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HEAT AND MASS TRANSFER IN NANO FLUID

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Abstract

Nano fluids In a variety of human endeavors, including engineering devices in power and chemical engineering, medicine, electronics, and others, nano fluids are utilized as a combination of a low concentration of Nano-sized metal or metal oxide particles and a base fluid. When compared to base fluids like oil or water, it has been discovered that Nano fluids have superior thermo physical properties like thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients. Base solvents can be aqueous or no aqueous, such as oil or ethylene glycol. Colloids have been made from Cu and Al2O3 nano particles with a sub-100 nm size. Heat trade assumes a critical part in cooling frameworks and furthermore in sun oriented nuclear energy age. Mixing a powder containing nano particles with a suitable base fluid yields a Nano fluid. The blend then, at that point, goes through sonication to separate any molecule agglomerations framed during blending to make a very much scattered nano particle suspension [1] Taylor, R.A.; et al. (2013). "Small particles, big impacts:

A review of the diverse applications of Nano fluids". A small amount of nano particles is suspended in base fluids like water, ethylene glycol, and so on to make Nano fluid. With or without the use of stabilization methods. Nano particles have a size of less than 100 nm on average. Nano fluid thermal conductivity As previously stated, Nano fluids outperform conventional heat transfer fluids in terms of heat transfer properties. The significantly increased thermal conductivity of the suspended particles in Nano fluids is one of the reasons.

Keywords : Energy conservation ,Nanotechnology ,Heat transfer ,Fluids ,Nano particlesColloids , Nano fluids ,Dispersions ,Thermal transport ,Thermo physical properties.

Introduction

From the perspective of energy conservation, there has always been a desire to discover novel sustainable development-based solutions to existing issues. This path now has a new horizon to explore thanks to the development of nano meter-sized materials. Nano fluids are fluid dispersions of such minute particles with sizes between 0 and 100 nm. Due to their improved thermal and physical properties, these novel fluids have found numerous uses in mass and heat transfer. Different kinds of nano materials that are dispersed in fluids produce distinct kinds of nano fluids. Each type of nano fluid has standard properties that are determined by the type of nano material [2]. Buongiorno, J. (March 2006). "Convective Transport in Nano fluids".

This chapter describes "Nano fluids" in detail and provides an overview of their various classifications. As an alternative to pure base fluids, nano fluids are advanced heat transfer fluids that incorporate nano particle materials with higher thermal conductivity to enhance the heat transfer process.

The experiments that were meant to improve the thermal conductivity of liquids produced nano fluids. The revolutionary idea of adding solid particles to HTFs to increase their thermal conductivity is credited with starting the development of nano fluids. Maxwell came up with this novel idea in 1873. When making water-based nano fluids, sodium dodecyl benzoic sulfate (SDBS) is used as a surfactant. Deionized water and three volume fractions of Cu nano particles are used to prepare nano fluid samples with a mean diameter of 25 nm [3]. "Argonne Transportation Technology R&D Center".

Nano Fluids

A brand-new fluid known as nano fluid has emerged as a result of the development of nanotechnology and its capacity to exploit it to improve the performance of solar devices. The new fluid (nano fluids) has a higher transfer characteristic than the base fluids because it is assembled by mixing solid nano particles with a high thermal conductivity witha low thermal conductivity base fluid [1, 2]. A nano fluid is a fluid in which a colloidal solution of nano particles in a base fluid is formed by nano meter-sized particles suspended in the base fluid [4]. Mankowitz, W., et al., Nano particle Heat Transfer Metals, oxides, carbides, or carbon nano tubes are typically the nano particles used in nano fluids, while water, ethylene glycol, and oil are the base fluids. Microelectronics, fuel cells, pharmaceutical processes, hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerators, chillers, and heat exchangers, grinding, machining, and boiler flue gas temperature reduction are just a few potential usesfor nano fluids' novel properties in heat transfer.

The type of Nano Fluids?

The Nano fluids generally fall into one of four categories: metal-based nano fluids, metal oxide-based nano fluids, carbon-based nano fluids, or mixed/hybrid metal-based nano fluids. The chosen nanoparticles were suspended in base fluids like ethylene glycol, water, or oil. The increased critical heat flux, the increased heat transfer, and the increased thermal conductivity of nano fluids make them promising coolants. The thermal conductivity of base fluids can be significantly improved with relatively low amounts of nano particles, according to research.

The benefits of Nano Fluid?

Microelectronics, fuel cells, pharmaceutical processes, hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, grinding, machining, and in addition, other methods like ball milling, mechanical stirring, and homogenization can also be used for large-scale nano fluid production. Nano fluids have novel properties that make them potentially useful in many applications in heat transfer. Ball milling is a simple process that is used for a lot of other things in industries. However, it takes a lot of energy and is not as efficient as other ways to prepare Nano fluids [5]. Das, Sarit K.; Stephen U. S. Choi; Wenhua Yu; T. Pradeep (2007). Nano fluids: Science and Technology. Wiley-Interscience. P Magnetic stirring, on the other hand, can be used to stir things mechanically. However, it is extremely ineffective at breaking down the agglomerates and has a lot of drawbacks. Even if mechanical stirring produces a nano fluid with very few agglomerates, it may take several hours to complete. Additionally, this results in a significant expenditure of energy. As a result, a high-pressure homogenizer might be a good choice for making stable nano fluids.

This is primarily due to the availability of large-scale homogenizers and their widespread application across industries. The use of stabilizers and dispersants also helps to keep the nano fluids stable. They are liquid additives that prevent individual particles from agglomerating by adhering to their surface. Be that as it may, such substances in the nano fluid will quite often give defilement, in this manner falling apart its life. nano fluid formulation also costs more because of this [6]. Kakaç, Sadik; Anchasa Pramuanjaroenkij (2009). "Review of convective heat transfer enhancement with Nano fluids" To produce Nano fluids on a large scale, there may be a number of such solutions; however, before approving their use, it is necessary to determine whether or not each of them is feasible. Likewise, a rule for a legitimate huge scope creation might be useful. Every single such strategy and abilities are still in their advancement stage. Still, using nano fluids on a large scale is difficult because of the cost of pumping power, their uncertain stability, and the possibility that erosion and corrosion willharm the material of the pipeline and equipment.

Methods of preparing nano fluids

There are several methods for making nano fluids: first step, second step, and additional methods to keep away from the sedimentation of nano particles during its activity, surfactant might be added to them. The preparation of the nano fluid is the first step before any implementations. As a result, researchers need to pay more attention in order to reach a satisfactory level of stability. According to colloidal theory, Brownian forces acting in opposition to gravity stop sedimentation in suspensions when the particle size falls below a critical radius. In various applications, smaller nano particles might be preferable· However, it has a high surface that causes them to clump together, making it difficult for researchers to create a stable nano fluid with the right concentration and diameter of particles. The two-step method and the one-step method are the two most common ways to make nano fluids, but other people have come up with some new ideas.

Nano fluid thermal conductivity

Poor heat transfer fluids include ethylene glycol (EG) mixture, oil, water, and conventional heat transfer fluids. As a result, numerous experiments have been conducted by researchers to boost these fluids' convection heat transfer by increasing their thermal conductivity. By adding solid nano particles with high thermal conductivity, the nano fluids acquire a high thermal conductivity. As an alternative to pure base fluids, nano fluids are advanced heat transfer fluids that incorporate nano particle materials with higher thermal conductivity to enhance the heat transfer process. This drew the attention of researchers, who decided to test a variety of nano particles with varying thermal conductivities in order to achieve a high rate of heat transfer and utilize them in various applications. The thermal conductivity of nano fluids was described by a number of equations in the literature· The most notable findings indicate that the base fluid (water, PAO) can increase the thermal conductivity of nano fluids by 5 to 10%. Based on particle size and base fluid thermal conductivity, there is no significant improvement in thermal conductivity over conventional base fluid, as reported.

Applications of Nano fluids for heat transfer process

Nano fluids are now a crucial component of heat transfer equipment because they offer a viable alternative for increasing heat transfer equipment's efficiency, minimizing its size, and conserving energy. Water is a good medium for heating processes and an important source for the application of solar energy because it is a good medium for heat transfer and a good medium for receiving and storing solar energy at sunrise. Although the FPSWH's thermal efficiency is relatively low, researchers have made numerous efforts to improve its performance. Using specific techniques, the FPSWH's thermal efficiency has improved. Numerous studies have been conducted to improve the FPSWH's performance and thermal efficiency. Nano fluids have been found to significantly boost heat transfer in recent studies. This is accomplished by incorporating high-thermal conductivity nano particle materials into the working fluid. Nano fluids are promising alternatives to base fluids, so research to improve and develop heat transfer equipment systems is ongoing [7]· S. Witharana, H. Chen, Y. Ding; Stability of Nano fluids in quiescentand shear flowfields.

Nano fluids for heat transfer augmentation

Due to their intriguing thermal behaviour and numerous heat transfer system applications, Nano fluids have piqued the interest of numerous researchers from a variety of fields. Various examinations have been led throughout the course of recent a long time to decide the thermo physical qualities of Nano fluids to find their relevance in heat move frameworks. Due to their superior thermal and physical characteristics in comparison to standard cooling fluids, Nano fluids are utilized in a variety of heat transfer applications. The purpose of this chapter is to provide a general overview of the Nano fluid concept, its formulation, the various types of Nano fluids, and the thermal and physical properties of those Nano fluids when exposed to a magnetic field. Furthermore, this part examines the trial investigation of normal convection heat move of Nano fluid in different depressions with and without the attractive field. It is evident from a close examination of the Nano fluids' heat transfer properties that these fluids have a lot of potential for enhancing natural convection heat transfer.

Large-scale production of Nano fluids

Since their discovery at the Argonne National Laboratory, Nano fluids have gained a lot of popularity among researchers and businesses alike. However, research on Nano fluids has only been limited to quantities below a liter. The rapid acceptance of the idea of Nano fluids by industrial society was noted in Choi's (1998) first report on the subject. The race to develop technologies for the commercialization of Nano fluids has since intensified. Nano fluids are produced on an industrial scale through a variety of routes that are dependent on standard laboratory-scale procedures. The majority of industries that produce Nano fluids have moved on from producing nano particles. On the other hand, very few companies have begun adding nano particles as value-added additives to the fluids that are already in use for specific applications. For this, they buy nano particles which are extravagant and subsequently increment the expense of the arranged Nano fluid. Also, the thermo physical properties of the Nano fluids cannot be made commercially viable using the one-step method, despite its convenience and advantages. The most difficult part of the two-step preparation of Nano fluids is stabilization, which requires serious skills and knowledge of the behavior of Nano fluids. The cavitation phenomenon is used in ultra-sonication to achieve uniform and stable nano particle dispersion in liquids. Ultra-sonication has been used by many scientists to prepare Nano fluids. Even though most laboratory-scale studies show that ultra-sonication is very effective, it cannot be used at an industrial scale. Alternately, a viable cavitation method, such as hydrodynamic cavitation, can produce the same phenomenon. Radkar and others 2019) used hydrodynamic cavitation to make ZnO Nano fluids that are based in water. The Nano fluids that were made in this way had better thermal properties. Kiu et al. created Nano lubricants by dispersing carbon nano tubes through hydrodynamic cavitation (2016). They tracked down better greasing up attributes of the Nano lubricant arranged utilizing hydrodynamic cavitation than that pre-arranged utilizing ultrasonic cavitation. Compared to the ultrasonic cavitation method, hydrodynamic cavitation can be extended tohigher volumetric production levels more easily.

Based on composition of nanomaterial

A single component, a mixture, or a composite of two or more components can makeup the nano materials dispersed in a fluid. The extent of intensity extended by the Nano fluid will undoubtedly be reliant upon the nano materials scattered, which is at last ward on its essential properties at the nano scale. Blend of at least two parts out of which one is in nano scale, generally known as a nano composite is just an endeavor to accomplish synergism in the majority of the cases. In order to accomplish this, it is crucial to select and synthesize the appropriate nano composite material that would be useful. Conventional andhybrid Nano fluids are the two types of Nano fluids based on the nano material's composition.

Nano fluid and stability

Nano fluid can be made after selecting the nano particles and the host fluid in a singlestep or in two steps. In a single step method, the chosen nano particles are typically and typically distributed over a large area in the base fluid to reduce the likelihood of cluster formation. Agglomeration is created during large-scale preparation is one of the major drawbacks of this method. Because of the strong interactions between the nano particles brought about by the presence of van der

Waals force, electrostatic force, buoyancy, and gravity, the issue of nano particle suspension in Nano fluid persists. Because the Nano fluid's life span is highly dependent on the fluid's stability, agglomeration and sedimentation of nanoparticles made it difficult for the fluid to function. However, surface modificationhelped. According to Derjaguin, Verway, Landau, and Overbeek (DVLO) theory, stability of Nano fluid is absolutely a factor of electrical double layer repulsive force and the van der Waals forces of attraction. In addition, the addition of surfactant, also known as the "2-step approach," has been explored and validated as methods to achieve a stable Nano fluid [8]. S. Witharana, H. Chen, Y. Ding; Stability of Nano fluids in quiescent and shear flow fields According to the theory, the forces of attraction must be less than the forces of attraction for a Nano fluid to be stable. The zeta potential analysis, sedimentation method, spectral analysis, electron microscopy, and light scattering method are all methods that can be used to evaluate Nano fluid stability.

Mass Transfer in Nano fluid

Because of its numerous applications in chemical engineering, thermal energy storage devices, heat exchangers, ground water systems, electronic cooling, boilers, heat loss from piping, and nuclear process systems, natural convection flow, heat and mass transfer through porous medium over curved bodies, has emerged as a significant field in recent years. Round calculations, cones, chambers, circles, wavy channels, and torus calculations are a few instances of bended bodies. The process of polymer systems has been the subject of a significant number of experimental and theoretical investigations into transport phenomena over cylindrical bodies. All of these studies are primarily concerned with the flow and heat transfer properties of common base fluids like oil, ethylene glycol, and water. A Nano fluid is a fluid that contains nano particles of the nano meter size in small volumes. The new composites known as Nano fluids are composed of solid particles of the nano meter size that are dispersed in conventional heat transfer fluids like engine oil, ethylene glycol, water, and toluene. The nano particles used in Nano fluids are typically made of non metals, metal oxides, carbides, nitrides, or other metals. In recent years, the idea of a Nano fluid as a way to improve the performance of heat transfer rates in liquids has been proposed. The nano meter-sized materials have distinct chemical and physical properties. Because they are small enough to behave like liquid molecules, they can pass through micro channels without clogging [9]. Forrester, D. M.; et al. (2016). "Experimental verification of Nano fluid shear-wave reconversion in ultrasonic fields". This fact has sparked a lot of research into the characteristics of Nano fluid heat transfer. According to numerous experimental and numerical studies, the presence of nano particles increases the base fluid's thermal conductivity by 15-40%. This much of an increase in thermal conductivity cannot be solely attributed to the added nano particles' increased thermal conductivity. There should be different components, which incorporate molecule agglomeration, nano particle size, volume portion, Brownian movement, thermo phoresis, molecule shape, surface region, temperature and fluid layering on the nano particle-fluid connection point, ascribed to the expansion in execution of the Nano fluids.

Traditional intensity move liquids like water, ethylene glycol, and motor oil have restricted heat move capacities because of their low intensity move properties. Metals, on the other hand, have thermal conductivities that are up to three times higher than those of these fluids. As a result, it makes sense to combine the two substances to create a heat transfer medium with the thermal properties of a metal but the behavior of a fluid. While conducting research on new coolants and cooling technologies, Choi was the first person to introduce a novel fluid known as Nano fluid. Eastman and co have observed in an experiment that when CuO nano particles with a volume fraction of 5% are added to the base fluid, the thermal conductivity of the base fluid (water) increases by up to 60%. This is because the base fluid duo to the suspension of nano particles has a larger surface area. Eastman and co have also demonstrated that when copper nano particles with a volume fraction less than 1% are added to ethylene glycol or oil, the thermal conductivity increases by 40%.

Choi and co. have reported that when carbon nano tubes are added to ethylene glycol or oil, the thermal conductivity increases by 150 percent. Furthermore, Xie et al. have observed that when Alumina nano particles are added, the thermal conductivity of Al2O3–ethylene glycol-based Nano fluids increases by 25–30 percent. Using scale analysis, Buongiorno identified seven potential mechanisms for the association of Nano fluid convection through the moment of nano particles in the base fluid. In addition, Noghrehabadi and Behseresht have looked into how a Nano fluid flows and transfers heat across a vertical cone that is submerged in a porous medium. Chamkha and other have discussed, respectively, the mixed natural convection flow through a porous medium saturated with a Nano fluid around a vertical cone and vertical cylinder. Rashad and co. presented mixed convective boundary layer flow of a Nano fluid in convective boundary conditions around a horizontal cylinder embedded in a porous medium. Nasrin and co. Chamkha and other Parvin and co. Abu-nothing and Chamkha have revealed stream and intensity move qualities of Nano fluid over various calculations, for example, twofold top driven chamber, to some degree warmed permeable layered depressions, odd-molded pit, cover driven hole in wavy wall, separately.

A revised model ofthe natural convection boundary layer flow of a Nano fluid past a vertical plate has been presented by Kuznetsova and Neild. In this paper the current model is reexamined so that the Nano fluid molecule division on the limit is latently controlled as opposed to effectively controlled and this model is actually more reasonable than the works distributed beforehand. Sheikholeslami et al. have examined the magnetic field's effect on the natural convection flow of Nano fluid across a horizontal cylinder. The effects of Ferro hydrodynamics and magnetohydrodymia on Ferro fluids have been discussed by Sheikholeslami and Ganji. Sheikholeslami has talked about how to simulate the flow and heat transfer of a Nano fluid over a permeable channel using the KKL correlation. Ravi Kumar and others have detailed MHD convective Rivlin-Ericksen stream over an upward plate by taking variable temperature and intensity ingestion. Rashidi and co have investigated the MHD free convection heat and mass transfer flow over a vertical stretching sheet with buoyancy effects and thermal radiation[10]. Sreekumar, S.; Shah, N.; Mondol, J.; Hewitt, N.; Chakrabarti, S. (June 2022). "Numerical Investigation and Feasibility Study on Maxine/Water Nano fluid Based.

Natural convection heat transfer overan annulus filled with Nano fluid under the influence of constant heat flux has been reportedin a number of representative studies on the characteristics of heat and mass transfer of various Nano fluids over various geometries. Srinivas Acharya and others have investigated the Soret and Dufour effects of mixed convective heat and mass transfer flow through a porous medium over a vertical wavy surface. MHD natural convection heat and mass transfer of Al2O3–water and Ag–water Nano fluids over a vertical cone with chemical reaction has been studied by Sudarsana Reddy and Suryanarayana Rao.

Conclusion

Natural convection boundary layer flow, heat, and mass transfer characteristics of a nano fluid over a horizontal circular cylinder placed in a porous medium under the revised boundary conditions have not been studied, to the author's knowledge, according to an examination of the existing literature· As a result, this issue is addressed, and the goal of this work was to numerically solve it using the Finite element method. This issue can be used in nuclear reactors, electronic cooling equipment, micro electromechanical systems, transportation, and the energy conversion heating and cooling process. Due to its significance in industry and medicine, the analysis of Nano fluids is currently a topic of great interest to contemporary researchers. In addition, magneto Nano fluids play a crucial role in the construction of power generators, petroleum reservoirs, gastric medications, cancer therapy, tumor removal with hyperthermia, asthma treatment, and sterilized devices, among other applications. Size, inertia, particle agglomeration, the Magnus effect, the volume fraction of the nano particle, Brownian motion, and thermophoresis are all examples of these

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phenomena.

Among every one of the systems Brownian movement and thermophoresis are viewed as vital. The thermophoresis acts against temperature angle, so the particles move from the district of higher temperature to the area of lower temperature. Additionally, Brownian motion frequently shifts the particles from regions with higher concentrations to those with lower concentrations. The Cheng–Mincowycz problem for natural convection boundary-layer flow in a porous medium saturated Nano fluid has been discussed by Nield and Kuznetsova. Kuznetsova and Nield investigated how thermophoresis and Brownian motion affected the natural convection boundary layer flow of a Nano fluid as it moved past a vertical plate. Khan and Pop have talked about how a Nano fluid flows through the boundary layer as it moves past a stretching sheet. Chamkha and other investigated the Nano fluid's mixed convection MHD flow as it moved past a stretching permeable surface with Brownian motion and thermophoresis effects. Noghrehabadi and others have demonstrated the heat and mass transfer properties of non-Darcy natural convection flow of a Nano fluid through porous media over a vertical cone.

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