Introduction of Taiwan Power Company's Linkou Power Plant Units 1 and 2

– Steam Temperature Control Improvement of Ultra-Supercritical Sliding Pressure One-through Coal-fired Boiler and Combustion Tuning by AI –

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Taiwan Power Company (TPC) Linkou Power Plant Units 1 and 2 are high-efficiency 600°C-class coal-fired ultra-supercritical pressure power generation units that were renewed from the existing units. They have commenced commercial operation as a stable power source in Taiwan, where the power demand has been increasing year after year. Units 1 and 2 adopt steam temperature control, which further improves the stability of the boiler outlet steam temperature and facilitates tuning. Furthermore, a new system featuring Artificial Intelligence (AI) is under development for the purpose of performing automatic combustion tuning of the boiler. The new system is utilized in Unit 2 and confirmed availability. MHPS is making further improvement in its precision, as well as further advancement of the AI performance.

1. Introduction

The construction of the boiler steel structure of TPC Linkou Power Plant Unit 1 started in February 2013 and commercial operation started in October 2016. The construction of the boiler steel structure of Unit 2 started in January 2014 and commercial operation began in March 2017. Mitsubishi Hitachi Power Systems (MHPS) was engaged in the design, manufacture and supply of the mechanical equipment including the turbine and boiler, providing a coal-fired ultra-supercritical pressure power generation plant with the world's best plant efficiency and reliability achieved by the company's collective strengths, including plant engineering and advanced main mechanical equipment technologies. This article features the boiler technologies and boiler combustion tuning by AI.

2. Project overview

In order to contribute to the stable supply of power in Taiwan, MHPS has been proceeding with a project to renew the existing subcritical pressure power plant with a high-efficiency 600°C-class coal-fired ultra-supercritical pressure power generation plant in the TPC Linkou Power Plant. The power plant output is 800MW×3 units. In order to utilize coal cleanly with high efficiency, ultra-supercritical (USC) pressure steam conditions were applied, each unit installed a selective catalytic reduction (SCR) system, particulate removal system, and flue gas desulfurization system were installed in each unit in consideration of environmental protection. The order for this project was jointly accepted by Taiwanese EPC firm CTCI and Mitsubishi Corporation, for which MHPS is in charge of the design, manufacturing and supply of the main mechanical equipment including the turbine and boiler. Units 1 and 2 have already commenced commercial operation. As for Unit 3, the boiler steel structure construction was completed in August 2016 and is scheduled to begin commercial operation in 2019.

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3. Boiler overview

Table 1 shows the boiler overview of the Linkou Power Plant. Because the project is a renewal of the existing power plant, the construction space is limited and the design was made in consideration of boiler size and other equipment arrangement. Highly-reliable materials most suitable for the steam temperature of 600°C were applied in the boiler heated and non-heated pressure parts. The performance coal is a mixture of bituminous coal and subbituminous coal. The furnace size and specifications of its auxiliaries are designed to be able to burn coal with a total moisture level of 20%.

Table 1 Overview of boilers

	Linkou Power Plant		
	Unit 1	Unit 2	Unit 3
Output（per 1 Unit）	800MW		
Boiler Type	Ultra-Supercritical Sliding Pressure One-through Boiler Radiant Reheat Type		
Main Steam Flow	2,404 ton/h (@BMCR)		
Boiler Outlet Steam Condition	25.38MPa/604℃/602℃		
Coal	Performance Coal＝Blending of Bituminous coal and Subbituminous coal		
Commercial Operation Date	Oct, 2016	Mar, 2017	(2019)

The pulverizer has a capacity equivalent to the largest existing size, and Xwin® technology is applied for the roller and table liner materials. **Figure 1** presents the Xwin® technology. With Xwin®, highly wear-resistant special ceramics are embedded on the grinding surfaces of the high-chrome cast iron roller and table liner, improving the wear resistance immensely. After 1,000 to 2,000 hours of use, the Xwin® layer appears on the surfaces of the roller and table liner where dimples of several millimeters occur, trapping more coal therein, which leads to the reduction of slip vibration. Xwin® is applicable not only to new pulverizrs, but also when replacing the rollers or tables in existing pulverizers.

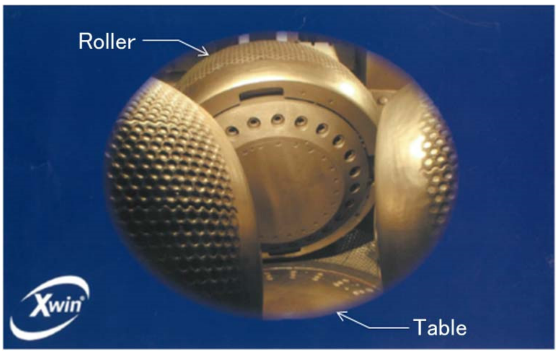

Figure 1 Xwin® technology

4. Improved steam temperature control

The control logic for superheater outlet steam temperature control, which has been improved based on experience, was applied to Linkou Power Plant Units 1 and 2. Generally speaking, when the load change rate is increased, the control deviation is also increased during a load change or after the load is stabilized, and a long time is required for stabilizing the load. In other words, the improvement of the control deviation and load stabilization through increased controllability is the key point to improving the load change rate. As shown in **Figure 2** which is the existing control method concept, the water-fuel ratio (fuel) and the 2ry spray mainly control the superheater outlet steam temperature. Simultaneously, as the 2ry superheater de-superheating ratio (the balance between the fuel flow and spray flow) is controlled by the 2ry spray. Therefore, the fuel flow control and 2ry spray control slightly interfere with each other, delaying the stabilization of the superheater outlet steam temperature just after the load is reached in some cases.

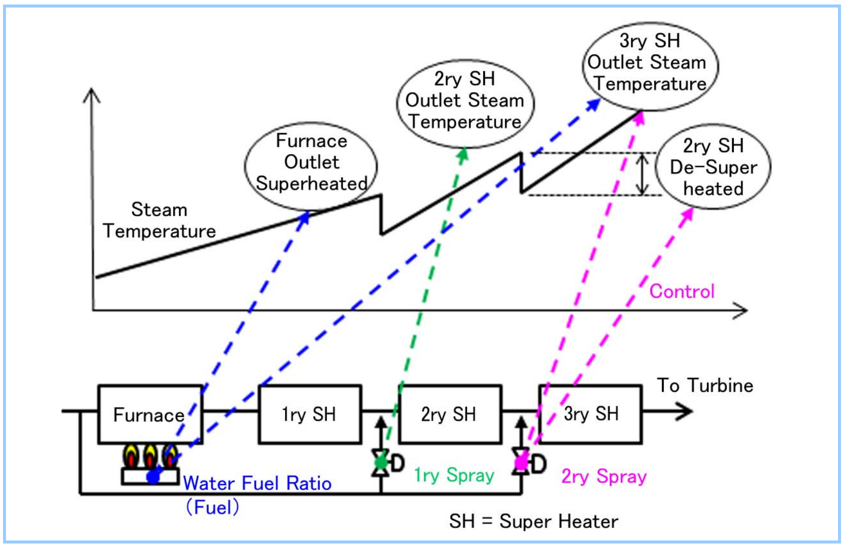

Figure 2 Conceptual diagram of steam temperature control (conventional)

Figure 3 shows the concept of the control logic which was improved for superheater outlet steam temperature stability. The 2ry spray focuses on the control of the superheater outlet steam temperature, while the fuel flow mainly controls the 2ry superheater outlet steam temperature. Furthermore, the 1ry spray controls the 1ry superheater de-superheating ratio (the balance between the fuel flow and spray flow). Accordingly, the control logic improves the adaptability to changes in the furnace heat absorption and 2ry superheater heat absorption, and avoid the mutual interference between the fuel flow and 2ry spray in the superheater outlet steam temperature control. Then, the control logic minimalized the time for the superheater outlet temperature stabilization.

The effect of the improved control logic has been confirmed in simulations. After that, the control logic is applied into Linkou Power Plant, and improvements of stabilization and responsiveness of the steam temperature were confirmed in the load change tuning test of an actual unit. Furthermore, due to the ease of adjustment, the tuning term has been successfully reduced.

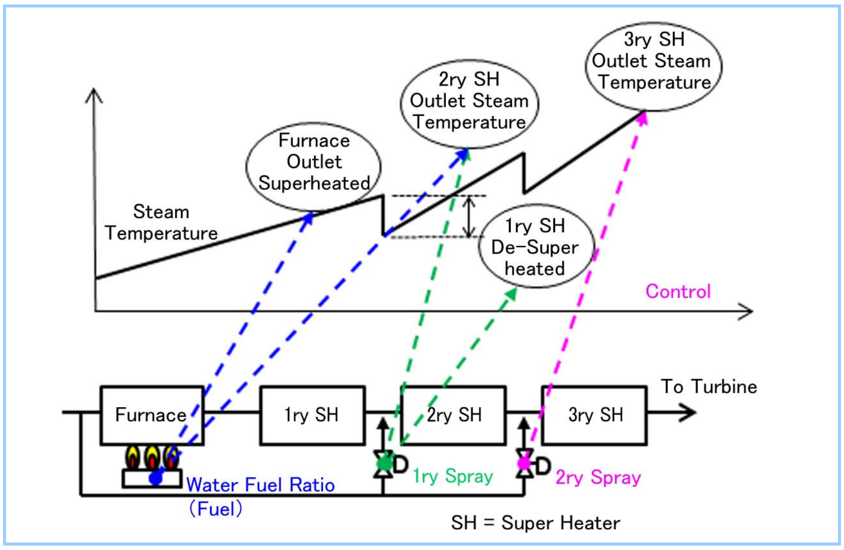

Figure 3 Conceptual diagram of steam temperature control (improved)

5. Combustion control through application of AI

A new system for automatic boiler combustion tuning by AI is under development. AI was utilized in a combustion tuning test for the Linkou Power Plant Unit 2 boiler, and its effect was confirmed. In the conventional combustion tuning test, the operation parameters including the burner windbox dampers opening, burner angle and pulverizer MRS speed are changed in order to adjust the boiler operation condition until the boiler achieves balanced operation condition in terms of the steam temperature characteristics, exhaust gas characteristics (NOx, CO and unburnt carbon in ash), etc. In the combustion tuning test by AI, we built a machine learning model related to the changes in operating parameters and boiler operation conditions. AI is able to suggest the operation setting parameters that would achieve a balanced boiler operation. The boiler combustion tuning test was carried out by setting the conventional operation items and operation items suggested by AI simultaneously. Eventually, the operation parameters suggested by AI were confirmed to be almost the same as those suggested by an experienced boiler engineer, demonstrating that AI could determine excellent boiler operating conditions.

6. Conclusion

Linkou Power Plant Units 1 and 2 have achieved all the predicted and guaranteed performance targets in terms of the steam temperature, combustion characteristics and exhaust gas characteristics in the commissioning and performance test, and are currently in stable operation. Unit 3 is under construction and is scheduled to commence commercial operation in 2019.

We confirmed that the improved steam temperature control method improved the stability and responsiveness of the superheater outlet steam temperature, and simplified the boiler tuning in an actual unit. The improved steam temperature control method will be applied to future projects to reduce the commissioning term. Furthermore, the effect of applying this improved steam temperature control method to existing power plants will be verified by simulations in order to contribute to the further improvement of the power control performance of thermal power plants, because it is assumed that the utilization of renewable energy will accelerate, and thermal power plants will be required to achieve more rigorous power control performance.

In addition, MHPS will continue seeking the advancement of combustion tuning by AI, as well as the application of AI in consideration of systems, their operational status and customer needs, to existing power plants, in an attempt to support customers achieve better operation.