POOL SCRUBBING AND HYDRODYNAMICS IN NATURAL WATER, SEA WATER AND WITH ADDITIVES

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Extended Abstract:

Pool scrubbing is an aerosol filtration system which consists in bubbling the gas flow through a pool of liquid in order to retain the aerosol in the liquid phase. Most pool scrubbing investigation dates back to 1980’s and 1990’s but the database allowed drawing some insights into pool scrubbing since there are still significant weaknesses: lack of systematic analysis of the parameters influencing pool scrubbing (i.e., submergence, particle size, etc.), no experimental tracking of variables like bubble size and shape. No less important, since the experimental programs were performed, some know-how has been lost throughout the years. Tests performed using the RSE SCRUPOS facility concerned both the study of hydrodynamics with measures of size, aspect ratio, bubble velocity in natural water, sea water and in the presence of additives and measures of aerosol retention in the same conditions.

Bubble Hydrodynamics

The bubble hydrodynamics measurements were carried out mainly with three technics: optical probe (local void fraction, bubble chord distribution and velocity), photo camera and video camera (bubble diameter and aspect ratio). The tests were performed in the SCRUPOS facility (SCRUbbing by POol and Spray facility) composed by a pool of 0.5 m x 1.0 m and 1.5 m high, with 2 glass walls to permit the view of the bubbles with the camera and two stainless steel walls with apertures for the optical probe (figure 1(a)). Three different axial measuring positions have been used to observe the evolution of the bubble properties during the rise in the pool and for each one of these three, multiple radial measuring points have also been adopted in order to describe the behavior of the swarm (figure 1(b)). The air injection velocity was from 16 to 71 m/s so to have different flow regimes. The double optical probe was used to measure the size of the bubbles.

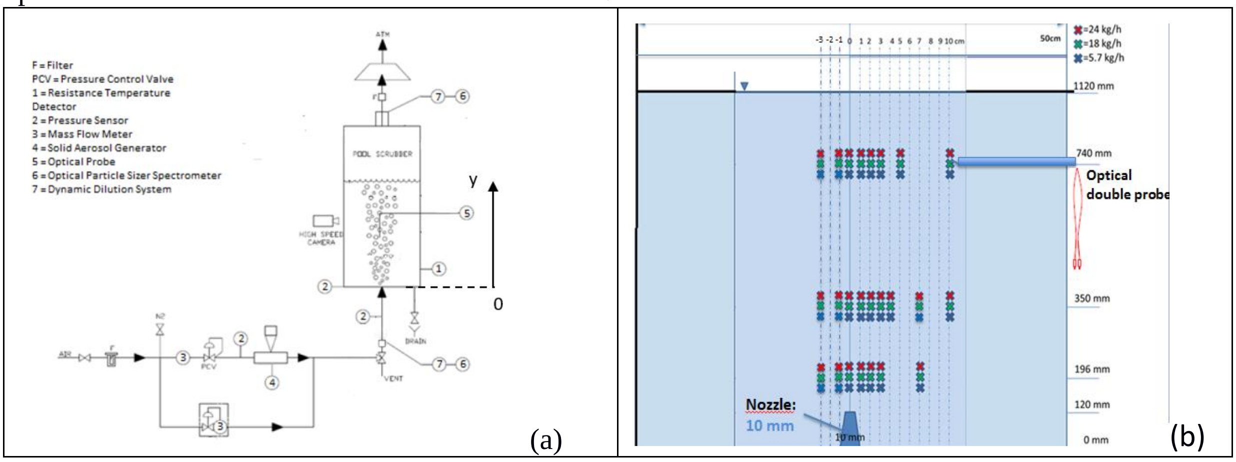

Figure 1: (a) Scrupos facility for pool tests layout and (b) test matrix for the optical probe measurements.

This data elaboration allowed to find the most probable bubble diameter and it was confirmed by the photos (figure 2 (a)- (b) -(e) and (c)-(d)-(f)). In the injection zone different physical properties of the liquid phase caused differences in bubble size distribution and in absolute velocity for higher mass flow rate (figure 2 (e) e (f)): in jet regime, bubbles in sea water and water with surfactant had similar behavior but different from bubbles in demineralized water (smaller jet column and a lot of small bubbles). This was due to the higher tendency to break-up because of the lower surface tension in the case of the surfactant and even the inhibited coalescence caused by the presence of electrolytes for the seawater. Bubbles in demineralized water presented higher velocities compared to that in the other two fluids only for higher mass flow rate. The first big bubbles breaked into a swarm of smaller bubbles and the velocity decreased during the rising. In the higher part of the pool, the difference between bubble diameters and velocity for the different condition like mass flow rate, nozzle diameters and even pool liquid are not so big.

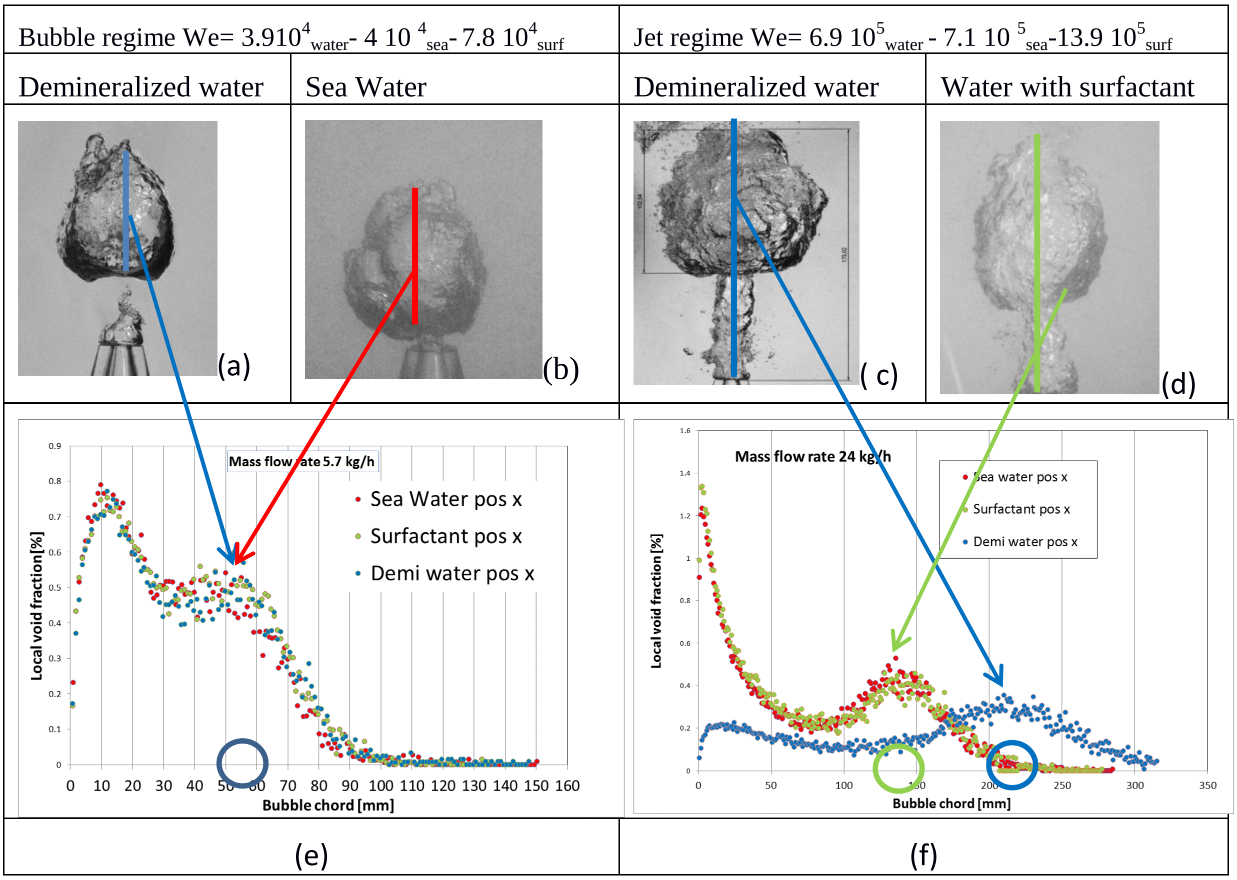

Figure 2: big bubble in the injection zone for mass flow rate of 5.7 kg/h in demimeralized water (a) and sea water (b) and for mass flow rate 24 kg/h in water (c) and water with surfactant (d). Size distribution of the local void fraction at 7.6 cm from the top of the 10 mm vertical nozzle and in central radial position for mass flow rate of 5.7 kg/h in three different pool liquid (e) and with mass flow rate of 24 kg/h (f).

Decontamination Factor

The decontamination factor (DF) was calculated as the ratio between the particle concentration carried by the gas stream just before the inlet of the pool and at the outlet. Measures were done with 0.4 µm aerosol with different liquid in the pool in the same condition of gas flow and nozzle diameter: DF measured in sea water and in water with surfactant are higher than that in demineralized water due to different bubble size and velocity. Indeed for small bubbles, the contact surface between the liquid and the gas phases increases and slower velocity means higher fly time. The tests allowed validating a simplified model to describe the evolution of the bubbles inside the pool. One major recommendation is that bubble size and break up model assumptions should take into account both aerosol deposition surfaces (function of size and shape), evolving during rising and distribution of rising velocity of bubble swarms.