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Effect of mass fraction of long flame coal on swelling pressure and microstructures of cokes

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Abstract

Long flame coal are abundant and widely distributed in China, but the resource utilization is quite low, the production efficiency is not high. Stamp-charging coke making technology can bend some long flame coal, which can reduce production cost and expand the coking coal resources. The long flame coal of different mass fraction is added into prime coking coal including fat coal from Longhu, 1/3 coking coal from Xinjian and coking coal from Didao in experiment. The swelling pressure is tested on-line detection using pressure sensor in coke making process, and the pores are observed by scanning electron microscopy. The results show that, the swelling pressure first increase and then decrease with the temperature increased and the maximum swelling pressure reduces gradually with mass fraction of the Long flame coal from Shenmu increased in coke making process. The SEM images of resultant coke display that the coke get more and more loose and the amount of pores is increased with mass fraction of the long flame coal from Shenmu increased. The amount pores and the pore diameter both is minimum for coking coal from Didao as prime coking coal under the same fraction of long flame coal.

Key words: swelling pressure; coke morphology; long flame coal; stamp-coking technology

Introduction

Long flame coal is a kind of bituminous coal with lowest coal rank that is slightly higher than lignite but lower than any other coal products. It has weak baking, low caloric value, high volatile and high tar production rate. The proved reserves is over 155.1 billion tons in China (Chen et al., 2010). As non-coking coal, it is used as fuel for power generation, locomotives, gas-making and general boiler, in addition to low-temperature carbonization, residential use and to produce crude oil after being added hydrogen and liquefied (Volynkina and Strakhov, 2010).

Stamp charging has been established as a versatile technology which not only improves the coke properties that can be obtained from a given coal blend, but also broadens the coal base for coke making, permitting the use of inferior coals without impairing the coke quality (Dash et al., 2007). Over the years, the steel company has slowly and steadily gained a wealth of experience in fine tuning and optimizing this technology. One of the major learnings is the flexibility in selecting a coal blend for producing coke of acceptable quality, with minimum cost and without affecting the health of the batteries. The technology has the advantage of producing coke with higher yield compared to conventional top charging (Banerjee et al., 2006). In China non-coking coal reserve largely and distribute widely. Using the method of stamping coke, we can use more poor coking capacity coals such as medium and high volatile long-flame coal.

Some long flame coal are added to coking coal and coking with a stamping coke oven, which will certainly change the swelling pressure of the coking process. It has again raised the possibility of dangerously high coking pressures being exerted on the coke-oven walls (Barriocanal et al., 1998). Heat from the walls, roof and hearth of the oven results in a tube or envelope of plastic coal being formed and this moves towards the oven centre as carbonisation proceeds. Any wall pressures generated rises to a broad maximum quite soon after charging and then falls gradually until the plastic layers approach each other in the oven centre. Then it rises again, as the plastic layers coalesce, to a sharper maximum and finally falls as the material in the oven centre solidifies. In addition, the change of coking pressure will affect coke morphology, which has been proved by the SEM images in this study.

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The objective of the studies described in this article was seek relationships between the coking pressure generated by coals and the long flame coal of different mass fraction and microstructures of coke, the aim being to try to identify the best ratio of long flame coal and coking coal from the results of small scale laboratory tests.

1 Raw material, experimental methods and apparatus

1.1 Coal samples

Four different rank coals were used in this experiment. They were 1/3 coking coal of Xinjian, fat coal of Longhu, and coking coal of Didao are chosen as the prime coking coal, and long flame coal from Shenmu is chosen as added coal. For testing the coking pressure, the raw coal was smashed and screened through mesh size of 80. The results of proximate analysis, caking index, plastic layer indices, dilatometry audibert-arnu for the coals used in this study are shown in **Table 1**.

1.2 Apparatus

The home-made equipment is used to monitor the swelling pressure in coke making process and the schematic drawing of equipment is shown in **Fig. 1**.

1.3 Experimental details

The coal sample is dried in air for 60 min, then grind and sieve to particle size < 1.5 mm. The mixed coals with designed proportion of different coals is put into the coal cup, and then is tamped until the bulk density of 1.0 ton/m^3. And then the coal cup is put into the oven. The oven is heated to 250°C at 8°C/min, then to 730°C, at 3°C/min. The as-prepared dry coke, remove the coke head and tail, is cut into 10 mm × 10 mm, which are rinse with water to get rid of the coke powder and then are dried it in air to observe the block with a scanning electron microscope (SEM515, Royal Dutch Philips Electronics Ltd., Holland).

2 Results and discussion

2.1 Effect of mass fraction of long flame coal on swelling pressure

The influence of mass fraction of long flame coal on swelling pressure is shown in **Fig. 2**. With the mass fraction of long flame coal increased, the swelling pressure reduces gradually. The swelling pressure for three prime coking coal added different mass fraction of long flame coal first increased and then decreased with the temperature increased. The maximum swelling pressure for fat coal and 1/3 coking coal added different mass fraction of long flame coal were achieved around 610°C, while for coking coal

Table 1 Properties of the coal samples

Coal sample	Proximate analysis			G	Y (mm)	b (%)
	M_{ad} (%)	A_d (%)	V_{daf} (%)			
Shenmu long flame coal	5.66	4.54	40.89	2	7.1	-
Xinjian 1/3 coking coal	1.13	9.35	30.87	90	15.1	92.8
Longhu fat coal	1.16	9.06	28.18	97	20.6	163.75
Didao coking coal	0.83	10.39	25.68	82	16.5	45.9

M_{ad}: moisture in the analysis sample; A_d: ash in dry basis; V_{daf} : volatile matter in dry ash-free basis; G: a new classification parameter of bituminous coals; Y: max thickness of plastic layer; b: the maximum dilatation in Audibert-Arnu dilatometer test; –: no dilatability and not tested.

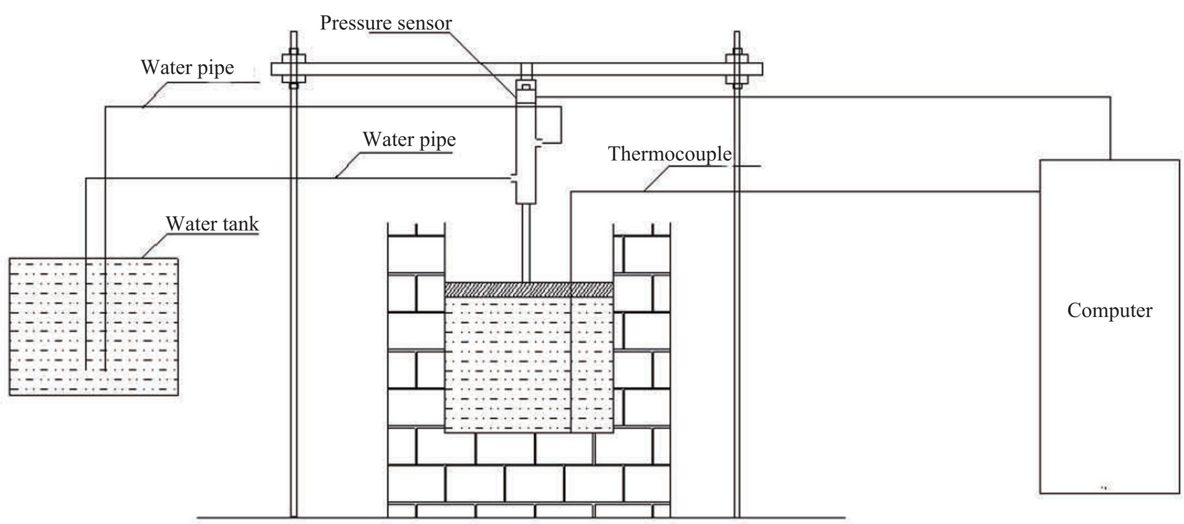

Fig. 1 Swelling pressure test apparatus.