**Visualization of aluminum dust flame propagation in two different lengths prototypes: some experimental considerations**

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**Highlights**

* Aluminum dust flame propagation in two different lengths tubes: 70 cm and 218 cm
* Comparison of visualization and physical measurements (pressure): pulsating behavior
* Influence of rupture disk on flame propagation (pulsating behavior)
* Influence of optical properties of the walls (radiative thermal losses)

**1. Introduction**

Dust explosion is a major hazard for all industries dealing with powders, as all fine flammable dusts can cause an explosion when dispersed. These industries have to predict the consequences of potential explosions in given scenarios. To predict dust explosion consequences, models commonly used for gas explosions can be adapted. Although these models can be adaptable for organic dust explosions they are not accurate enough in case of metallic dusts [1]. Experimental studies are necessary to understand flame propagation mechanisms for these metallic dusts. Aluminum dust flame propagation is studied inside two prototypes of different lengths.

**2. Methods**

The first prototype is a vertical tube of 700 mm height and 150x150 mm square cross section. Walls are made of glass to visualize the dust dispersion and the flame propagation. The dust is dispersed by the discharge of two 1-liter compressed air vessels inside four vertical dust injection tubes, located in the corners of the tube. A fully characterized spark between two electrodes ignites the dust cloud. The energy of the spark is measured for each test. For the tests presented here, this energy is about 13 J. A rupture disc is located at the top of the prototype to limit the overpressure inside the prototype and also to keep control on the dust concentration. Details of this experimental setup can be found in [2].

The longest prototype is adapted from this first one. It consists of three parts of the previous prototype. Dust is injected on the two first stages. The rupture disc is located between the second and the third floor. No dust is initially present in the third floor, which is used to visualize the flame propagation after the rupture disc. Details of the second setup can be found in [3].

Aluminum powder with a mean diameter of 6.5 μm is studied. Flame propagation is analyzed thanks to fast camera and pressure sensors.

**3. Results and discussion**

Aluminum dust flame propagation is recorded in both prototypes. Pulsating behavior of light intensity is observed during the propagation of the flame. These light intensity pulsations correspond with the pulsations obtained with the different pressure sensors. Other authors also observed light pulsating behavior during aluminum dust flame propagation [4].

Complementary experiments are realized with the smallest prototype. First the influence of the rupture disc on flame propagation is investigated. This rupture disc has a weak rupture resistance (rupture around 35 mbar) to limit the influence of its rupture on the flame. Experiments are realized with and without the presence of this rupture disk. Diminution of the pulsating behavior of the flame is observed for the tests realized without the rupture disc.

In each prototype, the main pressure peak is recorded after the flame leaves the prototype, while the flame front is inside the exhaust duct. Change of optical properties of the walls is supposed to explain this main pressure peak. Inside the prototype, the walls are made of glass. The flame is supposed to present in this case important radiative thermal losses at the walls. On the contrary, the exhaust duct is made of galvanized steel. Inside this duct, the flame is supposed to present less radiative thermal losses leading to an acceleration of this flame. For this purpose, experiments are realized in the smallest prototype. Some walls of glass are covered of aluminum paper. With two opposite walls covered of aluminum paper, a more important pressure peak inside the prototype and a faster flame propagation are observed confirming the hypothesis of the influence of optical properties of the walls on aluminum dust flame propagation.

**4. Conclusions**

Aluminum dust flame propagation has been studied inside two different lengths prototypes. A pulsating behavior has been observed especially inside the longest porotype. Observations made inside this prototype conducted to realize complementary experiments inside the smallest one. This pulsating behavior decreases when the rupture disc is not present inside the prototype.

An important pressure peak has been recorded as the flame reached the exhaust duct with each prototype. This effect is probably linked to optical properties of the walls. The walls of the prototype are made of glass, presenting a potential thermal loss by thermal radiation for the flame. Inside the galvanized steel exhaust duct the flame is accelerated by decreasing the thermal losses of the flame. This observation emphasizes the importance of the properties of the walls for experimental investigation but also for comparison with numerical results. For safety purpose, this result underlines the importance of the material used for exhaust ducts inside industrial plant and its influence in case of accident.

**References**

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