Numerical Simulation of the Reaction and Flow on the Membrane Wall of Entrained Flow Gasifier

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Highlights

- Slag flows in the membrane wall of entrained flow have been studied
- The reaction information on the membrane wall have been revealed
- The influences of operation parameters (swirl number) on slag flows gasifier are discussed.

1. Introduction

The entrained-flow coal gasification technology is a clean and highly efficient conversion process. According to the feed stock status, the entrained-flow coal gasification technology can be classified into coal water slurry (CWS) gasification technology and pulverized coal (PC) gasification technology. The pulverized coal membrane wall-lined entrained-flow gasification technology is ideally suited for coal with high ash fusion temperature and ash content in comparison.

In the membrane wall-lined / refractory bricks-lined entrained-flow gasifier, the combustible components in the coal are converted into the gas phase, and the mineral content in the coal is converted into ash. Most of the ash particles or droplets mingled with carbon component are deposited on the refractory or membrane wall and form a slag layer. The carbon component on the surface of the slag layer will continued react with the gasification agent. The reaction characteristic of the trapped particle and its influence on the gasifier performance are received great interest. In addition, the slag phase transformation, heat transfer and flow characteristics on the membrane wall of the gasifier have direct influence on the gasifier's safe and stable operation.

In this paper, a comprehensive model with gas-particle-slag flow and reaction models was used to model an industry gasifier. The reaction information of the deposited particle on the membrane wall have been revealed, and the operation parameters on slag flows gasifier are discussed.

2. Methods

In this study, we use the comprehensive gasification model (CGM) to investigate the slag flow, phase transformation characteristics, and heat transfer to the membrane wall, as well as discuss the influence of SN on multiphase flow and reaction processes. In CGM mdel, the muliphase physical and chemical processes including spatial region and membrane wall region, such as gas-particle two phases flow, moisture evaporation, coal devolatilization, heterogeneous reactions, homogeneous reactions [1], slag surface reaction [2], slag phase transformation, molten slag transfer and heat transfer [3] are modeled.

3. Results and discussion

Table 1 shows comparison of particle proportional distribution, residual carbon ratio and carbon conversion of the trapped particle and fly ash particle. From these data, we can find that the residual carbon ratio in the

trapped particle is only about 4%, which is significantly lower than in fly ash 18.5%. Due to the wall reaction, about 22.5% carbon of the trapped particle are converted in the membrane wall.

Table1 The carbon conversion ratio in trapped slag and fly ash

Parameter	Trapped particle	Fly ash
Mass ratio %	55.4	45.6
Residual carbon ratio (%)	4.1	18.5
Carbon conversion%	99.1	95.1
The carbon conversion ratio in wall reaction %	22.5	/

Figure 1(a) shows the total slag thickness and molten slag thickness profiles along the membrane wall. From the top to the bottom, the total slag thickness decreases up to the reattachment point and then increases up to the bottom of the gasifier. The effect of SN on the total slag thickness (up to the reattachment point)is greater than the region below the reattachment point. Figure 1(b) displays the molten slag velocity distribution along the membrane wall. From the top to the bottom, the mean velocity of the molten slag increased to a maximum value of 0.8-1.0D, and then the molten slag kept running at a stable value. With the increase of the swirl number, the molten slag velocity increased.

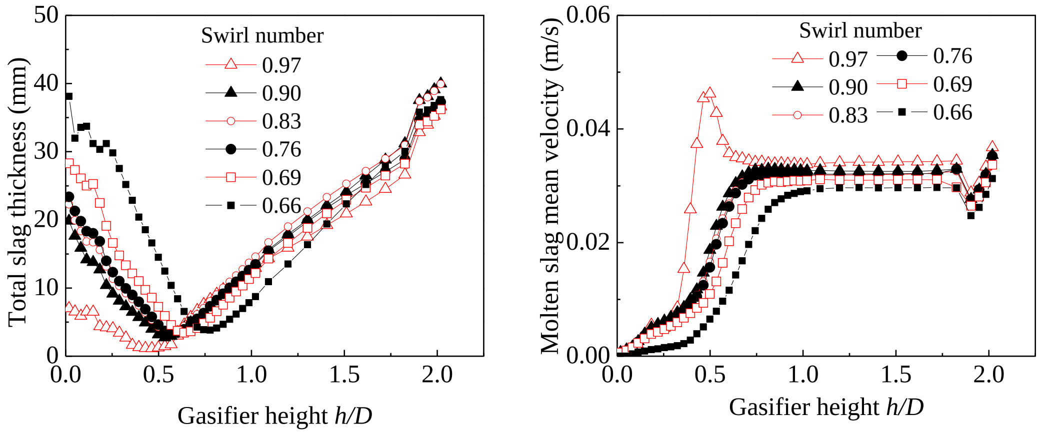

Figure 1. Influence of the swirl number on slag thickness and velocity distribution on the membrane wall (a left, b right)

4. Conclusions

CGM was used to study the gas-particle/droplet flow and reaction, particle deposition, wall reaction, slag flow and heat transfer for a entrained flow gasification. The wall reaction information on the membrane wall had been revealed, and influence of the swirl number on slag thickness and velocity distribution on the membrane wall had been discussed.

References

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Keywords
Slag; Numerical simulation; Gasification;