Wire Debris Modeling of the Z-Accelerator

D.R. Williamson and J.P. Blanchard

Fusion Technology Institute, University of Wisconsin-Madison
williamson@wisc.edu, blanchard@engr.wisc.edu

The Z-Accelerator is an intense x-ray source located at Sandia National Laboratory. On a typical shot, 20 MA of current passes through a cylindrical array of wires over tens of nanoseconds. The result is the release of 2 MJ of low-energy x-rays at approximately 200 TW. The wires are mostly vaporized in this time, but some wire fragments remain[1]. We have developed a model for the deformation of these wires as they accelerate towards the center of the device. While the shot is generally over 200 nanoseconds, the model only covers times on the order of 1-4 nanoseconds, as it is a continuum model.

The model begins with a 2-D model in a commercial finite element code (ANSYS) that determines the forces and magnetic fields the titanium wires experience early in a typical shot. The magnetic field around the wires reaches a maximum of 210 Tesla when the current is a maximum. ANSYS provides a force per unit length that is applied to the wire over time.

The forces that are determined in ANSYS are used in a separate computer code that solves the equations of motion for the wires. The code solves the 1-D wave equation with a periodic forcing function, using only the early portions of a cycle to approximate a monotonically increasing load. As the wire is displaced from its initial position, the tension should increase as the length of the wire increases. An incremental model is used to update the tension as the wire is displaced, effectively linearizing an inherently nonlinear problem[2].

Results will be described that show the wires' behavior as a function of the initial tension applied to the wire. Also shown will be the estimates of the different fragment sizes remaining after the wire has undergone fragmentation. The fragment sizes will be estimated using existing fragmentation models.

1. Golub, T.A.; Volkov, N.B.; Spielman, R.B.; and Gondarenko, N.A., "Multiwire screw-pinch loads for generation of terawatt x-ray radiation," (1999), *Applied Physics Letters*, Vol. 74, No. 24., page 3624
2. Tolonen, T; Välimäki, V; and Karjalainen, M., "Modeling of Tension Modulation Nonlinearity in Plucked Strings," (2000), *IEEE Transactions on Speech and Audio Processing*, Vol. 8, No. 3, May 2000, page 300-310