STEADY STATE SIMULATION AND EXERGY ANALYSIS OF SUPERCRITICAL COAL-FIRED POWER PLANT WITH CO₂ CAPTURE

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Abstract

Coal-fired power plants play a vital role in meeting energy demands. Supercritical Coal-fired power plants (SCPP) are widely utilized throughout the world for electricity generation. Coal-fired power plants are the single largest sources of CO₂ emissions. An integration of high efficient power plant with CO₂ capture will lead to a better management of this challenge. However, integrating a power plant with CO₂ capture incurs serious energy penalty due to use of energy for solvent regeneration in the capture process. Reducing the exergy losses associated with the power plant systems is another way of improving the system efficiency and thereby reducing cost. Exergy analysis is a useful tool for providing a detailed breakdown of the losses (in terms of exergy destruction) associated with the power plant and the capture plant. It can be used to evaluate the performance of SCPP with CO₂ capture and to identify possible process modifications to improve the plant thermal efficiencies.

This paper presents steady state simulation and exergy analysis of SCPP integrated with post-combustion CO₂ capture with solvents for efficiency improvement and emission reduction. It focuses on the exergy loss analysis of the entire SCPP with CO₂ capture process. This study include (i) steady state simulation of SCPP and post-combustion CO₂ capture; (ii) energy and exergy analysis of SCPP with CO₂ capture (iii) sensitivity analysis to reduce exergy losses in the integrated system.

The data used for the simulation was obtained from a Greenfield design case study based on a 500 MWₑ SCPP unit with CO₂ capture (Halsbeck, 2002). The simulation was validated by comparing the predictions against the predictions of the reference case. The simulation shows that the once-through boiler exhibits the highest exergy loss, while the coal pulveriser shows the least exergy loss. Sensitivity analysis was carried out on each section of the SCPP and the CO₂ capture to investigate the effect of changes in design conditions to exergy loss. The analysis shows improvement in reducing exergetic losses in the system without incurring additional penalties.

Keywords: simulation, exergy analysis, CO₂ capture, supercritical, sensitivity analysis

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