Enhancement of the Impinging Diffusion Flame by Splash Plate

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Summary The flame stretch mechanism of the impinging flame is investigated by splash plate. Two types of the splash plate with flat plate and 60 degrees in sharp edge are conducted in this experiment. Slip condition occurs at the jet-to-jet impingement and no-slip condition takes place at the jet flow on the splash plate. A portion of the fluid energy will transfer to the radial direction by the no-slip condition. Therefore, it tends to overcome the flame stretch and spreads the impinging flame out. Because the direction of the splash plate with shape-edge, the fuel and the air entrain mutually. The higher temperature region spreads toward the air side. The enhancement of combustion efficiency by splash plate is evident.

BACKGROUND

It is clear that the potential core of the jet flow increases with the jet velocity. Similarity, the flame length of the jet flame also increases with jet velocity. Two opposing jets impinge together at an inclined angle, and form a mixing flow field illustrated in Fig.1. During the impinging process, the jet flow velocities may decrease and attain a minimum at the impinging point. The momentum energy transfers to increase the flow intensities and mixing rate. Therefore, the combustion rates are accelerated as compared with a single jet flame [Su & Liu, 1999].

In order to investigate the entrainment and mixing effect, one of the impinging jet was replaced by nitrogen gas [Su & Liu, 2002]. Compared with the pure impinging diffusion flame, it becomes transparent and stable. The flame stretch is destroyed by the nitrogen molecules and increases the mixing rate with the surrounding air. The flame length is also shortened.

In the present research, the flame stretch effect is investigated by splash plate mechanism illustrated in Fig.2. Two types of the splash plate with flat plate and 60 degrees in sharp edge are conducted in this experiment. The boundary conditions of the impinging point in Fig.1 and Fig.2 are different. Slip condition occurs at the jet-to-jet impingement and no-slip condition takes place at the jet flow on the splash plate. A portion of the fluid energy will transfer to the radial direction by the no-slip condition. Therefore, it tends to overcome the flame stretch and spreads the impinging flame out.

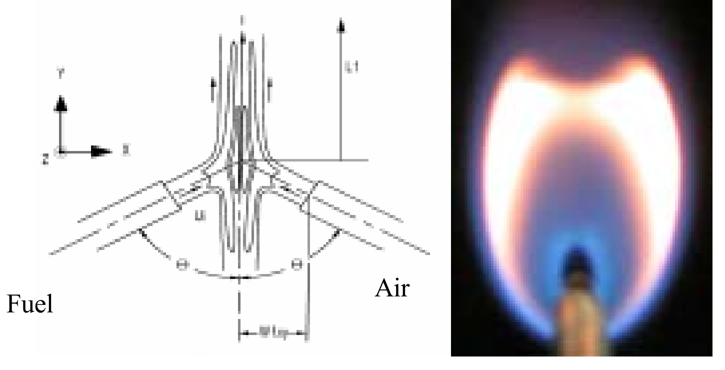
The methane fuel and air jets are supplied from high-pressure tanks with high sensitive pressure regulators. Half of the intersection angle between the two jets, θ, is adjusted to 72^{o} in this investigation. The distance between these two jets is 4 times that of its inside-diameter. The geometric coordinates of the impinging flame, the co-plane of the jet-to-jet are set to the X-Y plane. The Y-Z plane is then perpendicular to the co-plane. The origin of the coordinates is at the center of the impinging points. According to the temperature range in these tests, a K-type thermocouple is selected and located on the three-dimensional transverse.

The fuel and air jets locate at opposite side, the result of the main reaction zone will concentrates at the fuel side as illustrated in Fig.3. The higher temperature region above 1000 degrees Celsius are distributed from X= 4 mm to 7 mm and Y= 9 mm to 17 mm. Figure 4 illustrates the temperature results of the impinging flame on the splash plate of flat-plate type. The higher temperature region above 1000 degrees Celsius are distributed from X= 2 mm to 10 mm and Y= 4 mm to 22 mm. Its combustion efficiency is higher than the result in Fig.3. Figure 5 illustrates the temperature results of the impinging flame on the splash plate of shape-edge type. The higher temperature region above 1000 degrees Celsius are distributed from X= 0 mm to 7 mm and Y= 5 mm to 21 mm. Because the direction of the splash plate with shape-edge, the fuel and the air entrain mutually. The higher temperature region spreads toward the air side. The enhancement of combustion efficiency by splash plate is evident.

References

[1] Su, A. and Liu, Y. C., 1999, "Pulsation of Impinging-Diffusion Flame on the Flat Plate," Proceeding of PSFVIP-2.

[2] Su, A. and Liu, Y. C., 2002, "Investigation of Impinging Diffusion Flames with Inert Gas," International Journal of Heat and Mass Transfer, Vol. No. 45/15, pp. 3251-3257.



Y-Z plane

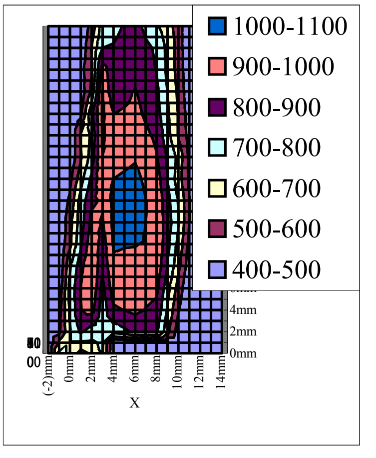
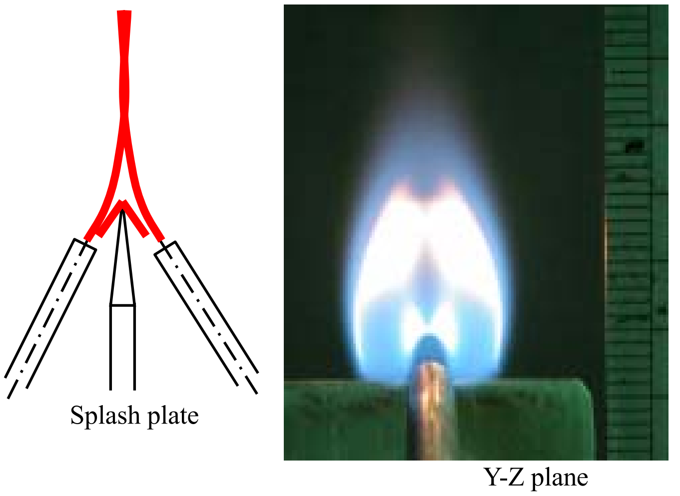


Figure 3: Temperature profile at X-Y plane of Z=0 under air at Re=185 and CH4 at Re=225

Figure 1: Configuration of the impinging flame.



Y-Z plane

Figure 2: Configuration of the mechanism of the splash plate between these two jets.

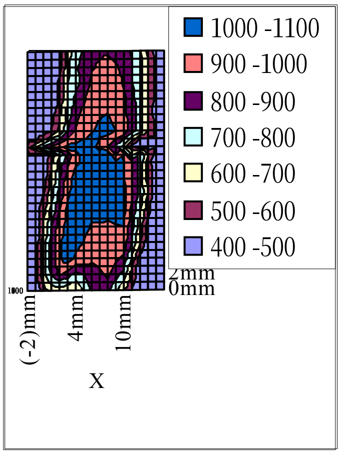


Figure 4: Temperature profile at X-Y plane of Z=0 with flat-plate type of splash plate under air at Re=185 and CH4 at Re=225.

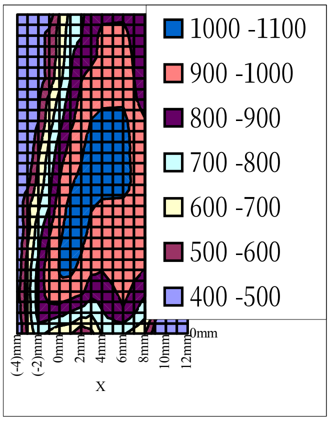


Figure 5: Temperature profile at X-Y plane of Z=0 with shape-edge type of splash plate under air at Re=185 and CH4 at Re=225.