Silicon Dust Explosions: An Experimental Study of Flame Propagation in Dust Extraction Systems

Andreas Faye [a], Anders Bjørnsen [a], Matthijs van Wingerden [a],
Torfinn Buseth [b], Geir H. Pedersen [c], Trygve Skjold [a]
[a] University of Bergen, Department of Physics and Technology, Bergen, Norway
[b] Elkem AS Technology, Kristiansand, Norge
[c] Gexcon AS, Bergen, Norway

Abstract

Dust explosions represent a hazard in various branches of the process industry, including facilities for producing silicon and silicon alloys [1]. Pure silicon (Si) is a semiconductor that is extensively used in integrated circuits (i.e. computers, mobile phones, etc.), as well as photovoltaic (PV) panels that convert sunlight into electrical energy. Ferrosilicon (FeSi), magnesium-ferrosilicon (FSM), and other silicon alloys are crucial components in the manufacturing of high-quality steels. Systems for extracting and collecting fugitive dust in industrial facilities consists of hoods connected to pipes and ducts for capturing and transporting the dust, and air cleaning (cyclones and filters) and moving (blowers and fans) devices. Although several researchers have investigated dust explosions in pipes [2], previous studies of silicon dust explosions in dust extraction systems are scarce [3]. The experimental setup consisted of a 32-litre explosion vessel connected to pipes of varied sizes: 245, 157 and 62 mm (inner diameter). Pipes of different sizes could be connected by expanders/reducers. After distributing a uniform layer of dust in the pipes, corresponding to a given nominal dust concentration, flame propagation supported by dust lifting were initiated by igniting a dust cloud in the vessel. Piezoelectric pressure transducers measured the explosion pressure in the vessel and pipes, and a camera captured the flames emitted from the open end. The initial reference tests with pipes of different dimensions resulted in explosion pressures in the range 1-5 bar. However, experiments with several connected pipes of varying dimension, replicating a typical configuration of an industrial dust extraction system, resulted in significantly higher pressures. A configuration with four gradually smaller pipes, for a total length of the experimental rig of about 25 meters, and dust layers corresponding to a nominal dust concentration of 1000 g m^{-3} in the pipes, resulted in explosion pressures and shock wave velocities exceeding 50 bars and 1000 m s^{-1}, respectively. A preliminary analysis indicates that the interaction with the final reduction, from 157 to 62 mm, causes the flame front to accelerate to an unstable fast deflagration.

References

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