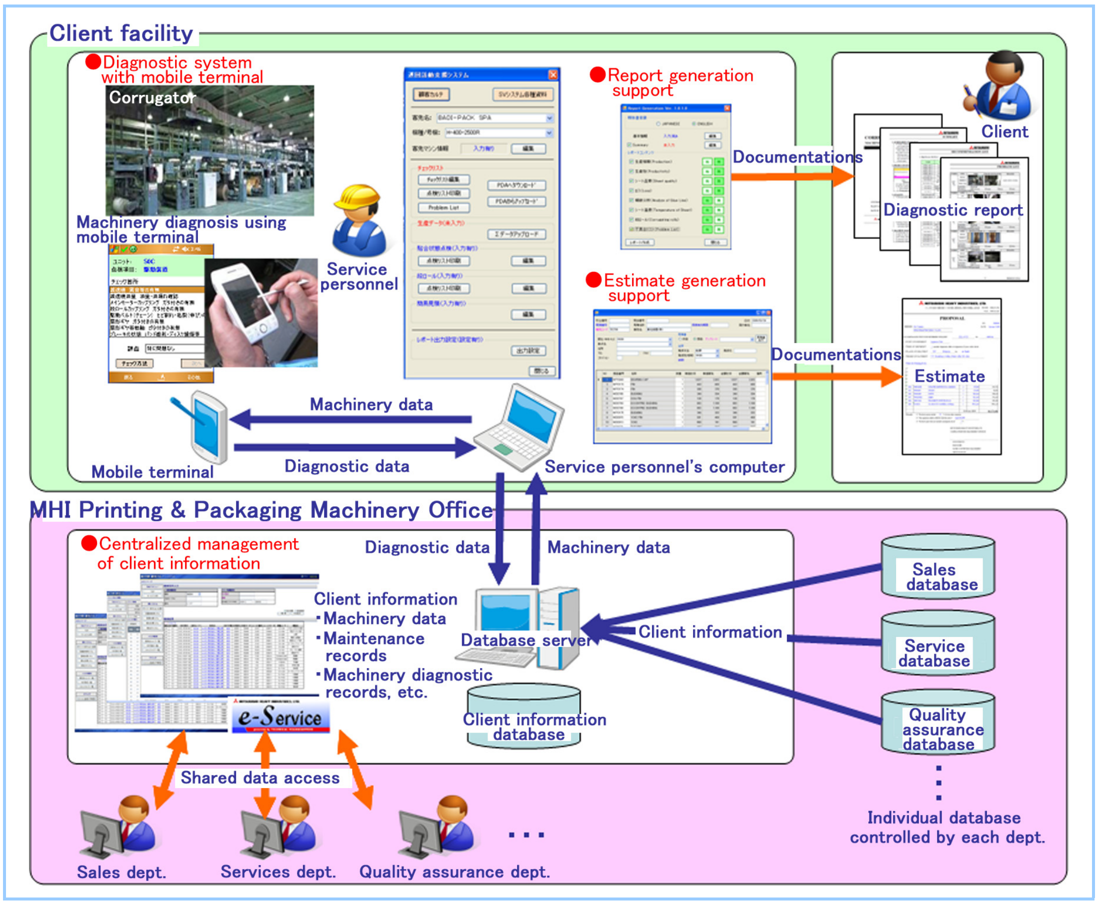

Figure 1 Overview of IT support system for service visits

2.2 Effectiveness of the operational support system with service visits

Thanks to the above-mentioned features, the new system has gained high client satisfaction by providing prompt delivery of service solutions for operational availability and performance improvement at production sites.

Through improvement in equipment availability, the system is able to conduct service visits for MHI products other than paper converting machinery.

3. Remote Monitoring Technology (Gas Turbines)

This chapter describes a remote monitoring technology that supports improvement in equipment availability. As environmental issues have become a global concern, the need for high efficiency, low-carbon transformation is growing among power generation companies, while increasing importance is being placed on the operational stability of power plants for ensuring stable electricity supply. As part of the operations/maintenance services for gas turbine plants, MHI has (since 1999) been providing remote monitoring services from its Remote Monitoring Center (RMC) located at the Takasago Machinery Works, offering operational assistance to clients around the world.

3.1 Remote monitoring system

The configuration of the remote monitoring system is shown in **Figure 2**. The system enables continuous monitoring of a power plant's operational status by extracting facility operational data to the local data server, and transmitting it to the RMC through the data communication line. All data received from each unit are displayed on a monitoring terminal in real time, and permanently stored in the RMC data server, thus facilitating more efficient historical data analysis and concurrent data management.

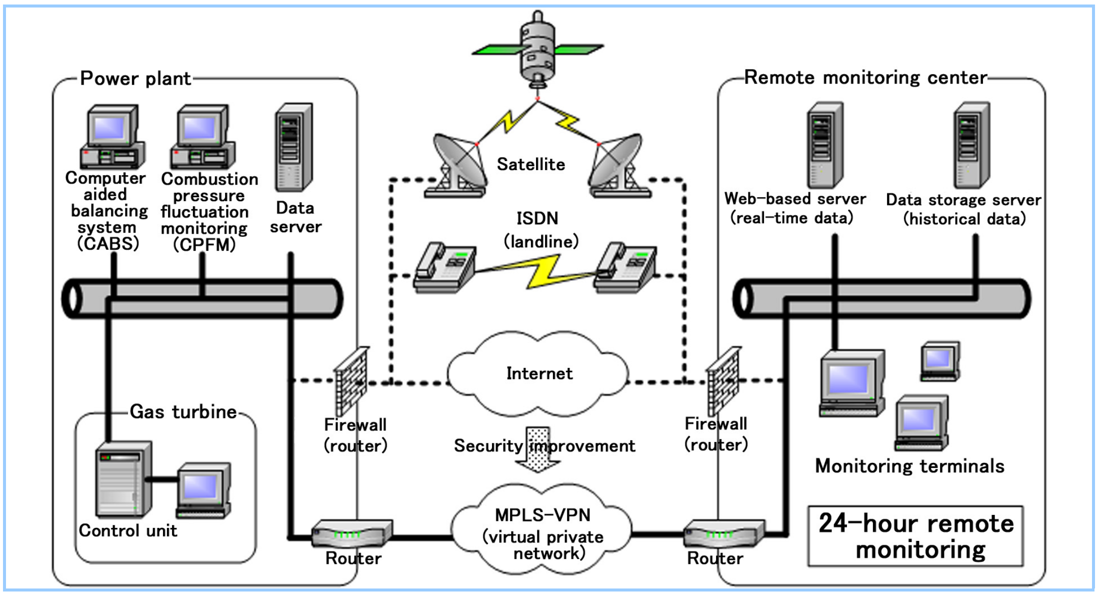

Figure 2 Configuration of MHI's remote monitoring system

3.2 Remote monitoring services

Implementation of the remote monitoring system has allowed MHI to provide prompt operational assistance to clients. Operating in three shifts to provide 24-hour support, highly trained and experienced RMC personnel assist clients with safe and stable power plant operation by swiftly investigating the causes of failure and facilitating restoration efforts (**Figure 3**). Whereas troubleshooting previously relied on data provided by clients, the RMC now obtains data related to an operational failure immediately after the incident, and combines this information with stored historical data to conduct a speedy analysis, thereby significantly shortening the time required to correct the situation. The RMC also focuses on enhancing abnormality diagnosis technology for prevention and early detection of trouble.

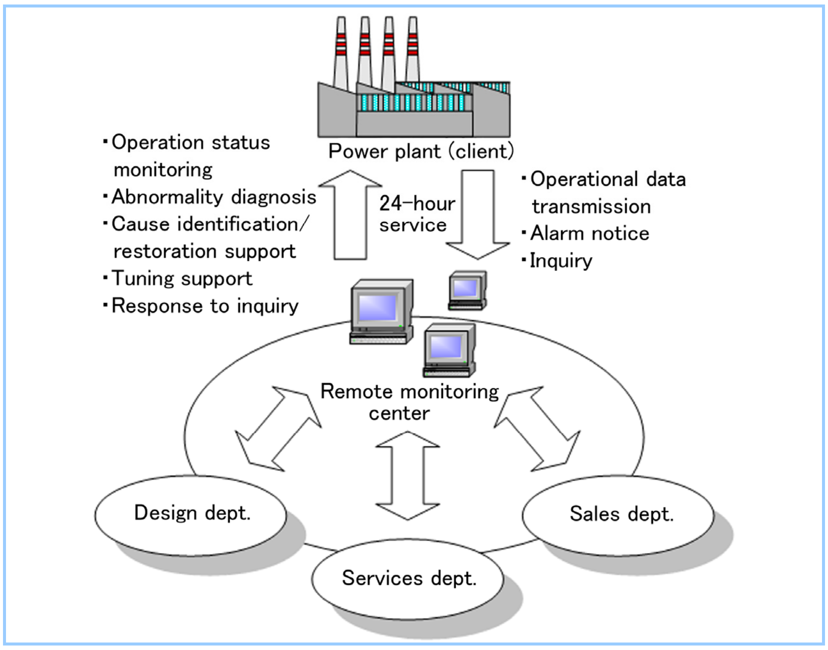

Figure 3 Overview of remote monitoring services

3.3 Abnormality diagnosis technology

The traditional diagnostic process for abnormality detection during gas turbine monitoring assesses whether various operational parameters remain within threshold levels. When a parameter exceeds the threshold level, an abnormality alarm is generated. However, in many cases, damage to the equipment might have already occurred. In-depth analysis of past incidents via the remote monitoring system permits the identification of “small” parameter changes that appear prior to the alarm, indicating potential problems. The early detection of such indicators enables the prevention or minimization of damage caused by operational failures (**Figure 4**). In a gas turbine operation, there are more than 100 key monitoring parameters, the values of which are affected by various factors, such as operating and atmospheric conditions. Hence it is difficult for an operator to instantly detect an abnormality during normal real-time monitoring.

MHI has developed an abnormality diagnostic system using a pattern recognition technique, known as the Mahalanobis Taguchi method (MT method), which helps to detect the slight shifts from the standard pattern that are early indicators of abnormality. In the MT method, the Mahalanobis distance (MD) between the standard pattern (consisting of multiple variables, and referred to as the unit space) and the sample pattern is calculated to determine whether the sample pattern is normal or abnormal. Thus, instead of separately verifying the values of numerous parameters (**Figure 5**), the MD permits a comprehensive diagnosis of gas turbine operation based on a single index. Furthermore, the calculation of signal-to-noise ratios (SN ratios) using the orthogonal array enables root cause identification (**Figure 6**). An automatic diagnostic system based on the MT method is employed at the RMC to prevent critical failure through early detection of the “small” changes in parameters that appear prior to the triggering of an alarm. The remote monitoring services, including abnormality diagnosis, help minimize equipment damage and unplanned outages, resulting in improved operational availability.

This remote monitoring technology, centered on the abnormality diagnosis developed for gas turbine plants, is now being adapted to medium-lot machinery.

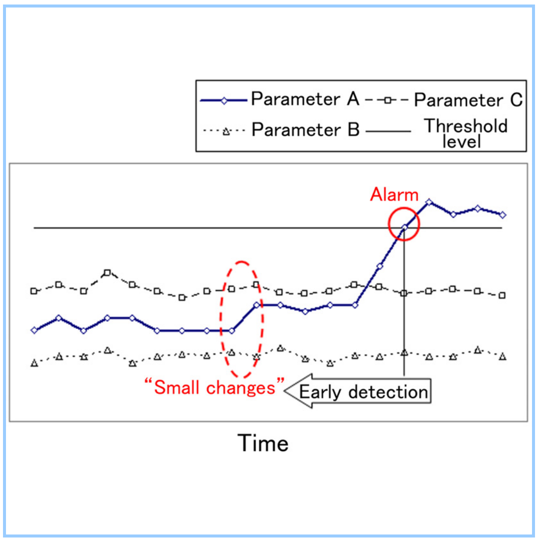

Figure 4 Indication of potential problems

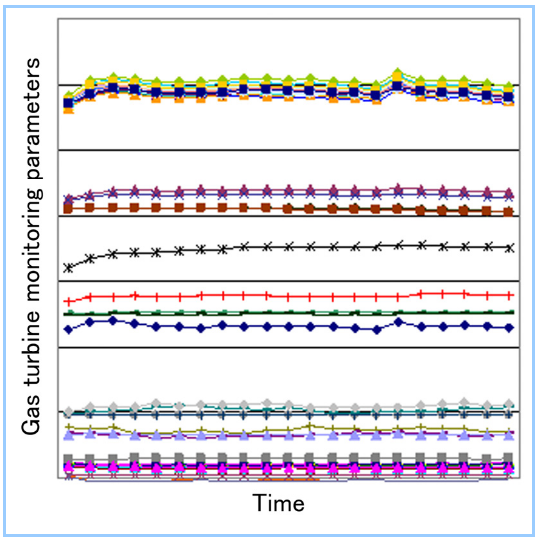

Figure 5 Traditional trend monitoring method

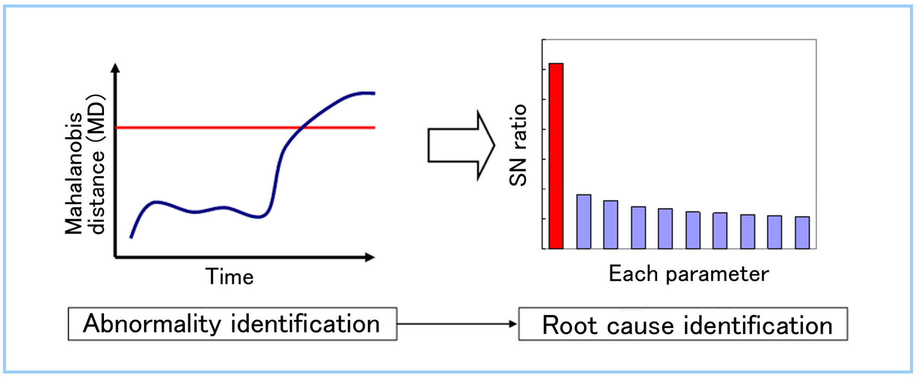

Figure 6 Abnormality diagnosis system based on the MT method

4. Ordering/Inventory Management System for Spare Parts (Thermal Power Plant)

Periodic replacement of spare parts is a crucial aspect of maintaining the performance of client equipment. Supplying spare parts to clients in a timely manner is especially important for large-scale plants, where potential replacement parts should be immediately available during routine equipment inspections. A spare parts management system must be able to readily respond to urgent cases and quickly handle estimates and inquiries, to facilitate client selection of the correct items and to promptly process and deliver client orders.

This chapter describes services that improve the efficiency of the ordering process by adapting existing spare parts portal systems for medium-lot machinery to MHI's custom-designed products, such as thermal power plants.

4.1 Spare parts ordering system

The configuration of the spare parts ordering system is shown in **Figure 7**, and a screenshot is displayed in **Figure 8**. Clients can quickly find any desired items on a list drawn from MHI's existing spare parts database, searching by equipment category or with keywords such as parts descriptions or ID codes. Following the search, clients can verify product data on the MHI website, or make online inquiries for further information before identifying the required parts and proceeding with their orders. Once an order has been placed, up-to-date order status information (e.g., order processed, order shipped, etc.) is available online to provide clients the assurance and peace of mind that their orders are being properly handled.

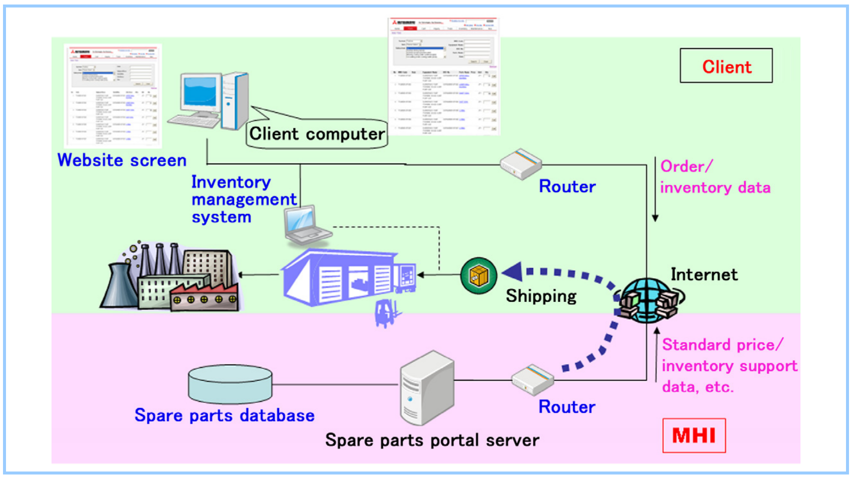

Figure 7 System configuration

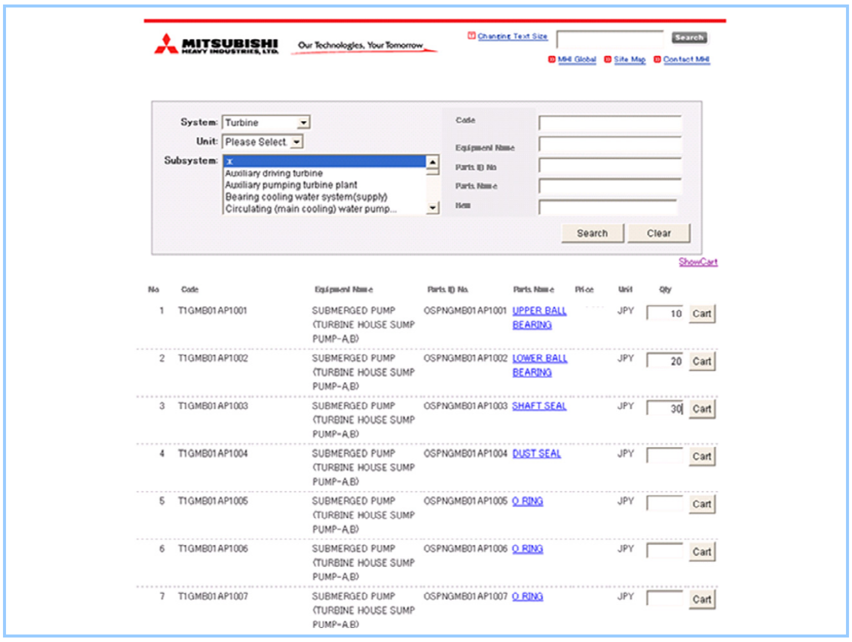

Figure 8 System screenshot

4.2 Integration with inventory management system

Optimal inventory management services for spare parts are offered to clients who are able to share their inventory data with MHI. By monitoring these data, MHI provides clients with various inventory support services, such as prompting the restock of spare parts for which a shortfall is anticipated at the time of a scheduled equipment inspection. In addition to assisting clients with equipment inspection planning, MHI's inventory management system also functions as a communication tool between MHI and its clients.

The system is already in place for overseas plants, and has been well received by clients. Using the existing system as a platform for further development, MHI plans to implement systematic inventory management at more plants at both domestic and overseas locations.

5. Consultation Service Providing Cost-benefit Estimates for Machinery Revamping/Replacement (Compressor)

Large-scale machinery tends to have a long operational lifespan. Accordingly, MHI aims to enrich its lineup of revamping services for reliability improvement and cost-effective operation of existing facilities through implementation of the latest technologies. Using an example involving compressors, this chapter illustrates the ways in which MHI's consulting services provide optimal upgrading solutions to maximize client benefit via comprehensive evaluation of the economic and environmental efficiencies of machinery revamping/replacement projects, with due consideration given to facility data and area characteristics.

5.1 Client machine database and support system tool for client visit planning

The screenshots in **Figure 9** show the process flow of the machine database and support system tool for client visit planning.

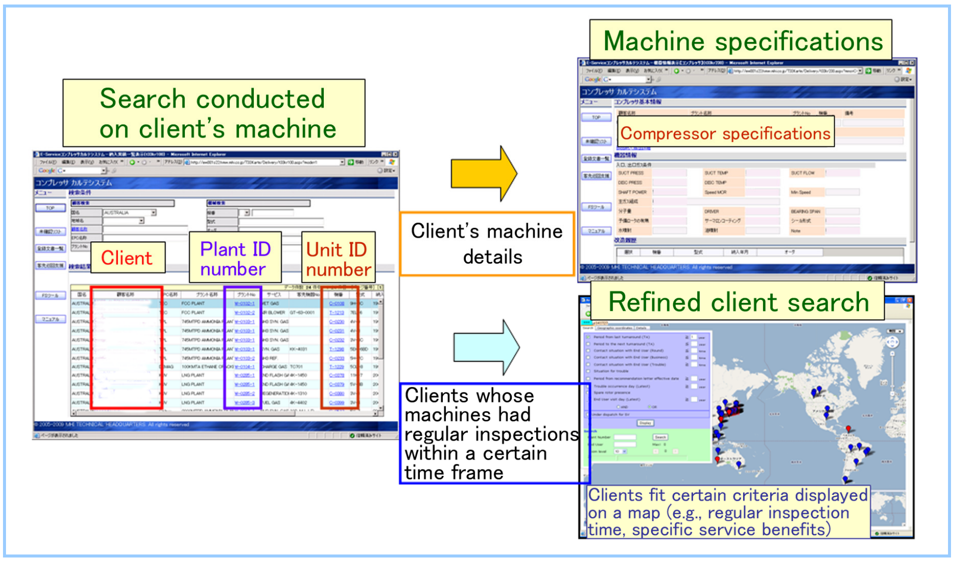

Figure 9 Client machine database with visit planning tool

As with the previously mentioned system for paper converting machinery, the client machine database allows users to instantly retrieve all information related to client machines throughout the product life cycle, including machine ID number, specifications, client information, incompatibility data, etc. The support system tool for client visit planning prioritizes client service visits by combining maintenance history and geographical data stored in the machine database. The tool can also be used for more effective planning and preparation, by ordering the visits according to the locations of a group of clients whose machines fit specific criteria, such as length of time since the last scheduled inspection.

5.2 Revamping/replacement solution system

Figure 10 shows screenshots of the revamping/replacement solution system, which quantitatively evaluates the effect of equipment revamping/replacement on performance and reliability improvement and cost reduction at a client plant. In this particular example, the estimate shows that by replacing the existing equipment, steam costs and CO_2 emissions per plant capacity unit can be reduced by approximately 15 percent.

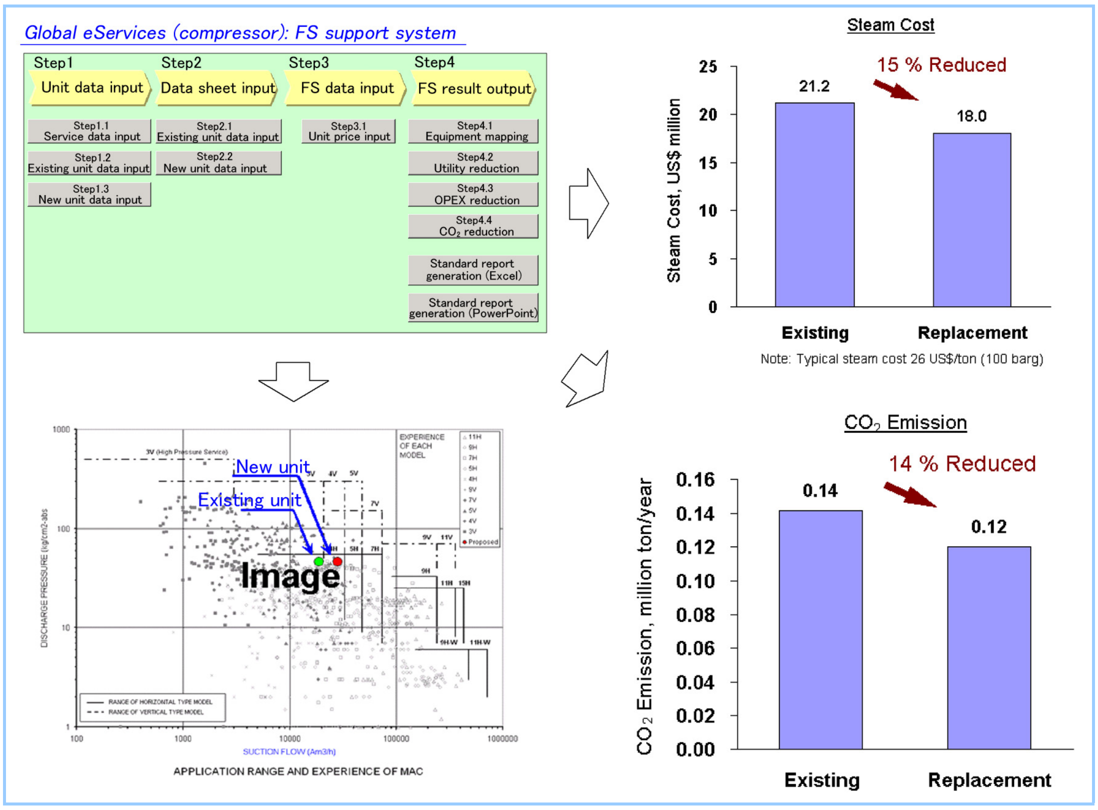

Figure 10 Revamping/replacement solution system

Power efficiency gained from replacing existing compressors and drive units, combined with local energy costs and CO_2 primary unit data, is automatically translated into economic and environmental improvements for quantitative analysis.

The system contributes to improve the value of facilities by offering clients an accurate understanding of the benefits of MHI's revamping/replacement services.

6. Conclusion

MHI is currently pushing ahead with a company-wide e-service project to enhance service technologies, since our products (despite their wide-ranging applications) still share many commonalities in service-related operations. Joint meetings on service technology are regularly held as part of this initiative. As a result, by making the best use of MHI's unique advantages as a manufacturer of a broad range of products, diverse service offerings are being provided by integrating the technologies for custom-designed products, medium-lot machinery and mass-produced items. The services referred to in this article are just a few examples of this lineup.

MHI continues to engage in the development of technologies that offer clients optimal benefits from our products and services.