Stability Analysis and Flow Characterization of Multi-Perforated Plate Premixed Burners

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NO reduction on multi-perforated plate burners, often used in domestic water-heater appliances, constitutes a great design challenge for manufacturers. Reducing the flame temperature by using lean premixed mixtures is one method used to attain low-NO emissions but this results in instability issues on most existing designs. A study of the stabilization of methane and propane flames on several configurations of burner plates was carried out, focusing on the influence of the burner plate on flame stabilization. The hole pattern on the perforated plates follows a hexagonal centered distribution, illustrated in Figure 1 and differ from each other on the hole diameter, spacing between holes and number of holes, in 10 different configurations. The first task of this work consisted in taking the stability limits for each burner plate. From the results, it was inferred that the distance between holes is the predominant geometric parameter of the plate conditioning the mechanisms of flame stabilization and the remaining parameters, number of holes and diameter, have subtle or no influence on the stability limits. Figure 2, shows the blowoff stability limits for plates H, F and G, with 1mm, 2mm and 3mm between holes, respectively, and the same number of holes (19) and diameter (1,5mm). Direct visualization of the flow and PIV measurements suggest that the stabilization of the flame is affected by entrained cold air that flows into the gaps between the main flow jets of air-fuel mixture, diluting the premixed reacting mixture and decreasing the reacting zone temperature and chemical reaction rates, accordingly. The results also show that as the gap, or the distance between holes is higher, the more cold air is entrained and the less stable is the flame. In fact, axial velocity profiles on Figure 3 indicate that the flow velocity increase due to the thermal expansion of the gases is not present on the reacting flow of plate G, with the larger gap between holes, suggesting that the cool entrained air drained most of the reaction preventing the thermal expansion of the combustion products. Thus, the presence of a secondary flow of fresh air flowing inside the flame structure, inside the gaps between main flow jets, dilutes with the reacting flow, decreasing the local flame laminar speed which leads to flame quenching and, consequently, blowoff.

![Fig. 1 Hole pattern on the perforate plates](image)

![Fig. 2 Blowoff limits for burner plates with 1,5mm diameter and 19 holes.](image)

![Fig. 3 axial velocity component of the reacting and non-reacting flow of a propane-air mixture along the central axis of the central hole for plates H and G (left) and the transversal profile of the reacting and non-reacting flow for plate G downstream the flame front.](image)