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Development of the Three-Tower Chemical Looping Coal Combustion Technology

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Abstract

To protect the environment changing, coal combustion must reduce its CO_2 emission by capture and storage. Chemical looping is a potentially high technology for coal combustion with CO_2 capture efficiently. A chemical-looping combustion system, using circulating fluidized bed witch consist two main reactors, a fuel reactor and an air reactor. An oxygen carrier, typically a metal oxide, is employed to transfer oxygen from the air reactor to the fuel reactor, and circulates between these two reactors.

During 2012-2014, JCOAL, MHPS (Mitsubishi Hitachi Power Systems (2012-2013 Babcock-Hitachi)) and IAE(The Institute of Applied Energy) have a project funded by NEDO (New Energy and Industrial Technology Development Organization) to surveyed chemical looping technology development in the world, studied market needs of chemical looping combustion, investigated carrier costs and reactivity, etc., in order to reduce CO_2 separation recovery cost to 2,500 yen/ton of CO_2 or less. A small-scale reactor was used to study the behaviors of the direct reaction of coal with an oxygen carrier. It was found that the coal conversion efficiency increases with increasing iron level in the carrier, that the volume of unreacted CO gas increases when oxygen use in the carrier exceeds the range of Fe_2O_3 --> Fe_3O_4, and that there is no notable surface melting that could obstruct particle circulation at 950°C or less.

A basic model of the CLC process was produced using the AspenPlus software and used to analyze the process under the conditions of a 250MWth plant. It found that the volume of circulating CLC carrier is roughly the same as the circulation of CFBC medium, and that inner desulfurization and ultra-low NO_X combustion are possible.

Using the results of research and process analysis, a three-tower chemical looping coal combustion technology that consists primarily of an air reactor (AR), coal reactor (CR), and volatiles reactor (VR) was selected, and an conceptual design was produced for the reactor configuration and technical parameters.

Keywords: CO2 capture, Coal, Combustion, Chemical looping

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1. Introduction

To protect the environment changing, coal combustion must reduce its CO_2 emission by capture and storage. Chemical looping is a potentially high technology for coal combustion with CO_2 capture efficiently.

A chemical-looping combustion system, which is schematically presented in Fig. 1, using circulating fluidized bed witch consist two main reactors, a fuel reactor and an air reactor. An oxygen carrier, typically a metal oxide, is employed to transfer oxygen from the air reactor to the fuel reactor, and circulates between these two reactors.

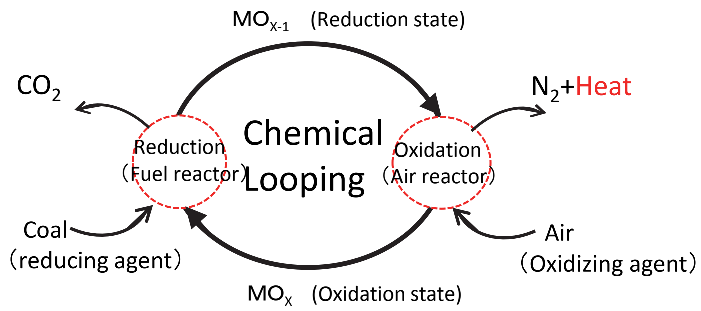

Fig. 1 Schematic diagram of CLC

The main reactions by using Fe base carrier in the fuel reactor and air reactor are:

Fuel reactor: $Fe_2O_3 + 1/6C(Coal) \rightarrow 2/3Fe_3O_4+1/6CO_2$

Air reactor: $2/3Fe_3O_4 + 1/6O_2(Air)\rightarrow Fe_2O_3 + Q$

During 2012-2014, JCOAL, MHPS (Mitsubishi Hitachi Power Systems (2012-2013 Babcock-Hitachi)) and IAE(The Institute of Applied Energy) have a project funded by NEDO (New Energy and Industrial Technology Development Organization) to surveyed chemical looping technology development in the world (2012), studied market needs of chemical looping combustion (2013), investigated carrier costs and reactivity, etc., in order to reduce CO_2 separation recovery cost to 2,500 yen/ton of CO_2 or less (2014).

2. Market research

Fig. 2 shows CLC market as possible in a range of 100MWe -500MWe. From the perspectives of both engineering companies and suppliers of fluidized beds and other technologies used in CLC, the market research surveyed paper, cement, and other plants that use industrial boilers and would likely be early adopters of CLC. While CLC is a desirable technology for the future because it does not require energy to perform CO_2 separation and capture, there is a need to determine its safety and operational performance when used for power generation. Based on the findings of the research, it was also conducted on the use of CLC by IPPs and PPSs.