Heat Transfer Enhancement With Nanofluids A Thesis

Heat transfer enhancement has seen rapid development and widespread use in both conventional and emerging technologies. Improvement of heat transfer fluids requires a balance between experimental and numerical work in nanofluids and new refrigerants. Recognizing the uncertainties in development of new heat transfer fluids, Advances in New Heat Transfer Fluids: From Numerical to Experimental Techniques contains both theoretical and practical coverage.
The automotive cooling system is a significant part of the car that removes the engine generated heat outside across the radiator. The increasing demand of nanofluids for industrial applications has led many researchers to focus on the subject in the last decade. The limited thermophysical properties and heat transfer fo liquids across the car radiator have resulted in much research to find better coolant fluids. Space constraints are another key issue in the evofofotua applications to remove heat from high heat flux generating surfaces of automobile engines. In order to improve thermophysical properties of the coolant fluid to enhance heat transfer in the automotive cooling system, nanofluids have been utilized as a coolant. This study aims to enhance heat transfer with a slight pressure drop in the automotive cooling system by using multi types of

nanoparticles dispersed in various types of basefluids. The appropriate type of nanofluids and the influence of different nanofluids on the heat transfer performance for the car cooling system have been identified. The radiator performance efficiency to reduce the radiator size and weight has been studied. The friction factor and heat transfer enhancement using different types of nanofluids are studied. The TiO2 and SiO2 nanopowders suspended in four different base fluids (pure water, EG, 10%EG+90%W and 20%EG+80%W) are prepared experimentally. The thermophysical properties of both nanofluids and base fluids have been measured and validated with the standard and the experimental data available. The experimental test rig setup included a car radiator, collecting tank, pump, rotameter, valves and plastic tubes. The evaluation of the friction factor and heat transfer coefficient by taking readings of the temperature and pressure drop under laminar flow condition were conducted. The volume flowrate was found to be in the range of (1-5LPM) for pure water and (3-12LPM) for other base fluids; while, the inlet temperature and nanofluid volume fraction were in the range of (60-80oC) and (1- 4%) respectively. The CFD analysis for the nanofluids flow inside the flat tube of a car radiator under laminar flow was carried out. A simulation study was conducted by using the finite volume oaotfm to solve the continuity, momentum, and energy equations.

The geometry meshing of problem with a description of the boundary conditions was performed by using commercial software to determine the friction factor and heat transfer coefficient. The experimental results showed the friction factor decreased with the increase of the volume flowrate and increased with the increase of nanofluid volume fraction but slightly decreased with the increase of the inlet temperature. The simulation results showed good agreement with the experimental data with deviation not exceeding 4%. The experimental results showed the heat transfer coefficient increased with the increase of the volume flowrate, the nanofluid volume fraction and the inlet temperature. The simulation results showed good agreement with the experimental data with deviation not exceeding 6%. In addition, the SiO2 nanofluid showed higher values of the friction factor and heat transfer coefficient than TiO2 nanofluid. The base fluid (20%EG+80%W) gave higher values of the heat transfer coefficient and proper values of friction factor compared to other base fluids. The 4% of SiO2 nanoparticles suspended in (20%EG+80%W) base fluid was significant augmentation of heat transfer in the automobile radiator. The regression equations among input (Reynolds number, Prandtl number, and nanofluid volume fraction) and response (friction factor and Nusselt number) were found to be correlated. The experimental results were compared with the experimental data available and there were good agreements with a maximum deviation of approximately 5%.

Heat Transfer Enhancement Using Nanofluid Flow in Microchannels: Simulation of Heat and Mass Transfer focuses on the numerical simulation of passive techniques, and also covers the applications of external forces on heat transfer enhancement of nanofluids in microchannels. Economic and environmental incentives have increased efforts to reduce energy consumption. Heat transfer enhancement, augmentation, or intensification are the terms that many scientists employ in their efforts in energy consumption reduction. These can be divided into (a) active techniques which require external forces such as magnetic force, and (b) passive techniques which do not require external forces, including geometry refinement and fluid additives. Gives readers the knowledge they need to be able to simulate nanofluids in a wide range of microchannels and optimise their heat transfer characteristics Contains real-life examples, mathematical procedures, numerical algorithms, and codes to allow readers to easily reproduce the methodologies covered, and to understand how they can be applied in practice Presents novel applications for heat exchange systems, such as entropy generation minimization and figures of merit, allowing readers to optimize the techniques they use Focuses on the numerical simulation of passive techniques, and also covers the applications of external forces on heat transfer enhancement of nanofluids in microchannels

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(Cont.) Critical heat flux enhancement in nanofluids of up to 100% was experimentally observed. The cause of this enhancement was determined to be the decreased static contact angle of nanofluid boiled surfaces. The increased wettability modified the growth of bubbles prior to CHF and promoted rewetting of hotspots at CHF. In parallel quenching tests, rewetting temperatures and velocities were simultaneously measured for the first time. Surfaces that had been pre-boiled in nanofluids were found to have significantly higher rewetting temperatures and velocities than clean surfaces. Interpretation of the experimental data was conducted with consideration of the governing surface parameters and existing models. It was found that there is significant room for improvement of most pool boiling models, especially with regard to surface effects. The research performed in this thesis help demonstrate the power of the infrared thermography technique and its potential for future improvement of boiling models.

In the present book, nanofluid heat and mass transfer in engineering problems are investigated. The use of additives in the base fluid like water or ethylene glycol is one of the techniques applied to augment heat transfer. Newly, innovative nanometer-sized particles have been dispersed in the base fluid in heat transfer fluids. The fluids containing the solid nanometer-sized particle dispersion are called "nanofluids." At first, nanofluid heat and mass transfer over a stretching sheet are provided with various boundary conditions. Problems faced for simulating nanofluids are reported. Also, thermophysical properties of various nanofluids are presented. Nanofluid flow and heat transfer in the presence of magnetic field are investigated. Furthermore, applications for electrical and biomedical engineering are provided. Besides, applications of nanofluid in internal combustion engine are provided.

While robust progress has been made towards the practical use of nanofluids, uncertainties remain concerning the fundamental effects of nanoparticles on key thermo-physical properties. Nanofluids have higher thermal conductivity and single-phase heat transfer coefficients than their base fluids. The possibility of very large thermal conductivity enhancement in nanofluids and the associated physical mechanisms are a hotly debated topic, in part because the thermal conductivity database is sparse and inconsistent. This thesis reports on the International Nanofluid Property Benchmark Exercise (INPBE) in which the thermal conductivity of identical samples of colloidally stable dispersions of nanoparticles, or 'nanofluids', was measured by over 30 organizations worldwide, using a variety of experimental approaches, including the transient hot wire method, steady-state methods and optical methods. The nanofluids tested were comprised of aqueous and non-aqueous basefluids, metal and metal oxide particles, near-spherical and elongated particles, at low and high particle concentrations. The data analysis reveals that the data from most organizations lie within a relatively narrow band (± 10% or less) about the sample average, with only few outliers. The thermal conductivity of the nanofluids was found to increase with particle concentration and aspect ratio, as expected from classical theory. The effective medium theory developed for dispersed particles by Maxwell in 1881, and recently generalized by Nan et al., was found to be in good agreement with the experimental data. The nanofluid literature contains many claims of anomalous convective heat transfer enhancement in both turbulent and laminar flow. To put such claims to the test, we have performed a critical detailed analysis of the database reported in 12 nanofluid papers (8 on laminar flow and 4 on turbulent flow). The methodology accounted for both modeling and experimental uncertainties in the following way. The heat transfer coefficient for any given data set was calculated according to the established correlations (Dittus-Boelter's for turbulent flow and Shah's for laminar flow). The uncertainty in the correlation input parameters (i.e. nanofluid thermo-physical properties and flow rate) was propagated to get the uncertainty on the predicted heat transfer coefficient. The predicted and measured heat transfer coefficient values were then compared to each other. If they differed by more than their respective uncertainties, we called the deviation anomalous. According to this methodology, it was found that in nanofluid laminar flow in fact there seems to be anomalous heat transfer enhancement in the entrance region, while the data are in agreement (within uncertainties) with the Shah's correlation in the fully developed region. On the other hand, the turbulent flow data could be reconciled (within uncertainties) with the Dittus-Boelter's correlation, once the temperature dependence of viscosity was included in the prediction of the Reynolds number. While this finding is plausible, it could not be directly confirmed, because most papers do not report information about the temperature dependence of the viscosity for their nanofluids.

ABSTRACT: Nanofluids have been demonstrated to be promising for heat transfer enhancement in forced convection and boiling applications. The addition of carbon, copper, and other high-thermal-conductivity material nanoparticles to water, oil, ethylene glycol, and other fluids has been determined to increase the thermal conductivities of these fluids. The increased effective thermal conductivities of these fluids enhance their abilities to dissipate heat in such applications. The use of nanofluids for spray cooling is an extension of the application of nanofluids for enhancement of heat dissipation. In this investigation, experiments were performed to determine the level of heat transfer enhancement with the addition of alumina nanoparticles to the fluid. Using mass percentages of up to 0.5% alumina nanoparticles

suspended in water, heat fluxes and surface temperatures were measured and compared. Compressed nitrogen was used to provide constant spray nozzle pressures to produce full-cone sprays in an open loop spray cooling system. The range of heat fluxes measured were for single-phase and phase-change spray cooling regimes. Introduction to nanofluids--their properties, synthesis, characterization, and applications Nanofluids are attracting a great deal of interest with their enormous potential to provide enhanced performance properties, particularly with respect to heat transfer. In response, this text takes you on a complete journey into the science and technology of nanofluids. The authors cover both the chemical and physical methods for synthesizing nanofluids, explaining the techniques for creating a stable suspension of nanoparticles. You get an overview of the existing models and experimental techniques used in studying nanofluids, alongside discussions of the challenges and problems associated with some of these models. Next, the authors set forth and explain the heat transfer applications of nanofluids, including microelectronics, fuel cells, and hybrid-powered engines. You also get an introduction to possible future applications in large-scale cooling and biomedicine. This book is the work of leading pioneers in the field, one of whom holds the first U.S. patent for nanofluids. They have combined their own first-hand knowledge with a thorough review of theliterature. Among the key topics are: * Synthesis of nanofluids, including dispersion techniques and characterization methods * Thermal conductivity and thermo-physical properties * Theoretical models and experimental techniques * Heat transfer applications in microelectronics, fuel cells, and vehicle engines This text is written for researchers in any branch of science and technology, without any prerequisite.It therefore includes some basic information describing conduction, convection, and boiling of nanofluids for those readers who may not have adequate background in these areas. Regardless of your background, you'll learn to develop nanofluids not only as coolants, but also for a host ofnew applications on the horizon.

This experimental study presents heat transfer enhancement by slurry of fluid additive particles through metal foams. This research has been done in two separate parts based on the type of particles added to the base fluid(Water). Experiments have been conducted with aluminum metal foams with variety of pore densities in conjunction with nanofluids and slurry of microencapsulated octadecane as cooling fluids. Experimental tests for various wall heat fluxes, inlet velocities and particle concentration are carried out. Also the effect of porous media structure on heat transfer enhancement and mixing phenomena is studied. In the first part, by adding phase change material particles to water, enhancement in heat transfer happens mainly due to the departure of unmelted particles from center of the channel toward the heated surface area by mixing processes in the porous channel. In the second part, metallic nano particles increase the heat transfer rate by enhancement in effective thermal conductivity of the fluid.

Heat Transfer Enhancement in Microchannel Heat Sink Using Nanofluids.

Turbulent nanofluids flows in Rib-Groove channel are numerically investigated. The continuity, momentum and energy equations were solved by means of a finite volume method (FVM). A commercial CFD package, FLUENT, is used to perform the modeling and simulation. Different Rib-Groove shapes are used (Rectangular Rib, Triangular Rib, Trapezoidal Rib, Rectangular Groove, Triangular Groove, and Trapezoidal Groove). Four different types of Nanoparticles (Al_2O_3, CuO, SiO_2, and ZnO) with different volumes fractions in the range (0-4)% and different nanoparticle diameters in the range (25-80)nm, are dispersed in the base fluid (water, glycerin and engine oil) are used. In this study, several parameters such as different Reynolds numbers in the range of 5000
This report provides a literature review on the research and development work contributing to the current status of nanofluid technology for heat transfer applications in industrial processes. Nanofluid technology is a relatively new field, and as such, the supporting studies are not extensive. Specifically, the experimental results and theoretical predictions regarding the enhancement of the thermal conductivity and convective heat transfer of nanofluids relative to conventional heat transfer fluids were reviewed and assessments were made of the current status to derive future research and development directions for industrial applications. Pertinent parameters were considered individually as to the current state of knowledge. Experimental results from multiple research groups were cast into a consistent parameter, 'the enhancement ratio, ' to facilitate comparisons of data among research groups and identification of

thermal property and heat transfer trends. The current state of knowledge is presented as well as areas where the data are currently inconclusive or conflicting. Heat transfer enhancement for available nanoparticles is known to be in the 15-40% range, with a few situations resulting in orders of magnitude enhancement. The direction of future research should be to substantiate the lower range results and to continue investigations into the higher enhancements. The focus of this study is primarily transportation applications. However, some attention is given to other industrial applications of nanofluid heat transfer. Also discussed are barriers to be addressed prior to commercialization of nanofluids.

ABSTRACT: Spray cooling is a technique for achieving large heat fluxes at low surface temperatures by impinging a liquid in droplet form on a heated surface. Heat is removed by droplets spreading across the surface, thus removing heat by evaporation and by an increase in the convective heat transfer coefficient. The addition of nano-sized particles, like aluminum or copper, to water to create a nanofluid could further enhance the spray cooling process. Nanofluids have been shown to have better thermophysical properties when compared to water, like enhanced thermal conductivity. Although droplet size, velocity, impact angle and the roughness of the heated surface are all factors that determine the amount of heat that can be removed, the dominant driving mechanism for heat dissipation by spray cooling is difficult to determine. In the current study, experiments were conducted to compare the enhancement to heat

transfer caused by using alumina nanofluids during spray cooling instead of de-ionized water for the same nozzle pressure and distance from the heated surface. The fluids were sprayed on a heated copper surface at a constant distance of 21 mm. Three mass concentrations, 0.1%, 0.5%, and 1.0%, of alumina nanofluids were compared against water at three pressures, 40psi, 45psi, and 50psi. To ensure the suspension of the aluminum oxide nanoparticles during the experiment, the pH level of the nanofluid was altered. The nanofluids showed an enhancement during the single-phase heat transfer and an increase in the critical heat flux (CHF). The spray cooling heat transfer curve shifted to the right for all concentrations investigated, indicating a delay in two-phase heat transfer. The surface roughness of the copper surface was measured before and after spray cooling as a possible cause for the delay.

Applications of Nanofluid for Heat Transfer Enhancement explores recent progress in computational fluid dynamic and nonlinear science and its applications to nanofluid flow and heat transfer. The opening chapters explain governing equations and then move on to discussions of free and forced convection heat transfers of nanofluids. Next, the effect of nanofluid in the presence of an electric field, magnetic field, and thermal radiation are investigated, with final sections devoted to nanofluid flow in porous media and application of nanofluid for solidification. The models discussed in the book have applications in various fields, including mathematics, physics, information science, biology, medicine, engineering, nanotechnology, and materials science. Presents the latest information on nanofluid free and force convection heat transfer, of nanofluid in the presence of thermal radiation, and nanofluid in the presence of an electric field Provides an understanding of the fundamentals in new numerical and analytical methods Includes codes for each modeling method discussed, along with advice on how to best apply them

"The thermal, rheological and morphological characteristics of mineral oil based nanofluids were investigated. Nanofluids were produced with the two-step method dispersing AlN and TiO2 nanoparticles in mineral transformer oil (TO). The mass fractions of the produced nanofluids were 0.01, 0.1 and 0.5 wt%. Thermo-phyisical properties were measured such as thermal conductivity and dynamic viscosity. A comparison of two produced nanofluids: non-modified surface nanoparticles, and modified nanoparticles with oleic acid (OA) is presented and shown to improve stability while preserving thermal properties. SEM images are obtained for dry droplets of the produced nanofluids to observe differences between concentrations and particles surface treatment. The thermal performance of the produced nanofluids is also investigated when used as a cooling fluid in a system that operates under an internal natural convection regime. This system consists of a closed annular vertical cavity that is filled with base fluid and nanofluids. The inner cylinder works as a constant heat source while the outer cylinder removes the thermal energy with a constant temperature condition. The manufactured cavity allows the variation of aspect ratio (height / gap between cylinders) to two fixed values. This experimental setup is instrumented with 12 thermowells and thermocouples to obtain a temperature profile and for calculating heat transfer coefficients and Nusselt numbers. Nanofluids and base fluids are tested in this system to evaluate the effect in the free convective heat transfer coefficient under high Rayleigh numbers (10E6 - 10E8). Additionally, a numerical solution is presented, validating the temperature data of the experiments, and providing velocity profiles. Correlations for Nusselt number in terms of Rayleigh numbers and aspect ratios are adjusted from these solutions. It was found experimentally and confirmed numerically, that low concentrated nanofluids perform best in natural convection coolers."--descripción del autor.

Intended for readers who have taken a basic heat transfer course and have a basic knowledge of thermodynamics, heat transfer, fluid mechanics, and differential equations, Convective Heat Transfer, Third Edition provides an overview of phenomenological convective heat transfer. This book combines applications of engineering with the basic concepts o

This Brief addresses the phenomena of heat transfer enhancement. A companion edition in the SpringerBrief Subseries on Thermal Engineering and Applied Science to three other monographs including “Critical Heat Flux in Flow Boiling in Microchannels,” this volume is idea for professionals, researchers, and graduate students concerned with electronic cooling.

Heat exchangers are widely used in the industrial sector, e.g. in the refrigeration, air conditioning, petrochemical, and agricultural food industry. The high cost of energy and material has resulted in an increased effort aimed at producing high performance heat exchanger equipment. Passive methods of heat transfer enhancement do not need external power for enhancement. One of these kinds of passive technique is twisted tape inserts that enhance the performance of heat exchangers. Using multiple twisted tape inserts gives better enhancement than a single twisted tape insert. Using nanofluid gives also better thermal performance than water. Therefore, nanofluid along with twisted tape inserts was used in this study. For this study, different combinations of multiple twisted tape inserts were designed and fabricated. These different combinations contain dual, triple, and quadruple twisted tapes. Directions of twists are also varied which enables to study the effect of different swirl flow generators. Nanofluid is used with various volume concentrations of 0.07%, 0.14% and 0.21% in order to investigate the effect of nanoparticle concentration on heat transfer enhancement. Experimental investigation was carried out by having a constant heat flux condition and by varying the volume flow rate of flow from 2 to 10 lpm.

There are two purposes of this research, to design and build a heat transfer cell that could accurately calculate heat transport coefficients of various fluids and to determine if the increased heat transfer capabilities of nanofluids can be applied to cooling transformers by using the heat transfer cell to measure the enhancement. The design and construction of a heat transfer cell that could accurately calculate heat transport coefficients of various fluids was successful. A heat transfer cell was built and tested on several fluids to confirm the accuracy of the design and the experiments. Three fluids were successfully tested overall for their thermal conductivity values, and one fluid was tested for its convection coefficients in the heat transfer cells. Values for the thermal conductivity and the convection coefficients were obtained during this experiment that agreed with commonly accepted values for the testing fluids. The average value for the thermal conductivities for mineral oil of the first design in the 1/4" diameter cell is 0.15 w/m2c, and agrees well with the commonly accepted values of mineral oils. The value commonly accepted value of thermal conductivity for mineral oil is 0.14 w/m2c at 25°C, the first heat transfer cell yielded a thermal conductivity value of approximately 0.16 w/m2c at roughly 25C. The heat transfer cell was also used to calculated convection coefficients of mineral oil, and values were obtained within the limits for natural convection according to Incropera, contributing more to the validity of the results from this heat transfer cell. A second heat transfer cell was designed to determine the thermal conductivities of more thermally sensitive fluids, offering a wider range of materials that can be tested. The second design places the thermocouples directly at their assumed position of the wire and the wall temperatures for calculation purposes, yielding more accurate results and can therefore more accurately calculate the thermal conductivities of various fluids. The second design calculated a thermal conductivity of water to be 0.59 w/m2c, while the commonly accepted value is 0.58 w/m2c, which is well within a tolerable range of error to accept this value as accurate at the experimental conditions. This heat transfer cell also calculated the thermal conductivity value for AMSOIL synthetic motor oil to be 0.12 w/m2c and 0.10 w/m2c for mineral oil, both of these values are within the expected ranges of thermal conductivity for oils. The second goal of applying the heat transfer enhancement properties of a nanofluid to a transformer cooling application proved to be futile for Copper Oxide(40nm) and Carbon coated Copper nanoparticles(25nm) in mineral oil. All of the attempted nanofluids fell out of suspension within a timeframe of a day, and in a transformer cell where natural convection is the only means of flow available that contributes to keeping the nanoparticles suspended, there is not enough flow to keep the nanoparticles from falling out of suspension. That is why unless the transformer industry moves towards another coolant besides mineral oil, heat transfer enhancement using Copper Oxide (40nm) or Carbon Coated nanoparticles (25nm) in a mineral oil nanofluid is not a viable option.

Microscale and Nanoscale Heat Transfer: Analysis, Design, and Applications features contributions from prominent researchers in the field of micro- and nanoscale heat transfer and associated technologies and offers a complete understanding of thermal transport in nano-materials and devices. Nanofluids can be used as working fluids in thermal systems; the thermal conductivity of heat transfer fluids can be increased by adding nanoparticles in fluids. This book provides details of experimental and theoretical investigations made on nanofluids for use in the biomechanical and aerospace industries. It examines the use of nanofluids in improving heat transfer rates, covers the numerical approaches for computational fluid dynamics (CFD) simulation of nanofluids, and reviews the experimental results of commonly used nanofluids dispersed in both spherical and nonspherical nanoparticles. It also focuses on current and developing applications of microscale and nanoscale convective heat transfer. In addition, the book covers a wide range of analysis that includes: Solid–liquid interface phonon transfer at the molecular level The validity of the continuum hypothesis and Fourier law in nanochannels Conventional methods of using molecular dynamics (MD) for heat transport problems The molecular dynamics approach to calculate interfacial thermal resistance (ITR) A review of experimental results in the field of heat pipes and two-phase flows in thermosyphons Microscale convective heat transfer with gaseous flow in ducts The application of the lattice Boltzmann method for thermal microflows A numerical method for resolving the problem of subcooled convective boiling flows in microchannel heat sinks Two-phase boiling flow and condensation heat transfer in mini/micro channels, and more Microscale and Nanoscale Heat Transfer: Analysis, Design, and Applications addresses the need for thermal packaging and management for use in cooling electronics and serves as a resource for researchers, academicians, engineers, and other professionals working in the area of heat transfer, microscale and

nanoscale science and engineering, and related industries.
The goals of this dissertation were (i) to investigate the mechanisms behind the thermal conductivity enhancement of nanofluids; (ii) to develop new combined mechanisms based on the analytical thermal conductivity model; (iii) to numerically investigate the fluid dynamics and heat transfer characteristics of nanofluids in a circular tube corresponding to the new analytical thermal conductivity model; (iv) to study the influence of the nanoparticle volume concentration, particle size, base fluid and temperature of nanofluids on the viscosity of nanofluids; (v) to examine the temperature effect on the thermal conductivity enhancement of nanofluids with physical mechanisms behind this enhancement and models; (vi) to investigate the local heat transfer coefficient of nanofluids associated with constant thermophysical properties or temperature dependent transport properties under the uniform heating and cooling condition with laminar flow regimes; and (vii) to investigate the Brownian motion based thermal conductivity model's effects on the channel wall by using a computational fluid dynamic (CFD) toolbox, which is called OpenFOAM, and enlighten how these models alter the temperature gradients at the channel wall as a function of position in the entrance region of an internal flow. Nanofluids are suspensions of nanoparticles (typically 2-100 nm with average particle sizes) in base fluids that are called conventional heat transfer fluids such as water, oil, ethylene glycol and mixtures. They have unique physical properties for practical engineering applications. It is crucial to

determine accurate viscosity and thermal conductivity models for the numerical simulation of nanofluids. Both of these thermophysical properties significantly affect the heat transfer performance and pumping power penalties of nanofluids, respectively. Thus, a comprehensive parametric study has been conducted to investigate the most appropriate models by comparing them with the existing experimental data. The most appropriate correlations have been determined and implemented into the OpenFOAM. The numerical results have shown that the Brownian motion based thermal conductivity models are not capable of explaining the thermal conductivity enhancement of nanofluids. In addition, the interfacial layer based thermal conductivity model has been applied to explain the thermal conductivity improvement of nanofluids, and it was observed that the introduction of the nanolayer thickness is still superficial. The intermolecular structure between the solid nanoparticles and base fluid molecules cause an interfacial layer. However, the thickness of this nanolayer may not make an important contribution to increase the thermal conductivity of nanofluids due to unrealistic prediction of the nanolayer and determination of the thermophysical properties of this nanolayer. Thus, a combined mechanism based thermal conductivity model, which consists of the effective medium theory, aggregation based thermal conductivity model and Brownian motion, has been developed to predict the existing experimental data. It was observed that this model closely agrees with the existing experimental data. This new analytical thermal conductivity model has been implemented into the OpenFOAM to investigate its effect on the heat transfer enhancement of nanofluids with using the temperature dependent thermophysical properties.

Featuring contributions by leading researchers in the field, Nanoparticle Heat Transfer and Fluid Flow explores heat transfer and fluid flow processes in nanomaterials and nanofluids, which are becoming increasingly important across the engineering disciplines. The book covers a wide range, from biomedical and energy conversion applications to materials properties, and addresses aspects that are essential for further progress in the field, including numerical quantification, modeling, simulation, and presentation. Topics include: A broad review of nanofluid applications, including industrial heat transfer, biomedical engineering, electronics, energy conversion, membrane filtration, and automotive An overview of thermofluids and their importance in biomedical applications and heat-transfer enhancement A deeper look at biomedical applications such as nanoparticle hyperthermia treatments for cancers Issues in energy conversion from dispersed forms to more concentrated and utilizable forms Issues in nanofluid properties, which are less predictable and less repeatable than those of other media that participate in fluid flow and heat transfer Advances in computational fluid dynamic (CFD) modeling of membrane filtration at the microscale The role of nanofluids as a coolant in microchannel heat transfer for the thermal management of electronic equipment The potential enhancement of natural convection due to nanoparticles

Examining key topics and applications in nanoscale heat transfer and fluid flow, this comprehensive book presents the current state of the art and a view of the future. It offers a valuable resource for experts as well as newcomers interested in developing innovative modeling and numerical simulation in this growing field.
INTERNATIONAL WORKSHOPS (at IAREC'17) (This book inclueds English (main) and Turkish languages) International Workshop on Mechanical Engineering International Workshop on Mechatronics Engineering International Workshop on Energy Systems Engineering International Workshop on Automotive Engineering and Aerospace Engineering International Workshop on Material Engineering International Workshop on Manufacturing Engineering International Workshop on Physics Engineering International Workshop on Electrical and Electronics Engineering International Workshop on Computer Engineering and Software Engineering International Workshop on Chemical Engineering International Workshop on Textile Engineering International Workshop on Architecture International Workshop on Civil Engineering International Workshop on Geomatics Engineering International Workshop on Industrial Engineering International Workshop on Food Engineering International Workshop on Aquaculture Engineering International Workshop on Agriculture Engineering International Workshop on Mathematics Engineering International Workshop on Bioengineering Engineering International Workshop on Biomedical Engineering International Workshop on Genetic Engineering International Workshop on Environmental Engineering International

Workshop on Other Engineering Science

In recent years, as per global forecasts, heat transfer enhancement is legion. In response, "nanofluid" is ranked first in the top echelons of researches, especially in the prestigious institutions worldwide in this field. You get an overview of studies and applications of nanofluids. However, to obtain a deep understanding of this text, the authors kindly propose that readers to have an adequate background of the nanofluid field. Next, this book presents a unified conception of a new typical nanofluid called "Hybrid nanofluid" that is a combination of two types of nanoparticles dispersed simultaneously in a base fluid. Accordingly, it has a superior exclusivity compared to the common nanofluid today. The emphasis throughout the book is on the thermal and hydrodynamic performance of hybrid nanofluid compared to that of nanofluid and also a conventional one. The book endeavors to attract a great deal of interest by employing text, pictures, graphs, and definitions to illustrate points and highlight concepts.

The purpose of this research is to determine the differences in heat transfer enhancement of poly alpha olefin oil after the addition of two types of carbon coated nanoparticles, specifically carbon coated cobalt and carbon coated copper nanoparticles. The carbon shell allows for the nanoparticles to be homogenously dispersed in the oil and remain stable throughout the experimental procedure. The nanofluids were prepared in concentrations of 0.5, 1.0, and 1.5 wt%. A constant surface heat flux testing rig is used to determine the heat transfer coefficients of the base fluids and the nanofluids. Inlet temperatures to the heat transfer section of the rig and flow rate of the fluid are varied to allow analysis of the impact of fluid temperature and Reynolds number. Testing occurred at temperatures of 50, 65, and 90 oC and fluid flow rates of 10 to 100 mL/s. The carbon coated copper nanoparticles showed the largest heat transfer enhancement at a fluid temperature of 65oC and at a loading concentration of 1.0 wt%. In general heat transfer enhancement decreased as both particle concentration and fluid temperature increased. The carbon coated cobalt nanoparticles exhibited the largest heat transfer enhancement at a fluid temperature of 90 oC and a particle concentration of 1.5 wt%. Heat transfer enhancement generally increased as both temperature and particle concentration increased. Overall heat transfer enhancement by the carbon coated copper nanoparticles was larger than the enhancement provided by the carbon coated cobalt nanoparticles at the same flow rate, temperature, and concentration. This is attributed to the higher thermal conductivity of copper metal.

Nanofluids are gaining the attention of scientists and researchers around the world. This new category of heat transfer medium improves the thermal conductivity of fluid by suspending small solid particles within it and offers the possibility of increased heat transfer in a variety of applications. Bringing together expert contributions from across the globe, Heat Transfer Enhancement with Nanofluids presents a complete understanding of the application of nanofluids in a range of fields and explains the main techniques used in the analysis of nanofuids flow and heat transfer. Providing a rigorous framework to help readers develop devices employing nanofluids, the book addresses basic topics that include the analysis and measurements of thermophysical properties, convection, and heat exchanger performance. It explores the issues of convective instabilities, nanofluids in porous media, and entropy generation in nanofluids. The book also contains the latest advancements, innovations, methodologies, and research on the subject. Presented in 16 chapters, the text: Discusses the possible mechanisms of thermal conduction enhancement Reviews the results of a theoretical analysis determining the anomalous enhancement of heat transfer in nanofluid flow Assesses different approaches modeling the thermal conductivity enhancement of nanofluids Focuses on experimental methodologies used to determine the thermophysical properties of nanofluids Analyzes forced convection heat transfer in nanofluids in both laminar and turbulent convection Highlights the application of nanofluids in heat exchangers and microchannels Discusses the utilization of nanofluids in porous media Introduces the boiling of nanofluids Treats pool and flow boiling by analyzing the effect of nanoparticles on these complex phenomena Indicates future research directions to further develop this area of knowledge, and more Intended as a reference for researchers and engineers working in the field, Heat Transfer Enhancement with Nanofluids presents advanced topics that detail the strengths, weaknesses, and potential future developments in nanofluids heat transfer.