Shinko Kobe No.2 700-MW Power Station of Kobe Steel, Ltd. as Largest IPP Facility in Japan

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OVERVIEW: Designed by Kobe Steel, Ltd. as an IPP (independent power producer) in Japan, the Shinko Kobe No. 2 Power Station—with a rated output of 700 MW—commenced commercial operation on April 1st, 2004. As a major equipment manufacturer, Hitachi has been involved in the construction of this plant from the start. Producing steam conditions corresponding to a main steam pressure at the turbine inlet of 24.1 MPa·g, a main steam temperature of 538°C, a reheated-steam temperature of 566°C, and a condenser vacuum pressure of –96.26 kPa, and adopting 40-inch (about 102-cm) blades as the last-stage blades, this steam-turbine was designed to attain high-efficiency power generation. This IPP also has a system for supplying steam to a nearby sake brewing maker, and specific control of this system is performed by the IPP. As a so-called "urban power plant" located in a suburb of Kobe city, this power plant has been installed according to a shortened construction schedule and with appropriate attention given to the concerns of local residents.

INTRODUCTION

AS a power plant of an IPP (independent power producer), the Shinko Kobe Power Station of Kobe Steel, Ltd.—with its main No. 1 and No. 2. generators producing 700 MW each (producing a total power output of 1,400 MW)—is the largest-scale coal-fired power plant of this type in Japan.

As a major equipment manufacturer, Hitachi has been engaged in the construction of the Shinko Kobe No. 2 Power Station since its construction started in February 2001—through power receiving and commissioning, to start up of commercial operation in April 2004 (see Fig. 1). Being located in close proximity to an urban area of Kobe city (i.e. an "urban-type power station"), this power plant is true to the theme of being in maximum harmony with the local

Fig. 1—Panoramic View of Shinko Kobe No.2 700-MW Power Station of Kobe Steel, Ltd.
As the largest power generating facility of an IPP in Japan, the Shinko Kobe No.2 700-MW Power Station commenced commercial operation on April 1st, 2004.

TABLE 1. Specifications of Power Generating Equipment
The main specifications of the power generating equipment installed by Hitachi in the Shinko Kobe No.2 700-MW Power Station are listed in the table.

Item		No. 2 specifications
Turbine	Power output	700 MW
	Main steam pressure	24.1 MPa·g
	Steam temperature	538°C/566°C
	Rotation speed	3,600 min^{-1}
	Pumping vacuum	–96.26 kPa
Generator	Capacity	780,111 kVA
	Hydrogen pressure	0.41 MPa
	Frequency	60 Hz
	Terminal voltage	25,000 V
	Power factor	0.90
Condenser	Cooling area	33,290 m^2
	Vacuum	–96.26 kPa
	Cooling water temperature	24°C
	Cooling water volume	108,500 m^3/h

area. In the following sections, an overview of the Shinko Kobe No. 2 Power Station and its main features are described in detail. The main equipment specifications of the plant are listed in Table 1.

DESIGN OVERVIEW

Application of High-efficiency Conversion

To improve the efficiency of the turbine plant, the latest technologies were adopted. As for the last-stage blades of the steam turbine, by optimizing the design of the steam cycle [for example, by applying 40-inch (about 102-cm) blades], the targeted improvement in the turbine plant efficiency of over 47% at rated output was met.

System Configuration

As for the turbine-plant steam cycle, a configuration that achieves 700-MW-class performance was introduced, thereby assuring high reliability while optimizing plant installation. Moreover, to meet a broad array of customer needs, the plant is operated as a heat source for supplying steam to companies such as sake brewing makers; that is, a special-purpose steam extractor was set up to extract steam from the steam turbine.

OVERVIEW OF STEAM TURBINE

A bird's-eye-view of the completed turbine (TC4F-40) is shown in Fig. 2, and its cross section is shown

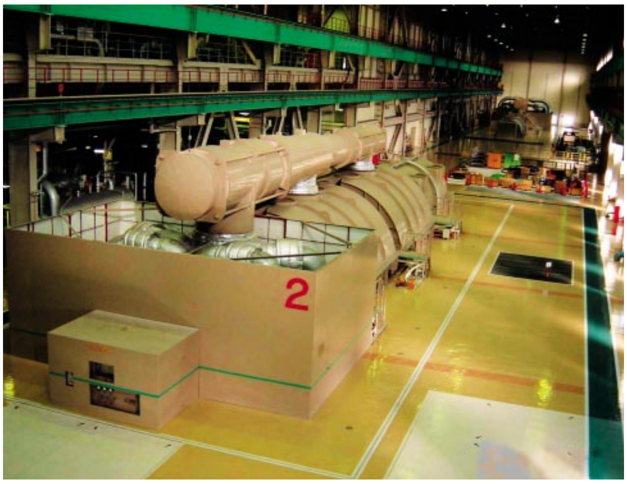

Fig. 2—View of Steam Turbine.
A full view of the steam turbine on turbine floor is shown.

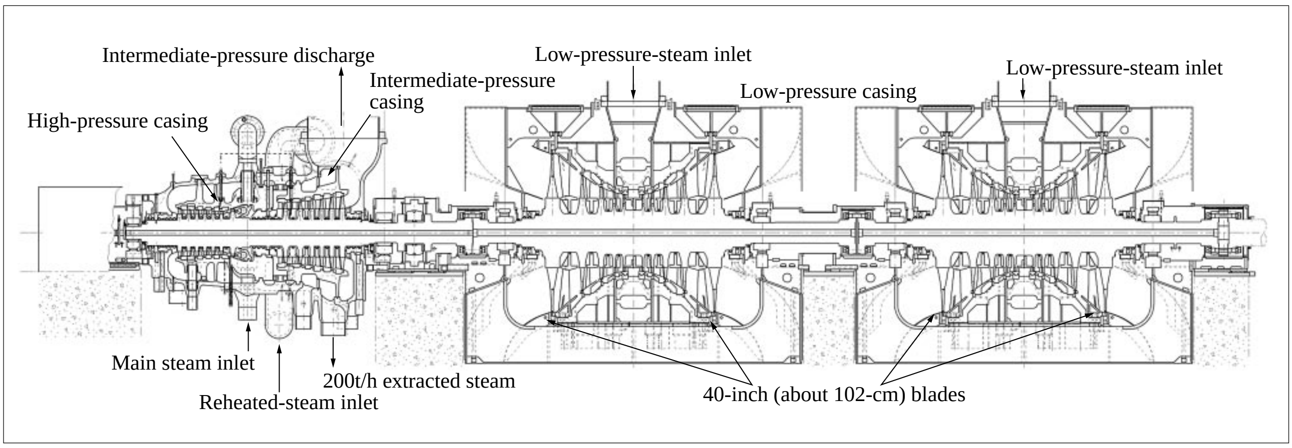

Fig. 3—Cross-sectional Diagram of Steam Turbine.
The steam turbine is composed of three casings: a single casing for high- and intermediate-pressures, and two for low pressure.

schematically in Fig. 3. The main features of this steam turbine are described in the following sections.

Structure of Steam Turbine

The steam turbine is composed of a total of three casings: one casing for high and intermediate pressure and two for low pressure. As for the intermediate-pressure turbine, it is constructed with a single casing under a steam reheating temperature of 566°C. And in the last turbine stage, time-proven 40-inch (about 102-cm) blades are adopted. The whole steam turbine consists of 33 rotor wheels: the high-pressure part has one gas stream through seven stages; the intermediate-pressure part has one gas stream through six stages; and the low -pressure part has four gas streams through five stages. To obtain the optimum extraction condition, the plant is designed so that steam is extracted from the intermediate-pressure casing at 200 t/h.

Techniques for Improving Steam-turbine Performance

As regards a steam turbine, with reliability of an IPP power plant as the first and foremost concern, we have applied conventional efficiency-improvement techniques proved effective up till now as much as possible. The main techniques applied for improving performance were high-load turbine blades, an AVN (advanced vortex nozzle), and 40-inch (about 102-cm) last-stage blades.

PLANT-MONITORING CONTROL SYSTEM

Known as a large-capacity (i.e. 700 MW) coal-fired power generating facility, this plant applies “Hitachi Integrated Autonomic Control System-7000 (HIACS-7000)” control equipment for power plants and multi-purpose HMI (human-machine interface) based on a POCs (process operator’s controls), and a plant-monitoring system for IPP industrial-use was established. The main features of this system are described below.

CRT Operation

(1) CRT operation comprises four POCs (touch-operation type) for providing visual display of the plant’s operational information and thus safe plant operability. Applied to electric equipment as well, the CRT operation provides wider coverage than that of conventional control equipment, and it provides a compact central monitoring board for monitoring plant operation from a central control room (see Fig. 4).

Fig. 4—Main Control Room of Shinko Kobe No.2 700-MW Power Station.
By means of CRT operation over the whole plant, the console panel and supplementary panels were made more compact, thereby allowing streamlining of the central control room.

(2) As well as having the function for CRT operation, the POCs are fitted with functions for plant-scheduling cost control, transmitted power control, and performance evaluation.

Control Equipment

As for the digital control equipment—namely, the sequence controller, the main turbine controller, and the automatic voltage regulator—the HIACS-7000 is applied for its high-speed, large-capacity processing ability. And making use of HIACS-7000’s capability for processing as functional units enables the control equipment to be constructed in such units. This control equipment and the POCs are connected by high-speed, large-capacity fiber interface. At the same time, an interface through a gateway is set up between the boiler control equipment in order to assure excellent response and coordination between all plant equipment. Furthermore, to enable automatic operation, the circuitry of the control equipment is configured to allow automatic plant start-up and shutdown. The control circuits are programmed in a block-circuit format so that the circuit configurations are expressed in an easy-to-follow manner.

INSTALLATION AND CONSTRUCTION

Since the installation and construction of the Shinko Kobe No. 2 Power Station was carried out during operation of the No.1 plant, operational adjustments regarding related companies were made beforehand, and installation methods aimed at improving

Fig. 5—Installation Status of Main Steam Lead Pipes and Reheated Steam Pipes.
By welding the main steam lead pipes and reheated steam pipes after the assembly of the steam turbine, the processing time for the whole installation is shortened.

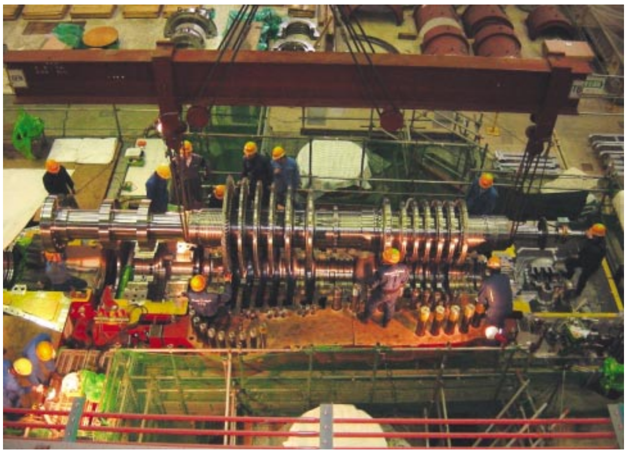

Fig. 6—Installation Status of Lower-casing Diaphragm as Main Assembly.
Cleaning and maintenance procedures for each of the lower-casing diaphragms was reviewed, making it unneccessary to disassemble the diaphragms for the final check. Therefore, assembly procedure for the main turbine could be shortened.

operational efficiency were rationalized. These operations are summarized below.

Streamlining Assembly Sequence for Main Steam Turbine

To decrease the present amount of work, according to relaxed regulations, the assembly procedure of the main steam turbine and the construction methods were rationalized. There are four main points regarding these operations.

(1) The welding for the main steam lead pipes and the reheated-steam pipes was done after the assembly of the steam turbine (see Fig. 5).

(2) The upper casing was removed during the welding operations for the low-pressure steam turbine casing and condenser.

(3) All of the lower-casing diaphragms were constructed as a main assembly without pre-assembly (see Fig. 6).

(4) The number of points for measurement of packing gap was reduced.

Adopting this assembly procedure for the main steam turbine enabled the process for the installation work of the steam turbine to be shortened by about one month.

Streamlining of Oil-flushing Operation

By discharging foreign substances mixed into the lubrication-oil system, the oil-flushing operation keeps the lubrication oil for the bearings of the steam turbine and generating unit within the specified cleanliness factor for the supplied turbine oil, and the intended stable operation can thus be continued.

In the conventional flushing operation, actual oil pumps are used to flush out all systems on block, so it takes time for the turbine oil specified cleanliness factor to drop within the criterion. In contrast, the new flushing method uses temporary pumps with a larger capacity than the conventional one, and performs separate flushing for the different parts of the system. As a result, flow velocity in the pipes is increased, and fouling accumulated in the pipes can be cleaned out more quickly. Moreover, installing temporary strainer filter unit at the outlet of the pump makes it possible to trap foreign matter promptly.

As a consequence of adopting this new oil-flushing procedure, the flow velocity in the pipes is increased by three times compared to that in the case of the conventional method, adequate cleaning results are obtained in a shorter time, and the efficiency of the installation work is increased.

Just-in-time Production

Compared to the installation of the No. 1 power station, that of the No. 2 had less space for keeping raw materials on site and difficulty in securing areas for finished products. Accordingly, the dispatch processes at the manufacturer's sites were coordinated according to the progressing condition at the power-plant site so that finished products were delivered to meet the "just in time" production concept. And shortening the period that products were kept in open storage meant that protective measures were unnecessary, thereby making product-quality management more effective.

CONCLUSIONS

In this paper, the main equipment and features of the Shinko Kobe No. 2 Power Station of Kobe Steel, Ltd. were overviewed. As largest-scale power plant of an IPP in Japan, the designed Shinko Power Plant has been constructed to cover the power demand of Kobe city and is now running smoothly. From now onwards, Hitachi will continue to improve its contributions to society through development of power plants that operate in harmony with the environment.

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