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Flow Analysis and Characteristics Comparison of Double Pipe Heat Exchanger Using Enhanced Tubes

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ABSTRACT: *In this investigation, augmented surface has been achieved with dimples strategically located in a pattern along the tube of a concentric tube heat exchanger with the increased area on the tube side. Augmented surfaces to increasing the heat transfer coefficient with a consequent increase in the friction factor. In this analysis to modify the inner tube of double pipe heat exchanger using dimpled tube. The concentric tube heat exchanger is design from Juin Chen a.et.al. Correlation. In this design the inner tubes consider as the hot flue gas and outer tube is nano fluid. Here In this study the properties of nano fluid from the alumina as the nano fluid with ethyl glycol as the base fluid. a. From this design calculation the heat transfer co efficient is increased compared to plain concentric tube heat exchanger. Similarly the effectiveness is 8% increased compared to plain concentric tube heat exchanger. The theoretical results show that the using dimpled tube in concentric tube heat exchanger gives better performance. The modeling and analysis is carried out to vary the dimple tube cross sections, ellipsoidal and spherical shapes using CFD. Finally the enhanced dimple tube is compare with the theoretical, analytical and analysis the results.*

I. INTRODUCTION

Heat exchanger may be defined as equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running cost. Heat exchangers are mostly used devices in many areas of the industries such as material processing, food preparation refrigerators, radiators for space vehicles, automobiles and air conditioning etc. A lot of methods are applied to increase the thermal performance of heat transfer devices such as treated surfaces, rough surfaces, swirling flow devices, coiled tubes, and surface tension devices.

A great deal of research has focused on various augmentation techniques with emphasis on rough surfaces, transverse or spiral ribs, transverse grooves, knurling, corrugated and spirally corrugated tubes, straight fins, and spiral and annular fins.. Nano fluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water.

1.1 General

Heat exchangers are devices which facilitates the transfer of heat from hot fluid to cold fluid. There are numerous types of heat exchanger which varies in structure and function according to the need. Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then “dumped” into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its “value”. The

Strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved.

1.2 Heat Exchangers

Heating and cooling of materials and fluids is an essential part of processing, production, and fabrication and shop floor jobs in engineering practice. Heat exchangers are used for the above purpose by utilizing the basic principles and correlations of heat transfer along with other relevant physical and engineering principles.

1.3 Classifications of Heat Exchangers

There are several types of heat exchangers which may be classified on the basis of a) Nature of heat exchange process b) Relative direction of fluid motion c) Design and constructional features. Based on the nature of heat exchange process a) Direct contact heat exchangers b) Indirect contact heat exchangers.

1.4 Concentric tube heat exchanger

Concentric tube heat exchangers are used in a variety of industries for purposes such as material processing food preparation and air-conditioning. They create a temperature driving force by passing fluid streams of different temperatures parallel to each other separated by a physical boundary in the form of a pipe. This induces forced convection, transferring heat to and from the product.

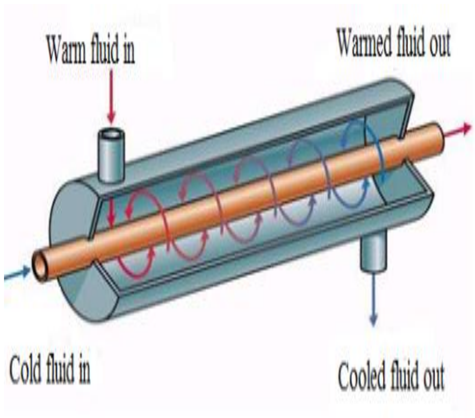

Fig.1.1 Concentric tube heat exchanger

The thermodynamic behaviour of concentric tube heat exchangers can be described by both empirical and numerical analysis. The simplest of these involve the use of correlations to model heat transfer however the accuracy of these predictions varies depending on the design. For conditions where thermal properties vary significantly such as for large temperature differences the seider-tate correlation is used. This model takes into consideration the differences between bulk and wall viscosities.

1.5 APPLICATIONS

Some of heat exchanger applications are following,

- Radiator
- Air conditioner
- Heat engine
- Oil cooling
- Boiler
- Engine cooling
- Waste heat recovery

1.6. DIMPLED TUBE

The dimpled tubes provide heat transfer rates that are higher than the rates found in smooth tubes under similar conditions. This is an important development for the energy conversion and process industries. It was demonstrated that more heat transfer and an earlier transition to high heat transfer can be accomplished through the use of dimpled tubes. Tubes have been evaluated and can be designed to produce more heat transfer than smooth tubes under fouling conditions.

Dimpled tube picture is shown in below:

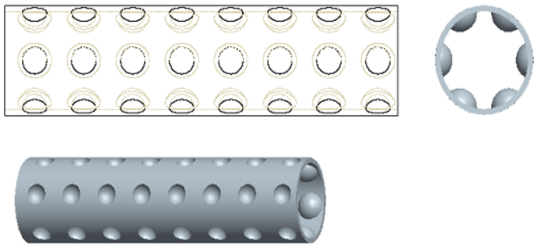

Fig.1.2 Dimpled tube

Dimpled surfaces can create one or more combinations of the following conditions that are favourable for increasing the heat transfer coefficient with a consequent increase in the friction factor:

- ❖ Interruption of the development of the boundary layer and increase of the degree of turbulence
- ❖ Effective heat transfer area increase, and
- ❖ Generation of rotating and/or secondary flows

Two different dimpled shapes are used.

- ❖ Spherical dimpled tube
- ❖ Ellipsoidal dimpled tube

The enhanced structure for both the ellipsoidal and spherical dimple could disturb, swirl, break the boundary layer developing, and enhance the mixing of the hot and cold fluid and then improve the heat transfer of the tubes.

1.6.1. Spherical dimpled tube

Sketch of dimpled tube with spherical shapes is shown in Figure stands for the projected diameter of spherical dimples,

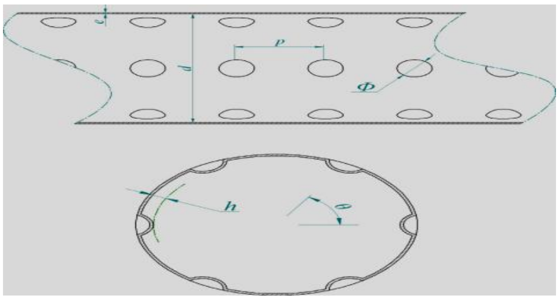

Fig.1.3 Spherical dimpled tube

1.6.2 Ellipsoidal dimpled tube

Sketches of dimpled tubes with ellipsoidal shape are shown in figure, stands for the projected diameter of ellipsoidal dimples.

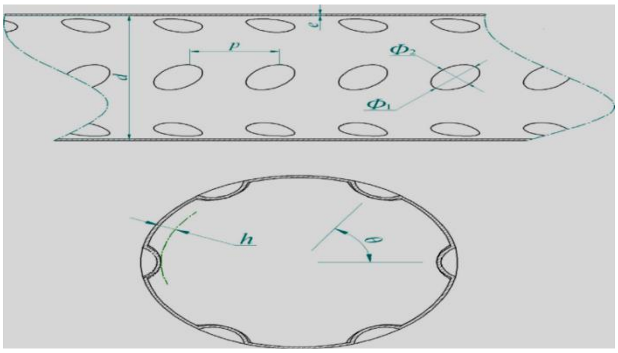

Fig.1.4 Ellipsoidal dimpled tube

1.7 INTRODUCTION TO NANOFLUIDS

Nanofluids are a new class of fluids engineered by dispersing nanometre-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluid are nanoscale colloidal suspensions containing condensed nonmaterial. They are two-phase systems with one phase (solid phase) in another (liquid phase). Nanofluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields. For a two-phase system, there are some important issues we have to face. One of the most important issues is the stability of nanofluids, and it remains a big challenge to achieve desired stability of nanofluids. In this paper, we will review the new progress in the methods for preparing stable nanofluids and summarize the stability mechanisms.

In recent years, nanofluids have attracted more and more attention. The main driving force for nanofluids research lies in a wide range of applications. Although some review articles involving the progress of nanofluid investigation were published in the past several years most of the reviews are concerned of the experimental and theoretical studies of the thermo physical properties or the convective heat transfer of nanofluids. The purpose of this paper will focuses on the new preparation methods and stability mechanisms, especially the new application trends for nanofluids in addition to the heat transfer properties of nanofluids.

1.7.1 Advantages of Nanofluids

- High specific surface area and therefore more heat transfer surface between particles and fluids.
- High dispersion stability with predominant Brownian motion of particles.
- Reduced pumping power as compared to pure liquid to achieve equivalent heat transfer intensification.
- Reduced particle clogging as compared to conventional slurries, thus promoting system miniaturization.

1.7.2 Applications of Nanofluids

- Transportation (Engine cooling/vehicle thermal management)
- Electronics cooling
- Defence
- Space
- Nuclear systems cooling
- Heat exchanger

II. LITERATURE SURVEY

S.E.Juin Chen,et.al.(2001).(1).Heat transfer enhancement in dimpled tubes, Coaxial-pipe heat exchanger using Six dimpled copper tubes of varying geometries were used for comparison with a standard smooth tube. This experiment under performed by turbulent flow. Water as test fluid and experimental method. Best dimpled tube was tube 6, which had the largest dimple depth-to-tube inside diameter ratio, dimple depth to-pitch ratio, dimple depth-to-dimple diameter ratio, and number of dimple columns. Tube 6 have high heat transfer coefficient are significantly larger (between 1.25 and 2.37 times) than those for the smooth tube. Friction factor for all the dimpled tubes are 1.08 to 2.3 times higher than the value for the smooth tube.

A. Kukulka et.al, (2011).(2). Development and evaluation of enhanced heat transfer tubes, Enhancement tube and smooth tubes are compared and material is enhanced 304 L stainless steel tube and steel. This experiment under performed by Turbulent flow in the range of Reynolds Numbers near 2900. Water as working fluid. Increases in heat transfer for most Enhancement tubes are in excess of 120% over smooth tubes and minimize the fouling rate. Inlet water flow was a constant rate of 6 L/min. After the prescribed time, the tubes were drained, samples dried and measurements made. Rate of fouling for the smooth stainless steel tubes were compared to the average values of the four dimpled tubes. Dimpled tubes minimize the fouling rate and also provide heat transfer performance gains in excess of 100%.

D. Suresh et.al,(2010).(3). Experimental studies on heat transfer and friction factor characteristics of Cuo/water nano fluid under turbulent flow in a helically dimpled tube, Helically dimpled tube and plain tubes are compared. This experiment under performed by Turbulent flow Reynolds number in the range between 2500 and 6000. CuO/water and water as working fluid. Nano fluids are prepared by sol-gel method. Observed that with 0.3% volume concentration of copper nanoparticles dispersed in ethylene glycol, its thermal conductivity increased by 40%. The heat transfer results showed that Nusselt number with dimpled tube and nano fluids under turbulent flow is 19%, 27% and 39% (0.1%, 0.2% and 0.3% volume concentrations of nanoparticles in a fluid). Friction factors were about 2–10% higher than the plain tube.

S.W. Kim.et.al,(2012).(4). Numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion-in-dimple surface, Four different protrusion heights were considered and protrusion height to channel height (h/H) of 0.05, 0.10, 0.15, and 0.20. This experiment under performed by turbulent flow. Water as test fluid. CFD analysis and Experimental method and 40% negligible pressure drop, 24% increase heat transfer, increase friction factor up to 5–6% and volume goodness factor slightly increases by approximately 4%.

T.PedroG.Vicente,et.al,(2002).(5). Experimental study of mixed convection and pressure drop in helically dimpled tubes for laminar and transition flow. Helical dimpled tubes and smooth tube are compared. This experiment under performed by laminar and transition flows. Water and ethylene glycol as test fluids, Heat transfer increases suddenly and it is up to 5 times higher than the smooth tube value corresponding to laminar flow. The experimental results of isothermal pressure drop for laminar flow showed dimpled tube friction factors between 10% and 30% higher than the smooth tube ones. heat transfer of dimpled tubes can increases up to 30%.

T.A.Saleh(2002).et.al.(6). Flow and Heat Transfer Performance of A Dimpled-Inter Surface Heat Exchanger-an Experimental /Numerical Study. This paper presents and discusses the flow and heat transfer performance of a parallel/ counter flow heat exchanger, when the heat transfer surface is provided with dimples on one or both sides (cold fluid side and hot fluid side). Evaluation of the performance is based here on experimental and numerical data obtained for a typical such exchanger. It is found that the overall heat transfer rates that are 2.5 times greater for the dimpled surface compared to a smooth surface and the pressure drop penalties in the range of 1.5-2.0 over smooth surfaces.

W.F. Tsai, et.al. (1999). (7). Heat transfer in a conjugate heat exchanger with a wavy fin surface. A three dimensional computational study on conjugate heat exchangers was conducted Attention was specially directed towards studying extended surfaces used to increase heat transfer The strategy adopted in the present investigation of forced convection in a flow passage was to use the finite volume method Our implementation incorporated a SIMPLE based semi implicit solution algorithm which was applied to working equations formulated within the single phase catalo. The analysis allowed for marked changes in thermodynamic and flow properties. To better illuminate the flow and heat transfer characteristics in a flow passage bounded by two fins having wavy geometries we have plotted solutions in a three dimensions.

III. METHODOLOGY

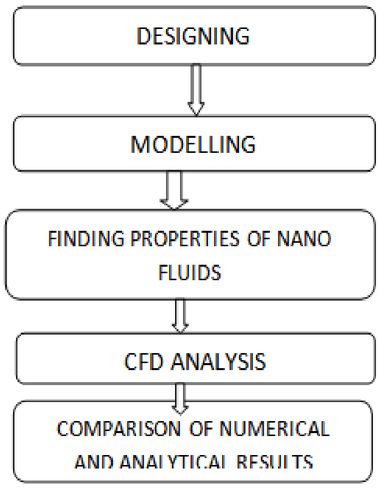

Chart 3: Methodology

IV. CONCLUSION

Augmented surfaces to increasing the heat transfer coefficient with a consequent increase in the friction factor. Here investigation dimpled tube is used. From theoretical calculation the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8% compare to plain tube concentric tube heat exchanger. From theoretical results shows that dimpled tube heat exchanger gives better performance. So we suggest the dimpled tube is used in concentric tube heat exchanger in various applications will give high heat transfer.

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