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Full Length Article

Steam gasification behavior during coal combustion and CaO regeneration in O_2/CO_2/steam atmosphere

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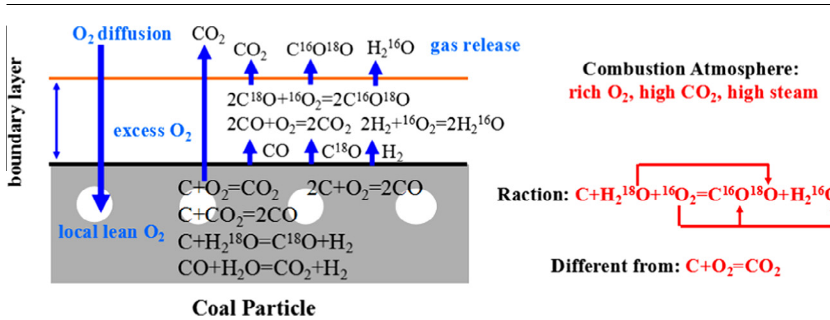
HIGHLIGHTS

- Both combustion and gasification reactions take place in O_2/CO_2/steam atmosphere.
- Combustion reaction is $C + H_2{}^{18}O + {}^{16}O_2 = C^{16}O^{18}O + H_2{}^{16}O$ in O_2/CO_2/steam atmosphere.
- O_2 promotes $C^{16}O^{18}O$ generation in fuel-rich environment.
- Steam accelerates the conversion of $C^{18}O$ to $C^{16}O^{18}O$.
- CO and H_2 are generated in internal pores before they are converted to CO_2 and H_2O.

GRAPHICAL ABSTRACT



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ABSTRACT

In this study, limestone was calcined in O_2/CO_2/steam atmosphere with heat supplied from coal combustion. Steam was supplied to the calciner to improve CaO reactivity. However, steam gasification behavior during coal combustion in O_2/CO_2/steam atmosphere is unclear. This experimental study was conducted to clarify the role of steam in coal combustion using an isotope tracer technique. $H_2{}^{18}O$ was used to continuously trace the reaction proceeding. In a fuel-rich environment, both CO_2 and steam gasification occurred, generating H_2, $C^{16}O$, $C^{18}O$, $C^{16}O_2$ and $C^{16}O^{18}O$. In an oxygen-rich environment, steam gasification still occurred and generated $C^{16}O^{18}O$. The combustion reaction equation should be described as $C + H_2{}^{18}O + {}^{16}O_2 = C^{16}O^{18}O + H_2{}^{16}O$ at high temperature and with high CO_2 and steam concentrations. The generation of $C^{16}O^{18}O$ highly depends on O_2 concentration in a fuel-rich environment but the O_2 supply has little influence on $C^{16}O^{18}O$ formation in an oxygen-rich environment. Moreover, the increase of steam supply accelerated $C^{16}O^{18}O$ formation. Steam gasification is generally involved in coal combustion reaction. $C^{18}O$ and H_2 are first locally generated within coal particles through steam gasification and they are reconverted to $C^{16}O^{18}O$ and $H_2{}^{16}O$ through combustion during the boundary layer reactions.

1. Introduction

As one of the greenhouse gases, CO_2 should be captured before it is released into the environment [1,2]. It is traditionally separated from the flue gas via post-combustion chemical absorption [3–6]. Among all the post-combustion CO_2 capture technologies, calcium

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