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Reacting System of Boundary Layer Flow of CuO-Oil-Based Nanofluid with Heat Generation through a Vertical Permeable Surface

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REACTING SYSTEM OF BOUNDARY LAYER FLOW OF CuO-OIL-BASED NANOFLUID WITH HEAT GENERATION THROUGH A VERTICAL PERMEABLE SURFACE

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(AAA1700149)

B. Tech. (Hons.) Pure and Applied Mathematics,

M. Tech. Applied Mathematics (LAUTECH)

A Ph.D Thesis Submitted to

THE DEPARTMENT OF PURE AND APPLIED MATHEMATICS,
FACULTY OF PURE AND APPLIED SCIENCES,
LADOKE AKINTOLA UNIVERSITY OF TECHNOLOGY, OGBOMOSO

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D) DEGREE IN APPLIED MATHEMATICS OF LADOKE AKINTOLA UNIVERSITY OF TECHNOLOGY, OGBOMOSO, NIGERIA

OCTOBER 2022

CERTIFICATION

This Thesis titled **Reacting System of Boundary Layer flow of CuO-Oil-Based Nanofluid with Heat Generation through a Vertical Permeable Surface** submitted by **ASELEBE Lateefat Olanike** was carried out under my supervision in the Department of Pure and Applied Mathematics, Ladoke Akintola University of Technology, Ogbomoso.

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ATTESTATION

I hereby attest that this research work was carried out in the Department of Pure and Applied Mathematics, Faculty of Pure and Applied Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

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ABSTRACT

The loss of energy in any thermo-dynamical system has been a challenge to power generating industries in recent times. It becomes necessary to control the factors responsible for this in order to prevent the engines from breaking down. The heat carrier fluids like water, oil, ethylene glycol etc. are useful in heat transfer but their performances are limited due to their low thermal conductivities. Nanofluids are known to enhance heat transfer properties better than conventional heat carrier fluids. The flow and heat transfer performance of nanofluids are highly influenced by their thermo-physical properties. This study, therefore, investigated the reacting system of boundary layer flow of CuO-oil-based nanofluids with heat generation through a vertical permeable surface.

The physical system was modeled into a system of Partial Differential Equations (PDEs) denoted as continuity, momentum, energy and concentration equations which were further simplified into a system of coupled nonlinear Ordinary Differential Equations (ODEs) by using suitable similarity variables. The considered nanofluids consisted of CuO as nanoparticles and engine oil as base fluid. During the analysis, the flow was considered to be steady, incompressible and two dimensional. Two cases were considered for the thermo-physical properties of nanofluids, viz-a-viz: temperature and concentration-dependent thermo-physical properties of CuO-Oil-based nanofluids with the physical parameters of viscosity variations (α,γ), specific heat (ξ,Σ), density (ϖ,Λ), thermal conductivity (ω,Ω), heat generation (δ), Brownian motion (Nb), thermophoresis (Nt), Suction (S), Grashof number (Gr), Biot number (*Bi*), Brinkmann number (*Br*), Chemical reaction (R),Permeability (K^*) and Prandlt number (*Pr*) at the free stream temperature T_∞

which moves over the right surface of the plate with a uniform free stream velocity U_{∞}. The resulting equations were solved numerically using fourth order Runge-Kutta method implemented on MAPLE 18.0 software. The velocity $f'(\eta)$, temperature $\theta(\eta)$ and concentration $\phi(\eta)$ profiles, skin friction coefficient $f''(\eta)$, Sherwood number $\phi'(\eta)$ and Nusselt number $\theta'(\eta)$ were examined for some associated physical parameters of CuO-Oil-based nanofluids and were presented via graphs and tables.

Results showed that as Gr, δ, ϖ, α, Λ, Ω, ω, γ, S, and φ increased the velocity profile increased and increase in K^* and Pr decreased the velocity profile in the two cases. The temperature of CuO-Oil based nanofluid increased as Ω, ω, K^*, and δ increased, but decreased as S, ϖ, Λ, ξ, Σ, α, γ and Pr increased. Furthermore, $f''(\eta)$ increased as ϖ, ω, γ, Λ, α, Ω, K^* and φ increased, but decreased as S and δ increased. $\theta'(\eta)$ increased as S, Ω, ω, φ and δ increased but decreased as ϖ, Λ and K^* increased. Also $\phi'(\eta)$ increased as K^*, δ and φ increased but decreased as S, ξ, Σ, ω, Ω increased.

In conclusion, combining some thermo-physical properties like thermal conductivity, viscosity, specific heat and density of CuO-oil-based nanofluids influenced the rate of flow of the fluid as well as the heat and mass transfer significantly. It also has the potential to reduce friction, fuel consumption and overheating of the engine which tends to prolong its life span.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES