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Dust Explosion: Raising awareness of combustible dust hazard

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Abstract. Dust explosion is a serious global industrial hazard since it can lead to property damage and business interruption as well as injuries and fatalities. Statistics shows increasing number of dust explosion incidents in industries around the world and discovered frequency of occurrence in 21st century. Hence, proper knowledge of dust explosion fundamentals such as dust explosion factors and dust explosibility are very important in preventing and mitigating this industrial hazard. Legislations and safety codes should be strictly followed by the industries since the mushrooming growths of industrial sectors all over the world. Lessons learned from the past incidents warrant the critical need for further sequence analysis. Safety education is essential to enhance awareness in the workplace and community for sustainable development.

INTRODUCTION

Dust explosions are a prevalent danger in numerous industries engaged in the production, processing, transportation, and storage of finely combustible solids. In developed nations, they are acknowledged as a significant industrial risk, with awareness of their potential dangers and associated risks often comparable to or even surpassing other well-established industrial hazards like vapor cloud explosions, aerosol or mist explosions, gas explosions, and condensed phase explosions. This classification of explosions in the chemical process industries is illustrated in Figure 1.

Dust explosion is often described as a rapid burning or rapid combustion of airborne finely divided particulate material that occurred in confined and unconfined area, involving deflagrations or detonations. Deflagrations are flame fronts travelling with a subsonic speed. The flame propagates by heat and mass transfer mechanisms with a pressure wave propagating ahead of the flame front. Detonations are characterized by flame fronts that move at speeds exceeding the sound barrier. In contrast to deflagrations, the unburned mixture in a detonation undergoes heating due to a shock wave, leading to a significant increase in temperature. Dust explosions often fall into one of two categories: primary or secondary. A primary dust explosion is the initial explosion resulting from the ignition of airborne dust. In this scenario, the fuel concentration surpasses the minimum explosive threshold and falls within the explosive range.

Within industrial settings, dust emerges as a byproduct of various processes, such as material transport, crushing, screening, sanding, and the removal of excess material. The mere generation of dust does not inherently present a safety or health hazard. Nevertheless, when combustible dust is generated and allowed to accumulate, it has the potential to result in disastrous outcomes. Since the dust concentration sufficient for an explosion seldom build up outside the process equipments, dust explosion will start within a container, a room or part of equipment such as silos, cyclones, hoppers, filters, bucket elevators and dryers. Depending on the amount of dust deposits, a weak primary explosion may trigger very devastating secondary dust explosion [2]. The blast wave from primary explosion could disturb dust deposit, forming a cloud and suitable explosive atmosphere, which may then be ignited by the propagation of the flame front as shown in Figure 2. The blast wave from the secondary explosion can induce accumulated dust to re-suspended due to whirling up of dust deposit and subsequently ignited, which may cause further dust explosions. This phenomenon is known as domino effect, which caused extremely severe damage to the process plants and equipments, injuries, fatalities and loss of production.