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Demonstration of Small Gas Bubbles for Mitigation of Cavitation Damage and Pressure Waves in Short-pulse Mercury Spallation Targets

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Abstract

Various populations of small helium gas bubbles were introduced into a flowing mercury experiment test loop to evaluate mitigation of beam-induced cavitation damage and pressure waves. The test loop was developed and thoroughly tested at the Spallation Neutron Source (SNS) prior to irradiations at the Los Alamos Neutron Science Center - Weapons Neutron Research Center (LANSCE - WNR) facility. Twelve candidate bubblers were evaluated over a range of mercury flow and gas injection rates by use of a novel optical measurement technique that accurately assessed the generated bubble size distributions. Final selection for irradiation testing included two variations of a swirl bubbler provided by Japan Proton Accelerator Research Complex (J-PARC) collaborators and one orifice bubbler developed at SNS. Bubble populations of interest consisted of sizes up to 150 μm in radius with achieved gas void fractions in the 10^{-5} to 10^{-4} range. Irradiation testing consisted of 800 MeV protons, typically 2.8×10^{13} per pulse with pulse length ca. 0.3 μs. Nineteen test conditions were completed each with 100 pulses. These included variations on mercury flow, gas injection and protons per pulse. The principal measure of cavitation damage mitigation was surface damage assessment on damage test specimens which were manually replaced with each irradiation test condition. Damage assessment was done after decontamination of the specimens by optical and laser profiling microscopy with maximum pit depth and damaged area fraction being the more valued results. Other data collection consisted of surface motion tracking by three Laser Doppler Vibrometers, dynamic strain response by fiber optic strain sensors, beam diagnostics for accurate charge and beam profile assessment, embedded hydrophones and pressure sensors, and sound measurement by a suite of conventional and contact microphones. The experiment will be described and a selection of preliminary results presented.