Characterization of migration and enrichment of Mn, Zn and Sr trace elements in coal-water slurry gasification process

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Highlights

- There are differences in the migration behavior of trace elements in the cooling process among the different atmospheres.
- The results of thermodynamic calculations show Mn and Sr elements mainly exist in the form of MnO and SrO respectively, and Zn element mainly exists in the form of gas-phase Zn monomers. at high temperatures,
- A small amount of MnO is transformed into Mn_2O_3, and a small portion of SrO is transformed into $SrAl_2O_4$ by combining with Al elements, while Zn element is further transformed into gas-phase Zn monomers by a small amount of ZnO. The proportion of MnO, SrO and gas-phase Zn monomers increases with the increase of coal-water slurry concentration.
- Mn and Sr elements tend to be enriched in the coarse slag, and Zn elements tend to be enriched in the fine slag. With the increase of temperature, Mn, Sr and Zn elements are enriched in the slag at the reducing atmosphere.

1. Introduction

Trace elements tend to volatilize more completely during combustion in coal-fired power plants than in laboratory-scale combustion environments [1]. The sludge combustion experiments showed that the inhibited volatilization of $ZnCl_2$(g) and the production of ZnO during oxyfuel combustion facilitated the recovery of Zn from the ash compared to air combustion [2]. At present, relatively few investigations have been carried out on the migration of Mn, Zn and Sr in the coal gasification process. There is a lack of comprehensive and systematic study to understand the migration of Mn, Zn and Sr in the coal gasification.

2. Methods

The trace metal elements morphology changes and enrichment characteristics of coal gasification were investigated with XRD, XRF, FactSage and ICP. The effects of coal-water slurry concentration, atmosphere, and gasification temperature on the elemental migration were studied by a tube furnace.

3. Results and discussion

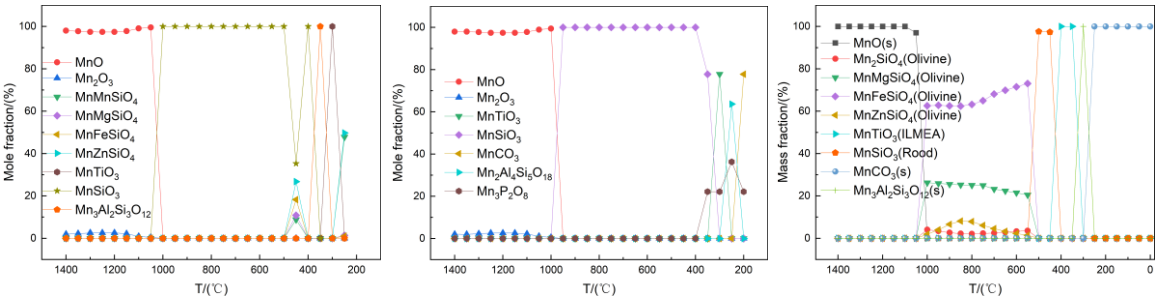
3.1 Transformation of Mn elements under different atmosphere

The morphological changes of Mn elements under different atmosphere are shown in Figure 1. After cooling down to 1000℃, MnO is transformed into $MnSiO_3$ under steam and carbon dioxide atmospheres, whereas it will combine with Fe and Mg elements to form silicates under industrial gasifier atmosphere. After further cooling down to 600℃, Mn element exists in the form of $MnSiO_3$ and $MnTiO_3$ under the industrial gasifier atmosphere, whereas Mn will combine with Zn, Fe and Mg elements to form corresponding silicates under the steam atmosphere. Under steam atmosphere, Mn will be combined with Zn, Fe and Mg elements to form corresponding silicates, while under carbon dioxide atmosphere, Mn will be combined with Al, Si and P elements until the temperature drops below 400℃.

3.2 Effect of different gasification conditions on elemental migration distribution

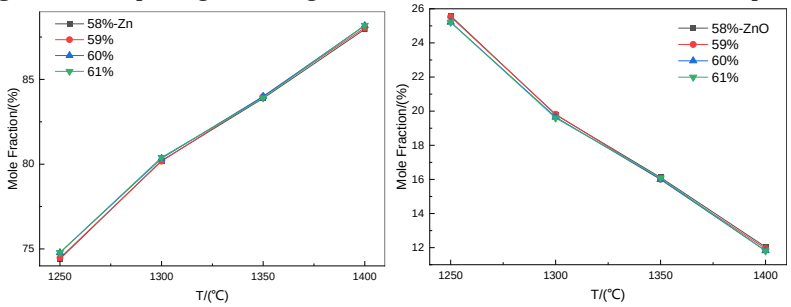
As shown in Figure 2, the elemental migration distribution of Zn in the gasification process under different coal-water slurry concentrations, it can be seen that Zn element mainly exists as gaseous Zn monomers at high temperatures. With the increase of temperature, ZnO of the liquid slag is continuously

transformed into gaseous Zn monomers. With the increase of coal-water slurry concentration, more ZnO is transformed into gas-phase Zn monomers.



(a) Steam atmosphere (b) Carbon dioxide atmosphere (c) Plant atmosphere

Figure 1. Morphological changes of Mn elements under different atmosphere.



(a) Zn (b) ZnO

Figure 2. Elemental migration distribution of Zn and ZnO during gasification

3.3 Investigation on the distribution characteristics and law of trace metal elements

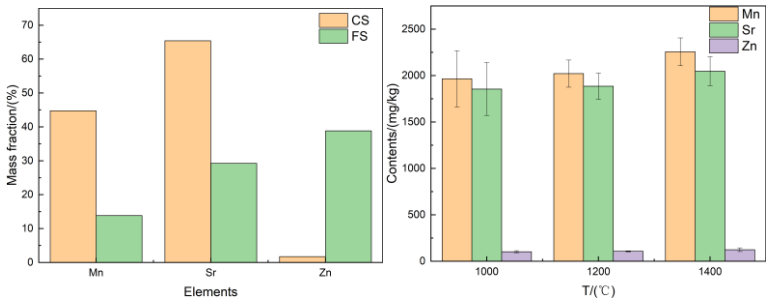


Figure 3. Distribution of trace mental (a) mobility (b) distribution

The mobility of metal elements is shown in Figure 3(a), Mn and Sr elements tend to be enriched in the coarse slag(CS), and Zn elements tend to be enriched in the fine slag(FS). Figure 3(b) shows the content of Mn, Sr and Zn elements with reducing atmosphere and different temperatures. It can be seen that Mn, Sr and Zn elements in the slag are enriched with the increase of temperature.

4. Conclusions

There are differences in the migration behavior of trace elements in the cooling process among the different atmospheres. The results of thermodynamic calculations show that Zn element mainly exists as gaseous Zn monomers at high temperatures. With the increase of temperature, ZnO of the liquid slag is continuously transformed into gaseous Zn monomers. With the increase of coal-water slurry concentration, more ZnO is transformed into Zn monomers of gas-phase. Mn and Sr elements tend to be enriched in the coarse slag, and Zn elements tend to be enriched in the fine slag. Under the reducing atmosphere, with the increase of temperature, Mn, Sr and Zn elements are enriched in the slag.

References

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Keywords
Coal-water slurry; Coal gasification; Trace elements; Thermodynamic; Migration and enrichment