Physics, Geometric, Material Model, and Experimental Considerations for Exploding Wire Simulation Validation

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Abstract

Output from electrically exploding wires (radiative emission, shock, etc.) has been studied since the early 1900's with emphasis on the multiphase nature of the burst beginning in the late 1950's [1,2]. A variety of approaches have been used to simulate the time-varying resistance. Early models invoked an electrical action metric as a means of predicting wire burst. First-principle exploding wire simulations have been attempted over the last decade as more sophisticated simulation codes have become available [3]. A lack of clarity as to which physics details must be captured (either computationally or experimentally) to consider the simulations adequately validated still persists. Four areas which require significant consideration include: 1) physics description, 2) experimental details, 3) geometric description, and 4) the material description.

Exploding wire experiments yield significantly different output depending on the surrounding environment (e.g. water, air, vacuum). These differences point to the different physics mechanisms impacting the observed performance. The physical connection between the source of electrical current and the wire also plays a significant role on when and where burst occurs first. From a modeling perspective, having equations of state and electrical conductivity models for metals spanning solid, liquid, vapor, and plasma phases are required to capture the time-history of the wire burst and feedback to the driving circuit. Equally important are the experimental details (e.g. driving circuit characterization, current and voltage diagnostic bandwidths, time/spatial diagnostics, reproducibility, and error estimation) required to ensure that the simulation is not chasing stochastic events. Details from each of these four areas will be discussed.

References

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[3] Doney, R. L. Vunni, G. B., and Niederhaus, J. H (2010) Experiments and Simulations of Exploding Aluminum Wires: Validation of ALEGRA-MHD, *Army Research Laboratory Report*, ARL-TR-5299

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