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Experimental Investigation on Pipe in Pipe Heat Exchanger Using Twisted Tape Insert

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Abstract: *The methods for heat transfer augmentation are relevant to several engineering applications. In recent years, the high cost of energy as well as material has resulted in an increased effort and aimed at producing more efficient heat exchange equipment. There is a necessity for minimization of a heat exchanger in specific applications, such as aerospace application, through an augmentation of heat transfer. For this purpose a pipe in pipe heat exchanger is used to improving the methods of heat exchange between two fluids which are at different temperatures.*

In order to improve heat exchanger performance in a better way a twisted tape is inserted into the inner pipe. These types of twisted tape inserted heat exchangers useful in both overhead condensers and compression inter stage coolers etc. The main objective of the project is to create turbulence in the hot fluid tunnel with the help of twisted tape inserts so that an increase in the heat transfer coefficient can be identified.

Keywords: *Twisted tape, Turbulence, Heat exchanger*

I. Introduction:

Heat exchangers are mostly used devices in many areas of the industries. Hence, the using of high performance heat exchangers result in saving of energy. heat transfer enhancement techniques used to improved Thermal performance of heat transfer devices. The turbulent generator along with each and every geometrical configurations have been used as passive heat transfer enhancement techniques and are the widely used tubes in several heat transfer applications, for example, air conditioning and refrigeration systems, heat recovery processes, chemical reactors, food and dairy processes.

Heat transfer augmentation using various types of swirl flow generators like twisted tapes, helical screw tapes have been widely reported in literatures. It has been noticed that such devices induce turbulence and superimposed vortex motion (swirl flow) causing a thinner boundary layer and consequently resulting in higher heat transfer coefficients. Twisted-tape inserts are, therefore, used to mix the gross flow effectively in laminar flow to decrease the thermal resistance in the core flow through the channel.

II. Materials:

Tubes (Copper)

Copper is a mostly used element with the symbol Cu and atomic number 29. It is a ductile, malleable, and soft metal with very high electrical and thermal conductivity. A freshly exposed surface of pure copper has a pink -orange color. Copper is used as conductor of heat and electricity, as a building material, and a constituent of various metal alloys, such as sterling silver used in Jwellery, cupronickel is used to make marine hardware and coins, and constantan used in strain gauges and for temperature measurement Thermocouples is used. Copper is one of the few metals that can occur easily in nature in a directly usable metallic form (native metals). The softness of copper is explains its high electrical conductivity (59.6×10^6 S/m) and high thermal conductivity, second highest (second only to silver) among pure metals at room temperature.

Outer covering (mild steel)

Mild steel is the less expensive of all steel and the most commonly used steel. Used in every type of product created from steel, it is very hard, weldable and high strength, although it easily rusts, very durable. It Containing a maximum of 0.29% carbon, In this type of steel is able to be magnetized and used in any project that requires a large amount of metal. Its structural strength prevents it from being used to create structural beams and load-bearing girders.

Number of the everyday objects that are created of steel are made using mild steel, including, motorcycle frames, Automobiles chassis and most cookware products. Due to its poor corrosion-resistance property, it must be painted, otherwise protected and sealed in order to reduce rust from damaging it. A light coat of oil or grease is able to seal this steel and aid in rust control.

Unlike high-carbon steel, mild steel is easily welded. The properties of the steel allow the electrical current to flow through the metal without distorting the makeup of the material. Some types of high-carbon steel, such as stainless steel, require special techniques in order to accurately weld the material.stainless steel Being less brittle than high-carbon steels, the mild steel variant is able to flex and give in construction projects where a high-carbon version could simply break down.

Terminology Used In Twisted Tape

A) Thermo Hydraulic Performance- For a particular Reynolds number, the thermo hydraulic performance of aninsert is said to be good if the heat transfer coefficient increases significantly with a minimum increase in frictionfactor Thermo hydraulic performance estimation is generally used to compare the performance of different insertsunder a particular fluid flow condition.

B) Overall Enhancement Ratio -The overall enhancement ratio is defined as the ratio of the heat transferenhancement ratio to the friction factor ratio.

C) Nusselt Number -The Nusselt number is a measure of the convective heat transfer occurring at the surface and is defined as hd/k, where h is the convective heat transfer coefficient, k is the thermal conductivity and d is the diameter of the tube.

D) Prandtl Number- The Prandtl number is defined as the ratio of the molecular diffusivity of momentum to themolecular diffusivity of heat.

E) Pitch- The Pitch is defined as the distance between two points that are on the same plane, measured parallel tothe axis of a Twisted Tape.

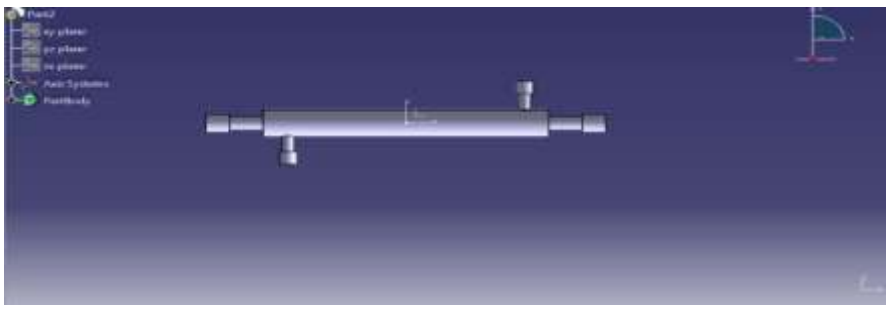
F) Twist Ratio- It is defined as the ratio of pitch length to inside diameter of the tube.

Twisted Tape Heat Exchanger:

Heat transfer rate enhancement is one of the fast growing areas of Heat transfer technology. In fact techniques are available for the improvement of various modes of heat transfer. Second and third generation enhancement technology is already in use in process industry. Coming to the Heat exchanger technology twist type heat exchangers, corrugated surface heat exchangers and extended surface heat exchangers have greater advantages when compared with conventional type of heaters.

A twisted tape is a passive heat transfer enhancement device, generally classified in a swirl flow type device category. Swirl flow devices consist of a greater variety of geometrical flow arrangements in order to produce a stable form of forced vortex fluid motion in confined flows. This device facilitates fluid agitation and mixing of heat patterns induced by swirl flow. The main advantages are mainly they do not require extra attention during assembly, maintenance, inspection and cleaning when intermediate viscous fluids are used.

This devices consists of helically twisted double radius oval tubes, welded their round ends to tube sheets. This device design is similar to structure of Human DNA which is double helical in patterns and extended all along the length and finally ends with DNA strands. The tubes contact one another at their wider sides, six times over the length of one twist pitch which makes the unit practically vibration free. The purely longitudinal shell side flow in twisted tube bundles thereby has an ability to provide high surface area (and density), low pressure drop, good heat transfer rates and coefficients.



III. Methodology:

The experimental setup is fabricated, where the outer covering is made of mild steel. The inlet and outlet valves are provided for both the inner and outer tubes such that the flows of cold and hot fluids are to be in counter flow. The flow is made to be counter flow for the double pipe heat exchanger for obtaining better results. Initially the water is being supplied to both the pipes inlet valves, where the normal water (at room temp) flows into both the pipes. We have the outlet collection of both cold and hot fluids at different ends. At the starting of the experiment the flow rate for both the outlets are measured. The flow rates for both cold and hot fluids are made such that there is a difference between their flow rates. The cold fluid have better flow rate than hot fluid because of the more existence of hot fluid movement in the heat exchanger, more is the chance for heat exchange in the system. Then the water which is flowing into the hot fluid pipe of heat exchanger is heated with the help of heater provided with the system. Here the system is left to operate, with water flowing through the inlets of both pipes and coming out of outlets of the pipes. During this out and in flow process, the hot fluid get temperature as it is being heated. Initially no twisted tape insert is provided inside the double pipe heat exchanger. A reading is taken at that moment which is the reference value. The readings that was taken are temperatures of cold and hot fluids at their inlets and outlets.

IV. Results :

The initial conditions of experimental values were taken for theoretical analysis. For the corrugated twisted pipe and normal pipe double tube heat exchanger the initial conditions were taken as same.
The results were as follows:
Temperature: (Normal pipe)
Hot water inlet : 373K
Hot water outlet : 369.3K
Cold water inlet : 303K
Cold water outlet : 305.6K
Temperature : (Corrugated Twisted pipe)
Hot water inlet : 373K
Hot water outlet : 354.6K
Cold water inlet : 303K
Cold water outlet : 312.2K

Heat Exchangers	Temperatures (k)			
	Cold water inlet	Cold water outlet	Hot water inlet	Hot water outlet
Twisted Pipe	303	321.2	373	354.6
Normal Pipe	303	305.6	373	396.3

V. Conclusion:

On the basis of work data carried out it was better to use the corrugated twisted pipes as a substitute to the normal pipes in the tubular heat exchangers.

By using these corrugated twisted pipes the effectiveness of heat exchangers will be increased as they have more thermal conductivity compared to that of the normal pipes, which can lead to the increase in efficiency of the industry or plant and production rate also could be increased.

The inclusion of twisted tape inserts into the hot fluid pipe of pipe in pipe heat exchanger in counter flow resulted in an improves in its effectiveness.

The increase in the effectiveness value of the heat exchanger is due to the creation of turbulence in the hot fluid channel using the twisted sheets inserts in double pipe.

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