Final Master's Thesis Defense

Chemical Engineering

THE UNIVERSITY OF KANSAS

Chemical & Petroleum Engineering

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Mitigation of Metal Dust Deflagrations via Thermal Analysis & Active Explosion Suppression

Abstract

Explosions induced by ignition of combustible metal powders continue to present a significant threat to metal handling and refining industries. Addition of non-combustible inert material to combustible dust mixtures, either through pre-mixing or high-rate injection as the incipient flame front begins to develop, is common practice for preventative inhibition or explosion protection via active suppression, respectively.

Metal dusts demonstrate an extremely reactive explosion risk due to amplified heat of combustion, burning temperature, flame speed, explosibility parameters (K_{St} and P_{max}), and ignition sensitivity. Upon ignition in a contained enclosure volume and propagation to interconnected vessels, metal dusts exhibit augmented explosion severity relative to organic fuels. Inhibition efficiency of suppressant agents utilized for active mitigation is shown to be reliant on fuel explosibility, discrete burning mechanism, and combustion temperature range, and thus may be increasingly variable depending on the fuel in question. For this reason, mitigation of metal powder deflagrations at moderate total suppressed pressures (relative to the overall strength of the enclosure) and at low agent concentrations remains challenging.

The aim of this study is to propose a method for the characterization of the inhibition efficiency of five suppressant agents (sodium bicarbonate [SBC], potassium bicarbonate [PK], monoammonium phosphate [MAP], diammonium phosphate [DAP], and sodium chloride-based [Met-L-X]) when mixed with both organic (cornstarch) and metallic (zinc and iron) fuels, utilizing simultaneous thermal analysis (STA) techniques. Additionally, this work validates lab-scale conclusions through metal dust suppression testing in Fike Corporation's 1 m^3 sphere combustion chamber and evaluates the efficacy of suppression agents with anticipated performance for the mitigation of iron and aluminum powder deflagrations.

Committee Chair:

Prof. Mark B. Shiflett

Monday, November 25th

Starts at 9:00 AM

1 Eaton Hall

Dean's Conference Room