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The effect of convection gas on coal pyrolysis characteristics

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Abstract. Nitrogen was introduced in the process of fix-bed pyrolysis reactor as convection gas, and the influence of convection gas/gas production rate ratio and material height on the heat transfer and pyrolysis products was researched. The results showed: With the increase of convection gas/gas production rate ratio, heat transfer coefficient was increased, when convection gas/gas production rate ratio was less than 1.79, volatile was brought out timely by convection gas, the secondary cracking was avoided, and tar yield was improved. With the increase of material height, tar yield was improved, pyrolysis gas yield and char yield were reduced, and heat transfer coefficient was decreased.

Introduction

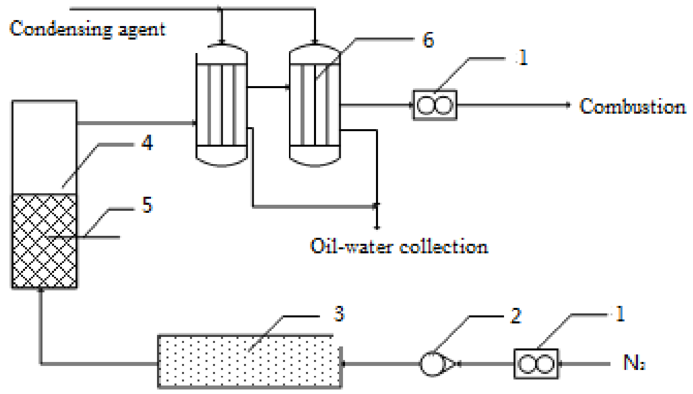
According to the international geologists predict, low rank coal will be as the main energy in the future, which was mainly distributed in the United States, Russia, Australia, China, Indonesia, Germany and Eastern European countries. In China, coal accounted for 94.3% in proven fossil energy reserves, of which low rank coal accounted for more than 50%. Low rank coal has the characteristics of high water content, high volatile, low calorific value, and so on. high calorific value of upgraded coal, tar and gas can be obtained through the low temperature pyrolysis. Therefore, it is one of the main ways for China to deal with the energy crisis by developing the coal chemical technology of low rank coal and realizing the clean and efficient utilization of low rank coal [1].

As the core technology of cascade utilization of medium and low rank coal, since twentieth Century, especially since the Second World War, coal pyrolysis technology had attracted extensive attention all over the world, developed a variety of pyrolysis technology. The typical pyrolysis processes in foreign countries mainly included: COED technology, Lurgi-Ruhrgas technology, Toscoal technology, etc.. The development and research of coal pyrolysis technology in China had been carried out since 1950s, mainly includes: LCC technology, MRF technology, SJ technology, DG technology, etc..

In order to improve the pyrolysis conversion rate, researchers had adopted various ways to optimize the pyrolysis process [2-4]. In the process of the low temperature pyrolysis of lignite in the fixed bed, the gas flow in the pyrolysis furnace was poor, the heat transfer and mass transfer resistance of the gas was large, and the efficiency of heat transfer and mass transfer was low, resulting in the low conversion efficiency of pyrolysis. In order to improve the conversion rate of lignite pyrolysis, based on the transfer theory of, this paper introduced the convection gas in the pyrolysis process, the influence of convection gas/gas production rate ratio, and material height on the heat transfer and pyrolysis products was researched.

Experimental

This low temperature pyrolysis experiment device was shown in Fig.1, and its processing capacity was 3kg per time. The device was mainly composed of preheating system, reaction system, water condensation system, pyrolysis gas measurement and instrument control system. The experimental process was as follows: firstly, the coal sample was broken, sieved and then put into the pyrolysis furnace, recorded t the material height. After the pre-heater reaching setting temperature, set convection gas/gas production rate ratio, pyrolysis temperature and residence time, recorded the data of wet type gas flowmeter, started the experiment. Volatile product was condensed by condensing system, oil/water mixture into the liquid storage tank, and pyrolysis gas discharged from the condenser into the wet-type flowmeter. After the experiment was finished, shut off the pre-heater and heating furnace, recorded wet-type flowmeter date. The oil/water mixture was separated. Weighted the char after the reactor temperature was lower than 50℃



1-wet type gas flowmeter 2-rotor flowmeter 3-preheater 4-pyrolysis reactor 5-mutipoint thermocouple

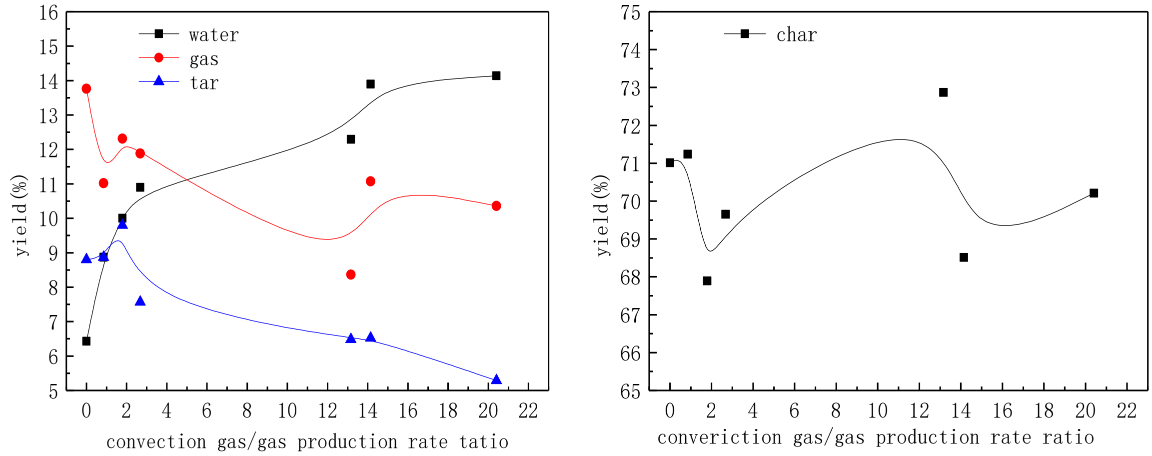
Fig.1 Schematic of the convection low temperature pyrolysis equipment

Results and discussion

The influence of convection gas/gas production rate ratio on pyrolysis

Convection gas/gas production rate ratio was one of the important parameters affecting the distribution of pyrolysis products. The lignite pyrolysis product distribution with different convection gas/gas production rate ratio was shown in Fig.2, with convection gas/gas production rate ratio increased, char and pyrolysis gas yield fluctuated larger, the tar yield increased first and then reduced. When the convection gas/gas production rate ratio was 1.79, the tar yield was the largest, and the convection gas/gas production rate ratio was 0.86 took second place. The reason that the tar yield increased first and then decreased was speculated that with the increase of convection gas/gas production rate ratio, the tar could not be completely cooled in the condenser, and some of the tar was entrained by the gas, thus reducing the tar yield.

In order to verify the speculation above, gas washing bottle was added following the oil gas condenser, the experimental results showed that with the increase of convection gas/gas production rate ratio, the tar content in the bottle increased. When the convection gas/gas production rate ratio was 0.86, there was no tar in the gas washing bottle. When convection gas/gas production rate ratio was 1.79, there were a little amount of tar in the gas washing bottle. When convection gas/gas production rate ratio was more than 2.68, there were obvious tar layer in the gas washing bottle, and increased significantly with the convection gas/gas production rate ratio. Known from the analysis of the relationship between convection gas/gas production rate ratio and tar yield, when convection gas/gas production rate ratio was small, the volatile escaped in the process of coal pyrolysis was quickly carried out, secondary pyrolysis was avoided, the tar yield improved with the increase of convection gas/gas production rate ratio. When the convection gas/gas production rate ratio exceed a certain value, the oil gas condensate system load increased, causing the tar could not be completely condensed, and tar yield decreased with the increase of convection gas/gas production rate.



a.Tar/ pyrolysis gas/ pyrolysis water yield	b.Char yield

Fig.2 The influence of convection gas/gas production rate ratio on productivity of pyrolysis product

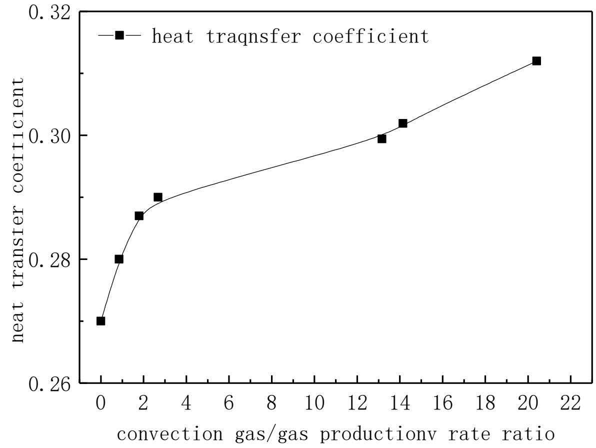


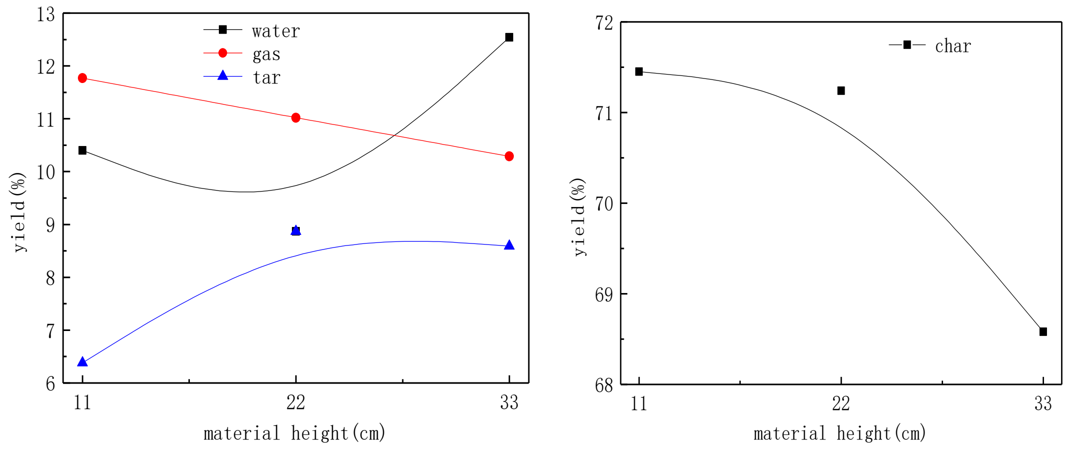
Fig.3 The influence of convection gas/gas production rate ratio on heat transfer coefficient

The heat transfer coefficient under different convection gas/gas production rate ratio in the pyrolysis process was shown in Fig.3, with convection gas/gas production rate ratio increase, the heat transfer coefficient increased. When the convection gas/gas production rate ratio was less than 1.79, with convection gas/gas production rate ratio increased, the heat transfer coefficient improved obviously. When the convection gas/gas production rate ratio was more than 1.79, with convection gas/gas production rate ratio increased, the heat transfer coefficient improved slightly.

The influence of material height on pyrolysis

In the pyrolysis process of coal, material height was one of the factors. With the same heating rate, the amount of samples were more, and the heat was more, resulted in slower temperature rise. The effect of the material height on the product was shown in Fig.4. With the increase of material height, the tar and pyrolysis water yield were increased, and the gas and char yield were decreased.

The effect of material height on the heat transfer coefficient was shown in Fig.5. The heat transfer coefficient decreased with the increase of material height, and decreased from 0.3006 W/(m*K) to 0.2605 W/(m*K). The reason for this phenomenon may be, with the material height increase, the amount of heat required for pyrolysis was more also, at the same heating rate, heating rate of coal sample would be slow, the gas generated from interior coal was difficult to escape, and the heat transfer coefficient decreased.



a.Tar/ pyrolysis gas/ pyrolysis water yield	b.Char yield

Fig. 4 The influence of material height on productivity of pyrolysis product

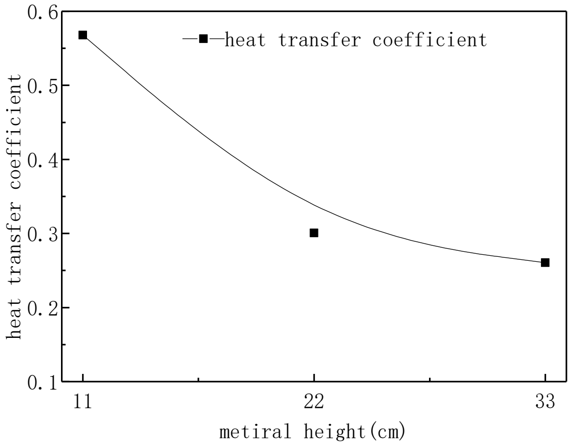


Fig.5 The influence of material height on heat transfer coefficient

Conclusions

In this paper, the influence of convection gas/gas production rate ratio and material height on the heat transfer and pyrolysis products was researched. The experimental results were as follows:

1) When convection gas/gas production rate ratio was less than 0.86, the introduced convection gas could bring out the volatiles released in the pyrolysis process in time, avoided the secondary pyrolysis of the volatiles and enhanced the tar yield. When convection gas/gas production rate ratio was more than 1.79, the load of pyrolysis device condensing system increased, the tar produced during pyrolysis could not be cooled in time, and some tar was entrained by the gas, resulted in lower tar yield.

2) With the increase of the material height, the tar yield and pyrolysis water yield increased, and the gas and char yield decreased, and the heat transfer coefficient decreased.

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