Experimental investigation of the influence of obstacles on flame propagation in propane-air mixtures and dust-air suspensions in a 3.6 m flame acceleration tube

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1 Introduction

Dust explosions pose a hazard whenever a sufficient amount of combustible material is present as fine powder, there is a possibility of dispersing the material forming an explosive dust cloud within a relatively confined volume of air, and there is an ignition source present. Detailed modelling of industrial dust explosions from first principles is a formidable task, and current methods for mitigating the effects of industrial dust explosions therefore rely on empirical correlations obtained from a limited number of experiments. Recent efforts at simulating the course of dust explosions by combining computational fluid dynamics (CFD) and correlations for turbulent flame propagation with combustion parameters derived from standardized experimental tests have produced promising results [1]. However, the results indicate that the correlations for turbulent burning velocity used in various CFD codes for gaseous fuel-air mixtures are less successful in reproducing the experimental trends observed for dust explosions [1, 2]. The aim of the present work is to investigate these discrepancies further, and to develop improved models that can benefit future use of CFD-codes in consequence assessments for industrial plants. This paper describes an experimental study performed in a 3.6 metres flame acceleration tube on the influence of obstacles on flame propagation in two types of combustible mixtures: propane-air mixtures, and mechanical suspensions of maize starch in air.

2 Experiments

The experimental approach is similar to that of Pu *et al.* [3], but with a somewhat larger apparatus, and with an up-to-date data acquisition system. The flame acceleration tube consists of three equal sections of length 1.2 metres, and internal cross-section 0.27 m × 0.27 m (Figure1). The tests described here are limited to constant volume explosions, but the tube also allows for vented explosions. For gaseous fuels, the explosive mixture is prepared by evacuating the tube and controlling the addition of gas by monitoring the pressure. Tests are typically performed with initial turbulence generated by injecting air from a high pressure reservoir, and this secures thorough mixing prior to ignition. For solid fuels, air from the high pressure reservoir disperses the dust in a pre-dispersion chamber, before the dust is injected into the vessel through nozzles (Figure 2). An ignition source, either a spark or a chemical igniter, initiates the combustion process in one end of the tube. Different types of sensors (thermocouples, capacitive sensors, optical sensors, and high-speed video) measure flame arrival along the length of the tube, and piezoelectric pressure transducers measure pressure development inside the tube.

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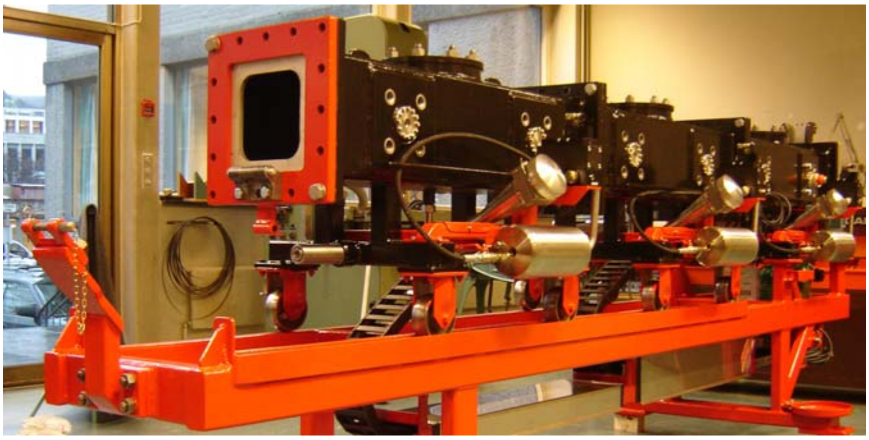

Figure 1 The 3.6 meter flame acceleration tube.

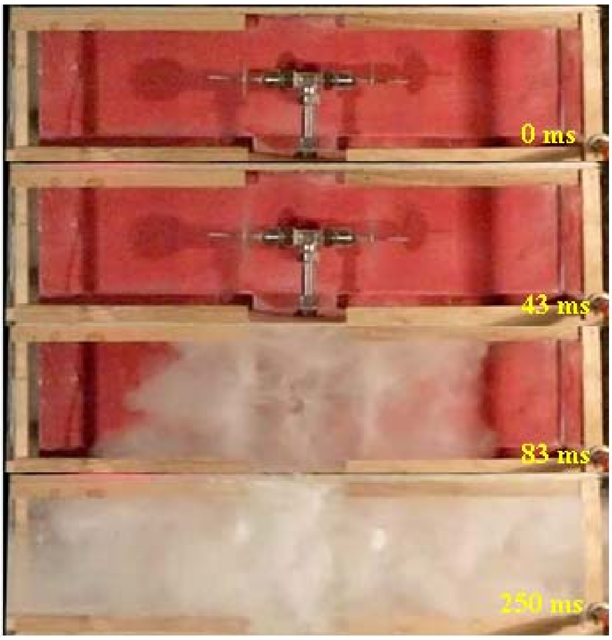

Figure 1 Sequence of pictures from initial testing of the dispersion system in a replica of a 1 metre section with the same cross section area as the flame acceleration tube.

References

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