

Application of Leading-Edge High-Efficiency USC Lignite-Fired Power Plant in Turow, Poland



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The Turow Power Plant (447.5MW (Net), 262bar(a)/597°C/609°C) in Poland is currently under construction, with the start of commercial operation scheduled for April 2020. The plant is targeting the world's highest level of efficiency for a lignite-fired power plant. Mitsubishi Hitachi Power Systems, Ltd. (MHPS) provides high-efficiency lignite-fired plant by applying its own lignite-fired tower boiler technology, lignite mill burner technology, ultra-supercritical (USC) technology and boiler flue gas heat recovery system. This report introduces the high-efficiency USC lignite firing technology applied to the Turow Power Plant.

1. Introduction

In Poland, lignite is produced in abundance, and many lignite-fired thermal power plants have been constructed. In 2014, MHPS received the order for the construction of the Turow Power Plant from Polska Grupa Energetyczna S.A. (PGE), which is the largest Polish energy company, and construction has been proceeding toward the commencement of commercial operation in April 2020. MHPS's own lignite-fired tower boiler technology, lignite mill and burner technology, USC technology, air quality control system (AQCS) and boiler flue gas heat recovery system are applied in this plant. As a lignite-fired power plant, this plant is targeting the world's highest level of efficiency. The high-efficiency USC lignite-fired technology applied to the Turow Power Plant is introduced below.

2. Project overview

In the Turow new unit construction project, Polska Grupa Energetyczna S.A. (PGE) is constructing a supercritical lignite-fired thermal power plant at its site near the Turow coal mines.

Three-company consortium consisting of the MHPS Group (MHPS and consortium leader, Mitsubishi Hitachi Power Systems Europe GmbH (MHPS-EDE)), Tecnicas Reunidas (Spain) and Budimex SA (Poland) was selected as the Engineering, Procurement and Construction (EPC) contractor and received the order in July 2014. Construction of the new unit was started on December 1, 2014. Plant construction period is 65 months and the commencement of commercial operation is scheduled for the end of April 2020.

MHPS-EDE within the EPC contractor consortium will deliver a lignite-fired tower boiler and boiler auxiliaries and environmental facilities (including the NO_x removal equipment and the electrostatic precipitator). MHPS will deliver turbine/generator set and turbine plant auxiliaries in addition to supplying the flue gas desulfurization (FGD) equipment. Tecnicas Reunidas and Budimex SA will be in charge of the supply of plant electrical equipment facilities and the cooling tower, as well as the civil engineering, civil works and equipment installation work.

Figure 1 shows the exterior view of the plant, and **Table 1** presents the major specifications of the Turow Power Plant.

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Figure 1 Exterior view of the plant (image)

Table 1 Major specifications of Turow Power Plant

Item	Specifications
Plant output	447.5 MW (Net)
Plant efficiency	>43% (Net)
Boiler	Tower type (120m) lignite-fired Steam conditions: 271bar (a)/600/610°C Steam flow rate: 1275 t/h (SH), 1061t/h (RH)
Turbine	Double flow 48-inch (TC2F-48) Steam conditions: 262bar (a)/597/609°C
Generator	603MVA, 21kV
Cooling system	Natural draft cooling tower
Noise (site boundary)	55dB(A) or less (45dB(A) at night)

3. Lignite-fired tower boiler

Lignite coal is used as main fuel. In general, high-temperature heat source is required for drying lignite coal because it has high moisture content. It also has high volatile matter and good combustibility, and as such it ignites easily. Since lignite has these characteristics, the combustion system that differs from that of bituminous coal and subbituminous coal was adopted in this plant.

Figure 2 presents an overview of the combustion system configuration of the boiler, and Table 2 shows the major specifications of the boiler.

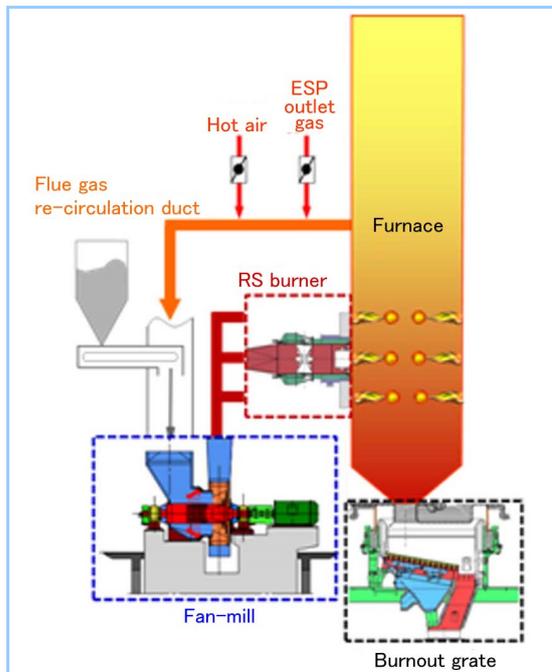


Figure 2 Overview of the combustion system configuration of the lignite-fired boiler

Table 2 Leading specifications of the boiler

Item	Specifications
Boiler type	Tower boiler (once-through, supercritical variable pressure, single reheat)
Steam conditions	
Main steam flow rate	1275 t/h
Superheater outlet pressure	271 bar (a)
Superheater outlet temperature	600°C
Reheater outlet temperature	610°C
Burner type	RS [®] burner
Mill type	DGS [®] mill
Draft system	Balanced draft
Steam temperature control	
SH outlet	Water/fuel ratio control, Spray attemperator
RH outlet	Spray attemperator

(1) Coal drying method

Because high-temperature drying heat source is required, part of the flue gas is circulated from the furnace outlet as a coal drying heat source. On the other hand, lignite has a high volatility and ignites easily. Therefore, the required drying temperature and maximum oxygen concentration are adjusted by mixing the hot flue gas discharged from the furnace with the cold flue gas downstream of the electrostatic precipitator (ESP) and hot air.

(2) Fan-mill

The fan-mill is an apparatus that has the functions of a primary fan and mill for conveyance and crushing. MHPS has two types: NV (Nasskohlen Ventilator) mill and DGS (Distributor Gebläse Schläger) mill. The NV mill crushes coal just by using the beater wheel, while the DGS[®] mill crushes coal using the beater heads in addition to the beater wheel. The type of mill to be used is selected by the properties of the coal to be used. The lignite coal used in the Turow Power Plant is relatively difficult to be crushed among lignite, and so the DGS[®] mill was adopted.

(3) Burner

The RS[®] (Rund Strahl) burner that was developed as a burner for lignite to achieve controlled ignition and combustion which lead to low NO_x emissions. The burners are installed all around the furnace wall. Three burners are linearly disposed in the vertical direction of the furnace wall from one mill.

(4) Burnout grate

At the bottom of the furnace, burnout grates are installed so that unburned carbon in ash is combusted to improve the boiler efficiency.

4. Flue gas heat recovery system

4.1 Overview

Lignite is characterized as a low heating value fuel with high water content. Due to these characteristics, the combustion air and the flue gas flow rate of the lignite-fired boiler is larger than that of the same class bituminous coal-fired boiler, and the size of the boiler is also larger. In general coal fired boiler, the heat of the flue gas is recovered in combustion air and utilized for improvement of the plant efficiency. However, in the lignite-fired boiler, the heat of the flue gas is larger than the required heat for the combustion air, and therefore, the surplus flue gas heat will be released through flue gas into atmosphere. In the Turow Power Plant, boiler flue gas heat recovery system is installed to exchange the surplus flue gas heat with the turbine plant feed water / condensate water, to improve the plant efficiency.

An overview of the system configuration and the operation method are described below.

4.2 System configuration

Figure 3 shows an overview of the system configuration of the boiler flue gas heat recovery system adopted in the Turow Power Plant. The boiler flue gas heat recovery system consists of two flue gas water heaters.

- i. Flue-Gas-High-Pressure-Water-Heater system (FGHPWH system): High-pressure flue gas water heater exchanges the heat from flue gas to feed water.
- ii. Flue-Gas-Low-Pressure-Water-Heater system (FGLPWH system): Low-pressure flue gas water heater exchanges the heat from flue gas to condensate water.

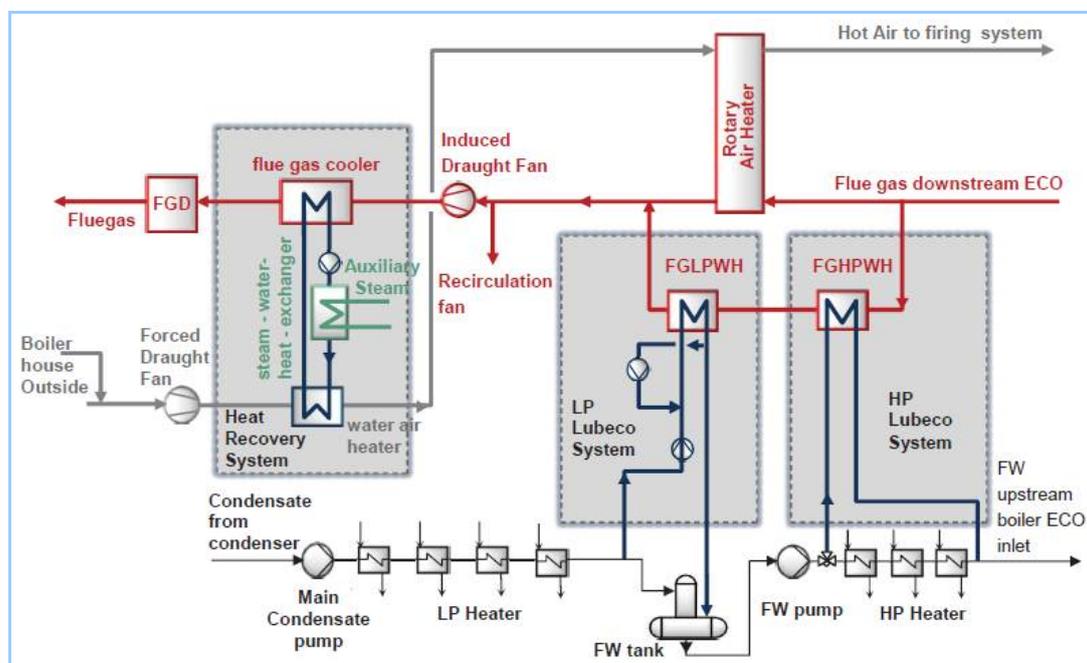


Figure 3 Overview of the system - Boiler flue gas heat recovery system

(1) High-pressure heat recovery system (water side)

The water side of the FGHPWH is arranged in bypass line of the high-pressure feedwater heaters and the dry heater. At the upstream of the high-pressure feedwater heaters, a three way control valve is installed and distributes the feedwater flow to the high-pressure feedwater heaters and FGHPWH. The feedwater in the FGHPWH is heated up and the preheated water is

led back to the main feedwater system via a three way control valve.

(2) Low-pressure heat recovery system (water side)

The water of the FGLPWH is taken from the downstream of the low-pressure condensate heaters and the preheated condensate from FGLPWH outlet is led back to the feedwater tank. A booster pump is installed to prevent flash of the condensate water at the FGLPWH outlet. In addition, a circulating pump is installed, which returns part of the hot condensate at the FGLPWH outlet to the inlet, to prevent the precipitation of SO₂ caused by the lowering boiler flue gas temperature.

4.3 Operation

(1) High-pressure heat recovery system

The feed water flow through the FGHPWH is load dependent. The required flow is adjusted by the three way control valve at the upstream of the high-pressure feedwater preheaters.

(2) Low-pressure heat recovery system

The inlet water temperature of the FGLPWH is controlled by the feed flow through the FGLPWH. The flow is adjusted by the control valve and the temperature set point depends on the SO₂ content.

5. Conclusion

This report introduced the high-efficiency USC lignite-fired technology applied to the Turow Power Plant. In Poland and other countries in Eastern Europe, lignite is produced in abundance, and high expectations have been placed on lignite-fired thermal power plants. At the same time, however, due to the rise in environmental awareness in recent years, further development of high-efficiency technology and environmental protection technology is required. MHPS has been working on developing high-efficiency USC technologies for many years. We will continue to make efforts to develop such technologies and contribute to the utilization of energy resources and the preservation of the global environment.