High Temperature Continuous Gas Purification and Graphitization System and Process for Carbon Particulate Materials

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Abstract. With the continuous development of modern science and technology, more and more new materials have been applied to production and life. As a new material, carbon granular material is made of carbon, graphite materials and other various raw materials with high carbon content through a series of processing technologies. China is one of the most widely used carbon materials in the world. The purpose of this paper is to optimize and enhance the application effect of carbon materials and promote the construction of a new economic model of energy conservation and emission reduction in China. The specific research is as follows:

Keywords: Carbon Granular Material, High Temperature Continuous Purification, Graphitization System, Process Technology.

Carbon particulate material is a new material prepared from various waste or auxiliary raw materials produced in industrial production. It can form a graphitization system through a certain preparation process, and then put into subsequent industrial production. It can be said that the preparation process of carbon particulate material is an important technical means for the sustainable development of modern industry. In the traditional preparation process of carbon particulate materials, there are some problems, such as poor purification efficiency and low purification degree, which can affect the performance of graphitization system of carbon particulate materials. Therefore, the high temperature continuous gas purification and graphitization system process proposed below aims to effectively improve the optimal performance of various carbon particle materials prepared by different raw materials.

1. Current Status of Purification and Graphitization System of Carbon Particulate Materials

1.1 Significance of Purification and Graphitization System of Carbon Particulate Materials

The purification of graphite is the basis for the preparation of all graphite materials, and is a common problem in the future development of graphite materials. Carbon particulate material is an important source of graphite material preparation in the new era. To achieve graphitization production through carbon particle material, the first thing is to manage the raw materials well. Based on the current industrial production practice, the common raw materials for the preparation of carbon materials include petroleum coke, pitch coke, metallurgical coke, anthracite, coal tar pitch and other auxiliary raw materials. Different raw materials have different sources and different graphitization conditions.
For example, petroleum coke is the main raw material for the production of various carbon materials. The ash content of this coke is relatively low, and it is easy to graphitize at high temperature. The characteristics of petroleum coke have a great impact on the performance of carbon particulate materials. Therefore, it is of great significance to develop a new technology for purification and graphitization of carbon particulate materials [1, 2].

(1) It is beneficial to continuously provide graphite materials for industrial production. In industrial production, continuous and high-efficiency graphite purification can provide continuous raw materials for industrial production and promote the transformation and upgrading of industrial production. A mature graphite material purification process can provide raw materials for the production line, get rid of the problem of raw material shortage, and realize transformation as well as upgrading for industrial production line.

(2) It helps to improve the efficiency and quality of industrial production. Graphite material is one of the main materials in many modern industrial fields. The performance of graphite material will directly affect the production efficiency and quality of the industry. The new purification process and graphitization system of carbon particulate materials can help the continuous production of graphite materials of the same quality to ensure the efficiency and quality of industrial production.

1.2 Current Status of Purification and Graphitization System of Carbon Particulate Materials
As mentioned above, graphite purification is the basis for the preparation of all graphite materials. At present, the graphite resources in the society mainly include natural graphite resources and artificial graphite resources. Carbon particle materials are the important sources of artificial graphite resources. It is urgent to complete the complex physical and chemical purification process for the further processing of carbon particulate materials into engineering graphite. Now, the common methods of graphitization and purification of carbon granular materials include flotation, alkali acid, hydrofluoric acid, chlorination roasting and high temperature. Different purification methods have different equipment requirements, carbon content and advantages and disadvantages. The details are shown in Table 1 below:

| Purification method         | Equipment requirements                | Carbon content of product | Advantage                                      | Disadvantage                                      |
|-----------------------------|--------------------------------------|---------------------------|------------------------------------------------|--------------------------------------------------|
| Flotation method            | Simple equipment                     | Generally 80% - 90%, high up to 95% | Low energy consumption and low cost           | Limited improvement of purity                      |
| Alkali acid method          | The equipment is simple and versatile | 99%-99.9%                 | Low one-time investment, high taste           | Large energy consumption, long process flow and large water consumption |
| Hydrofluoric acid method    | Simple equipment                     | 99%-99.9%                 | Simple process, low cost                     | Highly toxic, serious environmental pollution     |
| Chlorination roasting method| Complex equipment                    | About 98%                 | Low energy consumption and high efficiency    | Complex the equipment, limited purity of the product, unstable process, toxic chlorine gas, and serious environmental pollution |
| High temperature method     | The equipment needs to be specially designed and complex | Over 99.9%               | High carbon content of the product           | Large equipment investment, high energy consumption |
Through the analysis of several common purification technology of graphite, high temperature method is the most widely used and most efficient in purification technology. At present, it is shown by the application analysis of high temperature graphitization purification technology, the application of this technology needs to be equipped with a complete set of high temperature graphitization furnace equipment, including furnace body, induction heater, medium frequency power supply device, vacuum system, temperature measurement and temperature control system, water cooling system, hydraulic feeding and discharging mechanism, etc. The key technology is the design of induction heater. Both design requirements of this equipment system and the requirements for other factors are very high. For example, the impurity content of graphite raw material has the greatest influence on the purification effect of high temperature method. The impurity content of different carbon particulate materials is different. Therefore, it is very important to design a new high-temperature purification equipment and high-temperature purification process in order to use high-temperature method to continuously purify and graphitize carbon particulate materials [3].

2. High Temperature Continuous Gas of Carbon Particulate Materials and Graphitization System and Process Analysis

2.1. High Temperature Continuous Gas Purification Equipment for Carbon Particulate Materials
The basic operation principle of the new continuous high-temperature gas purification equipment is the same as that of the high-temperature purification method. The carbon particle material driven by each subsystem of the high-temperature equipment can realize the one-time purification movement, thus realizing the industrial practice and purification. In addition, the device can ensure that the reflected gas does not leak during operation, with strong sealing and low heat loss rate. The carbon content of the final purified graphite can be more than 99.9%, and the purification rate can reach 95kg/h, which meets the highest requirement of continuous mass production of high-purity graphite. In this paper, a new type of high temperature graphite purification furnace equipment is used. The equipment system can do a good job of sealing and bridging between the feeding bin and the heating zone, so as to avoid the external oxygen entering into the oxidized carbon particle material in the furnace, and also avoid the leakage of harmful gas generated by the carbon particle material in the graphite. In the traditional high temperature purification device, the automation level is low with poor equipment sealing. Therefore, a new high temperature continuous gas graphite purification furnace is designed. As shown in Figure 1. The (a) design drawing is a fully automatic feeding device drawing, which designs a special sealing screw in the feeding area to realize forced feeding. The separation design of the inlet and outlet is realized to ensure that the carbon particles can enter the high temperature heating area smoothly. In the process of feeding and discharging, the oxygen analyzer is set to monitor the oxygen content in the bin on-line. When the oxygen concentration is lower than the set value, the valve 2 will be opened automatically, so that the external oxygen can enter the furnace and complete heating. (b) The design drawing is a fully automatic discharging device drawing. In the device, automatic oxygen isolation gas replacement pipeline and discharge valve are also used, and intelligent cooling device is set to ensure that the purified graphite powder will not be oxidized in the discharge process.
2.2. High Temperature Continuous Gas Purification Technical Process of Carbon Particulate Materials

The working process of carbon particulate material high temperature continuous gas purification equipment. The working process of the equipment mainly includes four steps: automatic feeding, heating and purification, automatic discharging and tail gas treatment.① Automatic feeding: different carbon granular materials enter into the feeding bin through the feeding port of the feeding device, close the feeding valve, and pass through the gas replacement device, argon gas is introduced into the feeding bin to complete the gas replacement of carbon granular materials, so that the gas content in the feeding bin can react chemically, and the oxygen content can be reduced to a certain standard. The reaction carbon particles are fed into the heating system through the screw feeder, and the continuous feeding rate is maintained in the process, so as to ensure that the powder feeding rate in the feeding area is equivalent to the graphitization purification rate in the heating zone, for the purpose of continuous gas purification.

② Heating and purification: in this process, the carbon particulate materials which have already undergone chemical reaction will be further purified continuously. In the process of purification, the impurities in the carbon particulate materials can be volatilized as far as possible, and the carrier gas can reach the tail gas treatment system through the exhaust pipe. The purified carbon particles will leave the high temperature zone and continue to move forward, and enter the purification unit through its own gravity. In order to improve the purification rate, the frequency conversion motor is used to adjust the transfer rate and reaction time of graphite powder through the heating zone. Through the actual purification, the transfer rate can reach 6.76cm/min, the purification time is about 30min, and the final average value is 95.0kg/h.

③ Automatic discharging: carbon particles high temperature continuous gas purification and continuous discharge mainly through opening argon gas to replace the gas in the discharge bin, so that the air in the discharge bin can be discharged at the same time to complete the continuous discharge. ④ Tail gas treatment system: under the development concept of energy saving and emission reduction, the high temperature continuous gas purification process of carbon particulate materials needs to deal with toxic by-products to avoid environmental pollution. In this system, the gas is exhausted through the essence of the four level collection devices [4, 5].

Figure 1: (a) continuous feeding device: 1.charging valve, 2.gas conversion pipeline; 3. feeding bin; 4. feeding valve; 5. accumulative rotary feeder; 6. variable frequency motor  
(b) continuous discharging device: 1.cooling bin, 2.discharging valve; 3. gas conversion pipeline; 4. discharge bin; 5.discharge valve

Figure 1: High temperature graphite purification furnace
3. Matters Needing Attention to High Temperature Continuous Gas Purification and Graphitization System and Process for Carbon Particulate Materials

In a word, a kind of high temperature continuous gas purification and graphitization system and process of carbon particulate material will have a more process than the general graphite material, that is to effectively connect some raw material storage tanks and raw material transfer pumps in industrial production with high temperature graphite purification furnace. It is also required that the raw materials for the preparation of these carbon particulate materials can have stable performance characteristics. For example, the production of pitch coke is formed by the oxidation of high-temperature asphalt with hot air in an oxidation kettle. At this time, the temperature can reach 1300-1350 ℃, and it can be directly used without calcinations. The quality of petroleum coke depends on the ash, sulfur and volatile matter of petroleum coke, and its application rate and preparation process in graphitization purification are different. Therefore, attention to the production and preparation of carbon particulate materials in the high temperature continuous gas purification and graphitization system are different. In order to ensure the continuous high-speed purification of graphitization, it is required to optimize the preparation process of carbon particle materials in the future, and to optimize and upgrade the performance of high-temperature continuous gas purification equipment. For example, continuous research and development of new sealing materials for high temperature graphite purification furnace equipment, the application of PLC core controller in purification equipment, improve the automatic degree of graphite material purification. It is also required that the relevant scientific research and technology departments should pay attention to the research on the graphitization process of carbon particulate materials, so as to put forward new purification patent technology and put it into practical production and application.

4. Conclusion

To sum up, with the further development of green energy-saving concept, the construction of energy-saving ecological society has become an urgent task. As a widely used material in daily life and production, graphite has a higher and higher application rate in the future production. Therefore, it is of great practical significance to develop the next generation of industrial fossil ink purification equipment and technology. Using carbon particles as preparation materials to purify various graphite materials to meet the requirements of industrial production has become a topic of general concern in all sectors of society. At present, the high temperature continuous gas purification and graphitization system and process of carbon particulate materials has a new high temperature graphite purification device, which increases the purification rate and purification quality. However, the current high temperature continuous gas purification and graphitization system and process of carbon particulate materials are not immutable, which will be continuously optimized and improved with the development of industrial production technology. Therefore, in the future, we should be able to use the concept of innovation and optimization to do a good job in the optimization and upgrading of graphite purification technology of carbon particulate materials.

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