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Fluid mechanics is essentially the branch of physics which deals with the properties of fluids, namely liquids and gases, and their interaction with externally applied forces. Fluid mechanics is divided into fluid statics - the study of fluids at rest, and fluid dynamics - the behaviour of fluids while in motion. It is a branch of continuum mechanics, a subject which models matter without using the information that it is made out of atoms. Fluid mechanics, especially fluid dynamics, is an active field of research with many unsolved or partly solved problems and is mathematically complex.

When a certain stress is applied on an elastic material, the material undergoes some deformation and if this stress is removed the material retraces to its original position. In fluids, the stress depends upon the rate of deformation and when the stress is removed the strain rate becomes zero. But, the deformation it has accumulated persists, that is, it forgets its original position. In other words, it can be said that, fluids have no memory of the past history. But, there are some fluids like solution, polymers, which have some elastic properties, besides having fluid properties. Such fluids are called visco-elastic fluids.

A visco-elastic model can be illustrated by a spring dashpot assembly. If in a spring a certain force is applied to it, it is seen that, the spring extends by a certain amount which is proportional to the external force applied on it. On the other hand, in a dashpot when a certain force is applied on the piston, it is noticed that the piston moves with some speed which is proportional to the force applied to it. It can be well said that, the elastic properties of a material can be represented by a spring and the viscous properties by a dashpot.

Composite fluid and porous layers find their applications in the porous journal bearings. The surfaces of the joints in human beings, animals and birds have articulate cartilage, a smooth rubbery material that is attached to the solid bone. The surface of the particular cartilage is rough and porous, and hence, can trap the synovial fluid. The composite system also exist in numerous other engineering applications such as
fibrous and granular insulation where the insulation occupies only part of the space separating the heated and cooled walls, porous insulation of ducts which permit convective interaction between the duct walls and the ambient air, heat transfer from hair covered skin, grain storage and drying, paper drying, and food preparation and storage. In all of the above mentioned composite systems, fluid motion in one layer is not independent of that in the other, the interaction being strongly dictated by the conditions at the interface between the two layers.

The formation of geothermal reservoirs is generally believed to be associated with the volcanic activities or tectonic movements, which cause magmatic intrusions at shallow depths in the earth’s crust. Meteoric water, percolating down through the permeable formation, is heated directly or indirectly by the intruded magma and is then driven by buoyancy to the top of the aquifier. Modelling of such systems requires an extensive understanding of the convective interaction between the fluid layer and the adjacent permeable systems.

Due to wide ranging applications in the fields of Physics, Chemistry, and Chemical Technology and in situations demanding efficient transfer of mass over inclined beds, the viscous drainage over an inclined rigid plane has been the subject of considerable interest to theoretical and experimental investigators during the last several years.

Viscous fluid flow over wavy wall had attracted the attention of relatively few researchers although the analysis of such flows finds application in different areas such as transpiration cooling of re-entry vehicles and rocket boosters, cross hatching ablative surfaces and film vaporization in combustion chambers, especially the stream, where the heat and mass transfer takes place in the chemical processing industry. The problem by considering the permeability of the bounding surface in the reactors assumes greater significance.

Free convection flow involving coupled heat and mass transfer occurs frequently in several areas of chemical engineering and manufacturing process areas. A few representative fields of interest in which combined heat and mass transfer plays
an important role are designing of chemical processing equipment, formation and dispersion of fog, distribution of temperature and moisture over agricultural fields and fruit trees, crop damage due to freezing and environmental disorders. Thermal radiation has become a significant branch of engineering sciences and is an essential aspect of various scenarios in mechanical, aerospace, chemical and solar power engineering. The flow of Newtonian electrically conducting fluids is also of great interest in high speed aerodynamics, astronautical plasma flows, MHD boundary layer control, MHD accelerator technologies and the applications are many from the view of science and technology. Free convection flow involving heat transfer occurs frequently in an environment where difference between land and air temperature can give rise to complicated flow patterns. Many processes in engineering and manufacturing sectors, the product production occurs at high level of temperature and acknowledges radiation heat transfer for the design of pertinent equipment. Nuclear power plants, gas turbines and various propulsion devices for aircraft, missiles, satellites and space vehicles are few such examples in the engineering areas. Thermal radiation has become a significant branch of engineering sciences and is an essential aspect of various scenarios in mechanical, aerospace, chemical and solar power engineering. The study of effects of magnetic field on free convection flow is often found importance in liquid metals, electrolytes and ionized gasses. At extremely high temperatures in some engineering devices, gas, for example, can be ionized and so becomes an electrical conductor.

Chapter – 1 shows the detailed analysis of different varieties of fluids and the introductory study of conduction, convection and radiation effects in fluid flows. Also, the study made by several investigators on such flows has been re-examined. From the literature, it is seen that, most of the problems are related to the geometry where the bounding surface is mostly porous. The detailed survey shows that, considering the porosity of the bounding surface appears to be more realistic in practical situations. Therefore, in the fitness of real life situation, it is felt that, all earlier problems can be re-examined by taking into account the porosity of the bounding surface. And also at times, by virtue of geometry of the bounding surface and due to the inherent property possessed by the fluid, the magnetic field influences
the characteristic features of the flow entity. Literature concerning about the porosity, thermal radiation and magnetic influence are also studied.

The problem of unsteady state flow of a visco elastic fluid of second order type over an inclined rigid plane is examined by taking into account a uniform tangential force $F$ which acts on the free surface for a finite interval of time has been examined in Chapter – 2. The problem assumes greater significance in all such situations where the transfer of fluid from one container to another is involved.

The influence of various parameters that affects the velocity, film thickness and the fluid that adheres to the walls of the container has been examined in detail and analysed qualitatively. Also, the factors that influence the skin friction which occurs mainly when the fluid is being transported from one container/reactor to the other container/ reactor has been examined in detail. It is noticed that, as the visco elasticity of the fluid increases, the draining of the fluid along the rigid plane is found to be slow. Further, as time advances, the velocity is noticed to be proportional - which is in agreement with observable phenomena. Further, when the visco elasticity of the fluid medium is relatively low, the velocity profiles at the end of the bounding surface are slightly distinct and dispersed. Such a phenomenon can be attributed to the fact that due to low visco elasticity, the intra molecular forces are less dominant and are weak in nature. Hence, the variation could be seen for smaller values of visco elasticity. When the visco elasticity of the fluid medium is held constant and as time increases, it is seen that the flow rate increases. Similar such an effect is noticed even in case of skin friction. Also, it is noted that as the angle of inclination increases, the friction on the fluid bed decreases rapidly.

Chapter – 3 deals with the unsteady state flow of a visco elastic fluid of second order type over an inclined porous plate under the influence of gravity. Such a situation is an extension of the earlier problem and of course under different geometric conditions and situation. The fluid under consideration assumes to be of Rivlin Ericksen type. Problems of such type often occur widely in most of the Chemical Engineering situations, Pharmaceutical formulations and bulk drug productions. In the course of analysis, it is observed that the decrease in the fluid
velocity during the initial length of the plate is in accordance with the natural law of absorption. When the void space is fully saturated, due to the presence of the gravitational force and partly due to the inclination of the plate the fluid velocity increases at a rapid rate only in the later part of the plate.

Throughout the analysis, the angle of inclination and also participating flow entities has been analysed. It is noticed that the increase in the angle of inclination contributes to the more draining of the fluid. The skin friction on the plate has been examined in detail and illustrated graphically. The results are in agreement with the situation - when the flow is considered on a horizontal plate. As the porosity of the bounding surface increases, the flow rate is found to be proportional. An interesting observation is that, if the porosity of the fluid bed is held constant, the flow rate remains unchanged over a period of time. Relatively for smaller values of time, as visco elasticity increases the flow rate is in tune with such a parameter. However, for higher values of time the dispersion is found to be not that significant. It is observed that, increase in pore size of the boundary contributes to marginal increase in the flow rate. It is seen that, over a period of time and as it increases, initially a backward flow is observed and thereafter a forward motion is observed.

The case of unsteady state flow of a visco elastic fluid of second order type over an inclined porous plate under the influence of applied magnetic field is examined in Chapter – 4. In this problem, a uniform tangential force \( F \) in terms of Heaviside’s unit step function acts on the free surface for a finite interval of time and of course with different angles of inclination of the bounding surface. To be more realistic, the influence of gravitational pull is taken into consideration. The geometry of the problem remains essentially as that of previous cases. In addition to the above, a transverse magnetic intensity is applied over the system. The influence of porosity, magnetic field and the angle of inclination is found to be more predominant only at the later part of the plate length. It is seen that, the contribution of any of the above said parameters is found to be not that significant till the fluid reaches at least up to 60% of the plate length and predominant only in the later part. The most important aspect in this problem is the behavior of skin friction with respect to the various participating parameters in the field equations. It is seen that as the magnetic intensity
increases, the skin friction is noticed to be proportional. For higher intensity of magnetic field it is observed that the influence of porosity is not much on the skin friction. Also, when magnetic field and porosity are held constant and as time advances the skin friction decreases. A detailed analysis has been presented when the fluid under consideration possesses variable visco elasticity. Also, when the applied magnetic intensity is very large, the increase in the visco elasticity contributes to increase in skin friction. For constant values of magnetic field and visco elasticity, over a period of time the skin friction on the bounding surface is noticed to be decreasing.

Chapter – 5 deals with the Darcy’s effect on convective MHD flow of a second order fluid in an inclined porous channel. The case of laminar mixed convection flow of a visco elastic fluid of second grade through a porous medium in an inclined permeable channel has been examined in this problem. It is observed that as the Prandtl number increases, the velocity is found to be inversely proportional and also at times back flow is noticed. When the channel is held horizontal, the velocity profiles are parabolic. As the wall temperature increases, the velocity appears to be decreasing. Increase in the angle of inclination contributes to increase in velocity. However, nearly after 50% of the channel width, a reverse trend is observed. Such a pattern is found to be absent when the visco elasticity of the fluid is comparatively high. As the Darcy’s parameter increases, more of back flow is noticed. In general, the velocity profiles are found to be parabolic and the velocity is more when the channel is held vertical. Further, the cross flow Reynold’s number contributes to the velocity field significantly. It is seen that increase in cross flow Reynold’s number causes the velocity to decrease. The increase in visco elasticity for similar values of the Reynold’s number contributes to more of a backward flow.

In general, it is observed that the Darcy’s no. influences the flow pattern in the channel quite significantly. When the pore size of the fluid bed is held constant and when the visco elasticity is relatively very small, a forward motion is noticed while the trend is observed to be reverse when the fluid possesses high visco elastic values. Such an observation is found to be independent of the angle of inclination. For a fixed Reynold’s no. and the visco elasticity parameter, it is noticed that the velocity
of the fluid flow is found to be inversely related to the Darcy’s parameter. Only at the boundary layer situated in the upper plate, a forward motion is noted, while in the rest of the region more of the backward flow is noticed.

Decrease in the Darcy’s number contributes proportionally to the velocity. Also, decrease in the angle of inclination of the channel causes the fluid velocity to slow down. In a case where, the channel is inclined and all other parameters are held constant, increase in Darcy’s number contributes to the forward flow. Relatively, for smaller values of cross flow Reynold’s number and when the channel is inclined at $\pi/4$ and also when held horizontally, the flow is dominated in the forward direction. However, when the channel is positioned horizontally, and as the cross flow Reynold’s number is increased, a backflow is noticed.