# Crucial Role of Nanoparticles Aggregation Effect on Non-Darcian Flow of Micropolar Nanofluid over Riga Plate with Navier's Slip: A Regression Analysis

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## 1. ABSTRACT

It is a fact that adding nanoparticles to the base fluid increases its thermal conductivity. However, engineers encounter one big hurdle when they try to understand how internal molecular interactions like shapes and aggregation kinetics influence the fluid's thermal physical characteristics. Because of this, the aggregation kinematics of nano-particles becomes essential for determining the suitable thermal effect of particles at the nano-scale. So, the focus of this study is to examine the characteristics of nano-particle aggregation and its influences on the micropolar nanofluid flow past a Riga plate. Additionally, the influence of non-Darcy effects, non-uniform heat source/sink, and Navier slip effect are also considered in this study. Under these assumptions, the governing is formulated and altered to the ordinary differential equation. Numerical solutions are obtained using inbuilt function bvp4c in MATLAB software and outcomes are graphically depicted to study the impact of pertinent parameters on the flow field. We observed that nano-particle aggregation significantly enhances the temperature field and diminishes the velocity field. Also, the source/sink parameter upsurges the temperature distribution, and the modified Hartmann number enhances the velocity profile. This study will be useful for real-world fluid flow problems like blood, exotic lubricants, additive suspensions, liquid crystals, and polymeric fluids through microchannels and capillaries.

KEYWORDS: Regression Analysis, Nano-particle Aggregation, Navier slip effect, Riga plate, non-Darcy porous medium.

## 2. INTRODUCTION

Regular cooling fluids (like water and ethylene glycol) in machine operation can minimize the cost but enhancement of heat transfer is inadequate due to their weak thermal conductivity.

Therefore, nanofluids that help to get the best thermal productivity are developed and authenticated through experimental and theoretical studies. In recent years, the concept of nanofluids has widely spread as a prominent field of research as a result of its application in different domains including energy production, car radiators, aerospace industries, nuclear reactors, microelectronics, biomedical, and fuel cells, macro and micro-scale heat exchangers[1].

However, numerous experiments reveal that nano-particles in nanofluid may aggregate or settle down (sedimentation) [2]. When nano-particles combine to create a long structure termed nano-particle aggregation, these aggregated particles will minimize the nanofluid's stability which is essential in practical application, and this leads to limiting usage of nanofluid. Hence, an investigation of the characteristics of nano-particle aggregation is included in this study.

The study of electro-magneto-hydrodynamics (EMHD) has a potential application in various fields such as mechanical, civil, and chemical engineering especially in micro-coolers, submarines, and warm reactors. An electromagnetic device known as the Riga plate incorporates anodes and magnets on a flat plate to operate. Initially, this novel idea that can start an EMHD force has been suggested by Gailitis and Lielausis[3]. This inventive actuator helps delay the boundary layer's detachment and lessen the turbulence's effects. This study aims to advance and aid research on the flow caused by the Riga plate.

The current study investigates the characteristics of nano-particle aggregation and its influences on the flow field of the non-Darcy flow of a micropolar nanofluid past a Riga plate. In addition, the Navier slip and non-uniform heat source/sink effect are considered.

## 3. MATHEMATICAL MODELING

The following major steps will be performed to accomplish the mathematical modeling of the current investigation.

- Initially, governing equations for the non-Darcy flow of a micropolar nanofluid past a Riga plate will be studied under boundary layer conditions.
- Next, the relevant similarity variables are utilized to convert the governing equations into the dimensionless form. For this investigation, dimensionless physical quantities are also derived.
- Lastly, MATLAB's built-in function Bvp4c will be implemented to solve the resulting ordinary differential equations.

## 4. RESULTS AND HIGHLIGHTS

The aforementioned numerical solutions will be employed to evaluate the characteristics of fluid flow. Meanwhile, regression analysis was incorporated to analyze the frictional coefficient and heat transmission rate. This analysis will be performed on both the nanoparticles with/without aggregation, and the results will be depicted visually for the essential parameters.

The following summarizes a few noteworthy findings:

- Nano-particle aggregation significantly enhances the temperature field at the same diminishes the velocity field.
- Velocity profile diminishes for nano-particle volume fraction, Navier slip, and Darcy Forchheimer parameters for both cases of with aggregation and without aggregation.
- The degree of the microelement's rotation enhances the micro-rotation profile.

Finally, this work is beneficial in many industrial fields including thermal energy storage, polymer extrusion processes, petroleum reservoirs, recoverable systems, and cooling of an infinite metallic plate.

## REFERENCE

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