COMMENTS

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Comment on "Incipient air entrainment in a translating axisymmetric plunging laminar jet" [Phys. Fluids 14, 781 (2002)]

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The writers provided an original contribution to the topic of air bubble entrainment at plunging jets. While there were significant contributions on laminar and turbulent plunging jets,[1,2] the writers provided solid flow visualizations highlighting the influence of a cross-flow. Their contribution is a timely reminder that most research on plunging jet flows has been primarily limited to vertical jets plunging into a quiescent pool. The discusser argues that the paper's topic of "plunging laminar jet" might not be strictly correct. He also adds some comment on incipient conditions.

A basic question is: was the plunging jet inflow laminar or turbulent? The writers investigated 42 configurations for which the plunging jet inflow was not completely documented. Table I presents a comparison of inflow conditions for well-documented laminar and turbulent plunging jet flow studies. The jet impact Reynolds number and turbulence levels are summarized in columns 2 and 3 (Table I). The writers' study was conducted with jet Reynolds numbers and turbulence levels comparable to well-documented turbulent plunging jet studies.[3–6] Their turbulence levels were further two orders of magnitude greater than those observed in a laminar plunging jet study.[7] The discusser believes that the writers' study was conducted with turbulent rather than laminar plunging jets. For the free-jet, the nozzle edge is a flow singularity and a mixing layer develops next to the jet free-surface downstream (Figs. 1 and 2). Several high-speed photographic studies of water jets discharging into air[2,8,9] highlighted a smooth-jet flow patterns for: $\rho_{\mathrm{air}}^{*} V_n^{2*} D_n/\sigma < 200$ to 2000.[2,10] The writers' experiments were conducted for

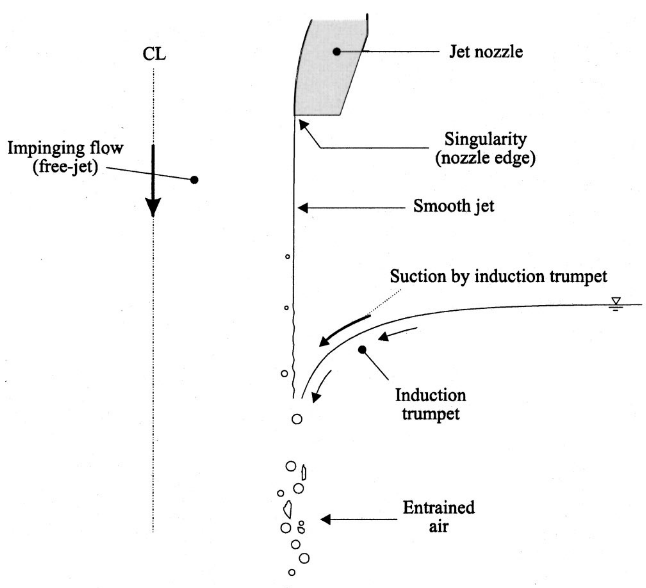

FIG. 1. Air entrainment at the plunge point; Definition sketch.

FIG. 2. Photographs of air entrainment at circular plunging jet in seawater: $D_n = 0.0125$ mm, $h = 0.050$ m, $V_j = 2.46$ m/s, $Fr_j = 7.2$—Underwater view, flow from top to bottom (after Chanson *et al.*, Ref. 5).

TABLE I. Comparison of inflow conditions used in plunging jet studies.

Reference (1)	$\mathrm{Re}_j=\rho^* V_j^* D_j/\mu$ at jet impact (2)	$Tu=v'/V$ in free-jet (3)	Geometry (4)	Remarks (5)
Chirichella *et al.*	$6E+3$ to $2.6E+4$	0.2 to 0.35%	Circular	
El-Hammoumi (Ref. 7)	$2.3E+4$ to $4.4E+4$	0.000 16 to 0.0028%	Circular	Laminar jets
McKeogh (Ref. 3)	$2.2E+3$ to $4.1E+4$	5 to 10%	Circular	Turbulent jets
Ervine *et al.* (Ref. 4)	$1E+3$ to $4E+4$	0.3 to 8%	Circular	Turbulent jets
Chanson *et al.* (Ref. 5)	$1.2E+4$ to $3E+4$	0.4 to 1.1%	Circular	Turbulent jets
Cummings and Chanson (Ref. 6)	$6E+3$ to $1.1E+4$	0.5 to 1.4%	Two-dimensional	Turbulent jets

$\rho^*_{\mathrm{air}} V_n^{2*} D_n/\sigma = 0.09$ to 0.9 and it is understandable that the vertical jets would have a visually smooth appearance, although the free-jet was turbulent.

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