The effect of drying degree on pulverulent rate and strength of lignite

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Abstract. In order to obtain the drying characteristics of lignite, the effects of drying temperature and drying time on the pulverulent rate and strength of Tianji lignite were researched. The experimental results showed that lignite appeared obvious shrinkage, cracking and powdering in the process of drying. The fall strength and compressive strength of dry lignite decreased with the increase of dehydration rate. With the increase of drying time, the damage degree of pore structure of lignite increased, and part of the pore structure was blocked. With the increase of drying temperature, the damage degree of coal pore structure increased, and the pulverulent rate increased obviously, and fall strength and compressive strength decreased significantly. In order to improve the dehydration rate, fall strength and compressive strength, and reduce pulverulent rate, the drying time should be less than 4 hours, and drying temperature should be about 200°C.

1. Introduction

International geologists predicted that lignite would be one of the major energy in the future, accounting for about 40% of the world's total coal reserves. Lignite resources in China was also very rich, lignite reserves accounted for about 13% of the country's proven reserves of resources. In future, how to make use of lignite resources scientifically, reasonably and fully will be of great significance to the sustainable development of coal industry [1-3].

As the lowest degree of coal, lignite has characteristics of high moisture content, high ash, high volatile, rich oxygen-containing groups, strong chemical reactivity, and low calorific capacity. It is difficult to separate, reserve and for direct use. The reuse of lignite after upgrading is an effective way of reducing energy consumption and improving lignite utilization efficiency. At present, there are three kinds of lignite upgrading technology: dry separation upgrading, drying upgrading and pyrolysis upgrading. Of these three, drying upgrading is the main means of lignite quality upgrading [4-6].

High moisture is one of the most important characteristics of lignite, and it is also one of the most important parameters of its products properties. Therefore, dehydration is the key of the lignite upgrading. After dehydration treatment, most water in lignite was removed, and the calorific value increased significantly. However, due to the loose structure and the rich internal capillary of the lignite, the strength was significantly decreased in dehydration process, resulting lignite powdering, the large amount of dust in the tar, the low intensity of the semi-coke and so on in the subsequent pyrolysis. Therefore, it is of great significance to study the effect of drying degree on the pulverulent rate and strength of lignite, and to select suitable drying conditions.
2. Experimental
The independent research and development fixed bed drying device whose processing capacity was 30kg was used in the experiment. The test procedures were as follows: firstly, analyzed the moisture content, crushing strength and compressive strength of coal samples according to the national standard sampling. Then, loaded the coal sample into the drying device after being crushed, screened and weighed, measured the height of the material layer, purged with nitrogen, set the drying temperature and the drying time, turned off the power when it was reached the setting drying temperature and setting holding time. Last, When the temperature dropped to below 50℃, opened the door, removed the hopper, measured height of the material layer and weight, screened with 10mm sieve, recorded the weight of undersized compost, and analysis of dry coal moisture, crushing strength, compressive strength and pulverulent rate.

Tianji lignite was used in the experiment, after being crushed and sieved, 10-50mm grade was selected as the test coal sample. The effects of drying time and drying temperature on the characteristics of lignite were investigated. The analysis results of coal samples were shown in Table 1.

![Figure 1. Dehydration rate of coal samples under different drying time](image1)

![Figure 2. Pulverulent rate of coal samples under different drying time](image2)

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| Table 1. Analysis results of coal samples |
|------------------------------------------|
| Total moisture | Industrial analysis wt% | Elemental analysis wt% |
| M<sub>t</sub>% | M<sub>fat</sub> | A<sub>d</sub> | V<sub>daf</sub> | F<sub>daf</sub> | S<sub>t,d</sub> | C<sub>daf</sub> | H<sub>af</sub> | N<sub>af</sub> |
| 28.84 | 8.33 | 10.56 | 38.62 | 54.90 | 0.17 | 74.99 | 4.24 | 0.67 |

3. Results and discussions

3.1 The influence of drying time on properties of dry coal
Drying time is one of the most important factors which affect the drying effect, energy consumption and processing capacity. Under the condition of appropriate drying temperature, on the one hand, if the drying time is too short, it will cause low the dehydration rate of lignite and high water content in the lignite, which will reduce the oil production rate and gas production rate, on the other hand, if the drying time is too long, it will cause a lot of energy waste, reduce the amount of treatment.
The relationship between drying time and dehydration rate was shown in Figure 1. With the drying time increase, dehydration rate was increased significantly, however, the slope of the curve decreased gradually. The dehydration rate was 67.31% when the drying time was 3h, and the growth of dehydration rate began to decrease with the drying time sequentially increase. This was because when the lignite was dried a certain degree, it would enter the deceleration drying stage, and the slope of the water yield began to decrease with the increase of drying time.

The relationship between different drying time and pulverulent rate was shown in Figure 2. With the increase of drying time, pulverulent rate increased significantly, however, the slope of the curve decreased gradually. Pulverulent rate was 4.55% when the drying time was 4h, and the growth of pulverulent rate began to decrease with the drying time sequentially increase.

Effect of drying time on fall strength and compressive strength were shown in Figure 3 and Figure 4 respectively. With the increase of drying time, both fall strength and compressive strength were decreased obviously; however, descend range declined significantly after the drying time was more than 4h. In the range of 0-4h, fall strength and compressive strength decreased fast with the increase of drying time, and more than 4h, fall strength and compressive strength decreased slowly with the increase of drying time.

By investigating the effects of drying time on dehydration rate, pulverulent rate, fall strength and compressive strength, in a relatively short period of drying time, surface structure of lignite was damaged, big hole collapsed firstly, swelling and cracking phenomenon were appeared, specific surface area and porosity were increased, and broken into smaller aperture structure. With the increase of drying time, the damage degree of lignite pore structure was deepened, and the cross reaction between the hole and the hole resulted in the blockage of the pore structure. In order to improve the dehydration rate, fall strength and compressive strength, and reduce the pulverulent rate, the drying time should be less than 4h.

3.2 The influence of drying temperature on properties of dry coal

Drying temperature has a very important effect on the dehydration of lignite. Increasing the drying temperature can improve the heat transfer and mass transfer in the drying process, thus shortening the drying time and improving the drying efficiency. However, the high drying temperature will not only increase the energy consumption, reduce energy utilization, but also make coal pyrolyze, reduce the tar yield and gas yield. Therefore, it is of great significance to study the effect of drying temperature. The effect of drying temperature on the dehydration rate, pulverulent rate, fall strength and compressive strength are shown in Figure 5-8.
As shown in Figure 5, dehydration rate increased with the increase of temperature in the drying process, and the damage degree of the coal pore structure increased, which promoted the removal of water in the pores. When the drying temperature was below 200°C, the dehydration rate increased obviously with the increase of drying temperature. When the drying temperature was higher than 200°C, the dehydration rate decreased with the increase of drying temperature.

As shown in Figure 6, pulverulent rate increased with the increase of drying temperature. When the drying temperature was below 200°C, pulverulent rate increased obviously with the increase of drying temperature. When the drying temperature was higher than 200°C, pulverulent rate decreased with the increase of drying temperature.

As shown in Figure 7 and Figure 8, During the drying process, both fall strength and compressive strength of dry coal increased with the dry temperature increase. When the drying temperature was lower than 200°C, both fall strength and compressive strength decreased slowly with drying temperature increase. While when the drying temperature was higher than 200°C, both fall strength and compressive strength decreased fast with drying temperature increase.

Therefore, in the drying process of Tianji lignite, when the drying temperature was higher than 200°C, the influence of drying temperature on improving the drying effect was little, pulverulent rate increased, fall strength and compressive strength decreased significantly. Therefore, the optimum drying temperature in the process of Tianji lignite drying should be at about 200°C.
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