NUMERICAL INVESTIGATION OF THE EFFECTS OF PARTIAL CONFINEMENT ON VAPOUR CLOUD EXPLOSIONS ON A ROAD

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ABSTRACT

An accidental release of flammable gas during transportation may enable the formation of a premixed cloud of flammable gas and air on the road. Under ideal unconfined conditions, combustion of this cloud would typically evolve as a flash fire, which would not produce significant overpressure. However, ignition may result in a powerful vapour cloud explosion (VCE) if there are regions within the gas cloud that are sufficiently confined or obstructed. Partially confined or obstructed areas on the road may occur due to the presence of vehicles or other objects, such as noise barriers. Indeed, the space beneath a group of closely positioned vehicles, where the flow is largely restricted to two-dimensional expansion, is a likely source of a powerful blast. While gas explosions in industrial settings have been extensively researched, little research has been specifically devoted to gas explosions in open traffic environments. Therefore, more research efforts in this type of environment are needed to complement the current knowledge. This article presents a numerical investigation of the effects of confinement under a group of vehicles on the characteristics of the explosion of a gas cloud on a road using Computational Fluid Dynamics. Several scenarios consisting of groups of vehicles with varying ground clearance engulfed by a stoichiometric propane-air cloud were analysed. A clear enhancement of overpressure was observed due to the presence of vehicles compared to completely unconfined conditions. In all scenarios, the maximum overpressure was obtained within one meter outside the congested region. In scenarios with a single vehicle, the maximum overpressure decreased as the ground clearance increased. However, in cases with three or more vehicles, the overpressure increased with increasing ground clearance. The study also examined the effects of noise barriers on the road. An infinitely rigid barrier located on one side of the road led to a 30 % increase in maximum overpressure. However, even barriers that failed at relatively low overpressure (5 KPa) enabled up to 20 % increase in overpressure. Finally, the study highlighted the usefulness of Computational Fluid Dynamics methods in investigating vapour cloud explosions in complex settings.