Measurement of void fraction and velocity profiles in rectangular free-falling jets

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Abstract

Air entrainment generates energy dissipation in turbulent free-falling jets, in where self-aeration processes reduce the velocity and increment the jet thickness. This experimental study presents an analysis of some air-water properties in rectangular free-falling jets. Two specific flows were considered with falling distances up to 1.2 m. A conductivity phase-detection probe was used for measuring the void fraction distributions, while a Pitot-Prandtl tube was used for obtaining the velocity profiles. The jet thickness was also analyzed during the fall. The results show the evolution of the inner jet core, with aeration increment, and a small reduction of the velocity field during the fall. Slightly differences have been observed when comparing the upper and lower nappe trajectories.

Keywords: free-falling jets, air entrainment, phase-detection probe, air-water flow, laboratory model.

Methods

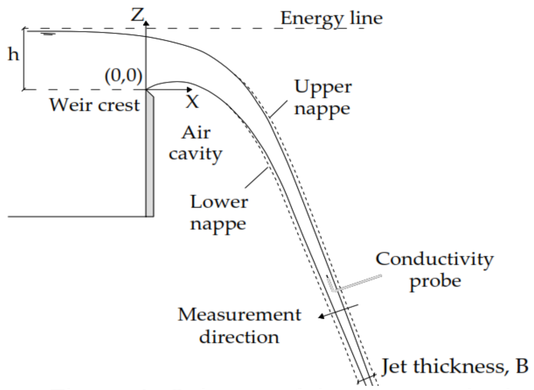

Figure 1: Scheme of the rectangular jet.

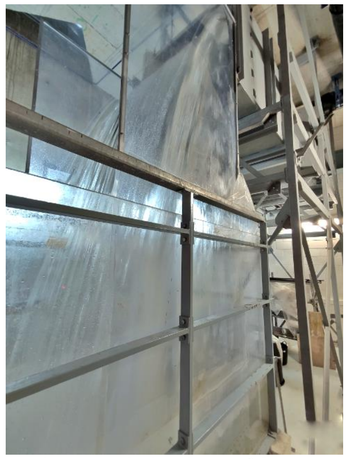

Figure 2: Experimental device of large scale at the Universidad Politécnica de Cartagena.

Table 1: Experimental tests

Specific flow q (m³/s/m)	Energy head h (m)	Velocity V_i (m/s)	Reynolds number R_e (-)	Weber number W_e (-)
0.048	0.080	1.78	47,148	1,162
0.072	0.109	2.07	70,721	2,029

Results

1. Void fractions distributions

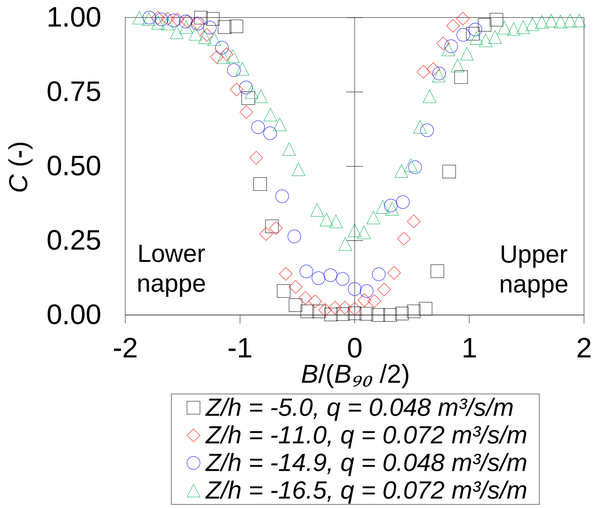

Figure 3: Void fraction distribution for different dimensionless falling distances.

2. Velocity profiles

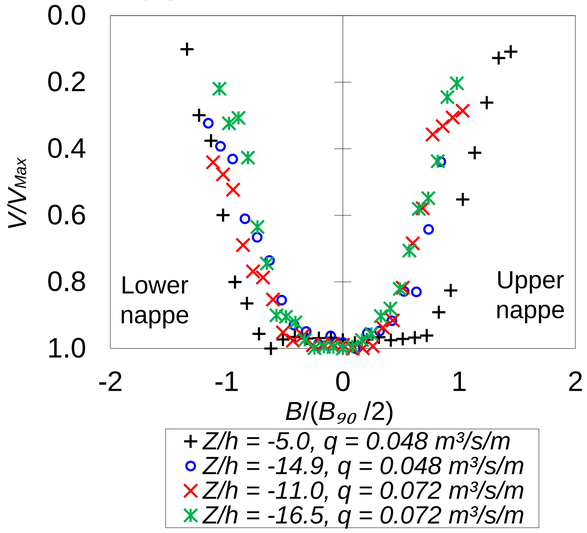

Figure 4: Velocity profiles for different dimensionless falling distances.

Conclusions

- During the fall, the amount of air that enters into the jet tends to increase; it modifies the cross-section profile and the jet thickness.
- For $Z/h \leq -11.0$, the inner jet core showed non-aerated water ($C = 0$); for $Z/h > -11.0$, the air entrainment reaches the center of the jet (minimum void fractions between 0.08 and 0.25).
- The maximum velocities of each cross section are such as their correspondent gravitational velocities; however, the velocity tends to rapidly reduce outside of the non-aerated core.
- Although the falling distance is relatively small (up to 1.20 m), a slight velocity reduction effect has been observed in the core of the jets.

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