Effect of Catalyst Segmentation with Cavities on Combustion Enhancement of Multi-Fuels in a Micro Channel

Yueh-Heng Li\textsuperscript{1}, Guan-Bang Chen\textsuperscript{2*}, Fang-Hsien Wu\textsuperscript{1}, Tsarng-Sheng Cheng\textsuperscript{3}, Yei-Chin Chao\textsuperscript{1**}

\textsuperscript{1}Department of Aeronautics and Astronautics, National Cheng Kung University
Tainan, 701, Taiwan, ROC

\textsuperscript{2} Energy Technology and Strategy Research Center, National Cheng Kung University
Tainan, 701, Taiwan, ROC

\textsuperscript{3} Department of Mechanical Engineering, Chung Hua University
Hsinchu, 300, Taiwan, ROC

The effects of the proposed novel design of catalyst segmentation with cavities on H\textsubscript{2}/CO/CH\textsubscript{4} multi-fuels combustion enhancement in a micro-reactor are investigated by numerical simulation with detailed heterogeneous and homogeneous chemistries of methane, carbon monoxide and hydrogen. Numerical results reveal that the heterogeneous reaction in the prior catalyst segment can produce active chemical radicals and catalytically induced exothermicity, and homogeneous reaction is subsequently induced and anchored in the following cavity. CO/H\textsubscript{2} mixture can sustain in high flow velocity in two catalyst configurations caused by their high sticking coefficients, so that CO/H\textsubscript{2} can lightoff on catalyst segment. CO/CH\textsubscript{4} mixture can be stabilized in high flow velocity in two catalyst configurations. In the upstream catalyst segment incomplete combustion of methane yields carbon monoxide, and. the following catalyst segments fully consume carbon monoxide due to the preferred CO catalytic reaction of high sticking coefficient on the platinum surface. Furthermore, OH and H radicals from methane also enhance CO gas reaction by switching chemical pathway. As regards CH\textsubscript{4}/H\textsubscript{2} mixture, only multi-segment catalyst with cavity can stabilize gas reaction in a high flow velocity. Cavity can collect radicals and maintain wall temperature, so that it can successfully sustain gas reaction in a high flow velocity even though hydrogen provides low volumetric energy density. These processes of multi-fuel catalytic combustion belong to mutual assisting coupling between the heterogeneous and homogeneous reactions, instead of mutual competing in a conventional catalyst reactor. In this way, fully methane conversion and complete combustion can be accomplished in a short distance. And the existence of the cavity can appreciably extend the stable operation range of the multi-fuel micro-reactor in a wide variety of inlet flow velocities.

Correspondence to: gbchen26@gmail.com