Dissipation rate in turbulent bubbly von Karman flow

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Bubbly flows are ubiquitous in nature and have been shown to control gas fluxes between the atmosphere and the ocean[1]. Understanding the coupling between turbulent energy, energy dissipation and bubble size distribution therefore is of prime interest. We present an experimental study of these processes in a von Karman flow. A turbulent von Karman flow is generated by two counter-rotating disks fitted with blades. This flow has been investigated extensively as a model for turbulence because of its high shear rate in the middle plane, creating a strongly turbulent mixing zone. Energy dissipation ϵ in single phase turbulent von Karman flow follows the asymptotic behaviour in the high Re limit :

$$\epsilon \propto \rho R^5 \Omega^3 \tag{1}$$

where R and Ω respectively are the radius and the rotation rate of the disks, ρ is the fluid density [2]. The proportionality constant depends on geometrical parameters (distance between the disks, height of the blades, radius of the tank...). We show experimentally that in the presence of air bubbles in water, this relation is not valid anymore as soon as the air volume fraction is above $\alpha \simeq 5\%$. We report a drastic reduction of energy input in the system (and therefore energy dissipation), depending on void fraction : up to 30% compared with a single phase flow at the same effective density.

Laser Doppler Velocimetry measurements (LDV) using particles or bubbles as trackers allow us to investigate the effects of bubbles both on the forcing efficiency and on the mixing zone.

Références

1. D.W.R. Wallace & C.D. Wirick, Large air-sea gas fluxes associated with breaking waves *Nature*, **356**, 694–696 (1992).
2. O. Cadot & al., Energy injection in closed turbulent flows : Stirring through boundary layers versus inertial stirring, *Physical Review E*, **56-1** (1997).