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A Study of Small Fluid Particle Motions in Different Fluid

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ABSTRACT
An investigation of small fluid particle motions in different fluid with compressibility changes, translational motions and pulsational motion is presented. When the particles are very small as compared to other relevant scales for the motion wavelength in the acoustic case. The approximate solution indicates that the motion of a particle can be characterized by a uniform translational motion where each point of the particles has a velocity, a rigid-body rotation with angular. Velocity without a change of volume. Each of these motions can produce a change in the suspension compressibility because it may affect the volume of a suspension. Ultimately each of these contributions can be related to energy-dissipation mechanism but it is advantageous to cast the problem in terms of the various particle motions that can be exist.

Key Words: *acoustic, compressibility, translational motion. pulsational motion.*

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I. INTRODUCTION:

It is known from basic fluid kinematics that the most general motion of a sufficiently small material element can be represented as the sum of uniform translation, a rigid-body rotation, and a stretching motion that can be split into a uniform expansion (or contraction), and a deformation of the element without a change of volume. Although the theorem does not apply to particles of finite size, we may expect that it remains approximately valid when the particles are very small when compared to other relevant scales for the motion wavelength in the acoustic case. If so, the motion of a particle can be characterized by a uniform translational motion where each point of the particles has a velocity u_p a rigid-body rotation with angular velocity Ω_p, a uniform expansion with a volume-rate change du_p/dt, and a change of area, $dA_p,/dt$, without a change of volume.

Each of these motions can produce a change in the suspension compressibility because it may affect the volume of a suspension. Ultimately, each of these contributions can be related to energy - dissipation mechanism but it is advantageous to cast the problem in terms of the various particle motions that can exist.

SOLUTION AND DISCUSSION

In what follows we ignore shape oscillations as well as particle rotation, so that the only remaining particle motions are the rigid-body translation and the uniform expansion/contraction, or pulsational, motion. Thus the equations for the by sound speed and the attenuation can be expressed by Temkin [1999] as

$\frac{c_s^2(o)}{c_s^2(o)} \propto^2 = 1 + \Re[K_s(\omega) / K_s(o) - 1]_{tr} + \Re[K_s(\omega) / K_s(o) - 1]_{pul} + \ldots$ ..(1) $2\alpha \frac{-c_s^2(o)}{c_s^2(o)} = |\Im\{K_s(\omega)\} / K_s(o)|_{tr} + |\Im\{K_s(\omega)\} / K_s(o)|_{pul}$ …...... …..(2)

Where the symbol $\Re$ and $\Im$ and used to represent real and imaginary parts.

It is possible to include, at this stage, shape oscillations and particle rotations, which, like mass evaporation and condensation, would make additional contributions. However, for particles whose radius is smaller than the wavelength, shape oscillations are negligible. Particle rotations, on the other hand, do not exist in a strictly plane wave in dilute suspensions because of the symmetry of the motion around a sphere. If the right hand sides of equations (1) and (2) are known and are denoted respectively by X (ω) and Y (ω) the solution of these equations can be expressed as

$\frac{c_s^2(o)}{c_s^2(\omega)} = \frac{1}{2} X + \frac{1}{2}(X^2 + Y^2)^{1/2}$ …… ………………… ...(3)

and

$\alpha^{-} = \frac{1}{2}Y\ [\frac{1}{2}X + \frac{1}{2}(X^2 + Y^2)^{1/2}\ ]^{-1/2}$ ……… ………………… …(4)

These may be simplified considerably when both the dispersion and the attenuation effects are small. After neglect α^{-2} compared to unity in equation (1) And set $c_s(\omega) = c_s(o)$ in equation (2) thus obtaining

$\frac{c_s^2(o)}{c_s^2(\omega)}$ = X (ω) ……………….. ……….. …………………… ……(5)

and

α ⁻ = $\frac{1}{2}$ Y (ω) ……………………… …………………….. …….(6)

COMPRESSIBILITY CHANGES

The departing point in the calculation of the compressibility is

($K_s = -\frac{1}{sT}\frac{d(\delta\tau)}{dp}$)

To use this equation we first consider a small volume element δτ having n equal particles which are allowed to pulsate, thereby changing their volume. The mass of the particles in the volume element δM_p, and that of the fluids is δM_f. The volume element is chosen so that it always contains the same particles and the same fluid, that is, $\delta M = \delta M_p + \delta M_f$, is a constant. The corresponding volume, $\delta T = \delta T_f + \delta T_p$, is, however, variable. We may obtain δM_p, and δM_f, in various ways, for example, in terms of the particle and fluid phase densities; σ_p and σ_f defined by $\sigma_p = \phi_u \rho_p$ where $\rho_p(t) = u_p \int_{up}^{-1} \rho_p(X,t)dv$ is the average density within one particle. Thus $\delta M_f = \sigma_f \delta T_f$. Similarly, for the fluid mass, we obtain $\sigma_f = (1-\phi_u)\rho_f$, where $\rho_f(t) = (\delta T_f)^{-1} f_{\delta tf}(X,t)dv$ is the average fluid density in the element, so that $\delta M_f = \sigma_f \delta T_f$. thus the density of the suspension element is

$$\rho = (1-\phi v)\rho_f + \phi v \rho_p \quad \text{……………………..} \quad \text{…………………. (7)}$$

This is known as the effective density in a suspension, and may also be written in terms of the mass fraction. Thus

$$\frac{1}{\rho} = \frac{1-\phi_m}{\rho_f} + \frac{\phi_m}{\rho_p} \quad \text{…………. …………….. …….. (8)}$$

TRANSLATIONAL MOTIONS

The contribution to the suspension compressibility arising from the translational motion was evaluated recently for dilute suspensions of rigid particles and is given by

$$\left(\frac{K_S(\omega)}{K_S(o)} - 1\right)_{tr} = \frac{c_m}{1+c_m}(v-1) \quad \text{…………. ……………. …… (9)}$$

where c_m is the mass loading, given by $c_m = \sigma_p/\sigma_{fo}$, $v = u_p/U_f$, where $\mathbf{u_p}$ is the complex translational velocity of a particle in a sound wave, evaluated in the absence of other particles, and U_f, is the complex velocity of the fluid in the sound, wave, evaluated in isentropic conditions and without particles.

PULSATIONAL MOTION

The contributions due to the pulsational motions may be expressed in terms of the pulsational velocity of the particle's surface, and this can, in turn, be expressed in terms of the pressure and temperature in the particles.

When the frequency of oscillation is finite, the changes of pressure and temperature in a particle are different from those of the fluid at some distance from it. That is, the suspension element is generally not in equilibrium. However, the volume element, δT, has been defined in such a manner so that it contains the same fluid and particles during the pulsations. Then, the total mass contained in δT is conserved so that the Lagrangian rate of change of the total mass in δT is zero, or d(ρ δT)dt=0. Thus

$$\frac{1}{\delta T}\frac{d(\delta T)}{dt} = \frac{1}{\rho}\frac{d\rho}{dt} \quad \text{……………. ……………. (10)}$$

Since ρ is well defined in terms of the particles and fluid density averages and of the mass fraction, which is constant during the pulsations owing to our choice of volume element, the right hand side of equation (10) can be easily obtained from equation (8). Thus taking the derivative and linearizing the result, we obtain

$$\frac{d\rho}{dt} = \left[\frac{1-\phi_m}{\rho_{f_o}}\frac{d\rho^{-1}f}{dt} + \frac{\phi_m}{\rho_{p_o}}\frac{d\rho^{-1}p}{dt}\right]\rho_o^2 \quad \text{……….. …….. (11)}$$

Where $\rho^{-1} f$ and $\rho^{-1} p$ are the fluctuations of the average density in the suspension element, and where ρ_o is the ambient suspension density.

REFERENCES

[1]. Franken, P. and Ingard, U; J. Acoust soc. Am. 28, 126 (1956)
[2]. Goldman, E: J. of the Acoust. socity of America. 47,768 (1970)
[3]. Garabedian, P.R. "partial Wifferential equations" willey New York (1964)
[4]. Lill, Citt: Phys, Fluids; 12, 1642 (1969)
[5]. Rayleigh, L's (2009) Theory of sound Vol.2 P133.
[6]. Rudinger. G. (1973) wave propagation in suspensions of solid particles in gas flow applied mechanics Review : 26, 273-79.
[7]. Spitzer, L. Jr. NDRC rept. No 6, 20 (1943)
[8]. Treyssede, F. Gabard. G and Ben Tahar, M ;J. Acount soc. Am, 113(2), 705 (2003).
[9]. Trammell, G.T; sound waves in water Containing Vapour - Bubbles; Journal of appled Physics; 33(5), 1662 (1962).
[10]. Temkin, S. Z: Fluid, Mech, 380, 1 (1999).
[11]. Mile worki, P.A, T. Fluid Mech: 679, 628, (2011).
[12]. P. Joly, and R. weder J. Flued mech: 494, 469 (2009).