UCRL-TR-219117

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February 17, 2006

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

ISENTROPIC COMPRESSION WITH A RECTANGULAR CONFIGURATION FOR TUNGSTENE AND TANTALUM, COMPUTATIONS AND COMPARISON WITH EXPERIMENTS

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Isentropic compression experiments and numerical simulations on metals are performed at Z accelerator facility from Sandia National Laboratory and at Lawrence Livermore National Laboratory in order to study the isentrope, associated Hugoniot and phase changes of these metals [1].

3D configurations have been calculated here to benchmark the new beta version of the electromagnetism package coupled with the dynamics in Ls-Dyna and compared with the ICE Z shots 1511 and 1555.

The electromagnetism module is being developed in the general-purpose explicit and implicit finite element program LS-DYNA® in order to perform coupled mechanical/thermal/electromagnetism simulations. The Maxwell equations are solved using a Finite Element Method (FEM) for the solid conductors coupled with a Boundary Element Method (BEM) for the surrounding air (or vacuum). More details can be read in the reference [2][3].

1.1 CONFIGURATION OF THE NUMERICAL SIMULATIONS

3D configurations, built with the TrueGrid® mesh generation program, have been used with a lagrangian description using coarse and finer mesh resolutions.

The bottom of the anode and cathode are connected to a circuit with a capacitors bank. The experimental configuration of the shots 1511 and 1555 is presented Figure 3. The experimental current was injected in the numerical simulations as input data.

The coarse mesh resolution has about 1 element/mm in all directions, depending of the part. The 1.3 mm thick samples instead of the experimental ones have 2 elements on the side for each sample. The 0.7 mm thick panel below the samples has only 1 element on the side. This coarse mesh is presented Figure 1.

The finer mesh has finer elements on the side of the samples and the panel, and keep the coarse mesh resolution in the other directions: 10 elements on the side for the 0.7 mm thick panel below the samples and 10 elements on the side for each samples 0.4 mm thick, 0.5 mm thick, 0.6 mm thick and 0.7 mm thick. This finer mesh is presented Figure 2.

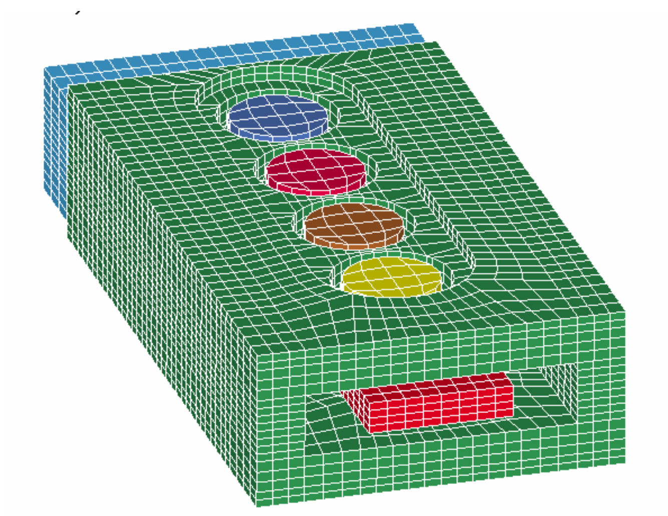

Figure 1 : coarse mesh of the rectangle configuration

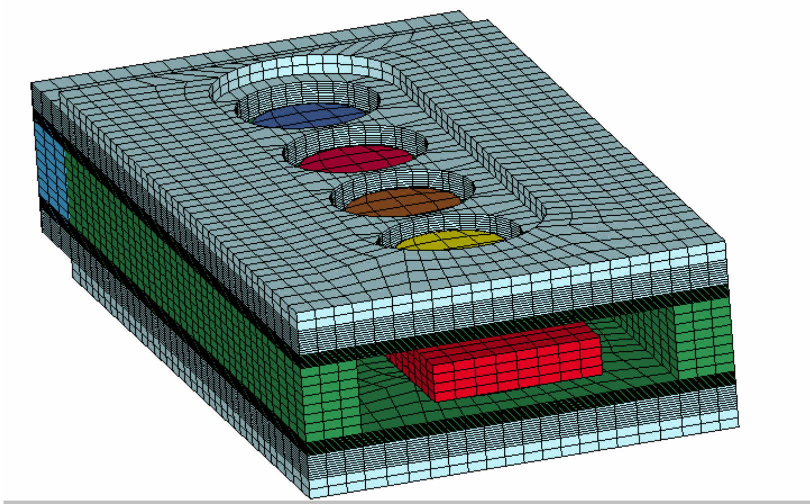

Figure 2: finer mesh of the rectangle configuration

1.2 MODELS DESCRIPTIONS

Steinberg constitutive law has been used for the metals [4]. Classical Gruneisen equations of state have been applied for the metals. The heat capacity and the thermal conductivity have been used for the thermal solver.

The main assumptions are no phase change, no plasma, conductivity constant for the anode and cathode. The diffusion of the current could be taken into account, but has not been tested yet here. It is possible to take into account the conductivity change versus the temperature (electrical resistivity equation of state), but has not been tested yet here. Further studies should take these into account.

Therefore, a surface resolution has been used between the anode and the cathode with constant electrical conductivities for Tungsten 17.7 e+6 Ohm^{-1} m^{-1} and for Copper 59.1 e+6 Ohm^{-1} m^{-1}.

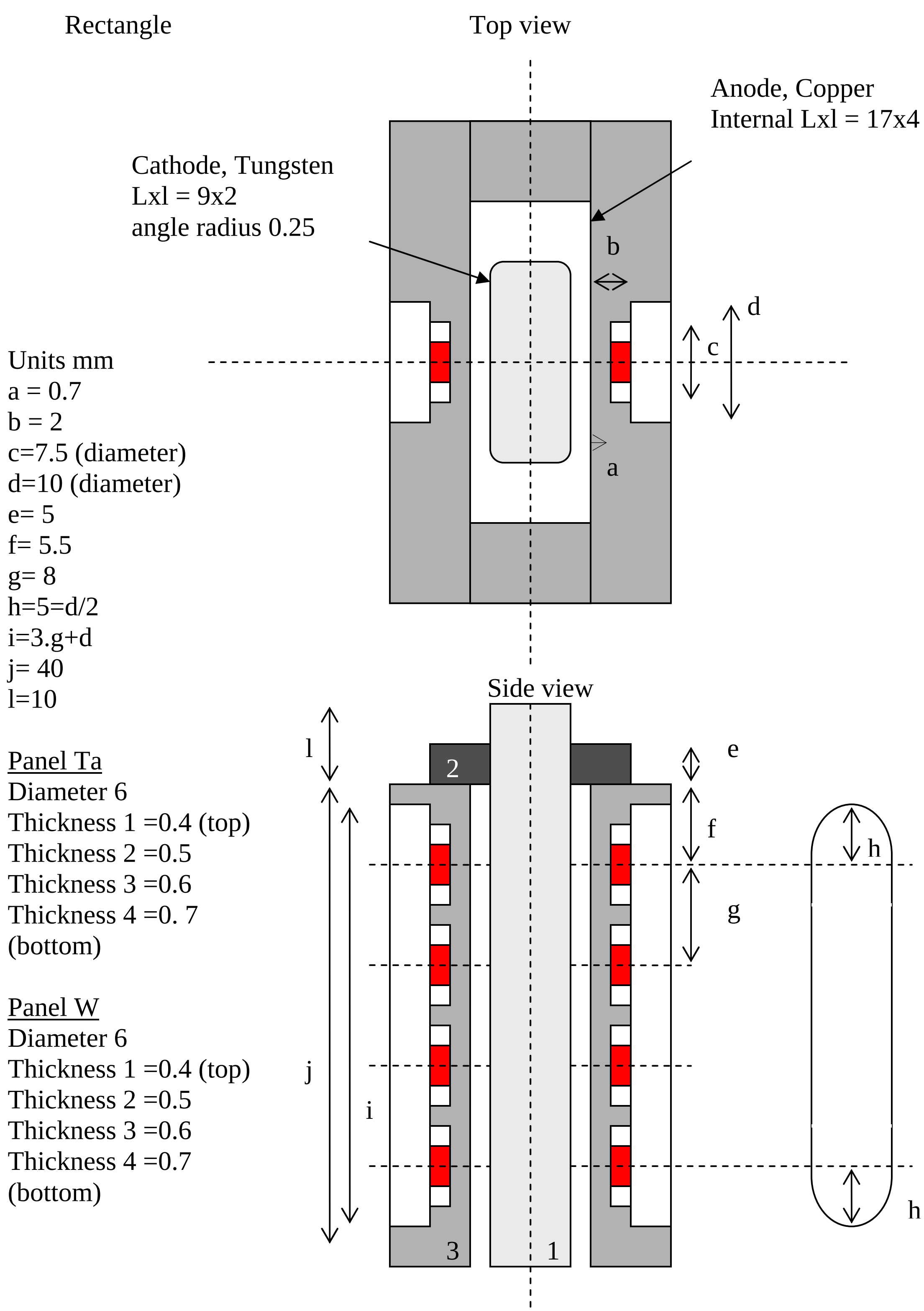

Figure 3 : Experimental set-up of the rectangle configuration

1.3 NUMERICAL SIMULATION RESULTS

The experimental currents are presented Figure 4. The numerical results with the coarse mesh are presented Figure 5 and Figure 6 using the current of the shot 1967, Figure 7 and Figure 8 using the experimental current of the shot 1511.

The numerical results give free surface velocities of 3.5 km/s for the tungsten samples. The calculated pressure reaches about 2.7 Mbars at the panel / Tungsten interface. The free surface velocity of the Tantalum sample gives 14 % more velocity compared to Tungsten, which is due to the interface copper / sample difference. This needs to be confirmed by a finer mesh of the samples and a finer mesh of the copper panel.

The comparison with experiments is on-going. The numerical simulations are on-going with a finer mesh and a tilt configuration of the cathode versus the anode.

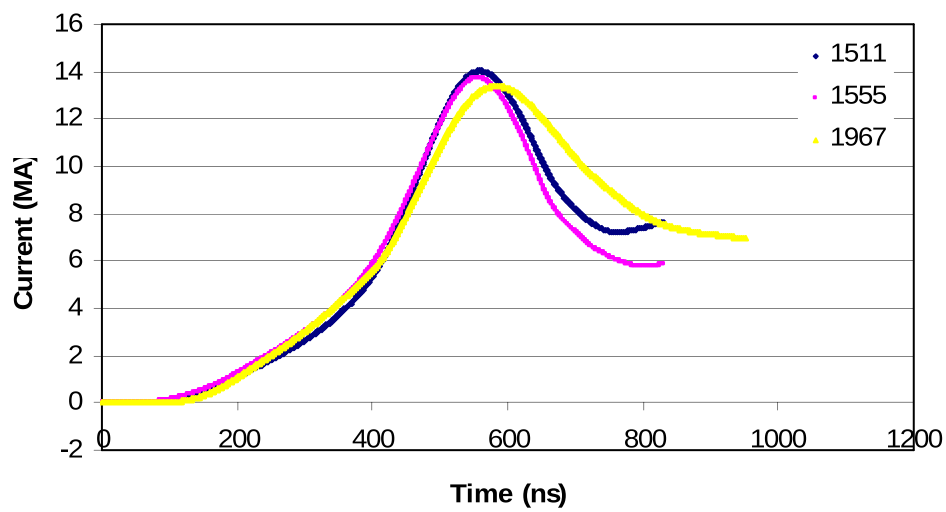

Figure 4 : Experimental current versus time for shots 1511, 1555, 1967

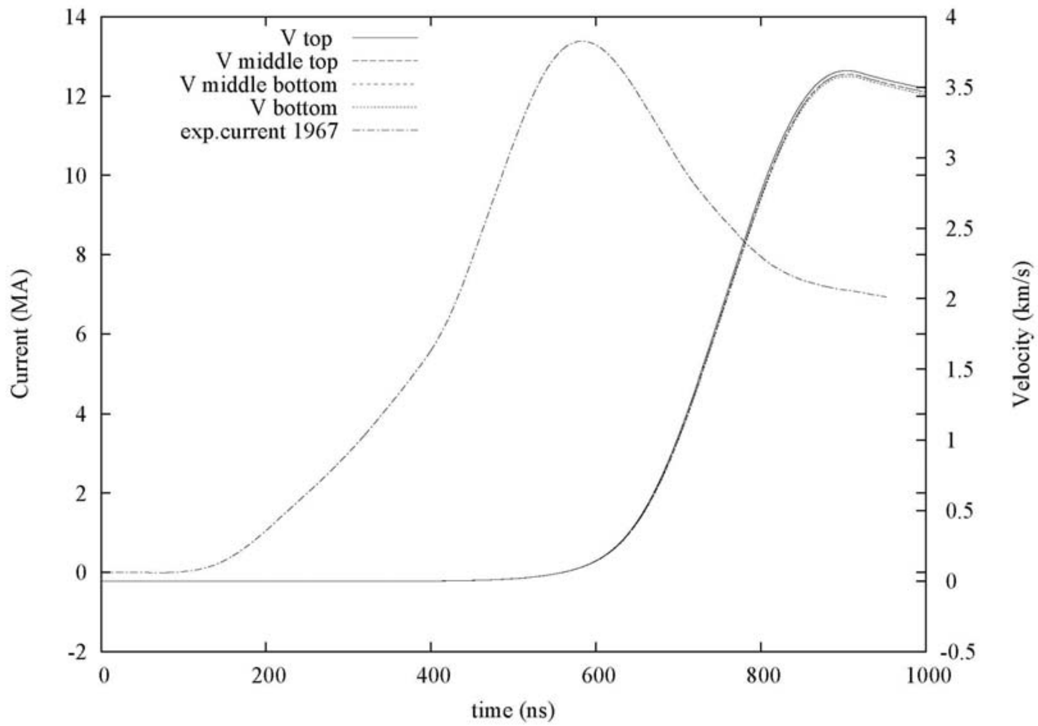

Figure 5 : Current and free surface velocities for Tungstene samples versus time for the rectangle configuration using the current of the shot 1967, coarse mesh

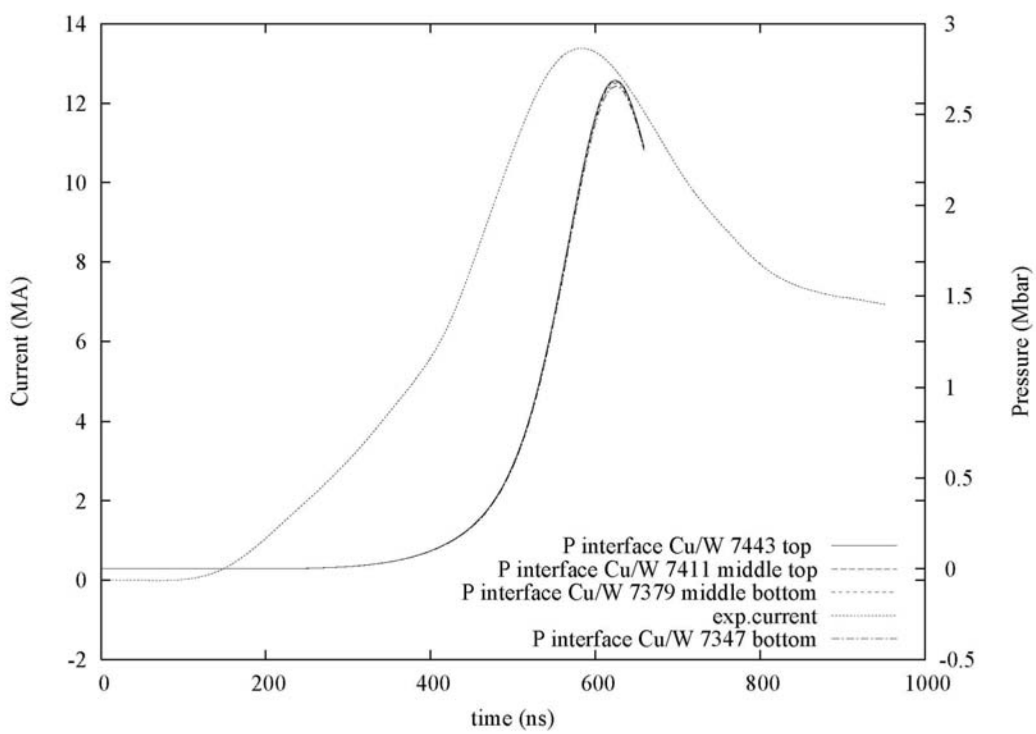

Figure 6 : Current and Pressure versus time for the rectangle configuration using the current of the shot 1967, coarse mesh

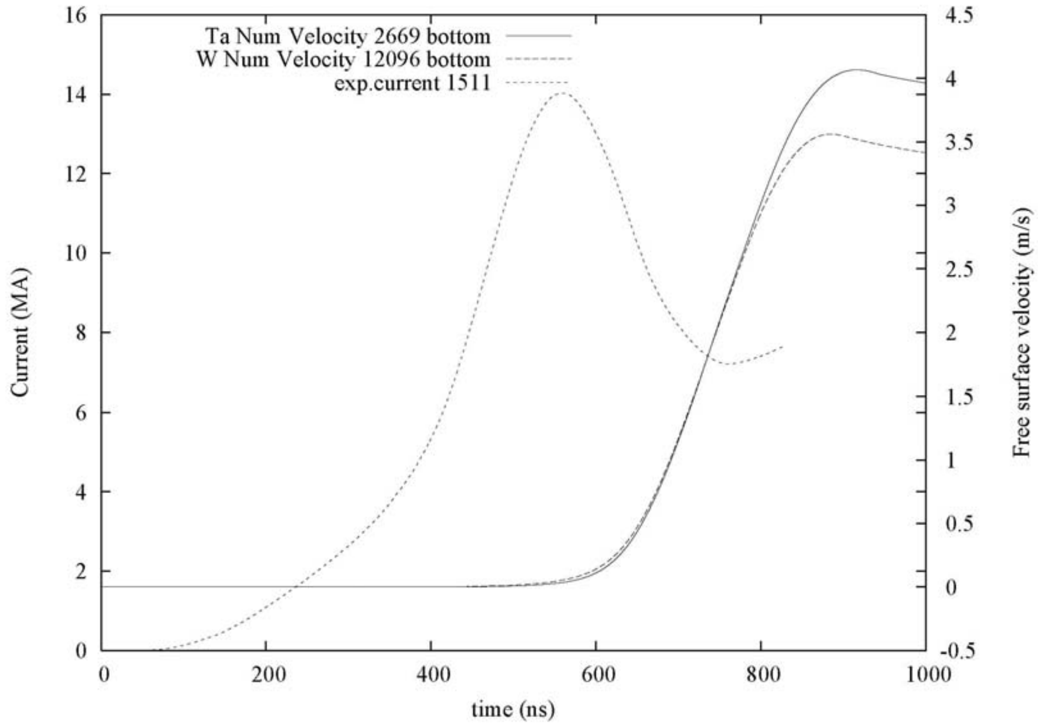

Figure 7 : Comparison of the free surface velocities between the bottom Tungsten and Tantalum samples, current 1511, coarse mesh

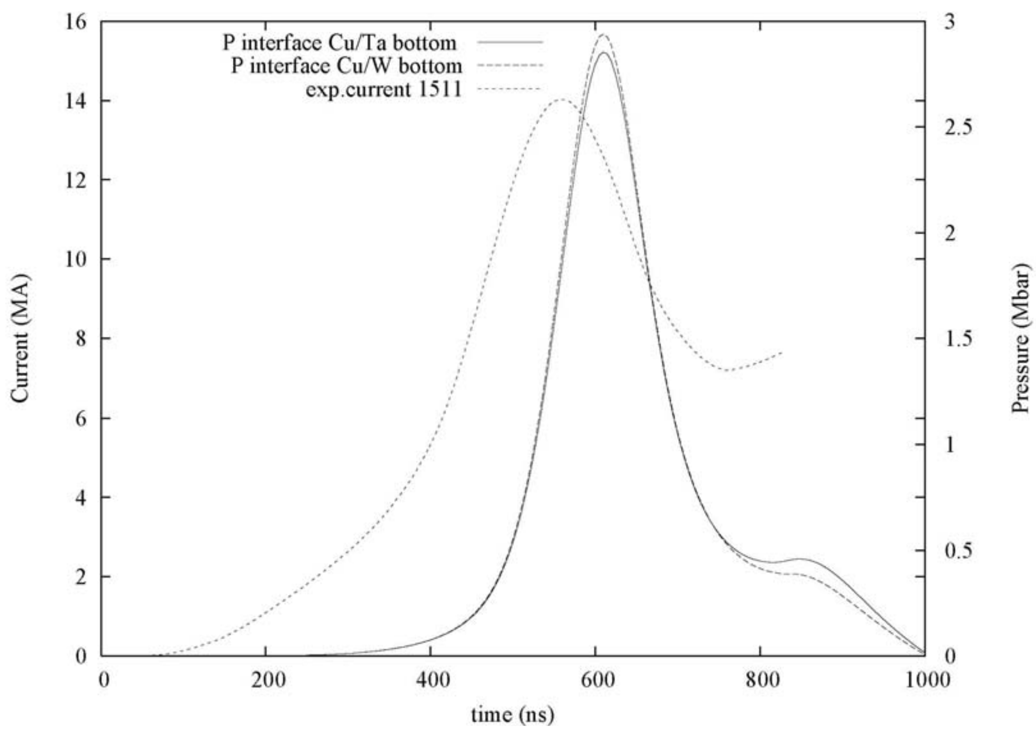

Figure 8 : Pressure and current versus time at the interface Copper / Ta and / W bottom samples, numerical simulations, current 1511, coarse mesh

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