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Numerical analysis on a double pipe heat exchanger with twisted tape induced swirl flow on both sides

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Abstract

Twisted tape inserts are widely used for enhancing heat transfer in heat exchangers. They enhance heat transfer by inducing swirl flow in the flow channel, thereby enabling good mixing within the fluid and by increasing the effective flow length of the flow channel. They also increase pressure drop but their overall performance is found to be advantageous in many cases. In this work, an attempt is made to analyse the performance of a modified double pipe heat exchanger with twisted tape induced swirl flow on both sides. The numerical analysis were done in turbulent flow conditions with twisted tape inserts of twist ratio 5 and 3. The results obtained are validated using established correlations available in the literature. The fin effect of twisted tape is also discussed.

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Keywords: Double pipe heat exchanger; Flow channel, Twisted tape; Swirl flow; Twist ratio; Annulus; Fin effect

1. Introduction

Heat exchangers are one of the most important class of thermal energy handling devices used in industries. Their specific applications can be found in power production, space heating and air conditioning, waste heat recovery, chemical processing etc. Heat exchangers are generally regarded as complex devices. Among them, the double pipe heat exchangers are the simplest type in construction and analysis. But their importance is no way less, since they are widely used in industries.

The need to improve the thermal performance of heat exchangers have led to many modifications on them so as to affect energy, material cost savings as well as consequential mitigation of environmental degradation. These

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methods are referred to as heat transfer enhancement or heat transfer augmentation techniques. Enhancement techniques, reduce the thermal resistance in a conventional heat exchanger by promoting higher convective heat transfer coefficient with or without increase in surface area. As a result, the size of a heat exchanger can be reduced or the heat duty of an existing heat exchanger can be increased. The various heat transfer enhancement techniques can be classified as "passive" and "active" techniques. Passive techniques do not require direct input of external power. They generally use surface or geometrical modifications or incorporate an insert material or additional device. In the case of active techniques, some form of external power is applied to achieve the desired flow modification and improvement in the rate of heat transfer. Twisted tape (TT) inserts are one of the most important passive heat transfer enhancement methods used in circular channels. It is a swirl flow device. When they are inserted in circular channels, swirl flow is imparted to the fluid. The enhancement in heat transfer is due to the agitation of fluid, increase in effective flow length and mixing induced by cross stream secondary flows. Twisted tapes are identified by a parameter called "Twist ratio" usually denoted by *y* and is given by

$$y = {}^{H}/_{d} \quad (1)$$

Fig.1 shows the characteristic dimensions of twisted tapes.

Nomenclature

C_p	Specific heat, J/kg K
D_h	Hydraulic diameter, m
d	Diameter of the tube, m
f	Friction factor
f_a	Friction factor associated with modified heat exchanger
f_0	Friction factor associated with ordinary heat exchanger
H	Half pitch of twisted tape, m
h_a	Average heat transfer coefficient, W/m^2 K
h_l	Local heat transfer coefficient, W/m^2 K
k	Thermal conductivity, W/m K
L	Length of flow channel, m
Nu	Nusselt number
Nu_a	Nusselt number associated with modified heat exchanger
Nu_o	Nusselt number associated with ordinary heat exchanger
Pr	Prandtl number
ΔP	Drop in static pressure, Pa
Q	Heat flux, W/m^2
Re	Reynolds number
S	Source term of energy
T_b	Bulk mean temperature, K
T_w	Wall temperature, K
V	Velocity, m/s
y	Twist ratio
ρ	Density, kg/m^3
μ	Dynamic viscosity, kg/m-s

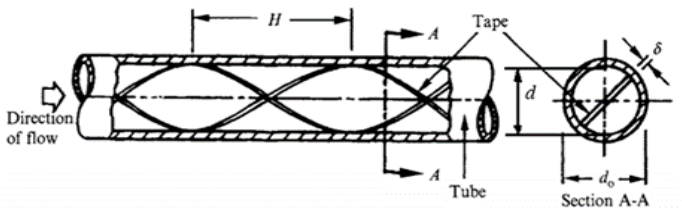

Fig. 1. Twisted tape insert