Indonesia's First Super Critical Subbituminous Coal-Fired Power Plant Commences Operation (815MW Expansion Project for PT Paiton Energy)

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In Indonesia, where the economy has continued to grow dramatically in recent years, it is indispensable to improve infrastructure for the maintenance and enhancement of growth. The Indonesian government cites as its policy targets the development of a stable supply of electricity, the diversification of energy sources and a higher rate of electrification, as well as other goals. With the above in the background, the first super critical power plant that Mitsubishi Heavy Industries, Ltd. (MHI) delivered in Indonesia continues commercial operation.

1. Introduction

The design of this power plant was based on the recent super critical coal-fired power plant technologies developed in Japan. With its net output exceeding 815MW, this is the first super critical power plant in Indonesia consisting of a super critical boiler exclusively firing domestically produced subbituminous coal, and the largest-class super critical tandem compound-type steam turbine. As the EPC (Engineering Procurement Construction) contractor with an FTK (full turn-key) scope including boiler, steam turbine and BOP (Balance of Plant) equipment (partly as a consortium for construction), we delivered and constructed the said facilities successfully in April, 2012 as scheduled in the contract. The following is an outline of this power plant.

2. Outline of the Power Plant

2.1 Outline of the power plant

Table 1 shows the major equipment of the super critical subbituminous coal-fired power plant, with a net output of 815MW.

Table 1 Plant Major Equipment

Boiler	1 set	Coal handling system	1 set
Steam turbine	1 set	Intake system	1 set
Generator	1 set	Seawater desalination plant	1 set
Electrostatic precipitator	1 set	Water treatment system	1 set
Flue gas desulfurization system (seawater scrubber)	1 set	Electrical equipment	1 set
Stack	1 set	Control system	1 set
Ash handling system	1 set		

2.2 Main features

(1) Subbituminous coal firing

The power plant has a super critical boiler exclusively firing subbituminous coal and a total of 6 kinds of subbituminous coal were considered for the design of the power plant.

(2) Indonesia's first super critical power plant

With the demand for high-efficiency power plant also growing overseas from the viewpoint of the environmental feasibility, super critical power plant was adopted for the first

time in Indonesia.

(3) Expansion into narrow space

The expansion power plant was installed in the narrow space sandwiched between the existing No. 2 and No. 5 power plants, which became a vacant space due to the economic crisis in Indonesia. The existing ash storage silos, waste water treatment system, coal handling system, light oil system, fuel unloading jetty etc., which are owned by the customer of No. 7 and 8 power plants, were designed as common equipment with the expansion plant.

2.3 Plant performance and specifications

Super critical power plant with the steam condition of 24.4 MPa(g)× 538/566 deg. C has been adopted in consideration of the environmental feasibility and the excellent performance more than the designed value was confirmed. **Table 2** shows the major specifications of the power plant.

Table 2 Plant Major Specifications

Boiler	Type	Supercritical vertical furnace waterwall sliding pressure operation once-through boiler radiant reheat (out-door) type
	Steam flow	2,695 t/h
	Main steam pressure	25.8 MPa(g)
	Main stream temperature	542 ºC
	Reheat steam temperature	568 ºC
Steam turbine	Type	Tandem compound, quadruple exhaust flow, reheat condensing type
	Rated output	865.9 MW
	Main steam pressure	24.4 MPa(g)
	Main steam temperature	538 ºC
	Reheat steam temperature	566 ºC
	Rotation	3,000 min^{-1}

3. Boiler

Figure 1 shows the external appearance of the boiler.

Figure 1 Boiler

3.1 Available exclusive firing of subbituminous coal

This boiler is designed to exclusively firing subbituminous coal, which has been growing demand recently because of its less impact on environment due to the lower ash and sulfur content and its abundance of deposits. Subbituminous coal has characteristics of high moisture content, more prone to slagging/fouling and spontaneously combustible compared with bituminous coal. The moisture content of the subbituminous coal used in this plant ranges from about 30wt% (as received), so that the coal can be pulverized and dried by using ordinary vertical mill. Slagging/fouling is limited, using an appropriate furnace size, arrangement of heating surfaces and the installation of soot blowers. Against the high spontaneous combustibility, selection of proper

mill outlet temperature is important, and a mill inert system using steam is installed. **Table 3** shows main properties of the coal considered in designing this plant.

Table 3 Properties of Main Coal

Item	Design range
Total moisture content	About 30 wt%
Higher heating value (AR-base)	Minimum 4,500 kcal/kg
Ash content	Maximum 3.0 wt%
Ash melting point (IDT reducing atmosphere)	Minimum 1,150 ºC

3.2 Employment of a vertical waterwall system

An MHI-developed and well-proven vertical waterwall system has been employed. This system has the following advantages:

(1) Low pressure drop: the pressure drop is low due to the low mass velocity, permitting boiler feedwater pump operating power to be conserved and the feedwater system's design pressure to be reduced.

(2) Simple structure: the furnace can be easily supported, proving its excellence in terms of reliability, ease of installation and maintainability.

(3) Temperature uniformity: the small ratio of friction loss at the heating section to the total drop of evaporator pressure mitigates any changes in flow caused by endothermic fluctuations of the furnace, thus maintaining temperature uniformity.

(4) Scarce ash deposition: the vertical direction of the tubing makes it easier for slag to drop off in the coal-fired boiler, thereby preventing a large amount of ash from depositing in the furnace.

3.3 Firing equipment

The in-furnace NOx reduction system (A-MACT), where combustion air is supplied after securing an enough NOx reduction space with the low-NOx A-PM burner has achieved quite low NOx/unburned carbon. In commissioning period, quite favorably low NOx emissions and unburned carbon contents of ash were achieved, demonstrating that our low-NOx technology is also effective to boilers exclusively firing subbituminous coal.

4. Steam Turbine

Figure 2 shows the external appearance of the steam turbine.

Figure 2 Steam Turbine

The steam turbine is of a tandem compound-type consisting of a combined casing made up of a high-pressure turbine, an intermediate pressure turbine and two low-pressure turbine casings by the single shaft. It has the largest-capacity unit as a three-casing structure for our steam turbine lineup. The high-pressure turbine is of a single-flow design. The intermediate-pressure turbine is of a single-flow design and arranged opposite to the high-pressure turbine. Steam turbines of this output-class have so far had casings that separate the high-pressure turbines from the intermediate-pressure turbines, but technologies proven in the TEPCO Hirono No. 5 unit have resulted in a high- and intermediate-pressure combined casing, thus implementing a compact design. The low-pressure turbine is of a double-flow design, applying 35.4-inch ISB (Integral

Shroud Blade) last stage blades. For the reaction blades, fully three-dimensional blade design is applied toward higher performance.

4.1 Design characteristics

The high- and intermediate-pressure turbine applied is the 600 to 900MW standard high- and intermediate-pressure combined casing of supercritical steam condition for the 50Hz unit module, and is designed with stronger cost competitiveness. This standard frame supposes a main steam/reheat steam temperature of up to the 600ºC class, and for the design of large components, only alterations to the materials were made and changes in shape were avoided as much as possible, thereby allowing the design lead time to be shortened and materials to be diverted in the future. Additionally for performance improvement, the sliding pressure operation of the main steam pressure characteristics is applied in this project and steam turbine is of full arc admission mode eliminating the control stage of the high-pressure turbine.

4.2 Operational record

After operation started, various supervisory data including the shaft vibration were sufficiently lower than the allowable values and stable operation was observed. Further, the steam turbine achieved higher levels of efficiency exceeding the design value.

5. Flue Gas Desulfurization System

Figure 3 shows the external appearance of the flue gas desulfurization system.

This is our world's largest-class double contact flow scrubber (DCFS)-type seawater scrubber, treating about 3 million Nm^3/h of flue gas flow in one absorber.

The same core parts, which we have many actual delivered records in Limestone-Gypsum-type desulfurization systems, were used for flue gas-liquid contact within the absorber in order to ensure performance.

With a simple structure and high performance as its characteristics, higher SO2 removal efficiency than the design value was confirmed.

Figure 3 Flue Gas Desulfurization System

6. Conclusion

Amid so far-delayed delivery of every IPP (Independent Power Producer) item within Indonesia, we were able to deliver the largest-class conventional plant to the customer on time and with higher performance than expected. In addition to making a contribution to Indonesia's domestic demand for electric power, benefiting business owners was also our pleasure. Notably, we were able to not only satisfy the customer, but also demonstrate within Indonesia our capability to pursue large-scale projects. It is our desire to play an active part in the future power supply in this country with growing demand.