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Experimental study of gas deflagration temperature distribution and its measurement

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ABSTRACT

Explosion temperature is one of the main factors in combustible gas explosion accidents. Despite all this, this problem has not yet received considerable attention, especially few fundamental data related to the temperature distribution of gas explosions in closed vessels in literatures. According to characteristics of gas deflagrations, this work developed a gas explosion temperature measurement system whose response time to temperature is approximate 10 μs. By using this system, an experimental study was carried out which is concerned with the deflagration temperature distribution of premixed methane–air mixtures in the 20 L spherical vessel with a diameter of 168 mm. Experimental results show that temperatures on or near the wall are obviously lower than those in the center part of the vessel and there is a conspicuous gradient from the wall to the center part of the vessel. In the inside of the vessel, the deflagration temperature of premixed methane–air mixtures near the ignition spot at the center of the vessel can approximately reach 1200 °C, while near the wall, only 300 °C. This result throws a light on the specific regularity of gas temperature distribution near the boundary. It is possible to provide an important basis for understanding the general characteristics of gas deflagrations in closed vessels as well as choosing good measurement designs. Otherwise, if the ignition is located in the geometrical center of the spherical vessel, velocity of the flame increases with the distance away from the center inside the vessel, and when the flame arrives at the inner wall, this velocity descend sharply.

1. Introduction

Pressure and temperature are two important parameters to describe characteristics of gas explosions, in which the latter can cause the called temperature effect that is the main form of disaster in explosion accidents. In the closed spherical vessel filled by the premixed methane–air, the flame starts from the ignition point and propagates forward to the wall of the vessel along the direction of radius. The pressure increases gradually during the flame propagation. Values of explosion pressures at various experimental environments have been reported in many publications [1–13]. The experimental study of explosive combustion of LPG was performed, and several explosion characteristics of LPG–air in terms of the transient pressure–time records were determined [14]. Explosion pressure in premixed methane–air mixtures in an elongated explosion vessel is influenced by ignition position and obstacles [15]. Experimental measurement results of explosion pressures in the 40 dm^3 explosion chamber was presented and the rate of explosion pressure rise as a function of molar methane concentration in the mixture with air was found [16]. Explosion and detonation pressure characteristics of dimethyl ether experimentally were investigated by use of a spherical vessel [17].

The temperature measurement of gas explosion is more difficult compared with the pressure measurement of gas explosion. The measured data are hardly available. Ono, et al. [18] measured the gas temperature of capacitance spark discharge, and nevertheless, the used optical method cannot obtain the history of transient local high temperature varying with time. Imamura, et al. [19] investigated the properties of the temperature field of the hot current, the temperature rises in the hydrogen jet flame and hot currents measured were 100–1000 K. The state of jet flame is different from that in quiescent premixed gas. Moreover, temperature–time history was not presented in this literature. Few works have made a contribution to the instantaneous temperature measurement for gas explosion since it is very difficult to operate the measurement of temperature due to complicated temperature response of gas explosions. To the best of the authors knowledge, no publications directly refer to the experimental results of temperature distribution for real gas explosions yet. Ronney et al. [20–22] assessed the requirements for temperature measurements in microgravity combustion experiments. They also studied premixed gas flames

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