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Research Paper

A Review on Stability and Flow Problems of Couple-Stress Fluid in Presence of Magnetic Field Through Porous Medium

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Abstract: *A magnetic field is the region around a magnet or current carrying conductor where magnetic force can be experienced. In fluid dynamics, it is a vector field that interact with an electrically conducting fluid and exerts a force on moving charges within the fluid influencing its motion and flow behaviours. This paper presents a literature review on the stability and flow problems of couple-stress fluid in presence of magnetic field through porous medium. The main purpose of this paper is to discuss about the findings of the most extensive research into the field of stability and flow of couple-stress fluid that has been conducted over the past few years to present.*

Keywords: *Stability and flow, Couple-stress fluid, magnetic field, porous medium.*

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I. INTRODUCTION

A fluid is a liquid, gas or materials that may continuously move and deform under an applied shearing stress or external force. They have zero shearing modulus or in simple terms are substances which cannot resist any shearing force applied to them. The matter is usually divided into two classes, namely fluids and solids. In the absence of any external force, the matter has a definite shape under given thermodynamic conditions then it is called a solid and if the matter takes the shape of the container then it is called a fluid. Fluids are broadly subdivided into two categories, called the liquids and gases. A liquid is a nearly incompressible fluid that conforms to the shape of its container but retains a constant volume independent of pressure. The volume is definite if the temperature and pressure are constant. A gas is a compressible fluid. Not only will a gas conform to the shape of its container but it will also expand to fill the container. Thus, a liquid possesses a definite volume but not a definite shape because of intermolecular forces which hold it together. On the other hand, a gas neither has a definite volume nor a definite shape. Fluids of which the viscosity, or internal friction, must be taken into account are called viscous fluids and are further distinguished as Newtonian fluids if the viscosity is constant for different rates of shear and does not change with time. The viscosity of non-Newtonian fluids either varies with the rate of shear or varies with time, even though the rate of shearing is constant. Fluids in a class in this last category that become thinner and less viscous as they continue to be stirred are called thixotropic fluids. The study of fluid flows is important to understand the various phenomena occurring in the nature. It is also important from applications point of view. In many industrial establishments the various types of fluids are to be transported from one place to another place under varied conditions. This requires the in-depth study of fluid flows in order to design the system to transport these fluids from one place to another.

In nature, every physical system is subjected to small disturbances. Many times these small disturbances are responsible for the initial onset of instability. We can define stability as a quantity being immune to small disturbances. Thus, the stability we mean permanent type of equilibrium state. For an equilibrium state or a steady flow to be of permanent type, it must not only satisfy the mathematical equations but must also be stable against arbitrary small perturbations. Hydrodynamics and Hydromagnetic Stability, famously detailed by **Chandrasekhar [1]** studied fluid motion and the stability of conducting fluids under magnetic fields. It focuses on how flows, such as Bénard convection or shear flows, become unstable. Key concepts include Rayleigh-Taylor instability, Kelvin-Helmholtz instability, and magnetic field effects on stability, crucial for understanding astrophysics, engineering, and atmospheric phenomena. The discussion of the stability of a hydrodynamic and hydromagnetic system proceeds in the following manner, to suppose that all parameters of the system are kept constant, except one, which is continuously varied, in the range of physically realizable values of the parameter. We shall then pass from stable state to unstable state when the particular parameter takes a certain critical value. We then say that instability sets in at this value of the chosen parameter when all others have their pre-assigned values. This value of the chosen parameter defines the marginal states. Thus, if all the initial states are classified as stable or unstable, assuming to the criteria stated, then in the space of parameters, the locus, which separates stable and unstable states and occurs when there exists some perturbation whose amplitude remains constant with time.

II. FLOW OF FLUID THROUGH POROUS MEDIUM

Fluid flow through porous media is the manner in which fluids behave when flowing through a porous medium, for example sponge or wood, or when filtering water using sand or another porous material. As commonly observed, some fluid flows through the media while some mass of the fluid is stored in the pores present in the media. Classical flow mechanics in porous media assumes that the medium is homogenous, isotropic, and has an inter-granular pore structure. It also assumes that the fluid is a Newtonian fluid, that the reservoir is isothermal, that the well is vertical, etc. Traditional flow issues in porous media often involve single-phase steady state flow, multi-well interference, oil-water two-phase flow, natural gas flow, elastic energy driven flow, oil-gas two-phase flow, and gas-water two-phase flow. The movement of a fluid through porous media is described by the combination of Darcy's law with the principle of conservation of mass in order to express the capillary force or fluid velocity as a function of various other parameters including the effective pore radius, liquid viscosity or permeability However, the use of Darcy's law alone does not produce accurate results for heterogeneous media like shale, and tight sandstones, where there is a huge proportion of nano-pores. The movement of a fluid through porous media is described by the combination of Darcy's law with the principle of conservation of mass in order to express the capillary force or fluid velocity as a function of various other parameters including the effective pore radius, liquid viscosity or permeability. However, the use of Darcy's law alone does not produce accurate results for heterogeneous media like shale, and tight sandstones, where there is a huge proportion of nano-pores. This necessitates the use of a flow model that considers the weighted proportion of various flow regimes like Darcy flow, transition flow, slip flow, and free molecular flow.

III. COUPLE-STRESS FLUID

The theory of couple stress fluids was first developed by **Stokes [2]** as an extension of classical continuum mechanics to model fluids with micro-rotational effects. In this theory, each fluid particle can experience not only translational motion but also rotational motion, leading to asymmetric stress tensors and the emergence of higher-order stress terms.

Research on couple stress fluids focuses on Modeling non-Newtonian, microstructure liquids (e.g., polymer solutions, lubricants, biofluids) that exhibit size-dependent behaviour. Key projects involve analyzing flow dynamics, heat transfer, and instability in porous media, MHD (magnetic fields), and rotating systems using numerical methods like BVP4C and HAM.

A couple-stress fluid is a class of visco-elastic non-Newtonian fluid that accounts for the effects of microstructure and internal rotational interactions within the fluid. Unlike classical Newtonian fluids, which consider only force stresses, couple stress fluids include couple stresses (moments per unit area) arising due to the presence of suspended particles, long-chain molecules, or micro-elements capable of undergoing rotation.

- **Microstructure Interaction:** Couple stress fluid theory considers the presence of couple stresses and body couples, acknowledging the influence of microstructure.
- **Non-Newtonian Behaviour:** They are a sub-class of non-Newtonian fluids where the viscosity behaviour differs from the classical, linear Newton's law.
- **Applications:** They accurately model liquids with suspended particles, such as blood, liquid crystals, and various polymeric suspensions.
- **Governing Equations:** The governing equations of motion are a generalization of the classical Stokes (or Navier-Stokes) equations, featuring higher-order terms for the extra stress tensor.

3.1 Assumptions of Couple-stress Fluid Theory

i. The fluid consists of rigid or semi-rigid micro-elements.
ii. Body couples and micro-inertia effects are usually neglected.
iii. The fluid is incompressible and isotropic.
iv. The characteristic length scale of microstructure is small but finite.

3.2 Examples of Couple Stress Fluids

Couple-stress fluid models are applicable to Lubricants containing polymer additives, Biological fluids such as blood and synovial fluid, Liquid crystals, Suspensions and colloidal fluids and Industrial fluids with micro-particles.

IV. CONCEPT OF POROUS MEDIUM

In materials science, a porous medium or a porous material is a material containing pores (voids). The skeletal portion of the material is often called the "matrix" or "frame". The pores are typically filled with a fluid (liquid or gas). The skeletal material is usually a solid, but structures like foams are often also usefully analyzed using concept of porous medium.

A porous medium is most often characterised by its porosity. Other properties of the medium (e.g. permeability, tensile strength, electrical conductivity, tortuosity) can sometimes be derived from the respective properties of its constituents (solid matrix and fluid) and the media porosity and pores structure, but such a derivation is usually complex. Even the concept of porosity is only straightforward for a poro-elastic medium. Often both the solid matrix and the pore network (also known as the pore space) are continuous, so as to form two interpenetrating continua such as in a sponge. However, there is also a concept of closed porosity and effective porosity, i.e. the pore space accessible to flow. Porous medium are widely encountered in natural systems such as soils, rocks, biological tissues, and manufactured materials including filters, foams, ceramics, and packed beds. Two macroscopic properties of porous medium which may be used to describe fluid flow are described as follows:

4.1 Porosity

Rocks are made up of grains or crystals that fit together. In cases where the fit is very tight and there are no gaps or pore spaces between the grains or crystals, we say that this rock has no porosity. At the other end of the scale, some rocks have lots of pore space between grains and so there is room for air, water or other liquids and gases. In the top diagram, where there is any material (or cement) in the rock to fill in the gaps holding the grains together, there will be less pore space. The bottom diagram shows that the more space between the grains, the greater the porosity. The porosity of a rock varies because of the size of the grains in the rock and the shape of the grains. Another factor that affects the porosity of a rock is whether or not there is any material in the rock (or cement) to fill in the gaps between pore spaces and hold the grains together. If a rock has a lot of gaps between grains it is said to have good porosity and a lot of water can fit between the grains. A rock with good porosity can hold a lot of groundwater.

4.2 Permeability

For groundwater to be able to get into a rock with good porosity it must also have good permeability. For a rock to be permeable and for water to move through it, the pore spaces between the grains in the rock must be connected. Permeability is therefore a measure of the ability of water to move through a rock. In the top diagram, even though there is good porosity, there is material (or cement) in the rock to fill in the gaps blocking the pore space between the grains so the water at the bottom cannot flow to the top – the pores are not connected. In the diagram on the bottom, there is nothing to stop the flow of water – the pores are all connected.

V. MAGNETIC FIELD

A magnetic field is the region around a magnet or current carrying conductor where magnetic force can be experienced. Magnetic field in fluid dynamics especially is the branch called Magnetohydrodynamics. Magnetic field is defined with respect to conducting fluid like plasmas liquid metals or electrolysis. In fluid dynamics, it is a vector field that interact with an electrically conducting fluid and exerts a force on moving charges within the fluid influencing its motion and flow behaviours.

Examples

- **Magnetohydrodynamics (MHD):** -Studies electrically conducting fluids (liquid metals, plasmas, electrolytes) moving through a magnetic field, where the magnetic field creates electric currents that alter the fluid motion.
- **Magnetorheology:** Magnetic fields change the viscosity and flow characteristics of smart fluids (ferrofluids) containing suspended magnetic particles.
- **Fluid Manipulation:** Magnetic fields can induce fluid flow and create "lattices," useful for mixing or pumping, especially in microfluidics.

- **Magnetic Damping:** Used in industrial metallurgy to reduce turbulent fluctuations in molten.

The action at a distance of a magnetic field on the fluid has many practical applications. Examples in the metals processing industry include the control of liquid metals in continuous casting process, plasma welding, electrolytic hall cells for aluminium smelting, electromagnetically supported melts, and many others. Another big application area concerns the nuclear industry, where liquid metal blankets are used for their high heat transfer properties and shielding capabilities under the influence of strong magnetic fields. Also, application of the magnetic field of medical science is one of the important topics in magneto-science. Now, an alternative promising drug instead of that available before and has its side effect, may be at hand by exposing a person to a magnetic field could improve blood flow around their body. The experiment in the hostile environment encountered in all these applications is extremely difficult to perform. Also, the field of MHD is complex as it involves the solution of both the Navier-Stokes equations characterizing fluid flow and Maxwell's equations for the magnetic field. For that reason, mathematical models capable of addressing the MHD problem are practically desirable. This is especially true in instances where the two fields are strongly coupled. The study of various magnetic fields and fluid interactions may be divided into two main categories electro hydrodynamics (EHD), which deals with electric force effects and magneto hydrodynamics (MHD), which deals with the interaction between magnetic fields and fluid conductors of electricity. The magnetic field effect refers to the influence of an applied magnetic field on the physical behaviour of an electrically conducting fluid. When such a fluid flows in the presence of a magnetic field, electric currents are induced within the fluid. These currents interact with the magnetic field and produce a resistive force known as the Lorentz force, which opposes the motion of the fluid. As a result, the magnetic field significantly affects the velocity distribution, flow stability, pressure gradient, and heat transfer characteristics of the fluid. In fluid dynamics and Magneto hydrodynamics (MHD), the magnetic field effect is widely studied because it can be used to control fluid motion**,** reduce turbulence**,** and enhance or suppress flow stability**,** especially in porous media and non-Newtonian fluids such as couple stress fluids The magnetic field effect plays an important role in many engineering and scientific applications, including MHD power generators, cooling of nuclear reactors, geothermal systems, biomedical engineering, and industrial fluid transport.

5.1 Magnetic field effect

Magnetic field effect is the physical phenomenon where a magnetic field exerts force, attracts, repels, or manipulates magnetic materials, moving charged particles, or current-carrying conductors. It is characterized by field lines, magnetic force (Lorentz force), and attraction/repulsion between poles, often synonymously referred to as magnetic force, magnetic influence, or magnetic attraction/repulsion.

Examples

- **Electric Motors:** Motors in household appliances and electric vehicles use magnetic fields to generate motion by applying force to current-carrying conductors. Convert electrical energy into mechanical energy by using a magnetic field to exert force on a current-carrying wire.
- **Electromagnets**: Use an electric current through a wire to create a temporary, controllable magnetic field (used in cranes, bells).
- **Generators**: Utilize a magnetic field to induce a current in a rotating conductor.
- **Loudspeakers/Microphones**: Convert electrical signals into sound waves (or vice-versa) using magnetic forces.
- **Compass Navigation**: The Earth's magnetic field acts on a magnetized needle to show direction.
- **Particle Deflection**: Magnetic fields are used in televisions (CRT) or particle accelerators to steer electron beam.

VI. LITERATURE REVIEW

In this section, a review of literature has been done related to fluid, stability theory and magnetic field effect as follows:

Kumar [3] has discussed about effect of couple-stress fluid flow on Magnetohydrodynamics peristaltic blood flow with porous medium through inclined channel in the presence of slip effect - blood flow model. In his study, effect of couple stress fluid flow on Magnetohydrodynamics peristaltic blood flow with porous medium trough inclined channel in the presence of slip effect-blood flow study have been studied under the assumption of long wavelength approximations. The expressions of the axial velocity, transverse velocity, pressure gradient, volume flow rate, average volume flow rate, pressure rise and shear stress are obtained and discussed through graphs. **Nayak and Dash [4]** have discussed Magnetohydrodynamics couple -stress fluid flow thought a porous medium in a rotating channel. In this paper, the problem of transient hydromagnetic flow of an electrically conducting couple stress fluid in a rotating frame of reference through a saturated porous channel under the influence of pulsatile pressure gradient is presented. The novelty of the proposed work is to analyze the effect of couple stress as well as the case of steady and pulsatile pressure gradient on a flow through a porous saturated rotating channel. Further, the discussion on steady and pulsatile pressure gradient has made the study interesting. It is note worthy to remark that the presence of pulsatile pressure gradient has rendered the secondary flow to be positive where as in case of steady pressure gradient it is all through negative for all cases. Further, the strong magnetic interaction and higher rotation initiate flow instability in the central region of the channel. Moreover, greater magnetic interaction contributes to smoothness of the profile and oscillatory pressure gradient increases the secondary velocity preventing backflow, which are beneficial to MHD rotating generator system. **Kumar [5]** has discussed about the effects of the couple stress fluid flow on MHD peristaltic motion with uniform porous medium in the presence of slip effect. In his study, he investigates the effects of the couple stress fluid flow on the Magnetohydrodynamics peristaltic motion with a uniform porous medium in the presence of slip effect. The analysis is carried out under the assumption of long wavelength approximations. Expressions of the axial velocity, transverse velocity, pressure gradient, volume flow rate, average volume flow rate, pressure rise and shear stress are all obtained. The effects of various emerging axial velocity, transverse velocity, pressure gradient shear stress are discussed through graphs. **Chavaraddi et al. [6]** have discussed about effect of magnetic field on Kelvin-Helmholtz Instability in a couple -stress fluid layer bounded above by a porous layer and below by a rigid surface. In his study, Kelvin-Helmholtz instability (KHI) appears in stratified two-fluid flow at surface. When the relative velocity is higher than the critical relative velocity, the growth of waves occurs. It is found that magnetic field has a stabilization effect whereas the buoyancy force has a destabilization effect on the KHI in the presence of sharp inter-face. The RT instability increases with wave number and flow shear, and acts much like a KHI when destabilizing effect of sheared flow dominates. It is shown that both of ablation velocity and magnetic field have stabilization effect on RT instability in the presence of continued interface. In this paper, we study the effect of magnetic field on Kelvin-Helmholtz instability (KHI) in a couple-stress fluid layer above by a porous layer and below by a rigid surface. A simple theory based on fully developed flow approximations is used to derive the dispersion relation for the growth rate of KHI. We replace the effect of boundary layer with Beavers and Joseph slip condition at the rigid surface. The dispersion relation is derived using suitable boundary and surface conditions and results are discussed graphically. The stabilization effect of magnetic field takes place for whole waveband and becomes more significant for the short wavelength. The growth rate decreases as the density scale length increases. The stabilization effect of magnetic field is more significant for the short density scale length. **Nallapu and Kiran [7]** have discussed about effect of magnetic field and slip on a two fluid model for couple-stress fluid flow thought a porous medium. In this paper a two-fluid mathematical model for a couple stress fluid flows in a porous medium has been studied in the presence of a magnetic field through a narrow channel under the influence of slip condition. It is assumed that core region contains couple stress fluid and Newtonian fluid in the peripheral region. It is found that the effective viscosity decreases with couple stress parameter and Darcy number but increases with core magnetic parameter slip at the wall and hematocrit. It is noticed that the effective viscosity increases with channel height. Further, the flow exhibits the anomalous Fahraeus-Lindqvist effect. **Kumar et al. [8]** have discussed about effect of horizontal magnetic field and horizontal rotation on thermosolutal stability of a dusty couple- stress fluid through a porous medium. The problem of the onset of double diffusive convection in a couple-stress fluid saturated with a porous medium is studied under the effects of magnetic field, rotation and suspended dust particles. Linear stability analysis based on the method of perturbations of infinitesimal amplitude is performed using the normal mode technique for the case of free-free boundaries. The governing hydrodynamic and hydromagnetic equations of fluid flow are governed by the Brinkman model. The stability analysis examines the effects of various embedded parameters for the stationary mode both analytically and graphically. The principle of exchange of stabilities holds good in the absence of solute gradient parameter. Also, the sufficient conditions responsible for the existence or non-existence of over stability are obtained. **Devakar et al. [9]** have discussed about unsteady flow of couple stress fluid sandwiched between Newtonian fluids through a channel. The aim of this article is to study the unsteady flow of immiscible couple stress fluid sandwiched between Newtonian fluids through a horizontal channel. The fluids and plates are initially at rest. At an instant of time, a constant pressure gradient is applied along the horizontal direction to generate the flow. The time dependent partial differential equations are solved numerically using the finite difference method. The continuity of velocities and shear stresses at the fluid-fluid interfaces has been considered. The obtained results are displayed through graphs and are discussed for various fluid parameters pertaining the flow. The volume flow rate is also obtained numerically for diverse fluid parameters and is presented through a table. It is noticed that fluid velocities increased with time and reached a steady state after a certain time level. Also, the presence of couple stresses reduced the fluid velocities. Volume flow rate increased with Reynolds number and is reduced by increase of ratio of viscosities. **Jaiswal and Yadav [10]** have discussed about a micropolar- Newtonian blood flow model through a porous layered artery in the presence of a magnetic field. In his study, he presents a two-phase model of blood flow through a porous layered artery in the presence of a uniform magnetic field. The characteristic of suspensions in blood allows us to assume blood as a micropolar fluid in the core region and plasma as a Newtonian fluid in the peripheral region of a blood vessel.

The wall of a blood vessel is porous and composed of a thin Brinkman transition layer followed by a Darcy porous layer of different permeabilities. A magnetic field of uniform strength is transversally applied to the direction of blood flow. The authors obtained an analytical solution of the problem of blood flow through the composite porous walled artery. Analytical expressions for the flow velocity, microrotational velocity, flow rate, and stresses at the wall have been obtained in the closed form using the modified Bessel function. The effects of various flow parameters on the two-fluid model of blood flow are analyzed graphically. An important conclusion which is drawn from the solution of the present problem is that the different permeabilities of Darcy and Brinkman regions of the porous layered artery have a significant effect on the flow. **Hassan [11]** has discussed about entropy generation on analysis of a reactive hydromagnetic couple stress fluid flow through a saturated porous channel. This study investigates the analysis of a reactive hydromagnetic fluid flow of a couple stress fluid through a saturated channel with porous materials. The analytical expressions for the fluid motion and heat transfer are obtained to find the rate of entropy generation with the use of modified Adomian decomposition method (mADM) as well as determining the critical values. The results are compared with previously obtained results to validate the use of mADM. Also, the impact of magnetic strength and other thermophysical parameters are presented and discussed in tables and graphs to show the impact of magnetic strength on fluid motion, heat transfer and rate of entropy generation. **Pundir et al. [12]** have discussed about thermal instability of couple-stress ferromagnetic fluid in the presence of variable gravity field rotation and magnetic field. In his study, the theortical investigation of the effect of couple-stress, rotation, magnetic field and magnetization on the thermal convection in a couple-stress ferromagnetic fluid in the presence of variable gravity field, rotation and uniform magnetic field. For a flat fluid layer contained between two free boundaries, an exact solution is obtained using a linearized stability theory and normal mode analysis. For the case of stationary convection, couple-stress and magnetic field have both stabilizing and destabilizing effect under certain conditions, while in the absence of rotation, both these parameters have stabilizing effect and destabilizing effect Also, rotation has a stabilizing effect on the system and destabilizing effect. It is also found that magnetization has a stabilizing effect on the system. The critical Rayleigh number for the onset of instability is determined numerically and graphically also. **Nadian et al. [13]** have discussed about hall current effect on double diffusive convection of couple-stress ferromagnetic fluid in the presence of varying gravitational field through a porous medium. In his study, the effect of hall current on a couple-stress ferromagnetic fluid heated and soluted from below in the presence of varying gravitational field and horizontal magnetic field through a porous media is considered. A linearized hypothesis and normal mode procedure are utilized to get dispersion relation. For the case of stationary convection, stable solute gradient has a stabilizing effect on the system. Medium permeability and couple-stress both have stabilizing and destabilizing effects under specific conditions. Additionally, magnetic field and hall current have both stabilizing as well as a destabilizing effect on the system under some conditions. It is likewise discovered that in the absence of stable solute gradient, magnetization has a stabilizing effect on the system. Oscillatory modes are introduced in the system in the presence of magnetic field (hence hall current) and stable solute gradient, though in their nonappearance, the principle of exchange of stabilities is satisfied in the system. Graphs also have been plotted by giving some numerical values to the parameters. **Kumar and Singh [14]** have analyzed the stability in couple-stress Magneto- fluid. The aim of the present research was to study the effect of magnetic field on the layer of electrically conducting couple-stress fluid heated from below in porous medium. Following the linearized stability theory, Boussinesq approximation and normal mode analysis, the dispersion relation is obtained. The stationary convection, stability of the system and oscillatory modes are discussed. For the case of stationary convection, it is found that the couple-stress parameter and magnetic field have stabilizing effect on the system whereas the medium permeability has a destabilizing effect on the system. The magnetic field introduces oscillatory modes in the system which was non-existent in its absence. A sufficient condition for the non-existent of overstability is also obtained. **Maurya and Deo [15]** have discussed about effect of magnetic field on Newtonian fluid sandwiched between non-Newtonian fluids through porous cylindrical shells. The present work deals with the influence of magnetic field on Newtonian fluid sandwiched between two porous cylindrical pipes which are filled with micropolar fluids. Fluid motion is occurring along z-axis and applied magnetic field is taken in the direction perpendicular to the direction of fluid motion. On applying appropriate boundary conditions, velocity profiles, microrotations, flow rate and shear stresses are obtained for the corresponding fluid regions. The graphs for volumetric flow rate and fluid velocity are plotted and discussed for different values of micropolar parameter, couple stress parameter, porosity, viscosity ratio parameter, Hartmann number, conductivity ratio parameters and Darcy numbers. **Nadian et al. [16]** have discussed about study of double-diffusive convection in a rotating couple-stress ferromagnetic fluid in the presence of varying gravitational field and horizontal magnetic field saturating in a porous medium. The results of double-diffusive convection on the liquid coatings of ferromagnetic liquids is studied by researchers by various theoretical and hydrodynamics concepts of hydrodynamics. However this study is done in presence of varying gravitational field. The study of such couple-stress ferromagnetic fluids in presence of fluctuating gravitational field is still not explored. As we know that gravitational field varies on different points on the earth; for this reason the study of couple-stress ferromagnetic liquids in presence of variable gravity fields is highly required. In this paper we studied the impact of medium permeability, stable solute gradient, couple-stress, rotation, magnetic field, and magnetization of a couple-stress ferromagnetic fluid in presence of variable gravitational field. For this study a coating of couple-stress ferromagnetic fluid saturating in a porous medium when fluid layer is heated and soluted. We examined the results of the magnetic field on couple-stress ferromagnetic fluids, its thermosolutal instability during rotation. A linearized concept and normal mode technique are used to acquire the dispersion relation. For the case of stationary convection, medium permeability, couple-stress, and magnetic field have both stabilizing and destabilizing results under certain conditions. A stable solute gradient has a stabilizing result on the system. Also, the rotation has a stabilizing result and destabilizing result for the system. It is likewise observed that in the absence of a stable solute gradient, magnetization has a stabilizing result on the system. The critical Rayleigh number for the onset of instability is decided numerically and graphically also. The principle of exchange of stabilities is observed to keep genuine in the absence of rotation, magnetic field, and stable solute gradient under certain conditions. **Kumar et al. [17]** have discussed about hydromagnetic instability of a dusty couple- stress ferromagnetic in fluid in the presence of rotation through a porous medium. In his study the effect of dust particles, medium permeability, couple-stress, rotation, magnetic field and magnetization on thermal instability of a layer of couple-stress ferromagnetic fluid saturating a porous medium. By using linearized theory and normal mode analysis, the dispersion relation has been obtained. In case of stationary convection, it is found that dust particles always have destabilizing effect on the system. Medium permeability and couple-stress have both stabilizing and destabilizing effect under certain conditions, while in the absence of rotation and magnetic field, medium permeability has a destabilizing effect and couple-stress has a stabilizing effect on the system. Furthermore, magnetic field has both stabilizing and destabilizing effect under certain conditions, while in the absence of rotation, it has a stabilizing effect on the system. It is also found that both rotation and magnetization have stabilizing effect on the system. The principle of exchange of stabilities is valid in the absence of rotation and magnetic field under certain conditions. **Stanly and Vasanthakumari [18]** have discussed about an analysis of hall currents on couple -stress fluid heated from below with magnetic field. This study aims to focus on the effect of hall currents on the thermal stability of a couple-stress fluid with a uniform horizontal magnetic field. The thermal perturbation method is used for the analytical solution. The analysis is administered within the framework of linear stability theory and normal mode technique on the convection for a fluid layer contained between two boundaries for which an exact solution is obtained. Findings For the case of stationary convection, a dispersion relation governing the effect of hall currents magnetic field and couple stress are derived. Results from the current study concluded that magnetic field has stabilizing effect whereas hall currents are found to have a destabilizing effect on the system. Couple stress, however, has a dual character in contrast to its stabilizing effect in the absence of hall currents. The Oscillatory modes are introduced due to the presence of a magnetic field in the system. Graphs are plotted by giving numerical values to the parameters to depict the stability characteristics in each case. **Prasad and Sarkar [19]** have discussed about an analytical study of couple stress fluid through a sphere with an influence of the magnetic field. The present work concerns to study of the steady, axisymmetric slow flow of couple-stress fluid through a rigid sphere in the transverse magnetic field. Boundary conditions on the sphere surface are the zero couple stress condition and tangential slip condition. The stream function, vorticity vector, and pressure term are obtained. The drag acting on the sphere in the presence of MHD is calculated. Here, we graphically represented the Hartmann number, couple stress, and slip parameters effect on the drag coefficient. Some well-known results of the drag are deduced. **Mahesh et al. [20]** have discussed about Impact of an inclined magnetic field on couple stress fluid flow over a stretching surface with effect of Stefan blowing radiation and chemical reaction. In his study, he focuses on the investigation of the couple stress Nanofluid flow with the inclined magnetic field, heat and mass transfer effect. The impact of parameters such as the Schmidt number, the Prandtl number, the Stefan Boltzmann constant, and the magnetic field parameter is evaluated. The regular partial differential equations (PDEs) are mapped into ordinary differential equations (ODEs) and solved analytically, while the exact solution of heat and mass transfer is given in terms of confluent hypergeometric function. It is shown that the impact of the couple blowing effect has primitive impact on velocity, temperature and concentration profiles. The magnetic parameter, by posing a magnetic field normal to the stretching sheet, reduces the flow velocity, the couple stress fluid parameter increases the amplitude of oscillations in velocity and skin friction coefficient, the heat source/sink parameter increases the temperature of the fluid, the volume fraction of the nanoparticles increases the thermal efficiency of the fluid, the chemical reaction parameter decreases the temperature of the fluid, and, finally, the thermal radiation increases the nanofluid temperature. **Kumar [21]** has discussed about magneto- rotatory convection in couple -stress fluid. In his study Thermal convection is the most convective instability when crystals are produced from a single element like silicon and the thermal instability of a fluid layer heated from below plays an important role in geophysics, oceanography, atmospheric physics, etc. The flow through porous media is of considerable interest for petroleum engineers, for geophysical fluid dynamicists and has importance in chemical technology and industry. Many of the flow problems in fluids with couple-stresses indicate some possible experiments that could be used for determining the material constants, and the results are found to differ from those of Newtonian fluid. Keeping this in view, the present work was to study the effect of a uniform vertical magnetic field on the couple-stress fluid heated from below in the presence of a uniform vertical rotation through permeable media. The present problem is studied using the linearized stability theory, Boussinesq approximation, normal mode analysis, and the dispersion relation is obtained. The stationary convection, stability of the system, and oscillatory modes are discussed. In the case of stationary convection, the rotation postpones the onset of convection. The magnetic field and couple-stress may hasten the onset of convection in the presence of rotation while in the absence of rotation; they always postpone the onset of convection. The medium permeability hastens the onset of convection in the absence of rotation while in the presence of rotation, it may postpone the onset of convection. The rotation and magnetic field are found to introduce oscillatory modes in the system which was non-existent in their absence. A sufficient condition for the non-existence of overstability is also obtained. **Vignana [22]** has discussed about effect of magnetic field in a porous layer saturated couple stress fluid with flow and internal heat source. In his study, onset of internally heated convection in a porous medium saturated couple-stress fluid with the effect of throughflow and magnetic field is investigated. The governing non-dimension equations are solved using the normal modes, which leads to an eigenvalue problem for the linear stability analysis. The eigenvalue problem is solved by bvp4c in MATLAB R2020a. The critical values of the Rayleigh number are obtained for different prescribed values of the other physical parameters. **Miqdady and Idris [23]** have discussed about effects of a magnetic field and rotation on the onset of double-diffusive micropolar fluids convection with couple- stress in a saturated porous medium. In his study, the linear stability analysis was performed to study the effects of magnetic field and rotation on the onset of double-diffusive micro-polar fluid convection in a horizontal porous layer. The perturbation method is used to analyze the combined effect of the magnetic field and temperature variation on fluid stability through a porous medium. It found that the convective behavior is significantly reduced or decreased by the impact of the critical thermal Rayleigh number. It likewise found that the rotation, couple stress parameter, Chandrasekhar number, Lewis number, and the number of solutes Rayleigh have stabilizing effects. **Gupta et al. [24]** have discussed about effect of magnetic field on chaos in couple stress liquid saturated in porous layer. Using the theory of dynamical system, they investigated chaotic behavior due to the thermal convection in a couple stress liquid saturated porous layer in the presence of a magnetic field and heated from below for low Prandtl number. The Galerkin truncatated approximation is used to find the Lorenz like model. The fourth-order Runge-Kutta method is employed to obtain the numerical solution of the nonlinear dynamical system. We found that there is a proportional relation between the couple stress parameter and scaled Rayleigh number and consequently the porous media gravity-related Rayleigh number. **Molimol et al. [25]** have discussed about impact of magnetic field on peristaltic transport of nano-couple stress fluid in an inclined porous tube.In his study, a theoretical investigation of peristaltic transport of couple-stress nanofluid under the influence of a magnetic field in an inclined porous tube. With low Reynolds number, long wavelength approximations, appropriate analytical methods are employed to investigate the fluid's velocity, frictional force, time-averaged flux, nanoparticle phenomena, pressure drop, and temperature profile. The effects of various physical parameters, including the thermophoresis parameter, Brownian motion parameter, local nanoparticle Grashof number, and local temperature Grashof number, on frictional force and pressure drop characteristics are investigated. Graphs are used to illustrate expressions for pressure drop, velocity, nanoparticle phenomena, temperature profile, and frictional force. **Chauhan et al. [26]** have discussed about influence of couple stress and magnetic fluid on the performance of step slider bearing. This theoretical investigation delves into the performance of step slider bearings, considering the influence of couple stress and magnetic fluid as the lubricating medium. Employing a non-linear model for magnetic field intensity aims to optimize bearing performance. Modifying the Reynolds equation for step slider bearings incorporates theories from Neuringer and Rosensweig for magnetic fluid flow dynamics and the Stokes micro-continuum model to account for couple stress effects. Solving the Reynolds equation with appropriate boundary conditions determines key parameters such as pressure, load capacity, center of pressure, and frictional force. Analytical formulations for load-bearing capacity and pressure distribution are produced, and MATLAB is used to analyse the integrals that appear in these two expressions. The results of the investigation are then explained via graphical representations. The findings demonstrate a notable improvement in load-carrying capacity ferrofluid based system as compared to non-magnetic fluid. Additionally, increasing coupling stress and magnetization parameters results in a drop in the frictional coefficient and an increase in both load capacity and frictional force. The use of magnetic fluid lubrication significantly increases the beneficial effects of couple stress fluids. It is discovered that the impact of magnetic fluid lubrication increases the load-carrying capacity by at least 22.30 % in the presence of couple stress. The synergistic effect of couple stress and magnetic fluid lubrication demonstrates the potential for optimizing the bearing performance beyond conventional methods. **Yadav et al. [27]** have discussed about Magnetohydrodynamics flow of couple stress fluid with temperature dependent viscosity inside a heated rectangular porous channel. In their study, fluids with microstructures play an important role in the microfluidic and nanofluidic systems that have significant industrial and biomedical applications. In this study, a novel mathematical model is developed to investigate the transport of couple stress fluid with temperature-dependent viscosity through an inclined porous channel under the influence of a magnetic field that applied transversally to the axis of the channel. The variation of viscosity along with the temperature is modeled using Vogel's model, and the thermodynamic irreversibility of the system is quantified through a detailed entropy generation analysis, which has not been adequately addressed for such flow configurations in the existing literature. The highly nonlinear governing equations associated with the proposed model is solved by using a semi-analytical homotopy perturbation method (HPM), and the accuracy of the analytical solutions is validated through comparison with a numerical shooting method. The effects of pertinent physical parameters, including the Hartmann number, Darcy number, Brinkman number, couple stress parameter, and angle of inclination on velocity, temperature, skin friction, and entropy generation are systematically examined. The results of the present study reveal that a rise in magnetic field strength, temperature-dependent viscosity, and Brinkman number significantly suppress the flow velocity, while temperature-dependent viscosity markedly enhances entropy generation near the channel walls. Through the analysis, it is found that entropy generation can be decreased up to 15 -25%by using higher Hartmann numbers, highlighting the strong role of magnetic effects. Furthermore, it is noticed that the Bejan number decreases by nearly 15–20% with the enhanced Darcy number when the fluid transport takes place through porous medium. The present study provides new physical insights into thermo-magnetohydrodynamics transport of couple stress fluids in porous media which is highly relevant to applications in microfluidic devices, biomedical flows, environmental transport processes, and thermal management systems.

VII. CONCLUSION

The present paper is a review on stability and flow problems of couple-stress fluid in presence of magnetic field through porous medium. Several studies that have examined the flow and stability of fluid under different conditions have revealed important findings that have contributed to our understanding of fluid dynamics. As a result of these studies, we have a greater understanding of fluid behavior in the presence of magnetic fields as well as many other conditions. In order to develop machinery and systems that work well in different places and environments, it is crucial to understand these concepts. A deep understanding of fluid-porous material interactions is essential for a variety of technical applications, such as groundwater management, oil recovery, and environmental remediation. Using these investigations, we have gained valuable insight into basic fluid dynamics, which has been applied in several areas, including environmental science, industries, engineering, and space exploration, where the effect of magnetic fields on fluid dynamics has a critical role to play.

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