International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 9; Issue 09(B); September 2020; Page No.23114-23115
DOI: http://dx.doi.org/10.24327/ijcar.2020.23115.4570

Research Article

VELOCITY OF SMALL PARTICLES IN A COMPRESSIBLE FLUID

Kumar Sanjeev

Department of Physics V.K.S. University Ara, India-802301

A R T I C L E I N F O

Article History:
Received 4th June, 2020
Received in revised form 25th June, 2020
Accepted 18th August, 2020
Published online 28th August, 2020

Key words:

Amplitude of fluid velocity, Specific heat ratio, Suspensions compressibility, Thermal attenuation.

A B S T R A C T

The density and viscosity of a compressible fluid increases as pressure increases but tends to leave off at high pressure. We have significant compression or expansion on a gas so that thermodynamic states temperature, internal energy, entropy can change. Smaller particles have a larger surface area to mass ratio so there settling rates are slowed more by frictional dragging than are larger particle. The applications of studies would be helpful in designing mixing devices, designing of particle separator devices and the prediction of the settling of pollutant particles, seeds and pollen.

INTRODUCTION

When a plane wave travels through a suspension of small particles multiple scattering occurs and part of the incident is transferred to the scattered fields. The multiple scattering theories have been extensively exploited by many investigators in order to explain wave dispersion and attenuation observed in experiments dealing with wave propagation in non-homogeneous fluids and solids. In order to obtain good agreement with theory Allegra find it necessary to include thermal effects, as well as higher-order terms in the attenuation results. In aerosols at low frequencies the thermal attenuation is proportional to $\gamma - 1$, where γ is the specific heat ratio for the fluid and in water this quantity is very small. Because of this, the viscous attenuation generally overwhelms the thermal attenuation in liquid suspensions. A theory for acoustic attenuation and dispersion is developed by Temkin on the basis of the changes of the suspension's compressibility produced by the relative motion between host fluid and particles, which shows that a first principles approach, based on the relative temperature and translational velocity between particles and fluid, is possible.

Velocity of Small Particles in Compressible Fluid

The point of departure is the drag force that acts on a free rigid sphere in a viscous fluid which is executing translational oscillations of small amplitude. Gravity effects will be ignored. Because the sphere is free to move, it will acquire an oscillatory motion having the same frequency and direction as that of the wave. but not necessarily the same amplitude and phase as that of the fluid. As a result, the fluid will exert a force on the particle, which we will give now. Thus if ω is the circular frequency of the oscillation, *m* the mass of the sphere, and v the kinematic viscosity of the fluid, According to the Temkin et.al the force acting on a sphere moving with velocity $u_p - u_f$ relative to the fluid is

$$F_p = mz\frac{du_f}{2\nu} - 6\pi\mu_f a\,(1+\sqrt{\frac{\omega a^2}{2\nu}})\,(u_p-u_f)$$

$$-\frac{1}{2}mz\,(1+\frac{9}{2}\sqrt{\frac{2\nu}{\omega a^2}})\,\frac{d(u_p-u_f)}{dt} \quad \text{--(1)}$$

where z is the ratio of fluid density ρ_f to particle material density ρ_p. This equation is often expressed in terms of a non-dimensional parameter y, given by

$$y = \sqrt{\omega a^2/2\nu}. \quad \text{--(2)}$$

This gives the ratio of particle radius to the depth of the oscillatory viscous layer around the sphere,

$$z_p = \sqrt{2\nu/\omega}.$$

It should be noted that because of the definition of y, equation (1) the force for a given particle size as a function of the

Corresponding author: **Kumar Sanjeev**
Department of Physics V.K.S. University Ara, India-802301

frequency, or the force for a given frequency on particles having different sizes.

The first term, which is the only one remaining in the equation where there is no relative velocity, is due to acceleration of the fluid, and acts on the particle even if it moves entirely with the fluid. Clearly, such a particle would feel the same force that a fluid particle of the same volume and shape would feel, and since this fluid particle would have a mass *mz* and an acceleration $\frac{du_f}{dt}$.

When a relative accelerated motion exists, there appear two additional forces, one of which exists whether the fluid is viscous or not. This is the reaction of the surrounding fluid on the accelerating particle. For a spherical particle in an inviscid fluid it is given by mz

$$[d(d(u_p-u_f) / dt]/2$$.

If viscosity is now included, this reaction is modified by the factor (1 + 9/2y) which take into account the oscillatory nature of the viscous layer around the particle. and of its thickness in relation to the particle radius α.

To obtain the velocity of the small particles by equating the force equation (1) to m du_f/du, and by taking the time dependence to be proportional to the complex factor exp $(-i\omega t)$. The solution may be expressed as

$$\bar{u}_p = 3z \frac{y(2y+3) + 3i\,h}{2y^2(2+z)+9yz+9iz\,h} \bar{u}_f .$$

--(3)

Where h = 1+y

From equation (3) we may obtain the amplitude of the sphere's velocity and its phase relative to the fluid. Thus if

$$u_p = U_p \cos(\omega t - \eta)$$, then

$$\frac{u_p}{U_0} = 3z \times \sqrt{\frac{4y^4+12y^3+18y^2+18y+9}{4(2+z)^2y^4+36zy^3(2+z)+81z^2+(2y^2+2y+1)}}$$

--(4)

$$\tan\eta = \sqrt{\frac{12h\ y^2(1-z)}{4y^4(2+z)+12y^3(1+2z)+27z(2y^2+2y+1)}},$$

--(5)

where U_0, is the amplitude of the fluid's velocity.

The result for the amplitude shows that the particle moves completely with the fluid when y→0, and that in the opposite limit, when y→0, its amplitude is given by the well known inviscid result

$$\frac{U_p}{U_0} = \frac{3z}{2+z}$$ --(6)

References

1. Buckingham, M. I ; "Compressional and shear wave properties of marine sediments : Comparision between theory and data" : J. Acoust. Soc. Am : 117, 137, (2005).
2. Baudoin, M *et al*; " An extended eoupled phase theory for the sound propagation in polydisperse concentrated suspensions of rigid particles. J. Acoust. Soc. Am ; 121, 3386 (2007).
3. Carstensen, E.L.& Foldy, L. L; Propagation of sound through a liquid containing bubbles, J. Acoust. Soc. Am; 19,481 (1947).
4. Davidson. G. A. and Scott. D. S. :Finite amplitude waves forms in an aerosol : 5,55 (1974).
5. Egashira, R ; Yano, T and Fujikawa, S ; Linear wave propagation of fast and slow modes in mixtures of liquid and gas bubbles ; fluid Dynamics Research; 34, 317 (2004).

****