HEAT INTEGRATION STUDY OF COMBINED CYCLE GAS TURBINE POWER PLANT INTEGRATED WITH POST-COMBUSTION CO₂ CAPTURE AND COMPRESSION

Xiaobo Luo, Meihong Wang*

School of Engineering, the University of Hull, Cottingham Road, Hull, United Kingdom, HU6 7RX

Abstract:
Reducing CO₂ emissions to achieve greenhouse gas emissions target is a significant challenge both technically and commercially. Carbon capture and storage (CCS) will make a vital contribution towards reducing the CO₂ emissions. The advent of cheap natural gas provides chances for more combined cycle gas turbine (CCGT) power plant to be built in the near future. CCGT power plant emits about half of the CO₂ per kW electricity generated compared with the coal-fired power plant.

For CCGT power plant integrated with post-combustion CO₂ capture, an efficiency penalty was reported with a reduction of net plant efficiency from 58.5% to 50.6%. Therefore potential improvements are needed to reduce the energy penalty to gain a better economic profile of capture plant deployment.

In this paper, steady state models including CCGT power plant, MEA-based post-combustion CO₂ capture and compression process were developed using the computer software package Aspen Plus®. An advanced supersonic shock wave compression technology was adopted for the CO₂ compression. The shock wave compression only needs two stages of compression (vs. 6 to 16 stages for the conventional multi-stage approach), the potential capital cost saving for compression chain is up to 50% in addition to reduced footprint requirement. The discharge temperature of compressed CO₂ is as high as 246°C-285°C due to higher compression ratio, providing an opportunity for heat integration.

In this study, two integration options were evaluated. The first option is to recover the compression heat to integrate into the steam cycle of power plant to generate more steam for power generation. The second option is recover the compression heat to provide heat to MEA solvent regeneration in CO₂ capture process. The evaluation results of these two options were compared with the base case using conventional compressors, which shows the heat integration increases the energy efficiency of the power plant.

Keywords: Carbon Capture, CCGT, CO₂ compression, Process integration, Heat recovery

Acknowledgement: The authors would like to acknowledge the financial support from EU FP7 (Ref: PIRSES-GA-2013-612230).

*Corresponding author: e-mail: Meihong.Wang@hull.ac.uk Tel: +44 1482 466688