Impact of Boundary-Layer Cutting on Free-Surface Behavior in Turbulent Liquid Sheets

S.G. Durbin†, M. Yoda, and S.I. Abdel-Khalik

G. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0405 USA
†*(404) 385-1891 gte397r@mail.gatech.edu*

The HYLIFE-II conceptual design uses arrays of high-speed oscillating and stationary slab jets, or turbulent liquid sheets, to protect the reactor chamber first walls. A major issue in thick liquid protection is the hydrodynamic source term due to the primary turbulent breakup of the protective slab jets. During turbulent breakup, drops are continuously ejected from the surface of turbulent liquid sheets and convected into the interior of the cavity, where they can interfere with driver propagation and target injection. Experimental data for vertical turbulent sheets of water issuing downwards from nozzles of thickness (small dimension) $\delta = 1$ cm into ambient air are compared with empirical correlations at a nearly prototypical Reynolds number $Re = 1.3 \times 10^5$. A simple collection technique was used to estimate the amount of mass ejected from the jet surface. The effectiveness of boundary-layer cutting at various "depths" into the flow to reduce the source term and improve surface smoothness was evaluated. In all cases boundary-layer cutting was implemented immediately downstream of the nozzle exit. Planar laser-induced fluorescence was used to visualize the free-surface geometry of the liquid sheet in the near-field region up to 25δ downstream of the nozzle exit. Large-scale structures at the edges of the sheet, typically observed for $Re < 5.0 \times 10^4$, reappeared at $Re = 1.3 \times 10^5$ for sheets with boundary-layer cutting. The results indicate that boundary-layer cutting can be used to suppress drop formation, *i.e.* the hydrodynamic source term, for a well-conditioned jet but is not a substitute for well-designed flow conditioning.