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Heat Transfer Enhancement In Concentric Tube Heat Exchanger : A Review

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Abstract

In this paper, the research on concentric tube heat exchanger with tangential injectors by passing nanofluid on cold side for enhancing heat transfer rate is described. Different properties of nanofluid were studied and based on that, Al2O3 nanofluid was selected due to its great particle stability dispersion. Range of Reynold's number for research purpose is kept between 2500-4500. Three cases were considered in which water was to be passed through both hot and cold side, then nanofluid was to be passed through the cold side and then nanofluid was to be passed to the cold side using tangential injection. Mass flow rate was to be varied in all cases. Based on the research, when heat transfer rate is calculated is these three cases, it is expected that Nusselt number using nanofluid increases about 20-30 percent over distilled water and about 10-20 percent by tangential injection. By using concentric tube heat exchanger with nanofluid using tangential injection, considerable improvement in the heat enhancement factor is expected.

Keywords :- Nanofluid, Al_2O_3, tangential injection, concentric tube heat exchanger.

I. INTRODUCTION

A heat exchanger is an equipment in which heat exchange takes place between two fluids that enter and exit at different temperatures. The main function of heat exchanger is to either remove heat from a hot fluid or to add heat to the cold fluid. Heat exchangers have been widely used in many areas of the industry from the quenching of request to save the energy and energy sources to air conditioning and cooling. Heat exchangers are widely used in many engineering applications, for example, applications in chemical industry, power production, food industry, environment engineering, waste heat recovery, air conditioning, and refrigeration. Types of Heat Exchanger are Concentric tube, Plate type, Shell and Tube type,
Compact type. The direction of fluid motion inside the heat exchanger can normally catagorised as parallel ow, counter ow and cross ow. In this experiment, study on only the parallel ow and counter ow. For counter ow, both the hot and cold fluids flow in the opposite direction. Both the fluids enter and exit the heat exchanger on the opposite ends. In this experiment, Concentric Tube type Heat Exchanger is used. The

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concentric tube heat exchanger was designed in order to study the process of heat transfer between two fluids through a solid partition. It was designed for a counter-ow arrangement and the logarithmic mean temperature difference (LMTD) method of analysis was adopted. Combination of conventional fluids and solid nanoparticles called nanofluid. Different types of nanofluids are Al2O3, SiO2,
CuO, TiO2. The general aim of heat transfer is to reduce the dimension of the heat exchanger for the desired heat passing. The efficiency of the heat exchangers is expected from the parameters such as the physical properties of the fluids, the input temperatures of the fluids, the physical properties of the heat exchanger material, the surface area, kind shape of the interface, whether the fluid ow is laminar or turbulence and the environmental conditions. By taking into consideration these parameters, the improvement of the heat transfer in the heat exchanger could be made by using one from the active and passive methods. The active methods included the methods such as the vibration of surface, the vibration of fluid, with the mechanical methods. These methods require extra the outer power sources. The passive methods are included the methods such as the rough surfaces, the swirl ow devices, the gas mixtures without giving any extra the outer power sources. In this study the swirl flow through tangential injection device that is one of the passive methods is used for increasing the heat convection coefficient. In this work, the effect of heat transfer enhancement of swirl generator with tangential injection of fluid was examined. The tangential injectors are placed such that they are equidistance along the length of pipe to improve the efficiency of heat transfer in concentric pipe heat exchanger the injectors are designed and placed such that it creates tangential ow in the pipe. In this experiment, both water and nanofluid are used as a cold fluid and water is used as hot fluid. Hot fluid will ow through outer tube and cold fluid will ow through inner tube. Pressure gauges are to be mounted on entry and exit of both tubes. Heat exchanger is a device for transferring heat from one medium to another medium at different temperature. Heat exchanger utilizes the fact that, wherever there is a temperature difference between two medium ow of energy occurs. So, that heat will ow from high temperature medium to low temperature medium. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, natural gas processing, and sewage treatment. The classic example of heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heat the incoming air.

Heat transfer enhancement techniques :-

The heat transfer rate can be improved by introducing a disturbance in the fluid ow, which can be achieved by with the twisted tape/turbulator insert in circular tube. Enhancement techniques can be broadly classified into three different categories:
1. Passive Techniques
2. Active Techniques
3. Compound Techniques.
Passive techniques generally use surface or geometrical modifications to the ow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing ow behavior (except for extended surfaces) which also leads to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. Heat transfer augmentation by these techniques can be achieved by using.

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1. Inserts: Inserts refer to the additional arrangements made as an obstacle to fluid flow so as to augment heat transfer. Different types of inserts are:

- Twisted tapes and coils
- Ribs and baffles
- Fins

2. Treated Surfaces: This technique involves using pits, cavities or scratches like alteration in the surfaces of the heat transfer area which may be continuous or discontinuous. They are primarily used for boiling and condensing duties.
3. Rough surfaces: These surface modifications particularly create the disturbance in the viscous sub- layer region. These techniques are applicable primarily in single phase turbulent flows.
4. Extended surfaces: Plain _ns are one of the earliest types of extended surfaces used extensively in many heat exchangers. Finned surfaces have become very popular now a day owing to their ability to disturb the flow weld apart from increasing heat transfer area.
5. Additives for liquids: This technique involves addition of solid particles, soluble trace additives and gas bubbles added to the liquids to reduce the drag resistance in case of single phase flows. In case of boiling systems, trace additives are added to reduce the surface tension of the liquids.

Active techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired ow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in any practical applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases. Various active techniques are as follows:

1. Mechanical Aids: Examples of the mechanical aids include rotating tube ex- changers and scrapped surface heat and mass exchangers. These devices stir the fluid by mechanical means or by rotating the surface.
2. Surface vibration: They have been used primarily in single phase flows. A low or high frequency is applied to facilitate the surface vibrations which results in higher convective heat transfer coefficients.
3. Fluid vibration: Instead of applying vibrations to the surface, pulsations are created in the fluid itself. This kind of vibration enhancement technique is employed for single phase flows.
4. Electrostatic welds: Electrostatic weld like electric or magnetic welds or a combination of the two from DC or AC sources is applied in heat exchanger systems which induce greater bulk mixing, force convection or electromagnetic pumping to enhance heat transfer. This technique is applicable in heat transfer process involving dielectric fluids.
5. Injection: In this technique, same or other fluid is injected into the main bulk fluid through a porous heat transfer interface or upstream of the heat transfer section. This technique is used for single phase heat transfer process.
6. Jet impingement: This technique is applicable for both two phase and single phase heat transfer processes. In this method, fluid is heated or cooled perpendicularly or obliquely to the heat transfer surface.

Compound technique is the one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo- hydraulic performance of a heat exchanger.

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II. LITERATURE REVIEW

Georgiana Madalina Moldoveanu, et. al, This paper shows an experimental study on thermal conductivity of hybrid nanofluids made of Al_2O_3–SiO_2 suspended in pure water. Also, simple nanofluid samples, with various volume fractions of Al_2O_3 and SiO_2 were prepared and used for comparison. Analysis clearly outlined the influence of volume fraction on thermal conductivity and few correlations were proposed based on experimental results.

Nanofluids are suspensions which consist from a base fluid (such as water, ethylene glycol, and engine oil) and solid particles with a diameter of less than 100 nm. Due to higher thermal conductivity of solid particles compared to liquids, it may be obtained working fluids with significant enhanced thermal conductivities that can be used in thermal devices. Realizing the unique properties of nanofluids and their potential, in last years, a novel class of nanofluids, which consist from two or three solid particles suspended in the base fluid, called hybrid nanofluids, was developed. Numerous studies have been conducted to investigate the thermal-physical properties of nanofluids and hybrid nanofluids. If the studies on the thermal conductivity of alumina nanofluids can be easily found in the current literature, regarding the silica nanofluids, only few studies on thermal conductivity are reported in literature, although these types of nanoparticles are low cost, and therefore, can be purchased more easily.

The thermal conductivity of SiO_2/water was investigated. The mass fraction of SiO_2 nanoparticles were 1.0%,3.0%, and 5.0%respectively, at temperature of 20^oC to 50^oC.The result concluded that, the thermal conductivity increases with increase in both temperature and mass fraction. The thermal conductivity of SiO_2 is different than other existing models, and the difference is 14%. Hybrid nanofluid have thermal conductivity larger if compared to alumina nanofluid, due to strong influence of adding silica nanoparticles.

This paper presents the experimental results of study on thermal conductivity for two nanofluids and their hybrid. Al_2O_3 – water, SiO_2 – water nanofluids and Al_2O_3 - SiO_2 – water hybrid nanofluid were used. Results showed an increase of thermal conductivity with volume fraction increase, as well as with temperature rise. Higher volume fractions of SiO_2 nanoparticles placed in studied hybrid nanofluids leads to higher thermal conductivities.

Three types of nanofluids were prepared:- Al_2O_3+warer, Sio_2+water, and Al_2O_3+SiO_2+water.The nanofluids selected are on the basis of weight% oxide, volume% oxide, average particle size nm, ph value, molecular weight g/mole etc.

Mehdi Bahiraei, et. al, It has been known that heat exchangers have proven to be important devices in engineering field. Recently nanofluids are employed as coolants in them. This paper show the use of different nanofluid in different types of heat exchangers.
Most of the times, fins are used as a way of increasing heat transfer rate. But fins increase the weight and volume of the heat exchangers. So, to overcome these restrictions nanofluids are used in cold fluid in heat exchanger. Also, nanofluid has great thermal conductivity and proper stability.
In concentric tube heat exchanger, The results showed that the use of Al2O3–water nanofluid significantly gives higher heat transfer coefficients than those of the base fluid with the enhancement of greater than 12%. For the same range of Reynolds number, addition of nanofluid resulted in about 14 % increase in heat

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transfer rate. It was found that nusselt number is highest for CuO-water. In comparison with water, 30% heat enhancement was seen for 2% nanofluid.
Research studies conducted on double-pipe heat exchangers are dependent on type of nanofluids used. Hybrid nanofluids can be applied in the future as promising nanofluids for heat transfer.
Use of concentric tube heat exchanger was studied. Also, with the help of comparison of different nanofluids, selection of proper nanofluid is to be done.

Gulsah Cakmak, et. al, In this paper, undertaken to enhance heat transfer rates, swirling motion was imposed on the hot air by placing injectors with various diameters and numbers in triangle line rows on the entrance section of the inner pipe of the concentric heat exchanger. The experiments were carried out for counter current flow models of the fluids at different Reynolds numbers. The results showed that up to 93% enhancements could be accomplished in heat transfer rates. Different types of active and passive techniques foe heat enhancement were studied. Active techniques include use of external power like vibration by mechanical methods. Passive techniques include change in geometry of the system like changing the diameter of injectors. After this study, swirl flow was generated i.e. passive techniques which was used to calculate the results. Due to generation of swirl flow with the help of injectors along the length which were inclined less than 90-degree, heat transfer rate was calculated. Also, Nusselt number was calculated. Diameter of the injectors was decreased and also the number of injectors were increased accordingly. As the diameter of injectors was decreased and the no. of injectors was increased, the heat transfer rate and also the Nusselt number was increased. Also, the increase in Nusselt number was low of smaller Re numbers while it became greater of high Re numbers. Swirl flow will be generated with the help of tangential injection. Reynolds number will be kept constant throughout the process. Concentric tube heat exchanger is to be used.

D.Han et. al. In this paper nanofluid is used to enhance heat transfer rate . Initially experiment was conducted on distilled water used as cold side on heat ex- changer . This is to establish the accuracy of the measurement for comparison while using nanofluid as cold fluid. Present experiment conducted by using nanofluid on cold side of heat exchanger. Nanofluid is used with different concentrations with Reynolds number varying between 20000 to 60000.heat transfer coefficient increase with increase in Reynolds no. Then experiment conducted with different concentrations of nanofluid and varying temperature range within 40C to 50C it is seen that at higher temperatures convective heat transfer rate is higher and Nusselt number achieved is larger compared to initial test. From this temperature study an important characteristics of nanofluid is its strong dependency of thermal conductivity was understood. Result from the experiment show significant improvement over the Nusselt number rising upto 24.5 percent. by varying concentration of nanofluid convective heat transfer increase and by increasing inlet temperature heat transfer of nanofluid is increase.

Chang et al.Experimental studied when uid is injected tangentially, the tur- bulent flow field in the tube heated uniformly from the wall. The experiments where conducted by injecting air through injectors placed on the periphery of a 88.9 mm inside diameter and 2.5 m long acrylic tube. Six injectors of 22.23 mm diameter where used tangential to provide total momentum flux ratio of 2.67 was obtained in the experiments. Temperature profiles where measured with resistance thermometer probe. Profiles for mean velocities in the axial and tangential directions, as well as Reynolds stresses were obtained using a single

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rotated straight hot wire and a single rotated slanted hot wire anemometer. No significant difference in mean velocities Reynolds stresses were found between the adiabatic experiments and diabatic ones. Two measure mechanisms for enhancement of heat transfer are identified: (1) high maximum axial velocity near the wall produces higher heat flux from the wall; and (2) high turbulence level in the middle region of the tube improves mixing and thus the rate of heat transfer. In injection induced swirl ow, the kinetic energy of the mean ow and its decay rates, and the turbulence level decreases with the axial distance. However high turbulence is necessary to transfer the kinetic energy of the man ow to the turbulence energy in a decaying process. The high turbulence production, in turn, slows down the rate of decrease of turbulence level.

III. RELEVANCE

Use of concentric tube heat exchanger was studied. Also, with the help of comparison of different nanofluids, selection of proper nanofluid is to be done depending on the availability, heat tranfer rate, cost, thermal conductivity, etc. Nanofluid is used to achieve the heat transfer enhancement in the double tube heat exchanger. The nanofluids selected are on the basis of weight percent oxide, volume percent oxide, average particle size nm, ph value, molecular weight g/mole etc. Swirl flow will be generated with the help of tangential injection.

IV. MOTIVE

The general aim of heat transfer is to reduce the dimension of the heat exchanger for the desired heat passing. The efficiency of the heat exchangers is affected from the parameters such as the physical properties of the fluids, the input temperatures of the fluids, the physical properties of the heat exchanger material, the surface area, kind shape of the interface, whether the fluid flow is laminar or turbulence and the environmental conditions. So, different types of heat enhancement techniques include use of fins, vibration of surface, generator. Fins are frequently used, due to this technique weight and volume of heat exchanger increases and techniques like vibration of surface have limited applications because it requires external power source. Tangential injection is used to generate swirl flow which is useful in the increase of heat convection coefficient. The thermal conductivity of nanofluid is about 700 times that of water. Also surface to volume ratio of a nano particle is comparatively more. For thermal industry, the replacement of cooling and heating water with nanofluids has the potential to conserve 1 trillion Btu of energy.

V. CONCLUSION

Heat exchanger has many engineering applications such as air conditioning, chemical reactor and refrigeration systems, etc. The performance of this industries mainly depends on the performance of heat exchanger. So, to increase the performance of heat exchanger many techniques have been investigated on enhancement of heat transfer rate and decrease the size and cost of the heat exchangers. In most of applications and key areas like power plants, process amp; chemical industries uses surface enhancement methods.Present work mainly emphasis on the both passive and active methods of heat transfer enhancement. In this work, to enhance the heat transfer rate with the help of nanofluids in passive method used. In the active method fluid is injected in annulus space to generate turbulence through tangential injectors. There are six injectors are used to generate turbulence. Nanofluid is used as a working fluid as cold fluid. From the experiment it shows that, as reynolds number increases heat transfer coefficient also

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increases. Heat transfer enhancement by nanofluid and tangential injection as compared to water as working fluid and parallel flow.

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