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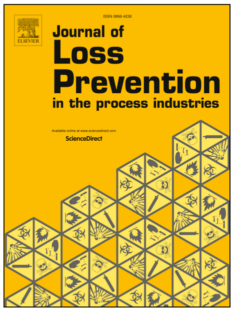

Factors influencing and a statistical method for describing dust explosion parameters: A review

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Factors influencing and a statistical method for describing dust explosion parameters: A review

Jiangshi Zhang[a], Peihui Xu[a,*], Longhao Sun[a], Wenyue Zhang[a], Jianghong Jin[b]

[a]*State Key Lab of Coal Resources and Safe Mining, College of Resources and Safety Engineering, China University of Mining & Technology (Beijing), Beijing, PR China*
[b]*Beijing Municipal Institute of Labour Protection, Beijing 100054, PR China*
*Corresponding author. E-mail addresses: xpeihui@163.com (P. Xu)

Abstract: The maximum and minimum values of dust explosion parameters are indeterminate because the possibility of explosion has not been quantified under conditions that approach the explosion limit. In this review, the influencing factors, laws, and mechanisms of dust explosion characteristics are described by comparing the differences in the methods for measuring the parameters in the ASTM, EN, GB, and ISO standards. The variation law of explosion parameters changes when crossing the limit values of the characteristic diameters and dust concentration. The similarities of certain influence mechanisms are also introduced. In addition, a new method is introduced to quantify explosion probability. The statistical nature of ignition is revealed by discussing the variability of the data overlap region of the "explosion" and the "no explosion" near the MEC and MIE measurements. The influence of sample size and positive factors on the statistical phenomena of ignitions were analyzed. The variability of the results increases when the conditions are not conducive to explosions. The values with 50% probability of explosion are independent of the number of trials and are less affected by the regression models. Reliable statistics can be obtained by sequential analysis methods in a small number of tests. The present work is a more accurate guide for the risk assessment of dust explosions, and introduces a potential statistical method to more accurately analyze the actual explosion characteristics.

Keywords: Dust explosion parameters; explosibility characteristics; influencing factors; explosion probability; statistical method

Introduction

Dust explosion parameters, namely, the minimum explosion concentration (MEC), minimum ignition energy (MIE), minimum ignition temperature of a dust cloud (MIT_C), maximum explosion pressure (P_{max}), maximum rate of pressure rise ($(dP/dt)_{max}$), and explosion index (K_{St}), are used for the evaluation of the sensitivity and severity of dust explosions. These parameters are critical for the risk assessment and safety management of dust explosions. Thus, the most important point in the evaluation is the accurate testing or calculation of the dust explosion parameters.

Several factors affect the accuracy of the explosion parameter measurements, such as dust sample constants (e.g., dust concentration, particle size, moisture, inertants, combustible agents, etc.) (Abbasi, 2007; Dufaud et al., 2012; Li et al., 2012; Boilard et al., 2013; Addai et al., 2016b). In general, the sensitivity and severity of dust explosions increase with the increase in the concentration of dust, oxygen, and combustible agents, and with the decrease in dust particle size, moisture, and inertants (Li et al., 2012; Norman et al., 2013; Addai et al., 2016d; Sweis, 2006; Yuan et al., 2014). Furthermore, experiments showed that the particle sizes of both the inert dust and combustible dust affect the inert effects of different inertants (Danzi et al., 2015). For example, flour may not be inerted by limestone if the particle size of the limestone is too large, and the inert quality of TiO_2 is not nearly as effective with nano-sized Ti particles (Yuan et al., 2017). In addition, more uniform distribution and higher ignition energy or temperature lead to lower values of the sensitivity explosion parameters (i.e., MEC, MIE, and MIT_C) and higher values of the severity explosion parameters (i.e., P_{max}, $(dP/dt)_{max}$, and K_{St}) (Kuai et al., 2011a; Yu et al., 2012; Cao et al., 2017). However, Yuan et al. (2012b) claimed that the overly high ignition energy may overdrive the combustion of dust clouds in a manner that the MEC may be underestimated. In addition, there are certain special cases. For example, the MEC and MIE values increase as the dust particle size decreases to the point that the diameter of the dust particle reaches a certain small value. This may be attributed to the fact that the size of the dust particle is so small that the dust agglomerates into large particles (Li et al., 2017). Thus, it is necessary to research the factors affecting the explosion characteristics deeply.

The measurement of dust explosion parameters is affected by the test apparatus and experimental conditions as well (Ren et al., 2009). Thus,