Entrainment Investigation on Impinging Diffusion Flame

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Abstract

Jet-impinging diffusion flames were produced and experimentally investigated. The impinging mechanism can enhance the turbulent fluctuatiuons and increase the combustion efficiency greater than that in a single jet flame. In addition, lower pressure loss shows a simpler design and higher reliability can be achieved. Various injector arrangements can provide well mixing and stable combustion [1]. Jet-to-Jet flame impingement is illustrated in Fig. 1. Usually, the injector can be coupled with pulsating device to obtain smooth propulsion. The pulsation effect can increase the combustion stability and efficiency [2]. Due to flame stretch force, the shape of the diffusion flame is commonly formed to a

symmetrical configuration. Besides, the flame sheet becomes an obstruction of the mixing rate between fuel gas and oxidizer. When the fuel gas was mixed with nitrogen gas, the stretch force is weakened [3]. Results show that shape of the impinging flame turns into flatter and increases its interaction area with oxidizer.

The injection momentum ratio is a useful injector design parameter for the prediction of combustion stability and performance [4]. For the gaseous hydrogen injection, the optimum momentum ratio of (mv)o/(mv)f ranges from 0.5 to 0.9. In the flame zone, it is difficult to observe the interaction of these two jet flows. In order to investigate the entrainment depth in the impinging flame, the nitrogen gas was used to replace one of the impinging jets, because the molecular weight of nitrogen gas is closed to the air. Therefore, the momentum ratio results can be simulated and observed in this present.

Figure 1 illustrates a set of jet-to-jet flame impingement. The inner-diameter of the two circular jets is 2 mm. The methane fuel was supplied from the high-pressure fuel tank. Half of the intersection angle between two jets, θ, is adjusted to 72^{o} in this investigation. The distance between these two jets is 4 times of its inner-diameter. The geometric coordinates of the impinging flame, the co-plane of the jet-to-jet is set to XY plane. The YZ plane is then perpendicular to the co-plane. The origin of the coordinate locates at the center of the impinging points. The K-type thermocouple is aligned in the flat plate to obtain the wall temperature. The flame temperature also can be obtained by the K-type thermocouple located on the two-dimensional traversing.

Figure 2 shows the picture of nitrogen-to-methane flame with mv(N_2, Re=185)/mv(CH_4, Re=226) = 1. Most of the combustion structure becomes transparent and almost can be seen through. The nitrogen entraining depth is closed to 3 mm. As increasing the mass flow rate to Re=235 and 290, respectively, the entrainment depth also increases to 7 ~ 8 mm. Figure 3 illustrates the temperature profile at the central line of impinging flame. The momentum ratio of nitrogen to methane approaches to 1 in Fig.3(a). The methane flame presents at the fuel side. As the momentum ratio approaches 0.5 in Fig.3(b), the methane flame tends to move to the nitrogen side. Also, higher momentum ratio of the fuel side results better and uniform mixture. The results of methane with air will also be presented.

Reference

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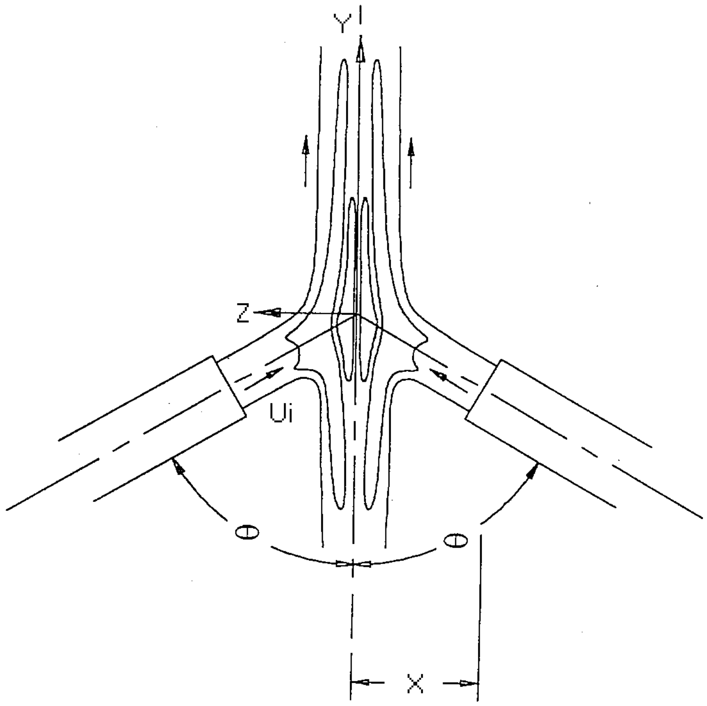
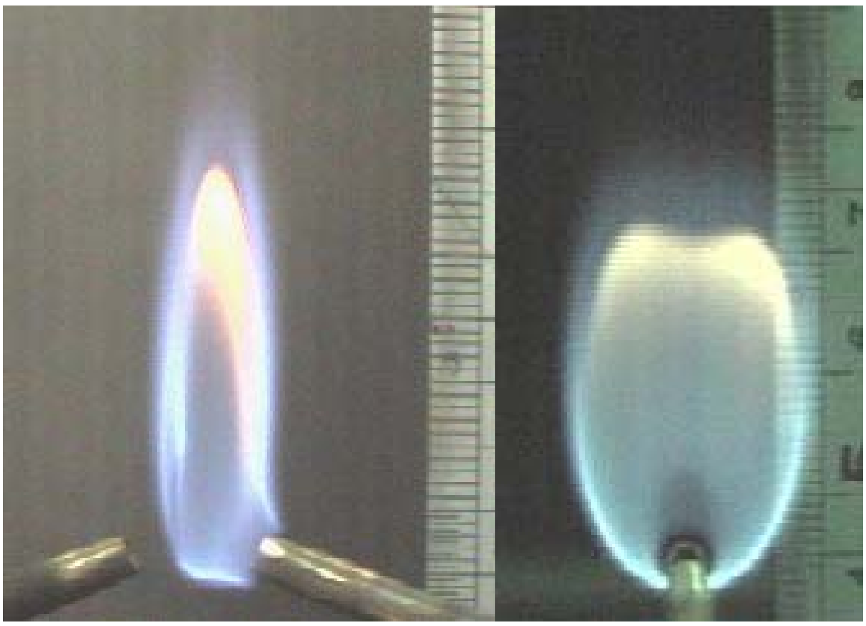
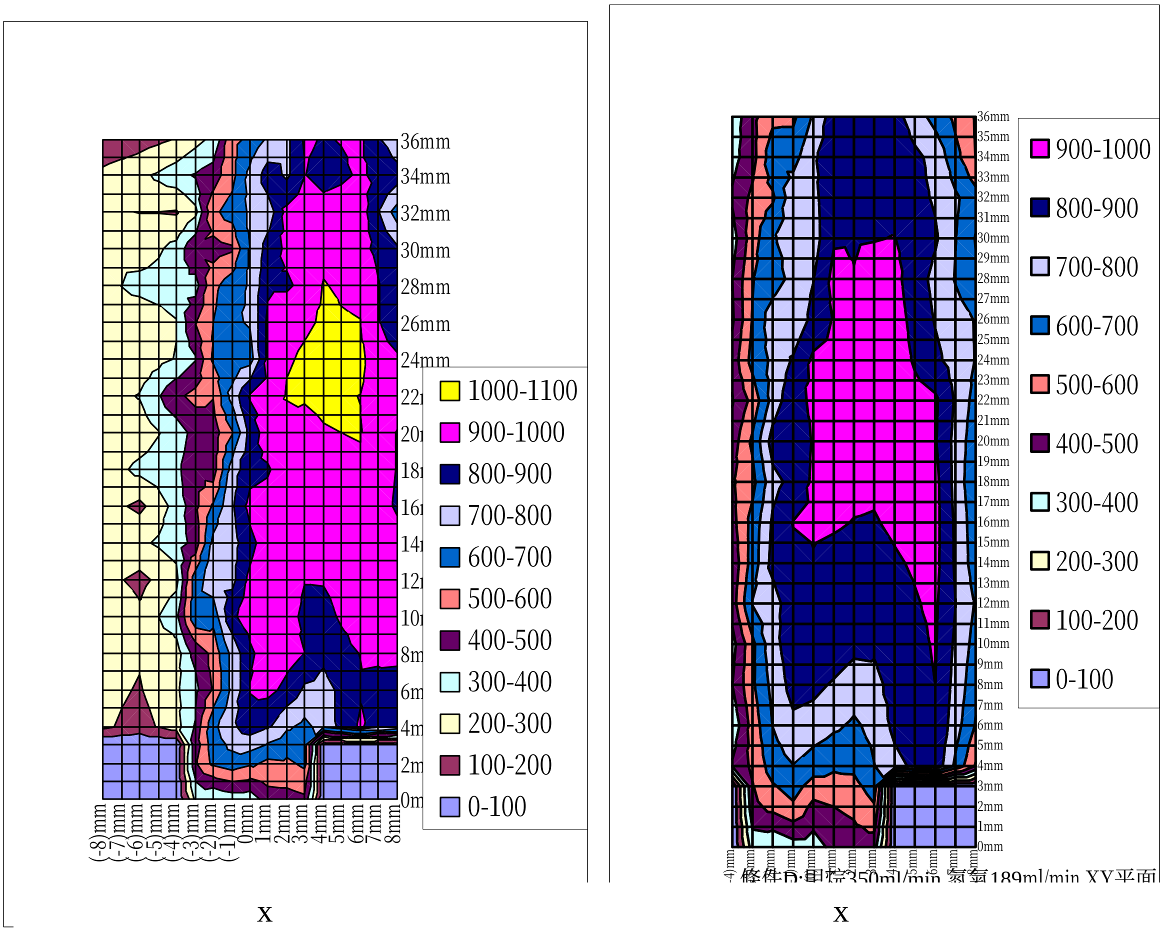


Figure 1: Configuration of jet-to-jet impingement



(a) XY plane (b) YZ plane

Figure 2: Impinging flame structure at mv(N_2, Re=130) : mv(CH_4, Re=160) = 1.



(a) (b)

Figure 3: Configurations of impinging diffusion flame in XY plane
(a) mv(N_2, Re=185) : mv(CH_4, Re=225) = 1 ; (b) mv(N_2, Re=130) : mv(CH_4, Re=225) = 1/2