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An improved coal-fired power plant configuration incorporating a supercritical CO_2 cycle

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Supercritical coal-fired power plants are more and more widely used for achieving satisfactory power generation efficiency and low green house gases emission. However, the superheat degree of steam bleeds in these power plants is relatively high and results in a large temperature difference in the heat transfer process within the regenerative heaters[1]. Moreover, in boiler tail surface, the unmatched flue gas and air heat rate also leads to a large temperature difference during the air-preheating process[2]. Large temperature difference during the heat transfer process leads to a large exergy destruction and thus is not thermodynamically desirable.

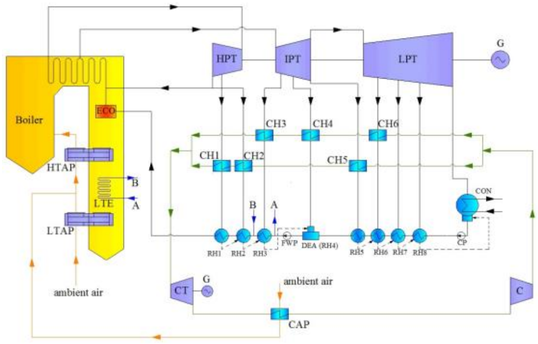

Figure 1. Schematic of the proposed power plant incorporating a S-CO_2 cycle.

CO_2 becomes a potential choice as working fluid for both heat engine cycles. Because of better temperature glide matching between heat source and working fluid during heat addition leading to no pinch limitation[3]. Considering the parameters of the steam bleed of supercritical power plants and air-preheating process, an improved coal-fired power plant incorporating a supercritical CO_2 (S-CO_2) cycle was proposed, schematically shown in Fig. 1. Six steam- CO_2 heaters are arranged to pre-cool the steam bleeds prior to the regenerative heaters. After expanding the CO_2 turbine, the exhaust heat is efficiently recovered and beneficially utilized to heat part of the combustion air of the boiler.

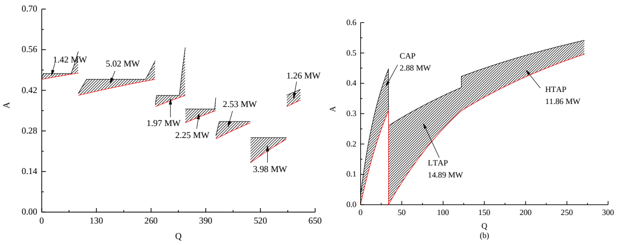

Figure 2. Exergy utilization diagrams of the feedwater and air pre-heating process.

Fig. 2 reveals the exergy utilization diagrams of the feedwater and air pre-heating processes of the proposed system. As can be seen, the exergy destructions of the feedwater and air heating processes are 18.43 MW and 29.63 MW, respectively, which are 3.21 MW and 1.95 MW lower than those of the reference power plant. From the perspective of the system performance, the overall electric power output from the proposed system is 7.79 MW higher than that of the reference power plant and the efficiency of the proposed system can reach as high as 46.0 %.

Acknowledgments

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