The behaviour of RTM-6 under shock loading

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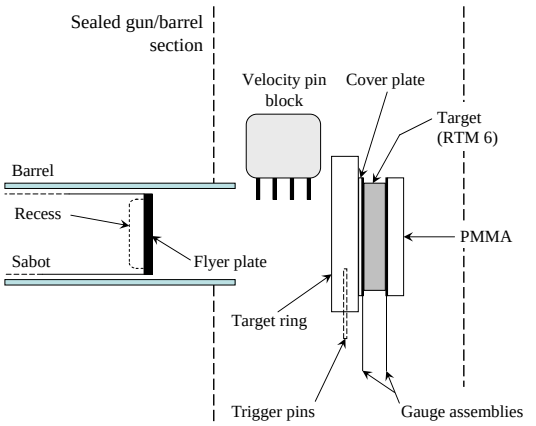
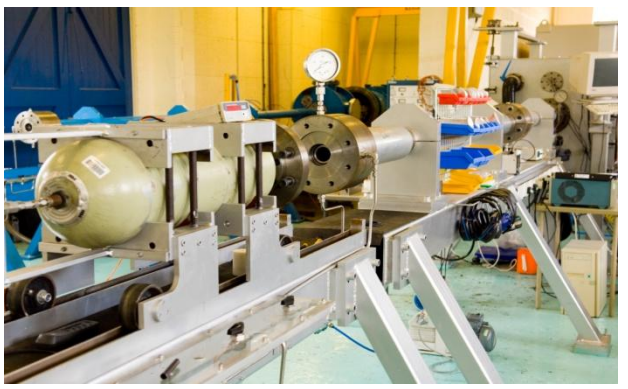
Introduction

RTM-6 is a commercially important aerospace-grade epoxy resin. Consequently, it is important to understand its behaviour under potential impacts that may occur, e.g. bird strikes, hail stones, deliberate attack (fragmenting munitions) or space-based impacts. Building on current knowledge of this important material, flyer-plate experiments were performed on RTM-6 at impact velocities of 40-500 ms^{-1}. The main area of interest was the low particle velocity regime where, given the polymeric nature of the resin, some non-linearity in the derived Hugoniot might be expected. In addition recent lateral gauge results which highlight changes in the behaviour of RTM-6 under shock are presented.

Experimental



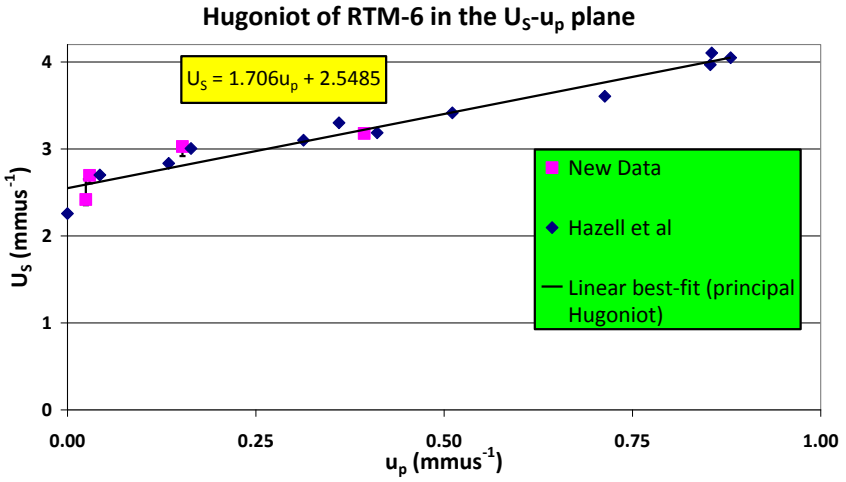


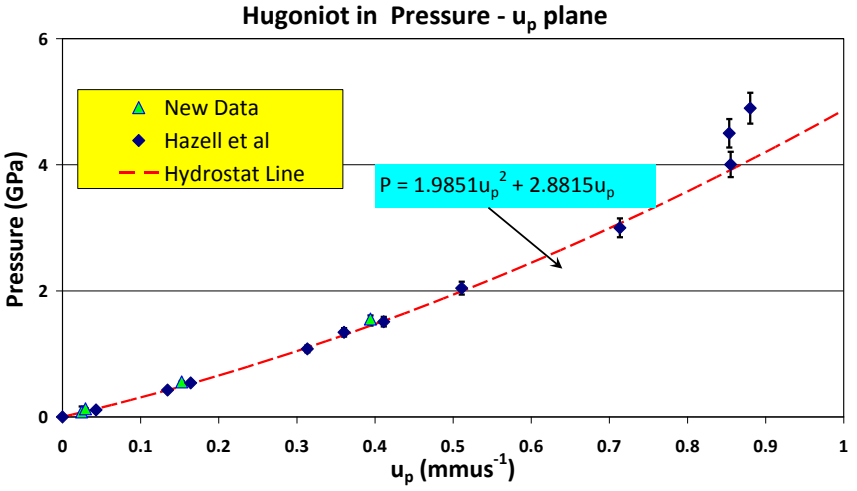
(above) Single stage 50 mm diameter gas-gun

(left) longitudinal gauge experimental setup

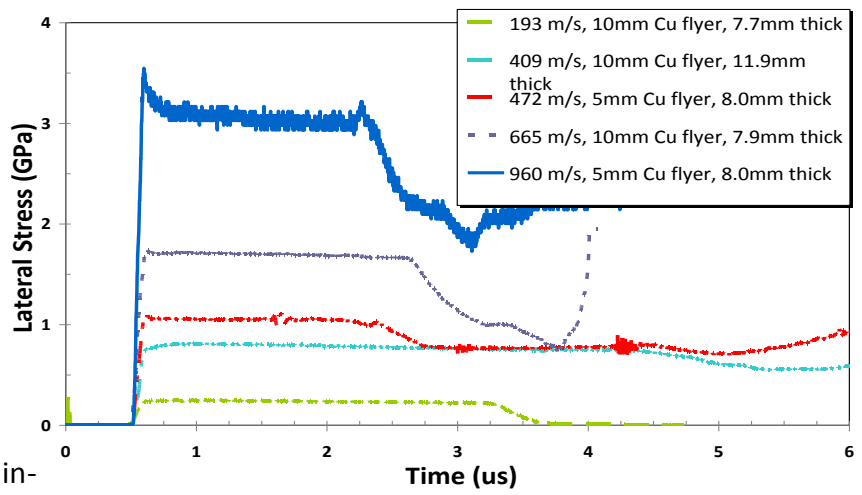
Experiments were conducted using a 50 mm diameter single stage gas gun fired via a bursting-diaphragm technique. Flat and parallel flyer plates were fired into RTM-6 targets in the velocity regime 40-500 ms^{-1}, with stress within the samples monitored using calibrated longitudinal Manganin stress gauges. For impact velocity $\leq$ 80 ms^{-1} a novel single bursting discs technique was employed with the mass of the sabot being altered as required to achieve the desired impact conditions.

Results





- Deviation above the hydrostat in the P-u_p Hugoniot at elevated pressures
→ apparent strengthening behind the shock with increased impact pressure
- No evidence of deviation from the U_S-u_p Hugoniot at low u_p values
  - U_S-u_p relationship appears linear for $u_p \geq 0.02$ mm/μs
  - Likely due to relatively strong inter-molecular bonds
- Gradient behind shock apparent in lateral gauge traces suggests change in strength: from $2\tau = \sigma_X - \sigma_Y$, decrease in σ_Y suggests strengthening



Future Work

- Experimental derivation of a value of Grüneisen Gamma for RTM-6
- Analysis of other resin-systems, focusing on low pressure regions of high strain-rate performance
  - Aerospace-grade resin SC-1008; a thermosetting plastic of commercial interest
  - Tape Wrapped Carbon Phenolic (TWCP) composites

P. J. Hazell, C. Stennett, G. Cooper "The Shock and Release Behaviour of an Aerospace-Grade Cured Aromatic Amine Epoxy Resin", Polymer Composite (2008) 1106-1110

D. Porter, P. J. Gould "A General Equation of State for Polymeric Materials" Journal of Physics IV France (2006) 373-378

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