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Heat Transfer Using Nanofluids and its Applications – A Review

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Abstract: This paper has been brought up for beginners to get into the very interesting topic of heat transfer focusing on the heat transfer by nanofluids This paper brings in a basic idea of how the nanofluids are produced and how they can be tested at varying parameters for the near ideal heat transfer process and this paper brings knowledge about the application of nanofluid.
Keywords: Heat transfer, nanofluids, production, thermal conductivity, coefficient of heat transfer

I. INTRODUCTION

Nanofluids are a mixture of base fluid and nanoparticles. It can also be considered a three-phase system comprising of "a solid phase"," a liquid phase", and an interfacial phase which contributes significantly to the system properties because of its extremely high surface-to-volume ratio in nanofluids. [17] These are the particles that exhibit superior heat transfer than any other regularly used method or instrument for heat transfer. There are many nanofluids but basically used ones are CUO, AL2o3, Ethylene glycol, and many more. We use Nanofluids as this provides a larger surface area for heat transfer also, we see of graphene can be seen with a good thermal conductivity as a good macroscopic property but can be hindered by basic microscopic properties such as Brownian motion, [8] the reasons will be discussed below.

II. THERMAL CONDUCTIVITY OF NANOFLUIDS

As per Fourier law of heat conduction, the rate of heat transfer is directly proportional to the area, and temperature difference and inversely proportional to the distance the heat must travel through.
Where K is the thermal conductivity of a material, similarly we know that the base fluids used in nanofluids have some thermal conductivity too which can be used for its application then why Nanofluid is produced.
Well, we use nanofluids rather than plain base fluids as it increases the surface area of base fluid together with nanoparticles [4] also concentration up to a certain point increases the thermal conductivity up to a certain temperature.
As previously stated, the Brownian motion and thermophoresis when considered give a significant increase to the thermal conductivity of nanofluids when not considered the values which have been increased suddenly start to deteriorate but this deterioration can be increased by an increase in the nanoparticle concentration [22] the viscosity of nanofluid particles is increasing at certain temperatures and again decreases after a particular time for a process such as vacuum evaporation. [1]
The high thermal conductivity of nanoparticles relative to common pure fluids enhances the single-phase heat transfer coefficient for fully developed laminar flow. The enhancement is far weaker for turbulent flow because of a weaker dependence of the heat transfer coefficient on thermal conductivity as well as decreased specific heat and increased viscosity with increased nanoparticle concentration. [12] The enhancement of thermal conductivity of particles is present at low volume fractions further to add more to this there is a more exaggerated increase in thermal conductivity when the nanofluids have a linear chain-linked structure formed within them.

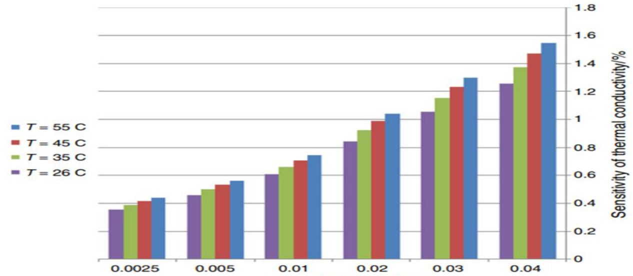

FIG: - 1_Sensitive analysis of thermal conductivity at different temperatures and concentrations [28]

A sensitive and clear analysis has been done in the paper [28] for the thermal conductivity is sensitive to the changes in particle loading at a given temperature. Now we further for this instance take up a nanofluid I.E AL203/water for further understanding of the above-stated data as we say. [29] Chon et al. examined the thermal conductivity of Al2O3/water nanofluids by the transient hot wire method in which the temperature changes from 21 to 71 degrees Celsius and the particle sizes of 11 nm, 47 nm, and 150 nm. Afterward, they stated that increasing the particle size results in a decrease in the thermal conductivity enhancement. Also, for the 4 % concentration, a temperature of 71 degrees Celsius, and a particle size of 47 nm, the enhancement magnitude was 28 %. Also, from [14] we can say that magnetic property to has a very vital and significant role in thermal conductivity and heat transfer.
The viscosity of nanofluids plays a key role in predicting heat transfer characteristics. [16]

III. MEASUREMENT OF THERMAL CONDUCTIVITY

Thermal conductivity of Al2O3-water nanofluids with various concentrations and the temperature range between 26 and 55° C was measured by a KD2 Pro instrument manufactured by Decagon Devices Inc. This instrument acts based on the transient hot wire approach; the KD2 Pro takes measurements at 1-s intervals during a 90-s measurement cycle. The accuracy of the device is ± 5 %. The experiments are repeated three times for each case and the average value is reported. A hot water bath is used to stabilize the temperature and a thermometer with an accuracy of 0.1C is used to measure the temperature. [5] Thermal conductivity has got no direct relation with the material type but it increases as the particle's density increases. [6] Surface to volume ratio is a basic factor for deciding the Thermal conductivity of the material. [7]

IV. SYNTHESIS OF NANOFLUIDS

Synthesis of nanofluid is mostly by two processes

A. One-Step Process

The base fluids and the Nanoparticle are simultaneously mixed together forming the Nanofluid but the main factor after production is the stability of Nanofluids. In the one-step process the stability is higher as the chances of agglomeration and coagulation are minimized as the process of drying, storage, and transportation of nanoparticles are minimized. [2]

B. Two Step Process

In the process the Nanoparticles are produced separately also the base fluid is kept separate afterward they are mixed in small quantities for less wastage and less agglomeration also by this process, we can produce what is called a hybrid nanofluid comprising of two nanoparticles which gives its own properties in the field of heat transfer.[23] In this process too, there are many ways to approach highly stable nanofluids. For increasing stability and removal of agglomeration, nanofluids suspensions were sonicated for 30 minutes using a probe (10 mm diameter) ultrasonic processor (Electrotonic; E1-250 W) at 220 V followed by ultrasonic vibrations for 90 minutes using water bath ultrasonic cleaner (Toshcon; SW4). [3]

V. ENHANCEMENT OF HEAT TRANSFER

As per [9] while observing the heat transfer enhancement of the nanofluids we see for Ethylene Glycol–cAl2O3 and water–cAl2O3 there was a significant increase seen in ethylene glycol nanofluid as compared to water-cAL2O3 this is due to wall shear stress induced which is greater in water nanofluid rather than ethylene glycol nanofluid The above conclusions can be drawn on the basis of nusslets number and Reynolds number and many other hydrodynamic parameters considering many cases as these all factors play an important role in the enhancement of heat transfer. The extensive nature of hydrodynamic properties has been shown in the paper [9]

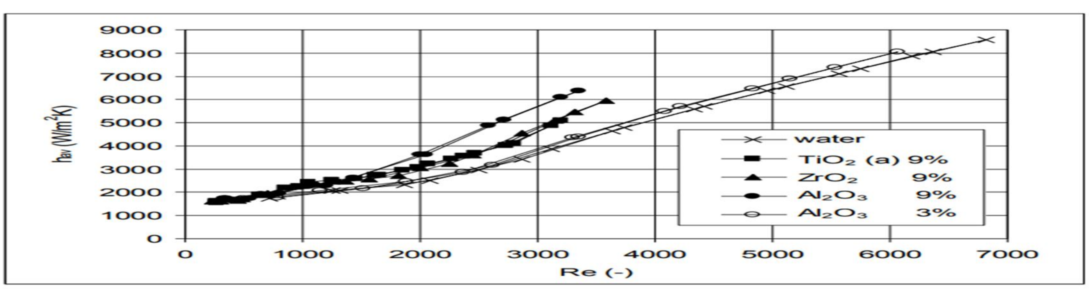

Fig 2 (10): - comparison of the average heat transfer coefficients of water and of suspensions of nanoparticles in water vs. Reynolds number.

We know that the increase in particle concentration increase thermal conductivity also increasing the heat transfer coefficient and thereby it increases the wall and fluid temperature of nanofluid relative to their base fluid counter parts which eventually decreases the specific heat of nanofluids caused by the lower specific heat of solids than the fluid.

From [11] we can see that the heat transfer enhancement is higher in laminar flow rather than in turbulent flow as factors such as flow rate, viscosity, and specific heat.

Thermophoresis is the process in which the mixture of particles that can move are presented in the force of a temperature gradient due to which they move this can be the basic procedure as it is moving from higher to lower like a kind of bulk or density difference so the heat transfer takes places easily. [15]

To bring in more of to it an experiment was carried out in paper [21] in which AL2O3—water was used as coolant with a comparison to distilled water in which it was found that A significant improvement in the heat transfer coefficient (18%) was achieved using the nanofluid compared to the distilled water. The heat transfer coefficient was evaluated based on the log mean temperature difference. The experiment showed the minimum convective thermal resistance at a higher volume fraction and the Reynolds number of the nanofluid about 15.72% lower compared to the distilled water

[13] Furthermore advanced and sophisticated theories of solid-fluid flows have been discussed in this paper [24-27] because these can be directly in correlated with the flow of nanofluids.

VI. APPLICATION

The basic application for which this whole new synopsis was done regarding the nanofluid is for the heat transfer

Basically, we need heat transfer by nanofluid for coolant purposes

1) In automotive engines as used coolant is nanofluid to measure the heat transfer coefficient [19]
2) Formulation of heat transfer in natural convection [20]

VII. CONCLUSION

This paper brings all the major aspects together regarding the topic of heat transfer through nanofluids

This can give the basic ideas on what is nanofluids, what does it comprise, and why nanofluids

Also, we discussed the enhancement of thermal conductivity of the base fluid and nanoparticles and its enhancement caused by the addition of both in one other we also had various methods for the measurement of thermal conductivity of nanofluid out of which the hot wire method was used as stated as thermal conductivity is one of the major factors in heat transfer.

To addition we saw how various parameter such as viscosity, Reynolds number, shear force flow of fluids and many hydrodynamic factors affecting the heat transfer process significantly.

Further, we saw the application of it as a major coolant that can be used for cooling purposes which is a major issue in the automobile and the electronics world.

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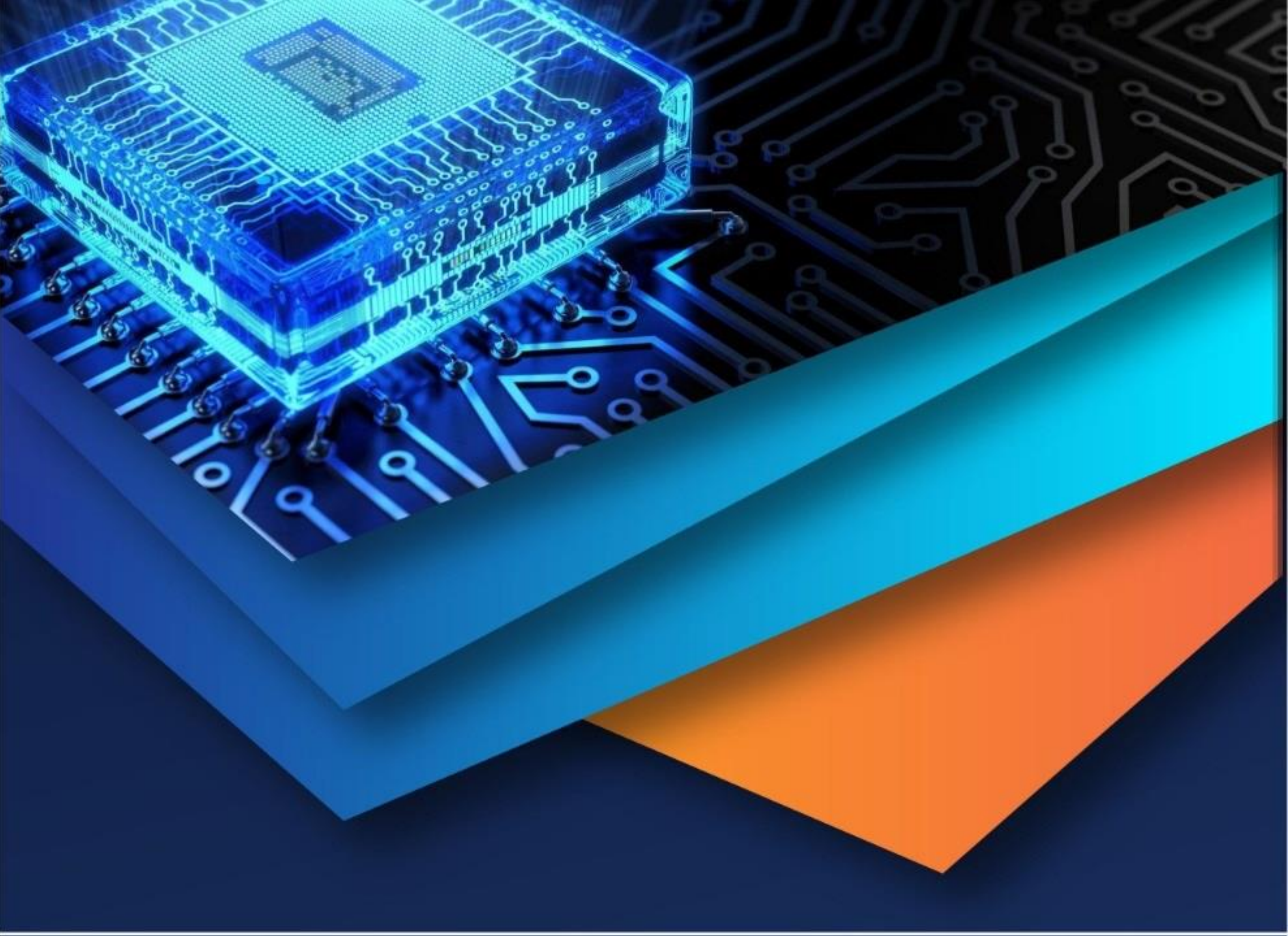

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