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Experimental Study and Analysis of Heat transfer Enhancement of Tube in tube Heat exchanger using Delta winglet and Conductive fluid

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Abstract— The heat transfer characteristics of water based conductive fluid in a Tube in tube heat exchanger with the aid of delta winglet will being study. Investigations will be on the effects of Reynolds's number and Nusselt number with the effect of the water based conductive fluid concentration on the heat transfer. An increase in the volume concentration of the nanoparticles in the base fluid caused a significant enhancement in the overall heat transfer characteristics compared to that of water. When a delta winglet will be used, further increment in overall heat transfer coefficient will find for a particular Reynolds's number and Nusselt number. This study is a comparison for Laminar flow and Turbulent flow of water based conductive fluid for heat transfer enhancement depending on Reynolds's Number and Nusselt Number. Study also involves analysis of heat transfer enhancement of tube and tube heat exchanger using delta winglet by water based conductive fluid.

Key words: Active method, Delta winglet

I. INTRODUCTION

Conductive fluid is a new engineered heat transfer liquid and envisioned to describe a fluid in which nanometer-sized particles are suspended in conventional heat transfer basic fluid. Choi was the first who used nanoparticles as suspensions in conventional heat transfer fluids to increase thermal conductivity of these fluids. This has come after a long time of trying to use such suspensions like suspending coarse solid particles (milli- meter or micrometer particles) to improve heat transfer properties of thermal fluids. However, fluids with millimeter or micrometer suspended particles have many problems which could not be over-come like rapid sedimentation, clogging of small channels, excessive pressure drop and the abrasive actions of the particles cause erosion of working systems' components and pipelines, thus there was a real need for a new heat transfer fluid which maintain its properties without side effects on the working systems. The use of nano size solid particles as an additive suspended into the base fluid (nanofluids) is a technique for the enhancement of heat transfer.

In the last 20 years many studies have been published reporting on nano fluids thermo physical properties and performance as heat transfer fluids. However the published results are not always consistent and numerous questions concerning nano fluid properties as well as their specific behavior remains unanswered.

There have been great research interests in exploring the effectiveness and feasibility of using nanofluids as convective heat transfer fluids. Several possible mechanisms for enhancement of heat transfer in nanofluids have been postulated including thermal conductivity enhancement, Brownian motion, thermophoresis, diffusionphoresis, and so on. Compared with suspended conventional particles of millimeter or micrometer dimensions, nanofluids show better stability, high thermal conductivity with negligible pressure drop. By suspending Nano sized particles in heating or cooling fluids, the heat transfer performance of such fluids can be significantly improved. This is due to the following:

- The suspended nanoparticles can increase the surface area and heat capacity of the fluid.
- The suspended nanoparticles can increase the effective thermal conductivity of the fluid.
- The interaction and collision among particles, fluids and the flow passage surface are intensified.
- The dispersion of nanoparticles flattens the transverse temperature gradient of the fluid in its flow passage.
- The pumping power is low when compared to that of pure fluids to achieve equivalent heat transfer enhancements.

There is reduced particle clogging when compared to conventional slurries. Due to the enhanced thermal properties of nanofluids, majority of recent studies are focused on convective heat transfer behavior of nanofluids in laminar and turbulent flows. Almost all of these works report the enhancement of nanofluid convective heat transfer.

Nowadays, twisted-tape inserts have widely been applied for enhancing the convective heat transfer in various industries, due to their effectiveness, low cost and easy setting up. Energy and material saving consideration, as well as economical, have led to the efforts to produce more efficient heat-exchanger equipment. Therefore, if the thermal energy is conserved, the economical handling of thermal energy through heat-exchanger will be possible. The development of high performance thermal systems has stimulated interest in methods to improve heat transfer. The goal of enhanced heat transfer is to encourage or accommodate high heat fluxes. The heat transfer techniques enables heat exchanger to operate at smaller velocity, but still achieve the same or even higher heat transfer coefficient. This means that a reduction of pressure drop, corresponding to less operating cost.

Heat transfer augmentation techniques refer to different methods used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques are used in heat exchangers. Some of the applications of heat exchangers are-in process industries, thermal Power plants, air-conditioning equipment's, refrigerators, radiators for space vehicles, automobiles etc. These techniques broadly are of three types viz. passive, active and compound techniques.

II. DIFFERENT METHODS OF HEAT TRANSFER ENHANCEMENT

Generally, heat transfer enhancement methods are classified in three broad categories:

1) Active method: This method involves some external power input for the enhancement of heat transfer; some examples of active methods include induced pulsation by cams and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, etc.
2) 2. Passive method: These methods generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. For example, use of inserts, use of rough surfaces etc.
3) Compound method: Combination of above two methods.

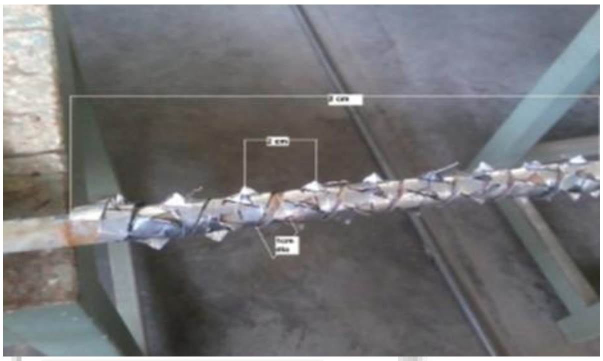

Fig. 1: Delta winglet

A. *Review of Work Carried Out:*

In order to formulate the present research problem along with the methodology that could be adopted for accomplishing this research work, the selective review of the relevant literature surveyed is presented briefly, in following categories:

– Heat transfer enhancement using different inserts
– Heat transfer enhancement using Conductive fluid

Prajapati et al (2012) reveal that there is wide applicability of twisted tape in tubular heat exchanger. Heat transfer rate is increase by using twisted type inserts then the plain tube used plain because twisted type tube insert is increase the turbulence of the flow. Also it is reduce the pressure drop and fouling factor.

Garcia et al (2005) focus on Helical-wire-coils fitted inside a round tube has to characterize their thermo-hydraulic behavior in laminar, transition and turbulent flow. By using water and water–propylene glycol mixtures at different temperatures, a wide range of flow conditions have been covered: Reynolds numbers from 80 to 90,000 and Prandtl numbers from 2.8 to 150. Six wire coils were tested within a geometrical range of helical pitch $1.17 < p/d < 2.68$ and wire diameter $0.07 < e/d < 0.10$. Experimental correlations of Fanning friction factor and Nusselt number as functions of flow and dimensionless geometric parameters have been proposed. Results have shown that in turbulent flow wire coils increase pressure drop up to nine times and heat transfer up to four times compared to the empty smooth tube. At low Reynolds numbers, wire coils behave as a smooth tube but accelerate transition to critical Reynolds numbers down to 700. Within the transition region, if wire coils are fitted inside a smooth tube heat exchanger, heat transfer rate can be increased up to 200% keeping pumping power constant. Wire coil inserts offer their best performance within the transition region where they show a considerable advantage over other enhancement techniques.

Ahmed et al (2012) focused on the heat transfer and flow structure characteristics, studied with the presence of vortex generators (VG). Different types of VGs are displayed. The VGs are embedded, attached, punched or mounted in laminar or turbulent boundary layer were investigated. The impact of VG on convective heat transfer coefficient and friction factor when VGs are present in rectangular channel, triangular duct, flat-plate, fin-tube heat sink, and plate heat exchanger were reviewed. Several arrangements for single, row, and two-dimensional array of VGs through the flow direction are summarized. The main conclusions can be briefly drawn as follows:

– Pointing down rectangular winglet vortex generators yield higher heat transfer rate than pointing up rectangular winglet vortex generators.
– Winglets provide better performance in heat transfer than wings. Delta-winglet pair performs slightly better than a rectangular-winglet pair for identical parameters.
– Heat transfer becomes steady at lower Re number while it becomes unsteady at the higher Re number values when VG is used.
– VGs were successfully used in narrow and micro channels to improve the heat transfer rate.

Ranakoti et al (2012) focused on the study of heat transfer enhancement by Nano fluid, Nano fluids are suspensions of nanoparticles in fluids that show significant enhancement of their properties at modest nanoparticle concentrations. This paper focuses one explaining the basic mechanisms of improvement in heat transfer by addition Nano particles.

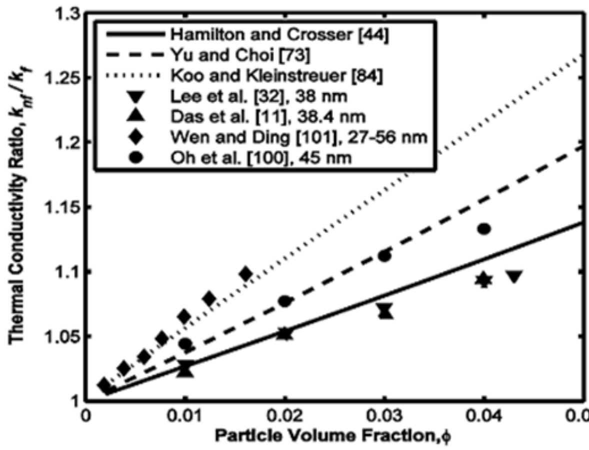

Fig. 2: Particle volume Fraction vs. Thermal conductivity

As we increase the particle volume fraction of the Nano fluids the thermal conductivity will increases simultaneously. But from the figure we see that some authors have got different variation of the thermal conductivity with variation of the Nano particle volume fraction.

Peyghambarzadeh et al (2011) presented traditionally forced convection heat transfer in a car radiator is performed to cool circulating fluid which consisted of water or a mixture of water and anti-freezing

materials like ethylene glycol (EG). In this paper, the heat transfer performance of pure water and pure EG has been compared with their binary mixtures. Furthermore, different amounts of Al2O3 nanoparticle have been added into these base fluids and its effects on the heat transfer performance of the car radiator have been determined experimentally. Liquid flow rate has been changed in the range of 2–6 liter per minute and the fluid inlet temperature has been changed for all the experiments. The results demonstrate that nanofluids clearly enhance heat transfer compared to their own base fluid. In the best conditions, the heat transfer enhancement of about 40% compared to the base fluids has been recorded. The experimental results have demonstrated that the heat transfer behaviors of the nanofluids were highly depended on the particle concentration and the flow conditions and weakly dependent on the temperature. Our results indicate that nanofluids have great potential for heat transfer enhancement and are highly suited to apply in practical heat transfer processes. This provides promising ways for engineers to develop highly compact and effective radiators for cars. These higher heat transfer coefficients obtained by using nanofluid instead of water allow the working fluid in the car radiator to be cooler.
The addition of nanoparticles to the coolant has the potential to improve automotive and heavy-duty engine cooling rates or equally causes to remove the engine heat with a reduced-size cooling system. Smaller cooling systems result in smaller and lighter radiators, which in turn benefit almost every aspect of vehicle performance and lead to increased fuel economy.

A.A. Rabienataj Darzi et al (2011) focused on the effects of Al2O3 nanofluid with a mean diameter of 20 nm on heat transfer, pressure drop and thermal performance of a double tubes heat exchanger. The effective viscosity of nanofluid was measured in various temperatures ranging from 27 °C to 55 °C. Experiments were carried out at different Reynolds numbers ranging from 5000 to 20,000, approximately, and in various nanoparticles concentration up to 1% by volume. Results indicate that there is a good potential in promoting the thermal performance of heat exchanger by adding nanoparticles in the investigated ranges where there is not a severe pressure drop penalty. The empirical correlation was created for Nusselt number variation based on the Reynolds number and nanoparticles concentration.

In the present study, the fully developed turbulent heat transfer and the pressure drop behavior of Al2O3-water nanofluid in double tubes heat exchanger have experimentally investigated. Results were provided as Nusselt number, pressure drop, relative Nusselt number and friction factor and thermal performance of heat exchanger.

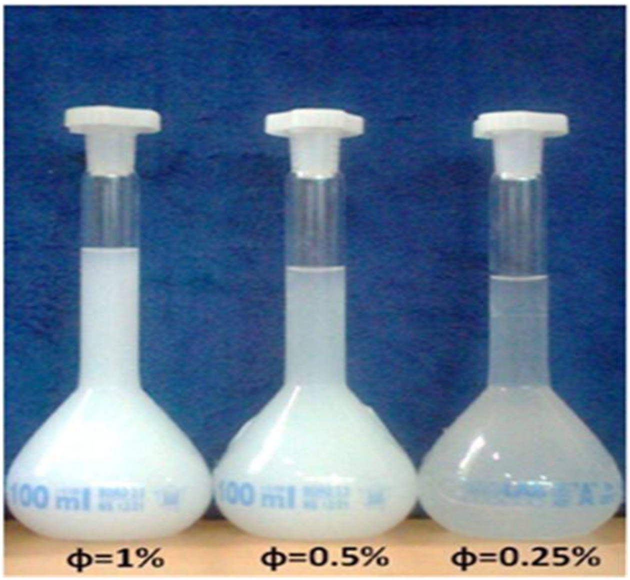

Fig. 3: Samples of prepared conductive fluids

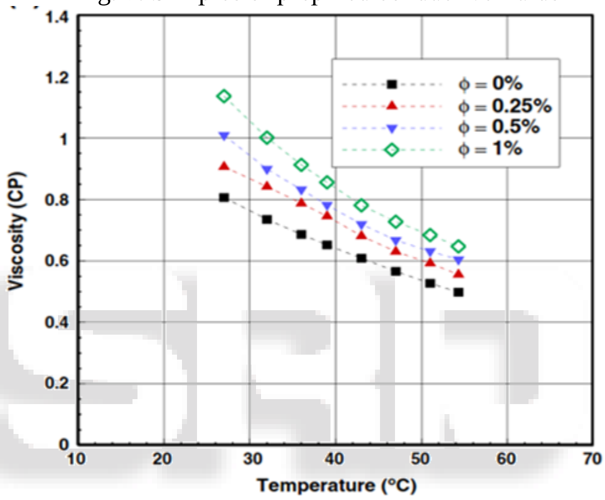

Fig. 4: Temperature (°c) vs. Viscosity

Results indicate that by increasing the Concentration of nanofluid, the heat transfer and the pressure drop simultaneously increase. Meanwhile, by increasing temperature of the fluid, viscosity of the fluid will decrease as shown in Fig.4 the heat transfer rate and friction factor intensify at higher and lower Reynolds number respectively Hence, it can be concluded that adding the nanoparticles to the base fluid has better result at higher Reynolds number.

III. Conclusion

The critical literature review reveals that there is wide applicability of delta winglet and different inserts in tube in tube heat exchanger using different conductive fluids. Heat transfer rate is increase by using delta winglet inserts and conductive fluids then the plain tube and using water as a fluid because delta winglet and tube insert is increase the turbulence of the flow. Also it is reduce the pressure drop and fouling factor. Conductive fluid also increases the heat transfer enhancement.

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