Continuous Operation Results of Pre-combustion CO\textsubscript{2} Capture Process Integrated with Coal Gasifier and Desulfurization Process

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ABSTRACT
SEWGS (Sorption Enhanced Water Gas Shift) process is one of options for pre-combustion CO\textsubscript{2} capture using dry absorbent and water gas shift catalyst. In this process, the thermodynamic equilibrium in the shift reaction can be enhanced to give more hydrogen yield by adding a CO\textsubscript{2} absorbent into the shift reactor. Total integrated system consists of coal gasifier, warm gas cleanup process (two interconnected fluidized bed desulfurizer), and one loop SEWGS process. In this paper, continuous operation results of the warm gas cleanup process and one loop SEWGS process using dry absorbents at high temperature and pressure conditions were discussed. Dry absorbents were produced by KEPCO RI (Korea Electric Power Corporation Research Institute) by means of spray-drying method. Continuous operation was performed at high pressure (21 bar for gasifier, 20 bar for warm gas cleanup process, and 18 bar for SEWGS process) and reaction temperature was 550 °C for desulfurizer and 227 °C for SEWGS reactor. Totally integrated operation was maintained up to 32 hours. We could get high sulfur capture efficiency more than 99 % in the desulfurizer, high CO conversion more than 97 % and CO\textsubscript{2} capture efficiency more than 90 % in the SEWGS reactor.

KEY WORDS: Pre-combustion CO\textsubscript{2} capture; desulfurization, SEWGS; dry absorbents; WGS; catalyst; integration

INTRODUCTION
Hydrogen production is the most fundamental part of the hydrogen energy system, and has always been the object of intense and vigorous research and development. World hydrogen production has been growing rapidly at 8-10 % per annum for many years (Kothari et al., 2004). At present, hydrogen is produced mainly from fossil fuels, water and biomass. However, more than 90% of the hydrogen is produced from fossil fuels (IEA report, 2004).

Series of gasification of coal, water gas shift, and CO\textsubscript{2} separation is the predominant production route to hydrogen from coal for commercial scale application as shown in Fig. 1. However, this process needs multiple-steps such as high- and low-temperature water gas shift reaction as shown Eq. 1 to improve hydrogen yield, and CO\textsubscript{2} removal process to separate almost pure hydrogen from the gas mixture of CO, CO\textsubscript{2}, and H\textsubscript{2}. To separate CO\textsubscript{2} from the exit stream, additional energy and equipments are required. More than 22% of hydrogen generation cost comes from CO\textsubscript{2} separation process for purifying hydrogen (Maurstad, 2008).

Although the previous process has been used for many years, there are some areas for improvement. The previous process requires many reactors and many kinds of catalysts and/or absorbents. Therefore, it will be extremely desirable if new concepts can be developed which can reduce the capital and operating costs of the conventional process (Ryu, 2009, Ryu et al., 2011, 2012, 2013). To overcome disadvantages of the conventional system, SEWGS (Sorption Enhanced Water Gas Shift) system has been developing. Eqs. 2-3 and Fig. 2 explain concept of SEWGS system. The thermodynamic equilibrium in the shift reaction can be enhanced to give more hydrogen yield by adding CO\textsubscript{2} absorbent into the shift reactor. Carbon dioxide is then captured as a solid carbonate as soon as it formed, shifting the reversible water-gas