

# Mechanical Engineering Master's Defense

## Characterization of the Dynamic Strength of Aluminium at Extreme Strain Rates and Pressures

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### abstract

The study of response of various materials to intense dynamic loading events, such as shock loading due to high-velocity impacts, is extremely important in a wide variety of military and industrial applications. Shock loading triggers extreme states, leading to high pressures and strain rates, and neglecting strength is a typical approximation under such conditions. However, recent results have shown that strength effects are larger than expected, so they must be taken into account. Recently, hydrodynamic instabilities, the most common being the Rayleigh-Taylor (RTI) and Richtmyer-Meshkov (RMI) instabilities, have been used to infer the dynamic strength of materials at high pressure conditions. In our experiments and simulations, a novel RMI approach is used, in which periodic surface perturbations are made on high purity aluminium target, which was laser ablated to create a rippled shock front. Due to the slow linear growth rate of RMI, the evolution of the perturbations on the back surface of the sample as a result of the rippled shock can be measured via Transient Imaging Displacement Interferometry (TIDI). The velocity history at the free surface was recorded by spatially resolved laser velocimetry. These measurements were compared with the results from the simulations, which were implemented using rate independent and rate dependent material models, to characterize the dynamic strength of the material. Simulations using the elastic-perfectly plastic model, which is rate independent, failed to provide a value of dynamic yield strength that would match experimental measurements of perturbation amplitudes. The Preston-Tonks-Wallace (PTW) model, which is rate dependent model, worked well for aluminium. This model was, in turn, used as a reference for calibrating the rate dependent Steinberg-Lund model and the results from simulations using the calibration models were also compared to experimental measurements.

April 14, 2017; 10:00AM; GWC 487