Advanced Technologies of Preventive Maintenance for Thermal Power Plants

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OVERVIEW: Although thermal power generating facilities are aging, flexible operation in response to changes in the demand for electrical power is required. To extend the life and manage the maintenance of those facilities, advanced preventive maintenance technology is important. For that reason, Hitachi has been grappling with nondestructive inspection, life assessment technology, rationalization technology for scheduled inspections of the boilers, steam turbines, gas turbines and other machinery used in thermal power generation to strengthen preventive maintenance and increase the efficiency of maintenance. Recently, we have been developing products and services for advanced support for maintenance and preservation through the use of IT (information technology) and network technology, going beyond what has previously been available.

INTRODUCTION

IN recent years, startup and shutdown operations have become frequent in aging thermal power generation facilities, and preventive maintenance technology has steadily been increasing in importance from the viewpoints of extending the scheduled inspection interval and strengthening the independent management of facilities. Furthermore, concerning preservation of the global environment as well, there is also a strong demand for the reduction of CO_2 emissions through improved generation efficiency and fuel conversion in existing facilities.

Under such circumstances, Hitachi is going beyond the application of new technology that has been developed for new power plants to old facilities, and has taken up the challenge of developing our own preventive maintenance technology.

Together with these advanced technologies and products, Hitachi is making use of IT, which has developed rapidly in recent years, to provide global services that contribute to life-cycle cost minimization for power generation facilities (see Fig. 1).

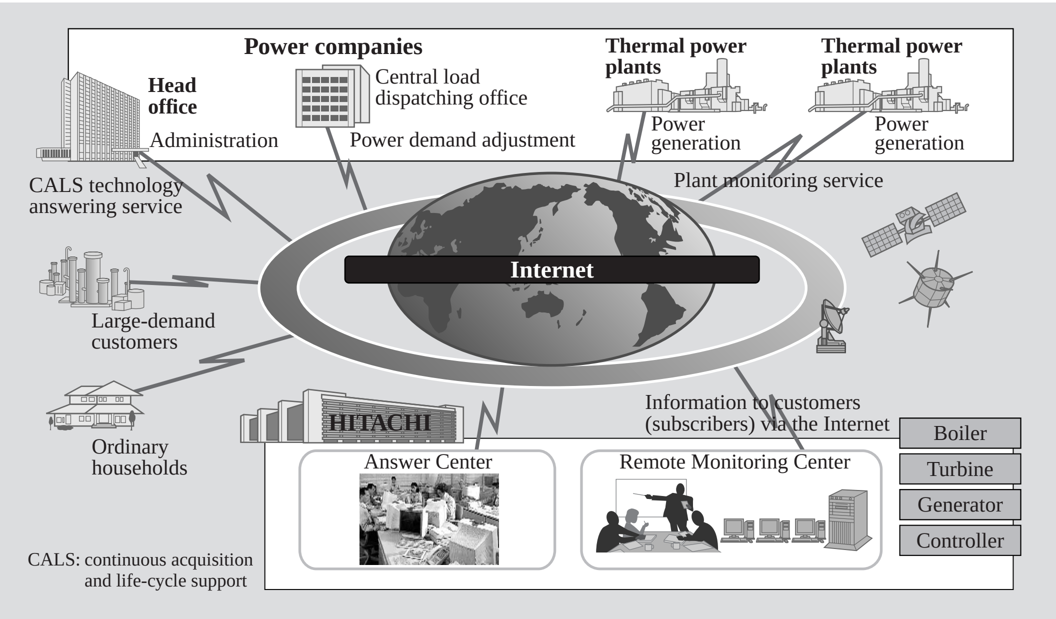

Fig. 1—Preventive Maintenance Solutions for Thermal Power Plants Provided by Hitachi.
Hitachi is making full use of IT to provide the newest preventive maintenance systems and services for thermal power plants.

Here, we describe the latest technology for the preventive maintenance of thermal power plants.

APPLICATION OF IT TO PREVENTIVE MAINTENANCE OF THERMAL POWER PLANTS

Hitachi is proceeding to add intelligence in a wide range of fields by making use of IT and the proprietary knowledge we have accumulated in various industrial areas with the objective of being the customers' "Best Solutions Partner" by offering new solutions.

In the field of preventive maintenance for thermal power plants, too, we have taken up the challenge of using IT and network technology to provide services for the support of advanced maintenance and preservation that go beyond what has been available to the customer in the past.

With the increasingly severe demands on the operation of aging thermal power plants, typified by extension of the period for scheduled inspections and DSS (daily start-up and shut-down) operations, there is increasing need to know the quantitative state of the facilities, such as by monitoring operation at times of transition and knowing the deterioration state of equipment, in addition to the regular monitoring of operation. There is also a demand for the provision of performance evaluation technology for life-cycle cost minimization, as well as the provision of operation methods that use such technology to optimize efficiency and the provision of operation data management services. To meet that demand, Hitachi is developing services which make use of IT, such as plant monitoring services and engineering services.

As example of an engineering service, a means of providing information over the Internet is illustrated in Fig. 2. In that service, subscribing customers can get speedy answers to technical questions via the Internet by directly accessing the Answer Center Web Site set up by the Thermal Power Preventive Maintenance Department, a process that previously required waiting for written responses. It is also possible to access information on the latest operation and maintenance technology and improvements in real time. This service can be provided to overseas customers as well as to domestic power companies.

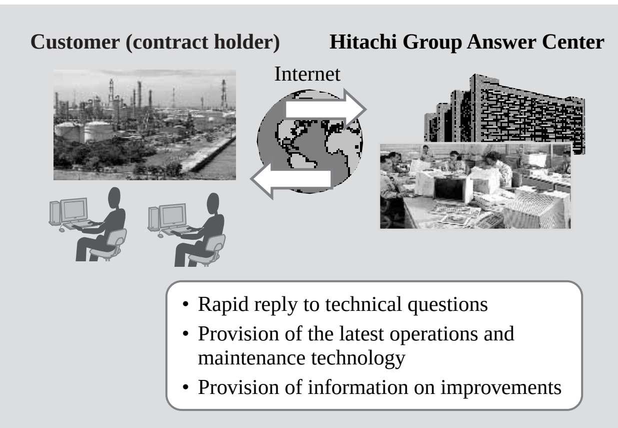

Fig. 2—Mechanism for Providing Technical Information via the Internet.
Technical questions from customers can be answered quickly and the latest information can be provided over the Internet.

PREVENTIVE MAINTENANCE TECHNOLOGY FOR THERMAL POWER PLANTS

In an environment of deregulation, there has been little progress in the construction of new thermal power generation. Furthermore, load conditions have recently become severe, including operation according to varying load (middle load operation), etc., and there is an accelerating trend of material damage. To cope with that problem, Hitachi is promoting the development and application of preventive maintenance technology for boilers, steam turbines, gas turbines, and other core technologies of thermal power plants, as described in the following sections.

Preventive Maintenance Technology for Boilers

Application of the latest development technology

The conventional techniques for nondestructive inspection of boiler materials and parts include PT (liquid penetrant testing), MT (magnetic particle testing), and UT (ultrasonic testing), among others. These types of inspection, however, have problems such as:
(1) difficulty of inspecting narrow gapped areas,
(2) requiring a large amount of associated work, and
(3) difficulty of lifetime diagnosis or can predict quantitative damage progress.

To cope with these problems, Hitachi has been developing various kinds of scheduled inspection rationalization technology to achieve lower-cost, timely inspection by reducing the preparation work and to achieve fast, highly accurate inspection by employing advanced inspection equipment without direct contact. The main diagnostic points and diagnosis technology are shown in Fig. 3. These rationalized technologies are already being applied in actual plants.

Of these technologies, ELFOSS UT (electronic focus sector scan ultrasonic testing), which can

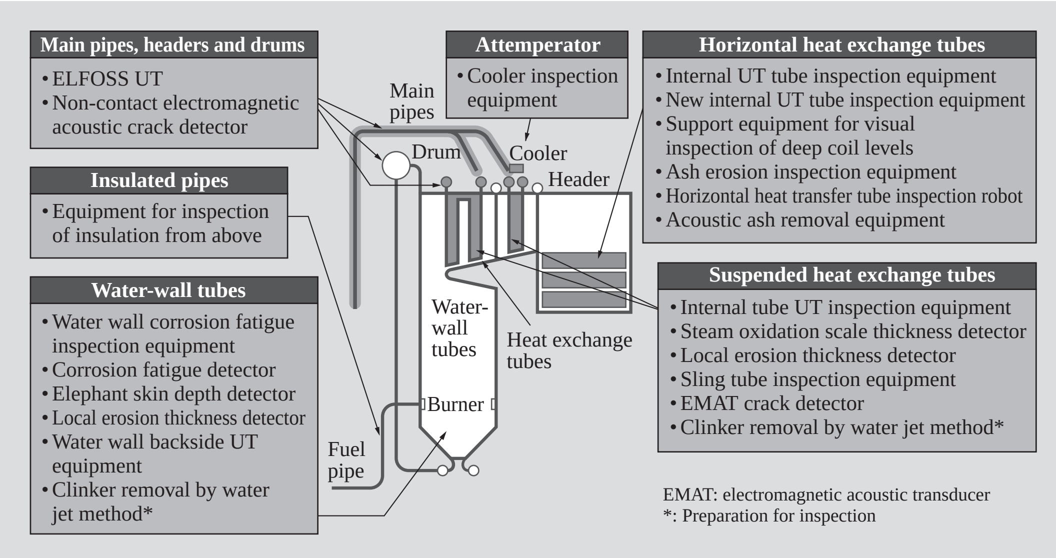

Fig. 3—Main Diagnostic Points and Diagnosis Technology.
Hitachi has developed inspection equipment that is capable of non-destructive, quantitative evaluation of all of the pressure containment parts of the boiler.

evaluate internal defects in the welds of main pipes, is described below:

ELFOSS UT can evaluate defects contained in welds and in narrow nozzle stubs by electronic focusing and sector scanning techniques. A major feature of this device is that the scanning range of the UT probe is smaller than that used in the conventional UT method, so the defect size and location can be determined accurately.

The results of ELFOSS UT inspection of a plate (100-mm thick) butt weld that contains an artificial defect are shown in Fig. 4. The defect detected by the nondestructive method matches well with the defect as confirmed by cross-section examination. With such an excellent defect detection capability, this equipment is being applied to precise inspection of important areas, such as the welds of main pipes.

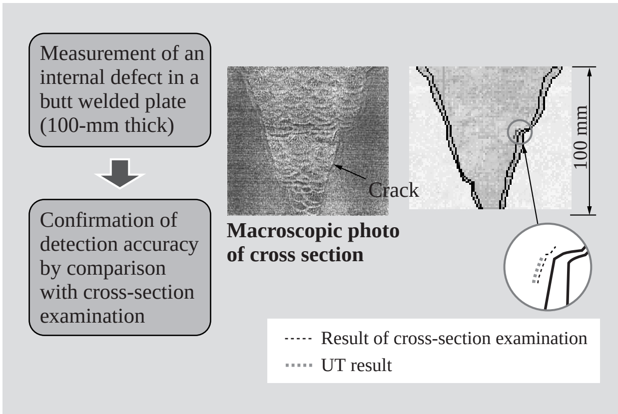

Fig. 4—ELFOSS UT Performance.
The results of inspecting a sample butt weld that contains an internal defect show that the defect size and location can be detected accurately.

Scheduled inspection rationalization technology

The various types of nondestructive inspection equipment shown in Fig. 3 are all capable of quantitative evaluation of defects, and can also be called rationalized technologies with respect to shortening inspection time for schedule inspections. In addition to such higher performance of the inspection equipment itself, rationalization technology such as for shortening the preparation time for inspection is also desired.

For example, in the furnace of coal-fired boilers, fused ash adheres to places such as the bends in the heat exchange pipes that are suspended from the top of the furnace. Such ash may grow to form hard clinkers. Because it is very dangerous if those clinkers fall inside the furnace, they should be removed before installing the scaffolding and performing the inspection and repair work at the time of scheduled inspections. The removal of the clinkers in this way requires much time and labor.

For that reason, we turned attention to WJ (water jet) technology, and developed a special nozzle that produces several times the force of the conventional nozzle. Using this nozzle reduces the time required for clinker removal significantly, and the time from the shutdown of a plant to the beginning of inspection and repair can be greatly reduced.

Preventive Maintenance Technology for Steam Turbines

Lifetime diagnosis of steam turbines

For high-temperature components of aging steam turbines, accurate preventive maintenance and extension of machine life is becoming established.

On the other hand, for low-temperature components, of which low-pressure turbines are a typical example, damage related to corrosion has been appearing in recent years. In most of those cases, corrosion fatigue cracking or SCC (stress corrosion cracking) is seen in the severely corrosive phase transition zone environment. To deal with these problems, we are establishing highly accurate lifetime evaluation technology derived from an understanding of actual operation in service. That technology is based on analysis of the vibratory response in grouped blades in the low pressure stage and accumulating data on the occurrence and growth of corrosion pitting in the actual environment. As a result, we are trying to maintain the reliability of low-temperature parts in a corrosive environment by recommending the overhaul of low-pressure turbines that have been in service for 20 years or more by removal of the bucket.

Development of scheduled inspection technology for improving in efficiency

With the continuing relaxation of regulation, there is an even stronger demand for improvement in the operating efficiency of facilities as well as the lowering of maintenance costs. For those reasons, we are endeavoring to raise the efficiency of work involved in the scheduled inspection of turbines and to develop various types of technology for increasing efficiency and conserving energy. The technology for rationalizing scheduled inspection work not only improves that work directly, but also includes technologies, such as facility diagnosis technology, that minimizes that work and asset management technology that in turn increases the efficiency of managing the scheduled inspection data.

(1) Rationalization technology for scheduled inspections

To shorten the scheduled inspection process, we have developed tapered sleeve type bolting equipment for the bucket coupling and oil flushing reduction equipment. The tapered sleeve type bolting equipment allows smooth bolt extraction, so the bolt loosening time can be reduced to half a day per coupling. Previously, five to seven days were required to flush the oil for cleaning the bearings and bearing box after completing the assembly of the turbine and generator. The oil flushing reduction equipment, however, achieved results that fully satisfy the specified bearing oil cleanness requirement in only three days, as well as reducing the test operation time.

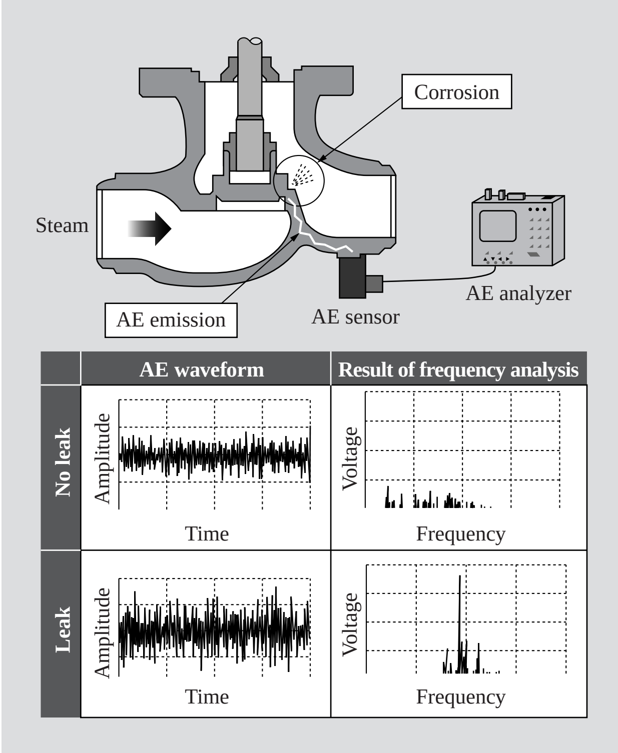

Fig. 5—Mechanism for Detecting Steam Leaks in Stop Valves and AE Waveform for a Leak.
An example application of AE to stop valves and other static parts.

(2) Facility diagnosis technology

For facility diagnosis, we developed leak diagnosis technology that makes use of AE (acoustic emission). Up to now, AE diagnosis has been applied to abnormality detection in rotating parts such as turbines and pumps. Now we have developed technology for applying this method to steam leaks in stop valves as well. An application example is shown in Fig. 5.

(3) Asset management technology

As an asset management technology, we have developed a scheduled inspection record and history management application system. Rapid and paperless recording of data from the time of measurement to data management is made possible by using a network to connect the inspection site and the persons responsible for data approval and management. This inspection recording application is linked to a history management system, and serves to provide data for the history management of assets. In this way, the various types of information from the inspections is databased for each asset so that the deterioration trend of each asset can be known. Furthermore, data mining is done easily by time series of the maintenance data for each asset or by phenomenon. A sample window

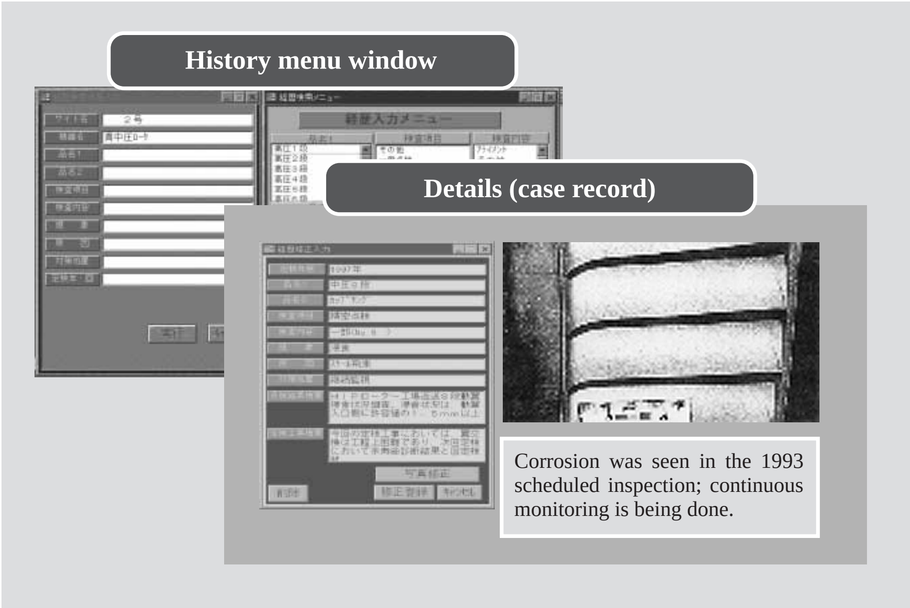

Fig. 6—Screen Images from the Turbine History Management Application.
Detailed information on each asset is easily grasped.

from the turbine history management application is shown in Fig. 6.

Introducing the various types of rationalization equipment that have been developed can shorten the standard process for a 600-MW turbine to about five days and a 10 to 15% saving in energy can be expected.

Preventive Maintenance Technology for Gas Turbines

The load conditions are very severe for gas turbines, which use high-temperature combustion gases as the working fluid. For that reason, differently from steam turbines, the hot gas path components that are placed in the path of the combustion gases have a relatively short operating time and are repaired repeatedly during the course of use.

Maintenance costs for repair, reconditioning and part updating are a large proportion of the cost of generating electricity, so the advancement of preventive maintenance technology is important in terms of economy as well as reliability.

Lifetime management and repair of hot gas path components

The life of hot gas path components is shortened by creep, abrasion, oxidation and other such damage that is related to operating time and by damage that occurs as the result of repeated startups and shutdowns, such as low-cycle fatigue.

Accordingly, lifetime management employs the equivalent operating time method, which takes into account the effects of the number of startups, shutdowns and sudden changes in load, etc. as well as the actual operating time. When the equivalent operating time reaches the specified lifetime, that component is considered to have reached the end of its operating life.

Concerning the hot gas path components, if the inspection result exceeds the judgement criteria, the component is repaired. See Table 1 for a description of the repairs.

Of those, the latest repair technology that is currently being used in actual plants is described below.

Gas turbine bucket recoating repair

Gas turbine buckets are subjected to severe

TABLE 1. Hot Gas Path Component Repairs
Examples of the latest gas turbine repair technologies are described in this table.

Component	Description of Repair
Static blade of turbine	• Welding repair of cracks (build-up) Brazing and diffusion bonding • Creep deformation repair • Recoating
Turbine bucket	• Tip welding build-up • Recoating
Combustion liner	• Welding repair of cracked parts • Replacement of spring seals, collars, etc. • Recoating
Transition piece	• Welding repair of cracks and abrasion • Creep deformation repair • Recoating

conditions of centrifugal force and high thermal stress load in the high-temperature and high-pressure combustion gases. For that reason, Ni-based super-alloys are used and an oxidation resistance coating is applied to the bucket surface to protect the base material. With long-term use of the buckets, the coating suffers damage by deterioration, so it is necessary to strip the old coating and recoat the buckets before the base material is damaged. Measures are also taken against erosion of the bucket tips by high-temperature oxidation. Hot tearing from welding heat flux usually occurs in Ni-based super-alloys with high Ti or Al content, so it is a difficult material to weld. In recent years, however, low-current welding methods have been developed, so repair by build-up welding has become practical for the low-stress bucket tips.

Gas turbine nozzle blade diffusion brazing repair

Gas turbine nozzle blades suffer thermal fatigue cracking due the thermal stress caused by start-up and shut-down. Those cracks must be repaired by welding during the course of nozzle blade use. There is a tendency for multiple thermal stress cracks to appear over a wide area of the nozzle blades, so repairing them takes a great deal of time and effort. Furthermore, deformation of the nozzle blades occurs in proportion to the amount of heat applied during the welding. Diffusion brazing repair avoids that problem by using a brazing filler metal that has about the same composition as the base metal, but with a low melting point metal added. This method involves cleaning the surfaces of the cracks, flowing the filler metal into the cracks and then diffusing the filler metal into the blade metal with a heat treatment. This method reduces labor for the repair and prevents deformation of the blades. By using both welding repair and diffusion brazing repair, we are reducing labor and extending the life of nozzle blades.

CONCLUSIONS

We have described the development situation for IT application technology and the latest technology relevant to boilers, steam turbines, gas turbines in the field of preventive maintenance for thermal power plants, as well as how Hitachi is solving problems related to this technology.

Hitachi will continue to propose IT services, including Internet application technology, and core technology services.

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