The Preliminary Continuous Test of Silica-PEI Sorbents in the Lab.-Scale Two Bubbling-Beds System

Young Cheol Park1*, Jae-Young Kim1, Je-Min Woo1, Sung-Ho Jo1, Seung-Yong Lee1, Jong-Ho Moon1, Hyunuk Kim1, Chang-Keun Yi1, Hyojin Lee1, and Colin E. Snape2

1Korea Institute of Energy Research
2University of Nottingham

Abstract

In this study, the lab.-scale two bubbling-beds system (TBS) has been used to continuously test the performance of silica-PEI sorbents, which has been supplied by the University of Nottingham (UNOTT). The sorbents contain 40 wt.% of PEI for CO2 sorption and have multiple peaks of particle size distribution. The TBS mainly consists of a bubbling-bed sorption reactor, a bubbling-bed desorption reactor, a riser for pneumatic conveying of solid from the sorption reactor to the desorption reactor, and a cyclone for solid-gas separation. The dimensions of sorption and desorption reactor are the same, 100 mm in inner diameter and 1,000 mm in height. The sorption and desorption temperature has been maintained at approximately 70°C and 130°C, respectively. The gas flowrate at the sorption and desorption reactor has been 20 lpm (15 vol.% of CO2) and 15 lpm (N2), respectively. The bed height, which can be measured by differential pressure gauge, has been maintained at around 250 to 300 mmH2O for both reactors. The sorbents has been preliminarily tested for almost 24 hours at the given operating conditions by varying solid circulation rate to analyse the CO2 removal efficiency in the sorption reactor and the dynamic sorption capacity of the sorbent. As a result, the CO2 removal efficiency was 72.5%, 84.2%, 92.7%, and 95.0% and the dynamic sorption capacity of sorbents was 6.36 wt.%, 5.05 wt.%, 3.08 wt.%, and 2.20 wt.% at the solid circulation rate of 2.7 kg/h, 4.6 kg/h, 8.4 kg/h, and 12.2 kg/h, respectively. It is obvious that the CO2 removal efficiency has increased and the dynamic sorption capacity of sorbents has decreased as the solid circulation rate increased. Based on the results, we can say that it is simultaneously capable of above 80% of CO2 removal efficiency and above 5.5 wt.% of dynamic sorption capacity of sorbents when N2 was used as the fluidizing medium in the desorption reactor. It is necessary to evaluate the performance of the sorbents when CO2 or steam was used as the fluidizing medium in the desorption reactor so as to recover high-concentrated CO2 stream from that reactor. Besides the performance of the sorbents, attrition of them is also important physical property for the long-term stable operation. The elutriation rate for 24 hours was almost 8.63% w/w since the sorbents have multiple peaks of particle size distribution. The efficiency of main cyclone was 99.58% w/w and the mean particle size of the elutriation from the main cyclone was 48 micron. It is obvious that the attrition rate of the sorbents should be reduced by making the sorbents with unimodal particle size distribution. We confirm that the attrition rate of the same sorbents has been dramatically decreased when we’ve just used unimodal particle size distribution. Korea Institute of Energy Research (KIER) has tested 100 kg of sorbents at the bench-scale unit (BSU), of which configuration has been exactly the same as the TBS. Based on the experimental

* To whom all correspondence should be addressed. (E-mail: youngchp@kier.re.kr)
results of BSU, KIER and UNOTT has developed a next-generation post-combustion CO₂ capture technology using silica-PEI sorbents.