Trends and Future Outlook for Thermal Power Plants

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1. Introduction

Recent events have caused modern society to appreciate anew the benefits it derives from electricity. A wide-ranging massive power outage extending from the northeastern United States to Canada and a power failure throughout all of Italy have occurred, and have had large impacts on the life of residents in those areas. In Shanghai, rotating power outages have been implemented for years and are a large impediment to normal business activities. In Japan, a stoppage of the operation of all nuclear power plants owned by The Tokyo Electric Power Co., Inc. caused a great deal of anxiety, but aided by the cool summer weather, ultimately did not result in a power outage. When a large-scale power outage occurs, trivial problems gradually increase and may potentially cause the collapse of large systems.

Power plants are part of the infrastructure of modern society and it is essential that these power plant facilities by constructed so as to achieve a higher level of reliability. Moreover, it is the mandate of companies involved in this industry to contribute to society by realizing higher performance and lower cost.

2. Market Trends

The climate surrounding Japan's domestic electric utility industry is as severe as ever due to sluggish growth in the demand for electrical power, the ongoing decrease in electrical power rates, the advancement of electric utility deregulation, the establishment of new environmental taxes, and the rapid rise in prices of such fuels as oil and coal. Power generation by means of renewable energy has been favored following the enforcement of the "Special Measures Law Concerning the Use of New Energy by Electric Utilities" (RPS law) and then the Kyoto Protocol, which came into effect in February 2005. However this market sector will be stalled in a wait-and-see situation for the next 1 to 2 years, during which time, efforts to develop new power sources are expected to idle.

In overseas markets, there is strong demand for electrical power in both the public and private sectors of the BRICs (Brazil, Russia, India and China) where there has been a significant increase in demand for electrical power, for Libya which has recently returned to the international arena, and the Southeast Asian countries of Indonesia and Vietnam. In these countries, the supply of electrical power has not caught up with the speed of economic growth and industrialization, and this demand for many new power generating plants is expected to continue for several years. These power plants will be mainly medium and small capacity facilities, which is Fuji Electric's area of expertise. Fuji Electric has a track record of many successful applications including pure power generation and cogeneration plants based mainly on coal-fired power generation, and combined cycle power generation achieved by connecting an add-on to an existing gas turbine.

3. Technical Trends

Fuji Electric was founded approximately 80 years ago through a partnership between The Furukawa Electric Co., Ltd. and Siemens AG., to introduce European technology to Japan at a time when US technology was already widespread. Fuji Electric has been involved in the production of thermal power plants for approximately 40 years and has supplied many distinctive products by introducing technology from Siemens during construction of mainly utility thermal power plants. Table 1 shows the history of growth in Fuji Electric's main technologies and businesses. Recently, Fuji Electric has delivered a ultra-supercritical pressure steam turbine to the Isogo Thermal Power Station of The Electric Power Development Co. (EPDC). This ultra supercritical pressure steam turbine increases the efficiency of the power plant, or in other words, reduces the environmental load. Figure 1 shows a view of the entire EPDC Isogo Thermal Power Station Unit No. 1.

Meanwhile, with the deregulation of the electric power industry, power plants are now being constructed by independent power producers (IPPs) and Fuji Electric is supplying various types of economically beneficial equipment to these plants.

Table 1 History of changes in Fuji Electric’s main technologies and businesses

Category \ Era	1970s	1980s	1990s	2000s
Thermal power plants for utility in Japan	▼TEPCO Ooi Thermal Power Station, Unit No. 3 (first pure sliding pressure operation in Japan)	▼EPDC Ishikawa Coal Thermal Power Station, Unit Nos. 1 and 2 (high-temperature turbine) ▼Okinawa Electric Power Makiminato, Unit No.9 (Fully automated oil thermal power) ▼Kansai Electric Power Miyazu Energy Research Center, Unit No.2 (DSS operation)	▼Tohoku Electric Power Noshiro Thermal Power Station, Unit No.1 (50 Hz, 600 MW large-capacity tandem machine)	▼EPDC Isogo Thermal Power Station, new Unit No.1 (600 MW ultra-supercritical pressure plant)
Thermal power plants for private use and IPP plants in Japan		▼UBE Industries, Ube plant (145 MW, largest private-use power plant in Japan)	▼Fuji Electric Gas Turbine Research Center (69 MW gas turbine made by Siemens) ▼Kobe Steel, Kakogawa Works (axial flow exhaust turbine)	▼UBE Power Center (60 Hz max. global vacuum pressure impregnated insulation air-cooled generator)
Overseas thermal power plants	▼Philippines: Battan, Unit No.2 (full-scale entry into overseas business of thermal power plant for utility) ▼Australia: Gladstone Unit Nos. 1 to 4 (direct hydrogen-cooled generator)	▼Thailand: Mae Moh, Unit Nos. 4 to 13 (largest thermal power plant in Southeast Asia) ▼Pakistan: Jamshoro Unit No.1 (largest indirect hydrogen-cooled generator)	▼Taiwan: FPCC FP-1, Unit Nos. 1 to 4 (60 Hz, 600 MW large-capacity tandem machine)	▼Bangladesh: Meghnaghat (combined-used turbine, large-capacity air-cooled generator)
Geothermal power plants	▼EPDC Onikobe Geothermal Power Plant (generator delivered)	▼El Salvador: Ahuachapan, Unit No.3 (full-scale entry into geothermal power plant business) ▼USA: Coso Geothermal Power Plant, Unit Nos. 2 to 9 (modular turbo-set)		▼Indonesia: Wayang Windhu, Unit No. 1 (world’s largest single-casing geothermal turbine) ▼TEPCO, Hachijojima Geothermal Power Station
Technical development	▼Direct hydrogen-cooling method ▼Global vacuum pressure impregnating facility for medium and small-size generator	▼High-temperature 12Cr rotor ▼22 kV-class F resin/ F insulation ▼F resin/ F II insulation	▼Improved 12Cr rotor for high temperature ▼Experimental prototype of 126 MVA air-cooled generator ▼Global vacuum pressure impregnating facility for large-size	▼Completion of new Shiraishi Factory ▼Automated stator winding machine ▼22 kV-class global vacuum pressure impregnated insulation system

Fig.1 EPDC Isogo Thermal Power Station new Unit No. 1

Fig.2 View of the entire UBE Power Center Plant

The construction of utility thermal power plants in Japan has reached as standstill at present and is not expected to recover soon. Additionally, IPP planning has also become saturated. Figure 2 shows a view of the entire UBE Power Center Plant that was constructed as an IPP plant. Fuji Electric will continue to develop products while carefully monitoring these market trends in the future. The technical trends of medium and small capacity power plant equipment, which are Fuji Electric's main products at present, are described below.

3.1 New small-capacity non-reheat steam turbines

Fuji Electric has newly developed a steam turbine (FET-N type) having a simple configuration suitable for small capacity (25 to 50 MW) applications. A first unit is already in operation in China, and a second unit has already been shipped and is being installed onsite.

3.2 Large non-reheat steam turbines

Fuji Electric's expertise is greatest in the technical field that involves private-use power plants. These plants have multiple steam processes and require complex control. In a turbine, the process steam flow rate is controlled as required, and at the same time the electrical power output is adjusted. In the past, the output power was approximately several tens of MW but, in response to market needs, technology has been developed to achieve larger turbines capable of greater than 160 MW output.

3.3 Single-casing reheat steam turbines

Fuji Electric has developed a reheat steam turbine configured with a single casing instead of the conventional two-casing construction, and a first unit has already been placed in service. Shortening the length of the turbine shaft has enabled a reduction in construction costs, including civil engineering work, and the realization of a more economical plant.

3.4 New digital control system

A new digital control system (TGR) that provides integrated control for a turbine and generator, and uses Fuji Electric's MICREX-SX, which is a high-performance PLC, has been placed into commercial operation and it being applied to other plants.

3.5 Remote monitoring

A remote monitoring system has been developed that periodically gathers operating status data from power generating equipment that has been delivered to a remote overseas location and transmits that data via the Internet to a maintenance department, where it is received. Thus, even when a failure occurs in remote onsite equipment, the customer can be instructed quickly as to the appropriate measures, thereby minimizing downtime and reducing the customer's loss. Moreover, appropriate advice concerning preventative maintenance is also provided in order to avoid downtime due to mechanical failure.

4. Steam Turbines

Various improvements to steam turbine technology have been previously requested in order to enhance the thermal efficiency and space efficiency of thermal power plant facilities. In the large-capacity generator sector, Fuji Electric has advanced the development of 600 MW-class supercritical pressure steam turbines, and together with the improved thermal efficiency due to higher temperature and pressure steam conditions and the development of large turbine blades, has reduced the number of low-pressure turbine casings to realize more compact turbines. In the medium and small-capacity generator sector, technology has been developed to increase the efficiency, compactness and serviceability of steam turbines, enabling smaller initial investment and higher reliability. Fuji Electric has continued to improve the space efficiency by migrating from the conventional three-casing structure to a two-casing structure and then to a single-casing structure. With the increase in capacity, the ability to maintain stability of the shaft system as the distance between bearings increases in a steam turbine and measures to prevent erosion of the low-pressure blades presented technical challenges that have since been overcome due to greater analytical precision and structural improvements. A single casing turbine of 165 MW maximum capacity has already been brought to market and is achieving good operating results. In order to reduce the construction costs associated with a combined cycle steam turbine, axial flow steam turbines are being widely used. Fuji Electric will continue to advance the development of technology to improve efficiency and lower the cost of medium and small capacity turbines.

5. Generators

Air-cooled generators, due to their low construction cost, short production time and ease of operation and maintenance, are gradually beginning to be used in applications traditionally associated with hydrogen-cooled generators. At present, Fuji Electric's air-cooled generators are suitable for applications ranging up to 280 MVA for 60 Hz generators and 300 MVA for 50 Hz generators. Because air, which has lower cooling performance than hydrogen, is used as a coolant with larger capacity generators, Fuji Electric implemented a technical verification test by fabricating a 126 MVA experimental generator and taking on-line measurements at more than 1,000 on the stator and rotor. The results of this test demonstrated that it was possible to manufacture a large-capacity air-cooled generator having sufficient reliability.

For hydrogen-cooled generators, indirect cooling is also being used instead conventional direct cooling. Indirect cooling is the method of cooling used in air-cooled generators, and technology acquired during the development of air-cooled generators is also being applied to hydrogen-cooled generators. At present, the applicable range for indirect hydrogen-cooled generators has an upper limit of 450 MVA.

6. Geothermal Power Plants

There are presently no plans for the construction of geothermal power plants in Japan. The reason for this lack of plans is the high cost due to risks associated with underground resources, the large initial investment that is required, and the long lead time required to coordinate and reach a consensus concerning treatment of national parks and existing hot springs. However, small-scale binary power generation that utilizes previously unused steam and hot water from a hot springs region is a promising model for economical geothermal power plants because there are no drilling costs and the lead time is short. The RPS law has been enforced since 2003, obligating electrical power suppliers to use renewable energy. Because geothermal binary power generation is also included in this category, the construction of geothermal power plants is expected to gain momentum.

Overseas, due to the slowdown in the global economy that began with the Asian currency crisis from 1997 through 1998, developing countries postponed or froze almost all their geothermal development plans that required an initial investment or involved investment risk. However, in response to the increase in demand for electrical power that accompanied the subsequent economic recovery, plans that use public funds such as yen loans or financing from the Asian Development Bank for investigating geothermal resources and constructing geothermal power plants have been reinvigorated.

In the past, geothermal power plants commonly adopted affordably-priced single-flash cycle. In order to achieve a more efficient use of resources, double-flash cycle, combination with binary cycle using brine from flash cycle and cogeneration of hot water for house heating using exhaust or extracted steam are adopted.

In order to improve plant efficiency and the utilization rate of geothermal turbines, the following technologies are recognized as important for geothermal power plants: technology for preventing the adhesion of and removing silica scale from turbines, monitoring techniques and easy maintenance, and measures to prevent the adhesion of silica on re-injection piping or a re-injection well. Geothermal steam contains a minute amount of hydro-sulfuric gas and, as environmental quality standards become stricter, an increase is expected in the number of installations of equipment for removing this hydro-sulfuric gas, which previously had been released into the atmosphere.

7. After-sales Service

After-sales service has been implement thus far in a close working relationship with the user, mainly by providing periodic inspections of delivered equipment and replacing or repairing parts for preventative maintenance. These activities include responding to incidences of sporadic failure and also providing various suggestions for improvements. Periodic inspections are necessary to ensure the safety of a plant, and in Japan, this is a characteristic of a regulated industry protected by laws. As the relaxation of regulations results in a shift from mandatory periodic inspections to voluntary inspections, technical suggestions by manufacturers are being closely scrutinized based on economic criteria to determine whether they are absolutely necessary for ensuring stable operation. Against this backdrop, specialized maintenance service companies have already begun operating in Europe and the US. The necessity for periodic inspections is also being recognized in Southeastern Asia, and these European and US maintenance companies are early participants in those markets. Fuji Electric intends to leverage its reliable and responsive after-sales service in order to insure the stable operation of power plants, and to compete as an equipment manufacturer against these specialized maintenance companies.

After-sales service for an aged plant can encompass plans for major renovations or renovation of the entire plant in order to reuse the plant's facilities. These types of plans can be diverse and may involve conversion of the type of fuel that was used originally at the time of construction, massive renovation of the entire plant—such as changing the operating principle of the power plant, and repairing or replacing worn out parts to prolong the service life of the equipment or reducing maintenance cost and enhancing the efficiency of the plant. Technology has also made great advances since the time of the initial construction and a wide range of measures are available for problem solving.

8. Conclusion

Thermal power plants are industrial goods that produce electricity. Moreover, these plants are important to customers and are presumed to have a service life of greater than twenty years. Accordingly, the reliability of a power plant is considered most important, followed by after-sales service and then economic efficiency. As demand for electrical power increases throughout the world, Fuji Electric intends to continue to strive to supply power plants that provide reliability, high performance and low price in accordance with the needs of customers.