Electrification of alumina nanoparticles experiencing haphazard motion and thermophoresis: Dynamics of water-based nanofluid on a vertical surface

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1. INTRODUCTION & OBJECTIVE

1.1 Introduction

Conventional working fluids cannot prevent overheating due to the increased heat output in modern systems as it necessitates higher heat transfer rates. Choi [1] has introduced the term “nanofluid” to describe a new class of fluid that incorporates nanoscale metallic/non-metallic particles suspended in a conventional fluid, proving an excellent thermal conductivity improvement. Research is still going on for the enhancement of thermal conductivity of nanofluids, Mishra et al. [2]. The modelling of magneto-hydrodynamics (MHD) free convection nanofluid flow past a vertical surface with various physical aspects has been studied by several researchers Refs. [3-5]. In all these investigations, the base fluid is considered as electrically conducting. However, hardly any attention has been given in the available literature on the nanoparticle electrification mechanism in a non-conducting base fluid while modelling the nanofluid flow which has significant effect on modeling heat transfer aspects of nanofluids, Soo [6] & Kang and Wang [7].

1.2 Objective

The objective of this study is to incorporate the nanoparticle electrification mechanism in modelling free convective alumina-water nanofluid flow and to investigate the significance of electrified alumina nanoparticles on the optimization of heat and mass transfer in the free convection alumina-water nanofluid flow containing electrified alumina-nanoparticles adjacent to a vertical plane wall. It is expected that the nanoparticle electrification mechanism would be a new approach for heat transport enhancement in nanofluids which could lead to improve the quality of finished plane wall-shaped products in industries.

1.3 Methodology

The governing equations of the flow field are converted into locally similar equations employing similarity variables and are solved using the MATLAB bvp4c package. the impacts of alumina-nanoparticle electrification parameter and buoyancy ratio parameter on non-dimensional concentration, temperature and velocity profiles, as well as dimensionless coefficients of heat and mass transfer, are thoroughly examined.

Keywords: Nanofluid, Heat transfer, Mass transfer, nanoparticle electrification, Buoyancy, free convection

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

The significant results are highlighted herewith.

1. The velocity of the nanofluid in the boundary layer region increases with the increase in alumina-nanoparticle electrification parameter, whereas it decreases with the buoyancy ratio parameter.

2. An increase in buoyancy ratio parameter raises the temperature of the nanofluid, whereas an increase of alumina-nanoparticle electrification parameter lowers the temperature near the plane wall.

3. Increasing buoyancy ratio parameter enhances the concentration of nanoparticles while increasing alumina-nanoparticle electrification parameter slows down the concentration in the vicinity of the plane wall.

4. The dimensionless heat and mass transfer coefficients of alumina-water nanofluid is improved with alumina-nanoparticle electrification parameter while both reduce with the buoyancy ratio parameter.

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