HEAT TRANSFER AUGMENTATION IN TUBE IN TUBE TYPE HEAT EXCHANGER USING WIRE COIL INSERT

Mr. Amit Waghode[1] ,Mr. M.D. Shende[2]

[1] *Student, Mechanical Engineering, SYCET AURANGABAD , Maharashtra, India*
[2] *Assistant Professor Department of Mechanical Engineering,SYCET AURANGABAD ,Maharashtra, India*

ABSTRACT

The present review paper is on the performance of tube in tube type heat exchanger with different types of inserts. Heat exchanger are widely used in many mechanical industries, power plant etc. it is required to optimize the performance of heat exchanger. Therefore augmentation technique is used which include active, passive and combine technique. The passive technique is widely used because it is not required extra power. In passive technique use twisted tape or wire coil which is placed in flowing fluid tube then turbulence will create. Then laminar flows gets convert in to turbulent flow which result increases in heat transfer rate.

Keyword: *heat exchanger, augmentation technique, types of insert.*

1. INTRODUCTION

Currently, thermal system are some of the most important system used in engineering application therefore, different type of methods have been researched & Developed to enhance heat exchange in this system & reach a high performance thermal operation. Heat transfer rate in conventional heat exchanger can be improved through a variety of augmentation technique that employs surface enhancements. This increasing in heat transfer rate occurs as a result of following condition that is created by the use of enhanced surfaces this conditions are interrupting of boundary layer development & rising degree of turbulence, increasing heat transfer area & generating of swirling or secondary flows. Recently many industrial application such as refrigeration, automotive & process industries have been employing heat transfer enhancement technique in order to improve the performance of heat exchanger

In all over the world energy demand is increasing day by day. International Energy Agency predicts this increment approximately to 50% in next 20 years. Increasing energy efficiency by its effective utilization is one of the alternative ways to battle this energy crisis. Of course, effective devising is immense for effective utilization of energy. In variety of industrial heat transfer processes heat exchangers are widely used.

2. IMPORTANT TERMS

Heat is a form of energy in transition and heat is flow from one system of higher temperature to another system of lower temperature without transfer of mass. Heat transfer [1] is the process of exchange in internal energy between the systems. According to second to second law of thermodynamics heat transfer or heat flow takes place from a body at higher temperature to a body at lower temperature. Following are the three modes of heat transfer from one body to another.

A) Conduction

It is a process of heat transfer from one particle to another in the direction of fall temperature. The position of particle remains fixed relative to each other. The heat transfer in the metal rod is due to conduction.

B) Convection

In convection heat is transfer by convection current from one particle of body to another. In this case, particles of body move relative to each other. The heat transfer in case of liquids & gases takes place due to convection.

C) Radiation

It is process of heat transfer from a hot body to cold body, in a straight line, without affecting intervening medium. The heat of sun reaches to us according to radiation.

Heat Exchanger: a heat exchanger is equipment where heat energy transferred from a hot fluid to a colder fluid. The transfer of heat energy between two fluids could be carried out (i) either by direct mixing of two fluids. It is also Known as direct contact heat exchanger. (ii) By transmission through a wall separating two fluids. It is also called as surface heat exchanger or regenerator.

There are many type of heat exchanger are classified according to the relative direction of hot & cold fluids.

(i) Parallel flow
(ii) counter flow
(iii) gross flow
(iv) condenser & evaporator
(v) compact heat exchanger
(vi) tube in tube type heat exchanger

Heat transfer enhancement or augmentation is a method of improvement of thermo hydraulic performance of heat exchanger. Augmentation method or techniques [2] are classified in to following three types.

1) Passive Techniques
2) Active Techniques
3) Compound Techniques

1. Passive Techniques:

The techniques generally using by some geometrical changes in to the flow channel incorporating some additional devices. These additional devices increases higher heat transfer coefficients by disturbing the existing flow behavior which also leads to increase in the pressure drop. The advantage of passive technique over the active techniques it does not require external power for circulating fluid. In passive technique following surfaces are widely used.

1) **Treated Surfaces:** The treated surfaces include cavities or some scratches like changes in the surface area which may be continuous or discontinuous. Treated surfaces generally used for boiling and condensing purpose.

2) **Rough surfaces**: The rough surface creates more turbulence than the plane surface. It creates some disturbance in flowing fluid. Rough surfaces are widely used in single phase turbulent flows.

3) Extended surfaces: extended surface also called as fins. Plain fins are widely used in many heat exchangers, electric motor etc.

4) **Swirl flow devices:** The swirl flow device produce swirl flow in the axial flow in flowing fluid hence it is called as swirl flow devices, Like as Helical twisted tape, twisted ducts etc. they can be used for both case in single phase as well as in two-phase flows.

5) **Displaced devices:** Displaced devices are generally used in forced convection. Displaced device improve the efficiency of heat exchanger indirectly.

6) **Coiled tubes:** By using coiled tubes secondary flows are generated because of curvature like structure of wire like structure which increases higher heat transfer coefficient. Coil tube generally used in most Region of boiling.

2. Active Techniques

The active techniques are complex than the passive method in the use as well as design point of view. It required some modification in rate of heat transfer.

Active techniques are not widely used because it required external power in many cases. It has limited applications. It required skilful person for starting and operating also. Active technique is less potential than the passive technique because it has to provide some external power. There are different types of active techniques are as given below.

1) **Mechanical Aids:** In mechanical aids includes rotating tube exchangers as well as scrapped surface heat are include. These devices stir the fluid by mechanical means or by rotating the surface.

2) **Fluid vibration**: In this technique some pulsations are created in fluid. This fluid vibration technique is used for single phase flows.

3) **Surface vibration:** In Surface vibration technique a low or high frequency is applied to greater accessibility for the surface vibrations which gives higher convective heat transfer coefficients.

4) **Electrostatic fields:** In this technique Electrostatic field like as electric or magnetic fields of the two from of DC or AC sources is applied in system of heat exchanger which induce greater bulk mixing and electromagnetic pumping to enhance heat transfer.

5) **Injection:** In Injection technique fluid is injected in to the main bulk fluid by using porous heat transfer interface, the injecting fluid is same or other also. It is applicable in only for single phase heat transfer process.
6) **Jet impingement:** In jet impingement technique fluid is heated or cooled perpendicular to heat transfer surface. Jet impingement technique is applicable for single phase as well as two phase heat transfer surface.
7) Suction: Suction technique is used for single phase heat transfer as well as two phase heat transfer surface also. In which the single phase fluid is withdrawn by using porous heated surface in other hand the two phase involves vapour removal through porous heated surface.

3. Compound techniques

In compound augmentation technique use combination of both passive as well as active technique it depends upon the requirement. In heat exchanger when use compound technique then increasing the thermo-hydraulic performance of heat exchanger.

3. TYPES OF INSERTS USED FOR HEAT TRANSFER AUGMENTATION

A. Twisted Tape

Varun [3] presented a review paper on studies of heat transfer augmentation using twisted tape insert he is concluded that the performance of twisted tape is more effective in laminar flow. Twisted tapes are well known heat transfer augmentation device. The augmentation of heat transfer is obtained by creating swirl flow of inside fluid. Therefore high velocities near boundary side and fluid mixing properly, then increases rate of heat transfer. In this system the heat transfer and pressure drop characteristic are governed by twist ratio of twisted tape also a small clearance is required in between twisted tape and inner boundary of pipe, when selecting with of twisted tape. There are different type of twisted tape are used according to required swirl flow like single swirl flow, co-swirl flow, counter swirl flow which is shown in fig.

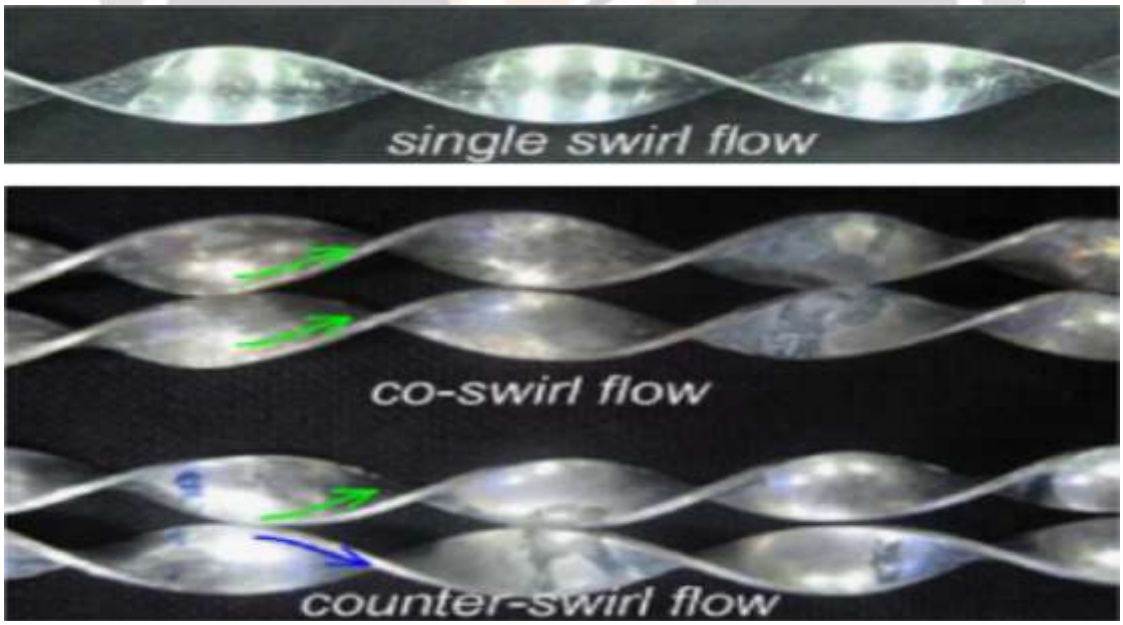

Fig 1 single swirl flow, co-swirl flow and counter-swirl flow

The twisted tape in heat exchanger system is quite effective method of heat transfer augmentation. By using twisted tapes increasing of Nusselt number and thermal performance is reported as well as some pressure drop is occurred. A number of experimental studies have been performed on heat transfer augmentation technique by Using twisted tape insert different types of geometries have been tested to check the heat transfer augmentation. Geometry of pipe and twisted tapes, flow characteristics are the major factor to control the thermo hydraulic performance. The twisted tape is also used in areas like refrigeration as well as solar thermal technologies etc it is

also used in microfiltration of milk. If in case milk occurs as low pressure loss turbulence promoter. In some cases it is found that the twisted tape with nanofluids and other geometries is also used.

B. Wire coil

According to Parag S. Desale [4] a lot of research work has been carried out on passive technique specially wire coil insert and twisted tapes of different width. In process industries the fluid used have high density because of high viscosity and dirt therefore they required high pumping power the pumping power is the important element and is drive to put constraint on selection of passive device when pumping power is issue pressure drop adds limitation on type of insert, as twisted tape causes more pressure drop than wire coil insert. By using coiled wire insert there is a considerable increase in heat transfer as well as pressure drop over the smooth tube. The Nusselt number rises with increases of Reynolds number and wire thickness and decrease of pitch ratio. The highest overall enhancement efficiency of 36.5% is achieved for wire pitch a/D=0.0892 and P/D= 1 ('a' is side length of equilateral triangular wire coil and 'D' is diameter of coil and p is pitch of coil). They work on all type of swirl flow devices and made comparison amongst all which include wire coil twisted tape and combination of both as shown in figure.

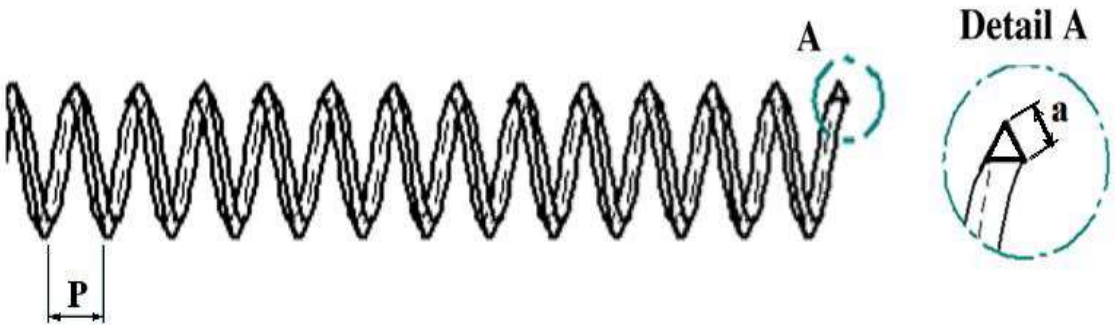

Fig. 2 details of wire coil

Fig.3 Wire coil with twisted tape.

In the heat transfer augmentation process pressure drop, friction factor and overall thermal performance of wire coil insert in tube, twisted tape insert and combine of both devices that is twisted tape and wire coiled may be same or different coil pitch ratio are also studied. Many of researchers and scientist have research on the correlation of Nusselt number and friction factor for all parameter. From the experiment on smooth tube test with wire coil insert, twisted tape insert and combination of both that is wire coil and twisted tape he is concluded that the twisted tape are high heat transfer improvement but poor in friction factor.

According to s. s. Joshi [5] the heat transfer in heat exchanger could be enhancement by using insert and spring of different diameter and their fixing arrangement. Using different type of annular insert causes slightly improvement in heat transfer coefficient similarly effectiveness of heat exchanger. They also studied on effects of annular insert and spring of different diameter and there fixing arrangement on the performance of concentric tube heat exchanger. He used mild steel wire spring, placed in a copper tube which is also takes place in galvanized iron (G. I.) which is shown in the following figure.

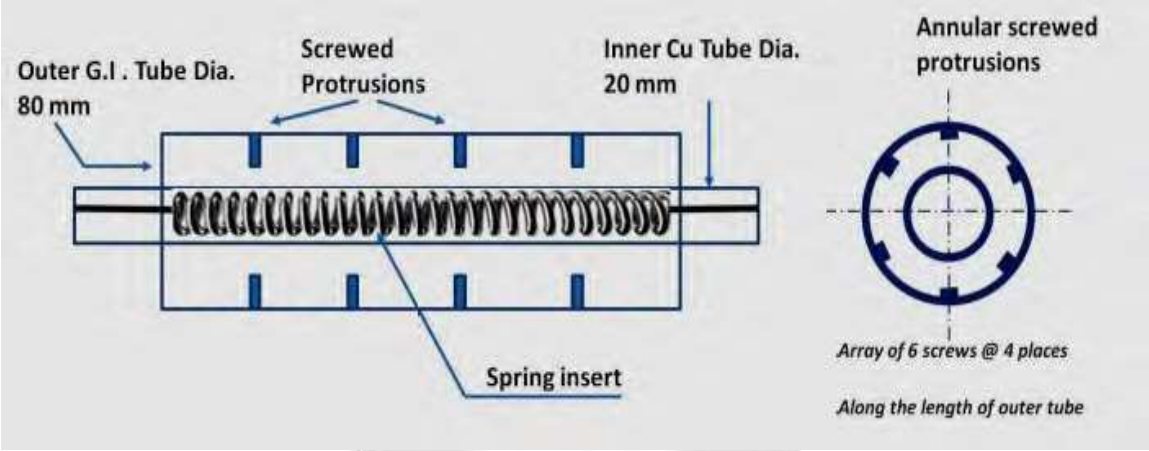

Fig. 4 Insert arrangement

The spring of different diameter and different thickness also there fixing arrangement causes more turbulence. Hence heat transfer is more and improvement in effectiveness of heat exchanger. When heat transfer is increases then at same time friction factor is also increases. He is also concluded that diameter of spring decreases then heat transfer and friction factor decreases.

Shashank S. Choudhari [6] studied wire coil of different material like as copper, aluminium and stainless steel. He concluded that Nusselt number for tube in which coil wire insert are higher than that of without coil wire insert tube. Because of coil wire insert it create some disturbance between flowing fluid and it develop boundary layer near the wall of pipe. Then temperature of the fluid is increases because contact surface area is increases. Similarly turbulence and whirling motion to water also create. He found that the maximum Nusselt number is obtained for copper coil wire than the aluminium and stainless steel coil wire. The copper, aluminium and stainless steel coil wire insert in test section cause heat transfer enhancement up to 1.58, 1.41 and 1.31 respectively. From above data he is concluded that copper can be used as coil wire insert due high heat transfer than other material. Also concluded that coil wire insert in double pipe heat exchanger enhances heat transfer with considerable pressure drop.

According to Mr. Kumbhar D. G. [7] swirl flow helps decreases the boundary layer thickness of the hot air flow and increase the residence time of hot air in the inner tube. Nusselt number is increases with decrease in pitch of wire coil and also for both conical wire insert. By using wire coil twist mixing and secondary fluid motion is generated. Therefore improve the convection heat transfer and then Nusselt number augmentation is decreases decrease rapidly with rise of Nusselt number. Wire coils are compared with a smooth tube externally pumping power then increase in heat transfer is occurred. He studied on the one conical coil insert and other is full length wire coil insert are placed in test tube through which as air as working fluid is passed.

According to Prof. Mathew V Karvinkoppa [8] when one coil wire is insert in inner tube of tube in tube type of horizontal concentric heat exchanger and hot fluid is passed in that inner tube then some turbulence is created similarly some pressure drop is occur due to that increases in heat transfer rate. Hi is also concluded that in case of more than one coil in tube in tube type heat exchanger. From experimentation effects of numbers n= 4, 5, 6 and incline angles of springs are as θ =0 deg., 7 deg., 10 degree and outer diameters of the springs is Ds=7.2mm, 9.5mm, 12mm respectively, for heat transfer and pressure drop by using spring coils as tabulators in a heat exchanger whose inner tube is heated by constant temperature water vapour on all surfaces.

According to Artur W. Krueger et al [9] the decreasing fouling in heat exchanger is depends upon types of spring insert arrangement. In first case spring insert is fixed at both ends and installed under tension. In the effect of circulating flow, then it is vibrate. In other case the second type of spring insert is freed to rotate as flow passes over it which result turbulence is create.

On the basis of detail study Inaba and Ozaki [10] perform experiment on heat transfer in a circular tube fitted with wire coil insert with water as a working fluid. He is developed correlation for the Nusselt number as a function of the Prandtl number. They also concluded that pressure drop is proportional to the length of the wire coil. Higher values of heat transfer coefficient and a small pressure loss is observed at inlet of tube while turbulent flow is observed at downstream of the wire coil.

Paisarn Naphon [11] he is work on the micro fin tubes which is very small and in which coiled wire is inserts. He is also study on the heat transfer characteristics, pressure drop of the horizontal double pipes. This pipe may be with and without coiled wire insert. The inner diameter of the micro-fin tube is 8.92mm and outer diameter of micro-fin tube is 9.52mm. This coiled wire was fabricated by bending a 1mm diameter iron wire into the coil wire with coil diameter of 7.80 mm. In which cold water is used as working fluid in shell side and hot water is used in tube side. The cold mass flow rates ranging between 0.01 to 0.07 kg/s and hot water mass flow rate is between 0.04 to 0.08 kg/s. The inlet cold temperature ranges from 15°C to 20°C and hot water temperature ranges from 40°C to 45°C.The obtained results is compared with the smooth and micro fin tubes. Then he concluded that the coiled wire insert had a valuable effect on the enhancement of heat transfer then friction factor is also increases. He also stated that wire coil effectiveness is inversely proportion to the Reynolds number.

4. CONCLUSION

In this paper reviews of all types of swirl flow devices and also made comparison. The heat transfer augmentation, pressure drop variation and overall thermal performance of tube inserted with wire coil insert alone, twisted tape insert alone and combine devices between twisted tape and constant or varying wire coil pitch ratio and varying diameter of wire coil are studied. The relation between Nusselt number and friction factor for all parameter are also studied. From studying all paper it concluded that the swirl flow helps decrease the boundary layer thickness of hot water flow and increase the residence time of hot water which result increases in heat transfer augmentation. The heat transfer augmentation and Nussult number is increases with decreases in pitch of wire coil.

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