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Shape Optimisation of a Gas Injector

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Abstract

One of the main functions of a gas injector in a domestic oven combustion system is to improve the air-fuel ratio in the burner in order to increase the efficiency in the reaction process (combustion). For such a case, it would be necessary to maximise the primary air that enters into the combustion system and this could be done by redesigning the internal geometry of the injector. By improving this design, it is expected that the chemical reaction process between the fuel and the air becomes cleaner since the mixture inside the burner would be closer to its stoichiometric value and therefore the flame would have a smaller diffusive component. Currently, experimentation is the most used methodology to find the most appropriate shape of the injector. This paper presents an alternative way of finding the injector's geometry by using shape optimisation. Navier-Stokes equations written in variational formulation were used to model the flow in the injector/mixer system. The aim was to maximise the primary air entrainment. A shape optimisation method based on Hadamard boundary variation using differentiation with respect to the domain was applied. Results showed improvements of 19.5% in the amount of air dragged into the burner for the optimised injector when compared to the original geometry. The geometry found by the optimisation procedure presents a manufacturability advantage as it requires less tooling to manufacture and allows greater dimensional accuracy.

Finally, the method presented is automatic and can be used over any injector-mixer combination, provided that they are axisymmetric. This approach has significant advantages over other experimental or computational methodologies due to its reduced time and cost of development