BURNERS, COMBUSTION AND HEAT TRANSFER

(601) - (*) - IMPLICATIONS AND RISKS ASSOCIATED TO HYDROGEN HYBRIDIZATION OF PREMIXED DOMESTIC BURNERS

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Draft Paper

The objective of this work is to assess both operational and safety limits associated to H_2-hybridization of two cylindrical burners used in domestic condensing boiler applications, originally designed for pure natural gas operation. The tested burners differ in terms of internal structure and porosity of the external multi-perforated wall, which affect the flame stabilization mechanisms. The first burner has a low porosity of 3% and an internal metallic structure that favours preheating of the fuel-air mixture exhausting through the perforations. The second burner has a porosity of 8%, while its design is such that reactants are less preheated with respect to the first burner. This makes the two systems ideal candidates to elucidate the factors that affect the burner response to the hybridization process. Both burners are designed to operate between 3 to 30 kW. In these experiments, methane is used as a surrogate of natural gas and it is eventually mixed with hydrogen. The experimental setup allows to control separately the mass flow rates of air, hydrogen and methane injected in these burners. The targeted perfectly mixed mixture is injected in a cylindrical plenum and it goes through several safety components before reaching the burner, located on top of the bench. The power originating from hydrogen is varied from zero to 100%. Flame stabilization is characterized over a wide range of lean equivalence ratios, and for increasing hydrogen fractions in the fuel, with pictures collected in the visible band. Simultaneously, the surface temperature of the tested appliance is recorded using a 2-color infrared pyrometer. Experimental results are presented by means of stabilization maps. On one side, they illustrate for both burners the ensemble of the stable operating conditions achievable in case of hydrogen admixture. On the other side they highlight several operational limits associated to the hybridization. For instance, the analysis of lean blow-off put in evidence the crucial role of hydrogen molecular diffusivity to extend stable operating conditions towards leaner mixtures. Moreover, measurements emphasize the impact of the high hydrogen burning rate on the heat load and surface temperature of the tested appliances, which could compromise the lifetime of the current systems. In addition to that, experimental data underline a strict dependence between the thermal state of the burner and flashback, which is investigated using thermal transient measurements. To sum up, the study confirms the challenges linked to the hydrogen exploitation in domestic burners, driving the attention on specific safety aspects that are not acknowledged as major constraint in case of standard fuel.

Palavras-chave : HYDROGEN COMBUSTION, HYBRIDIZATION, FLASHBACK