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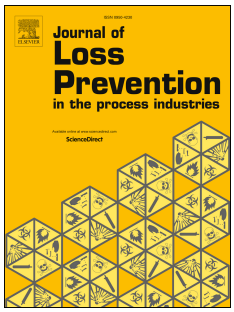

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Observations of microscopic characteristics of post-explosion coal dust samples

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Abstract: To reveal the microscopic characteristics of the post-explosion coal dust samples, coal dust explosion tests were performed in a 20 L spherical vessel. The explosion characteristic parameters, such as the maximum pressure (P_{max}), the maximum rate of pressure rise ($(dP/dt)_{max}$), ignition time (t) and the deflagration index (K_{St}) were recorded. Meanwhile, the post-explosion dust samples were collected and analyzed. The research efforts include particle size distribution analysis, SEM analysis and FTIR analysis of dust samples before and after the explosion. The particle size range of post-explosion dust samples became wider according to the mass percent analysis. The microscopic appearance of samples in same particle size range showed some similarity. The porous structure of dust samples was observed by improving the SEM magnification. The chemical structure of dust samples before and after explosion was analyzed by FTIR.

Key words: coal dust explosion; particle size distribution; microstructure; chemical structure

1. Introduction

In the process of coal mining, underground tunnels inevitably form coal dust deposits. It will cause heavy casualties and property losses once a coal dust explosion occurs. However, dust explosion is a complex phenomenon involving the simultaneous momentum, energy and mass transport reaction multiphase system (Dastidar et al., 1997). Present studies of dust explosions mainly focus on the explosion pressure, rate of pressure rise, explosion propagation characteristics and explosion suppression (Cao et al., 2014; Houim and Oran, 2014; Abbasi, 2007; Amyotte and Eckhoff, 2010; Zhang et al., 2014). Research of the characteristics of post-explosion coal dust samples can reveal the behaviors of coal dust in the explosion process. It is also able to provide evidence for the coal dust explosion accident investigation. Precise and detailed parameters of explosion residues can also provide reliable information regarding the accident inversion, thereby further improving the prevention of coal dust explosions (Amyotte et al., 2009; Goraya et al., 2004; Yuan et al; 2015). A previous study on post-explosion coal dust samples showed that incombustible contents of explosion residue are as high as or higher than raw coal (Cashdollar et al., 2007). Based on that, we can determine the dust explosion propagation distance. SEM analysis of dust samples reveals that the particle surface of post-explosion samples is smooth and exhibits molten inflation and porous structure (Medina et al., 2015; Cashdollar, 2000). For the original dust particle size of 1~1000μm samples, the particle size of post-explosion dust samples is similar to the original dust (Cashdollar, 2000; Medina et al., 2014). According to the TGA analysis and element analysis, element quality percentage of post-explosion dust samples decreases as the loss of volatile quality percentage decreases (Cashdollar, 2000).

In this study, the explosion characteristic parameters, particle size distribution, SEM images and FTIR spectrum of dust samples before and after explosion have been investigated. The porous structure of post-explosion dust samples is also observed. In this paper, we will mainly focus on the microstructure characters and the chemical structure of post-explosion dust samples by SEM and FTIR analysis. The results will be helpful to further understand behaviors of coal dust in the coal dust explosion process and provide the basis for coal dust explosion accident investigation material evidence analysis technology.

2. Experiment

2.1 Experimental material

The raw coal samples were taken from Laohutai coal mine in China. Proximate analysis result of the coal is shown in Table 1. After being crushed, the coal dust (250~425μm, 425~850μm) was made by screener with 20, 40 and 60 mesh sieve, and dried for 12 h in 50 ℃ in a constant temperature drying box. Finally, the dust sample was loaded into a clean valve bag for the explosion tests.

Table 1 Proximate analysis of coal sample

Coal type	Moisture content (wt.%)	Ash content (wt.%)	Volatile matter (wt.%)	Fixed carbon (wt.%)
Long flame coal	2.64	1.22	43.82	52.32

2.2 Experimental apparatus

The explosion test system includes three parts: the standard 20 L spherical vessel, the control system and the data