Heat Transfer enhancement in heat exchangers using passive techniques: A Review.

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Abstract— **from last many years the lot of efforts are taken by researchers to improve the heat transfer rate of heat exchangers which is also called as heat transfer augmentation. There are two methods to do so and those are active and passive methods. In the active methods we need the external power supply to increase the heat transfer rate and in passive technique we change the geometry to do the same. This paper basically focuses on passive methods. Twisted tape inserts of various geometries is showing the heat transfer enhancement without effecting the overall heat performance of the heat exchanger. This paper focuses on work done in passive methods of heat transfer in laminar as well as turbulent flow.**

Keywords— Twisted Tape inserts, heat transfer augementation, reynolds number, Friction factor.

I. INTRODUCTION

The process by which the heat transfer rate of the heat transfer system is improved is called as augmentation technique. The heat transfer rate of such devices should be increased without affecting the overall performance of the device. Due to this all the thermal researchers are finding out the various techniques to increase the heat transfer between the surfaces and the surroundings. Such recent techniques are now being used in design of heat exchangers. Apart from increasing the heat transfer rate, the efforts are also taken to reduce the size and cost of the heat exchanger.

AUGEMENTATION TECHNIQUES.

1. Passive techniques,
2. Active techniques,
3. Compound techniques.

1. Passive techniques –

   The technique in which no external power supply is required is called as passive augmentation technique. In this the surface structure is made rough to increase the heat transfer rate or an additional geometry is inserted in the flow channel.

   This will lead to increase in the pressure drop between the test sections. This is the principle used in passive techniques. Due to insertion of the inserts or surface modification turbulence is created in the device which will lead to disturb the boundary layer and increase the heat transfer rate.

   Methods used are.

1. Surface modifications,
2. Inserts,
3. Extended surfaces,
4. Use of additives.

2. Active techniques –

   When the external power supply is used to increase the heat transfer rate it is called as active augmentation technique.

   Methods used are.

1. Use of Magnetic field,
2. Reciprocating plungers,
3. Use of cams.

3. Compound techniques –

   When both the methods are used simultaneously to increase the heat transfer rate it is called as compound augmentation technique. This technique leads to more increase in the heat transfer as compared to the active and passive techniques used individually. But this would be at the cost of complex design. Due to which it is having limited application.

II. TWISTED TAPE INSERT TERMINOLOGY –

1. Thermo hydraulic performance – it is said to be good if the heat transfer coefficient increases significantly with a minimum increase in friction factor.
2. OVERALL ENHANCEMENT RATIO-

   The ratio of heat transfer enhancement ratio to friction factor ratio is called overall enhancement ratio.
3. NUSSELT NUMBER –

   It is the measure of convective heat transfer occurring at the surface.

III. LITERATURE REVIEW

Bodius Salam et al [1] studied experimentally the heat transfer enhancement in a tube using rectangular-cut twisted tape insert. The Reynolds numbers were varied from 10000-19000 and heat flux was varied from 14 to 22 kw/m^2 for smooth tube and 23 to 40 kw/m^2 for tube with twisted tape. The results were as under.

- The Nusselt number values were in the range of -6 to -25 % of the Gnielinski, 1976 value (Nu_{th}).
- The Nusselt number was enhanced by 2.3 to 2.9 times the Nusselt number of Plain tube.
- 68% of enhancement in heat flux as compared to heat flux for the plain tube.
- Friction factors values were greater by 39 to 80 % for twisted tape as compared to plain tube.
- The heat transfer enhancement efficiency increased with the Reynolds number and values were in the range of 1.9 to 2.3.

P. Promovonge et al. [2] in this experimental work the conical inserts were used in round tube to check the heat transfer enhancement. The air was used as working fluid. Various converging, diverging, and converging diverging conical rings were used as inserts. Three different d/D ratios were used 0.5,0.6, and 0.7. The results were as under.

- The heat transfer rates were found increased for conical rings of DR, CDR, and CR by 197 to 333 %, 138-234 % and 91-175 % respectively.
- The enhancement efficiency was increased for decreasing Reynolds number and diameter ratio.
- Heat transfer rates increased at the expense of high friction factor.

P. Murugesan et al. [3] in this experimentation two factors mainly heat transfer and friction factor for U-cut twisted tape insert was studied. The results of plain twisted tape were compared with U-cut twisted tape inserts. The results obtained were as under.

- The Nusselt number and friction factor values were higher for U-cut twisted tape as compared to plain twisted tape.
- The heat transfer enhancement was more dominant than rising friction factor.
- The size of the heat exchanger can be reduced by UTT.

A.V.N. Kapatkar. et al. [4] the main focus in this experimentation work was on laminar flow in circular tube with different inserts. In this the twisted tapes of different materials such as aluminum, Stainless steel, and insulated tape were used for study. The Reynolds number is in the range of 200-2000 so the flow is laminar. The twist ratios were from 3.4 to 5.2.The results obtained were as under.

- Maximum improvement in Nusselt number of amount 90 % was seen in Aluminum tapes with twist ratio of 4.2 and Reynolds number of 2000.
- For S.S. tape the maximum improvement in Nu is the range of 40% to 94% for the twist ratio of 5.2 and 4.2 respectively.
- For insulated Tapes this improvement is 40 % to 67 % for the same twist ratios.
  A. Rahul Kumar et al. [5] in this experimentation work the twisted tapes of different twist ratios are analyzed. The main aim of this experimentation was as under.
- Increase of heat duty of an existing heat exchanger without altering the pumping power,
- Reduce the heat exchanger size,
- Reduce the heat transfer surface area,
  The conclusion of the experiment is as under.
- Friction factor increases with decrease in twist ratio,
- For the same twist ratios the twisted tape shows high heat transfer coefficient and also the friction factor due to the turbulence.

Shashank S. Choudhari et al. [6] here instead of twisted tape coil wire insert is used to calculate the heat transfer enhancement and friction factor for double pipe heat exchanger.

The trail is conducted on coil wire of three different material like Aluminum, Copper and Stainless steel. The pitches used are 5, 10 and 15 mm respectively. The flow is turbulent as the Reynolds number is in the range of 4000 – 13000. The conclusions are as under.

- Copper inserts has highest heat transfer enhancement of 1.58 times as compared to plain tube.
- Aluminum and Stainless steel have enhanced only 1.41 and 1.31 times as compared to plain tube respectively.
- Friction factor increases with the decreasing pitch.

N.B. Dhamane et al.[7] here the wavy twisted tape is used instead of regular twisted tape to analyze the performance of heat exchanger. The wavy twisted tape of different wavy width of 13, 16 and 24 mm are used. The Reynolds number is varied from 4000 to 9500 by changing the mass flow rates. The heat transfer coefficient and pressure drop are calculated and compared with plain tube. The results are as under.

- The enhancement of heat transfer is in the range of 12 to 43 % for the wavy width of 13 mm and 9 to 38 % for wavy width of 24 mm. The main cause is centrifugal forces resulting in spiral motion of the fluid.
- Nusselt number increases with the reduction of tape width.
- Maximum Friction factor rise is 175 % for 13mm and 150 % for 24 mm wave width.
- The overall enhancement for the tubes with wavy twisted tape inserts is 1.43 for 13 mm width and 1.38 for 24 mm width.

S. Naga Sarada [8] et al. this experimentation work mainly focuses on the effect of heat transfer enhancement using varying width of twisted tapes. The results obtained are as under.

- For full width tapes the enhancement is 36 to 48% and for 22mm width it is 33-39%.
- Reduction in width reduces the Nusselt number and friction factor also. The maximum rise in friction factor was 18 % for 26 mm width.
- The overall heat enhancement ration for full length twisted tape was 1.62 and 1.39 for 22 mm width.

Dr. A.G. Matani et al. [9] this paper deals with heat transfer enhancement for counter flow in a tube. Here the comparison of heat transfer is made between plain tube, wire coil and twisted tapes of two different twist ratios. The factors under study are Nusselt number, friction factor and thermal enhancement efficiency.
The results are as under.

- Pressure drop tends to increase with the rise in mass flow rate and friction factor as well as performance factor decreases for the inserted tube.
- The counter tube provides more friction factor and performance factor than the smooth tube for low values of Reynolds number.

IV. CONCLUSION

1. Effectiveness is increased with turbulence and does not have any direct relation with turbulence.
2. Enhancement in the Nusselt number, Friction factor, and enhancement efficiency in rectangular cut twisted tape.
3. Highest heat transfer rates were highest in converging diverging conical rings as compared with only converging and only diverging conical rings.
4. U-cut twisted tape inserts shows high heat transfer rate as compared to plain tube at the cost of friction factor.
5. Out of stainless steel, aluminum and insulated tape, aluminum is showing the maximum Nusselt number (i.e., heat transfer rate)
6. For different wavy width twisted tape the Nusselt number increases with the reduction of tape width.
7. Full length twisted tape shows maximum heat transfer rate as compared to partial length twisted tape.

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