Flow Conditioning Design in Thick Liquid Protection

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The HYLIFE-II conceptual design proposed using arrays of high-speed oscillating and stationary slab jets, or turbulent liquid sheets, to protect the reactor chamber first walls from damaging neutrons, ions and X-rays. Flow conditioning can be used to reduce turbulent fluctuations in these liquid sheets and thereby reduce surface ripple, or free-surface fluctuations, and delay jet breakup. Several flow conditioning configurations are studied experimentally for vertical turbulent sheets of water issuing downwards from nozzles of thickness (small dimension) $\delta = 1$ cm into ambient air for Reynolds numbers $Re = 5.0 \times 10^4$ and 1.3×10^5. In particular, the role of one or more fine screens in the flow conditioner was studied. As the flow conditioning element immediately upstream of the nozzle inlet, fine screens have been shown to have a major impact upon the sheet free-surface geometry. Planar laser-induced fluorescence was used to measure the free-surface geometry of the liquid sheet and its fluctuations in the near field at streamwise distances downstream of the nozzle exit $x \le 25\delta$. Laser-Doppler velocimetry was used to quantify the impact of different conditioning configurations on the cross-stream velocity component and its fluctuations just upstream of the nozzle exit. The results indicate that minor differences in velocity and velocity fluctuations near the nozzle exit can lead to major variations in free-surface geometry, and that free-surface fluctuations are strongly affected by changes in flow conditioner design, even in the near-field region of the flow. A single screen configuration was shown to produce the smoothest jets at both Reynolds numbers, with fluctuations of 3.3% at $Re = 1.3 \times 10^5$ and $x = 25\delta$.