Chemical Engineering Journal 446 (2022) 136880

Contents lists available at ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Review

A review on granulation of CaO-based sorbent for carbon dioxide capture

Xiaoyu Zhang [a], Wenqiang Liu [a,*], Shimeng Zhou [a], Zexin Li [a], Jian Sun [b], Yingchao Hu [c], Yuandong Yang [d]

[a] State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology, Wuhan 430074, China
[b] Engineering Laboratory for Energy System Process Conversion & Emission Control Technology of Jiangsu Province, School of Energy and Mechanical Engineering, Nanjing Normal University, Nanjing 210023, China
[c] College of Engineering, Huazhong Agricultural University, Wuhan 430070, China
[d] Institute of Thermal Science and Technology, Shandong University, Jinan 17923, China

ARTICLE INFO

Keywords:
Carbon dioxide
Calcium-based sorbent
Pellets
Granulation
Calcium looping

ABSTRACT

This review summarized the principles and processes of different granulation methods and analyzed the effects on the mechanical and CO_2 uptake performances. The extrusion method, extrusion-spheronization method, and casting method with the external force can compact the structure of sorbent to improve the compressive strength but decrease the initial CO_2 uptake capacity. The spheronization method and casting method without the external force only change the pellet shape to decrease unnecessary attrition without affecting the uptake performance. The performances of pellets prepared by the wrapped shell method are various primarily resulting from the structures of the shells. The pellets prepared from organic calcium precursor have larger CO_2 uptake performances but lower mechanical performances. The addition of inert binders can enhance the mechanical yet decrease the CO_2 uptake performance, however, the addition of pore-forming materials without extensive alkali elements can improve the uptake capacity but weaken mechanical performance. In addition, the increase of carbonator temperature can enhance the CO_2 uptake performance but decrease the CO_2 capture efficiency. The high calcination temperature can result in serious sintering and attrition, and the pellet with a small size owns a high carbonation rate and low attrition. Besides, the calcination at concentrated CO_2 and the presence of SO_2 during carbonation can also significantly deteriorate the cyclic uptake performance. However, the presence of water vapor during carbonation can relieve sintering. During fluidization, the large fluidization number can result in a high initial CO_2 uptake performance but enhance the attrition ratio. Besides, three prospective research aspects including enriching the research method, the systematic techno economic analysis, and the design of a continuous granulation system were suggested.

1. Introduction

Large emissions of CO_2 from the large-scale burning of fossil fuels are the major cause of global warming [1,2]. Nowadays, the concentration of CO_2 is significantly large and the decreased tendency is not observed [4-6]. That causes many ecological problems [7-9], such as the sea level rising, frequent occurrence of extreme weather, and so on. Therefore, it is urgent to reduce the emission of CO_2 produced by fossil fuel burning.

Carbon capture and storage (CCS) is considered one of the most promising technologies to extensively reduce CO_2 emission, and carbon capture is a significantly crucial part of CCS [10-13]. Nowadays, the amine scrubbing method is the only commercially applied one for CO_2 capture [14,15]. However, the method has many defects [16,17], such as serious energy consumption, corrosion and fouling problem, and so on. Hence, many efforts have been made to develop an economic and feasible method for CO_2 capture. Calcium looping (CaL) proposed based on a reversible reaction, $CaO + CO_2 \leftrightarrow CaCO_3$, is considered one of the most possibly industrial application methods for CO_2 capture at a large-scale [18,19], due to cheap and readily available raw material, large CO_2 uptake capacity (theoretically, 0.786 g CO_2/g sorbent, g/g), and easy settlement of spent adsorbents [20,21]. The CO_2 capture by CaL is mainly realized by an interconnected fluidized-bed reactor consisting of a carbonator and a calciner, as shown in Fig. 1. The flue gas containing CO_2 flows through a carbonator, and CO_2 is captured by the CaO-based sorbents in the reactor. The CO_2-free flue gas leaves the carbonator and the carbonated sorbents are transferred to a calciner and then

* Corresponding author.
E-mail address: wenqiang.liu@mail.hust.edu.cn (W. Liu).

https://doi.org/10.1016/j.cej.2022.136880
Received 28 February 2022; Received in revised form 19 April 2022; Accepted 6 May 2022
Available online 11 May 2022
1385-8947/