ICANS XX,
20th meeting on Collaboration of Advanced Neutron Sources
March 4 – 9, 2012
Bariloche, Argentina

Assessment of Pressure Wave Mitigation by Small Gas Bubbles as Measured by Dynamic Strain in Short-pulse Mercury Spallation Targets

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Abstract

The technique of using small gas bubbles to mitigate pressure waves and the associated cavitation damage in short-pulse mercury spallation targets was tested in an in-beam experiment conducted at the Los Alamos Neutron Science Center - Weapons Neutron Research Center (LANSCE - WNR) facility. Dynamic strain of the target vessel wall measured with fiber optic sensors was one of the methods used to assess pressure wave changes under the various bubble population test conditions. Conventional strain gauges are unsuitable due the intense electro-magnetic effects from the micro-second beam pulse. The fiber sensors and signal processing are immune to such effects, but must deal with fiber fluorescence from the radiation flash. They did this well enough to provide a credible body of useful data. A distinction can be made between sensors mounted on the target wall in or near the beam spot and those some distance away. Those further away showed the strongest damping and reduction in strain magnitude with certain bubble populations. Strain responses close to or in the beam were also reduced and dampened with the initial strain peaks were less affected. This may be interpreted as there being stronger pressure wave attenuation compared to absorption. A selection of strain and corresponding bubble population data will be presented and compared, along with predicted responses from a simulation that does not account for bubble mitigation. These data, as well as other data from the experiment, provide a basis for benchmarking advanced numerical simulations that attempt to more completely include relevant physics such as: shock, multi-phase flow, cavitation, fluid-structure interaction, and bubble interactions. Such advanced tools would be very helpful in predicting damage vulnerable regions in liquid metal spallation target vessels.