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Modelling and Simulation of Natural Gas-Fired Power Plant Integrated to a CO2 Capture Plant

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Abstract : Regeneration energy requirement and ways to reduce it is the main aim of most CO2 capture researches currently being performed and thus, post-combustion carbon capture (PCC) option is identified to be the most suitable for the natural gas-fired power plants. From current research and development (R&D) activities worldwide, two main areas are being examined in order to reduce the regeneration energy requirement of amine-based PCC, namely: (a) development of new solvents with better overall performance than 30wt% monoethanolamine (MEA) aqueous solution, which is considered as the base-line solvent for solvent-based PCC, (b) Integration of the PCC Plant to the power plant. In scaling-up a PCC pilot plant to the size required for a commercial-scale natural gas-fired power plant, process modelling and simulation is very essential. In this work, an integrated process made up of a 482MWe natural gas-fired power plant, an MEA-based PCC plant which is developed and validated has been modelled and simulated. The PCC plant has four absorber columns and a single stripper column, the modelling and simulation was performed with Aspen Plus® V8.4. The gas turbine, the heat recovery steam generator and the steam cycle were modelled based on a 2010 US DOE report, while the MEA-based PCC plant was modelled as a rate-based process. The scaling of the amine plant was performed using a rate based calculation in preference to the equilibrium based approach for 90% CO2 capture. The power plant was integrated to the PCC plant in three ways: (i) flue gas stream from the power plant which is divided equally into four stream and each stream is fed into one of the four absorbers in the PCC plant. (ii) Steam draw-off from the IP/LP cross-over pipe in the steam cycle of the power plant used to regenerate solvent in the reboiler. (iii) Condensate returns from the reboiler to the power plant. The integration of a PCC plant to the NGCC plant resulted in a reduction of the power plant output by 73.56 MWe and the net efficiency of the integrated system is reduced by 7.3 % point efficiency. A secondary aim of this study is the parametric studies which have been performed to assess the impacts of natural gas on the overall performance of the integrated process and this is achieved through investigation of the capture efficiencies.

Keywords : natural gas-fired, power plant, MEA, CO2 capture, modelling, simulation
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