

PARTICLE DEPOSITION CHARACTERISTICS IN ENTRAINED FLOW COAL GASIFIER

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Short paper

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Cold state experiment and numerical simulation are carried out to study particle deposition process. The deposit mass can be divided into two parts, one directly collides with the wall and the other is brought by the backflow. The deposit flux increases with the increase of gas flow rate or water flow rate or both, and decreases with the increase of the central channel gas flow rate.

Key words: entrained flow coal gasifier, particle deposition, experiment

Introduction

Concern over greenhouse gas emissions and the need for greater efficiency in the utilization of coal have led to increased interest in clean coal technology. Coal gasification, as one of the most important clean coal technologies, not only can promote the coal utilization efficiency, but also can reduce the pollutant emission. The entrained flow coal gasification is the most promising gasification technology in the future. Liquid slag tapping is adopted in entrained flow coal gasifier. Molten ash slag particles collide with the wall under the effect of turbulent gas flow, form a liquid slag layer, and then leave gasifier from slag tapping hole at the bottom of gasifier. Liquid slag tapping is one of the key factors that affect the long-term continual operation of entrained flow coal gasifier. Many researches on slag layer behavior have been carried out [1-3], but there are few researches have been carried out on particle deposition process.

Research on deposition characteristics of molten particles is important for detecting the slag layer behavior, insuring the continual operation of gasifier and protecting the refractory or water wall [4-6]. For entrained flow coal gasifier operates at critical condition, it is difficult to detect the deposition process and characteristics through direct experiment. Few researches have been done on molten particle deposition. In this paper, cold state experiment and numerical simulation are carried out on particle deposition process, respectively.

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Experiment system

The coal state experiment system is shown in fig. 1. The experiment system contains liquid circle, model gasifier, computer, electronic balance, and so on. The model gasifier is designed based on a certain commercial operation entrained flow coal gasifier. Three channels nozzle is adopted in the experiment system. The nozzle is set at the top of the gasifier. The experiments are carried out under cold state. Liquid droplet is used to substitute the molten coal ash slag particle, and nitrogen is used to substitute the syngas. Liquid is atomized by nitrogen in the nozzle, then flow in the gasifier. Droplet and nitrogen form complex gas liquid flow in the gasifier. Some droplets collide with the wall, form a liquid film, and then flow out the gasifier, while others flow out the gasifier with nitrogen. Collecting vats are set on the wall of middle part of the gasifier. The mass of droplets deposit in the collecting vat is weighted to detect the deposit characteristics. The collecting vats are only distributed in the middle part of the gasifier. The mass of deposit particles in other two parts are not weighted in the experiment. There are 6 lines of collecting vats in the circle direction of gasifier, and each line has 6 collecting. So there are 36 collecting vats on the wall of gasifier. The size of collecting vat is 60×20 mm. The collecting vats are named line A, B, C, D, E and F in the circle, and row 1, 2, 3, 4, 5, and 6 along the height. It is observed that droplet collides to the wall and forms a liquid film, the droplet would not return back to hearth. The nozzle used in the experiment system is 3 channels nozzle. The effect of liquid flow rate, gas flow rate, working condition, ratio of the gas flow rate of central channel and outer channel are studied in the experiment.

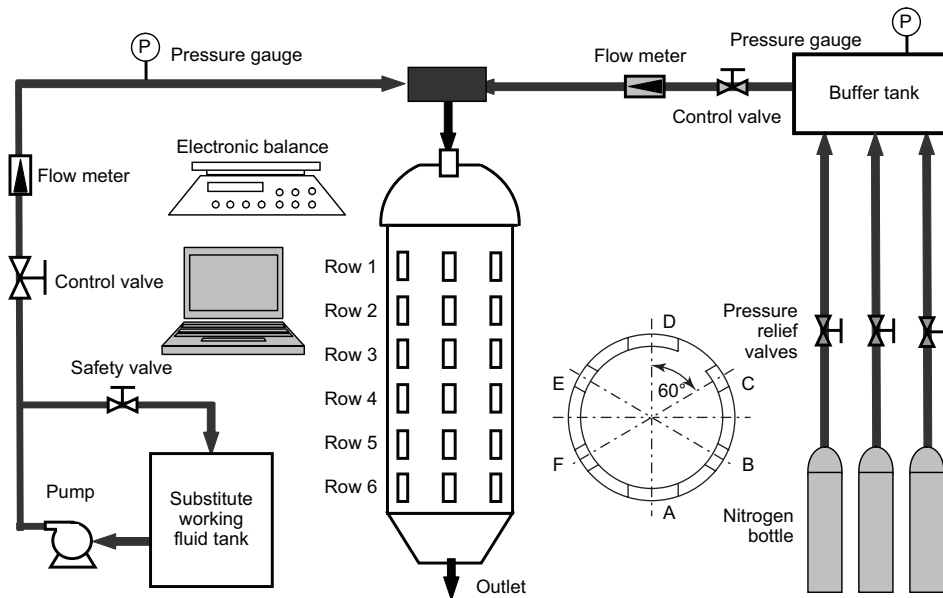


Figure 1. Schematic diagram of particle deposit system

Experiment results

In order to minimize the effect of time on the experiment results, three cases with the same working condition but different time were carried out and the results are shown in fig. 2.

The ratio of central channel gas flow rate and outer channel flow rate is 0.15:0.85. The deposit fluxes of 6 collecting vats along the circle at the same row are not uniform, the deposit flux in the following is the average value of the 6 collecting vats the same row. The deposition flux increases from row 1 to row 5, and reach its maximum value at row 5. Considering the large gas flow rate in 3 channel nozzle, 10 minute is chosen as the experiment time. As shown in fig. 3, at the first three arrows deposit fluxes of case 3 and case 4 are bigger than case 2 at the same place. But at arrow 4 to arrow 6, the deposit flux increases with the increase of gas flow rate. The deposit mass can be divided into two parts, one is directly collide with wall and the other is brought back by backflow. The droplet diameter decreases with the increase of the gas flow rate. Case 3 has the minimum gas flow rate, so it has the largest droplet diameter. The mass of droplets that directly collide with wall after they flow out nozzle is bigger than case 2 and case 4. The place that backflow take place is high, which leads to the largest deposit place is high too, at row 4. Under these two effects, the deposit flux at row 1 to row 3 is the largest in these three cases. Case 4 has the largest gas flow rate, so the atomizing efficiency is better than other two cases. Backflow is more violent than case 2 and case 3. The mass of droplets that collide with wall is larger than case 2 and case 3, but the droplet is smaller than those two cases, too. The mass flux of row 1 to row 3 is bigger than case 3 but smaller than case 2. But the mass flux of row 4 to row 6 is bigger than other two cases. The biggest deposit flux appears at row 5 and the deposit flux of row 4 is also very big. The gas flow rate of case 2 is between case 3 and case 4, the atomization efficiency is also between case 3 and case 4. The droplets that collide with wall are less than case 3, and effect of backflow on particle deposition is not as big as case 4. It has the smallest deposit flux at row 1, row 2 and row 3 in these three cases.

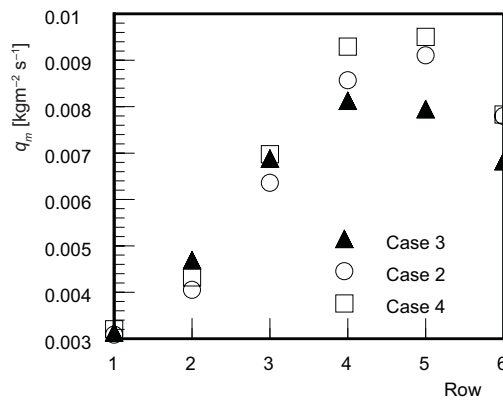
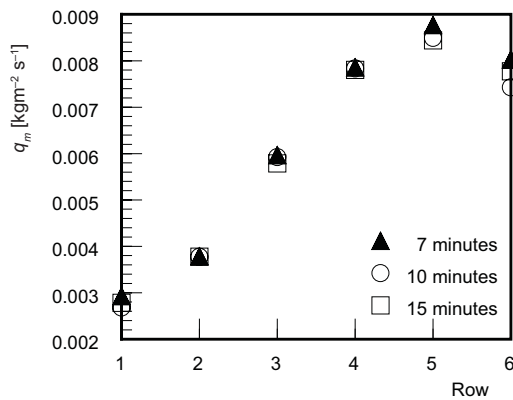


Figure 2. Effect of time on deposit flux (q_m)

Figure 3. Effect of gas flow rate on deposit flux (q_m)

The deposit flux at row 4 to row 6 is less than case 4 but more than case 3. Three cases were carried out to study the effect of water flow rate on the deposit characteristics, the result can be seen in fig. 4. These 3 cases have same deposit flux tendency. Row 5 has the biggest deposit flux in these three cases, which is different from the front cases. Comparing with the front experiments, it can be concluded that gas flow is the main factor that influences the deposit flux tendency in entrained flow coal gasifier. Droplet diameter decreases with the decrease of water flow rate, under the same gas flow rate. Case 5 has smallest water flow rate, the effect of backflow on droplet is significant. The number of droplets which are brought back by backflow increases, but the number of droplets directly colliding with wall decreases. The deposit flux of case 5 is about

12.6% less than case 2. Case 6 has the biggest water flow rate, the atomization efficiency is bad, and has the biggest droplet. The influence of gas flow on droplet is small. It is observed that the number of particles that directly collide with wall increases, and number of droplets directly collide with down part of the gasifier increases too. The deposit flux of case 6 is about 6.3% more than case 2. Gas flow rate and liquid flow rate change together with same percentage, and the results are shown in fig. 5. The main factor that affects atomization efficiency is the difference between liquid velocity and gas velocity at the out of nozzle. The bigger the flow rate is, the larger the velocity difference is, and the better the atomization efficiency is. These three cases have same deposit flux tendency. Row 5 has the biggest deposit flux. Case 7 has the worst atomization efficiency, and the biggest droplet diameter. Gas flow has the least influence on droplet behavior. The droplet brought back by backflow is less, but the droplet directly colliding with wall is more. The deposit flux is about 8.5% less than case 2. Case 8 has the best atomization efficiency, and the smallest droplet diameter. Gas flow has significant effect on droplet behavior. The droplet brought back by backflow is more. The deposit flux is about 15.9% more than case 2.

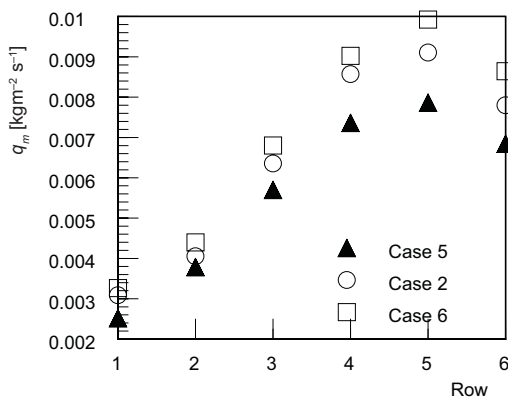


Figure 4. Effect of water flow rate on deposit flux (q_m)

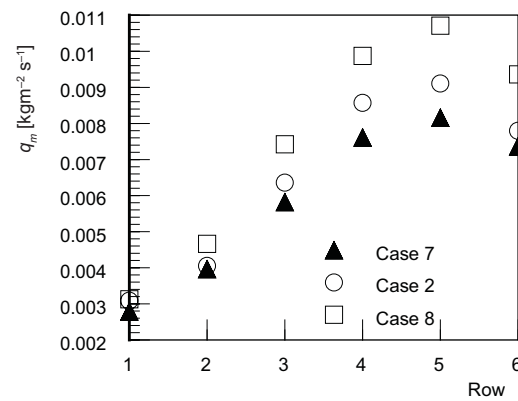


Figure 5. Effect of working condition on deposit flux (q_m)

Conclusions

The deposit mass can be divided into two parts the one directly collide with wall and the one brought by backflow. The deposit flux increases with the increase of gas flow rate or water flow rate. The deposit flux decreases when the central channel gas flow rate increases. The influence on the first 3 rows is smaller than the other 3 rows. A model is proposed to describe the particle deposition process, and simulations were carried out. The simulation result has the same tendency with the experiment result. The difference between simulation and experiment is about 15% percent.

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