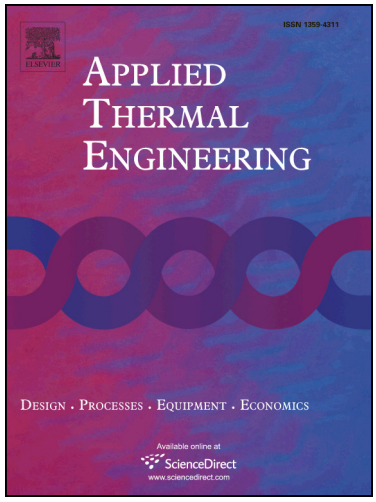

Flow and thermal analyses of regenerative cooling in non-uniform channels for combustion chamber

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Flow and thermal analyses of regenerative cooling in non-uniform channels for combustion chamber

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Abstract: Regenerative cooling is considered one of the most prospective thermal protection techniques in hypersonic vehicles. However, the non-uniform flow distribution in the cooling channels has the potential to lead the combustion chamber to overheat. In the present study, the regenerative cooling channels designed in a variety of non-uniform patterns are proposed. The conjugated flow and heat transfer behaviors of coolant and solid combustion chamber are numerically investigated. The scaling factor (Ω), i.e., height/width ratio, channel inlet/outlet manifold configuration, and relative angle (ω) of the inlet/outlet tube on flow and heat transfer characteristics are discussed. The numerical prediction is in reasonable agreement with previous numerical and experimental data. Results reveal that the basic configuration (Ω=1) contributes dramatic non-uniform flow in the channels near the inlet tube. The non-uniformity becomes more evident in the case of ω=60°. The scaling factor (Ω) exerts stronger influence on flow distribution in channels and the reformed case of Ω=0.9 for Ch-1~4 gives the best flow uniformity and temperature distribution. The flow distribution is less sensitive to the outlet manifold than the inlet manifold.

Keywords: Thermal protection; Engine; Regenerative cooling; Flow uniformity; Conjugated heat transfer

Nomenclature

c_p	Specific heat at constant pressure, J/(kg·K)
Ch	Cooling channel
$D_{L,ij}$	Molecular diffusion
$D_{T,ij}$	Turbulent diffusion
F_x, F_y, F_z	Body force of x, y, z axis, N
F_{ij}	Production by system rotation