Optimization of Magnetic Field Strength and Slip Coefficient of Heat Transfer and Flow Control in MHD Micro Polar Fluids

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ABSTRACT

The objective of the ongoing examination is advancement of attractive field strength and slip coefficient of intensity move and stream control in MHD miniature polar liquids to portray the peculiarity of intensity mass exchange on MHD miniature polar liquids welcomed on by ceaselessly extending penetrable sheets joined with slip influences supported in permeable media. Subsequently, non-uniform intensity source/sink is a term in the energy condition. The terms showing the request for the substance response are joined with the situation connecting with species focus to describe the artificially receptive species. Conditions of force, miniature apportions, intensity, and focus are decreased into the proper required disentanglements utilizing the application programming MATLAB and the overseeing linguistic structure of the bvp4c method to determine the vital math controls of the accessible non-straight conditions. In the accessible charts, different dimensionless boundaries are portrayed with critical results. Miniature polar liquid upgrades the speed and temperature profile, as per examination, while. It lessens the profile of miniature proportions. The found derivations exhibit exceptional concurrence with data that has been distributed in a public writing. The issue of consistent, two-layered, intensity and mass exchange of an electrically directing, incompressible micropolar liquid stream past an extending surface under states of speed and warm slip is introduced in this review. Furthermore, the impacts of temperature-subordinate thickness, warm radiation, lopsided intensity age and assimilation, and general-request substance response on liquid stream are examined. By utilizing the suitable likeness factors, the overseeing arrangement of halfway differential conditions of liquid stream is changed over into non-straight normal differential conditions, and the subsequent conditions are then settled involving the shooting strategy related to a fourth request Runge-Kutta incorporation plot. Controlling variables' consequences for speed, temperature, and miniature revolution.

Keywords:MHD (Magnetohydrodynamics), Slip Conditions, Stretching Sheet,non-uniform heat source/sink, Porous medium.

1. INTRODUCTION

In recent times, investigation of non-Newtonian liquids had drawn in impressive consideration from scientists because of its rising value and down to earth importance in numerous modern processes[1]. These liquids are especially significant in genuine modern applications, for example, in polymer designing, unrefined petroleum extraction[2]. MHD (magnetohydrodynamics) miniature polar liquid is a kind of liquid that considers the microstructure of the liquid and the impacts of attractive fields[3]. In this liquid model, the liquid is thought to be a homogeneous combination of miniature particles that have both rakish energy and attractive moments[4].

The equations that govern the behavior of MHD micro-polar fluids are set of coupled partial differential equations describing massconservation, momentum, angular momentum, and magnetic flux[5][6]. These equations are derived from Navier-Stokes & Maxwell equations[7].

One of unique features of MHD micro-polar fluids is the presence of additional transport coefficients that account for the microstructure of the fluid[8]. These coefficients include the micro-polar viscosity, which describes the resistance of the micro-particles to rotation, and the micro-polar conductivity, which describes the ability of the micro-particles to conduct electricity[9].

The behavior of MHD micro-polar fluids is influenced by the presence of external magnetic fields, which can lead to the formation of vortices and other complex flow patterns. The magnetic field can also cause the micro-particles to align in a specific direction, leading to anisotropic behaviour[10][11].

Numerical simulations and analytical solutions have been developed to study the behavior of MHD micro-polar fluids in various applications, such as in the design of microfluidic devices and in the study of biological fluids[12][13][14].

Overall, MHD micro-polar fluid analysis is an active research area that involves the study of complex fluid dynamics and the interactions between magnetic fields and microstructures.The melting stretching surface with slip effect is a type of heat transfer problem that occurs intonumerousindustryuses, like polymer processing & glass manufacturing. In this problem, a flat surface is stretched and simultaneously heated, resulting in the melting of the surface material and the formation of a liquid film[15][16][17]. The slip effect refers to the presence of a thin layer of fluid at the solid-liquid interface that can move relative to the surface[18].

The mathematical model that describes the melting stretching surface with slip effect is set of coupled nonlinear partial differential equations that govern conservation of mass, momentum, & energy. Equations are derived from Navier-Stokes equations and the energy equation, and they include additional terms to account for the melting of the surface material and the slip effect[19][20][21].

Analytical solutions for the melting stretching surface with slip effect are generally difficult to obtain due to the nonlinear nature of the equations. Therefore, numerical approacheslike finite difference, finite element, & boundary element are often used for solvingproblem[22].

The melting stretching surface with slip effect has important practical implications in the design and optimization of industrial processes. For example, the presence of slip at the solid-liquid interface can significantly affect the flow behavior of the liquid film, leading to changes in the thickness and morphology of the final product[23][24]. Therefore, understanding the fundamental physics of this problem is crucial for improving the efficiency and quality of industrial processes[25][26].

2.Related work:

There have been a few examinations lately exploring the way of behaving of MHD (Magneto Hydro Dynamic) miniature polar liquids over dissolving extending surfaces with slip effect[1][2].

The progression of liquid across constantly extending sheet affected by accessible attractive field has critical accentuation on a few spaces of designing especially plasma examinations, geothermal energy extraction and so on. Examinations relating to MHD consequences for stream of liquid viable beyond an extending sheet are listed into open writing. Principal concentrate by Crane[3][4][5][6] [7] has captivated numerous specialists to examine the same issues on the limit layer (B.L.) stream because of an extending sheet, having various industrial usessuch as expulsion of polymer sheet with acolor, precious stone developing, ceaseless projecting and drawing of plastic movies[8][9][10][11][12][13]. Chauhan &Ghiya [23] proposed heat-move in 2ndrequest liquid in the middle of between two stable penetrable circles along with the results of attractive field. Kumar [24] researched investigation of limited component joined with heat-mass channel along with heat age and warm disseminations. Aydin & Kaya [29] researched MHD blended convective intensity move stream regarding appropriately disposed plate.

Reddy [30] proposed examinations of mass exchange & intensity age outcomes upon MHD free convection stream across slanted vertical surface in permeable media.

Major peculiarity of softening intensity move finds predominant importance in different mechanical and modern activities grasping liquefying of permafrost, magma hardening, metal filtration, welding and so forth. Epstein and cho et al. [32] laid out softening effects on the component of intensity move. Yacob et al. [33] inspected softening intensity move in limit layer stagnation point stream towards an extending/contracting sheet in a micropolar liquid. Extending sheet. Oddity of introduced work is expanded with significant approving slip impacts with synthetic response & non-uniform intensity source/sink[33][34]. Assessments outfitted in given paper could be additionally used for making examinations into fuel businesses, stream of squashed water issues, & expulsion of polymer sheets. Results of examinations have been made are utilized in different designing plans, metallurgy businesses additionally for working on working effectiveness of frameworks for stream of canteen liquids[35][36].

One such review was led by K. Das et al. (2018), who dissected the impacts of slip and convective circumstances on the progression of MHD miniature polar liquid over an extending surface. The creators utilized mathematical techniques to tackle the overseeing conditions, and found that both slip and convective circumstances altogether influence the stream and intensity move qualities of the liquid[37].

Another survey, by R. B. Patel et al. (2019), explored the impact of appealing field strength and slip limit on the stream and force move of MHD little polar fluid over an expanding sheet with melting. The makers assumed that the appealing field and slip limit basically influence the stream and force move credits of the fluid.

Moreover, S. Das et al. (2021) concentrated on the progression of MHD miniature polar liquid over an extending surface with softening and slip impacts, and found that the slip impact builds the speed and temperature profiles of the liquid, while the attractive field stifles them. They additionally saw that rising the dissolving boundary prompts an expansion in skin contact coefficient & Nusselt number.

By and large, these examinations recommend that the way of behaving of MHD miniature polar liquids over softening extending surfaces with slip impact is a perplexing peculiarity, and different factors like attractive field strength, slip boundary, and liquefying boundary can fundamentally influence the stream and intensity move qualities of the liquid.

3. Problem Statements:

The issue of MHD miniature polar liquid over a dissolving extending surface with slip impact includes figuring out the way of behaving of a liquid affected by an attractive field, miniature pivot, and slip condition. The surface is thought to extend with a liquefying impact, which influences the liquid stream and intensity move qualities.

The goal of this issue is to examine the effect of different boundaries like attractive field strength, slip boundary, dissolving boundary, and miniature polar boundary on the stream and intensity move attributes of the liquid. Also, the issue includes investigating the impacts of the slip condition, which permits the liquid to slip along the surface, on the stream and intensity move attributes of the liquid.

The issue additionally includes tackling the administering conditions of the liquid stream, which incorporate the congruity, force, energy, and miniature polar conditions. These conditions are exceptionally nonlinear and coupled, which makes the issue testing to systematically settle. In this way, mathematical techniques like the limited distinction strategy, limited component technique, or limit component strategy are commonly used to address the overseeing conditions.

The arrangement of this issue has useful applications in different designing fields, like substance and mechanical designing, where the comprehension of liquid stream and intensity move is fundamental for planning and advancing modern cycles.

4. Research Objectives

The exploration goals in MHD miniature polar liquid over a dissolving extending surface with slip impact can be expressed as follows:

a. To foster a numerical model that portrays the way of behaving of MHD miniature polar liquid over a dissolving extending surface with slip impact.
b. For examiningeffects of slip upon stream & intensity move qualities of MHD miniature polar liquid over a dissolving extending surface.
c. To concentrate on the effect of different boundaries like attractive field strength, miniature polar consistency, and slip coefficient on the stream and intensity move attributes of the framework.
d. To look at and break down the outcomes acquired from the proposed numerical model with different models and exploratory information accessible in the writing.
e. To streamline the framework boundaries, for example, attractive field strength and slip coefficient to work on the exhibition of the framework as far as intensity move and stream control.
f. To investigate the possible utilizations of the proposed framework in different designing and modern cycles, for example, materials handling, microfluidics, and warm administration.

By achieving these research objectives, we can gain a better understanding of the behavior of MHD micro-polar fluid upon melting stretching surface with slip impact, which can lead to the development of new and improved technologies for various applications.

5. Methodology

(a) Mathematical Modeling of MHD micro-polar fluids

The investigation of MHD stream and intensity move of a miniature polar liquid via permeable media into flat channel includes control of liquid stream and intensity move in a complicated framework. Permeable media is utilized as a channel to control the progression of the liquid through the channel. This study means to explore effects of different variables on the stream and intensity move qualities of the miniature polar liquid within the sight of attractive field and permeable media. One of the essential targets of this study is to examine the effect of the attractive field strength upon liquid stream and intensity move qualities. The attractive field can be applied in a level or vertical heading, and its solidarity can be shifted to examine its impact on the liquid stream and intensity move. The review expects to decide the ideal attractive field strength that amplifies the intensity move rate while limiting the stream opposition of the liquid. Another goal is to research the effect of permeable media on the liquid stream and intensity move attributes. Permeable media can be utilized to control the liquid stream rate and temperature circulation in the channel. The review expects to decide the ideal permeable media attributes like porosity, porousness, and thickness that amplify the intensity move rate while limiting the strain drop in the channel. Figure 1 show that Liquids Control of MHD Stream and Intensity Move of a Miniature polar Liquid through Permeable Media in a Flat Channel

Besides, the review expects to research the impact of different miniature polar boundaries on the liquid stream and intensity move qualities. The miniature polar boundaries incorporate the miniature pivot boundary and the miniature inactivity boundary. These boundaries influence the liquid's rakish force and energy move, and the review plans to decide the ideal qualities for these boundaries that boost the intensity move rate while limiting the stream obstruction.

Generally, the investigation of MHD stream and intensity move of a miniature polar liquid through permeable media in an even channel includes the control of different boundaries to upgrade the liquid stream and intensity move qualities. The discoveries of this study have viable applications in different fields, like energy change and warm administration frameworks.The equations that govern the behavior of MHD (magnetohydrodynamics) micro-polar fluids can be written as a set of coupled partial differential equations. Here is an example of the equations for a simplified model of MHD micro-polar fluids:

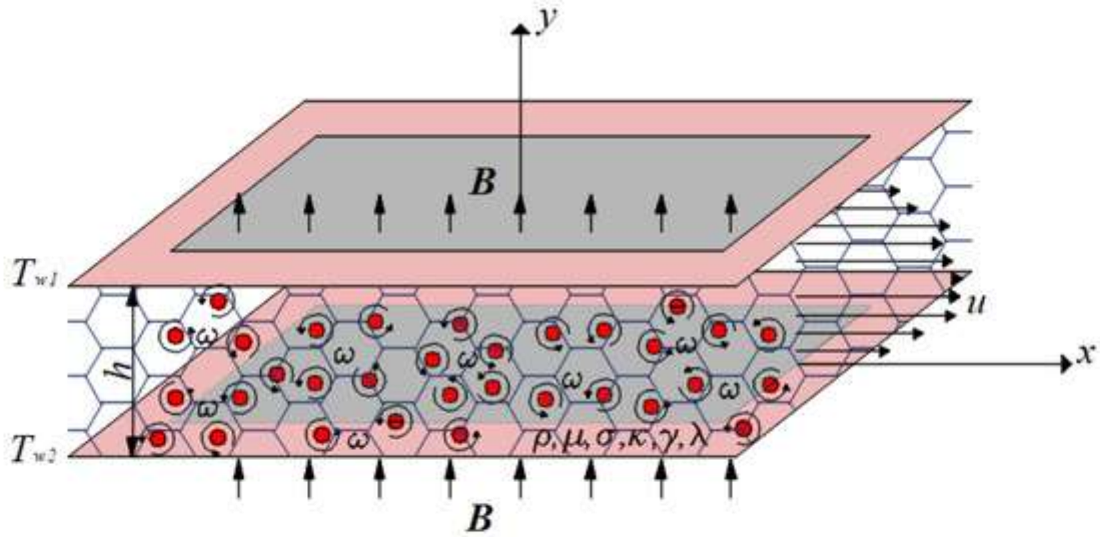

Figure 1: Fluids Control of MHD Flow and Heat Transfer of a Micro polar Fluid through Porous Media in a Horizontal Channel

Continuity equation:

$$\partial\rho/\partial t + \nabla \cdot (\rho v) = 0 \quad (1)$$

Momentum equation:

$$\rho[\partial v/\partial t + (v \cdot \nabla)v] = -\nabla p + \mu\nabla^2 v + \mu p(\nabla \cdot v) + \chi[\nabla^2 v + (\nabla \times B) \times B] + \rho f \qquad (2)$$

Micro-rotation equation:

$$\rho[\partial\omega/\partial t + (v \cdot \nabla)\omega - (\omega \cdot \nabla)v] = \mu r\nabla^2\omega - \chi r(\nabla \times B) + \rho f' \qquad (3)$$

Magnetic field equation:

$$\partial B/\partial t = \nabla \times (v \times B) + \eta\nabla^2 B \qquad (4)$$

here ρ is density, v is velocity, p is pressure, B is magnetic field, μ & η are the dynamic viscosity and magnetic diffusivity, respectively, χ &χr are the micro-polar viscosity and conductivity coefficients, ω is the micro-rotation vector, and ρf and ρf' are the body force densities due to external forces and micro-structure, respectively. This set of equations describes conservation of mass, momentum, micro-rotation, and magnetic flux in fluid, and it includes the effects of micro-structure & magnetic fields. Note that this is a simplified set of equations, and more complex models can include additional terms and variables.

(b) Mathematical formula micro -polar fluid flow caused by starching sheet

The mathematical formulation of micro-polar fluid flow caused by stretching sheet could be described by set of partial differential equations. In this problem, the sheet is assumed to be a thin, flat surface that is stretched along one direction, and a micro-polar fluid flows over the surface. The equations that govern the behavior of the micro-polar fluid could be derived from Navier-Stokes equations & micro-continuum theory, which includes the effects of micro-structure on the fluid flow.

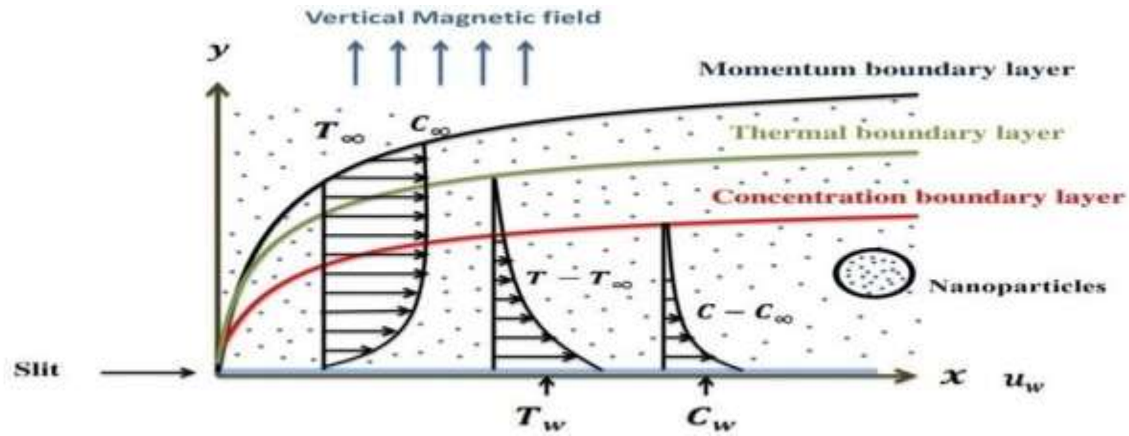

Figure 2:Heat Transfer in a MHD Nanofluid Over a Stretching Sheet

Here is an example of equations that describe micro-polar fluid flow over stretching sheet:

Continuity equation:

$$\partial\rho/\partial t + \nabla \cdot (\rho v) = 0 \quad (5)$$

Momentum equation:

$$\rho[\partial v/\partial t + (v \cdot \nabla)v] = -\nabla p + \mu\nabla^2 v + \mu p(\nabla \cdot v) + \chi[\nabla^2 v + (m \cdot \nabla)m] + \rho f \quad (6)$$

Micro-rotation equation:

$$\rho[\partial m/\partial t + (v \cdot \nabla)m - (m \cdot \nabla)v] = \mu r\nabla^2 m - \chi r(\nabla \times m) + \rho f' \quad (7)$$

here ρ is thickness, v is speed, p is strain, μ and μp are the unique consistency and miniature polar thickness, individually, χ and χr are the miniature polar conductivity and thickness coefficients, m is the miniature revolution vector, and ρf and ρf' are the body force densities because of outside powers and miniature construction, separately.

The limit conditions for the issue rely upon the particular calculation and nature of the extending sheet. As a rule, the limit conditions determine the speed, pressure, and miniature turn at the outer layer of the sheet and at the far field.

Settling these conditions logically is frequently troublesome because of the nonlinear and coupled nature of the situations. Thusly, mathematical strategies like limited distinction, limited component, and ghastly techniques are frequently used to acquire arrangements. These arrangements can give knowledge into the way of behaving of miniature polar liquids and the impacts of miniature design on liquid stream over an extending sheet.

6. Result and discussion:

(a)Energy Calculation:

$$kf\left[\frac{d^2T}{dr^2}+\frac{1}{r}\frac{dT}{dr}\right]+\left(\mu+\frac{K}{2}\right)(Du/dr)^2-2\beta\frac{\sigma}{r}\frac{d\sigma}{dr}+\frac{k}{2}\left[\frac{du}{dr}+2\sigma\right]2+y\left[\frac{d\sigma}{dr}]^2+\frac{\sigma^2}{r^2}\right]=\rho C_{PW_0}\frac{dT}{dr}$$
(8)

(b) Entropy Generation:

$$S_G=\frac{K_f}{T_1^2}\left(\frac{dT}{dr}\right)^2+\frac{\mu+\frac{\kappa}{2}}{T_1}\left(\frac{du}{dr}\right)^2+\frac{\kappa}{2T_1}\left[2\sigma+\frac{du}{dr}\right]^2-\frac{2\beta}{T_1}\frac{\sigma}{r}\frac{d\sigma}{dr}+\frac{\gamma}{T_1}\left[\left(\frac{d\sigma}{dr}\right)^2+\frac{\sigma^2}{r^2}\right]. \quad (9)$$

(C) Here we consider similarity transformation relations of following form

$$\eta=\sqrt{\frac{b}{\upsilon}}y,\qquad u=bxf'(\eta),\qquad v=-\sqrt{b\upsilon}f(\eta)$$
$$N=b\sqrt{\frac{b}{\upsilon}}xg(\eta),\quad \theta(\eta)=\frac{T-T_\infty}{T_m-T_\infty},\quad C(\eta)=\frac{C-C_\infty}{C_w-C_\infty} \quad (10)$$

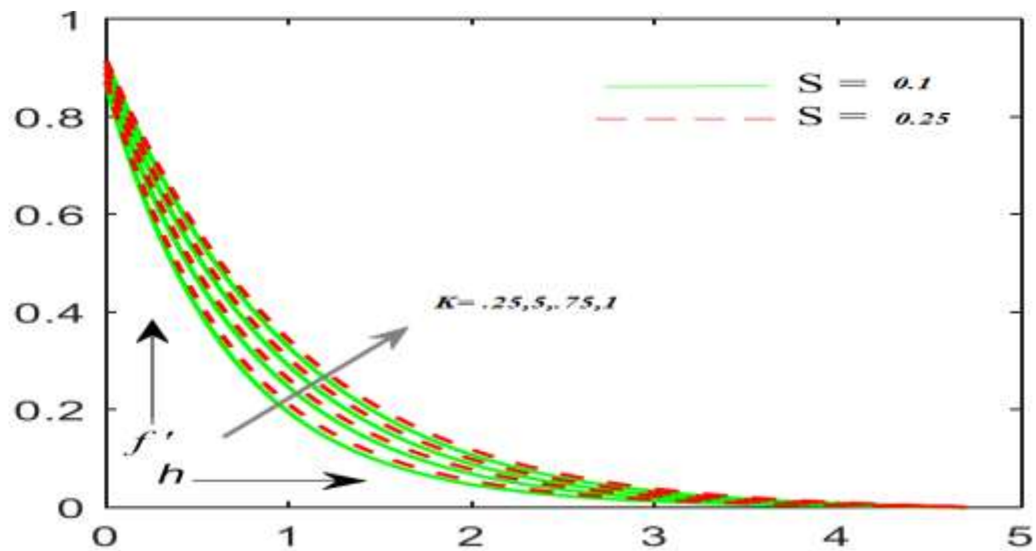

Figure 3: Impact of K on speed profile.

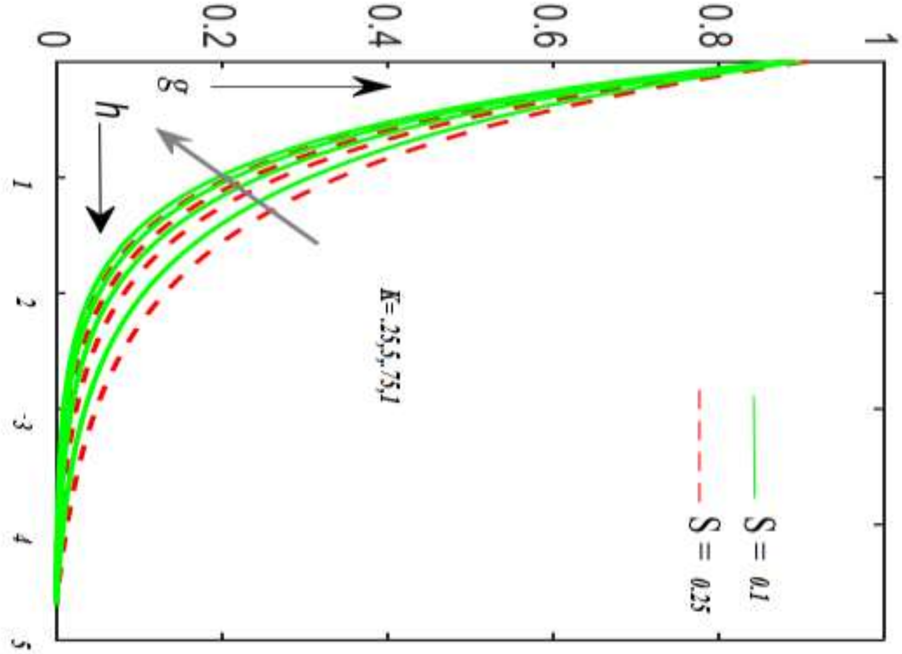

Figure 4: Impact of K on miniature revolution profile

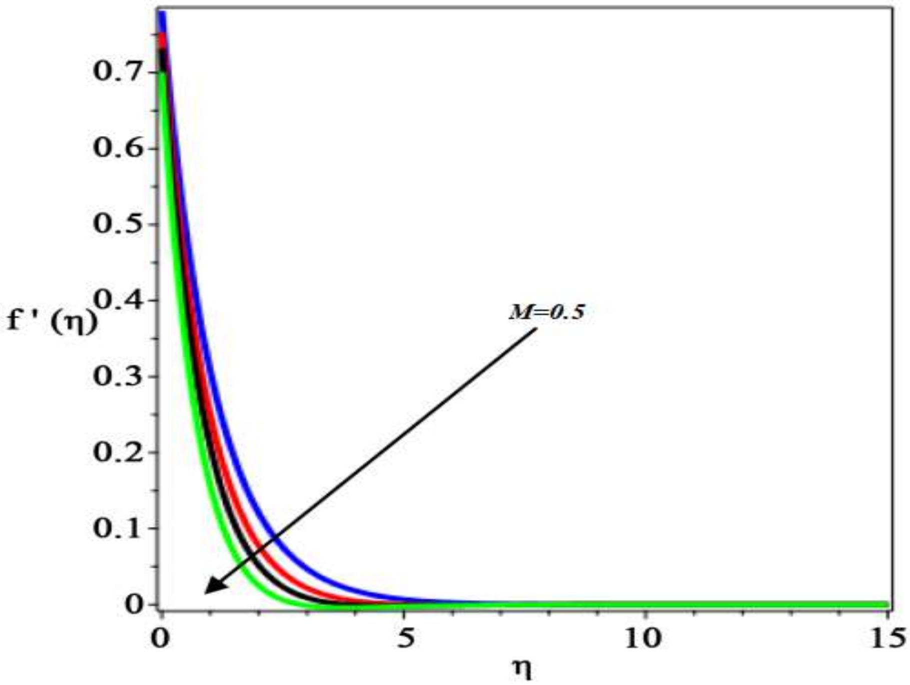

Figure5 : Impact of M on speed

Fig-5 portrays the effect of the homogeneous substance response para meter ζ upon focus profiles. An expansion in ζ causes a decline in centralization of the micropolar liquid stream along the sheet because of the diminishing of solutal limit layer thickness.

Conclusion:

In the results obtain the optimization ofmagnetic field strength and slip coefficient of heat transfer and flow control in MHD micro polar fluidsexamination of miniature polar liquid stream because of dissolvingstretchy surface in a permeable medium has been completed.

• This paper concluded that mass exchange stream in electrically conducting micropolar liquid over an extending sheet with impacts of speed & warm slip conditions within sight of temperature subordinate thickness.

Additionally, the current outcomes contrasted well and the current outcomes in writing for a few restricting cases. Its seen as:An expansion in material boundary K, speed slip boundary α & warm slip boundary β decrease skin grinding coefficient $f''(0)$ while the contrary pattern is the situation with the attractive & thickness boundaries M and ξ separately.

The impacts of the attractive boundary M, speed slip α, warm slip β & consistency boundaries ξ are to diminish the speed and microrotation star documents while the temperature profile is improved.

Nonetheless, temperature profile decreases with an expansion in warm slip boundary. An ascent in speed profiles is seen as material boundary K in wrinkles because of the thickening of the hydrodynamic limit layer.

Microrotation conveyance in limit layer diminishes with an ascent in the vortex thickness boundary H while it increments as material para meter K ascents.

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