Shock compression of water and solutions of ammonium nitrate

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Modern mining explosives employ solutions of ammonium nitrate, where the solution is the oxidising component of a fuel/oxidiser mixture. This thesis is primarily concerned with the shock response of water and of aqueous solutions of ammonium nitrate. Of particular interest are the temperatures induced through shock compression. An experimental facility, using a single-stage gas gun in the 'plate impact' configuration, is described, along with associated experimental diagnostics. Measurements of, and improvements to, the tilt at impact are reported. The problem of shock temperature is discussed, including a brief review of the relevant literature. It is demonstrated that direct measurement of shock temperature is a complex issue that is not yet fully understood, whereas determination of temperature from an equation of state is an established technique.

In a series of experiments, plate impact techniques were utilised to determine the Hugoniot and, through shock/reload experiments, the equation of state of water and aqueous solutions of ammonium nitrate. In-situ manganin gauges were used to measure stresses in the liquids and, from the arrival times of the shock wave, determine the shock velocity. Linear shock velocity–particle velocity Hugoniots for the liquids were determined, up to particle velocities of $1\,\mathrm{km\,s^{-1}}$, with uncertainties on the intercept and slope of these Hugoniots of $5\,\%$. A Mie-Grüneisen equation of state was used to describe the shock/reload experiments. Approximate calculations of shock temperature are reported. Increasing ammonium nitrate concentrations resulted in greater calculated temperatures. It was demonstrated that the liquids investigated in this thesis show a temperature dependence of the Grüneisen parameter, Γ, which cannot be accommodated in the model. The present work is believed to be the first demonstration of this effect in shock compressed liquids. The data presented provide constraints on future theoretical development of equations of state.