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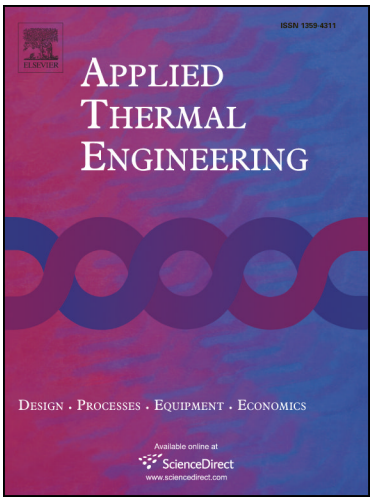

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Numerical study of buoyancy's effect on flow and heat transfer of kerosene in a tiny horizontal square tube at supercritical pressure

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Abstract: The flow and heat transfer characteristics of China No.3 aviation kerosene (RP-3) flowing in a tiny horizontal square tube at supercritical pressure under gravity are numerically studied, focusing mainly on the secondary flow and buoyancy effects on heat transfer at different flow parameters. The heated length of the tube is 480 mm while the inner length of side is 2 mm. Results indicate that buoyancy will cause secondary flow, and the intensity of secondary flow decreases with mass flow rate and pressure, while increases with volume heat source density. The heat transfer coefficient difference between the walls also decreases with mass flow rate and pressure, while increases with volume heat source density. Temperature of the top wall is higher than that of the bottom wall, while the average heat flux of the top wall is lower than that of the bottom wall. Heat transfer coefficient of the bottom wall is the highest, while that of the top wall is the lowest. Jackson's criterion and Petukhov's criterion were tested to assess the application of the two criteria in the present study. Results indicate that Jackson's criterion can be used to judge the buoyancy effect quantitatively while Petukhov's criterion can not.

Key Words: Supercritical pressure, heat transfer characteristics, buoyancy, secondary flow

NOMENCLATURE

Symbols

A	Area of cross section (m^2)
c_p	isobaric specific heat capacity [kJ/(kg · K)]
g	gravitation [9.81m/s^2]
G	mass flux [kg/(m^2 · s)]
Gr	Grashof number
Gr_q	practical Grashof number in Petukhov's criterion
Gr_{th}	critical value of Grashof number in Petukhov's criterion
h	Heat transfer coefficient [W/(m^2 · K)]
H	enthalpy (J/kg)
k	turbulent kinetic energy (J)
$\dot{m}$	Mass flow rate (g/s)
l	Characteristic length (m)
Nu	Nusselt number
P	Pressure (MPa)
Pr	Prandtl number
q	Effective heat flux (W/m^2)
Re	Reynolds number
u_i, (i, j, k)	velocities in x, y, z directions (m/s)
u_i', (i, j, k)	deviation of u_i from its average amplitude (m/s)
V_{Sec}	velocity of secondary flow (m/s)
x_i, (i, j, k)	Cartesian coordinate
Y^+	dimensionless distance from solid wall

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