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Review on principles, recent progress, and future challenges for oxy-fuel combustion CO_2 capture using compression and purification unit

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ABSTRACT

The emission of anthropogenic carbon dioxide (CO_2) as a result of fossil fuel burning is regarded as a leading cause of global warming and environmental problems. An efficient method to capture CO_2 from flue gases is oxy-fuel combustion. CO_2 compression and purification unit (CO_2CPU) is a promising process to capture CO_2 from oxy-fuel combustion flue gases. However, the widespread implementation of this method is encountered with different techno-economical and legal challenges. The present study aims to review the principles and latest advances of CO_2CPU process as well as the challenges this process may encounter in the future. The CO_2CPU system is introduced and the latest research on the optimization and dynamic investigation of this process are reviewed. In addition, relevant standards and specifications of CO_2 product as well as the effect of impurity are collected. Finally, a summary of the future challenges and research directions is presented.

1. Introduction

During the period from 1760 to 1840, especially from the beginning of the Industrial Revolution, anthropogenic activities increased the emission of greenhouse gases, particularly CO_2, from 280 ppm to 370 ppm [1]. During the same period, the average worldwide temperature experienced a rise in the range of 0.6 °C and 1 °C [2]. The accumulation of greenhouse gases in the atmosphere has resulted in a gradual increase in the average Earth temperature which has been called global warming and turned into a widespread concern over the recent years [3]. Global warming as a great threat to life on earth will lead to some problems such as sea level rise which is associated with the loss of coastal area, and sever weather conditions such as drought, hurricane, and flood [4]. CO_2 was the most produced flue gases from industrial emissions, around 33% of which was produced as a result of burning carbon-intensive fossil fuels such as coal and oil [5]. As the scientists are aware of the significant effect of this pollutant on global warming, CO_2 emission became the most serious environmental issue in the 21st century [6]. Accordingly, in the latest global agreement to combat climate change (the Paris Agreement enacted in 2016), the United Nations Framework Convention on Climate Change (UNFCCC) member states committed to reduce CO_2 emissions, although this pollutant is still increasingly generated throughout the world. Based on a report by the International Energy Agency (IEA), due to higher energy demand in 2018, annual CO_2 production reached 33.5 Gt and have grown by an average of 2.4% per year. It is forecasted that due to increase CO_2 the mean worldwide temperature increase to around 3.2 °C, by 2100, and hence, significantly affecting the earth and human activities [7]. The contribution of the primary sources of CO_2 emission which was obtained from the data extracted from IEA in 2018 is presented in Fig. 1 [8]. As illustrated in Fig. 1 electricity and heat production, by accounting for 42% of the globally emitted CO_2, is the main cause of CO_2 emission. Also, more than 65% of CO_2 emission are resulted from combusting a huge quantity of coal and natural gases, which show the significant impact of these processes on climate change.

To reduce CO_2 emissions, there are different approaches such as expanding renewable energies such as solar and wind energies [9], fuel switching from coal to natural gas [10], applying regulations on the total CO_2 emission [11], utilizing CO_2 as a raw material [12], enhancing plant efficiency to more energy saving [13], and applying carbon capture and storage (CCS) approach [14]. However, due to the great world energy demand and based on the fact that renewable energies still need more work to make them economically competitive to the fossil fuel price, more need is felt for the continuous use of reasonable and sustainable fossil fuels with decreased environmental consequences which requires the integration of the CCS technologies [15]. CCS does not aim to decrease the formation of CO_2, rather to capture it from emissions and store it under the earth's surface, for example in unused oil and gas fields, and deep saline formations [16]. Capturing CO_2 from the primary

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