

Enhancement Of Heat Transfer Using V-Jagged Twisted Tape In Circular Tube.

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Abstract: In The Present Work Enhancement Of Heat Transfer In A Circular Tube Was Investigated By Inserting V-Jagged Twisted Tape. The Twisted Tape Used Had 100mm Pitch And Two Different Materials (Copper And Aluminium) Were Used. The Experiment Were Conducted Keeping Constant Heat Flux And By Varying Mass Flow Rate Using Working Medium As Air. The Heat Transfer Rate, Friction Factor, Nusselt Number Were Determined And Compared With The Plain Tube And Plain Tape. The Twisted Tape Having Jag Of Width And Depth ($We=10mm, De=8mm$) And ($We=10mm, De=10mm$) Were Used.

Keywords: Heat Transfer, Twist Ratio, Reynolds Number, V-Jagged Twisted Tape,

I. Introduction

The The Heat Transfer Duty Or Thermal Performance Of Heat Exchangers Can Be Improved By Heat Transfer Enhancement Techniques. There Are Lot Of Investigations Carried Out On The Shape, Size, And Orientation, Etc. Of The Various Inserts And Rough Surfaces Like Coiled Wire, Twisted Bar, Helical Screw Etc. Several Investigators Have Attempted To Design A Roughness Element, Corrugated Or Wavy Channels, Which Can Enhance Convective Heat Transfer With Minimum Increase In Friction Losses. Hsieh And Huang [1] Conducted Experimental Studies For Heat Transfer And Pressure Drop Of Laminar Flow In Horizontal Tubes With Strip Type Inserts, And Found That, Friction Factor Increases For Tubes With Inserts As Compared To Bare Tube Values Were Typically Between 1.1 And 1.5 For $6500 < Re < 19500$. S. Naga Sarada [2] Experimental Investigated The Augmentation Of Turbulent Flow Heat Transfer In A Horizontal Tube By Means Of Varying Width Twisted Tape Inserts With Air As The Working Fluid. Experiments Were Carried Out For Plain Tube With/Without Twisted Tape Insert At Constant Wall Heat Flux And Different Mass Flow Rates. Which Resulted In Enhancement Of Heat Transfer By 36 To 48% For Full Width and 33 To 39% For Reduced Width-22 Mm Inserts. Chinaruk Thianpong [3] Investigated Experimentally The Influences Of The Perforated Twisted Tapes (Pts) On The Heat Transfer, Pressure Loss And Thermal Performance Characteristics. The Experiments Were Performed Under Uniform Wall Heat Flux Condition By Using Pts With $Y/W = 3, 4$ And $5, D/W = 0.11, 0.14$ And 0.17 And $S/W = 0.4, 0.6$ And 0.8 where Y Is A Twist Length, D Is A Perforation Hole Diameters Is A Spacing Between Holes (Pitch) And W Is A Tape Width. The Increase In Heat Transfer Rate By Using PT Is Found To Be In Range Of 36–85%, Over Those Of The Corresponding Plain Tube. Heat Transfer Rate Increases With Decreasing Tape-Twist Ratio And Pitch Ratio. Bodius Salam [4] Experimentally Investigated Tube-Side Heat Transfer Coefficient, Friction Factor, Heat Transfer Enhancement Efficiency Of Water For Turbulent Flow In A Circular Tube Fitted With Rectangular-Cut Twisted Tape Insert. An Average Of 68% Enhancement Of Heat Flux Was Observed For Tube With Rectangular-Cut Twisted Tape Insert Than That Of Smooth Tube. C. Thianpong [5] Have Conducted Experiments With Perforated Twisted Tapes With Parallel Wings (PTT) For Reynolds Number Between 5500 And 20500 In A Heating Tube To Determine Heat Transfer And Pressure Drop Characteristics Of Turbulent Flow. The Results Showed Those Heat Transfer And Friction Factors Were Significantly Influenced By The Presences Of Wings And Holes On Perforated Twisted Tapes. Watcharin Noothong [6] Have Performed Experiments With Twisted Tape Inserts In A Double Pipe Heat Exchanger To Determine Flow Friction Characteristics. The Experimental Results Revealed That The Increase In Heat Transfer Rate Of The Twisted-Tape Inserts Is Found To Be Strongly Influenced By Tape-Induced Swirl Or Vortex Motion. Over The Range Investigated, The Maximum Nusselt Numbers For Using The Enhancement Devices With $Y = 5.0$ And 7.0 Are 188% And 159%, Respectively, Higher Than That For The Plain Tube. Snehal S. Pachegaonkar [7] Analysed Heat Transfer And Pressure Drop Characteristics Of Double Pipe Heat Exchanger With Annular Twisted Tape Insert, The Heat Exchanger With Annular Twist Tape Of Angle 450 Resulted In Highest Increase In Nusselt Number Over Plain Double Pipe Heat Exchanger And Heat Exchanger With Annular Twisted Tape Of Angle 600. S. Eiamsa-Ard [8] Investigated Experimentally, Influence Of The Oblique Delta-Winglet Twisted Tape (O-DWT) And Straight Delta-Winglet Twisted Tape (S-DWT) Arrangements In A Tube Using Water As Working Fluid. To Determine Heat Transfer, Pressure Drop. M.M.K. Bhuiya [9] Have Investigated Experimentally Augmentation Of Heat Transfer For Turbulent Fluid Flow Through A Tube By Using Double Helical Tape Inserts. The Effects Of Insertion Of The Helical Tape

Turbulators With Different Helix Angles (9°, 15°, 21° And 28°) On Heat Transfer And Pressure Drop In The Tube For Reynolds Number Ranging From 22,000 To 51,000 Were Examined. It Was Found That The Nusselt Number, Friction Factor And Thermal Enhancement Efficiency Increased With Decreasing Helix Angles. Halit Bas [10] Have Studied Flow Friction And Heat Transfer Behavior In A Twisted Tape Swirl Generator Inserted Tube. The Effects Of Twist Ratios (Y/D = 2, 2.5, 3, 3.5 And 4) And Clearance Ratios (C/D = 0.0178 And 0.0357) Are Discussed In The Range Of Reynolds Number From 5132 To 24,989. P. Murugesan[11] Investigated The Effect Of V-Cut Twisted Tape Insert On Heat Transfer, Friction Factor And Thermal Performance Factor Characteristics In A Circular Tube For Three Twist Ratios (Y=2.0, 4.4 And 6.0) And Three Different Combinations Of Depth And Width Ratios (DR=0.34 And WR=0.43, DR=0.34 And WR=0.34, DR=0.43 And WR=0.34)

Experimental Set-Up And Procedure

The Experimental Study On Passive Heat Transfer Augmentation Using V-Jagged Twisted Tape Inserts For A Twist Ratio And With Aluminum And Copper As A Material Were Carried On In A Single Phase Flow Heat Exchanger As Shown In Fig 1



Fig 1 Experimental Setup.

1. Switch ON The Unit.
2. Use Power Control Button On The Panel To Get Voltage At Around 87volts & Current At Around 0.455 Amps. This Will Start The Heating Process.
3. Now Blower Should Be Started With Valve Opening At 100% Level.
4. The Temperatures Will Keep On Rising Continuously. When Steady State Is Reached, Note All The Temperatures For The Smooth Tube.
5. Now Open The Connection Of The Blower Outlet And Pipe Through The Flange Provided At The Interface.
6. Now Put The Inserts Of Aluminium, Copper One By One Inside The Test Pipe And Again Make The Connections Between The Blower And The Test Pipe.
7. The Temperatures Will Keep On Rising Continuously. When Steady State Is Reached, Acquire The Data And Observe All The Results.
8. At Steady State Note Down Height Differences Across Two Limbs Of Water U-Tube Manometer Which Corresponds To Flow Rate, Also Note The Rise Of Liquid In Inclined Manometer Corresponding To Pressure Drop.
9. Repeat The Steps From (2) To (9) For Different Power Levels And Different Valve Positions.

Heat Transfer Calculations

A: Heat Transfer Equations:

The Following Are The Data Reduction Equations Used To Analyse The Experiments.

- (1) $T_s = (T_2 + T_3 + T_4 + T_1) / 4$
- (2) $T_b = (T_1 + T_2) / 2$
- (3) Of Air, $Q_a = C_d * A_0 * (2 * G * H_{air})^{1/2}$
- (5) Velocity Of Air, $V = Q_a / A$
- (6) Reynold Equivalent Height Of Air Column = $(\rho_w * H_w) / \rho_A$
- (4) Discharge, S No, $Re = (VD) / \nu$
- (7) $Q = M * C_p * (T_6 - T_1)$
- (8) $H = Q / (T_s - T_b) * A$
- (9) $= Hd / K$

$$(10) F = \frac{\Delta P}{\frac{L}{D} * \frac{\rho_a V^2}{2}}$$

$$(11) H = \frac{Nu_{with}/Nu_{w/o}}{(f_{with}/f_{w/o})^{1/3}}$$

B: Validation Of Plain Tubes:

In This Experiment The Nusselt No And Friction Factor For Plain Tube Were Found And Compared With The Nusselt No And Friction Factor Obtained From Dittus Boelter And Petukhov Equations. The Equations Are As Below:

$$Nuth=0.023Re^{0.8}Pr^{0.4}$$

$$Fth=(0.790 \ln Re - 1.64)^{-2}$$

Figures

It Is Observed From Fig 2 That Nusselt Number Increases With Increase Reynolds Number. The Copper V-Jagged Twisted Tape With Width(We) Of Jagg=10mm And Depth(De)=8mm Has Highest Nusselt Number As Compared To Aluminium And Plain Tube. The Highest Value Of Nusselt Number Obtained Is 94.20 Respectively.

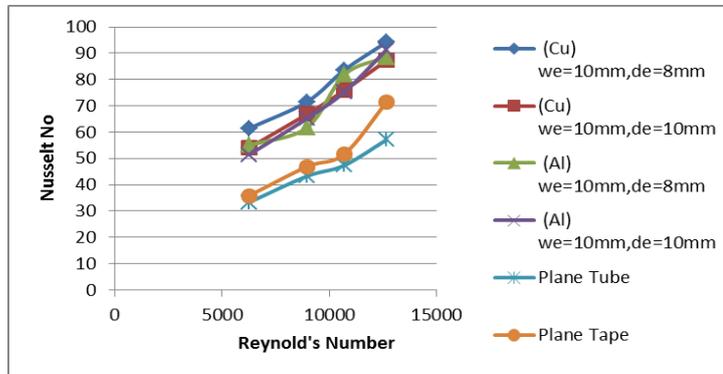


Fig 2 Variation Of Nusselt Number With Reynolds Number For Various Inserts

It Is Observed From Fig 3 That Friction Factor Decreases With Increase In Reynolds Number. The Value Of Friction Factor Is Highest At Low Reynolds Number And Gradually Decreases As Reynolds Number Increases. The Friction Factor Is Highest For Copper Twisted Tape Having (We=10mm,De=8mm).

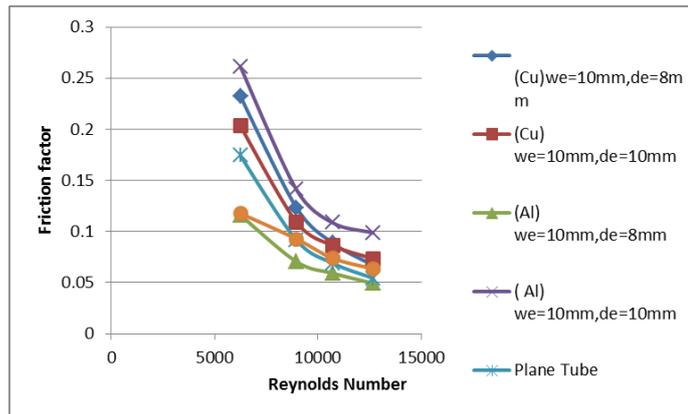


Fig 3 Variation Of Friction Factor With Reynolds Number For Various Inserts

It Is Observed From Fig 4 That Enhancement Gradually Decreases With Increase In Reynolds Number As Turbulence Increases With Increase In Reynolds Number. The Enhancement Is Highest For Tape Of Aluminium Having (We=10mm,De=8mm). The Value Of Enhancement Is Highest For Low Reynolds Number And The Value Is 1.6 As The Reynolds Number Varies Between 6000 To 13000.

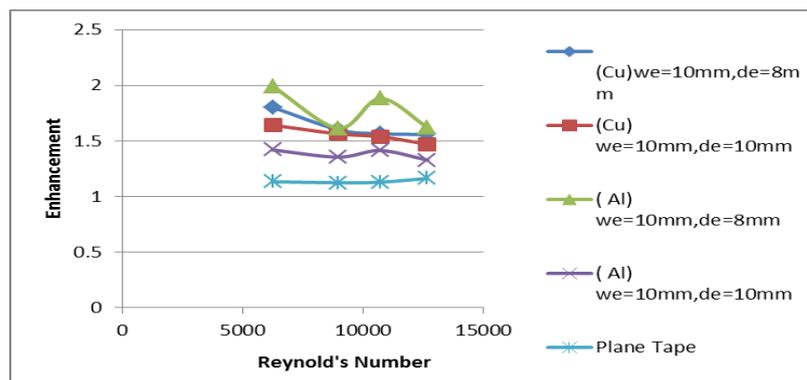


Fig 4 Variation Of Enhancement With Reynolds Number For Various Inserts

II. Conclusion

The Results Obtained From The Experiment Which Is Discussed Above Are Concluded Below And An Optimum Insert Is Obtained

1. It Is Observed That With An Increase In The Reynolds Number (Re) Ranging From 6000 To 13000, The Heat Transfer Coefficients Increases For V-Jagged Twisted Tape By 52% To 90% For Copper And 50% To 75% For Aluminium With Respect To Plain Tube Whereas The Friction Factor Decreases.
2. The Results Are Compared With Plane Twisted Tape & It Is Found That Aluminium V-Jagged Twisted Tape With (We=10m,De=8mm) Gives Highest Enhancement Of 75%.
3. When Theoretical And Experimental Values Are Compared Of Nusselt Number Then The Copper V-Jagged Twisted Tape With Width Of Jagg 10mm & Depth Of Jagg 8mm Gives 85% Rise In Nusselt Number And When Friction Factor Values Are Compared Then It Is Having Lowest Of 2.0 As Compared To The Other Inserts, Hence Proving The Insert To Be Better In Terms Of Heat Transfer Enhancement And Also At Lesser Pumping Power.
4. It Is Observed That Aluminium Tape With (We=10mm,De=8mm) Has Minimum Pressure Drop As Friction Factor Is Less And Is About 0.04 As Compared To Other Inserts And Hence As Highest Enhancement And Is The Optimum Tape .

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