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BASIC STUDY FOR COAL MOISTURE CONTROL INTEGRATING PNEUMATIC CLASSIFICATION TECHNIQUE

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BASIC STUDY FOR COAL MOISTURE CONTROL INTEGRATING PNEUMATIC CLASSIFICATION TECHNIQUE

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ABSTRACT

A technique of coal moisture control integrating pneumatic classification with flue gas as heating medium was put forward. With this technique, refined coal moisture control can be realized accompanying classification in one process, and considerable high-quality energy can be saved in coking and milling procedure. In this paper, coal classification and moisture control behaviors was investigated at different conditions. Based on experimental results, the basic parameters for the technique were worked out accordingly.

INTRODUCTION

In coking process, the output and the quality of coke can be reduced if moisture of refined coal which is usually >12% after natural dewatering, isn't pre-controlled to 6-9% before loading reported by Zhu Desheng (1). And moisture evaporation in coking oven will consume much high quality energy from combustion rooms. So it is better for coal moisture to be adjusted to 6-9% in practice, it'll be significant for saving high quality energy if moisture control can be realized with waste heat of flue gas of coking plant.

On the other aspect, Zhu Desheng (1) said that for facilitating process operation and enhancing quality of coke, the fraction of coal whose particle size is <3mm is usually about 60% should be about 80% when coal is coked. Coal needs to be milled before coking. If all coal is milled, the work and the consumption of mechanical energy of milling will be too large. Moreover, dust generated in loading process because of excess milling of small particle size coal will deteriorate coking process and reduce coke quality seriously. So, it is better to classify coal before milling.

Several moisture-control technologies of coal have been developed (2): heat-transfer-oil moisture control technology (3), steam moisture control technology (3) and fluidized-bed moisture control technology (4,5) . The first two are seldom employed because of their long process, huge equipment, complicated procedure, difficult dedusting and high cost. Especially they aren't adaptable to use flue gas directly as heating medium. Compared with the first two technologies, the fluidized-bed moisture control technology has very wide application in many fields because of better heat transfer efficiency, simple process and equipment with low cost, *et al*. And the flue gas can be used directly as heating medium. Moreover, fluidized bed can be used to classify coal (6,7,8) . Therefore, based on fluidized bed moisture control technology and fluidized bed classification technology, a technique of coal moisture control integrating pneumatic classification was put forward so that they could be carried out integratively in one process.

The concept of the technique is showed as following (Fig.1). Through bottom of a dryer-classifier integrated with upside smaller-cross-section pneumatic bed and bottom larger-cross-section fluidized bed, flue gas is transported into fluidizing bed and then pneumatic bed. Gas velocity is much larger in pneumatic bed than that in fluidizing bed because of their different cross-sectional area. At same time, coal is fed into the dryer-classifier through an inlet locating junction of pneumatic bed and fluidized bed. Under the action of gas flow, small particle size coal whose entrainment velocity is smaller than gas velocity in pneumatic bed is entrained up into pneumatic bed. But large particle size coal whose entrainment velocity is larger than gas velocity in pneumatic bed drops into fluidized bed, coal classification is achieved accordingly. Accompanying the moving of small particle size coal in pneumatic bed and large particle size coal in fluidized bed, coal moisture control is realized by flue gas. After those, small particle size coal is separated with waste flue gas and recovered. Waste flue gas is vented after dedusting. Large particle size coal is milled to <3mm after overflows from fluidized bed.

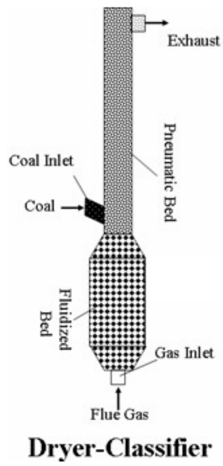


Fig.1 The schematic of coal moisture control integrating pneumatic classification

In order to provide rational guidance for pilot design of the technique, basic research including pneumatic classification and moisture control were investigated respectively in this paper.

EXPERIMENTAL

Feedstock

The characteristics of the coal (Henan Shuncheng Group, Henan Province, China) used in experiment were showed in Fig.2. From the left figure, it can seen that coal moisture measured by standard method (GB/T211-1996) declines with the increase of particle size, and is less than 10% and does hardly need to be controlled when particle size is bigger than 3mm. That is because moisture is mainly absorbed to outer surface of particle but not surface of inner micro-pores, and the outer surface area expands much more greatly than that of surface of inner micro-pores with the increase of particle size. From right figure, it can be seen that the fraction of coal whose size is less than 3mm is about 60%. According to Jin Yong, Zhu Jinzhan, Wang Zhanwen *et al*.(9), the mean diameter of <3mm of coal was 0.82mm whose entrainment velocity is about 5.5m/s, and the mean diameter of >3mm of coal was 5.84mm whose minimum fluidization velocity is about 1.37m/s.

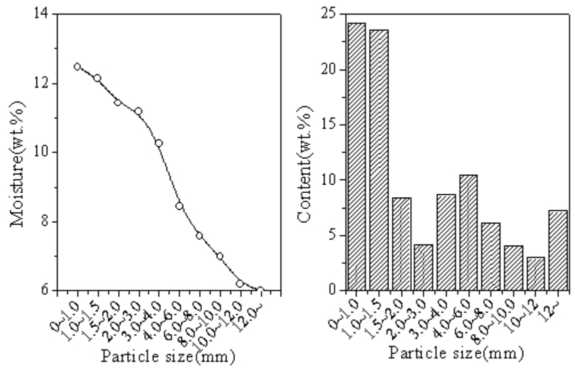


Fig.2 The characteristics of refined coal from coking plant

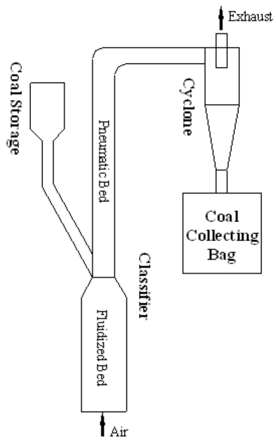


Fig.3 The schematic illustration of coal classification apparatus

Pneumatic Classification

The experimental classifier was showed in Fig. 3. The height and the diameter of pneumatic bed were 7.5m and 90mm. And the height and the diameter of fluidized bed were 5.5m and 120mm. Air was introduced at a certain velocity into fluidized bed and then pneumatic bed. The coal (it was dried before classification experiment) was fed into classifier through the inlet locating the junction of pneumatic and fluidized. Small particle size coal was entrained up to pneumatic bed, but large particle size coal dropped into fluidized bed. Coal was classified. After classification, small particle size coal was collected with a bag after gas-solid separation by cyclone. Large particle size coal was collected at the bottom of fluidized bed.

Coal Moisture Control

The apparatus for coal moisture control was showed in Fig.4. Air was sent into heater for being heated to a certain temperature and then fed into dryer that was full of fluidized quartz sand. After fluidized bed temperature was stable, a net basket filled with coal sample was dipped into the sand bath. Coal temperature was measured by a temperature sensor inserting in coal sample. After a period of drying, coal sample was taken out, and its moisture was measured by standard method.

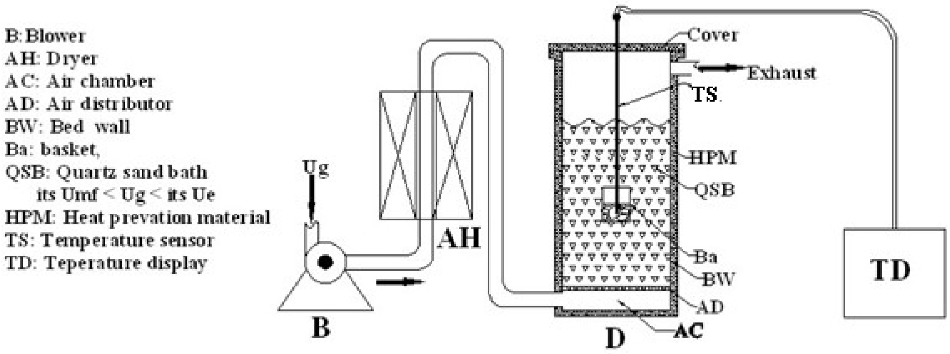


Fig.4 The apparatus for coal moisture control

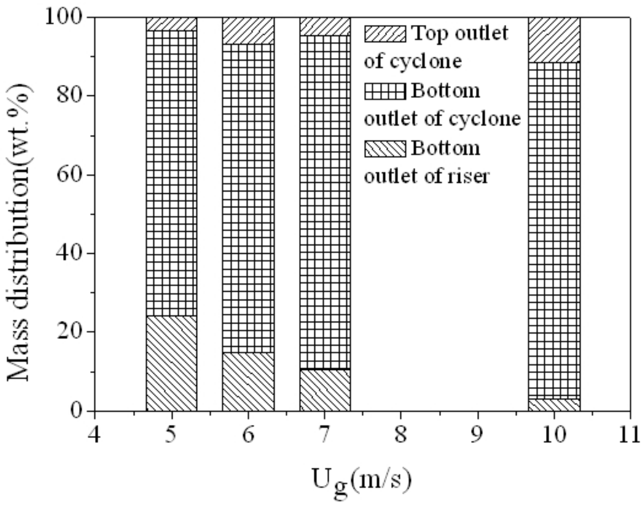


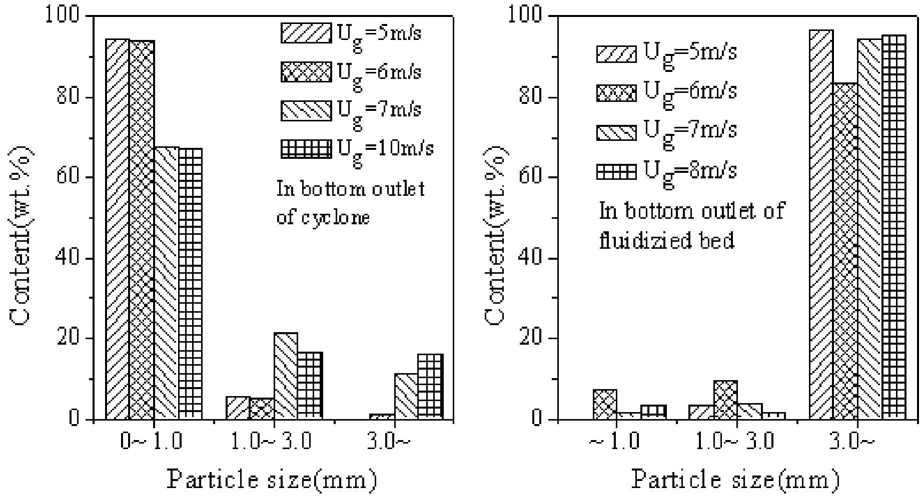
Fig.5 The mass distribution in different outlets at different air velocities

RESULTS AND DISCUSSION

The Effect of Pneumatic Classification

The classification effect was showed in Fig.5 and Fig.6. From the increasing output of coal in outlet of cyclone and the decreasing output of coal in outlet of fluidized bed, it is implied that entrained volume of coal rises with the raise of air velocity (Fig. 5). And the particle size of coal entrained was larger and larger (Fig. 6).That is because entrainment velocity of larger particle size coal is less than air velocity when air velocity increases. <3mm of coal can be entrained when air velocity is about 6m/s

(Fig.5 and Fig.6). Additionally, only about 40% of coal whose particle size is>3mm needs to be milled after classification (as showed in Fig. 2, Fig.5 and Fig.6). So, much energy can be saved, and excessive damage of small particle size can be reduced.



. Fig.6 The particle size distribution of coal in different outlets at different air velocities

The Effect of Gas Temperature on Coal Moisture Control

For investigating the effect of gas temperature on coal moisture control, basket with a certain particle size coal was dipped into sand bath and stayed for a certain period of time to dry coal under the conditions of U_g=6m/s, PS=1.0～1.5mm and a constant temperature of quartz sand bath. When coal was dried, its temperature was measured. After drying, coal moisture was measured by standard method. Coal was dried at different temperature of quartz sand bath at U_g=6m/s, PS=1.0～1.5mm. The effect of gas temperature was showed in Fig. 7.

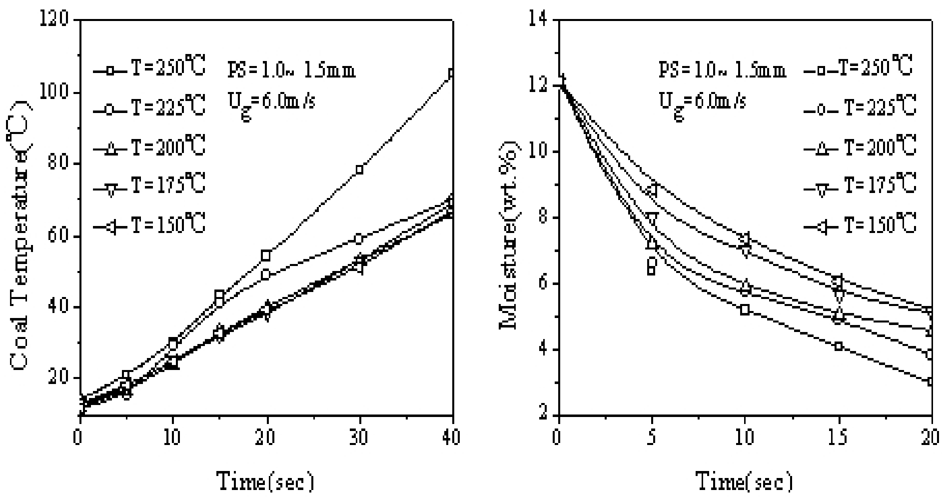


Fig.7 The effect of gas temperature on coal moisture control

The results in Fig. 7 show that the higher gas temperature is, the faster coal drying is, and the faster coal temperature increases. That is because more heat energy is transported into dryer and temperature gradient between flue gas and coal is enlarged so that heat transfer efficiency is enhanced when air temperature increases. Drying time is about 3～5s, and coal temperature can be promoted by about 10℃ when coal moisture is reduced from >12% to 6～9%.

The Effect of Gas Velocity on Coal Moisture Control

Basket with a certain particle size coal was encapsulated into sand bath and stayed for a certain period of time to dry coal under the conditions of T=250℃, PS=1.0～1.5mm and a constant gas velocity for investigating the effect of gas velocity on coal moisture control. Coal temperature was measured when it was dried. And coal moisture was measured by standard method after drying. Coal was dried at different gas velocity. The effect of gas velocity on coal moisture control was showed in Fig.8.

It can be seen from Fig. 8 that drying becomes faster and coal temperature is raised if gas velocity ascends. That is because if air velocity ascends, more heat energy is taken into dryer in unit time, and convective heat transfer which is the main heat transfer mode is strengthened so that coal can get more heat energy in unit time, in addition, the gas velocity and the vapor concentration gradient between coal and flue gas increase so that vapor carrying capacity of flue gas increases. It needs about 3～5s that coal moisture is reduced from >12% to 6～9%. At same time, coal temperature is raised by about 10℃.

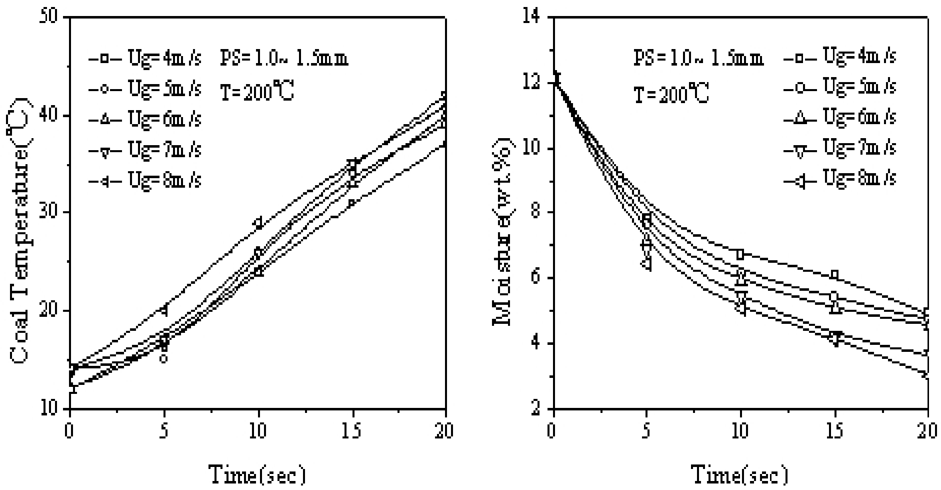


Fig.8 The effect of gas velocity on coal moisture control

The Effect of Coal Particle Size on Coal Moisture Control

To study the effect of coal particle size on coal moisture control, basket with a certain particle size coal was put into the bath and stayed for a certain period of time to dry the coal under the conditions of T=250℃, U_g=6m/s. During drying, coal temperature was measured. After drying, coal moisture was measured. Experiments were carried out with different size of coal particle. The effect of coal particle size on coal moisture control was presented in Fig. 9.

As showed in Fig. 9, with the increase of particle size, drying becomes slower and coal temperature decreases. That is because coal moisture and its evaporation energy increases rapidly with the decrease of particle size although heat transfer coefficient of small particle size coal is larger that of large particle size coal, and the effect of the former is larger significantly than that of the latter. It is enough for coal moisture is reduced from 12% to 6-9% in 3～5s. Simultaneously, coal temperature rise about 10℃.

Based on the experiment, a 2t/h of pilot equipment was designed. With the experimental results, basic parameters of the equipment were ascertained. For pneumatic bed of dryer-classifier, its height is at less 20m because of 3～5s of drying time and 6m/s of operating gas velocity. And its diameter can be gotten according to consumption volume of flue gas and operating gas velocity. For fluidized bed of dryer-classifier, it is enough for its height to ensure large particle size coal stay in fluidized bed about 3～5s because coal moisture does hardly need to be controlled when particle size is bigger than 3mm. And its diameter is about 1.4～1.5 times of that of pneumatic bed because the operating gas velocity in it which is about 2 times of minimum fluidization velocity of mean diameter 1.37m/s is about half of that of pneumatic bed.

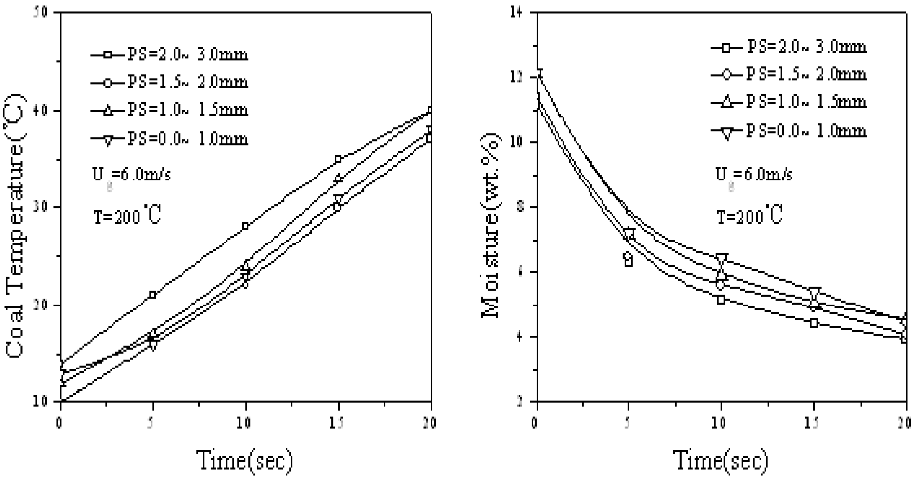


Fig.9 The effect of particle size on coal moisture control

CONCLUSIONS

A technique of coal moisture control integrating with pneumatic classification was put forward, and its basic research including pneumatic classification and moisture control were carried out. For pneumatic classification, gas velocity is key factor for classification. From experimental results, coal can be classified into >3mm and <3mm which is requested in coking processing when gas velocity is ≥ 6m/s. So after classification, excessive milling of small particle coal could be reduced, and considerable mechanical energy can be saved .For coal moisture control, three key factors including temperature and velocity of gas and coal particle size were investigated. Moisture control of all particle sizes coal from >12% to 6-9% can be realized under the conditions that gas temperature is about equal to flue gas emitted from coking industry, gas velocity is about 6m/s which is classification velocity of <3mm of coal, and coal temperature can be raised by about 10℃. And based on the experiment, a 2t/h of pilot equipment was designed. And the basic parameters of the equipment were ascertained.

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