INTRODUCTION

Circulating fluidized bed (CFB) coal-fired boiler, a proven cost-effective and environmental-friendly way for coal utilization, is under rapid development. In order to increase its power supply efficiency of the CFB power plant, an important way is to increase its steam parameters. Supercritical CFB combines the advantages of low emission of traditional CFB and high efficiency of supercritical steam cycle (Ragner, et al., 2003), and have attracted much attention in these year (Ray, et al., 1996; Bursi, et al., 1999; Nowak, 1999). The first supercritical CFB boiler of 460 MWe was designed by Foster Wheeler Company (FW), and will be put into operation soon in Poland (Kari, et al., 2003; Ilkka, et al., 2004; Stephen, et al., 2005).

More than ten 300MWe CFB boilers made with the technology introduced from Alstom or domestic have been put into operation in China (Yue, 2007; Guo et al., 2009). Based on the research results and application experience, the Chinese researchers and engineer have been working on the design of supercritical CFB (SCFB) boilers (e.g., Wu et al., 2004; Lu et al., 2007). The first SCFB boiler being demonstrated in China is of 600MWe. The project is financially supported by the national Ministry of Science and Technology (MOST).

THE DESIGN PRINCIPAL

A CFB boiler is obviously different from a pulverized coal fired boiler on the fuel, combustion method and heat flux distribution, etc. In furnace desulphurization using limestone is suitable for a CFB boiler.

Based on CFB boiler design theory (Yue, et al., 2005; Yue, 2007) and engineering experience, the fluidization and circulating quality could be determined by two key parameters: ash circulating rate $G_a$ and fluidizing velocity $u_f$. In the CFB design, it is also important to consider the erosion of water wall in the furnace. If $u_f$ is lower than a critical value for a certain coal, the erosion of water walls decreases effectively, as shown in Fig. 1. Furthermore, the supercritical boiler runs under both the supercritical and the sub-critical conditions during the application. Thus, the hydrodynamic stability and the thermal deviation of water wall must be considered carefully when the supercritical boiler is designed.

A once-through 600MWe SCFB boiler is designed according to the characteristic of the local fuel. The rated steam output of this boiler is 1900 t/h, with the main steam of 25.5 MPa in pressure and 571 °C in temperature, and the reheat steam 569°C in temperature. Once-through vertical membrane water walls are arranged in the furnace. Twin furnaces are combined to ensure the secondary air jet penetration depth. Shown in Fig. 2, six cyclones as well as six loopseals, six external heat exchangers (EHEs) under them are installed beside the furnace, three sets on each side. The secondary superheater and high temperature reheater are immersed in the EHEs, while the final superheater is the wing wall type hanging in the upper furnace.
The fuel gas out of cyclones is collected, and introduced from two sides into the secondary pass. The primary superheater and the low temperature reheater are installed in line in the heat recover pass, which is packed by steam cooled membrane wall. Below it, the economizer and the air preheater are installed. During the period of boiler start-up and shut-down, a circulation pump is used to ensure minimum amount of water flow through the evaporator. When the boiler load exceeds 35% THA (Turbine Heat Acceptance), the steam exiting the evaporators is slightly superheated. At that moment, the circulation system can be shut down and the boiler is in once-through operation mode. In order to optimize the distribution of the water flow rate in the water walls, smooth tubes and the end into the inlet headers are carefully selected in size.

The solid particles escaping from the furnace with gas are collected by the high efficiency cyclones. Some of the particles are returned into the furnace directly through loopseals, others are introduced into EHEs to rise the steam temperature. Four EHEs are used for the secondary superheater. The secondary superheater is divided...