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Full Length Article

Effect of vibration on the separation efficiency of oil shale in a compound dry separator

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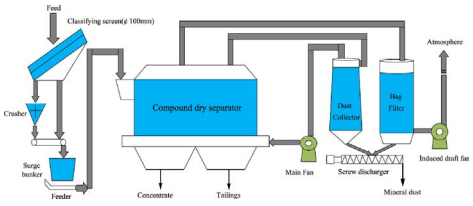
GRAPHICAL ABSTRACT



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ABSTRACT

Oil shale is a special energy source between coal and petroleum and is a potential alternative energy source. However, during oil shale mining, a large amount of Inorganic mineral impurities is produced. Thus, the grade of the oil shale is reduced, it can be effectively utilized by performing beneficiation through physical sorting to reduce impurities and upgrade the oil content. In this paper, the physical properties of oil shale were analyzed, beneficiation of 50-0 mm oil shale using a compound dry separator was proposed. The effect of vibration on the beneficiation process was emphatically investigated. The law of force between particles in different sorting areas and the effects of amplitude, frequency and angle of vibration on the energy law of different sorting area are systematically analyzed, The optimum operation parameters were obtained, and the sorting test was carried out. The results showed that when the force uniformity between the concentrate area and the tailings area is the best and the fluctuation range is minimum and the peak force of the particles corresponding to the concentrate area and the tailings area is 8.24 mN, 10.57 mN, 12.34 mN, 8.13 mN under the amplitude is 3.8–4.0 mm, frequency is 38-39hz. When frequency is 38 hz, Amplitude is 3.9 mm, the vibration acceleration of the concentrate area and tailings area are 24.78 m/s^2, 17.89 m/s^2, and the concentrate area was the main separation area, and the tailings area was mainly used to transport and discharge gangue. The separation tests were carried out under the optimum vibration parameters (A = 3.9 mm, f = 38hz, θ = 45°), The yields and oil content of the concentrate are 34.63% and 11.03%, while those of tailings are 65.37% and 1.01%, and the separating accuracy (probable error E) is 0.14 g/cm^3, the actual separation density is 2.33 g/cm^3. The vibration plays an important role in the compound dry separating oil shale efficiently.

1. Introduction

Energy is one of the most important foundation for human survival and development, The exploitation and utilization of fossil energy has promoted the development of the world economy and human society [1]. However, With scientific and economic development, the demand for energy is constantly increasing, The increase of energy consumption has become the objective necessity of today's economy and society, at

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the same time, energy security and resources shortage are also problems that human beings cannot be ignored [2]. However, coal and oil are non renewable fossil fuels that will eventually be consumed. Therefore, the search and development of alternative energy sources has become a priority [3].

Oil shale is a kind of special energy between coal and petroleum, it is a kind of special sedimentary rock containing abundant organic matter in the mineral body [4,5]. Globally, about 4.11×10^{12} t shale oil can be extracted out of this type of rock, it's reserves are up to 3 times of the global conventional oil and gas reserves which have been proved to be exploited and among fossil fuels, oil shale is second to coal in terms of calories [6–8]. Oil shale resources exploration and development potential is huge, is an important potential energy. However, during oil shale mining, a large amount of Inorganic mineral impurities is produced [9], which the grade of the oil shale is reduced and seriously affected the development and utilization value of oil shale [10]. If the oil shale ore to be sorted and purified can effectively discharge inorganic mineral impurities to improve the oil content and then improve the grade and greatly enhance the comprehensive utilization of oil shale efficiency, reduce environmental pollution [11,12].

Oil shale is a high-density material and some similarities exist in the physical properties between oil shale and coal [13]; the principle of coal beneficiation provides insights that are relevant to oil shale separation processes, while, the nature of the material determines the selection process. At present, the separation process mainly includes two kinds of wet separation and dry separation, traditional water separation processes mainly include the jigging washing process and heavy medium separation. Both these processes are barely able to provide the required oil shale separation density, and therefore ineffective with respect to the separation effects and inadequate for oil shale upgrading [14,15]. Oil shale has lower moisture content and higher density of inorganic mineral impurities, which is suitable for dry process. Oil shale can be separated effectively from inorganic mineral impurities by dry separation methods and improve the oil content. Existing researches on the dry sorting of oil shale show that the separation of > 6 mm oil shale using a compound dry separator and the separation of < 6 mm fine grain oil shale using a vibrating air-dense medium fluidized bed separator and better separation effect has been achieved [16–18]. However, studies concerning on the effect of vibration on the sorting effect are few. In this paper, we proposed the use of compound dry separation beneficiation oil shale and the effect of vibration on composite dry method separation oil shale is emphatically studied and the optimum vibration operation parameters are obtained. The paper is expected to provide technological and theoretical support for the promotion of oil shale dry beneficiation technologies in industries.

2. Experimental

2.1. Compound dry separating apparatus

Fig. 1 shows the apparatus used for the compound dry separation of oil shale in the present study. The apparatus is composed of a crude ore preparation system, a separator system, and an air supply and dust removal system. The crude ore preparation system comprises a pre-classification screen, crusher, surge bin, and other related elements. The crude ore is pre-classified and crushed before being conveyed to the surge bin and is fed to the compound dry separator, which produces concentrate and tailings. The air supply and dust removal system contains an air blower, induced draft fan, dust collector, air bag, and valve. This system is used for air supply and dust collection. The separation in the compound dry separator is carried out under the coordinative effect of airflow and vibration. Then the ores are layered by density. The low-density ores are layered on the upper layer, and high-density ores are in the bottom layer. As a result, the ores are beneficiated by density.

2.2. Vibration test system

2.2.1. Vibration acceleration test system

The separation process of the compound dry cleaning apparatus depends on density, particles obtain vibrational energy to move, due to the existence of a certain velocity difference between the particles of different density, the final separation is completed. However, the size of the speed have a certain relationship with acceleration. Therefore, it is necessary to study the effect of vibration on the sorting effect. First, we should investigate the variation law and the trajectory of vibration acceleration in different sorting areas. Vibration acceleration test system consists of an acceleration transducer, a digital vibration controller, and a computer. The system is used to test the bed acceleration of the compound dry separator. It is noted from Fig. 2 that the discharge baffle of the compound dry cleaning separator is divided into two parts from the feed end to the tailing discharge end, and were each placed at a measurement point in the two regions.

2.2.2. Particles force test system

The separation of particles by density is a dynamic process, Particles collide with each other during the sorting process, resulting in enhanced motion activity until the final sorting is completed. Based on this, it is helpful to optimize the particle movement parameters and improve the equipment sorting accuracy by studying the force characteristics of the particles on the bed. The particle force test system consists of a PCB-208C01 force transducer, data acquisition card, and computer. It is noted from Fig. 3 that the force transducer is installed at the test point in the concentrate area and tailings area and is fixed with a steel tube to test the force of the particle in the bed.

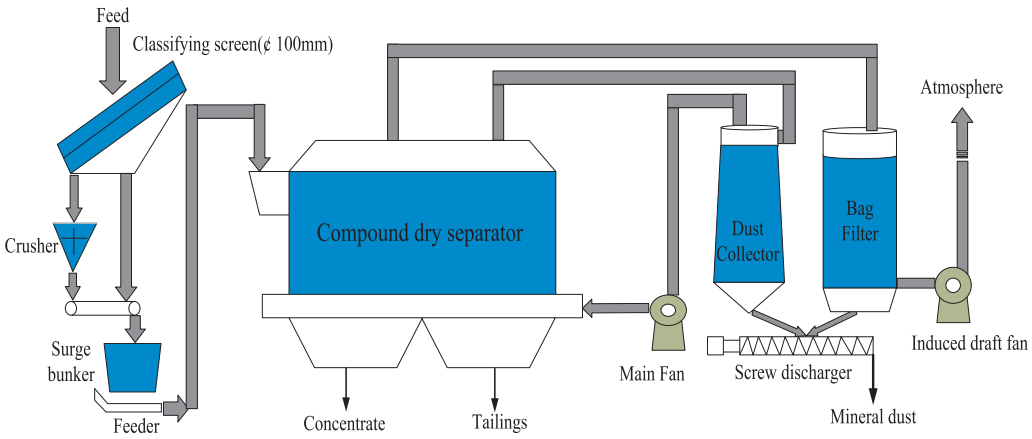

Fig. 1. Diagram of the oil shale compound dry separation system.