A Review on Heat Transfer Enhancement Using Nanofluids

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***Abstract*- Nanofluids are a fluids containing nanometer-sized particles, called nanoparticles. These fluids are Suspension of nanoparticles in customary fluids. Nanofluids have been the subject of escalated think about worldwide since spearheading analysts as of late found the odd thermal conduct of these fluids. The improvement of heat exchange utilizing nanofluids have been utilized as one of the detached heat move systems in a few heat exchange applications. It is considered to have extraordinary potential for heat exchange improvement and are exceptionally fit to application in heat exchange forms like microelectronics, energy units, pharmaceutical procedures, and half and half fueled motors, motor cooling/vehicle thermal administration, local icebox, chiller, heat exchanger, and in heater vent gas temperature decrease. This survey covers the upgrade of heat exchange by utilizing nanofluids and potential utilizations of nanofluids. This paper exhibits a refreshed audit of the heat exchange utilizations of nanofluids to create bearings for future work on the grounds that the writing around there is spread over a wide scope of controls, including heat exchange, material science, physical science, substance designing and engineered science.**

Index Terms- Heat Transfer, Enhancement, Active and Passive Techniques, Nanofluid, Nanoparticles, Heat exchanger.

I. INTRODUCTION

Heat exchangers are an essential part in an assortment of mechanical settings, for example, cooling frameworks, force plants, refineries, and in this way ceaseless endeavour are made to expand their heat transfer efficiencies. In late decades while there has been constant advance in enhancing the execution of heat exchangers by tending to their development and format issues, the poor heat transfer properties of the working liquids utilized as a part of the heat exchangers have still remained an essential execution constraining element for these frameworks.

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

(a) Active method: These techniques are more complex from the use and design point of view as the method requires some external power input to cause the desired flow modification and improvement in the rate of heat transfer. It finds limited application because of the need of external power in many practical applications.

(b) Passive method: These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop. These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately leads to an increase in fluid pressure drop.

(c) Compound method: A compound augmentation 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. When any two or more of these techniques are employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is termed as compound enhancement. This technique involves complex design and hence has limited applications.

Enhancement of heat transfer using various techniques has received strong attention over the years in order to reduce the size and cost of heat exchanger. Many techniques have been developed for enhancing heat transfer rate in heat exchanger as the effective ones: (1) Nanofluids (2) Inserting fluid turbulators and (3) Roughening heat exchanger surfaces. Although for better heat transfer, combination of all the three or any two techniques can be used.

Heat exchanger using Nano fluid is a device in which the heat transfer takes place by using Nano fluid.

1.1 Nanofluids

Nanofluids have attracted much attention recently because of their potential as high performance heat transfer fluids in electronic cooling and automotive. Performance of heat transfer equipment can be improved with studies related to a significant increase in heat flux and miniaturization. In many industrial applications such as power generation, microelectronics, heating processes, cooling processes and chemical processes, water, mineral oil and ethylene glycol are used as heat transfer fluid. Effectiveness and high compactness of heat exchangers are obstructed by the lower heat transfer properties of these common fluids as compared to most solids. It is obvious that solid particles having thermal conductivities several hundred times higher than these conventional fluids, as. To improve thermal conductivity of a fluid, suspension of ultrafine solid particles in the fluid can be a creative idea. Different types of particles (metallic, non-metallic and polymeric) can be added into fluids to form slurries. Due to the fact that sizes of these suspended particles are in the millimeter or even micrometer scale, some serious problems such as the clogging of flow channels, erosion of pipelines and an increase in pressure drop can occur. Moreover, they often suffer from rheological and instability problems. Especially, the particles tend to settle rapidly. For that reason, though the slurries have better thermal conductivities but they are not practical.

1.2 Nanofluid Synthesis

Planning of nanofluids is the first stride to the exploratory investigations of nanofluids. The best possible use of the capability of nanofluids relies on upon the planning of nanofluids. There are two principle routines to set up a nanofluid: The single-step planning procedure and the two-stage arrangement process.

1.2.1 Single-step synthesis process

The single-step readiness procedure demonstrates the blend of nanofluids in one-stage. A few single-step systems have been touched base for Nanofluid readiness. Akoh et al. investigated and built up a solitary step direct dissipation technique. In this technique the vaporized metal is dense and after that scattered by deionised water to deliver nanofluids. Leverage of blend by one-stage strategy is that Nano-particles agglomeration is minimized. Be that as it may, prime issue is that just low vapour weight liquids are good with such a procedure. One-stage arrangement process (chemical procedure) of nanofluids is given in the Figure.1

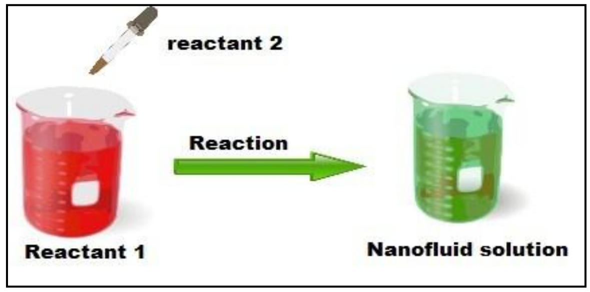

Figure 1: One-step preparation process of Nano-fluids

1.2.2 Two-step preparation process

Two-stage arrangement procedure is broadly utilized as a part of the union of nanofluids by blending base liquids with industrially accessible Nano powders got from diverse mechanical, physical and substance procedures, for example, processing, crushing, and vapour stage techniques. An ultrasonic vibrator or higher shear blending gadget is for the most part used to blend Nano Powders with host liquids. Incessant utilization of Ultra Sonication blending is obliged to lessen molecule agglomeration. A few writers proposed that two-stage procedure is exceptionally suitable for get ready nanofluids containing oxide Nano-particles than those containing metallic Nano-particles. Steadiness is a major issue that intrinsically identified with this operation as the powders effectively combine because of solid van-der-wal forces among Nano-particles. Regardless of such weaknesses this procedure is still prominent as the most financial procedure for nanofluids generation. The most widely recognized two -step strategy is indicated in Figure 2.

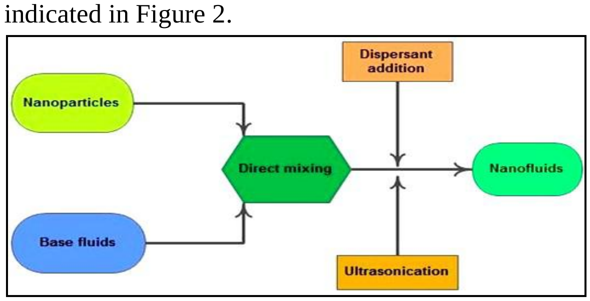

Figure.2: Two step preparation process of Nanofluids

1.3. Stability of Nanofluids
Nanofluids have an undesirable propensity which influences their capability to exchange heat because of their inclination to coagulation. Subsequently, investigation on steadiness is an unavoidable issue that can change the thermo-physical properties of nanofluids for application furthermore essential to dissect the compelling variables to the dependability of such suspensions. Underneath said is a brief talk on the strength development routines and dependability upgrade forms alongside a brief about the steadiness instruments identified with nanofluids.

1.4 Advantages of Nanofluids
Nanofluids cause drastic change in the properties of the base fluid so, the following benefits are expected to get on.

- Due to nano size particles, pressure drop is minimum.
- Higher thermal conductivity of nanoparticles will increase the heat transfer rate.
- Successful employment of nanofluid will lead to lighter and smaller heat exchanger.
- Heat transfer rate increases due to large surface area of the nanoparticles in the base fluid.
- Nanofluids are most suitable for rapid heating and cooling systems.
- Due to nano size particles, fluid is considered as integral fluid.
- Good mixture nanofluids will give better heat transfer.
- Microchannel cooling without clogging. Nanofluids are not only a better medium for heat transfer in general but they are also ideal for microchannel applications where high heat loads are needed.
- Cost and energy saving. Successful employment of nanofluids will result in significant energy and cost savings because heat exchange systems can be made smaller and lighter.

II. LITERATURE REVIEW

A considerable amount of experimental as well as analytical and computational research has been carried out on the enhancement of heat transfer. In this chapter, a brief survey of the relevant literature is presented to indicate the extent of work already reported in open literature pertaining to the enhancement of heat transfer by introducing nano fluid.

2.1 PREVIOUS WORK
L.B. Mapa et al.(1997): Measured enhanced thermal conductivity of Cu-water Nano fluid using shell and tube heat exchanger. Where the dimension of heat exchanger is 240x24x0.25mm, using 37 tubes. The outcome of this analysis is rate of heat transfer is increases with increasing flow rate and also its concentration. By nanoparticle dispersed into de-ionized base fluid a better enhancement is achieved
J. Koo et al.(2000): Investigated the nanoparticle collision and deposition in the surface wall with help of micro channel heat sink. Which has the dimension of 1cmx100micometerx300micrometer, water-Cuo and Cuo-ethylin glycol Nano fluids are through the micro channel heat sink? They are investigated the base fluid should possess high prandtl number, and get enhanced heat transfer rate by minimize particle-particle and particle-wall collision. Viscous dissipation effect is important of narrow channel, because Nusselt number high for high aspect ratio channel.
Shung-Wen Kang et al.(2001): Studied about the relation between thermal resistance-size of nanoparticle with help of 211 micrometer*217 micrometer sized and deep grooved circular heat pipe and heat pipe maintain 400C temperature. They are finalized thermal resistance is directly proportional to the size of the nanoparticle. Maximum reduction of thermal resistance by using 10 nm sized particles, because particle size is increasing the wall temperature also increases. So small sized particle suitable for enhanced heat transfer rate. Thermal resistance is decreases with increasing heat and concentration of Nano particle.
Shuichi Torri et al.(2001): Investigated convective heat transfer co efficient of diamond based Nano fluid by using heat tube apparatus. Specification of tube is 4.3mm, 4mm outer and inner diameter respectively, and applied 100W power unofomly.They are showed the heat transfer coefficient is increases with increasing concentration and Reynolds number of Nano fluid. But at the same time increased the pressure drop with increasing concentration of Nano particle.

S.J.Kim et al.(2002): Investigated formation of porous layer and wettability of Nano fluid using critical heat flux experiment and SEM images. They are used three different type of nanoparticles with different diameters such as Al2O3 (110-210nm), SiO2 (20-40nm) and ZrO2 (110-210). They are showed boiling is main factor to affect the heat transfer rate of Nano fluid. Due to nucleate boiling nanoparticle deposited on wall, so the porous layer is formed on the wall. Porous layer directly consequence for creating wettability, cavity and roughness of the surface wall. So heat transfer rate decreased due to boiling of Nano fluid.

PaisarnNaphon et al.(2003): Investigated the thermal efficiency of heat pipe using titanium-alcohol Nano fluid, heat pipe dimensions are 60mm and 15mm length and outer diameter respectively. The thermal efficiency increases with increasing tilt angle within 60o angle and concentration of nanoparticle.

Anil Kumar et al.(2004): studied the heat transfer enhancement of fin, utilizing AL2O3-Water Nano fluid analyzed using CFD. Rayleigh number increases due to Brownian motion, ballistic phonon transport, clustering and dispersion effect of nanoparticle. At high Rayleigh number flow rate at center of the circulation is increasing, so temperature is drop from center of fin. Volume of the circulation increases the velocity at center is increases as the result of increasing the solid-fluid heat transportation. Low aspect ratio fin is suitable for heat transfer enhancement, because heat affected zone is less.

Yu-Tang chen et al.(2005): Investigated the thermal resistance of heat pipe using Ag-DI Water Nano fluid, heat pipe made as 200cmx3mm length and thickness respectively. Heat resistance is increases with increasing concentration of Nano fluid up to 50ppm. Due to wettability of nanoparticle various geometry of wick is created on heat pipe.

Eed Abdel Hafez Abdel-hadi et al.(2006): Investigated the heat transfer analysis of vapor compression system using CuO-R134a Nano fluid, test section made of copper horizontal tube and heat is applied 10-40 KW/m2. Heat flux, concentration, and size particle is important factor to enhance the heat transfer rate of Nano fluid. Heat transfer rate is increases with increasing heat flux, up to 55% of concentration of Nano fluid and up to 25nm sized particles.

Somchaiwongwises et al.(2007): Investigated heat transfer enhancement and flow characteristic of Al2O3-Water Nano fluid using micro channel heat sink. The dimension of test section is 5x5mm and 50W heat is applied. Heat transfer is enhanced at high Reynolds number and high concentration of Nanofluid, because at high Reynolds number wall temperature is decreases and pressure drop is increased.

Yannar et al.(2008): Investigated the flow and heat transfer characteristic of spiral pipe heat exchanger using different type of Nano fluid with different concentration such as Al2O3-water, TiO2-water, CuO-water Nano fluid with 1%, 1% and 3% concentration respectively. Test section made of copper tube had the ratio of pitch per diameter is 7, mean hydraulic diameter is 30mm, 10mm diameter and 1600mm length. Heat transfer enhanced 28% at 0.8% concentration of Nano fluid, due to high concentration shear stress of Nano fluid is increased. Heat transfer enhancement is high in spiral pipe compared with circular pipe, because the pressure drop is high in spiral pipe. Heat transfer co efficient is decreases when axial distance of Nano fluid is increasing, because formation of boundary layer.

H.Niazmand et al.(2010): Studied convective heat transfer of carbon Nano tube-water Nano fluid using isothermally heated 900 curved pipe, and set an inlet temperature of fluid and wall is 293K and 363.15K. They analyzed the relation between peclet numbers and enhance heat transfer rate, inside the curve flow accelerate along the outer wall region due to centrifugal force, so maximum velocity shifted towards the outer wall of pipe and forming secondary flow. Secondary flow is formed due to curvature effect, so enhanced heat transfer by the secondary flow formation. Curvature effect is more promoted at Peclet number. Minimum intensity of flow occur at middle of the curve, due to high Reynolds number amplified the centrifugal force. Monolayer is formed at solid particle interface, so thermal conductivity of monolayer is much greater compared with bulk fluid.

Manag et al.(2011): Investigated the friction factor and heat transfer rate of CuO-Water and Al2o3-water Nano fluid using micro channel heat sink. Dimension of test section is 100x100x20000micrometter, assumed steady state laminar flow occurred, neglected the radioactive heat transfer and adiabatic constant heat flux applied at bottom of heat sink is

5000 W/cm2. As the result of increasing Nusselt number with increasing the Reynolds number and concentration but decreased the friction factor of Nano fluid. Compared the CuO-water and Al2O3-water Nano fluids the CuO-water Nano fluid showed better enhancement and low friction factor.

Praveen al et al.(2012): Studied the heat transfer enhancement Al2O3-water Nano fluid. Heat transfer rate is calculated with various temperature (250-800), various concentration (0.01-0.5%) and various Reynolds number (2500-5000). Heat transfer rate is increased with increasing Reynolds number and concentration of Nano fluid but decreased when increasing inlet temperature of Nano fluid.

Mahdi Pirhayati et al.(2013): Studied the pressure drop of Nano fluid at an inclined tube, tube having dimension of 12x120x0.9mm, cross section area of tube is circular and uniformly heat is applied on the surface of tube is 3200W/m2. As the result of pressure drop is increased with increasing the Reynolds number and concentration of Nano fluid. Inclined tube having less pressure drop compared with horizontal tube and minimum pressure drop is occurred, when the tube is inclined at 300 angles.

Manna et al.(2014): Investigated the thermal conductivity enhancement of SiC-water Nano fluid using transient hot wire device. Thermal conductivity of Nano fluid is increased with increasing the concentration of nanoparticle, 26% of maximum thermal conductivity is obtained when using 0.8% concentration of Nano fluid. Mechanically milled nanoparticles having high heat transfer enhancement. Nanoparticle volume and shape is important factor to enhance the thermal conductivity of Nano fluid, at 27nm sized nanoparticle enhanced 12% of thermal conductivity Nano fluid.

Shriram S. Sonawane et al.(2015): Investigated the heat transfer characteristics of Al2O3 – water nanofluids as a coolant used in concentric tube heat exchanger .The heat exchanger is fabricated from copper concentric inner tube with a length of 1000 mm. The nanofluids are the mixture of water as base fluid and Al2O3 particles in Nano range. The results obtained from the nanofluids cooling in concentric tube heat exchanger are compared with those from base fluids. The effects of inlet flow rate of hot fluids, Reynolds's number and composition of nanofluids on concentric tube heat exchanger are considered. It is observed that average heat transfer rates for nanofluids as cooling media are higher than those for the water as cooling media, and this increases with concentration of nanofluids' composition. The results of this study have technological importance for the efficient design of concentric tube heat exchanger to enhance cooling performance at low heat flux cooling systems

K.Somasekhar et al.(2016): In this study a multi pass shell and tube heat exchanger with 3 tubes modeling is done using CATIA and meshing has done using ICEM CFD software, simulations has done by using CFD-FLUENT software. Using Fluent, computational fluid dynamics software the pressure drop, heat transfer characteristics of Al2O3-water nanofluid, and Distilled water are analyzed under turbulent flow condition. Nanofluid such as Al2O3-H2O is used as cooling medium instead of Distilled water. Finally the CFD simulated results are compared with experimental results. The effects of Peclet number, volume concentration of suspended nanoparticles, and particle type on the heat transfer characteristics were investigated. Based on the results, adding of nanoparticles to the base fluid (Distilled water) causes the significant enhancement of heat transfer characteristics.

Rohit S. Khedkar et al. (2017): experimental study on concentric tube heat exchanger for water to nanofluids heat transfer with various concentrations of nanoparticles in to base fluids and application of nanofluids as working fluid. Overall heat transfer coefficient was experimentally determined for a fixed heat transfer surface area with different volume fraction of Al2O3 nanoparticles in to base fluids and results were compared with pure water. It observed that, 3 % nanofluids shown optimum performance with overall heat transfer coefficient 16% higher than water.

III. CONCLUSIONS

The present papers gives a review about the enhancement of heat transfer by using nanofluids by many authors that preformed an experimental and numerical investigations related to heat transfer enhancement using nanofluids. So, we need to understanding the fundamentals of heat transfer and wall friction from this review because has a significant importance for developing nanofluids for a wide range of heat transfer applications and we can concluded the following:

1. Heat transfer rate is directly proportional to the Reynolds number and peclet number of Nanofluid.
2. Increasing volume Concentration of nanoparticles increases the pressure drop of Nanofluids.
3. Spherical shaped nanoparticles increases the heat transfer rate of Nanofluids compared with other shaped nanoparticles.
4. The fine grade of Nanoparticles increases the heat transfer rate but it's having poor stability.
5. Increasing size of nanoparticales (diameter of NP) led to decreasing in heat transfer because area per unit volume decreases.

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