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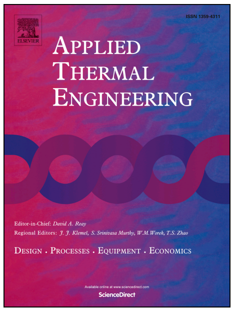

The Significance of Scaling Effects in a Solar Absorber Plate with Micro-Channels

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The Significance of Scaling Effects in a Solar Absorber Plate with Micro-Channels

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Abstract: This paper investigates the significance of some micro scaling effects in micro-channel absorber plates. These plates are to be used in a proposed compact (thin and light-weight) solar thermal flat plate collector (FPC). Forced convection experiments were performed on an instrumented metal plate with micro-channels. Reynolds numbers were in the range 10 – 100 and fluid inlet temperatures ranged from 5 – 40 °C. Scaling effects such as viscous dissipation and entrance effects had insignificant impact on the measured average Nusselt number. However, conjugate heat transfer and measurement uncertainties were significant. Conjugate heat transfer was found to reduce the Nusselt number which agrees with the literature, this also resulted in a Peclet number dependent Nusselt number. The local Nusselt number was observed to vary axially despite satisfying the criteria for neglecting entrance effects; this variation increased with the Graetz number. It was observed that the position of the thermocouples can result in an under-estimation of the Nusselt number. The results are beneficial for the design and operation of micro-channel absorber plates.

Keywords: Microchannel; Scaling effects; Absorber plate; Solar collector; Laminar flow; Conjugate heat transfer

Nomenclature

a	Channel depth (m)	p	Channel pitch (m)
b	Channel width (m)	Q	Heat supplied (W)
Br	Brinkman number (-)	q	Heat flux from channel walls (W/m^2)
c_p	Specific heat capacity (J/kg K)	q_L	Heat flux per unit length (W/m)
C	constant	Re	Reynolds number (-)
D_h	Hydraulic diameter (m)	S_c	Total surface area of channels (m^2)
F'	Collector Efficiency factor	T_f	Average fluid temperature (K)
f	Friction factor (-)	T_{in}	Fluid temperature at inlet (K)
Gz	Graetz Number (-)	T_{out}	Fluid temperature at outlet (K)
h	Heat transfer coefficient (W/m^2 K)	T_p	Average plate temperature (K)
k_p	Thermal conductivity of metal (W/m K)	v_m	Mean fluid velocity (m/s)
k_f	Thermal conductivity of fluid (W/m K)	ΔT_{pf}	Difference of plate & fluid Temperature (K)
L	Length of channel (m)	x	Position in flow direction (m)
L_t	Thermal entry length (m)	δ	Plate thickness (m)
L_y	Plate width (m)	ρ	Density (kg/m^3)
$\dot{m}$	Mass flow rate (kg/s)	μ	Dynamic Viscosity (Pa.s)
N_c	Number of channels in plate (-)	ν	Kinematic viscosity (m^2/s)
Nu	Nusselt number (-)	Δp	Pressure Drop (Pa)
Pe	Peclet number (-)	ω	Uncertainty (-)
Pr	Prandtl number (-)		

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