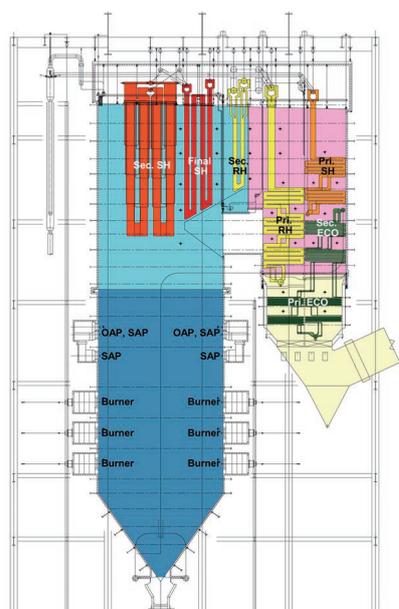


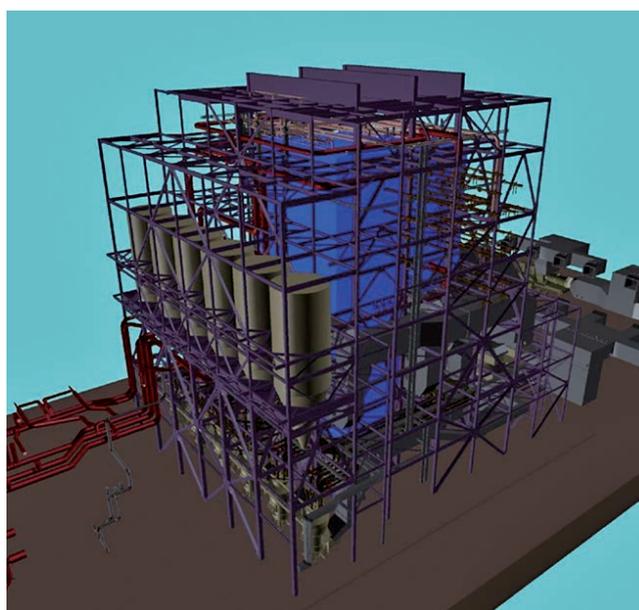
Contributing to Power Supply Stabilization and Economic Development in Malaysia

Subbituminous coal-fired ultra-super-critical boiler with thorough countermeasures against ash slagging and fouling

Coal is still an important energy source for power generation because coal reserves are rich and widely distributed, and its price is reasonable. IHI offers boiler plant based on its original technologies to countries all around the world. These technologies reduce CO₂ emission by improving efficiency to the highest global standards and effectively utilize resources by using low-quality coal.



Side view of the boiler for JEP



3D model of the boiler for JEP

Compared with other fossil fuels, coal has rich recoverable reserves, is distributed all over the world, and is inexpensive. That is why coal-fired thermal power plants still play an important role as a power source in all countries of the world including Japan.

On the other hand, compared to renewable energy resources, nuclear power, and other fossil fuels, CO₂ emission for the amount of power produced by coal is high. For this reason, coal-fired power plants need to improve power generation efficiency and reduce CO₂ emission to the extent possible in order to prevent global warming.

In addition, from the viewpoint of effective utilization of

coal reserves and economic efficiency, worldwide demand is increasing for power plants that can use 100% low-quality coal known as “subbituminous coal,” which has been used as a power source only to a limited extent so far.

It was in such circumstances that IHI received the order in 2014 for a thermal power plant that exclusively uses subbituminous coal with generation efficiency and electricity generating capacity at the highest global standards along with Toshiba Corporation and Hyundai Engineering Co., Ltd./ Hyundai Engineering and Construction Co., Ltd. (South Korea) in Malaysia, where the electricity demand is rapidly growing accompanying economic growth.

Outline of the project

JEP (Jimah East Power Plant) is located on the west coast of the Malay Peninsula about 50 km to the south of the capital Kuala Lumpur. The generation capacity of the plant is two units with 1 000 MW net output and it is one of the largest coal-fired power generation plants in the world.

IHI is responsible for the design, production, procurement, installation, and test operation of the Ultra-Super-Critical boiler (USC boiler) and its auxiliary equipment for JEP. The boiler uses subbituminous coal and generates ultrahigh temperature and ultrahigh pressure steam which are necessary for high efficiency power generation.

Characteristics of USC boilers made by IHI

IHI has supplied a lot of USC boilers both in and outside Japan so far and the company is proud of its boilers' high efficiency and reliability based on its rich experience and the latest findings. The main characteristics are stated below.

(1) Wall firing (Opposed firing)

IHI adopts the wall firing (opposed firing) method in which coal pulverized by coal mills (powdered coal) is combusted by opposing burners located on the front and back inner walls of a furnace. This method achieves excellent combustion efficiency and stability and uniform combustion temperature distribution near the exit of the furnace.

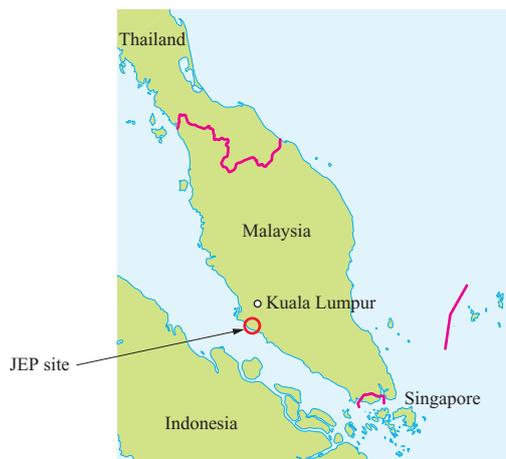
(2) Helical tube furnace

For USC boilers, it is necessary to set and control the amount and state of fluid that flows in the heat transfer tubes (water and steam) appropriately in order to prevent local overheating of the tubes that form the walls of a furnace (furnace wall tubes). In order to realize this, a helical furnace in which the tubes in the lower part of the furnace are arranged helically was developed. This structure makes it easy to even out the fluid state in each furnace wall and has high reliability for long term continuous operation.

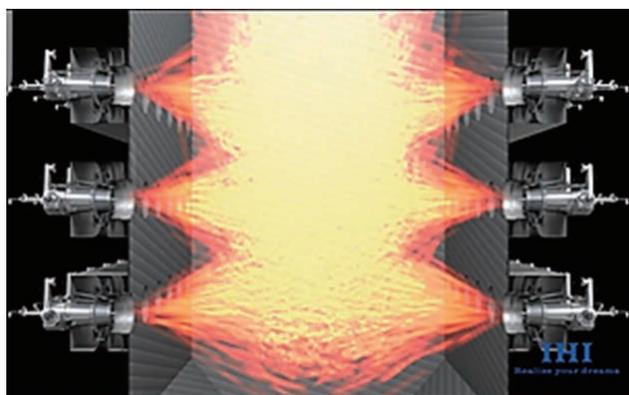
(3) Parallel path structure

As methods of controlling the temperature of steam generated from reheaters, there are ① the spray system in which low temperature water from the water supply system is injected into the reheater system and ② a system in which the reheat steam temperature is controlled by changing the gas flow rate passing through the reheater by recycling flue gases. However, these systems have certain disadvantages, namely, the drop in cycle efficiency due to the spray injection and the necessity of a power supply for fans to recycle flue gases.

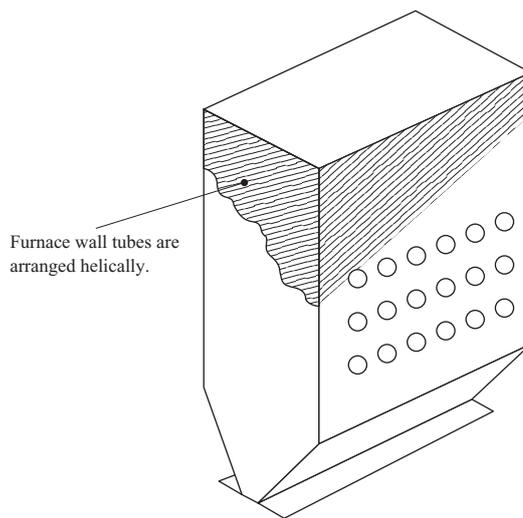
IHI adopts a control system with a parallel path structure in which the flow rate of gases flowing in the reheater path is controlled by a damper installed at the exit of the heat recovery area (reheater path/superheater path) of a boiler. This method enhances cycle efficiency and reduces the power consumption in the plant. In this



Location of JEP site

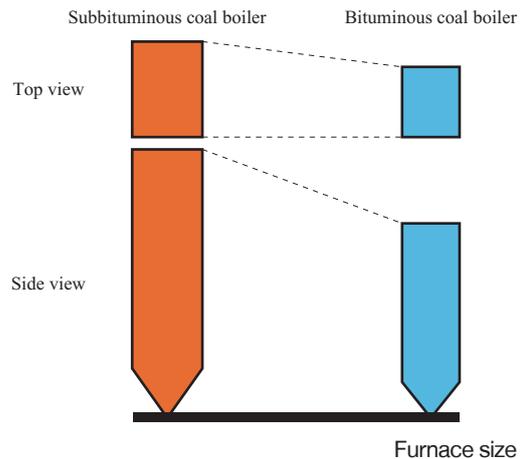
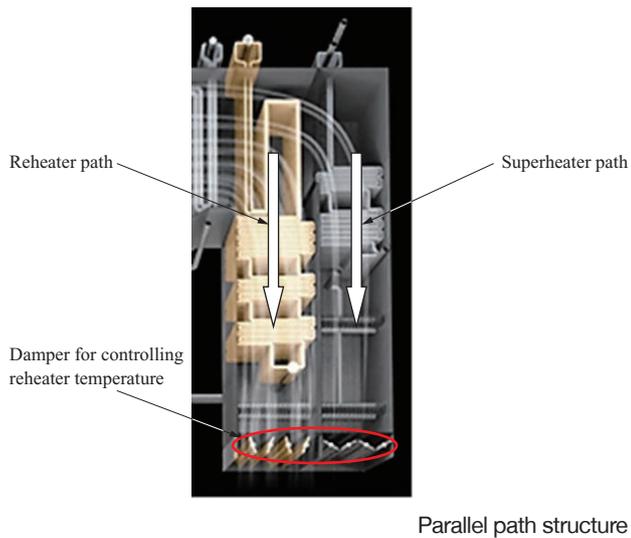


Wall firing (Opposed firing)



Helical structure in the lower part of the furnace

way, it offers the great advantage of enhanced total efficiency of the plant and thus a reduction in fuel consumption.



Design considerations concerning single firing of subbituminous coal

One of the main features of the boiler for JEP is that it can utilize 100% subbituminous coal, which is lower in quality than bituminous coal, which is generally used for coal-fired power generation. Compared to bituminous coal, subbituminous coal has several characteristics that are not desirable for fuel for power generation such as high water content, high volatility, low heating value, and low ash melting temperature. Of these features, it is extremely important to consider the high potential of combustion ash slagging and fouling to the heating element of the boiler due to the low ash melting temperature. If an excessive amount of ash slagging and fouling to each heat-transfer surface, heat transfer is deteriorated and serious troubles occur in operation. Therefore, it is necessary to design a boiler that suppresses ash slagging and fouling as much as possible and in which adhered ash can be removed during operation. The measures used in the JEP boiler are as follows.

(1) Furnace size

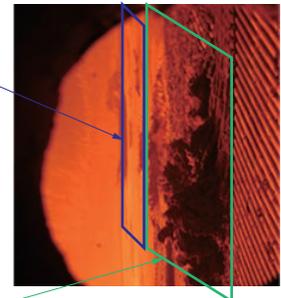
The size of the furnace of a coal-fired boiler has to be set so that the amount of heat absorption per unit area of the furnace and gas temperature at the furnace exit become adequate considering ash adherence, which varies among coal types, in order to avoid ash adherence to the furnace and the heat-transfer part downstream of the furnace exit. A furnace for single firing of subbituminous coal with high ash adherence potential is designed to be about 10-15% larger than boilers for bituminous coal. This design lowers the gas temperature around the furnace exit while suppressing the temperature in the furnace as much as possible. It also prevents melted ash from excessively adhering to the inner surface of the furnace wall and the superheater around the furnace exit.

(2) Furnace soot blower

In general, steam deslaggers, which use steam to remove

Areas with a less castable type burner throat (no ash adherence)

Areas without a less castable type burner throat (with ash adherence)



Example of application of a less castable type burner throat

ash from furnace walls, are used for bituminous coal boilers. However, water soot blowers, which are better at removing ash, are used for the JEP boiler in order to deal with subbituminous coal's higher potential for slagging. Water soot blowers jet high-pressure water against the furnace walls to remove ash much like a fire engine sprays water. The values measured by heat flux meters installed on the inner surface of the furnace walls are used as an index to determine the area and timing of spraying.

(3) Less castable type burner throat

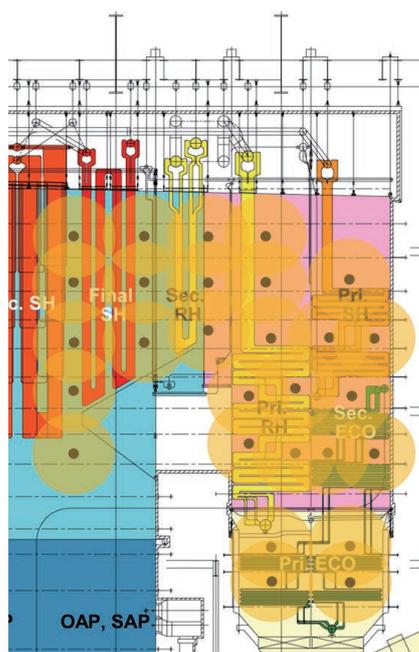
In the case of coal with higher potential for slagging, ash may start to adhere and grow from the fire-resistant material installed at the openings of burners on the furnace wall surfaces. In order to prevent this, the improved bent tube structure of furnace wall tubes is adopted to minimize the exposure of the fire-resistant material.

(4) Tube panel pitch of superheaters and reheaters

In order to prevent bridging by ash buildup between tube panels of superheaters and reheaters, the pitch between tubes (pitch between panels) is designed to be wider than that for bituminous coal boilers.

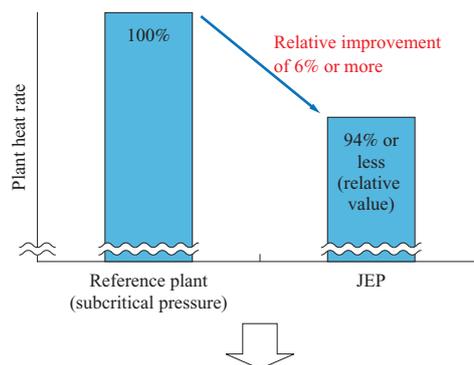
(5) Arrangement of steam soot blowers

The number of steam soot blowers for removal of ash buildup on superheaters and reheaters is larger than for bituminous coal boilers. It extends the effective range of the soot blowers.



(Note) Dots (●) : Indicate the locations of steam soot blowers

Arrangement of steam soot blowers



During 25 years of operation...
 - Cut in fuel cost by over 700 million US dollars
 - Cut in CO₂ emission by over 20 million tons

Comparison of plant heat rates

The JEP project is under construction right now with the start of commercial operation planned for 2019.

USC boilers made by IHI, with their high efficiency and reliability, will definitely contribute to the stable supply of electricity and the continued development of Malaysia as well as help to solve the global energy problem.

(6) Economizer

Economizers are installed at the downstream end of the boiler heat-transfer part where the flue gases exit. Although tubes with fins are generally used for bituminous coal boilers to improve heat-transfer efficiency, a mass of ash can accumulate on the tubes in the case of a fuel with higher potential for ash adherence. Therefore, bare tubes without fins were used as economizers. In addition, steam soot blowers are installed to prevent ash accumulation and to enhance ash removal.

Plant performance

By applying ultra-super-critical steam conditions, the plant heat rate (necessary input heat amount per unit generated electricity) has been improved drastically compared to that of conventional subcritical plants which were common in Malaysia. The plant heat rate has improved by more than 6% relative to the subcritical plants that IHI built in Malaysia in the past. This corresponds to a reduction of about 10 million tons of coal or over 700 million US dollars of fuel cost assuming the plants operate 25 years and coal price is 70 US dollars per ton.

In addition, over 20 million tons of CO₂ emission would be reduced during 25-years operating period.

Conclusion

USC boilers made by IHI realize economical and reliable operation by generating power with efficiency at the highest global standards in ultra-super-critical conditions as well as by single firing of 100% low-quality subbituminous coal.

Inquiries:

Boiler Basic Design Department,
 Boilers Business Unit,
 Resources, Energy & Environment Business Area,
 IHI Corporation
 Phone: +81-3-6204-7525
<https://www.ihi.co.jp/en/>