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IMPACT OF PRESENCE OF SUSPENDED PARTICLES IN STRATIFIED FLUID AND STABILITY UNDER INFLUENCE OF TEMPERATURE

Vivek Parkash[1]

[1]Assistant Professor of Mathematics, Dyal Singh College, Karnal (Haryana), India

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ABSTRACT -

Stratified fluid flows are the flows through a gravitational field whose origin lies in the changes in density within the field. The atmosphere and the oceans are both examples of stratified medium. The stratification of atmosphere is due to thermal reasons and the salinity induces stratification in oceans. If the fluid is not heterogeneous, the gravity has no effect on the flow of the fluid, in turn it is only responsible for hydrostatic pressure. Heterogeneity will also have minute effects even when force of gravity is absent. But the presence of both heterogeneity and the force of gravity is responsible for very strange and complicated things happening. One such situation is reflected in the instability of Rayleigh-Taylor configuration. Moreover presence of suspended particles in fluid flows makes the fluid much more sensitive to variations and deflections in temperature. The study of these flows is very crucial in several industrial applications and in atmospheric sciences. Moreover, the study of thermal instability of fluid layers with suspended particles is very essential for knowing the nature of these flows.

Keywords and Phrases: **heterogeneity, relaxation time, kinetic energy, thermohaline convections.**

1. CASE OF THERMAL INSTABILITY OF FLUID LAYERS HAVING SUSPENDED PARTICLES

Admirable work in this field was done by Saffman[1] and Veronis. Saffman[1] did a considerable good work in this direction. He investigated the effect of the dust particles in terms of two parameters, namely the contribution of dust particles in its motion and the relaxation time τ. Relaxation time τ denotes the rate of adjustment of velocity of dust particles with respect to the gas velocity change and is a function of size of the each particle individually.

2. CASE WHEN DUST PARTICLES ARE SUFFICIENTLY FINE IN SIZE

Saffman[1] discussed the case when the dust particles are sufficiently fine, so that the relaxation time is much smaller than the characteristic-time scale of the disturbances. The dust particles move in the gas roughly with the same velocity as that of the gas, so that the effect of the dust particles is simply to increase the density of the gas. He also discussed the case of coarse dust particles i.e. the case when the relaxation time is comparable or greater than the characteristic time of the disturbances. The physical explanation is that the disturbance has to flow round the particles, and the energy is dissipated. The kinetic energy present in the disturbances is responsible for this energy. This results in decrease in the amplitude of the perturbations. Thus the presence of dust particles, makes the system stable. It is also noted that the stabilizing action of the coarse dust depends only on the parameter $\Xi = \frac{f_d}{\chi\, f_{ds}}$ where f_d is proportional to the fraction of' dust particles and $f_{d\,s}$ is the size of the dust particles.

Thus, if f_d is kept constant, then an increase in the size of coarse and irregular shaped dust particles decreases the value and hence reduces the stabilizing effect.

3. THERMAL INSTABILITY OF A HORIZONTALLY FLOWING FLUID

Sharma & Sharma[2] studied the problem of thermal instability of a horizontal fluid layer through a porous medium in the presence of suspended particles. They proved that the effect of suspended particles as well as medium permeability was to destabilize the fluid layer. They also investigated the thermal instability of the layer in the presence of rotation and suspended particles. It was found that the rotation has a stabilizing effect but then PES is not valid. Finally, they examined the problem of thermo-solutal convection in a layer of fluid heated form below and subjected to a statically stable solute gradient through a porous medium with uniform rotation. It was also found that the medium permeability has got both stabilizing as well as destabilizing effects depending on the rotation parameters.

4. THERMO-SOLUTAL CONVECTION IN PRESENCE OF SUSPENDED PARTICLES

Sharma & Rani[3] studied the thermo-solutal convection in porous medium and analyzed the effect of suspended particles. They showed that for thermal Rayleigh number greater than or equal to solute Rayleigh number, PES is valid and that the oscillatory modes may come into play if the thermal Rayleigh number is less than the solute Rayleigh number. Also destabilization of the fluid layer is caused by the suspended particles. It was also deduced that the permeability of medium and solute gradient in stable mode respectively destabilize and stabilize the system. Moreover, the rotation stabilizes a certain wave number range in thermo-solutal convection in porous medium, which were unstable in the absence of rotation. Gupta et al generalized, their earlier result given in 1983[4,5] and established two separate semi-circle theorems for Vernonis's and Sterns's view point thermohaline convections with a uniform rotation and magnetic field. These results are valid for all wave numbers and for all combinations of rigid, conducting or insulating boundaries. Sharma and Singh[6] discussed the stability of a mixture of fluid and particles having density in variable form and having viscous nature under the impact of horizontal magnetic field which is present horizontally and having variable intensity. The benchmark that determines that both stability and instability behaves independently of what viscosity and suspended particles do. The magnetic field has a stabilizing impact on the system but the absence of magnetic field makes it unstable.

5. EFFECT OF VISCOSITY ON CONDUCTING PLAZMA

Prakash & Manchanda[7] studied the effect of magnetic viscosity and suspended particles on thermal instability of an infinitely conducting plasma in porous medium. It was noted that suspended particles, magnetic viscosity and magnetic field instigate the arrival of oscillatory modes in the system though earlier in their absence oscillatory modes were not noticed. As soon as instability in the system happens to be there in the form of stationary convection, the system noticed stabilizing as well as destabilizing behavior. They further showed that the medium permeability has destabilizing (or stabilizing) and magnetic field has stabilizing (or destabilizing) nature under certain conditions in the presence of magnetic viscosity, whereas in the absence of magnetic viscosity the magnetic field succeeds in stabilizing the thermal instability of plasma particle layer and the medium permeability and the suspended particles have destabilizing effect on the layer.

6. CASE OF STRATIFIED FLUIDS AND DISCUSSION ON ITS STABILITY

The history of this problem goes back to Rayleigh in 1900 who studied the instability of heterogeneous and incompressible fluid having almost zero viscosity and showed that the necessary and sufficient for a system to be stable is that the density should decrease upwards everywhere in the fluid region and if the density increased everywhere, the system is unstable. The direction of gravity is in the vertical direction acting downwards. Taylor[8] investigated the problem of instability of the plane interface between two fluids. This is called the Rayleigh-Taylor problem of instability. He showed that if the surface tension is neglected, then the system is stable if the upper fluid is lighter one and is unstable otherwise it also follows from the analysis that the surface tension succeeds in stabilizing a statically unstable arrangement for all sufficiently small wavelengths but the arrangement remains unstable for sufficiently long wavelengths. Hence when there is water above and air below, the maximum value of wavelength that is consistent with stability parameter comes out as 0.0173 m. This established a stabilizing role of surface tension. An experimental demonstration of the development of the Rayleigh-Taylor instability is described by Lewis[9]. For a detailed treatment of the problem one is referred to Chandrasekhar in 1961. Miles,in 1961, also proved that for $V^{'}(z), J^{'} > \frac{1}{4}$ everywhere in the flow domain is the sufficient condition for stability of heterogeneous shear flow. Sachdev and Narayanan[10] studied the instabilities of compressible stratified fluid in horizontal sheared motion. The integrated criteria of instability of heterogeneous shear flows given by Banerjee et. al.[11] is further modified by Banerjee and Gupta[12], by relaxing the very rigid condition on the curvature of the basic profile. Howerd's semi-circular region- in which complex wave velocity of any arbitrary unstable mode must be present, is also reduced.

RESULTS

a. It follows that for fine dust particles the critical Rayleigh number is reduced by the factor (1+ f_d), where f_d is the mass concentration of the dust particles. Thus the fine dust destabilizes the flow.

b. The perturbations dies in dust particles and there is no movement of coarse dust with the gas when perturbation is induced in the flow but goes along with the speed of initial flow, so that the net effect of the dust added to the gas flow is analogous to an extra frictional force proportional to the relative velocity. Thus coarse dust will increase the critical Rayleigh number for the existence of neutral disturbances of given wave length.

c. It was observed that in this case PES is satisfied and thus the marginal state is a stationary state.

d. It was deduced that solute gradient is responsible for the introduction of oscillatory modes which were not present when it was absent. The critical Rayleigh number was found to increase with the increase in Stable solute gradient as well as rotation parameters.

e. It is clear from the condition that the top heavy arrangement of the fluid is unstable.

f. Miles in 1961 and further in 1963 investigated the effect of small perturbations on the stability of parallel flow in an inviscid, incompressible fluid having density as variable. It was further proved that the dynamic instability of statically stable flows cannot be otherwise exponential, in consequence of which it suffices to consider spatially periodic, travelling waves.

CONCLUSION

The work done in this paper concerns the study of thermal instability of fluid layers having suspended particles, case of dust particles having sufficiently fine in size, thermal instability of a horizontally flowing fluid, thermo-solutal convection in presence of suspended particles, effect of viscosity on conducting plazma and case of stratified fluid and its stability. The study shows that the kinetic energy of the disturbances makes the disturbances flow around the particles and the energy is released. It is also observed that the permeability of the medium and the presence of suspended particles induces instability in the fluid. Moreover it is noticed that effect of rotation is to introduce stability in fluid layer. The application of magnetic field makes the system stable otherwise it remains unstable. The surface tension makes the fluid behave in a stable manner provided the wavelengths are infinitesimally small in size.

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