Modeling and Optimization of a Micro-scale Combustor using Computational Fluid Dynamics (CFD)

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Abstract: In the present thesis, a propane-air micro combustion-chamber is modeled and optimized using computational fluid dynamics (CFD). In the first step, a basic geometry was modeled and validated using existing experimental data. In the next step, the influence of the geometric ratios and hydrodynamics of flow inside the chamber on the efficiency of the combustion chamber was evaluated. The base geometry consisted of a stainless steel rectangular cube with length, width and depth of 10.21 mm and 3 mm, respectively. The wall thickness was 0.5 mm and the initial 10 mm of the chamber was considered as porous media with 0.9 porosity. CFD simulation was performed using fluent software, and for modelling of the chemical reactions, a kinetics consisting of 39 species and 176 reactions was employed. The effects of chamber depth, indentation on the wall surface, and placing a cylindrical and a triangular prism barrier in the flow direction on the temperature profiles and reaction rates were investigated. The results showed that for simple combustion chambers and the toothed combustion chamber, the main reaction area is near the walls. In the channels with barrier bodies, the reaction site moves behind the barrier body, causing a stagnant area to be placed in front of the barrier body, and the combustion reaction to occur well by increasing the residence time. In chambers with a barrier, the amount of heat exchanged through the walls increases. Given that the higher the temperature on the outer wall, the better the chamber is for photovoltaic systems, one can argue that out of the five simulated chambers, the semi-cylinder barrier combustion chamber could be considered for this purpose. Keywords: Micro-Scale Combustion, Numerical Simulation, Flame Temperature, Propane-Air

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