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JANNAF
PIB / 11th MSS / 9th LPS / 8th SPS
Joint Subcommittee Meeting
5 – 9 December 2016

Abstract Due Date: Monday, 11 July 2016

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*** Title:** Investigation of Damping Physics and CFD Tool Validation for Simulation of Baffled Tanks at Variable Slosh Amplitude

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Unclassified Abstract (250 – 300 words; do not include figures or tables)

* To meet the flight control damping requirement, baffles of various configurations have been devised to increase the natural viscous damping and decrease the magnitude of the slosh forces and torques. In the design of slosh baffles, the most widely used damping equation is the one derived by Miles, which is based on the experiments of Keulegan and Carpenter. This equation has been used in predicting damping of the baffled tanks in different diameters ranging from 12 to 112 inches. The analytical expression of Miles equation is easy to use, especially in the design of complex baffle system. Previous investigations revealed that some experiments had shown good agreements with the prediction method of Miles, whereas other experiments have shown significant deviations. For example, damping from Miles equation differs from experimental measurements by as much as 100 percent over a range of tank diameters from 12 to 112 inches, oscillation amplitudes from 0.1 to 1.5 baffle widths, and baffle depths of 0.3 to 0.5 tank radius. Previously, much of this difference has been attributed to experimental scatter. A systematical study is needed to understand the damping physics of baffled tanks, to identify the difference between Miles equation and experimental measurement, and to develop new semi-empirical relations to better represent the real damping physics. The approach of this study is to use CFD technology to shed light on the damping mechanisms of a baffled tank. First, a 1-D Navier-Stokes equation representing different length scales and time scales in the baffle damping physics is developed and analyzed. A well validated CFD solver, developed at NASA MSFC, Loci-STREAM-VOF, is applied to study vorticity field around the baffle and around the fluid interface to highlight the dissipation mechanisms at different slosh amplitudes. Previous measurement data are then used to validate the CFD damping results. The study found several critical parameters controlling fluid damping from a baffle: local slosh amplitude to baffle thickness (A/t), surface liquid depth to tank radius (h/R), local slosh amplitude to baffle width (A/W); and non-dimensional slosh frequency. The simulation highlights three significant damping regimes where different mechanisms dominate. The study proves that the previously found discrepancies between Miles equation and experimental measurement are not due to the measurement scatter, but rather due to different damping mechanisms at various slosh amplitudes. The limitations on the use of Miles equation are discussed based on the flow regime.

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