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Review of briquette binders and briquetting mechanism

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ABSTRACT

Briquette binder plays a key role in the process of briquette production. The quality and performance of briquette also depend on the quality of briquette binder. Different types of briquette need different briquette binder. Binder used in briquetting process can be divided into inorganic binder, organic binder and compound binder. The inorganic binders have many excellent advantages, such as abundant resource, low cost, excellent thermosability and good hydrophilicity. However, a major problem arising from the usage of inorganic binder is related to the ash increased in significant amount. The organic binders have many excellent advantages, such as good bonding, good combustion performance and low ash. But organic binder is easy to decompose and burn when it was heated, so the mechanical strength and thermal stability of organic binder briquette are poor, and its price is high. The composite binders are composed of two binders at least; the different binder plays the different role. The compound binder can make full use of the advantages of all kinds of binder, such as it can reduce the supplying amount of inorganic binder, reduce the cost of organic binder, improve the quality of briquettes, and get better performance of briquettes. This review will cover briquette binder literature. Due to many factors taking into consideration for briquettes process, up to the present, no uniform mechanism has been developed to solve briquette production. The clarification of briquetting mechanism of briquette binder is not only can provide a theoretical basis for binder development, but also can provide instructive theory for briquette industrial production. There are five main theories of non-binder briquetting mechanisms: bituminous hypothesis, humic acid hypothesis, capillary hypothesis, colloid hypothesis and adhesion molecules hypothesis respectively. But those hypotheses cannot fully explain the briquetting issues about lignite. There are three main theories binder briquetting mechanisms from the view of interaction of binders and the pulverized coal: solid bridge connecting, electrostatic attraction and liquid bridge connecting respectively. In this paper, the process of non-binder briquetting mechanism and briquetting mechanism with binder is also reviewed.

1. Introduction

China is rich in coal, while petroleum and natural gas constituting relatively small proportions. China is the biggest producer and consumer of coal in the world. More than 70% of the total energy in China is produced from coal combustion. This trend is expected to continue for the next 50 or more years [1,2]. Direct combustion of coal is not only inefficient, and will cause serious pollution (Fig. 1). Millions people die causing by lung and heart disease each year as a result of heavy emissions of pollutants (such as small particulates, sulfur dioxide, and mercury) by the transportation, storage, and combustion of coal. While the health risks are borne by local residents, the environmental impact of China's air pollution goes beyond its borders. Sulfur emissions from the combustion of coal cause acid rain, which may be carried by wind to fall in neighboring countries such as Japan and Korean, damaging crops, forests and fisheries, harming the ecosystems in the East Asian region (Fig. 1). With the enhancement of awareness of environmental protection, people have higher requirement on the environment. Therefore, clean and highly efficient utilization of coal is being an important scientific and technological issue. And clean coal technology has attracted much attention and become one of important themes of energy research. Clean coal technology represents a series of new techniques aiming to decrease the pollutant discharge and improve the energy utilization efficiency as much as possible in the processing, combustion and conversion etc. of coal. Such a series of techniques forms a system of clean and highly efficient utilization of coal [3]. Briquette is one of development direction of clean coal technology. In China, briquette is developed to adjust coal industry structure, increase coal utilization value, improve environment and realize sustainable development of coal industry [4].

Briquetting needs addition of a binding material to hold the briquette together for transportation, briquette forming and storage.

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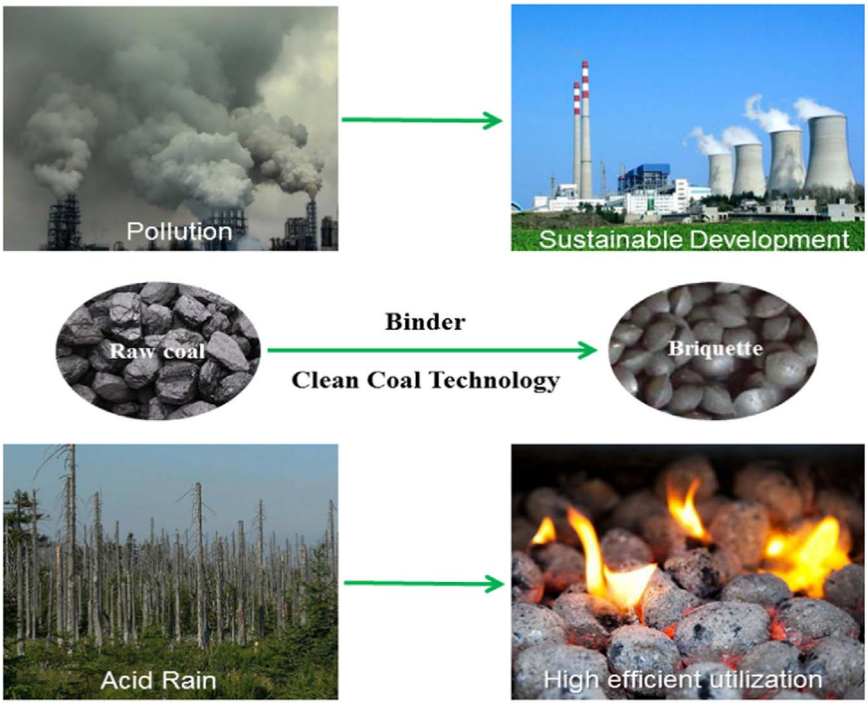

Fig. 1. Pollution and clean coal technology.

Briquette binder plays a key role in the process of briquette production. The strength, thermal stability, combustion performance and cost of briquette also depend on the quality of briquette binder [5]. Different types of briquette need different briquette binders. The experiment results showed that different binder has different bonding mechanism of the briquettes. Though some scholars have proposed several briquette hypotheses, no uniform mechanism has been developed to solve briquette production. To develop briquette technology, in this paper, briquette binder, the process of non-binder briquetting mechanism and briquetting mechanism with binder are reviewed.

2. Briquette binder

Generally, the properties required of a briquette binder can be summarized as follows [6]: a) strong bond, b) pollution-free, c) no effect on the heat release and combustibility of the coal, d) not interfere effect on the utilization of the coal, e) environmentally acceptable, f) economically available. Based on the difference of material composition, briquette binder can be divided into three types: organic binder, inorganic binder and compound binder.

2.1. Inorganic binder

The inorganic binders have many excellent advantages, such as strong adhesion, non-pollution, low-cost and good hydrophilicity. Clay, lime, plaster, cement, sodium silicate and sodium silicate are common types of inorganic briquette binders [7]. Inorganic binder can be divided into three types as industrial briquette binder, civilian briquette binder and environmental protection briquette binder. Table 1 provides an overview of the different inorganic binder types.

2.1.1. Industrial briquette inorganic binder

The properties required of industrial briquette inorganic binder are [8]: a) utilizing local resources, b) having low price and c) producing no pollution. Studies have shown that inorganic materials, bentonite clay, sodium silicate and magnesium chloride, which have good bonding ability as industrial briquette binder [9–16]. The physical and chemical properties of different industrial briquette inorganic binders are given in Table 2. The briquette that produced with this kind of binder can experience severe environment condition, it also has good waterproof. In general, the content of binder increased, adhesive effects enhanced. Dong et al. [13] studied the combustion characteristic of briquette prepared with the rate of slurry, raw coal and clay being 75:18:7, and found that the temperature of the boiler and the unit time of gas production rate are higher than that of lump coal and pulverized coal combustion, and the carbon content of slag and emissions of carbon monoxide contents were significantly lower. It indicates that briquette prepared by adding the inorganic binder did not only to reduce the harmful gas emissions, and improve the utilization of energy.

2.1.2. Civilian briquette inorganic binder

Lime and clay as the earliest binder, have been added in civilian briquette. Because the cohesive property of lime is not very strong, the addition amount of lime is large from 25% to 30% when it single is used. Bentonite clay is the best binder among all clay, the addition amount of bentonite clay is only 6–8%. Studies have shown that the burn-out ratio of briquette changes with increase of the content of inorganic binder [14]. When the content of inorganic binder is lower than 15%, the burn-out ratio of briquette has decreased slightly with increase of the content of inorganic binder. The burn-out ratio of briquette made by clay binder is a little higher than that by lime binder. When the content of the inorganic binder is more than 15%, the burn-out ratio of briquette prepared by clay binder has decreased sharply; the burn-out ratio of briquette binder by clay binder is lower than that by lime binder [14].

2.1.3. Environmental protection briquette inorganic binder

Some ingredients in inorganic binder can play a role of desulfurization, which can reduce sulfur dioxide and other pollutants generated in briquette combustion. A great deal of research has shown that some inorganic binders [16–18], such as iron oxide, magnesium oxide and calcium oxide, which can react with the sulfur in briquette to fix sulfur. The sulfur retaining performance of different materials is shown in Table 3. The most-used binder in environmental protection briquette is lime. The briquette prepared with lime binder has good performance and sulfur retention [15]. Sun et al. [19] reported a MS-type briquette binder prepared with MgO and its mixed liquid. It has been found that the adhesive composition of MgO played a very good role of sulfur