Automatic grinding particle size control technology and equipment

Zhijing Li, Yuxuan Wang, Zhongwu Jin and Yinjun Zhou
Changjiang River Scientific Research Institute, Wuhan 430010, Hubei, China

1 E-mail: wyx3335@163.com

Abstract. The article provides an automatic particle size control technology, which uses advanced particle analysis research technology and modern motor variable frequency control and computer software technology. It can quantify and control the particle size of all products within the grinding capacity of the high-pressure micro-mill. This technology can be widely applied to model sand processing in river engineering model tests, which can greatly improve the processing accuracy, work efficiency, environmental protection performance and reduce energy consumption of ordinary micro-powder mills.

1. Introduction
In the design of water conservancy project, it is necessary to carry out simulation test on the law of river and sediment. In the simulation test, there are strict requirements for the distribution and grading of sand particle size required by the model, and the particle size is generally below 0.1 mm. Therefore, the grinding particle size control technology is necessary.

In China, ball mill and roller press is widely used as pre grinding or combined grinding technology. Although the efficiency has been improved, the overall efficiency of particle size control accuracy cannot be greatly improved [1]. In addition, the processing technology of high-pressure micro powder mill [2, 3] is adopted. The mechanical control method of particle size distribution is to use manual air volume valve to adjust the air volume of air duct. However, this method of particle size control cannot accurately adjust the fineness of processed micro powder. The whole machine has low processing efficiency, large energy consumption, poor environmental protection and short service life [4]. Because the breeze control cannot be realized, the finished product with particle size less than 0.03mm cannot be controlled quantitatively. The total air volume is regulated by the air pipe bypass gate valve, which not only consumes energy, increases the dust removal amount, inconvenient operation, but also fails to realize the regulation of the breeze amount [5]. The main types of classifier are: through classifier, breaking classifier, V-type static classifier, V-type horizontal dynamic classifier, Tower Skirt classifier, high-efficiency classifier [6], whose sorting effect is affected by the process technology and equipment. In recent years, intelligent technology such as laser particle size analysis has also been developed to control the particle size of grinding, but its wide application is still limited by cost factors [7-10].

At present, foreign research on grinding technology is mainly focused on reducing the energy consumption of the grinding process, improving the grinding efficiency and reducing the power consumption of the grinding operation [11]. For example, with the support of the European Community, the French FCB company has developed a new type of grinding equipment with a compact structure of a ball mill and a new structure with low energy consumption of a roller press [12].
Its advantage is mainly that it finds a new way for the extrusion grinding process to realize the energy saving potential. It can save 20% -50% energy and increase the output more than double than the ordinary grinding system. In countries such as Germany and Japan, which are leading in grinding research technology, the main research objects are grinding technology and mechanical structure innovation [13]. For example, Professor K. Schonert of Germany proposed the new concept of bed crushing under high pressure for the first time from the energy point of crushing materials. The laboratory can grind 0.005mm material particles [14]. However, foreign countries have invested less in research on particle size control methods for industrialized processing, and have not studied much on production control methods of frequently change particle size.

The automatic particle size control technology provided in this article uses advanced particle analysis research technology and modern motor variable frequency control and computer software technology. It can quantify and control the particle size of all products within the grinding capacity of the high-pressure micro-mill. This technology can be widely applied to model sand processing in river engineering model tests.

2. Technical principle

The particle size production process of the milled product adopts the wind selection method. In addition to the critical air volume and wind speed, there are also factors affecting the particle size output, such as the specific gravity and humidity of the processed materials. The main machine of grinding equipment is a high-pressure micro powder mill improved on the basis of Raymond mill. The blower and rotary analyzer, which are the key equipment to form product particle size, are controlled by frequency control. Relying on the advanced particle technology, through a large number of sample processing experiments and analysis, to find the corresponding relationship between the product particle size distribution, output and control parameters of different processed materials under different humidity conditions, and to establish a computer mathematical analysis control model. Through the computer manual input set material varieties and processing particle size, humidity sensor online induction input working condition humidity data, computer automatic analysis and calculation, automatic output control blower and rotary analyzer speed. Finally, accurate speed control is realized to achieve the goal of product particle size control.

Figure 1. The micro-powder mill particle size precision control equipment.
3. Automatic control equipment
This section provides a micro-powder mill particle size precision control equipment, as shown in Figures 1 and 2. The control equipment mainly includes the main machine (4), blower (6), ultra-fine analyzer (8), frequency control motor (12, 13), micro particle analyzer (14), database module (15), console (17), etc. Among them, the ultra-fine analyzer can analyze and detect the particle size of the finished samples processed into micro powder, and the micro particle analyzer can obtain the sample grade distribution curve. The database module and the programming controller are set in the console, and the database module is used to accept the parameter of particle size distribution, the grading curve and its specific gravity, humidity, material. Besides, the control frequency and motor speed information of analyzer and blower are also transmitted to the database module in real time. According to the set parameters and the related data in the data module, the program controller calculates and generates the optimal control data parameters of the frequency conversion motor of the analyzer and the blower during the output processing. Sampling dishes can be placed at the detection end of the microparticle analyzer. The output end of the detection signal is connected with the database module. The output end of the programming controller is connected with the control end of the frequency conversion and speed regulation motor of the blower and the analyzer respectively.

![Figure 2. Schematic diagram of the control principle.](image)

In the pictures: 1—discharging valve, 2—powder collector, 3—feeding hopper, 4—main machine, 5—exhaust valve, 6—blower, 7—air volume valve, 8—ultra-fine analyzer, 9—duster, 10—display, 11—humidity sensor, 12—frequency converter speed control motor for blower, 13—frequency converter speed control motor for analysis machine, 14—micro particle analyzer, 15—database module, 16—programming controller, 17—console, 18—sampling dish, 19—key input panel.

4. Specific operation
The technology can be widely used in model sand processing in river model test, and also can be applied to grinding processing of various kinds of mineral products (Figure 3). The method for precisely controlling the particle size of a micro powder mill, the steps are:
Step 1: The same material is processed into fine powder samples under different humidity conditions and different operating frequencies of the analyzer and blower. The particle size and its distribution are analyzed with a microparticle analyzer, and a gradation curve is obtained.

Step 2: Enter the above-mentioned particle size distribution parameters, gradation curve and its specific gravity, humidity, material and analysis machine, blower control frequency, and motor speed information into the database module.

Step 3: After repeating the first and second steps multiple times, enter the particle size and gradation parameters through the key input panel, the programming controller calculates and generates the optimal control data parameters of the inverter motor of the analyzer and blower during processing according to the set parameters and related data in the database.

Step 4: Program the controller to display in real time, and print and record the particle size distribution data of the processed fine powder products and finished products.

Figure 3. Coal pieces are ground into coal powder, and pebbles are ground into sand.

5. Discussion
This technology can greatly improve the processing accuracy, work efficiency, environmental protection performance and reduce energy consumption of ordinary micro-powder mills. The main features include: (1) Particle size precision control, realizing accurate segmented automatic control within the range of 0.8mm-0.008mm of finished product particle size; (2) Energy saving, its energy consumption is only one third of that of ordinary grinding technology when the output and fineness are the same; (3) Small investment and high efficiency, its price is only one quarter of that of ordinary grinding technology when the output and fineness are the same; (4) High efficiency, it can adjust the speed of the blower and the frequency conversion motor of the analyzer in real time, and improve the efficiency of the mill by 30% to 50%.

In the field of river entity simulation research, the methods for the preparation and processing of model sand are relatively consistent, and still rely on manual screening and preparation in proportion. The process is complicated and the accuracy is difficult to control. At present, there are nearly 100 units engaged in river model test research in China, such as various public water conservancy research institutes, colleges and universities, etc., all lack automatic model sand processing systems, and foreign counterparts do not have similar equipment. Therefore, the grading and automatic control of the grinding and processing equipment faces obvious industry requirements, and it will greatly improve the efficiency, accuracy and degree of automation of river engineering model testing. At the
same time, this technology provides strong technical support for industries that require precise control of particle size during the grinding process of materials, especially for the development and production of small batch development products; It has opened a new road for the product research and development, expansion and product quality control of mineral materials, and provided a new technology platform.

6. Conclusions
This paper introduces an automatic particle size control technology which adopts advanced particle analysis technology, modern motor frequency conversion control and computer software technology. In this technology, the air volume, wind speed and wind direction of the main machine are precisely detected and controlled, and the numerical corresponding relationship between the speed control parameters and the product particle size is established to control the product particle size. During the grinding process of the main machine, the fine powder particles meeting the particle size standard are selected. This technology can be widely used in model sand treatment of river engineering model test, and can greatly improve the processing accuracy and working efficiency of ordinary micro grinding.

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