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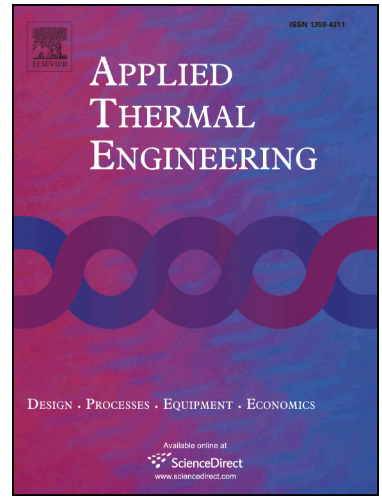

Research Paper

Analytical investigation of heat transfer and classical entropy generation in microreactors - the influences of exothermicity and asymmetry

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Analytical investigation of heat transfer and classical entropy generation in microreactors - the influences of exothermicity and asymmetry

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Abstract Heat transfer and entropy generation are analysed theoretically in a thermal model of microreactors accommodating processes with large heat of reaction. This includes an asymmetric, thick wall, partially-filled porous microchannel under local thermal non-equilibrium. The system features exothermicity/endothermicity within the solid and fluid phases to represent heat of chemical reactions and absorption of microwaves by the microstructure. For constant but uneven temperature boundary condition, analytical solutions are developed for the temperature profiles, Nusselt number (*Nu*) and local and total entropy generation. The influences of the system configuration and thermal specifications upon the heat transfer and irreversibilities are, subsequently, examined. This reveals the strong effects of the wall thicknesses and thermal asymmetry on the heat transfer and entropy generation of the microreactor. Most importantly, it is shown that for given exothermicities in the system there exist optimal wall and porous insert thicknesses that result in the maximum *Nu* and minimum total entropy generation. The presented analyses are therefore of practical significance and demonstrate the possibility of developing thermal and entropic optimal designs of the microstructure of microreactors.

Keywords: Microreactors; Porous media; Internal heat sources; Entropy generation; Local thermal non-equilibrium.

Nomenclature

a_{sf}	Interfacial area per unit volume of porous media, $\mathrm{m^{-1}}$	T_H	Inner temperature of the lower solid material, K
Bi	Biot number	T_s	Temperature of the solid phase of the porous medium, K
Br	Brinkman number	T_1	Temperature of the lower solid material, K
Da	Darcy number	T_2	Temperature of the upper solid material, K
h_4	Height of the microchannel, m	U	Dimensionless velocity of the fluid in the porous medium
h_{sf}	Fluid-to-solid heat transfer coefficient, $\mathrm{W.m^{-2}.K^{-1}}$	U_{f1}	Dimensionless velocity of the fluid in the porous medium
k_1	Reference thermal conductivity for lower solid material, $\mathrm{W\cdot m^{-1}\cdot K^{-1}}$	U_{f2}	Dimensionless velocity of the fluid in the porous medium
k_2	Reference thermal conductivity for upper solid material, $\mathrm{W\cdot m^{-1}\cdot K^{-1}}$	u_{f1}	Velocity of the fluid in the porous medium, $\mathrm{m\cdot s^{-1}}$
k_{ef}	Effective thermal conductivity of the fluid phase of the porous medium, $\mathrm{W\cdot m^{-1}\cdot K^{-1}}$	u_{f2}	Velocity of the fluid in the clear fluid, $\mathrm{m\cdot s^{-1}}$
k_{es}	Effective thermal conductivity of the solid phase of the porous medium, $\mathrm{W\cdot m^{-1}\cdot K^{-1}}$	**Greek symbols**	
k_{e1}	Ratio of the porous medium thermal conductivity to the lower solid material thermal conductivity	ω_f	Dimensionless volumetric internal heat generation rate for the fluid phase of the porous medium
k_{e2}	Ratio of the porous medium thermal conductivity to the upper solid material thermal conductivity	ω_s	Dimensionless volumetric internal heat generation rate for the solid phase of the porous medium