

Research on vertical crusher equipment for coal mining and processing

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Abstract

Coal plays an important role in human life, providing energy for many industries. Coal crusher is the key equipment, contributing to turning raw coal into suitable materials for different applications. These equipment are currently mainly provided by domestic and foreign companies, especially China. However, small and medium-sized coal companies currently face difficulties in the cost of importing crushing equipment and the incompatibility of actual production scale, so the investment and use of equipment are not guaranteed to be effective. Therefore, this study focuses on the design of vertical crusher equipment for small and medium-sized coal mining and processing in Thai Nguyen, Vietnam.

Keywords: Coal crusher, vertical crushing equipment, crushing technology, coal, machine manufacturing technology.

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I. Introduction

Coal crusher is a specialized equipment to crush large coal lumps into the desired size. This crushing process helps increase the contact area of coal with air, thereby improving combustion efficiency, heat exchange and maximizing the potential energy in coal.

On the market, there are many types of crushers serving coal mining and processing such as shaft crushers, jaw crushers, cone crushers, impact crushers... provided by domestic and foreign companies, especially from China. In the Northern mountainous region in general and in Thai Nguyen in particular, there are many companies and mines exploiting coal with different scales, large and small. However, many small and medium-sized coal mining and processing companies are currently facing difficulties in equipping crushing equipment due to high equipment investment costs. Therefore, these companies tend to use old Chinese equipment. In addition, because the working capacity of this equipment is not suitable for the small and medium mining needs of the company, the investment and use of the equipment is not guaranteed to be effective. Therefore, the implementation of the topic "Research on vertical crushing equipment serving the coal mining and processing process in Thai Nguyen" is a necessary and meaningful issue.

II. Content

2.1 Coal crushing

Coal crushing is the process of reducing the size of large coal pellets into smaller particles according to the needs of different industries. This process is usually done by specialized machines, using impact, cutting or pressing force to break the coal pellets. [1].

The purpose of coal grinding is to:

- Increase combustion efficiency: Finely ground coal burns more easily and efficiently than coarse coal, reducing the amount of fuel needed and increasing the operating efficiency of coal-fired equipment.
- Reduce dust emissions: Finely ground coal produces less dust than coarse coal, reducing environmental pollution.
- Ease of transportation and storage: Finely ground coal is easier to transport and store than coarse coal.
- Suitable for many applications: Finely ground coal can be used in many different applications, including power generation, cement production, steel production, and chemical production.

The coal crushing process includes the following steps:

- (1) Belt Conveyor: Coal is transported from the storage area to the crusher by belt conveyor.
 - (2) Coarse crushing: Coal is coarsely crushed into smaller pellets by jaw crusher, hammer crusher, or cone crusher.
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(3) Screening: Coal after being coarsely crushed will be screened to remove impurities and classify them according to size.

(4) Fine crushing: Coal is finely crushed to the desired size by disc crusher, hammer crusher, or cone crusher.

(5) Screening: Finely crushed coal is screened to ensure the desired size is achieved.

(6) Storage: Finely crushed coal is stored in silos or warehouses for later use.

In this process, coarse crushing and fine crushing stages play a major role.

2.2 Coal crushing equipment

A coal crusher is a type of crusher used to crush coal into the required size. There are many different types of coal crushers such as hammer crushers, cone crushers and vertical coal crushers..

The hammer crusher consists of a rotor, on which there are hammer blades for continuous impact. The hammer blades can have many different shapes depending on the grinding requirements and characteristics of each type of coal. When operating, the rotor rotates on a cast iron casing, with a mesh or a mesh around it to prevent coal from flying out. Coal will be fed into the hammer mill. The impact of the material with the rotating hammer blades and hitting the inner wall of the machine. The coal pellets will deform and break into smaller coal blocks. The operation continues until the coal is small enough to pass through the mesh and go out.

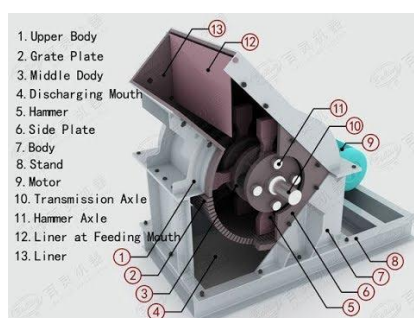


Figure 1. The hammer crusher

The cone crusher is composed of machine frame, transmission device, eccentric shaft, conical crushing chamber, spring system, hydraulic pressure station for adjusting the outlet. During operation, the eccentric shaft is rotated by the motor through the horizontal shaft and a pair of bevel gears. The structure of the crushing chamber and the eccentric shaft is to clamp the coal when the machine is working. The coal will be crushed when the eccentric shaft rotates to create a clamping gap with great pressure. The cone crusher crushes the coal pellets by using the moving working surfaces between the eccentric shaft and the fixed conical cylinder, The size of the final coal can be determined through adjusting the outlet width.



Figure 2. Cone crusher

Vertical crusher (vertical shaft crusher) can grind a variety of other materials including coal, aluminum ore, white lime, stone ore, phosphorus ore, iron ore, manganese, granite, limestone, gypsum, various oxides, carbide, emery, coke, clinker, etc. This type of machine can provide large capacity, save operating fuel, can grind large amount of coal (due to higher grinding chamber, larger crushing impact), convenient for maintenance and low cost.

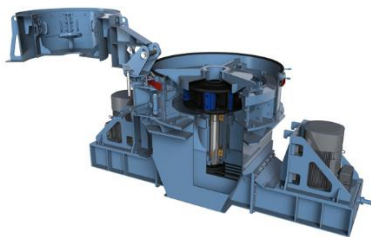


Figure 2. Vertical crusher

The vertical shaft crusher operates on the following principle: Raw coal after being quantified through the weighing conveyor of the coal feeder is transported into the crusher through the feeding pipe. Raw coal is poured directly into the center of the crushing table. The crushing table is driven by an electric motor through a gear box.

Due to the rotation of the grinding table, under the effect of centrifugal force, the raw coal is evenly distributed and enters the grinding area between the rollers. The frictional force and pressure of the rollers press on the grinding table through the coal material layer and then the coal will be crushed, crushed, and finely ground.

Although widely used in the coal crushing industry, hammer crushers are used for grinding high moisture coal or processing coal with lower hardness. Vertical crushers, on the other hand, integrate grinding, drying and separation operations in one unit and thus have significantly lower energy consumption than ball crushers. The abrasive concept has proven to be another advantage of vertical mills, as well as their flexibility in changing the properties of the feedstock fed to the crusher. Therefore, coal is now mainly ground in vertical crushers.

In general, although vertical crushers are widely used in coal crushing, the equipment is often imported and research by scientists in this field is still very limited.

In the world, vertical crusher is also considered a popular coal crushing equipment and is of interest to many scientists.

Vertical crushing technology was introduced by Loesche [7] in the mid-1990s for crushing clinker and slag. The crushing material is crushed in a Loesche roller crush between a rotating horizontal grinding path and a fixed crushing roller. The crushing process is mainly influenced by the compressive force. A certain amount of shear force will increase the number of fine particles in the crushing material. This effect is created by conical rollers, whose axes are inclined at an angle of 15° to the horizontal crushing path.

Hot air is supplied to the combined drying and grinding process to evaporate the moisture of the material. In a classifier above the grinding chamber, the finished material is separated from the grit, which can fall back to the grinding table for further grinding [8]. Vertical crushers have advantages over conventional grinding technology. In vertical crushers, crushing is more energy efficient and often produces a narrower particle size distribution [2], [4], [9]. Coal fracture occurs mainly by particle-particle contact or phase-phase contact [3]. Both fracture modes enhance the release of valuable mineral phases, which can lead to further improvements in the beneficiation process [6]. In addition, due to the dry crushing process, no process water is required, which will become more important in the coming decades. Vertical crushers are widely used today in the coal and cement industries [6]. However, the disadvantage of vertical crushers is the vibration of the rolls caused by frictional characteristics [5]. Simulation is the best way to optimize the grinding circuit to achieve economic operation. There are very few studies on vertical crush simulation.

In summary, it can be seen that, although there have been many research projects on vertical crushers, vertical shaft crushers for small and medium-scale coal crushing have not yet been widely studied and published by domestic and international scientists. Therefore, the research on crushing equipment for coal crushing is still an issue that needs to be focused on as a basis for manufacturing machines for coal crushing in practice.

2.3 The reality of using vertical crushers in coal production enterprises in Thai Nguyen, Vietnam

Coal reserves in Vietnam are very abundant, common in many provinces across the country such as Quang Ninh, Bac Kan, Thai Nguyen...

Thai Nguyen is located in the north of Vietnam and is considered the province with the second largest coal reserves in the country, including fat coal and coal concentrated in 02 districts (Dai Tu and Phu Luong). Of which, the potential for fat coal is about 15 million tons with relatively good quality, concentrated in the mines: Phan Me, Lang Cam. Coal with total reserves of about 90 million tons is concentrated in the mines: Ba Son, Khanh Hoa, Nui Hong.

Vertical crushers are widely used in coal crushing in Thai Nguyen because they have large capacity, save operating fuel, higher crushing chamber, larger crushing impact to help grind large volumes of coal. In addition, they are also convenient to maintain, have high efficiency, low failure rate and low cost. However, the current vertical crushers are mainly imported from China, which increases the investment cost, is passive in coal crushing operations and is not suitable for the small and medium crushing scale of many small and medium coal mining

and crushing facilities. Therefore, the research and manufacture of vertical crushers for coal crushing to serve provinces such as Thai Nguyen is a matter of practical significance.

2.3 The reality of training students in the field of Machine Manufacturing Technology at the Thainguayen University of Technology (TNUT)

One of the most important requirements for TNUT's Machine Manufacturing Technology students is to meet the technical skills output standard.

To meet this output standard, the students have been equipped with a relatively complete system of technical knowledge (about 51%). However, practical activities and internships (about 14%) mainly focus on training skills in processing specific details. The content of practice related to the research, design and manufacture of a detailed assembly or a whole device has not been focused. Therefore, technical skills are still relatively fragmented; Systematicity, practicality and completeness need to continue to improve.

Therefore, the research manufacturing of coal crusher will make a favorable environment for students of Machine Manufacturing Technology to improve their cognitive ability, form design thinking, linking theory with practice, linking learning and production... so this activity will contribute to improve the technical capacity of students.

2.4 Design, manufacture and testing of coal crusher equipment

a. Design and manufacture vertical crusher for coal crushing

The vertical crusher operates on the following principle: Raw coal after being quantified through the weighing conveyor of the coal feeder is transported into the crusher through the feeding pipe. Raw coal is poured directly into the center of the crushing table. The crushing table is driven by an electric motor through a gear box. Due to the rotation of the crushing table, under the effect of centrifugal force, the raw coal is evenly distributed and enters the crushing area between the rollers. The frictional force and pressure of the rollers press on the crushing table through the coal material layer, the coal will be crushed, and finely ground.

The specific vertical crusher design illustration is as follows:

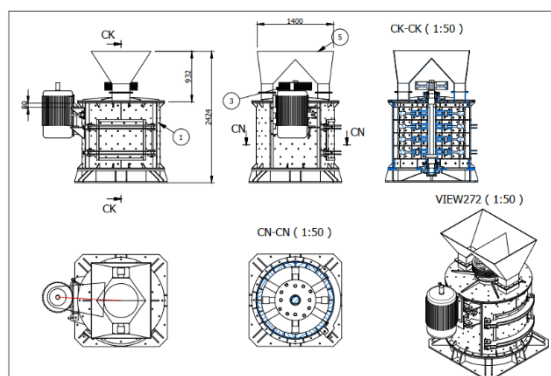


Figure 2. Design the vertical coal crusher

The designed coal crusher has been delivered to the factory. Some of the main machine details and the coal crusher manufactured and fully assembled are shown in detail as follows:

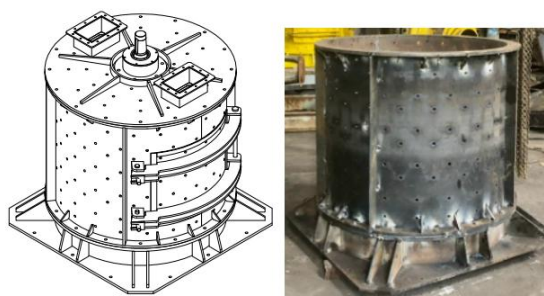




Figure 3. Some details of the crusher and the crusher product

The vertical crusher is designed with belt (109.6 kg), hopper (223,300 kg), motor base (78,367 kg), hanger (49,923 kg), motor shaft (4,303 kg), belt tensioner bolt, belt alignment pin, top cover, crushing body, crushing shaft, curved lining plate, top pillow opening cover, machine door, ball bearing, locking nut, locking pin.

b. Experimental results

The vertical crusher after being manufactured, tested and used to crush coal has ensured the necessary requirements. The coal after being crushed by the vertical crusher has ensured the size and requirements. The coal before and after crushing is shown as follows:



Figure 4. Crushed products

2.5 Conclusions

Vertical crusher is an important equipment in the coal mining and processing industry in general and in Thai Nguyen province, Vietnam in particular. The research results on the design and manufacture of vertical crusher have met the requirements of small and medium scale production, local production scale. Therefore, domestic mechanical enterprises can conveniently process and manufacture to serve the supply, operation and repair of equipment, ensuring the initiative and investment in machinery and equipment of enterprises to ensure economic efficiency.

Besides, the research results obtained from the topic are a practical basis in orienting students of Machine Manufacturing Technology to apply specialized knowledge into practice, meet the output standards of the industry and improve their ability to adapt to the profession after graduation.

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Huong Truong Thi Thu was born in 1979, was a bachelor of Mechanical Engineering Pedagogy in Thai Nguyen University of Technology in 2002, a master of Manufacturing Technology in Thai Nguyen University of Technology in 2008 and a PhD of Philosophy in Mechanical Engineering and Engineering Mechanics in Thai Nguyen University in 2015. She is working at the Faculty of Mechanical, Electrical, Electronic of Technology (MEET) in Thai Nguyen University of Technology. Her main researches are Technical Education and Mechanical Engineering Technology.