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Enhancement of Heat Transfer Using Nano Fluids –A Review

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Abstract-The important factor for rapid cooling and heating application is thermal conductivity. Modern nanofluid have high heat transfer rate compared to base heat transfer fluids because of low thermal conductivity .Nanofluid is nano sized particle such as metal, oxide, and carbide etc., dispersed into base heat transfer fluid. In this paper shows important factors affecting the thermal conductivity of nanofluid at different conditions. Many researchers had done to increase the heat transfer rate by considering high thermal conductivity of nanofluid. Fluid parameters like shape, size, clustering, collision, porous layer, melting point etc., affects thermal conductivity of the nanofluid .Thermal conductivity of Nanofluid can controlled by increased by controlling this type of parameters.

Keywords-Nanofluid, thermal conductivity, heat transfer rate, clustering, porous layer.

I. INTRODUCTION

A Nanofluid is a fluid that contain nanometre size metal particle, called nanoparticles. These fluid are engineering colloidal suspension of nano particle in base fluid. Nanoparticle used in Nano fluids are typically made of metals, oxides, carbides or carbon Nanotube. Common base fluids include water, ethylene glycol and oil. They exhibit high thermal conductivity and convective heat transfer coefficient compared to the base fluid.

1. Needs of Nano Fluid

- Nanoparticle increases the heat transfer rate due to high thermal conductivity.
- Heat transfer rate is increases due to large surface volume of nanoparticle in base fluid.
- Pressure drop is minimum. due to size of nanoparticles
- Drastic change in the properties of base fluid, by suspension of nanofluids.
- Successfully employed nanofluid will lead to lighter and smaller heat exchanger

2. Preparation of Nano Fluid

Nanofluids are supplied by two methods called the one-step and two-step methods. One step technique, the first step is production of nanoparticle and second step is the dispersion of the nanoparticle in a base fluid. Second technique is a mass production method of nano fluids by utilizing the inert gas condensation technique. The main disadvantage of two step method is form cluster during preparation of nanoparticle.

3. Application of Nano Fluid

Nanofluid can be used to cool automobile engine and welding equipment and cool high heat flux device such as high power microwave tube, and high power laser diode array. Nanofluid could flow through the tiny passage in MEMS to improve the efficiency. Some common applications are: - Thermal storage

- Nuclear cooling system
- Defence and space application
- Solar water heating
- Boiler exhaust flue gas recovery
- Cooling of electronic circuit
- Refrigeration
- Engine cooling

- Engine transmission oil
- Bio-medical application
- Drilling and lubrication

II. LITERATURE SURVEY

1. L.B. Mapa et al: Measured enhanced thermal conductivity of Cu-water nanofluid using shell and tube heat exchanger. Where the dimension of heat exchanger is 240 x 24 x 0.25 mm, using 37 tubes.Theoutcome of this analysis is rate of heat transfer is increases with increasing flow rate and also its concentration. By nanoparticle dispersed into deionized base fluid a better enhancement is achieved
2. J. Koo et al: Investigated the nanoparticle collision and deposition in the surface wall with help of micro channel heat sink which has the dimension of 1 cm x100 µm x 300 µm, water-Cuo and Cuo-ethylin glycol nanofluids are through the micro channel heat sink. They 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.
3. Shung-Wen Kang et al: Studied about the relation between thermal resistance-size of nanoparticle with help of 211 µm *217 µm sized and deep grooved circular heat pipe and heat pipe maintain 400°C temperature. They 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 nanoparticle.
4. Shuichi Torri: Investigated convective heat transfer co efficient of diamond based nanofluid by using heat tube apparatus. Specification of tube is 4.3mm,4mm outer and inner diameter respectively and applied 100W power unifomly. They are showed the heat transfer coefficient is increases with increasing concentration and Reynolds number of nanofluid. But at the same time increased the pressure drop with increasing concentration of nanoparticle.
5. S.J.Kim et al: Investigated formation of porous layer and wettability of nanofluid using critical heat flux experiment and SEM images. They are used three different type of nano particles with different diameters such as Al2O3 (110-2 10nm), SiO2 (20-40nm) and ZrO2 (110-210). They are showed boiling is main factor to affect the heat transfer rate of nanofluid. 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 nanofluid.
6. PaisarnNaphon et al: Investigated the thermal efficiency of heat pipe using titanium-alcohol nanofluid, heat pipe dimensions are 60 mm and 15 mm length and outer diameter respectively. The thermal efficiency increases with increasing tilt angle within 60° angle and concentration of nanoparticle.
7. Anil Kumar et al: studied the heat transfer enhancement of fin, utilizing Al2O3 -Water nanofluid 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 centre of the circulation is increasing, so temperature is drop from velocity at centre is increases as the result of increasing the solidfluid heat transportation. Low aspect ratio fin is suitable for heat transfer enhancement, because heat affected zone is less.
8. Yu-Tang chen: Investigated the thermal resistance of heat pipe using Ag-DI Water nanofluid, heat pipe made as 200 cm x 3mm length and thickness respectively. Heat resistance increases with increasing concentration of nanofluid up to 50ppm. Due to wettability of nanoparticle various geometry of wick is created on heat pipe.
9. Eed Abdel Hafez Abdel-hadi et al: Investigated the heat transfer analysis of vapour

compression system using CuO- R134a nanofluid, 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 nanofluid. Heat transfer rate is increases with increasing heat flux, up to 55% of concentration of nanofluid and up to 25 nm sized particles.

10. Somchaiwongwiseset al: Investigated heat transfer enhancement and flow characteristic of Al2O3Water nanofluid using micro channel heat sink. The dimension of test section is 5x5mm and 50 W 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.
11. Yannar et al: Investigated the flow and heat transfer characteristic of spiral pipe heat exchanger using different type of nanofluid with different concentration such as Al2O3-water, TiO2-water, CuOwaternanofluid 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 30 mm, 10 mm diameter and 1600 mm length. Heat transfer enhanced 28% at 0.8% concentration of nanofluid, due to high concentration shear stress of nanofluid 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 nanofluid is increasing, because formation of boundary layer.
12. Nawaf.H et al: Investigated the thermal performance of air-water heat exchanger using TiO2 Nanofluid. Air duct dimension is 100 x 30 x300 mm, and water flow through inside the pipe had 5 mm radius and 300 length. Air through external surface of pipe as the result of heat is transferred. Heat transfer coefficient is increases with increasing Reynolds number at constant volume of friction up to 0.6% and increasing concentration at constant Reynolds number up to 1000, but at high concentration needs high pumping power. Nusselt number is increases with increasing Reynolds number, high heat transfer is occurred in this condition, but decreases when axial distance is increasing at aerofoil particular angle of attack. Maximum heat is transferred at 0-1000 angle of aerofoil.
13. H.Niazmand et al: Studied convective heat transfer of carbon nanotube-water nanofluid using isothermally heated 900 curved pipe, and set an inlet temperature of fluid and wall is 293K and 363.15 K. 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.
14. Manag et al: Investigated the friction factor and heat transfer rate of CuO-Water and Al2O3 -water nanofluid using micro channel heat sink. Dimension of test section is 100 x 100 x 20000 µm, 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 nanofluid. Compared the CuO-water and Al2O3 -water nanofluids the CuO-water nanofluidshowed better enhancement and low friction factor.
15. Praveen al: Studied the heat transfer enhancement Al2O3-water nanofluid. 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 nanofluid but decreased when increasing inlet temperature of nanofluid.

16. Mahdi Pirhayati et al: Studied the pressure drop of nano fluid at an inclined tube, tube having dimension of 12 x120 x 0.9 mm, 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 nanofluid. Inclined tube having less pressure drop compared with horizontal tube and minimum pressure drop is occurred, when the tube is inclined at 300° angle.
17. Manna et al: Investigated the thermal conductivity enhancement of SiC-water nanofluid using transient hot wire device. Thermal conductivity of nanofluid is increased with increasing the concentration of nanoparticle, 26% of maximum thermal conductivity is obtained when using 0.8% concentration of nanofluid. Mechanically milled nanoparticles having high heat transfer enhancement. Nanoparticle volume and shape is important factor to enhance the thermal conductivity of nanofluid, at 27 nm sized nanoparticle enhanced 12% of thermal conductivity nanofluid.
18. Kavitha et al: Investigated thermal conductivity enhancement of TiO2-water nanofluid using transient hot wire device. Thermal conductivity of nanoparticle is increased when using spherical shaped nanoparticle, and thermal conductivity is dependent many parameter such as size, shape, stability, and coating of nanoparticle. Spherical shaped nanoparticle having high heat transfer rate compared with other shaped nanoparticle.

III. DISCUSSION

Various authors have performed the experimental investigation related to heat transfer enhancement and it's affecting factors by using Al2O3, CuO, TiO2, ZrO2, Ag, SiC and Diamond nanoparticle. Amongst all CuO and Al2O3 are frequently used for higher thermal conductivity, but many type of nanoparticle using to enhance the heat transfer rate at different application, and discussed many factor affecting the heat transfer rate of nanofluid. Mixing is important for enhancement of heat transfer rate, so ultrasonic mixture is suitable for enhance thermal conductivity of nanoparticle.

IV. CONCLUSION

1. Heat transfer rate increases with increasing concentration of nanoparticle.
2. Heat transfer rate is directly proportional to the Reynolds number and peclet number of nanofluid.
3. The fine grade of nanoparticles increases the heat transfer rate but it's having poor stability.
4. Clustering and collision of nanoparticles is main factor to affect the heat transfer rate of nanofluid.
5. Concentration of nano particles increases the pressure drop of nanofluid.
6. Spherical shaped nanoparticles increases the heat transfer rate of Nanofluid compared with other shaped nanoparticles.
7. Boiling was to reduce the enhancement of heat transfer rate.
8. Spiral pipe having higher heat transfer rate compared with the circular plain tube.
9. Inclined tube possess the low pressure drop compared with horizontal tube.

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