



Experiment study on mercury migration across wet flue gas desulfurization slurry under oxy-coal combustion atmosphere



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HIGHLIGHTS

- More mercury enriched in slurry solids of CaSO_3 than CaSO_4 .
- CO_2 atmosphere hindered Hg retention in solids and increased gaseous Hg^0 emission.
- CaSO_3 oxidation by O_2 led to less Hg retained in solid and more Hg^0 re-emitted.
- More Hg remained in the slurry liquid when Cl^- anions presented.
- 6 mM NO_3^- and 5 mM SO_3^{2-} cause Hg transferred from solids and liquid into gas phase.

ARTICLE INFO

Article history:

Received 20 October 2015

Received in revised form 4 February 2016

Accepted 31 March 2016

Available online 16 April 2016

Keywords:

Mercury
Oxy-coal combustion
Flue gas desulfurization
Gypsum

ABSTRACT

Mercury in oxy-coal combustion flue gas may cause liquid metal embrittlement and material failure to aluminum (Al) heat exchangers, which needs to be removed with high efficiency before CO_2 compression. Oxidized Hg (Hg^{2+}) is soluble thus can be co-removed with SO_2 in WFGD (Wet Flue Gas Desulfurization). However, the dissolved Hg^{2+} in slurry may also transform to the insoluble elemental mercury (Hg^0) form and re-emitted, resulting a reduction of total Hg capture efficiency in WFGD. This paper experimentally examined the Hg migration across WFGD under high CO_2 concentration atmosphere with simulated typical desulfurization slurry. Influences of solids (CaSO_4 , CaSO_3) and anions (Cl^- , NO_3^- , SO_3^{2-}) in slurry are considered. According to the results, solids of CaSO_3 with higher BET surface area are more favored for Hg retention than CaSO_4 . Slurry pH under high concentration of CO_2 was a little bit lower than air combustion atmosphere. The decreased pH in turn hindered Hg retention on both solids while the gaseous Hg^0 emission increased. For anions, 6 mM NO_3^- and 5 mM SO_3^{2-} both led to large amount of Hg transformed from CaSO_4 solids and liquid into the gas phase. The existence of 20 mM Cl^- can retain more Hg in the liquid, especially when NO_3^- and SO_3^{2-} coexisted. However, this effect was quite pH sensitive. As to CaSO_3 slurry, most of the Hg remained in slurry regardless the existence of other anions and atmosphere.

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1. Introduction

Energy consumption from coal combustion has produced large amount of pollutants, such as NO_x , SO_2 , as well as trace element mercury (Hg). Hg is a well-known neurotoxin while coal-fired power plants are the main anthropogenic mercury emission sources [1]. Due to the huge volume of combusted flue gas and the extremely low concentration of mercury in flue gas (in the order of parts per billion, ppb), at present there is none cost-effective mercury removal technology available for coal fired power plants. Recent years, oxy-coal combustion has showed the

potential of multi-pollutant control technology for CO_2 , NO_x , SO_2 , as well as mercury [2]. However, during flue gas compression for CO_2 liquification, mercury in flue gas may cause liquid metal embrittlement and material failure to aluminum (Al) heat exchangers, NO_x and SO_2 can cause equipment corrosion [3]. For the operation safety concern, those impurities must be removed before CO_2 purification and compression. As a reference, there is a Hg concentration limitation of $0.01 \mu\text{g}/\text{Nm}^3$ for natural gas compression [4]. This implicated that oxy-coal combustion is challenged by very high efficiency Hg removal.

Compared to Hg, the controlling technology for NO_x and SO_2 is quite mature and have been commercialized. These controlling technologies also showed co-benefits on Hg removal [5]. With high volatility and very low water solubility, elemental mercury

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