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Carbonation of steelmaking slag presents an opportunity for carbon neutral: A review

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ABSTRACT

An ambitious goal has been set to limit global temperature increase within 1.5℃ above pre-industrial levels. Iron and steel industry as one of the main industrial sectors, has always been accompanied by high energy input and high carbon dioxide emissions. Carbon capture and storage is one of the important technologies for the iron and steel industry to achieve deep reduction of emissions. Economic and effective material for carbon dioxide sequestration is still a problem that needs to be solved. In order to meet the challenges of the future, the feasibility of using steelmaking slag to promote carbon neutral in the iron and steel industry is discussed in this study. The present work systematically reviews the carbonation of steelmaking slag from three aspects: the carbonation processes and mechanism of steelmaking slag; the effect of operational conditions on carbon dioxide sequestration ratio and reaction rate; and carbon dioxide sequestration capacity of different types of steelmaking slag. The results show that steelmaking slag has a great potential for carbon dioxide sequestration, which can reduce almost 12–17 % of carbon dioxide emissions from the iron and steel industry. Moreover, challenges faced by the use of steelmaking slag for carbon dioxide sequestration and the prospects for the utilization of carbonated steelmaking slag are summarized.

1. Introduction

As one of the important industries in the world, iron and steel industry plays an irreplaceable role. In 2016, the world's crude steel output reached 1.63 billion tons [1]. On average, each ton of steel production could accompany with 1.8 tons of CO_2 emissions [2]. Globally, CO_2 emissions from iron and steel industry account for about 6–7 % of global CO_2 emissions [3]. In China, iron and steel industry is the third largest CO_2 emission industry after power industry and cement industry, accounting for 10 % of the domestic CO_2 emissions [4]. Incredible pressure was put on industries, as Paris Agreement has set to limit the temperature increase to 1.5℃ [5], which requests much higher CO_2 emissions reduction. Currently, hydrogen injection [6], solid biomass substitution [7], zero-C electricity substitution [8] and carbon capture and storage [9] are decarbonation technologies frequently used in industries. Among these technologies, carbon capture and storage technology is considered as a promising technology due to its CO_2 sequestration capacity. Recently, Ding et al. evaluated the value of carbon capture and storage technology in iron and steel industry, and suggested that new iron and steel plants could adopt carbon capture and storage technology to obtain significant economic value [10].

Carbon capture and storage is one of the most important strategies to minimize the greenhouse effect [11]. CO_2 mineralization, a well-known carbon capture and storage technology, was originally proposed by Seifritz in 1990. This technology involves in CO_2 sequestration in silicate minerals containing calcium and magnesium under simulated weathering process [12]. In order to speed up the carbonation process, CO_2 sequestration of alkaline waste is proposed by researchers due to its great CO_2 storage potential [13]. Currently, the amount of CO_2 sequestration of alkaline waste can achieve 4.02 Gt per year, which corresponds to 12.5 % reduction in global anthropogenic CO_2 emissions [14]. In China, CO_2 sequestration of alkaline waste can significantly reduce total CO_2 emissions by 19.2 % per year [14]. Iron and steel slag (steelmaking slag) is considered as one of the most effective industrial alkaline residues due to its high calcium oxide (CaO) and magnesium oxide (MgO) content [15]. Furthermore, steelmaking slag is the non-metallic by-product from iron and steel manufacturing [16]. Every year a huge amount of steelmaking slag waste is generated around the

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