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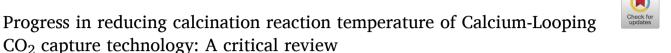
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Review



Rui Han^{a,b}, Yang Wang^{a,b}, Shuang Xing^{a,b}, Caihong Pang^{a,b}, Yang Hao^{a,b}, Chunfeng Song^{a,b}, Qingling Liu^{a,b,*}

a Tianjin Key Lab of Indoor Air Environmental Quality Control, School of Environmental Science and Technology, Tianjin University, Tianjin 300350, China

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ABSTRACT

The calcium looping (CaL) process is a promising CO_2 capture technology based on a reversible reaction, $CaO(s) + CO_2(g) \leftrightarrow CaCO_3(s)$, and the forward and reverse directions of this reaction are often referred to as carbonation and calcination. Although CaO-based sorbent has the advantages of abundant reserves, low cost, and high theoretical capacity of CO_2 , it is limited by significant sintering of CaO grains over carbonation/calcination cycles, resulting in a rapid decline in CO_2 capture performance. As an essential part of CaC technology, the $CaCO_3$ calcination stage has a decisive influence on the sintering degree of CaC grains. In this work, a systematic understanding of fundamental aspects of the $CaCO_3$ calcination is reviewed. The effects of calcination reaction conditions on the sintering of CaC grains and the resulting decline in CO_2 capture performance during the cyclic operation were discussed. A number of efforts to reduce the calcination reaction temperature, thus slowing down $CaCCO_3$ grains sintering, have been summarized, such as decreasing $CaCO_3$ crystallinity, doping $CaCO_3$ with alkali/alkaline earth salt, reducing CO_2 absolute pressure, injecting steam, as well as in situ converting CO_2 . Finally, the future development trends for the above strategies to reduce the $CaCCO_3$ calcination temperature are also recommended. We hope this work can help and inspire researchers to make breakthroughs in this field.

1. Introduction

It is well known that carbon dioxide (CO₂) is the primary greenhouse gas responsible for climate change, such as global warming and ocean acidification [1]. CO₂ capture and storage (CCS) technology is currently one of the most promising solutions to control CO₂ emissions and has been commercially demonstrated. CCS mainly includes 3 steps: CO₂ capture, transportation, and storage. Compared with the CO₂ transportation and storage steps, the cost of CO₂ capture accounts for 60 \sim 70% of the total cost of CCS [2]. Therefore, it is urgent to develop cost-effective CO₂ capture technology. The post-combustion amine scrubbing is currently the most mature CO₂ capture technology on the industrial scale. However, several issues related to this technology limit its large-scale application, including high regeneration energy (efficiency penalty of 9.9 \sim 14.0) [3], high cost (\$52 \sim 77/ton) [4], solvent degradation [5], corrosiveness [6], and reaction with other compounds in the flue gas (such as O₂, SO₂, NOx, and fly ash) [7,8].

In the past few years, the utilization of solids to capture CO_2 has been considered a more practical and inexpensive alternative [9-12]. The calcium looping (CaL) process is an emerging and promising CO_2 capture technology based on the reversible carbonation/calcination reaction [13,14].

Carbonation:

$$CaO(s) + CO_2(g) \rightarrow CaCO_3(s), \Delta H_{r,298K} = -178kJ \bullet mol^{-1}$$
 (1)

Calcination:

$$CaCO_3(s) \to CaO(s) + CO_2(g), \Delta H_{r,298K} = +178kJ \bullet mol^{-1}$$
 (2)

Compared with other CO_2 capture technologies, such as amine scrubbing technology, CaL technology has the following advantages: (1) Natural limestone or dolomite, which is abundant and environmentally friendly, can be used as the raw material to prepare CaO; (2) The CO_2 absorption capacity of CaO is relatively high, reaching 0.786 gCO₂/gCaO; (3) The energy consumption of CaL technology is relatively low

E-mail address: liuql@tju.edu.cn (Q. Liu).

^b State Key Laboratory of Engines, School of mechanical engineering, Tianjin University, Tianjin 300350, China

^{*} Corresponding author at: Tianjin Key Lab of Indoor Air Environmental Quality Control, School of Environmental Science and Technology, Tianjin University, Tianjin 300350, China.