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Single-phase heat transfer and flow characteristics of micro-fin tubes

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Abstract

Single-phase heat transfer and flow characteristics of micro-fin tubes were investigated experimentally. Four different tubes were used to obtain experimental heat transfer coefficients and friction factor with varying *Re* (3000–40,000) and *Pr* (4–7). The *Re* affected the friction factor in the fully turbulent region for test tubes. The micro-fin tubes show an earlier achievement of the fully rough region which starts at the Re_{ε} of 70 for roughened surface tube. Proposed empirical correlations showed relatively improved predicting performance and their mean deviation and root mean square deviation were less than 6.4%. From the point of efficiency index, the tube with higher relative roughness and smaller spiral angle showed better heat transfer performance than the tube with larger spiral angle and smaller relative roughness. Heat transfer area augmentation was the main contributor to the efficiency index.

Keywords: Correlation; Micro-fins; Heat transfer; Pressure drop; Efficiency index

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Nomenclature

a	correlation parameter [dimensionless]
A	tube inside area [m^2]
b	correlation parameter [dimensionless]
c_p	specific heat of fluid at constant pressure [J/kg K]
D	tube diameter [mm]
e	fin height [mm]
f	friction coefficient [dimensionless]
$F(Re_\varepsilon)$	dimensionless velocity at the tip of the roughness elements [dimensionless]
h	heat transfer coefficients [W/m^2 K]
k	thermal conductivity of fluid [W/m K]
L	test section length [mm]
m	mass flow rate [kg/s]
n	the number of fins [dimensionless]
N	total number of data
p	fin pitch for flow direction [mm]
P	pressure [N/m^2]
Pr	Prandtl number [dimensionless]
Pr_t	turbulent Prandtl number [dimensionless]
Q	heat transfer rate [W]
Re	Reynolds number [dimensionless]
Re_ε	roughness Reynolds number [dimensionless]
St	Stanton number [dimensionless]
T	temperature [°C]
t^+	non-dimensional temperature [dimensionless]
u	fluid velocity [m/s]
u^+	non-dimensional fluid velocity [dimensionless]
u_τ	frictional velocity [m/s]
V	mean fluid velocity [m/s]
y	distance measured from the tube wall [m]
y^+	non-dimensional distance from wall [dimensionless]
z	distance along the flow direction [m]

Greek symbols

α	thermal diffusivity [m^2/s]
β	the spiral angle of fins [rad]
Δ	difference [dimensionless]
ε_H	eddy thermal diffusivity for turbulent flow [m^2/s]
ε_M	eddy kinematic viscosity for turbulent flow [m^2/s]
η	efficiency index [dimensionless]
v	kinematic fluid viscosity [m^2/s]