Simulation of Forced Convection in a Pipe with Nano Fluids Using Ansys CFX Software

M. Pushparaj and Jose Anand Vino

Abstract--- *Conventional fluids such as water, ethylene glycol are normally used as heat transfer fluids. Various Techniques are applied to enhance the heat transfer. The low heat Transfer performance of these conventional fluids obstructs the performance enhancement. The use of additives is a technique applied to enhance the heat transfer performance of base fluids. Recently as in conventional heat nano fluids. The suspended metallic or non metallic nano particles change the transport properties and heat transfer characteristics of the base fluid. In this project we have considered the problem of forced convection flow of fluid inside a uniformly heated tube that is submitted to a constant and uniform heat flux at the wall. The heat transfer coefficient we analyzed at the same Reynolds number for both base fluids and nano fluids in the CFX software. The base fluids used for this work is water and ethylene glycol. The nano particles to suspended in the base fluids used for this work are a aluminum, aluminum oxide, copper, copper oxide and silver.*

Keywords--- *Nano fluids, Nano Particles, CFX.*

I. INTRODUCTION

Nano Fluids

In nano technology, a particle is defined as a small object that behaves as a whole unit in terms of its transport and properties. It is further classified according to size; In terms of diameter, fine particles on the other hand are sized between 1 and 100 nanometers, though the size limitation can be restricted to two dimensions. Nanoparticles may or may not exhibit size related properties that differ significantly from those observed in fine particles or bulk materials. This suspended nano particles can change the transport and the thermal properties of the base build. A recent development is that nano particles can disperse in conventional heat transfer fluids such as water, glycol or oil to produce a new class of high efficiency heat exchange media.

The Nanometer

The nanometer (International spelling as used by the International Burea of Weights and Measures; SI symbol: mm) or nanometer (American spelling) is a unit of length in the metric system, equal to one billion of a meter. The name combines the SI prefix nano –(from the Ancient Greek, Nano, "dwarf") with the parent unit nanometer (from Greek, meter n," Unit of measurement"). It can be written in scientific notation as 1x10m, in engineering notation as1 E- 9m,-9and is simply 1m/1,000,000,000. One nanometer equals ten Angstroms.

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Nano Flids Properties

Nano paricles are of great scientific interest as they are in effect, a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical properties regardless of its size, but at the nano-scale size-dependent properties are often observed. Thus, the properties of materials change as their size approaches the nano scale and as the percentage of atoms at the surface of a material become significant. For bulk materials larger than one micrometer (or micron), the percentage of atoms at the surface is insignificant in relation to the number of atoms in the bulk of the material. The Interesting and sometimes unexpected properties of nano particles are therefore largely due to the large surface area of the material, which dominates the contributions made by the small bulk of the material. Nano particles often possess unexpected optional properties as they are small enough to confine their electrons and produce quantum effects. For example gold nano particles appear deep-red to black in solution.

Nano paritcles of yellow gold and grey silicon are red in color. Gold nano particles melt at0C) Absorption of solar radiation is much higher in materials composed of nano particles than it is in the thin films of continuous sheets of material. In both solar PV and solar thermal applications, controlling the size, shape, and material of the paritcles, it is possible to control solar absorption.

Heat Transfer Enhancement

Heat transfer enhancement is an active and important field of engineering research. Based upon the research three possible mechanisms proposed for heat transfer enhancement. They are decreasing he thermal boundary layer, increasing the flow interruptions and increasing the velocity Gradient near the heated surface. The addition of small particles to the fluid can sometimes provide heat transfer enhancement. `However the works in this area provide the suspension of micro to macro size particles bear the following major disadvantages.

- The particles settle rapidly, forming layer on the surface and reducing the heat transfer capacity of the fluid.
- If the circulation rate of the fluid is increased sedimentation is reduced by the illusion of the heat transfer devices, pipe lines etc.
- The large size of the particles tends to clog the flow channels particularly. If the cooling channels are narrow.
- The pressure drop in the fluid increase considerably.

II. LITERATURE REVIEW

Analysis on Heat Transfer in Nanofluids for Al2 O3/ Water

Anchupogu. Praveen, penugonda Suresh Babu, Venkaa Ramesh Mamila

Nano fluid is a fluid having nano size paritcles, normally particle size less than100nm dispersed in the conventional base fluids such as water, engine oil, ethylene glycol, transformer oil which tremendously enhances the heat transfer characteristics of original fluid. Because of solid nano particles these fluids have thermal conductivities several hundred times higher than that of conventional fluids. Nano fluids show better stability, higher thermal conductivity, and no penalty in pressure drop. In the paper, a theoretical study has been carried out predict heat transfer co-efficient of nano fluids ***Al2 O3/*** water the heat transfer coefficient calculated for different temperature ranging from 25 to 80 with volume concentration ranging from 1 to 5% and heat transfer coefficient is compared with pure water. The results show that the percentage increase in heat transfer coefficient***Al2 O3/*** *water* with nano particles concentration was determined.

Theoretical Investigation of Heat Transfer Mechanisms in Nano fluids and the effects of clustering on Thermal Conductivity

Nano Hadi Pirahmadian, Azedeh Ebrahimi

Nano fluids are suspensions of nano particles in fluids that show significant enhancement of their properties at modest nano particles concentrations. Nano fluids, due to anomalously high thermal conductivity, are important in heat transfer. Regarding the various models of thermal conductivity, we show that thermal dispersion model for explaining nano fluids heat transfer results have better agreement with experimental results. Relationships between thermal conductivity and various factors such as temperature, concentration, and particle size are also displayed along with a discussion on clustering. There is a brief discussion on convection where the number of studies is limited. There is research currently being performed on the manipulation of the properties governing the thermal conductivity of nanofluids-the particle size, shape and surface area. Other factors that affect heat transfer are the material of the nanoparticles, particle volume concentration, and the fluid has generated many experimental studies, there is still disagreement over several aspects of heat transfer in nanofluids, primarily concerning the mechanisms behind the increased thermal conductivity.

Investigation of the effect of nanofluids particle size and temperature on heat transfer results in complicated trends due to the opposing effects of thermal conductivity and thermal dispersion on heat transfer in terms of particle size dependence. Numerical results are compared with experimental and numerical data in the literature and good agreement is observed especially with experimental data.

Natural convection heat transfer of nano fluids along a vertical plate embedded in porous medium

Ziya Uddin and Souad Harmand

The unsteady natural convection heat transfer of nanofluids along a vertical plate embedded in porous medium in investigated. The Darcy-Forchheimer model is used to formulate the problem. Thermal conductivity and viscosity models based on a wide range of experimental data o nanofluids and incorporating the velocity-slip effect of the nanoparticles with respect to the base fluid, i.e., Brownian diffusion is used. The effective thermal conductivity of nanofluids in porous media is calculated using copper powder as porous media. The nonlinear governing equations are solved using an unconditionally stable implicit finite difference scheme. In this study, six different types of nanofluids have been particle concentrations, particle size, temperature enhancement, and porosity of the medium on the heat transfer enhancement and skin friction coefficient have been studied in detail. It is found that heat transfer rate increases with the increase in particle concentration up to an optimal level, but on the further increase in particle concentration, the heat transfer rate decreases. For a particular value o particle concentration, small-sized particles enhance the heat transfer rates. On the other hand, skin friction coefficient always increase with the increase inparticle concentration and decrease in nanoparticles size.

Heat Exchanger using Nano fluid

Prof.Alpesh Mehta, Dines k Tantia, Nilesh M Jha, Nimit M Patel

This paper shows the research work on heat exchanger using nano fluid. In this paper we are using compact heat exchanger as heat transferring device while ***Al2 O3/*** as a nano fluid. The effect of the nano fluids on compact heat exchanger is analyzed by using 6-NTU rating numerical method on turbo-charged diesel engine of type TBD 232V-12 cross low compact heat exchanger radiator with unmixed fluids consisting of 644 tubes made of brass and 346 continuous fins made o copper. Comparative study of ***Al2 O3/*** + water nano fluids as coolant is carried out.

III. METHODOLOGY

In this project the two base fluids are selected namely water and ethylene glycol. To enhance the heat transfer rate of the above said base fluids the nano particles of Aluminium, Aluminium oxide, copper, copper oxide and sliver were chosen. The properties of the nano fluids are calculated by formulas. The thermo physical properties of water, ethylene glycol, Aluminium, Aluminium oxide, copper, copper oxide and sliver are tabulated and it is submitted in the formulas for finding the properties of nanofluids. In order to analyze the heat transfer rate of the base fluid and nanofluid CFX software is used. The nano fluids and the base fluids are analyzed under the same Reynolds number.

Nano fluids and Its Preparation

The superior properties of nano particle fluid mixtures relative to those fluids without particle or with large sized particle include high thermal conductivities, stability and prevention of clogging in micro channels. A liquid suspended with particles of nanometer dimension is termed a nanofluid. The nanoparticles used to produce nanofluids are aluminum oxide, aluminum, copper, copper oxide and silver. Nanoparticles can be produced on several processes such as gas condensation, mechanical attrition or chemical precipitation techniques. Gas condensation processing has an advantage over other techniques. This is because the particles can be produced under cleaner conditions and its surface can be avoided from the undesirable coatings. However the particles produced by this technique occur with some agglomeration, which can be broken up with smaller clusters by supplying a small amount of energy.

The preparation of nanofluid begins by direct mixing of the base fluid with nanoparticles. The delicate preparation of a nanfluid is important because nanofluids need special requirements such as an even suspension, durable suspension, stable suspension, low agglomeration of particles and no chemical change of the fluid. The reason for using nano fluids are when the nano-sized particles are properly dispersed nano fluids are expected to give many advantages.

Higher heat conduction is a major advantage of nanofluids as the large surface area of nano particles allow for more heat transfer. Particles finer than 20nm carry 20% of their surface making then instantaneously available for thermal interaction and also stability is another benefit of nano fluid as the particles are small, they weigh less and their chances of sedimentation are also less. This reduced sedimentation can overcome one of the major draw backs of suspensions, the setting particles and make the nano fluids more stable.

IV. Results And Discussion

The heat transfer coefficient of water at 313k (40^0c) is 31785.81 kW/m^2K. Form table it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with watet shows that increased heat transfer coefficient than the water in all percentages

V. Conclusion

In a uniform heated tube were analyzed at temperatures 400C, 500C and 600C. The results shows that the nano fluids have large heat transfer co-efficient than the original base fluids under the same Reynolds number. The suspended nano particles remarkably increased the forced convective heat transfer performance of he base fluid. At the same Reynolds number the heat transfer of the nano fluid increased with the particle volume fraction.

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References

[1] Thermal Engineering text book by Domkundwar & Arora
[2] Heat Transfer text book by Younis.A. Cenegal
[3] Design of Fluid and thermal system text book by william s. Janna.
[4] Apogee. netCo3.
[5] Aii season shine.co.
[6] Thermodyne boiler.com.
[7] Bdi cooling.com.
[8] Piping Engineering .com.

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