NUMERICAL INVESTIGATION OF HEAT TRANSFER AND FLUID FLOW IN HEAT EXCHANGERS WITH INSERTS

By

Eng. Alaa Eldin Omar Mahfouz

A Thesis Submitted to the Faculty of
Engineering at Cairo University in Partial
Fulfilment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY
In
MECHANICAL POWER ENGINEERING

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Keywords: **CFD, Nusselt number, Friction factor, Performance evaluation criteria, Twisted tape.**

Summary:

The effect of the twisted tape with different twisted ratios are numerically investigated on the heat transfer rate and friction factor to determine the optimum twisted ratio that give the highest heat transfer rate and the best thermal performance factor. The twisted tape with rod, helical twisted tape with rod, alternated clockwise and counterclockwise twisted tape, and vortex generators inserts are numerically investigated. Comparisons between these inserts and the plain tube are performed based on the heat transfer rate, friction factor, and the performance evaluation criteria.

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Nomenclature

d	Tube diameter, mm
$\vec{\mathbf{F}}_{\mathbf{b}}$	External body force, N
f	Friction factor
h	Heat transfer coefficient, W/m^2k
H	Twisted tape ratio
k	turbulent kinetic energy, J/kg
L	Length of the tube, mm
m	Mass, kg
$\dot{\mathbf{m}}$	Mass flow rate, kg/s
Nu	Nusselt Number
P	Pressure, Pa
Pr	Prandtl Number
PR	Pitch Ratio
Q	Heat transfer rate, W
$\mathbf{q}''$	Heat flux, W/m^2
Rc	Radius of curvature
Re	Reynolds Number
$\mathbf{S_E}$	External heat sources
T	Temperature, K
U	Instantaneous velocity component in x direction, m/s
V	Instantaneous velocity component in y direction, m/s
W	Instantaneous velocity component in z direction, m/s
w	Width of the twisted tape, mm
x	Distance between two vortex generators, mm
y	Length of 180^o twist, mm
$\mathbf{y^+}$	Non-dimensional distance
x, y, z	Cardinal coordinate components

Greek letters

$\Delta \mathbf{P}$	Pressure drop, Pa
$\boldsymbol{\kappa}$	Thermal conductivity, W/m k
$\boldsymbol{\rho}$	Fluid density, kg/m^3
$\boldsymbol{\mu}$	Dynamic viscosity, $N.s/m^2$
$\bar{\bar{\boldsymbol{\tau}}}$	Stress tensor, $kg/m.s^2$
$\boldsymbol{\varepsilon}$	Dissipation rate, W/s
$\boldsymbol{\epsilon}$	Effectiveness
∇	Gradient
$\boldsymbol{\omega}$	Specific dissipation

Superscripts and Subscripts

b	Bulk
h	Hot
i,j,k	Cartesian coordinates' directions
i	Inlet
o	outlet
surf	Inner tube surface
w	Water