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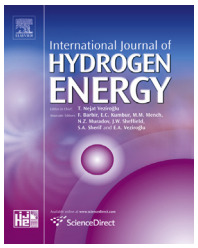

Simulation analysis of hybrid coal gasification according to various conditions in entrained-flow gasifier

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ABSTRACT

Today, as more and more power is required globally, securing a sufficient supply of energy is very important. Coal is one of the energy resources that may be useful in solving the energy crisis. Currently, we have to reduce greenhouse gas emissions. Coal gasification is one of the methods that use coal and at the same time solve the climate problem. This technology produces synthesis gas, which is composed of hydrogen, methane, and carbon monoxide, from coal through procedures of drying, pyrolysis, and gasification. In this study, KIDECO coal (HCK raw coal) and hybrid coal (biomass/coal = 10 wt%) were mixed with water to make a coal slurry. Hybrid coal is a fuel combining coal and sugarcane derived from bioliquid. Transportation of the coal slurry, which is related to slurry viscosity, was considered as an aspect of energy efficiency. Viscosity experiments were performed on the KIDECO coal and hybrid coal by Korea Institute of Energy Research (HCK coal) using a viscometer at 40, 50, and 60 wt% of water content. Simulation analysis was performed by the Aspen Plus program. In this study, the entrained-flow gasifier is the proposed basic model for simulating gasification of HCK raw coal and HCK coal. The carbon conversion and the cold gas efficiency were also calculated to analyze the energy efficiency. Sensitivity analysis was performed according to various conditions such as slurry water content, oxygen ratio, operating temperature, and operating pressure to investigate the process characteristics after verifying the basic model.

Introduction

Coal gasification is an important technology for use of clean coal today. Many countries such as China, the United States, and countries in Europe have been operating gasification plants. The Gasification Technologies Conference reports that synthesis gas produced 70,000 MWth in 2010. Currently, energy production from synthesis gas has increased to

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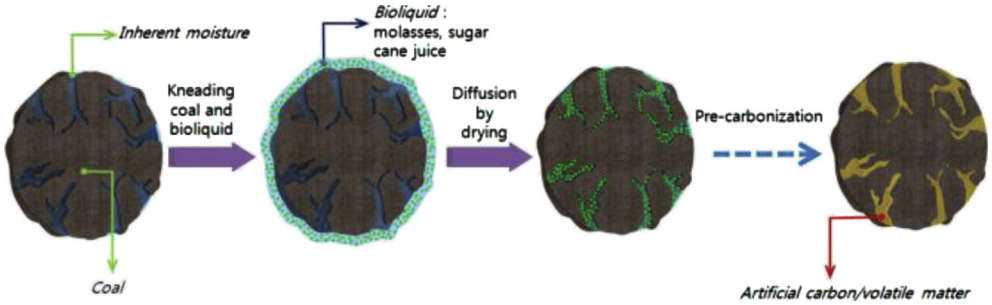

Fig. 1 – Schematic diagram of the preparation procedure of HCK coal (Source: Korea Institute of Energy Research).

approximately 100,000 MWth. This is mainly caused by increase in power consumption in the United States and chemical increase in China [1].

In this study, KIDECO bituminous coal from Indonesia was selected for the gasification technology. The biggest advantage of the KIDECO coal is its low sulfur content. This means that the flue gas desulfurization (FGD) process for the removal of SO_x is not needed. In addition, KIDECO coal has low ash levels. These advantages play an important role to achieve a clean gasification process and for cost reduction [2].

The two-in-one coal upgrading technology using biomass fuel was developed and manufactured by the Korea Institute of Energy Research (KIER). The hydrophilic surface of the coal is coated with carbon derived from biomass materials, and this procedure can modify the properties of the coal surface from hydrophilic to hydrophobic. This will prevent the re-adsorption of water to the drying coal. Thus, hybrid coal, which mixes the carbon contents of raw coal and biomass, can have a high calorific value. In this study, the hybrid coal produced was used as the fuel to perform the simulation experiments on with the purpose of improving the efficiency of coal gasification. The coal that is produced through a pretreatment process is called hybrid coal by KIER (HCK coal). The process steps for making HCK coal are as follows. First, a paste of raw coal and a solution derived from biomass is made. Second, the paste is fed into the carbonization furnace where drying and carbonization of the biomass-derived materials are carried out simultaneously. From this, the hybrid coal is obtained. Third, a water/alcohol, water/surfactant, or water/alcohol/surfactant dispersion medium may be selected and mixed with the hybrid coal. Subsequently, high density slurry from hybrid coal is produced. Fig. 1, provided by KIER, shows a conceptual diagram of the manufacturing process of HCK coal [3].

Prior to the simulation, the coal gasification type is discussed below. This study used wet gasification. Wet gasification involves coal being transported as slurry mixed with water. The entrained-flow gasifier was selected in this research as the gasification reactor. The main advantages of the entrained-flow gasifier are its application to all types of coal and the formation of clean gas without tar. Further, ash from the device is collected as an inert slag or glass material. Oxygen consumption increases when using coal water slurry (CWS) or coal that contains high moisture and ash in the entrained-flow gasifier [4].

GE Energy is a representative manufacturer of the entrained-flow gasifier. The basic model for the simulations in this study is based on the GE Energy gasifier. The reason for this is because this type of gasifier uses CWS feed and has features such as refractory-lined reactor, cooling with radiant cooler or quench, and slagging, and can use various fuels such as bituminous coal, pet coke, and blends of pet coke and low-rank coals [5].

A schematic presentation of the GE Energy gasifier is shown in Fig. 2. Briefly, coal slurry mixed with water and oxygen as an oxidizing agent is fed to the top of the reactor. The reactor temperature is approximately 1320–1430 °C; therefore, combustion of the coal slurry and oxygen occurs very fast at high temperature. The gasification reaction occurs with volatile matter and steam as the coal slurry moves downward. High-pressure steam and synthesis gas are produced because the GE Energy gasifier has a radiant syngas cooler from the middle to the bottom of the reactor.

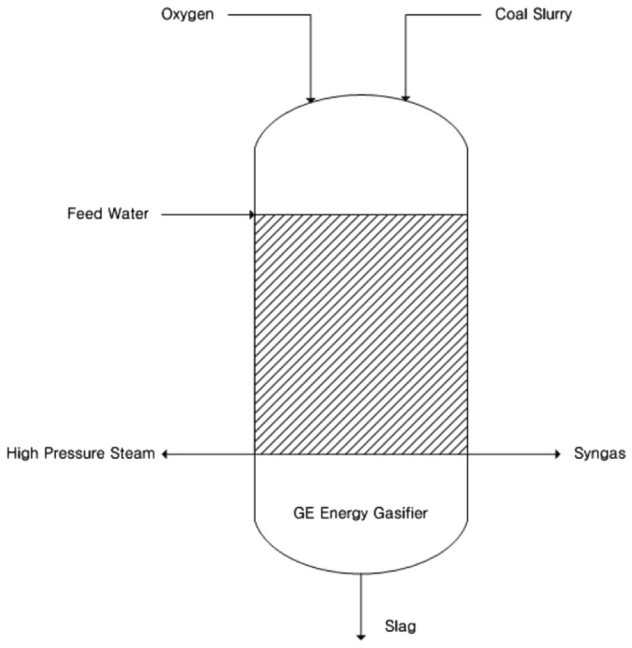

Fig. 2 – GE energy gasifier (entrained bed).