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Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts ☆

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Abstract

In the present work, heat transfer and friction characteristics were experimentally investigated, employing louvered strips inserted in a concentric tube heat exchanger. The louvered strip was inserted into the tube to generate turbulent flow which helped to increase the heat transfer rate of the tube. The flow rate of the tube was in a range of Reynolds number between 6000 and 42,000. The turbulent flow devices were consisted of (1) the louvered strips with forward or backward arrangements, and (2) the louvered strip with various inclined angles ($\theta = 15°$, 25° and 30°), inserted in the inner tube of the heat exchanger. In the experiment, hot water was flowed through the inner tube whereas cold water was flowed in the annulus. The experimental data obtained were compared with those from plain tubes of published data. Experimental results confirmed that the use of louvered strips leads to a higher heat transfer rate over the plain tube. The increases in average Nusselt number and friction loss for the inclined forward louvered strip were 284% and 413% while those for the backward louvered strip were 263% and 233% over the plain tube, respectively. In addition, the use of the louvered strip with backward arrangement leads to better overall enhancement ratio than that with forward arrangement around 9% to 24%.

Keywords: Enhancement heat transfer; Forward/backward; Louvered strip; Heat transfer; Friction factor

1. Introduction

Over the past decades, many engineering techniques have been devised for enhancing the rate of convective heat transfer from the wall surface [1,2]. The use of turbulator elements is a typical example of this application to increase the heat transfer coefficient from the flow surface through an increase in turbulent motion. Recently, heat transfer enhancement technology has been developed and widely applied to heat exchanger applications; for example, refrigeration, automotives, process industry, solar water heater, etc. The great attempt on utilizing different methods is to increase the heat transfer rate through the compulsory force convection. Meanwhile, it is found that this way can reduce the sizes of the heat exchanger device and save up the energy. In general, enhancing the heat transfer can be divided into two groups. One is the passive method, without stimulation by the external power such as a surface coating, rough surfaces, extended surfaces, turbulent/swirl flow devices, the convoluted tube, and additives for liquid and gases. The other is the active

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Nomenclature

A	Surface area of test tube, m^2
C_p	Specific heat at constant pressure, J/kg K
D	Tube diameter, m
f	Friction factor
h	Convective heat transfer coefficient, W/m^2 K
k	Thermal conductivity, W/m K
L	Tube length, m
$\dot{m}$	Mass flow rate, kg/s
Nu	Nusselt number
Pr	Prandtl number
Q	Heat transfer rate, W
Re	Reynolds number
T	Temperature, °C
U	Mean velocity in tube, m/s
ρ	Density, kg/m^3
μ	Dynamic viscosity, kg/m s
θ	Inclined angle, degree

Subscripts

ave	Average
b	Bulk
conv	Convection
h	Hot
H	Hydraulic
i	Inner
in	Inlet
o	Outer
out	Outlet
p	Plain tube
t	Turbulator
w	Water

method, which requires extra external power sources, for example, mechanical aids, surface-fluid vibration, injection and suction of the fluid, jet impingement, and use of electrostatic fields. The heat transfer enhancement techniques are performed in widespread applications. Those methods are, for instance, the insertion of twisted stripes and tapes [3–7], the insertion of coil wire and helical wire coil [8,9] and the mounting of turbulent decaying swirl flow devices [10–12] in several heat exchangers. The results of those studies have been shown that although heat transfer efficiencies are improved, the flow frictions are also considerably increased. In this report, the novel concept in augmenting heat transfer rate by using small louvered strip inserts is developed and investigated experimentally. The strips are mounted on the brass wire or core-rod, placed inside the inner hot water tube. The strips are expected to induce a rapid mixing and a high turbulent and longitudinal vortex flow like a delta wing, of course, resulting in an excellent rate of heat transfer in the tube.

2. Experimental apparatus

2.1. Experimental set-up

An experimental apparatus was conducted to study the heat transfer performance and friction factor in a tube with louvered strips inserts. The arrangement of the experimental system of a concentric tube heat exchanger was set up and the details of test