B_{wa} = stationary form and viscous drag between wall and phase a

g_x = axial component of acceleration due to gravity

j = mixture volumetric flux = $j_f + j_p = Q/A$

j_f = volumetric flow of phase f

j_p = volumetric flow of phase p

$\dot{m}$ = rate of vapor generation per unit volume

p = thermodynamic pressure

S = slip velocity = $v_x^g - v_x^l = u_f - u_p$

u_a = velocity of phase a

u_t = mixture velocity = $[\theta\rho_f u_f + (1-\theta)\rho_p u_p]/\rho_t$

V_{fi} = vapor drift velocity = $u_f - j = S(1-\theta) = S\alpha_l$

v_x^a = velocity of phase a

$\hat{v}$ = intrinsic velocity

v_∞ = terminal velocity

α_a = volume fraction of phase a ($\alpha_l = 1 - \alpha_g$)

ρ = mixture density = $\alpha_g\rho_g + \alpha_l\rho_l = \rho_t$

ρ_a = thermodynamic density of phase a

θ = α_g

$1 - \theta = \alpha_l$

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Reply to "Comment on the Drift-Flux Approximation in Transient Two-Phase Flows"

Consider the Lyczkowski[1] Eq. (13) for the relative velocity between phases:

$$\frac{\partial}{\partial t}(u_p - u_f) + \frac{\partial}{\partial x}\left[\frac{1}{2}(u_p^2 - u_f^2)\right] = 0 \ , \tag{13}$$

If we let

$$u_r = u_p - u_f \tag{1}$$

and

$$\bar{u} = \frac{u_p + u_f}{2} \ , \tag{2}$$

then Eq. (13) can be rewritten as

$$\frac{\partial u_r}{\partial t} + \frac{\partial}{\partial x}(u_r \bar{u}) = 0 \tag{3}$$

or

$$\frac{\partial u_r}{\partial t} + \bar{u}\frac{\partial u_r}{\partial x} = -u_r\frac{\partial \bar{u}}{\partial x} \ . \tag{4}$$

Using the well-known "method of Lagrange," we are able to derive a general solution for Eq. (4).

Associated with Eq. (4) is the system of first-order ordinary differential equations:

$$\frac{dx}{dt} = \bar{u} \ , \tag{5}$$

$$\frac{d\bar{u}}{\bar{u}} + \frac{du_r}{u_r} = 0 \ . \tag{6}$$

The solution for Eq. (6) is

$$\bar{u}u_r = c_1 \ . \tag{7}$$

If we assume that the phase velocities differ from each other as

$$u_r = f(x,t) \ , \tag{8}$$

where $f(x,t)$ is a nonzero arbitrary function of x and t, then from Eq. (7), we have

$$\bar{u} = \frac{c_1}{f(x,t)} = g(x,t) \ . \tag{9}$$

The solution for Eq. (5) is then given by

$$h(x,t) = c_2 \ , \tag{10}$$

and the general solution for the system of Eqs. (5) and (6) is therefore

$$\bar{u}u_r = H[h(x,t)] \ . \tag{11}$$

Since Eq. (11) is the general solution of Eq. (4) and our assumption $u_r = f(x,t)$ has not led to a contradiction, the phases can move with a relative velocity that is dependent on both space and time.

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[1] ROBERT W. LYCZKOWSKI, *Nucl. Sci. Eng.*, **71**, 77 (1979).

Comments on Neutron-Induced Fission in a Compressed DT-Pu Plasma

Recently, Perkins[1] published two interesting papers about the problem of neutron-induced fission in a compressed plasma composed of deuterium-tritium (DT) seeded with a small amount of ^{239}Pu. The main idea was to produce knock-on deuterium and tritium ions by making use of the collisional energy transfer of the kinetic energy of the fission fragments as they slow down to thermal energies. These suprathermal ions, possessing an average energy of ~5 kT, exhibit an increased fusion probability and hence neutron production. The latter would then couple directly to the fission process. Thus,

[1] S. T. PERKINS, *Nucl. Sci. Eng.*, **69**, 137, 147 (1979).