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Full Length Article

Properties of technological factors on screening performance of coal in an equal-thickness screen with variable amplitude

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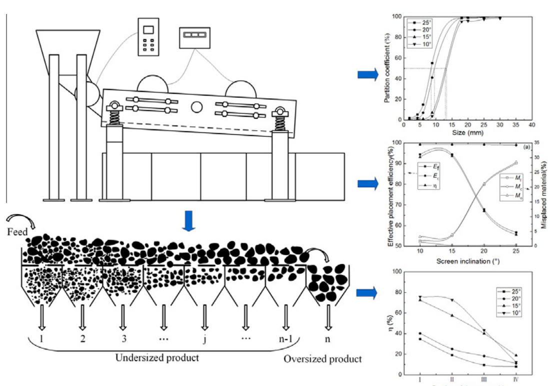
HIGHLIGHTS

- A VAETS was proposed for classification of coal.
- Effects of technological factors on screening performance of VAETS were studied.
- Method of multistage sampling was used to analyze sectional screening efficiency.
- Screening efficiency was used to evaluate the screening performance of VAETS.

GRAPHICAL ABSTRACT



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ABSTRACT

Screening has been widely used for the classification of particulate materials. Equal-thickness screen, which is characterized by large capacity and high efficiency, has been extensively applied in coal processing in recent years. In this paper, the method of multistage sampling and multilayer screening was used to analyze the particle size of screening products, the effects of screen surface inclination, unbalanced exciting force, excitation beam span and feed rate on the screening efficiency and partition size of coal in an equal-thickness screen with variable amplitude (VAETS) were investigated. The results showed that the sectional efficiency of the screen surface decreased along the material flow. With an increase in the screen surface length, partition size and screening efficiency gradually increased, and tended to attain a constant value. Screen surface inclination had a significant effect on partition size and screening efficiency, the partition size decreased, while the screening efficiency first increased and then decreased with an increase in the screen surface inclination. Unbalanced exciting force, excitation beam span and feed rate have a weaker impact on the partition size and screening efficiency of the VAETS. With an increase in the screen surface inclination, unbalanced exciting force, excitation beam span and feed rate, the screening efficiency first increases and then decreases. When screen surface inclination, unbalanced excitation coefficient, excitation beam span and feed rate have values of 15°, 1.228, 540 mm and 3.60 t/h respectively, the screening efficiency reaches its maximum value of 94.37%, while the corresponding total misplaced material is 2.92%.

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1. Introduction

Coal is one of most important fossil fuels and accounts for 30% of the world's energy resources [1–12]. In China, its total reserves were estimated at 5.9 trillion tons, while it provided 64% of the total energy consumed in 2015 [13–15]. An economical and effective clean coal technology should use coal in a sustainable way, resulting in energy savings, emission reductions and sustainable development [16–19]. Screening is one of the most basic techniques used to prepare coal, which is widely used for classification, product dehydration and medium draining [20–22]. An efficient screening technology can not only reduce the cost of coal production, but also optimize the structure of coal products, increase economic benefits, improve energy efficiency and reduce carbon dioxide emissions for the future development of coal industry [23–25]. In recent years, a number of large scale coal preparation plants have been constructed for heavy medium coal's preparation process, banana screens are used in which to increase the output, and achieve high efficiency and reliable performance [26,27].

Screening has widely been used for large-scale separation of materials in a number of processes in various industries [28]. Material characteristics (such as particle size and shape, particle-to-aperture ratio, granular moisture and density, and feed composition) and processing parameters (such as aperture of the sieve, material on the sieve surface, screen surface inclination, screen length and width, amplitude and frequency, and feed rate) have significant influence on the performance of screening operation [29–33]. For vibrating screens with equal thickness, an insight into the factors influencing the screening performance helps mineral engineers to control and optimize the screens. Cleary et al. [34,35] studied the separation of spherical and non-spherical particles using the same screen and presented a comparison of the screen's separation performances. The authors [34,35] also agreed that the flow of moist feed on the screen is determined by the particle size distribution and the feed viscosity, which is obtained from the relationship between the bed stratifying on the double-deck banana vibrating screen and the passage of particles through the screen with peak accelerations. Based upon wet screening on a double-deck banana vibrating screen, Fernandez et al. [36] have presented the effects of thickness and density of the bed on the flow behavior of particles. Dong et al. [30,33] have presented a numerical study of the flow of particles on a banana screen as a function of vibration parameters, including frequency, amplitude, and type of vibratory motion. Based upon the results, the authors determined the screening efficiency.

Although a lot of research has been done to study the effects of material properties and process parameters on the screen performances of equal thickness screens, some research gaps still exist in the study of process parameters, such as the study of effects of unbalanced forces and span of vibrating beam on the screening efficiency of the VAETS. Based upon the material sieving test to analyze the sieve surface inclination, unbalanced exciting force, excitation beam span, feed rate to synergy rule of material screening process in equal-thickness screens, partition size and screening efficiency, the current study aims at providing theoretical and technical support for the development of the VAETS.

2. Experimental

2.1. Apparatus

Fig. 1 shows the experimental setup of the VAETS system, which consists of a silo, feeder, VAETS, receiver, frequency converter and an air switch. The equal-thickness vibrating screen is constructed by exciting motors and bridges, reinforced beams, a sieve box, a screening surface, a spandrel girder, damping springs, and stents. The screening surface has an open area of 51.01% with length and width of 1.2 m and 0.6 m respectively. The sieve has a diamond array (as shown in Fig. 1) and each sieve pore is 15 mm in diameter.

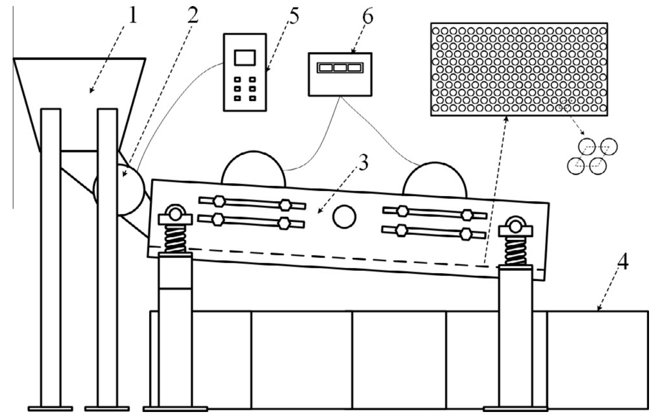

Fig. 1. Schematic of the VAETS system. 1 - Silo; 2 - Feeder; 3 - VAETS; 4 - Receiver; 5 - Frequency converter; 6 - Air switch.

During the experiments, coal was fed into the silo. The air switch was switched on and the vibrating screen was turned on. Once the vibrating screen began to run smoothly, the frequency converter was turned on and adjusted to control the feed rate and have a uniform material supply to the screen. Oversized and undersized particles were gathered in the corresponding material collectors. When there was no residual material in the silo, the frequency converter was switched off. The air switch was switched off and the screen were stopped once all the material from the end of the screen was discharged completely. Samples collected from the material collectors were then weighted and analyzed for various size fractions.

2.2. Materials

The coal samples were obtained from Zhangji mine in Xuzhou, China and the corresponding characteristics of the sample material have been presented in Fig. 2, which shows that the dominant size fraction is 13-6 mm and constitutes 50.00% of the samples. Size fractions like 50-25 mm and 3-0 mm occupy only a small portion

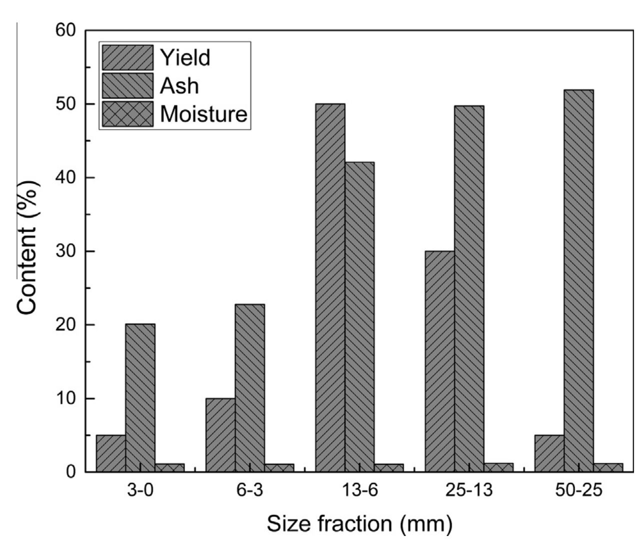

Fig. 2. Characteristics of the sample screening material.