applied sciences

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Editorial

Special Issue on Recent Developments of Nanofluids

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Received: 16 January 2018; Accepted: 23 January 2018; Published: 27 January 2018

1. Introduction

Recent advances in nanotechnology have allowed the development of a new category of fluids termed nanofluids. A nanofluid refers to the suspension of nanosize particles, which are suspended in the base fluid with low thermal conductivity. The base fluid, or dispersing medium, can be aqueous or non-aqueous in nature. Typical nanoparticles are metals, oxides, carbides, nitrides, or carbon nanotubes. These shapes may be spheres, disks, rods, etc. By using these additives, one can increase the heat transfer coefficient and consequently enhance the heat transfer value and performance of base fluids. Some of these fluids can be considered Newtonian fluids, but in many applications the Newtonian model is not very accurate; therefore, it has generally been acknowledged that non-Newtonian fluids exhibiting a nonlinear relationship between the stresses and the rate of strain are more appropriate in technological applications as compared to Newtonian fluids. Many industrial fluids are non-Newtonian in their flow characteristics and are referred to as rheological fluids, such as slurries (china clay and coal in water, sewage sludge, etc.) and multiphase mixtures (oil-water emulsions, gas-liquid dispersions, such as froths and foams, butter). Further examples displaying a variety of non-Newtonian characteristics include pharmaceutical formulations, cosmetics and toiletries, paints, synthetics lubricants, biological fluids (blood, synovial fluid, salvia), and food stuffs (jams, jellies, soups, marmalades), etc. Moreover, simulation of boundary layer flow of nanofluids is another aspect of this special issue that has various applications in engineering and industrial disciplines.

Existing literature indicates that despite a vast range of application, the investigation on proposed title was still scant. Consequently, researchers are invited to contribute their original research and review articles with this hope that this special issue will also serve as a forum for presenting innovative and new developments quite relevant for the scope of this special issue as specified in keywords.

A total of 12 papers were submitted for possible publication in this special issue. After a comprehensive peer review, only eight papers qualified to get the acceptance for final publication. The rest of papers could not be accommodated. The submissions were technically correct, but were not considered appropriate for the scope of this special issue. The authors are from geographically distributed countries such as China, Romania, South Africa, Iran, Pakistan, Malaysia, and Saudi Arabia. This reflects the great impact of the proposed topic and the effective organization of the guest editorial team of this special issue.

2. Nanofluids: Techniques and Applications

The effect of thermal radiation on the thin film nanofluid flow of a Williamson fluid over an unsteady stretching surface with variable fluid properties is investigated in [1]. Special attention has been given to the variable fluid properties. Analytical solutions of nonlinear governing equations are achieved by means of homotopy analysis method. Experimental values of the Prandtl number have been used to produce the results for the Williamson nanofluid, whereas the accuracy of the HAM results has been verified via numerical solutions. The effects of non-dimensional physical parameters—such as thermal conductivity, Schmidt number, Williamson parameter, Brinkman number, radiation parameter, and Prandtl number—have been thoroughly demonstrated and discussed. A comparison is also made for the validation of obtained results.

In the paper "On Squeezed Flow of Jeffrey Nanofluid between Two Parallel Disks", Hayat et al. [2] presented the magnetohydrodynamic (MHD) squeezing flow of Jeffrey nanofluid between two parallel disks. Constitutive relations of Jeffrey fluid are employed in the problem development. Heat and mass transfer aspects are examined in the presence of thermophoresis and Brownian motion. Jeffrey fluid subject to time dependent applied magnetic field is conducted. Suitable variables lead to a strong nonlinear system. The resulting systems are computed via a homotopic approach. The behaviors of several pertinent parameters are analyzed through graphs and numerical data. Skin friction coefficient and heat and mass transfer rates are numerically examined. They found that the larger values of Deborah numbers correspond to lower temperature and concentration profiles. Both temperature and concentration profiles are higher for larger values of thermophoresis parameter. The present analysis reduces to a Newtonian nanofluid flow situation as a limiting case of this model.

It is well known that the best way of convective heat transfer is the flow of nanofluids through a porous medium. In this regard, a mathematical model is presented in [3] to study the effects of variable viscosity, thermal conductivity and slip conditions on the steady flow and heat transfer of nanofluids over a porous plate embedded in a Darcy-type porous medium. The nanofluid viscosity and thermal conductivity are assumed to be linear functions of temperature, and the wall slip conditions are employed in terms of shear stress. The similarity transformation technique is used to reduce the governing system of partial differential equations to a system of nonlinear ordinary differential equations. The resulting system of ODEs is then solved numerically using the shooting technique. The numerical values obtained for the velocity and temperature profiles, skin friction coefficient, and Nusselt number are presented and discussed through graphs and tables. It is shown that the increase in the permeability of the porous medium, the viscosity of the nanofluid, and the velocity slip parameter decrease the momentum and thermal boundary layer thickness and eventually increase the rate of heat transfer. Moreover, the analysis can be extended to include the results for different water-based nanofluids, and a comparison can be generated on the heat transfer characteristics of different nanofluids. Clearly, there is an opportunity to consider/extend this problem with non-Newtonian nanofluid models and to perform experimental work on these systems.

The studies of classical nanofluids are restricted to models described by partial differential equations of integer order, and the memory effects are ignored. Fractional nanofluids, modeled by differential equations with Caputo time derivatives, are able to describe the influence of memory on the nanofluid behavior. In the paper [4], the heat and mass transfer characteristics of two water-based fractional nanofluids, containing nanoparticles of CuO and Ag, over an infinite vertical plate with a uniform temperature and thermal radiation, are analytically and graphically studied. Closed form solutions are determined for the dimensionless temperature and velocity fields, as well as the corresponding Nusselt number and skin friction coefficient. These solutions, presented in equivalent forms in terms of the Wright function or its fractional derivatives, have also been reduced to the known solutions of ordinary nanofluids. The influence of the fractional parameter on the temperature, velocity, Nusselt number, and skin friction coefficient is graphically underlined and discussed. The enhancement of heat transfer in the natural convection flows is lower for fractional nanofluids, in comparison to ordinary nanofluids. In both cases, the fluid temperature increases for increasing values of the nanoparticle volume fraction.

The magnetohydrodynamic thin film nanofluid sprayed on a stretching cylinder with heat transfer is explored in [5]. The spray rate is a function of film size. Constant reference temperature is used for the motion past an expanding cylinder. The sundry behavior of the magnetic nano-liquid thin film is carefully noticed which results in to bring changes in the flow pattern and heat transfer. Water-based nanofluids like Al_2O_3-H_2O and CuO-H_2O are investigated under the consideration of thin film. The basic constitutive equations for the motion and transfer of heat of the nanofluid with the boundary conditions have been converted to nonlinear coupled differential equations with physical conditions by employing appropriate similarity transformations. The modeled equations have been solved using homotopic approach and lead to detailed expressions for the velocity profile and temperature distribution. The pressure distribution and spray rate are also calculated. The residual errors show the authentication of the present work. The CuO-H_2O nanofluid results from this study are compared with the experimental results reported in the literature and are found to have excellent agreement. The present work discusses the salient features of all the indispensable parameters of spray rate, velocity profile, temperature, and pressure distributions which have been displayed graphically and illustrated.

In [6], the Brownian motion and thermophoresis effect of the liquid film flow over an unstable stretching surface in a porous space is presented. The main focus is on the variation in the thickness of the liquid film in a porous space. The graphical comparison of these two methods is elaborated. The physical and numerical results using h curves for the residuals of the velocity, temperature, and concentration profiles are obtained. The key observations concluded that higher values of porosity parameter generates larger open space and create hurdle to flow and as a result the flow field reduces. The larger values of Prandtl number reduces the thermal boundary layer due to which the temperature field reduces while the Eckert number is allied with the viscous dissipation term and lead to an increase the quantity of heat being produced by the shear forces in the fluid. Therefore, larger values of Eckert raise the temperature field. It is also seen that the larger values of thickness parameter transport more fluid in the boundary layer region and cooling effect is produced which absorbs the heat transfer from the sheet and, as a result, the temperature reduces.

A radial basis function (RBF) neural network with three-layer feed forward architecture was developed in [7] to effectively predict the viscosity ratio of different ethylene glycol/water based nanofluids. A total of 216 experimental data involving CuO, TiO_2, SiO_2, and SiC nanoparticles were collected from the published literature to train and test the RBF neural network. The parameters—including temperature, nanoparticle properties (size, volume fraction, and density), and viscosity of the base fluid—were selected as the input variables of the RBF neural network. The investigations demonstrated that the viscosity ratio predicted by the RBF neural network agreed well with the experimental data. In addition, by comparing the RBF predictive values and the experimental data published in various studies, it was demonstrated that the RBF neural network not only exhibited good modeling accuracy but also could effectively predict the influences of temperature, nanoparticle volume fraction, and diameter on the viscosity ratio of different ethylene glycol/water based nanofluids. Compared to the typical viscosity models, namely the Batchelor model and Chen model, the RBF neural network has a good ability to predict the viscosity ratio of different ethylene glycol/water based nanofluids. However, the prediction performance can be affected by the size of the data set. The present investigation may play an active role for developing the modeling of nanofluid viscosity. However, how to extend the application of ANN to predict other thermo-physical properties of nanofluids is still worthy of study in the future.

A two-way coupling of discrete phase model is developed in order to track the discrete nature of aluminum oxide particles in an obstructed duct with two side-by-side obstacles is explored in [8]. Finite volume method and trajectory analysis are simultaneously utilized to solve the equations for liquid and solid phases, respectively. The interactions between two phases are fully taken into account in the simulation by considering the Brownian, drag, gravity, and thermophoresis forces. The effects of space ratios between two obstacles and particle diameters on different parameters containing concentration and deposition of particles and Nusselt number are studied for the constant values of the Reynolds numbers and volume fractions of nanoparticles. The obtained results indicate that the particles with smaller diameter (dp = 30 nm) are not affected by the flow streamline and they diffuse through the streamlines. Moreover, the particle deposition is enhanced as the value of the space ratio increases. A comparison between the experimental and numerical results is also provided with the existing literature as a limiting case of the reported problem and found in good agreement.

3. Future Trends in Nanotechnology

Even as with the completion of this special issue, the material that advances the state-of-the-art of experimental, numerical, and theoretical methodologies or extends the bounds of existing methodologies to new contributions in applied nano-technology is still insufficient. Nanofluids strengthen solar energy applications such as heat exchanger design and medical applications including cancer therapy and safer surgery by heat treatment. Nanofluid technology can also help to develop better oils and lubricants for practical applications.

Acknowledgments: The guest editorial team of Applied Sciences would like to thank all authors for contributing their original work to this special issue, no matter what the final decisions of the submitted manuscripts were. The editorial team would also like to thank all anonymous professional reviewers for their valuable time, comments, and suggestions during the review process. We also acknowledge the entire staff of the journal's editorial board for providing their cooperation regarding this special issue. We hope that the scientists who are working in the same regime will not only enjoy this special issue, but would also appreciate the efforts made by the entire team.

Conflicts of Interest: The author declares no conflict of interest.

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