

Review of Enhancement of Heat Transfer Rate by using Inserts in Flow Channel

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Abstract

Heat transfer rate can be increased by using different heat transfer enhancement techniques. These techniques are used in heat exchanger. Some of the applications of heat exchangers are-in process industries, thermal Power plants, radiators for space vehicles, air conditioning equipment, refrigerators, automobiles etc. Inserts like twisted tape, edged disc can be used effectively in flow channel to increase the heat transfer rate. The present paper is review of the enhancement of heat transfer rate by using a suitable insert in flow channel.

Keywords: Heat Exchanger, Pressure Drop, Reduced Twisted Tape Insert, Reynolds number

I. INTRODUCTION

Heat transfer techniques are used to achieve high transfer rate with less power and to increase the efficiency of the system. There are mainly three types of techniques which are used for heat transfer enhancement: Many Engineering devices produce heat during their operation. If this heat is not removed rapidly to its surrounding atmosphere, this may cause rise in temperature of system components. This heat cause serious overheating problems in device and leads to failure of components so the produced heat within the device must be rejected to its surrounding to maintain the device at recommended temperature for its efficient working. The methods used in the cooling of high power density electronic devices vary widely depending on the applications and the required cooling capacity. The heat produced by electronic devices has to pass through a complex network of thermal resistances to the environment.

Nowadays, wire-coiled inserts have commonly been applied for improving the convective heat transfer in various industries, due to their cheap in manufacturing cost, easy setting up and high effectiveness. This insertion of wire-coiled in a heat exchanger tube is a passive enhancing technique. Due to wire-coiled insertion swirl occur in bulk flow, as a result thermal boundary disturb on the tube surface. It is necessary to consider the methods to improve the heat transfer for the development of high performance thermal systems. The analysis of improved heat transfer is allude to as heat transfer enhancement. Commonly a high thermal conductive material like copper, GI pipe used to made wire-coiled inserts.

A. Cooling Techniques:

1) Active technique:

In this technique we use external power to produce swirl effect to enhance heat transfer in heat exchanger like vibratos or stir bar.

2) Passive technique:

In this technique we simply apply some surface or geometrical modification by use of inserts or other devices like - twisted tape insert, edged disc, wire coil etc.

3) Compound technique:

In this we use both above techniques.

II. REVIEW OF WORK CARRIED OUT

The present paper give an overview of work carried out on heat enhancement techniques.

A. Review of previous work

Jeff T. Collins *et al.* [1] 2002 studied that when a copper mesh was insert which was made up of meshed rolled and with porosity significant low inside a cooling channel results significantly high heat transfer at low mass flow rate. High rate of heat transfer was achieved with less pressure drop.

Watcahrin Nooting *et al.* [2] 2006 studied experimentally the effects of Twisted-tape Inserts on Heat Transfer and flow friction characteristics in a concentric double pipe heat exchanger. By using twisted-tape with different twist ratios, $y = 5.0$ and 7.0 swirling flow or vortex motion was introduced. Finally, from the experimental result it was concluded that twist mixing improves the convective heat transfer.

Anil Singh Yadav [3] 2009 performed experiments to study the effects of half-length twisted-tape turbulators on heat transfer and pressure drop characteristics inside a double pipe U-Bend heat exchanger. The experimental results shown a significant improvement in heat transfer coefficient by 40% for half-length twisted tape. On the basis of equal mass flow rate, the heat transfer rate of half-length twisted tape is maximum and on the basis of unit pressure drop, the heat transfer performance maximum for smooth pipe.

S. Naga Sarada *et al.* [4] 2010 studied experimentally on enhancement of heat transfer using varying width twisted tape inserts with air as working fluid. Reduced twisted tape of widths ranging from 10mm to 22mm (less than inside dia. of tube) were used to reduce excessive pressure drop associated with full width twisted tape inserts. It was found that centrifugal forces resulting from the spiral motion of fluid was the main cause of enhancement of heat transfer of about 36 to 48% for full depth and 33 to 39% for reduced width-22mm inserts.

Kumbhar D.G. *et al.* [5] 2010 performed experiments to investigate heat transfer enhancement in a circular tube twisted with swirl generator. It was found that twisted tape inserts mixes the bulk flow well and performed better in laminar flow. The results also shown that twisted tape insert was more effective, when no pressure drop penalty considered. It was also concluded that twisted tape insert was not effective in turbulent flow, because it block the flow and therefore pressure drop increases.

Bodius Salam *et al.* [6] 2010 performed experiment for measuring tube-side heat transfer coefficient of water for turbulent flow in a circular tube fitted with twisted tape inserts. A uniform heat flux condition was maintained by wrapping Ni-chrome wire around the test section and the fiber glass over the wire. Final result showed that when Reynolds number increased, the Nu and heat flux also increased. About 70% enhancement of heat flux was observed.

P.K. Nagarajan *et al.* [7] 2010 performed experimental investigation of heat transfer and friction factor characteristics of circular tube fitted with 300 right-left helical screw inserts with 100 mm spacer of different twist ratio has been presented for laminar and turbulent flow. Finally, performance evaluation has been made and found that the performance ratio increases with increasing Reynolds number and decreasing twist ratio with the maximum for the ratio 2.93 both laminar and turbulent flow.

B. Tarun *et al.* [8] 2011 studied analysis of heat transfer in a heated tube with a different disc inserted to control heat transfer and fluid flow. Governing equations of laminar, two dimensional flow was solved via finite volume technique. Calculations were performed for different Reynolds number in the range of $335 < Re < 845$. It was concluded that a sharp-edged disc can be a good control element for heat transfer and fluid flow.

S.S. Joshi *et al.* [9] 2011 presented a review of heat transfer augmentation techniques referred to different methods used to increase rate of heat transfer without affecting much the overall performance of the system.

Panida Seemawuat *et al.* [10] 2012 performed a numerical prediction of a three-dimensional flow in the tube fitted with a twisted tape consisting of alternate axis. Quick scheme was introduced to investigate numerical diffusion. Finally, results of the flow structure, velocity vector, temperature field in the tube with *TA/TT* (*TA*- Typical Twisted with Alternate Axis, *TT*- Typical Twisted Tape) was reported. The numerical results showed that the use of *TA* leads to more uniform fluid temperature distribution than that of *TT*.

Pasaladi Madhu Kumar *et al.* [11] 2012 studied and compared experimentally heat transfer and pressure loss characteristics of a square ribbed duct with twisted tape as well as the case with twisted tape without any ribs. Considered fully developed laminar flow with constant heat flux wall conditions. Performance evaluated by using Ansys fluent 13. Results shown that for high Prandtl fluids there should be moderate spacing and higher twist ratio and for low Prandtl fluid like water, rib spacing should be higher and twist ratio should be lower. Because of pressure drop it was always recommended to run at lowest possible velocities.

Panida Seemawute *et al.* [12] 2012 visualized experimentally flow and heat transfer in tube with twisted tape (*TT*) consisting of alternate axis. The visualization was carried out via a dye injection technique. The effects of twist ratios (y/W) on heat transfer and fluid friction were also extensively examined. Finally concluded that for the same axial distance, the tape with smaller twist ratio produced more helical number than the one with larger twist ratio. The flow fluctuated in the tube with the twisted tape with alternate axis (*TA*) was assumed to be main factor of the amplifying friction loss of fluid flow.

Paisarn Naphon *et al.* [13] 2012 studied experimentally about characteristics of heat transfer of nano-fluids in the mini-rectangular fin heat sinks and the heat sink with three different channel heights were fabricated from the aluminum by the wire electrical discharge machine with the length, base thickness and width of 110, 2, and 60 mm, respectively. Finally it was found that average heat transfer rate for nano-fluids as coolant are higher than those for the de-ionized water as coolant.

M. Kannan *et al.* [14] 2012 studied experimental and analytical comparison of heat transfer in double pipe heat exchanger and methods in heat exchangers by extended surfaces, swirl flow device and obstruction devices. The system followed different geometric profiles for attainable heat transferred in experimental result and compare with simulation result. Finally, from the experimental and analytical results it was concluded that the annular method reached higher heat transfer than other methods.

Chuoqiao Yang [15] 2012 performed an experiment with helix coil inserted into cooling channel and build a mathematical model of wire-coil insert system to stimulate heat transfer performance and validate with theory and experimental data. Finally reached to a satisfactory agreement with both Dittus-Boelter correlation and experimental data.

Prof. Sashank S. Chaothari *et al.* [16] 2013 studied about characteristics and friction factor of horizontal double pipe heat exchanger using different material inserts within range of 4000-13000 Reynolds numbers. Finally significantly effect seen with coil wire on heat transfer and friction factor. With Copper insert heat transfer enhanced 1.58 times as compared to plain tube. On other side with Aluminum and Stainless steel showed 1.41 and 1.31 times heat enhanced as compared to plain tube. There was decrement in friction factor with an increment in coil wire pitch.

B. Silapakijwongkul *et al.* [17] investigated experimentally the Effect of clockwise and counterclockwise (C-CC arrangement) twisted-tape turbulators on heat transfer augmentation inside a double pipe heat exchanger. The experiments were undertaken for the Reynolds number range of 2200 to 11500 and for several twisted-tape pitch ratios, PR = 0.4, 0.6 and 0.8. Finally concluded that the mean heat transfer rates obtained from using C-CC twisted-tape arrangement and original twisted-tape arrangement were found to be 219% and 204%, respectively over the plain tube. The increase in friction factor was changed between 1.5 to 4.7 times in comparison with those for the original twisted-tape and the plain tube respectively depending on Reynolds number and pitch ratio.

Sonal N Ramteke *et al.* [18] 2014 presented a review on nano-fluid heat transfer enhancement with twisted tape insert. The heat transfer enhancement could be done by using passive technique just by changing the flow boundary conditions, geometry, or by enhancing the thermal conductivity of the fluid. Finally concluded that use of fine grade of nanoparticles results in increase in the surface area which results in increase rate of heat transfer.

Sumit S. Kalmegh *et al.* [19] 2015 presented a review of the passive heat transfer augmentation methods in a circular tube. Passive techniques, generally used surface or geometrical modification to the flow channel by incorporating inserts or additional devices to increase the heat transfer rate. Finally it was concluded that the heat transfer rate was increased by using inserts in circular tube as compare to circular plain tube, as these passive techniques increased the turbulence of the fluid flow in the circular tube and active techniques required external power source therefore a power cost that need to be considered, hence whole cost of system increased.

Mr. Khumbher D.G. *et al.* [20] studied heat transfer behavior in a tube with conical wire inserts in two ways: one with conical wire insert and other with full length wire coil insert in test tube, through which working fluid passed. Finally results revealed that Nusselt number values about 5%, 12% for conical wire insert and full length wire insert respectively and efficiency enhanced 0.78 to 0.98 as compared with plain tube.

III. CONCLUSION

- 1) Twist mixing produce by twisted tape improve convective heat transfer coefficient.
- 2) By using half-length twisted tape inserts, heat transfer coefficient increased by 40%.
- 3) By using reduced twisted tape, centrifugal forces resulting from spiral motion of fluid were the main cause of enhancement of heat transfer rate. It is 36-48% for full depth and 33-39% for reduced width-22mm.
- 4) Use of TA (twisted tape with alternate axis) leads to more uniform temperature distribution in fluid than TT (twisted tape).
- 5) Average heat transfer rate for nano-fluids as coolant are higher than those for deionized water as coolant.

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