ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 5, Issue 10, October 2020

A Study of Dispersion and Attenuation of Waves By Small Particles in Fluid

Kumar Sanjeev

Department of Physics, V.K.S University Ara, India
ksanjeevphysics75@gmail.com

Abstract— **During the recent years, there has been renewed interest in the study of dispersion and attenuation of waves by small particles in fluid. This interest is chiefly due to acoustic pulse got much attention for researchers and scientist for ultrasonic measurements of biological membranes and biomolecules to determine the volume fraction and the density, probing of marine sediments, characterization of coal slurries and monitoring of creaming and sedimentation of colloidal dispersions. The solution is obtained by approximate solutions of mathematical theory of dispersion and attenuation of wave by small particles in fluid.**

Keywords— **Attenuation, Compressibility, Dispersion, Suspension**

I. INTRODUCTION

When a plane wave travels through a suspension of particles like particulate composites (solid particles in solids), liquid suspensions (solid particles in fluid), and emulsions (fluid inclusions in fluid), multiple scattering occurs and part of the incident energy is transferred to the scattered fields. Parameters such as the frequency of the incident wave, the relative position among the particles, the geometry of the particles and the material properties of both matrix and inclusions affect the amount of this energy. Thus, although matrix and particles can be non-attenuative, the amplitude of waves propagating through suspensions decays and the decay rate is frequency dependent. For a plane wave the decay of its amplitude is expressed via a frequency dependent exponential coefficient known as an attenuation coefficient. On the other hand, the size of the particles as well as the material mismatch between particles and surrounding medium imply that the dynamic behavior of the composite medium is strongly depended on the excitation frequency of the incident wave. Macroscopically this means that the phase velocity of a plane wave traveling through a suspension of particles is frequency dependent. This phenomenon is known in the literature as wave dispersion.

It has been found out that, both in the case of fluid containing solid particles or droplets, the basic phenomenon responsible for attenuation and dispersion of waves is relaxation of the dispersed phase due to velocity and temperature differences between fluid and suspensions. In other words, attenuation and dispersion are caused by the inability of the suspensions to follow the changes in the fluid that are induced by the acoustic wave. Thus, one of the factors controlling attenuation and dispersion is the velocity of the suspensions are relative to that of the fluid.

The problem described above has been also considered by numerous investigators (Sewell, Rayleigh's, Keller, Temkin and Prosperetti) In an attempt to describe the theoretical and experimental results, these investigations have introduced a large number of models. The purpose of the present work in two fold, first to attempt to obtain a general solution of sound absorption of wave by suspensions of small particles in fluid useing techniques, ideas and results generated by approximate solutions. Next to determining to what extent experimental investigation involved attenuation and dispersion of wave can contribute to our basic knowledge of constitutive equations. Firstly we have explained the comparative study of earth atmosphere and nature of the sea in detail. We also considered the stratification of the sea, and structure of inosphere.

We have considered the effects of viscosity and compressibility changes between the suspension and fluid, under appropriate boundary conditions. We identified viscosity and heat conductivity as the effects contributing to the changes of compressibility through their action on the translational and pulsationals motions and on the temperature oscillation. In the case of relative motion between small particles and fluid, shows that whenever the velocity ratio differs from unity, the compressibility of the suspension will differ from its equilibrium value.

Attenuation and dispersion of acoustic wave in dilute suspensions of rigid particles has been studied by means of the Kramers-Kraning relationships, which relate the real and imaginary parts of the general susceptibility of a linear medium.

The classical theories of the propagation and attenuation of acoustic wave by particles suspended in a fluid are examined. The variations of the attenuation and velocity with frequency due to the particles filled gas are obtained. The frequency dependence of m can be found from a consideration of the expression (2.2.1) for viscous attenuation. The function I_μ

approches one asymptotically as the frequency increases. Actually in this model, the sphere is fixed in space only when the frequency of the sound is so high that the particles cannot follow the acoustic motions of the gas. Thus, I_μ goes to zero as the frequency goes to zero. At low frequencies where the particles can follow the acoustic displacements in the gas, there is no relative motion between the gas and particle. There is consequently no production of viscous waves and hence no viscous dissipation. At frequencies where I_μ is somewhere between zero and one, sewell's equation predicts to high a value for the attenuation. It is too high by a factor $\frac{1}{I_\mu}$. The attenuation expressions are proportional to n the number of particles per cubic centimeter.

The presence of the rigid sphere in a fluid medium gives rise to a reflected compressional wave, a compressional wave in the sphere, thermal and viscous waves inside and outside the sphere. The attenuation of sound in suspensions and emulsions arise from energy scattered by the sphere to infinity, i.e. distances x with $K_c x \gg 1$, as well as the energy absorbed in the vicinity of the suspended particle. The energy scattered by the particle is just that contained in the reflected compressional wave ϕ_r. The energy absorbed is equal to the total velocity potential at infinity in terms of incoming and outgoing waves and the difference in the energy carried by these waves yields the energy absorbed by the medium. The attenuation and dispersion by small particles suspended in an acoustic field can vary considerably for different values of C_m.

The attenuation of acoustic waves by suspension of small liquid particle (droplets) are considered. In the case of small droplets for which the effect of the surface tension is to alter the thermal dissipation resulting from heat conduction, while no effect on viscous dissipation is produced. This effect is found to be negligible in the case of the suspension of water droplets in air, i.e. F<<1. Hence, if the particles only slightly from the spherical shape in the curse of motion, Epstein and carhart's results for the sound attenuation in a gas with the suspension of liquid droplets apply even if the displacement of the particle is large as coropared to its radius. For air containing water droplets, the ratio of the thermal attenuation to the viscous attenuation is 7.2 to 0.3. It is seen that the thermal attenuation is predominant at low frequency range while the viscous attenuation is more important at high frequency range. We have presented a theoretical study to investigate possible reasons for attenuation in a flowing gas-vapor mixture in which condensation into suspended small liquid particle causes gradients in temperature and density along the direction of flow. It shows that these gradients affect acoustic attenuation in these ways

(i) they cause changes in the acoustic impedance of the medium which affect the acoustic pressure level but have relatively little effect on the acoustic intensity.
(ii) Gradients influence the mass and heat transfer between the small liquide particles and the gas-vapor mixture and therefore alter the dissipative processes which are responsible for attenuation of acoustic intensity. As a result, the attenuation of acoustic pressure level and intensity are not the same in a non uniform medium. In a condensing vapor the attenuation of acoustic pressure level is greater than that of intensity. Calculations show that the corresponding attenuation coefficients differ by almost one dB/m in the region where the gradients are largest, but the difference rapidly diminishes as the gar vapor mixture approaches uniform conditions, so the overall difference in attenuation is smaller. The effect of gradients on attenuation of acoustic pressure level is mainly due to the change in impedance. Their direct effect on the dissipative process is small except at low frequencies, when the acoustic wave length is of the same order as the characteristic distance for variation of the gas density and temperature.

We have studied a low frequency theory for the viscous attenuation and dispension of sound for plane waves traveling in isothermal suspensions of small particles, in the limit of small volume concentrations. The results for the viscous attenuation coefficieat are based on the complete force equation for a particle and velocity of a particle in a sound wave, and yield the complete dependence on the density ratio. At low frequencies the thermal attenuation is proportional to $\frac{1}{\rho} - 1$. The studies suggests that the theory agrees with the incompressible theory for low frequencies and with the compressible, inviscid theory at high frequencies. The equations can be easily applied for very wide frequencies range and sizes.

REFERENCES

[1] Sewell, S. J.T, Phil. Trans. R. Soc. London, A20, P.239-270 (1950).
[2] Epstein, S and Carhart, R. R. J. Acoust. Soc. Am 25, P.553 (1983).
[3] Theoretical Acoustics, Morse and Ingard, Mc-Graw-Hill, (1968).
[4] Theory of absorption and dispersion of forced plane waves – Truesdell. C.
[5] Onuki, A Phy. Rev,43, 6740 (1991).
[6] Elements of Acoustics-Temkin. S; Willey, New York,(1981).