AIDIC EFCE
ISCRE25 FLORENCE 2018
BRIDGING SCIENCE & TECHNOLOGY
The 25th International Symposium on Chemical Reaction Engineering
20-23 May 2018
Florence, Italy
www.aidic.it/iscre25

Gasification Characteristics of Deposited Char Particles on the Molten Slag Surface with In Situ Visual Technique Investigation

Zhongjie Shen[1,2], Qinfeng Liang[1,2], Jianliang Xu[1,2], Kuangfei Lin[3], Haifeng Liu[1,2,*]

1 Key Laboratory of Coal Gasification and Energy Chemical Engineering of Ministry of Education, East China University of Science and Technology, P. O. Box 272, Shanghai 200237, PR. China;
2 Shanghai Engineering Research Center of Coal Gasification, East China University of Science and Technology, P. O. Box 272, Shanghai 200237, PR. China;
3 State Environmental Protection Key Laboratory of Environmental Risk Assessment and Control on Chemical Process, East China University of Science and Technology, Shanghai 200237, PR. of China.
**Corresponding author: hfliu@ecust.edu.cn*

Highlights

- Gasification processes of deposited coal chars on molten slag surface were studied.
- Effects of ash content on deposited char gasification on slag surface were studied.
- Pore structure affected the gasification of char on molten slag surface obviously.
- Heat transfer analysis and reaction model were also proposed and modified.

1. Introduction

The entrained-flow coal gasification technology is widely applied for the clean and high efficient utilization of coal, both when integrated into a combined-cycle gas turbine power plant and when coupled to an synfuel chemical processing plant to produce liquid automotive fuel or hydrogen [1]. However, residual carbon was also found in the gasification slag from the industrial gasifier, which was potentially originated from partly-gasified carbons and unreacted pyrolytic carbons [2]. Montagnaro and Salatino [3,4] found that carbon particles entrapped onto the slag layer and formed a carbon coverage from a dispersed phase to a dense-dispersed phase. Li et al. [5] have found that the carbon conversion and reaction rates were more sensitive and higher than those without slag. Shen et al. [6,7] also have studied the gasification and combustion of bituminous coal char on the molten slag surface. However, coal chars with various ash content and pore structure performed different gasification characteristics, especially on the molten slag surface. The aim of this study is to investigate the gasification characteristics of coal chars (lignite coal char, bituminous coal char, anthracite coal char and petroleum coke) with CO_2 on molten slag surface using a high temperature stage microscope (HTSM). The evolution of different char particles during gasification on the molten slag were summarized with the effects of ash content, pore structure, surface tension and particle fragmentation. The heat transfer analysis and model modification, which was suitable for the gasification on the molten slag, were also proposed and verified with the comparison of experimental data.

2. Methods

Different coal char samples were prepared in the drop tube furnace under an argon atmosphere at high temperature of 1300 ℃. To study the gasification characteristics of char on the molten slag surface, the in situ experiments were carried out on the high temperature stage microscope (HTSM). The detailed introduction of the apparatus and method was given in our previous study of Shen et al. [7]. The char particles were spread on the ash layer, heated to 1300 ℃ at 100 ℃/min, and then held for 5 min to fully melt the ash into liquid slag. The gasification experiment followed and switched the gas flow from Ar to CO_2 as the gasification agent. Meanwhile the microscope camera system started and recorded the complete gasification process. The comparative experiments for the original char gasification on blank mediums were carried out the same as above.

3. Results and discussion

The gasification processes of chars on the molten slag surface are given in Fig. 1. Due to the different properties of carbon particles, the evolutions of particles performed different gasification characteristics. For lignite coal chars, particle shrank slowly at the beginning period of the gasification process while pores

occurred on the particle surface. An ash skeleton formed during the reaction and finally the ash was melted into the liquid slag. For bituminous coal, the whole gasification of char particle act as a shrinking particle and the coal ash gradually melted into the slag. The completed reaction times of lignite and bituminous coal chars was less than 1min while the time of anthracite coal char and petroleum coke needed more than 5min to complete the gasification, which mean the anthracite coal char and petroleum coke had lower reactivity. This difference of the gasification was corresponding to the reaction activity, particle fragmentation, pore structure and ash content. It was found that carbon particles on the molten slag shrank and the ash content finally was melted into the liquid slag, which was different form the original char gasification. Besides the molten slag layer was like a lava pool affording the heat to the particle gasification and this affected the gasification characteristics of different coal chars.

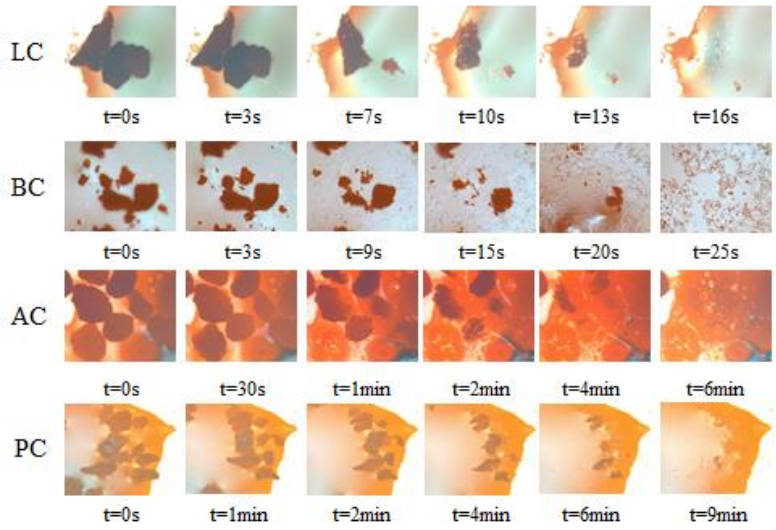

Figure 1. Photos of the gasification processes of chars on the molten slag surface in the in situ experiment. (LC: Lignite coal, BC: bituminous coal, AC: anthracite coal and PC: petroleum coke)

4. Conclusions

The gasification of carbon particle on the molten slag was studied by using the in situ visual technique. The reaction environment was different from the original gasification reaction due to the effect of molten slag. The carbon particles performed different gasification characteristics with the influences of ash content, surface tension, pore structure and particle fragmentation. The ash layer on the particle was melted into the liquid slag and part of the particle surface was covered by the slag, which might hinder the reaction, However, the high temperature of molten slag also afford heat to the particle and promoted the gasification. The gasification characteristics of deposited char particles on the molten slag surface affected the whole carbon conversion of the gasifier.

[1] F. Li, L.-S. Fan, Energ. Environ. Sci., 1 (2008) 248.
[2] S. Wu, S. Huang, L. Ji, Y. Wu, J. Gao, Fuel, 122 (2014) 67-75.
[3] F. Montagnaro, P. Salatino, Combust. Flame, 157 (2010) 874-883.
[4] F. Montagnaro, P. Brachi, P. Salatino, Energ. Fuel, 25 (2011) 3671-3677.
[5] P. Li, Q. Yu, H. Xie, Q. Qin, K. Wang, Energ. Fuel, 27 (2013) 4810-4817.
[6] Z. Shen, Q. Liang, J. Xu, B. Zhang, H. Liu, Fuel, 160 (2015) 560-567.
[7] Z. Shen, Q. Liang, J. Xu, B. Zhang, D. Han, H. Liu, Combust. Flame, 166 (2016) 333-342.

Keywords
Coal gasification; molten slag; deposited coal char; reactivity.