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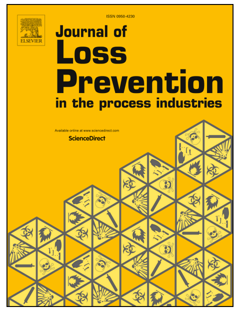

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Comparison of behavior and microscopic characteristics of first and secondary explosions of coal dust

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Abstract: Differences in behaviors of primary and secondary explosions of a bituminous coal dust were investigated using a standard 20 L spherical test vessel. The aim was to compare the explosibility and microstructures of residues of first and secondary explosions to obtain reference data for investigation of accidental explosions. The residues were analyzed by energy-dispersive spectrometry, scanning electron microscopy, and automatic surface area and pore analyzer. The first explosion showed a higher rate of heat release and higher total heat release, which indicated greater severity of explosion. The spatial distributions of C, Cl, and Si in the residues were uniform, whereas those of Ca, O, and Al occurred as discrete points. The carbon content decreased and Ca, Al, Si, Cl, and Fe contents increased as the reaction proceeded. Unexpectedly, the oxygen content was reduced by 4.41% during the primary explosion, but increased by 9.69% during the secondary explosion. The scanning electron microscopy picture of the secondary explosion residue exhibited a higher degree of fragmentation and a more developed pore structure. All isotherms of dust samples were of Type II and the shapes of the hysteresis loops were of Type H3 or Mixed Type H3–H4. Change of fractal dimension D2 illustrated increasingly complicated pore structures with advance of the explosion process.

Key words: secondary explosions; explosive residue; SEM and EDS analysis; pore structures

1. Introduction

In China, the annual yield of combustible dust products and related products has reached tens of thousands of tons. Coal dust ranks first in volume, followed by food and metal dusts. When combustible dust suspended in air reaches a certain concentration, the presence of an ignition source or high temperature can lead to an explosion. Based on an incomplete survey, 46 dust explosion incidents occurred in China between 2010 and 2016, in which 210 people were killed and 327 injured (SAWS, 2006). Two of the most serious explosions took place in Jiangsu Province (146 fatalities, 114 injuries) and Taiwan (12 fatalities, 500 injuries), which attracted the attention of the State Administration of Work Safety (SAWS). To prevent and mitigate dust explosions, SAWS drafted China's first guidelines for the prevention of flammable dust explosions in the workplace (SAWS, 2015). Surveys of these accidents showed that their extent often comprised the entire workshop, roadway, and even the whole facility. This can cause huge casualties, economic losses, and even endanger the safety of rescue workers. Therefore, further studies and new technology of dust control are still needed as strategies for explosion prevention (Han et al, 2016; Ji et al, 2016)

The shock wave produced by local suspended dust or other explosive material raises