Evaluation of increase in maximum pressure caused by flame propagation in semi-closed ducts

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Ducts of various structures and diameters are widely used in industrial processes to transport gases. In case of ignition of these flammable gases, the flame propagates into the ducts and causes the pressure to increase. In order to prevent heavy damage of ducts or equipment with ducts caused by such high pressure, it is important to understand the phenomenon of flame propagation in ducts.

In our experiments, flame propagation in semi-closed ducts filled with methane-air mixtures was investigated.

We investigated (1) the influences of bends on pressure increase and (2) the relationship between duct diameter and pressure increase. In the investigation of the influence of bends on flame propagation speed and pressure increase, we used three types of pipe geometries; ducts with no bend (straight), single 90 degree bend on 3 m distance from ignition side (L shape), and double 90 degree bends each 2 m distance from ignition side (Π shape) . These had same lengths and diameters which were of approximately 6000 mm length and 100 mm inner diameter. As a result of this experiment, in the case of an equivalent ratio condition of 0.7, flame propagating speed and pressure increased with the number of bends. It is commonly understood that turbulence generated at a bend causes flame surface to increase and leads to greater flame speed and pressure increase. As the equivalent ratio approaches stoichiometry, however, these trends disappeared. We are continually investigating what causes them.

Next, the relationship between duct diameter and pressure increase was investigated. Straight ducts of 5000 mm length and different inner diameters of 100 mm and 300 mm were used. As the result of this experiment, the duct of 100 mm inner diameter showed higher flame propagation speed and pressure increase than that of 300 mm.

In the case of an equivalent ratio of 1.0 and 1.2, the pressure in the duct of 100 mm inner diameter was 10 time as high as that of 300 mm. We think it was caused by two major reasons. Firstly, in a small diameter, the flame surface touched the wall at an early period and then it was stretched and increased in area. Thus flame speed increased and the pressure increased. As for the second reason, the propagating flame in the duct underwent drag caused by shear stress from the wall. As the duct`s diameter decreased, the effect of shear stress gained strength and the flame area increased.

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