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INVESTIGATION ON HEAT RECOVERY FROM DRY QUENCHING COKE OF LOW-RANK COAL UPGRADING

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ABSTRACT

Aiming at the problems of high moisture content of semi-coke products, high water consumption in the production process and severe environmental pollution in the production process of coal pyrolysis, the paper proposes the process of using semi-coke dry quenching coke waste heat recovery by using inert gas as quenching medium. The simulation calculation of the pyrolysis semi-coke dry quenching waste heat recovery process was carried out. The initial temperature, water vapor content, and gas flow rate of different medium circulating gases were studied. The relationship between the preheating outlet temperature and the drying temperature of the coal was analyzed, and the energy saving effect of the process was analyzed and verified by experiments. The results show that the pyrolysis semi-coke dry quenching coke waste heat recovery process is feasible; the quenching temperature and the coal drying waste heat outlet temperature have no significant relationship with the medium drying type, which is closely related to the specific heat of the gas; Compared with water-saving and energy-saving effect, it does not consume water, avoiding a series of problems caused by it. While meeting the process requirements, it can reuse 65-75% of the sensible heat of hot semi-coke. Theoretical analysis and experimental verification prove the good application prospect of this technology.

Keywords: Coal pyrolysis, dry quenching, energy balance; water saving; clean coal technology

1. INTRODUCTION

Due to its high energy efficiency, economical efficiency, and environmental friendliness, the coal pyrolysis process has attracted the attention of more and more experts in the industry[1]. At present, the industrially mature pyrolysis process mainly adopts the vertical internal heat furnace, using lump coal as raw material, and low-temperature pyrolysis. Most of its technical routes adopt natural drying of low-grade metamorphic coal first, and then lifted by bucket elevator to The top of the furnace is stored in a coal storage tank and continuously added to the dry distillation furnace[2]. The dry distillation temperature of the dry distillation section is about 750 °C. The heat used in the dry distillation is mainly mixed by the returning gas and air in the fire passage and then enters the dry distillation section through the fire mouth. The semi-coke of the lower part of the dry distillation section falls into the water sealing tank to be cooled and quenched and then discharged. The coke discharge temperature is approximately 90 °C. The waste gas rises along with the material layer in the dry distillation chamber. After the tar is collected and washed, part of the gas is headed back to the furnace under the action of the fan, and the remaining part is released. The temperature of the waste gas after treatment is about 60 °C, and the tar enters the sedimentation tank to separate.

In the actual production process, the return gas volume is about 760 m^3/t wet coal, the air volume is about 360 m^3/t wet coal, and the total circulating gas volume is 1120 m^3/t. However, due to the quenching of the water-sealed quenching method, the moisture content in the semi-coke is relatively high. The moisture content of the semi-coke is generally below 8%, and the gas consumption of repelling excess water can reach 60 m^3/t-70 m^3/t of semi-coke, the semi-coke water content after drying is still very large. The current water seal quenching process not only consumes a large amount of water, but the heat released from quenching and quenching cannot be recycled, and the high moisture and semi-coke export increases the transportation cost. Therefore, how to reduce the water consumption in the semi-coke production process and effectively recover the semi-coke sensible heat, and develop a water-saving and energy-saving environment-friendly quenching process is of great significance to the pyrolysis process.

The pyrolysis process includes coal drying, thermal decomposition, pyrolysis oil and gas dedusting, pyrolysis hot semi-coke cooling quenching, tar recovery and other processes[3]. Among them, the dry decomposition process of coal absorbs heat, and the pyrolysis hot semi-coke cooling process exotherms. From the perspective of energy optimization utilization, if the two are organically combined, it can play an energy-saving role. At the same time, the traditional wet quenching can be changed to dry quenching, which can play a role in water saving. In this study, a pyrolysis semi-coke dry quenching coke waste heat recovery technology is proposed for this problem, that is, using inert gas (such as low temperature dry distillation gas, nitrogen gas, dry flue gas, etc., the specific medium is selected according to working conditions) as a quenching quenching medium. Dry quenching, simultaneous use of semi-coke sensible heat in the process of coal preheating process, and simulation calculation of pyrolysis semi-coke dry coke quenching waste heat recovery process by Aspen Plus software, studied different inertia The relationship between the medium, the initial temperature, the gas flow rate and the pyrolysis semi-coke outlet temperature, the outlet temperature after coal drying, and the energy-saving and water-saving effect, and the test verification on the pilot test device is helpful to guide further experimental research.

2. MATERIAL AND METHODS

2.1 Material

The industrial analysis and elemental analysis of a coal type are shown in Table 1. The industrial analysis and elemental analysis of the pyrolysis semi-coke obtained after the pyrolysis reaction are shown in Table 2.

2.2 Method

The process of dry quenching waste heat recovery using inert gas as medium is shown in Figure 1. It mainly includes two units of pyrolysis semi-coke dry quenching and pulverized coal drying preheating. The process uses inert gas as the circulating medium, and the sensible heat carried by the hot semi-coke is replaced by the direct contact heat exchange into the circulating gas. The hot circulating gas is then directly in contact with the coal powder for heat exchange, and the sensible heat is used for the preheating of the coal powder to achieve waste heat recovery.

Table 1 Industrial analysis and elemental analysis of the raw material

Proximate analysis, ar				Ultimate analysis, d				
M	A	V	FC	C	H	N	S	O
10.5	7.94	29.57	51.99	74.42	4.3	0.91	0.26	8.92

Table 2 Industrial analysis and elemental analysis of pyrolysis semi-coke

Proximate analysis, ar				Ultimate analysis, d				
M	A	V	FC	C	H	N	S	O
0.72	8.02	14.86	76.57	80.26	2.94	1.17	0.19	7.42

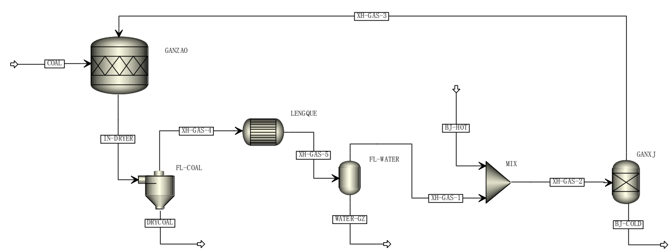


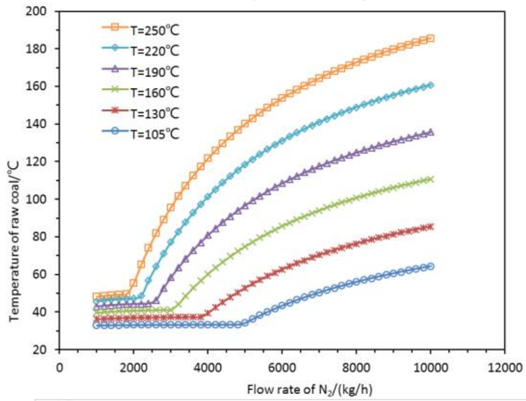
Fig 1 Dry quenching coke waste heat recovery model process

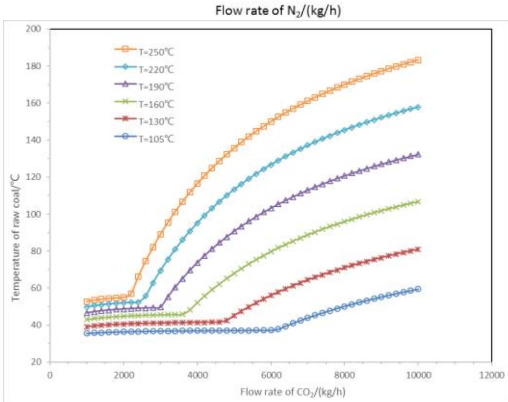
In the industry, air or flue gas is usually used as a drying or cooling medium, and some researchers use nitrogen, CO2 or cold gas as a medium for research. According to the specific process of dry quenching waste heat recovery, the calculation of the medium is nitrogen, carbon dioxide, simulated flue gas (N2, CO2, H2O volume fraction of 80.5%, 14.1%, 5.4% mixed gas) and simulation The initial temperature, water vapor content, and gas flow rate of the circulating gas when the gas (CO2, H2O, N2, H2, CO, and CH4 volume fractions are 22.5%, 5.0%, 46.9%, 6.9%, 11.4%, and 7.3%, respectively) The effect on the quenching outlet temperature and the drying outlet temperature. In actual application, which gas is used as the circulating gas is determined according to the site conditions.

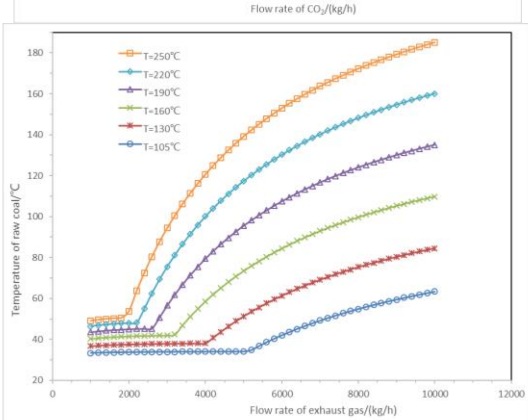
3. RESULTS AND DISCUSSION

3.1 Influence of circulating gas flow rate on coal drying outlet temperature

Coal preheating during pyrolysis generally requires that the outlet temperature not exceed 150 ° C to prevent precipitation of some of the gas components during the drying phase. The basic conditions for the simulation calculation are: atmospheric pressure, the circulating gas flow rate is between 500 and 10000 kg/h, and the initial temperature of the wet coal is 25 °C. After drying, the moisture content of the wet coal is reduced from 10.5% to less than 1%. In this paper, the effects of different temperatures (105 °C, 130 °C, 160 °C, 190 °C, 220 °C, 250 °C) and flow rate on the outlet temperature of dry coal were investigated by simulation. The experimental results are shown in Fig. 2. It can be seen from Fig. 2 that for the same temperature when the circulating gas flow rate is small, the dry coal outlet temperature is substantially unchanged.







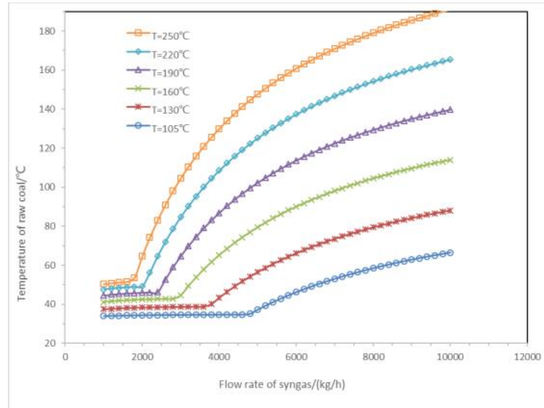


Fig 2 Effect of cycle gas temperature and flow rate on dry coal outlet temperature

When the flow reaches a certain value, the dry coal outlet temperature will increase rapidly. The reason for this phenomenon is that when the circulating gas flow rate is small, the coal does not reach the drying requirement, and some water (before the turning point in Fig. 2) exists, and the heat carried by the circulating gas is mainly used for drying the wet coal; The coal has reached the drying requirement (after the inflection point in Figure 2), and the residual heat carried by the circulating gas increases the temperature of the dry coal. At any temperature, there is an inflection point in the relationship between flow rate and outlet temperature, which is the minimum circulating gas flow rate at which the drying target can reach the target temperature. These inflection points are now listed separately, and the results are shown in Figure 3. From Fig. 3, the minimum flow rate and dry coal outlet temperature corresponding to the circulating gas at a certain temperature under the above drying conditions and requirements can be obtained. When the temperature of the drying medium is high, the flow rate of the drying medium is small, and if the temperature of the drying medium is low, the required flow rate is large.

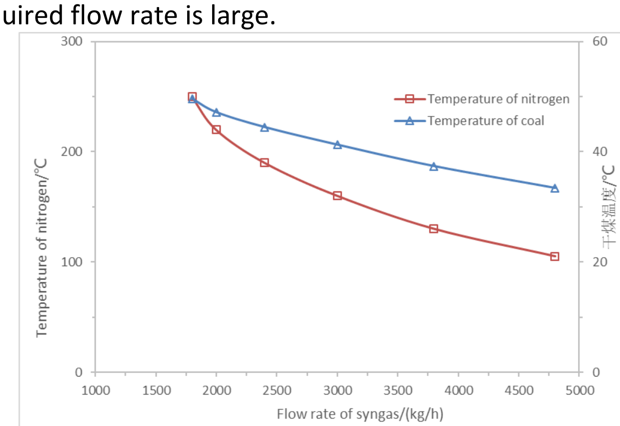
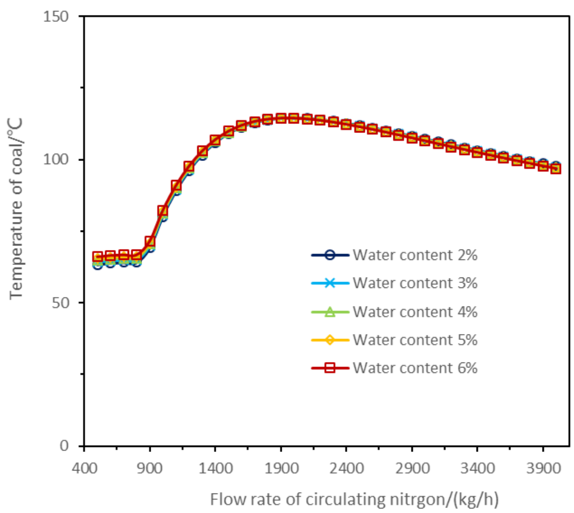


Fig 3 Relationship between circulating gas temperature and minimum flow rate and dry coal outlet temperature

3.2 Effect of Water Vapor Content in Circulating Gas on Coal Drying Exit Temperature

When an inert gas is used as the drying medium, the inert gas is both a heat carrier and a moisture carrier, so it is meaningful to study the effect of the water vapor content in the inert gas on the drying effect. The conditions for the simulation calculation are atmospheric pressure, and the inert gas flow rate is between 400 and 3900 kg/h. On this basis, the influence of different water content (2%, 3%, 4%, 5%, 6%) in the circulating gas on the coal outlet temperature was studied by Aspen plus V8.8 simulation calculation.



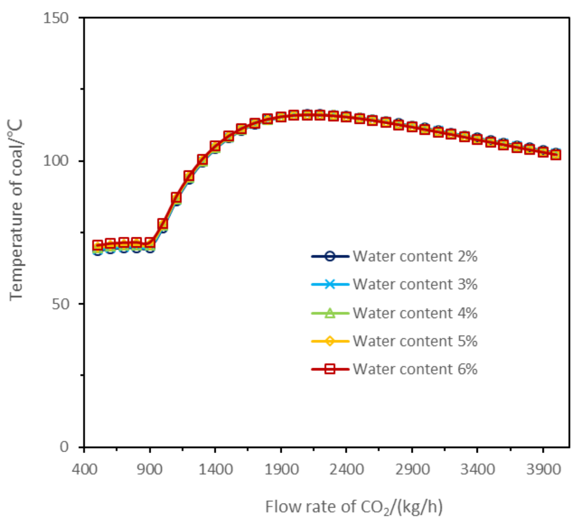


Fig 4 Effect of circulating gas water content on dry coal outlet temperature

The results are shown in Fig. 4. It can be seen from Fig. 4 that for the same relative humidity condition, the dry coal outlet temperature firstly changes with the increase of the circulating gas flow rate. After reaching a certain flow rate, the temperature begins to rise linearly because the heat is mainly used when the flow rate is small. In the removal of moisture, when the moisture is removed to a certain extent, the heat is mainly used to heat the pulverized coal. As the relative humidity increases, the water vapor in the outlet wet nitrogen is more likely to reach saturation, and more heat is used to raise the temperature of the coal powder, so the pulverized coal outlet temperature is higher.Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

4. CONCLUSION

(1) Simulation calculation and experimental verification show that the dry quenching coke waste heat recovery process is feasible, with environmental protection, energy saving and water saving effect. Through calculation, it is found that nitrogen, CO2, flue gas, cold gas, and other media are used as circulating gases respectively, and the change rules are the same for quenching cooling and drying preheating process. Which media to choose depends on the specific conditions.

(2) At any temperature, there is an inflection point in the relationship between the flow rate and the dry outlet temperature, which is the minimum circulating gas flow rate at which the drying target can reach the circulating gas temperature. When the temperature of the drying medium is high, the flow rate of the drying medium is small, and if the temperature of the drying medium is low, the required flow rate is large. The minimum flow rate of the drying medium and the dry coal outlet temperature are related to the specific heat of the drying medium. When the dry coal outlet temperature is the same, the larger the specific heat, the lower the minimum flow rate of the drying medium.

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