CHEMICAL ENGINEERING TRANSACTIONS Volume 25, 2011
Editors Jiří Jaromír Klemeš, Petar Sabev Varbanov, Hon Loong Lam

ISBN 978-88-95608-16-7 ISSN 1974-9791
DOI: 10.3303/CET1125002

Process Simulation of CO_2 Chemical Absorption Based on Self-Heat Recuperation Technology for Pre-Combustion Process

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The pre-combustion capture is widely applied in hydrogen production which consists of gasification/reform process with H_2/CO_2 separation process, and the H_2/CO_2 separation process is applied to integrated coal gasification combined cycle power plant (IGCC). IGCC can achieve higher power generation efficiency than conventional power plant. However, CO_2 capture process reduces this efficiency. This is because CO_2 separation from gas mixtures requires huge amount of energy. In this study, we analyzed the pre-combustion process combined CO_2 separation process based on self-heat recuperation technology (SHR). The electric generation efficiency can be improved by SHR compared with conventional IGCC.

1. Introduction

Nowadays, the effects of global warming are becoming more obvious due to increased energy consumption in over the world. Thus, there has been a great discussion about the mitigated global warming. Anthropogenic emissions of greenhouse gases (GHGs) are factor in a causation of global warming. One of the anthropogenic emissions is carbon dioxide (CO2). CO_2 results from the combustion of fossil fuels. Coal has been performed important role as the primary energy source since industrial era in the fifteenth century. Coal could be supplied as a stable energy in the fossil-fuels, because the reserves-to-production ratio (P/R) is longer than others. Total recoverable reserves of coal around the world and current reserves-to-production ratio are estimated at 909 billion tons and 129 years, respectively (U.S.IEA website, 2010). The term is longer than other fossil fuels. However, global demand of coal has expanded more and more.
To use the coal effectively, many researchers have paid more attention about IGCC (Madzivhandila et al. 2009).
IGCC has achieved fuel efficiency rate to 43.5 percent (LHV) (Decamps et al. 2007). IGCC consists of gasification/reform process and power generation process. Recently, IGCC is integrated also H_2 and CO_2 separation processes to reduce CO_2 emission. However, the fuel efficiency rate is approximately reduced 10% by counting H_2/CO_2 separation processes (Decamps et al. 2007, Davison et al. 2007, Riemer et al. 1995).

Please cite this article as: Kishimoto A., Kansha Y., Fushimi C. and Tsutsumi A., 2011, Process simulation of co2 chemical absorption based on self-heat recuperation technology for pre-combustion process, Chemical Engineering Transactions, 25, 7-12
DOI: 10.3303/CET1125002

Recently, an innovative exergy recuperation technology has been developed for industrial processes: gasification process based on exergy recuperative gasification (Tsutsumi, 2006), heating and cooling thermal process based on self-heat recuperation (Kansha et al. 2009), distillation process based on self-heat recuperation (Kansha et al. 2010(a), 2010(b)). For example, the modularity based on self-heat recuperation for the distillation process was found to reduce the required energy more than 75% in comparison with conventional distillation processes (Kansha et al. 2010(b)). By using the self-heat recuperation technology, the energy requirement of thermal process was drastically reduced (1/3-1/22). Recently, Matsuda et al. (2010) reported that the hydro-desulfurization process with self-heat recuperation technology can reduce the energy input and the exergy input to 46% and 20%.

In this paper, we applied the exergy recuperation technology to CO_2 chemical absorption process for the pre-combustion CO_2 capture. The process modularity of CO_2 gas chemical absorption and stripping processes based on exergy recuperation technology can achieve a considerable reduction in energy consumption. The process simulation of exergy recuperative CO_2 gas separation in pre-combustion capture was conducted by using a process simulator PRO/II (Invensys plc.) to calculate the energy input in comparison with the conventional CO_2 gas separation process based on exergy recuperation.

2. Description of the IGCC with pre-combustion CO2 separation

Figure 1 shows the conventional IGCC with pre-combustion CO_2 separation. Coal is gasified using the air or O_2 rich gas. The O_2 rich gas is produced from cryogenic air separation process (ASU).

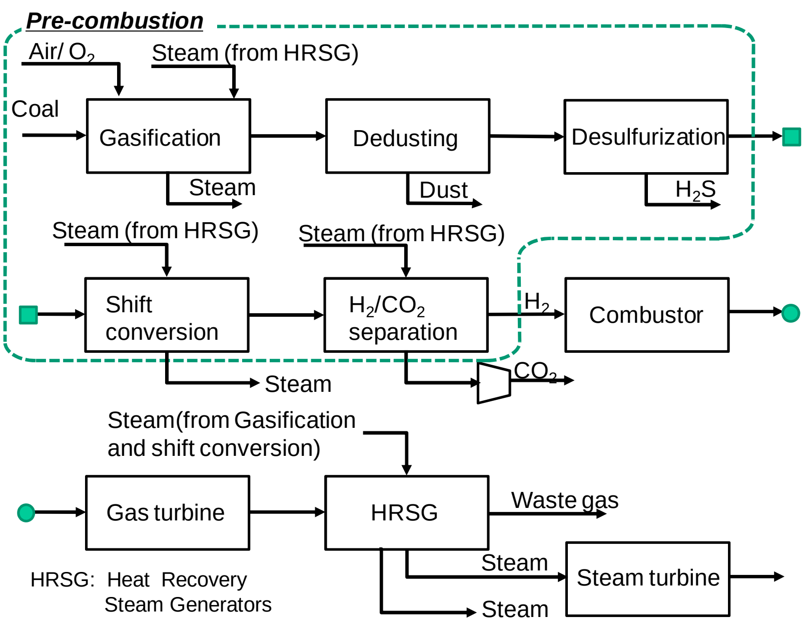

Figure 1: IGCC plant with pre-combustion CO_2 separation