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Heat Transfer Enhancement Techniques with Inserts Different Geometries – A Review

Pravin S.Nikam [1], Prof. R.Y.Patil [2],Prof. P.R.Patil [3], Prof.P.N.Borse [4]

1(M.E Scholar SGDCOE Jalgaon (MS), India)
2(Professor & Head of Mechanical Engg. Department SGDCOE, Jalgaon (MS), India)
3(Asst.Prof. SGDCOE Jalgaon (MS), India)
4 (Asso. Prof. SGDCOE Jalgaon (MS), India)

Abstract:

In day-to-day life, we come across many processes where we see the usage of heat exchangers. Some examples where heat exchangers are extensively utilized are air conditioning plants, thermal power plants, food processing plants etc. The basic requirement in these industries is to utilize the heat energy used in the heat exchangers efficiently. This can be done either by developing new designs that are energy efficient or by modifying the present designs in such a manner that they give better performance under the same working conditions. Hence, heat exchangers that would provide more heat transfer at the minimum size and cost are requirement of the present industries. Hence they use the various heat transfer technique for enhance the heat transfer rate. In this paper review of research work in last decade on heat transfer enhancement.

Keywords — **Enhancement; heat transfer; twisted tape inserts; pressure drop; flow.**

I. INTRODUCTION

The need to develop efficient heat exchangers has been partially fulfilled by using increased heat transfer rates. In the recent years, considerable emphasis has been placed on the development of various augmented heat transfer surfaces and devices.

The heat exchanger industry has been striving for enhanced heat transfer coefficient and reduced pumping power in order to improve the thermo hydraulic efficiency of heat exchangers. A good heat exchanger design should have an efficient thermodynamic performance, i.e. minimum Generation of entropy or minimum destruction of energy in a system incorporating a heat exchanger. The major challenge in designing a heat exchanger is to make the equipment compact and to achieve a high heat transfer rate using minimum pumping power.

Augmented surfaces can create one or more combinations of the following conditions that are indicative of the improvement of performance of heat exchangers

II.NOMENCLATURE:

A convective heat transfer area (π*DL*), (m2)
*A*0 area of orifice, (m2)
Ap test section inner tube area, (π/4 *D*2) (m2)
Cp specific heat of air, (J/kg K)
d air discharge through test section (m3/sec)
Dh hydraulic diameter (4*A*/*P*), (m)
D Inner diameter of test section, (m)
H pitch ,(mm)
w width of tape insert,(mm)

H/D twist ratio
H/w modified twist ratio
f the friction factor(theoretical) for plain tube
f friction factor(experimental) for plain tube
fi friction factor obtained using tape inserts
h experimental convective heat transfer coefficient, (W/m2*K*)
hw manometer level difference,(m)
hair equivalent height of air column, (m)
k thermal conductivity, (W/mK)
L length of test section, (m)
m. mass flow rate of air, (Kg/sec)
Nui Nusselt number (experimental) with tape inserts, (*hDh/k*)
Nu Nusselt number (experimental) for plain tube
Nuthe Nusselt number for plain tube (theoretical)
Pr Prandtl number
p pitch, (m)
P wetted perimeter, (m)
Δ*P* pressure drop across the test section, (Pa)
Q total heat transferred to air (*Qc* + *Qr*), (W)
Qc heat transferred to air by convection, (W)
Qr heat transferred to air by radiation, (W)
Re Reynolds number, (ρ *u D*/μ)
*T*1, *T*6 - air temperature at inlet and outlet, (°C)
*T*2, *T*3, *T*4, *T*5 - tube wall temperatures, (°C)
Ts average Surface temperature of the working fluid, (°C)
Tb bulk temperature, (°C)
U air velocity through test section, (m/sec)
Greek symbols
v Kinematic viscosity of air, (m2/sec)
ε*C* emissivity of Copper
μ dynamic viscosity, (kg/m s)
η Over all enhancement ratio

III.HEAT TRANSFERVENHANCEMENT TECHNIQUES:

Heat transfer enhancement techniques are generally divided into two main categories: active and passive enhancements. Passive enhancement technologies are "installed" during the manufacturing process of the heat exchanger and require no further input during operation whereas active technologies require some mechanical or electrical power input during operation. Recently a new technique named as compound technique is also used for heat transfer enhancement. Two or more of the active and passive techniques may be utilized Simultaneously in compound techniques to produce an enhancement that is larger than the individual technique applied separately.

Active Heat Augmentation Techniques include:

- Mechanical aids
- Surface vibrations
- Fluid vibration
- Electrostatic fields (DC or AC)

Passive Heat Augmentation Techniques include:

- Treated surfaces
- Rough surfaces
- Extended surfaces
- Displaced enhancement devices
- Swirl flow devices
- Coiled tubes
- Surface-tension devices
- Additives for gases
- Additives for liquids

Some examples of compound techniques are given below:

- Rough tube wall with twisted tape
- Rough cylinder with acoustic vibrations
- Internally finned tube with twisted tape insert
- Finned tubes in fluidized beds
- Externally finned tubes subjected to vibrations
- Gas-solid suspension with an electrical field
- Fluidized bed with pulsations of air.

IV.PERFORMANCE EVALUATION CRITERI A:

In most of the practical applications of enhancement techniques, the following performance objectives, along with a set of operating constraints and conditions, are usually considered for evaluating the thermo hydraulic performance of a heat exchanger:

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- Increase in the heat duty of an existing heat exchanger without altering the pumping power or flow rate requirements
- Reduction in the approach temperature difference between the two heat exchanging fluid streams for a specified heat load and size of exchanger

- Reduction in the size or heat transfer surface area requirements for a specified heat duty and pressure drop
- Reduction in the process stream pumping power requirements for a given heat load and exchanger surface area.

Different Criteria used for evaluating the performance of a single - phase flows are:
* Fixed Geometry (FG) Criteria: where the physical envelope of the heat exchanger is fixed and the performance enhancement comes from better surface designs (for example).
* Fixed Number (FN) Criteria: where the cross-sectional envelope of the heat exchanger is fixed but the length is allowed to vary.
* Variable Geometry (VG) Criteria: the net tube side cross-sectional flow area is allowed to increase to accommodate a higher friction factor.

FG criteria is used for evaluating the performance of single phase flows.

V. TWISTED TAPES:

To enhance the heat transfer rate for the equation of heat transfer is Q = h.A. ΔT . in this equation we increase the heat transfer mean we want to increase the Q i.e. heat transfer rate we need to increase (

h, A , ΔT) these parameter after that the heat transfer rate increases but in this equation the h i.e. heat transfer coeff. And ΔT i.e. change in temperature these two term we can't increases hence only one parameter we increase i.e. A to improve the heat transfer rate if A increase then and then Q increase hence for improving area we uses the fin are the extended surfaces and inserts the twisted tape. Twisted tape is placed in the flow passages but it also reduce the hydraulic diameter of the flow passage. Heat transfer enhancement in the tube is due to the flow blockage ,partioning of the flow and secondary flow .flow blockages increases the pressure drop and leads to viscous effects,because of a reduced free flow area.

- Different types of twisted tape insert

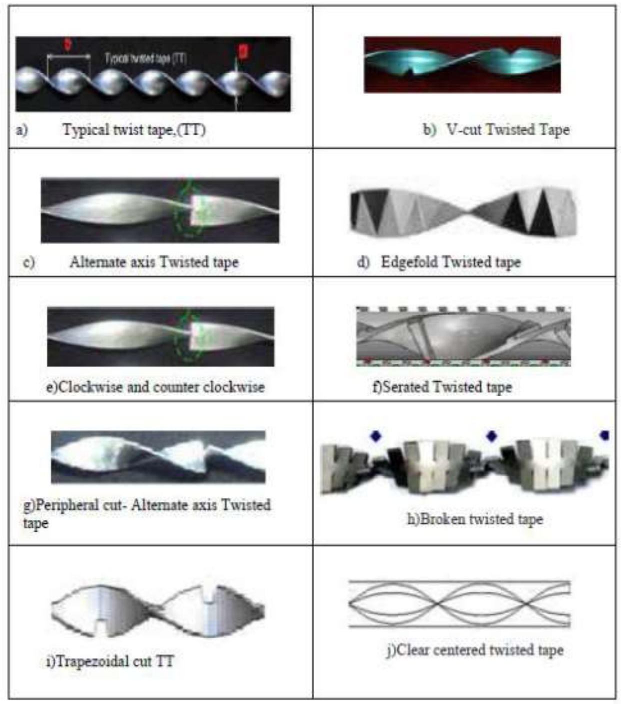


Fig.1. Different types of twisted tape

VI. HEAT TRANSFER CALCULATIONS:

$Ts= (T2+T3+T4+T5)/4$ (1)

$Tb= (T1+T6)/2$ (2)

Equivalent height of air column,

$hair= (\rho\ w^* \ hw)/\ \rho a$ (3)

Discharge of air,

$d=Cd\ Ap\ Ao\ \sqrt{}\ (2ghair)/\ \sqrt{}\ (Ap2- Ao2)$ (4)

Velocity of air flow, $U=d/Ap$ (5)

Reynolds number, $Re=U\ D/v$ (6)

(To calculate Re while using tape inserts, Dh instead of D is used)

$Nu\ the= 0.023\ Re0.8\ Pr\ 0.4$ (7)

$Q = m^*Cp^*(T1-T6)$ (8)

$Qr=\sigma^*A^*\varepsilon C^*(Ts4-Tb4)$ (9)

$H = (Q- QR)/(A\ (TS - TB))$ (10)

$Nu = h\ D\ /K$ (11)

(To calculate Nu while using tape inserts, Dh instead of D is used)

$fthe = 0.25\ (1.82 * \log10\ ReD -1.64)-2$ (12)

$f =\Delta P\ /\ ((L/D)\ (\rho aU2/2))$ (13)

$\eta = (Nui/Nu)/\ (fi/f)0.\ 333$ (14)

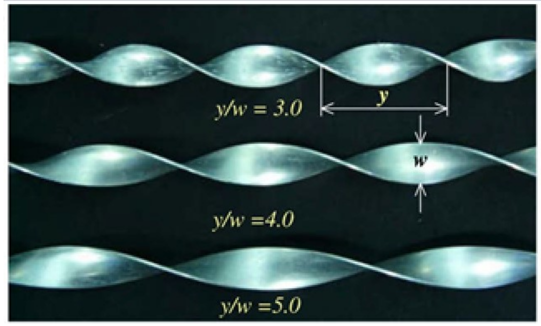
VII. PIPE WITH INTERNAL THREADS:

To produce the turbulent flow through the pipe for good heat transfer characteristics one of the method used is to use a pipe with internal threads. Shrirao [7] studied heat transfer and friction factor characteristics of horizontal circular pipe using internal threads of pitch 100mm, 120mm and 160mm with air as the working fluid. The transitional flow regime is selected for this study with the Reynolds number range 7,000 to 14,000.

VIII. HEAT TRANSFERV ENHANCEMENT USING DELTA WINGLET TWISTED TAPE :

High performance heat transfer system is of great importance in many industrial applications. Therefore, the heat transfer enhancement techniques are widely applied in heat exchangers, in order to
improve heat transfer coefficient All tapes used in the present work are made of aluminium strip with 0.8 mm thickness (d) and 19.5 mm width (w). Firstly, aluminium strip was twisted to produce a typical twisted tape. A tape was subsequently modified to obtain the DWT by cutting at the edge of the tape with oblique shape and straight shape to produce an oblique delta-winglet twisted tape (O-DWT) and a straight delta- winglet twisted tape (S-DWT), respectively. Then the outer part of the cut was arranged to 90o (degree) relatively to the inner part, forming delta-winglet shape. The length between the two cuts was set equally to the pitch length (y). heat transfer rate, friction factor and thermal performance factor behaviours in the tubes fitted with the delta winglet
twisted tapes (oblique or straight delta-winglet twisted tape) for different twist ratios (y/w) and depth of wing cut ratios (DR) are reported

Various Types Of Delta Winglet Twisted Tape:



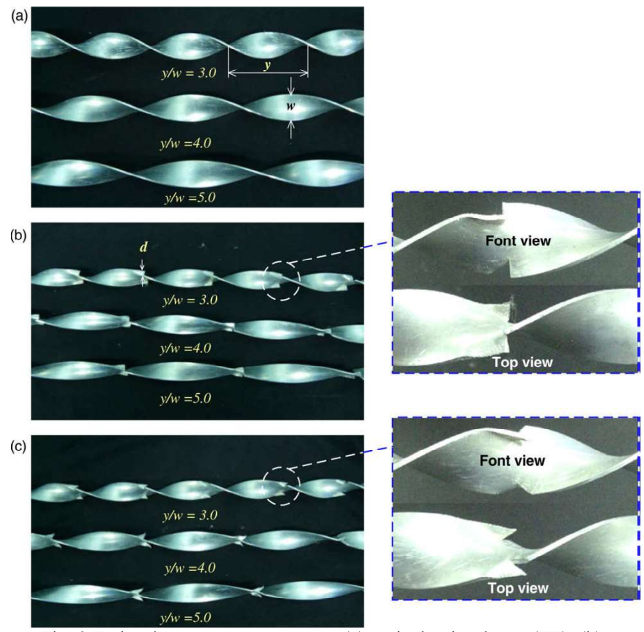


Fig. 2.Twisted tape vortex generator: (a) typical twisted tape (TT), (b) straight delta-winglet twisted tapes (S-DWT) and (c) oblique delta-winglet twisted tapes (O-DWT).

IX. PERFORATED TWISTED TAPE:

To obtain better heat transfer perforated twisted tapes are also used. Bhuiya [5] worked on Nusselt number, friction factor and thermal performance factor in a circular tube equipped with perforated twisted tape inserts with four different porosities of Rp = 1.6, 4.5, 8.9 and 14.7%. He conducted experiments in a turbulent flow regime with Reynolds number ranging from 7200 to 49,800 using air as the working fluid under uniform wall heat flux boundary condition.

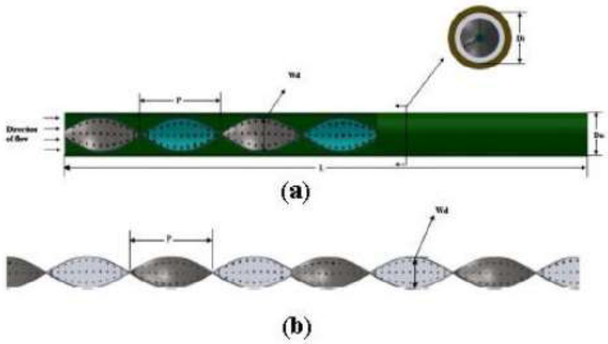


Fig.3.Geometry of test section fitted with perforated twisted tape insert; (b) Geometric parameters of the perforated twisted tape insert

CONCLUSION:

In this paper the we study the various methods of heat transfer and and modes of heat transfer and the performance evaluation criteria and the various techniques such as using delta-winglet twisted ,tapes and pipes with internal threads , perforated twisted tape for these study the performance of enhancement of heat transfer with inserting the various geometry . and conclude that the effect of inserting the various geometry is enhance the heat transfer rate.

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