World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:11, No:11, 2017

Oxidation and Reduction Kinetics of Ni-Based Oxygen Carrier for Chemical Looping Combustion

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Abstract : Carbon Capture and Storage (CCS) is one of the important technology to reduce the CO_2 emission from large stationary sources such as a power plant. Among the carbon technologies for power plants, chemical looping combustion (CLC) has attracted much attention due to a higher thermal efficiency and a lower cost of electricity. A CLC process is consists of a fuel reactor and an air reactor which are interconnected fluidized bed reactor. In the fuel reactor, an oxygen carrier (OC) is reduced by fuel gas such as CH_4, H_2, CO. And the OC is send to air reactor and oxidized by air or O_2 gas. The oxidation and reduction reaction of OC occurs between the two reactors repeatedly. In the CLC system, high concentration of CO_2 can be easily obtained by steam condensation only from the fuel reactor. It is very important to understand the oxidation and reduction characteristics of oxygen carrier in the CLC system to determine the solids circulation rate between the air and fuel reactors, and the amount of solid bed materials. In this study, we have conducted the experiment and interpreted oxidation and reduction reaction characteristics via observing weight change of Ni-based oxygen carrier using the TGA with varying as concentration and temperature. Characterizations of the oxygen carrier were carried out with BET, SEM. The reaction rate increased with increasing the temperature and increasing the inlet gas concentration. We also compared experimental results and adapted basic reaction kinetic model (JMA model). JAM model is one of the nucleation and nuclei growth models, and this model can explain the delay time at the early part of reaction. As a result, the model data and experimental data agree over the arranged conversion and time with overall variance (R^2) greater than 98%. Also, we calculated activation energy, pre-exponential factor, and reaction order through the Arrhenius plot and compared with previous Ni-based oxygen carriers.

Keywords : chemical looping combustion, kinetic, nickel-based, oxygen carrier, spray drying method
Conference Title : ICCEHC 2017 : International Conference on Chemical Engineering and Heterogeneous Catalysis
Conference Location : Paris, France
Conference Dates : November 20-21, 2017