Φ_F fluid density, kg/m^3
Φ_P particle density, kg/m^3

REFERENCES

Archimedes, ≈280 BC. On Floating Bodies.
Clift, R., 1992, On the formulation of hydrodynamic stability criteria in fluidized beds. *Powder Technol.* **72**, 199.
Frajese, A., 1974. *Archimede: Opere.* UTE, Firenze.
Jean, R. H. and Fan, L. S., 1992, On the model equations of Gibilaro and Foscolo with corrected buoyancy force. *Powder Technol.* **72**, 201.
Johnson, P. C. and Jackson, R., 1987, Frictional–collisional constitutive relations for granular materials with applications to plane shearing. *J. Fluid Mech.* **176**, 67.

Chemical Engineering Science, Vol. 48, No. 19, pp. 3440–3442, 1993.
Printed in Great Britain.
0009–2509/93 $6.00 + 0.00

Hydrolysis of fatty oils: effect of cavitation

(*Received* 18 *May* 1992; *accepted for publication* 25 *March* 1993)

INTRODUCTION

Acoustic cavitation resulting from ultrasound irradiation is known to cause chemical change in organic/inorganic compounds (Suslick, 1990). Localised high temperatures and pressures generated during collapse of a vapour cavity bring about this change. Hydrodynamic cavitation was generated in a simple flow loop [Fig. 1(a)] by throttling a valve downstream of the pump. The collapsing vapour cavities generated during throttling are capable of oscillating with ultrasonic frequencies and conditions, similar to an ultrasonic generator, and are expected to be generated downstream of the cavitating valve (Harrison and Pandit, 1990).

Hydrolysis of fatty oils with water/steam, which requires operating temperatures of 250 to 350°C and pressures of 3–15 atmospheres, was chosen as a model reaction. Cavitation resulting from ultrasonic irradiation and throttling the valve (Fig. 1) was used to generate localised conditions, similar to the operating conditions required for the fat hydrolysis. These extreme temperature and pressure conditions are generated during the collapse of the vapour cavity as discussed before. The magnitude of this effect depends on the size of the cavity and surrounding pressure and the physicochemical properties of the liquid. These hot spots have temperatures of several thousand degrees centigrade and localised pressures of several hundred atmospheres. The lifetimes of these hot spots are of the order of 1×10^{-8} to 1×10^{-9} s (Vogel *et al.*, 1989).

Following expressions correlate volume oscillation frequencies of the collapsing vapour cavities.

For cavities partially filled with non-condensable gases (Strassberg, 1956)

$$f_0 = \left(\frac{3\gamma P_\infty}{\rho r_0^2}\right)^{1/2} \Big/ 2\pi \qquad (1)$$

where f_0 = volume oscillation frequency (Hz), γ = ratio of specific heats, P_∞ = pressure far away from the bubble (N/m^2), ρ = density of the surrounding liquid (kg/m^3) and r_0 = initial or mean radius of the cavity (m).

From the above expression, cavities smaller than 200 μm will oscillate with frequencies which lie in ultrasonic range and, hence, their effect is expected to be similar to that of an ultrasonic generator.

Also, in a flow loop system, cavitation number defines the onset and severity (no. of cavities) of the cavitation phenomena. Cavitation number is defined as $C_v = (P_3 - P_v)/(1/2\rho v_L^2)$, where P_3 is the pressure further downstream of the throttled valve (N/m^2) (Fig. 2), P_v is the vapour pressure of water at the operating temperature and v_L is the fluid velocity (m/s) at the constriction (throttled valve). Yan (1989) has shown that cavitation inception occurs at C_v = 1.5 to 2.5 depending on the size of the constriction (extent of throttling of the valve) and severity of the cavitation increases with further reduction in the cavitation number.

EXPERIMENTAL

The hydrolysis of castor oil and kerdi oil were carried out first with an ultrasonic generator and second in the flow loop at cavitation number less than that required for the inception. Oil–water mixtures of different concentrations (1 to

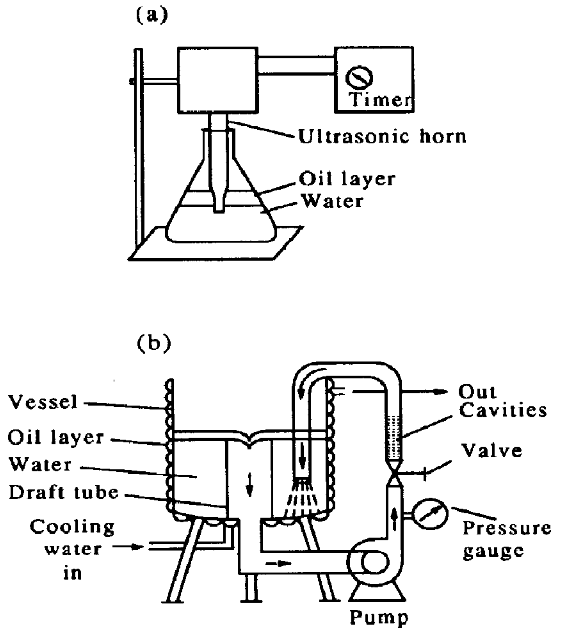

Fig. 1. (a) Experimental set-up; ultrasonic generator. (b) Experimental set-up; cavitating valve.