Separation and Purification Technology 299 (2022) 121734

Contents lists available at ScienceDirect

Separation and Purification Technology

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

Cryogenic technology progress for CO_2 capture under carbon neutrality goals: A review

Minghai Shen [a,b], Lige Tong [a,b,*], Shaowu Yin [a,b], Chuanping Liu [a,b], Li Wang [a,b], Wujun Feng [c], Yulong Ding [d]

[a] School of Energy and Environmental Engineering, University of Science and Technology Beijing, Beijing 100083, China
[b] Beijing Key Laboratory of Energy Saving and Emission Reduction for Metallurgical Industry, University of Science and Technology Beijing, Beijing 100083, China
[c] Beijing Jingneng Energy Technology Research Co. Ltd., 100022 Beijing, China
[d] Birmingham Centre for Energy Storage & School of Chemical Engineering, University of Birmingham, B15 2TT, UK

ARTICLE INFO

Keywords:
CO_2 capture
Cryogenic
Condensation
Sublimation
Distillation

ABSTRACT

This review discusses the cryogenic capture system from the perspective of constructing new cryogenic capture system structures, exploring the optimal system parameters, and analyzing the challenges faced by different cryogenic capture systems. The gas that needs to remove CO_2 undergoes desulfurization, denitrification and dust removal treatment, which can effectively reduce impurities and remove, and ensure the progress of the subsequent carbon capture process. Among the cryogenic technologies of carbon capture, cryogenic distillation is restricted by the concentration of carbon dioxide (CO_2) in the gas and cost, and it cannot be widely popularized. Cryogenic condensation offers a wide range of industrial applications because it may immediately liquefy CO_2 for oil displacement. Currently, the most concerned cryogenic sublimation can capture low-concentration CO_2 at a rate of 99.9% at 13.5 vol%, and energy consumption and annual investment costs can also be effectively reduced. In general, cryogenic CO_2 capture technology provides remarkable cost and efficiency benefits compared with other carbon capture technologies. By 2030, China's CO_2 capture cost will be 13–57$/t, and it will be 3–19$/t in 2060. Combining fixed costs and operating costs, the total abatement cost is 65$/t CO_2, which is similar to the cost of 54$/ton CO_2 in Japan and 60–193$/t CO_2 in Australia. By 2060, the carbon emission reduction ratio of carbon capture, utilization, and storage (CCUS) will account for about 10% of the total emission reduction, so the research on CCUS is very urgent. It must break through the extreme utilization of cold energy and energy consumption barriers as well as increase the efficiency of the system.

1. Introduction

The issue of global climate change has become one of the key issues that the international community has generally paid attention to in recent years [1–3]. Excessive emissions of carbon dioxide (CO_2) and other greenhouse gases are known to be the main cause of global climate change, of which CO_2 accounts for 65% of global greenhouse gas emissions. Fig. 1(a–b) show the CO_2 emissions of energy-based related industries represent the largest share of global emissions, accounting for about 69% of total global anthropogenic greenhouse gas emissions [4]. According to statistics from the International Energy Agency [5], driven by the increase in energy demand in 2018, global energy-related CO_2 emissions increased by 1.7%, reaching a record high of 3.31 billion t of CO_2. The Copenhagen Conference put forward carbon emission reduction requirements for various countries. As a result of the worldwide public opinion climate, several governments are paying increasing attention to carbon emissions.

As a country with the largest carbon emissions in the world and the sixth per capita carbon emissions, China faces an immense pressure for energy saving and emission reduction. As the world's largest developing country, China's energy demand increased substantially in 2018, and its growth rate accounted for one-third of global energy demand growth. China's CO_2 emissions rank first in the world, accounting for 28.6% of the world's total CO_2 emissions. In September 2020, China proposed the 2060 target. China faces many challenges, striving to reach the peak of CO_2 emissions by 2030 and achieve carbon neutrality by 2060. At present, more than 120 countries and regions in the world have proposed carbon–neutral goals. Fig. 1(c–d) display the peak time of the steel

* Corresponding author at: School of Energy and Environmental Engineering, University of Science and Technology Beijing, Beijing 100083, China.
E-mail address: tonglige@me.ustb.edu.cn (L. Tong).

https://doi.org/10.1016/j.seppur.2022.121734
Received 9 May 2022; Received in revised form 10 July 2022; Accepted 13 July 2022
Available online 16 July 2022