Abstract

Economic Development of a country largely depends on efficient generation and consumption of energy. The living standard of the people of a country is often roughly estimated by the per capita consumption of energy. However, the conversion and use of different forms of energy have a negative impact on environment, and of late, the technologists are facing formidable challenge of meeting the growing energy demand of the world without having any significant adverse effect on the environment. Coal continues to be the most important fossil fuel for power generation. However, the conventional pulverised fuel (PF) boiler based power generation from coal is neither efficient nor environment-friendly with respect to the present accepted standard. As a result, highly energy efficient and environmentally acceptable methods of coal based power generation, formally called 'clean coal technology', are being developed. The most promising clean coal technologies which have achieved demonstration or commercial status are atmospheric pressure fluidised bed combustion (AFBC), pressurised fluidise bed combustion (PFBC) and integrated gasification combined cycle (IGCC). Different alternatives of 'combined cycles' using one or more of these 'clean coal technologies' are emerging as the advanced power generation techniques for the future application.

Thermodynamic analysis is a tool to evaluate the performance of an operating or proposed power plant. The first law cycle analysis based on energy balance can certainly lead to the assessment of the overall efficiency of the plant. However, such an analysis cannot identify and quantify the sources of loss, which lead to that result. The second law analysis is necessary for a complete thermodynamic performance study as this quantifies the 'quality' of energy and provides a greater insight.

The present work discusses some thermodynamic and experimental studies related to clean coal technologies. A few 'gas-steam combined cycles' using coal in an efficient and environmentally benign way are conceptualised and analysed. The heat recovery steam generator (HRSG) is the component that combines 'topping' coal based gas cycle and 'bottoming' steam cycle and provides the most critical in a combined cycle. In a separate analysis, the optimal design and operation of a HRSG for minimum irreversibilty were determined. The analysis of a basic IGCC and the effects of supplementary firing on its performance are presented. A new combined cycle with partial gasification and pressurised fluidised bed combustion as the topping gas cycle and a supercritical steam cycle as the bottoming one is proposed and analysed. Experimental investigation was carried out to study the bed temperature and gas concentration profiles in a laboratory-scale circulating fluidised bed (CFB) combustor burning an Indian coal to understand the CFB combustion and emission characterestics. A plate-type impact separator and a reverse flow cyclone were used for gas-solid separation in the primary loop of the CFB of this experiment. The performance studies of these gas-solid separators and a comparison between these two are also included in this work.