Study of the deposition characteristics of particles on the slag wall of a gasifier

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Highlights

- The types of particle deposition after impacting the slag wall can be classified into five.
- Collision theory is introducted in the study of deposition characteristics of particles.
- Particle desposition is due to the change of slag wall viscosity with temperatures.
- Slag wall fusion characteristics affects the coefficient of restitution of particle rebound.

1. Introduction

Experimental studies of particle deposition on slag walls and advances in simulation have revealed some of the properties of the near-wall behavior of particles under gasification conditions[1,2]. But there is still a lack of accurate methods for predicting the deposition behavior of particles in the gasifier. Experimental studies have also focused on particle motion and reaction characteristics in air bed gasifiers, with imperfect studies of particle deposition characteristics and even less research on the particle trapping behavior of slag wall[3]. However, the deposition of coal particles in the gasifier is the fundamental cause of residual carbon deposition, so it is important to study the near-wall behavior of coal particles under gasification conditions. This study combines a self-built visual drip tube furnace with a high-speed camera to monitor in real-time the movement process of coal particles near the slag wall under gasification conditions. It conducts a dynamic analysis of the particle deposition process, investigating the influence of slag wall temperature on particle deposition characteristics.

2. Methods

In this study, a plane between 60 ° and 30 ° was chosen as the impact surface. The coal ash from MHJ is heated in a muffle furnace to 1400 degrees Celsius to prepare slag. Seven grams of coal ash is spread on the surface to form a 3mm thick slag wall inside the muffle furnace. According to the deformation temperature (1130 ℃), softening temperature (1218 ℃), hemisphere temperature (1233 ℃), and flow temperature (1246 ℃) of MHJ coal ash, the temperature intervals for setting the slag wall are 25 ℃, 800 ℃, 900 ℃, 1000 ℃, 1100 ℃, 1200 ℃, 1250 ℃, and 1300 ℃, respectively.

An important part of this study is the calculation of the velocity of the particle movement, which is mainly obtained by image processing of the distance of the particle movement process versus the time of the movement process. The actual size and time of the particle movement process are obtained by the image processing software ImageJ, and the velocity is then calculated by dividing the distance by the time.

3. Results and discussion

Figure 1 illustrates the process of particle impact at different temperatures of the slag wall and summarizes the types of deposition. Based on the dynamic changes observed after particles impact the slag wall, deposition characteristics can be categorized into five types: rebound after impacting the slag wall, rebound after blocking for a distance, fragmentation after impacting the slag wall, rolling along the surface after impacting the slag wall, and adhesion to the wall. As shown in Figure 2, the probabilities of deposition of particles on the cold and the hot slag wall are statistically analyzed. As the slag wall temperature changes from 25 ℃ to 1000 ℃, there are only two deposition types of particles upon impacting the slag wall, and the rebound probability remains nearly constant. From 1000 ℃ to 1250 ℃, the probability of rebounding decreases significantly with the increase in the wall temperature. After the wall temperature reaches the flow temperature, the number of types of particle

deposition becomes four, and the probability of adhesion and blocking distance phenomenon both increase with increasing temperature.

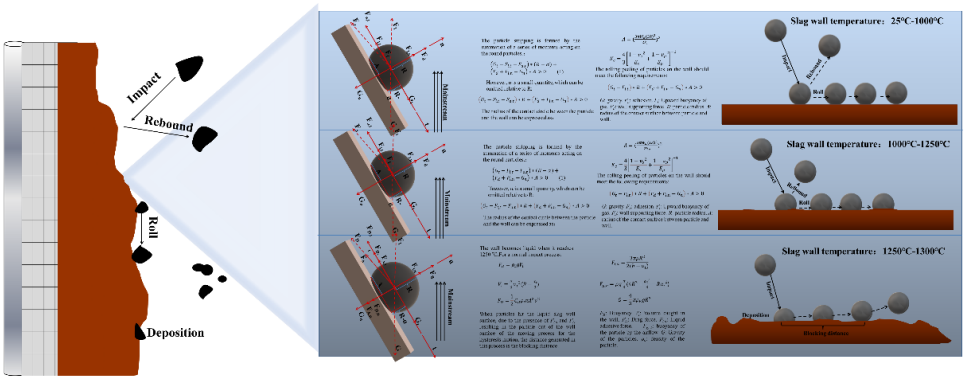

Figure 1. The particle deposition process changes with variations in the temperature of the slag wall.

Figure 1 provides a dynamic analysis of particles impacting different temperature slag wall surfaces, and in conjunction with Figure 2, explains the reasons for different deposition types occurring at different slag wall temperatures. When the slag wall temperature is from 25 ℃ to 1000 ℃, the coal particles impact the wall as an elastically deformed elastic-plastic impact. The degree of wall deformation caused by temperature changes is relatively small and does not alter the tangential force. Therefore, the rebound probability remains nearly constant. And when the slag wall flow temperature is reached, particle impacts on the wall transition to wet collisions, the blocking distance phenomenon occurs.

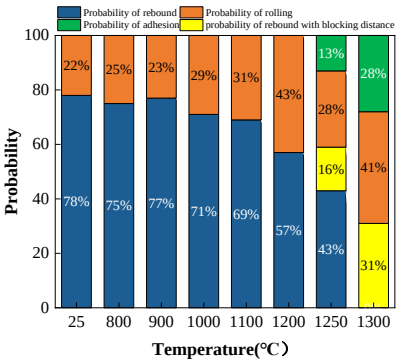

Figure 2. Variation trend of particle deposition probability with slag wall temperature.

4. Conclusions

Based on the visualization system, the effect of different slag wall temperatures on the deposition characteristics of coal particles after impacting the slag wall was investigated. Five deposition types were found in this study. The study found that when the slag wall surface temperature is below the deformation temperature, the probability of particle rebound after impacting the wall surface is highest, exceeding 70%. When the slag wall temperature is higher than the deformation temperature, the probability of rebound decreases gradually with the increase of the slag wall temperature. And when the slag wall flow temperature is reached, the blocking distance phenomenon occurs.

References

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Keywords
Coal particles; Impact; Deposition characteristics; Gasification; Slag wall