Effects of Gyrotactic Microorganism on MHD Mixed Convective Nanofluid Flow Over a Sheet with Convective Boundary Condition and Radiation Near a Stagnation Point

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1. INTRODUCTION & OBJECTIVE

The study of nanofluid flow over a sheet near a stagnation point with gyrotactic microorganisms under the influence of magnetohydrodynamic (MHD) mixed convection is crucial for various industrial and biological applications. MHD concerns the behaviour of electrically conducting fluids in the presence of a magnetic field, significantly affecting fluid flow and heat transfer. Gyrotactic microorganisms, such as certain algae, exhibit a unique behaviour by aligning themselves against the flow direction, significantly affecting fluid dynamics. Mixed convection involves the combination of natural and forced convection, which is vital in many practical applications, such as cooling systems and chemical reactors. Convective boundary conditions refer to situations where heat transfer occurs at the boundary surface, influencing the temperature distribution within the fluid. Radiation affects the energy transport within the fluid, while chemical reactions can alter the thermal and concentration fields.

The main goal of this study is to investigate how gyrotactic microbes influence mixed convective nanofluid flow over a sheet in the presence of convective boundary conditions and radiation close to a stagnation point in MHD. The objectives of this study are as follows:

(i) To determine how the nanofluid's flow and thermal profiles are affected by factors like radiation, chemical reactions, heat generation, Peclet number, and motile parameter.

(ii) To determine how magnetic parameters, biot number, thermal grashof number, solutal grashof number, bioconvection schmidt number, and lewis number affect the velocity, temperature, and density profiles of motile microorganisms.

(iii) To solve the governing ordinary differential equations into partial differential equations using similarity transformations in MATLAB bvp4c.

(iv) To validate the numerical results by comparing them with existing literature. By accomplishing these goals, the study hopes to provide insight into the complex behaviour of nanofluid flows, which could lead to advancements in a wide range of technical and industrial domains, such as cooling systems, bioreactors, and tailored medication administration.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

The results reveal that the magnetic parameter, radiation, and Biot number significantly influence the velocity profile. An increase in the magnetic parameter decreases the velocity profile due to the Lorentz force acting as a drag. Higher radiation parameters enhance thermal buoyancy, increasing the velocity profile. Higher Biot numbers improve heat transfer at the boundary, increasing fluid velocity near the surface. The temperature profile is affected by radiation, heat generation, and chemical reactions. Increased radiation raises the temperature profile due to enhanced radiative heat transfer. Higher heat generation increases fluid temperature, promoting thermal gradients. Exothermic chemical reactions elevate the temperature profile, while endothermic reactions decrease it. The density of motile microorganisms is impacted by the solutal grashof number and biot number. Increased solutal grashof number enhances buoyancy, increasing the density of motile organisms near the surface. Higher Biot numbers improve mass transfer rates, affecting the distribution of motile organisms. Heat transfer characteristics, represented by the Nusselt number, are influenced by radiation, chemical reactions, and the presence of motile organisms. Enhanced radiation and exothermic reactions increase the Nusselt number, indicating better heat transfer, while endothermic reactions lower it. The presence of motile organisms enhances heat transfer by increasing the overall thermal energy within the fluid. Skin friction is influenced by the magnetic parameter and thermal Grashof number, with higher magnetic parameters increasing skin friction due to the lorentz force, while increased thermal Grashof numbers reduce skin friction by promoting smoother flow due to enhanced buoyancy effects.

Highlights:

- Enhanced cooling systems can benefit from higher radiation parameters and exothermic reactions, which improve heat transfer efficiency.
- Magnetic parameters can be adjusted to optimize flow control in MHD systems, reducing skin friction and managing fluid velocity.
- Bioreactors and chemical reactors can leverage higher Biot numbers and solutal Grashof numbers to enhance mass transfer and microbial distribution, improving reaction rates and product yields.
- In targeted drug delivery systems, the presence of motile organisms and optimized thermal parameters can enhance the precision and efficacy of treatments.

These findings offer valuable insights into optimizing conditions for enhanced flow and heat transfer characteristics, and they align well with existing literature, validating the model. They significantly advance industrial and biomedical applications involving nanofluids and gyrotactic microorganisms. This research opens new avenues for improving efficiency and effectiveness in various technological processes, such as cooling systems, bioreactors, and targeted drug delivery, by leveraging the unique properties of nanofluids and the behaviour of gyrotactic microorganisms.

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