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Mechanical properties of energetic components

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This thesis presents research into the mechanical response of particulate polymer composites, both energetic and inert, that contributes towards the wider understanding of deformation and damage mechanisms in Polymer Bonded Explosives (PBXs). Specifically, high and low strain-rate compression experiments were performed on several composites, with a view to measuring their elastic properties. A brief review of PBXs, polymers and particulate composites forms chapter 1.
A key piece of mechanical testing apparatus, the Split Hopkinson Pressure Bar (SHPB), is critically assessed in chapters 2 and 3. The gauge calibration procedure was critically evaluated; the necessity of dispersion correction was investigated; and a method for allowing for the finite specimen transit time was introduced. Chapter 4 presents a comparison of methods of estimating a high strain-rate elastic modulus, including ultrasonic and pulse-shaped SHPB measurements. All methods returned moduli within the expected range and in broad agreement with each other.
Chapter 5 describes SHPB and ultrasonic transducer experiments performed on a UK PBX and binder at temperatures ranging from -100°C to 30°C. Results build upon and agree with published findings, demonstrating a lower glass transition temperature in the binder than in the PBX, implying that the binder in the PBX experiences a higher strain-rate. Chapter 6 reports experiments performed on three cast RDX-HTPB composites, where quantifiable damage was introduced at high strain-rate using a Direct Impact Hopkinson Bar, and the resulting composite modulus was measured quasi-statically. The most abrupt decrease in modulus due to damage was measured for the composite containing bimodally distributed filler particles.
Finally, in chapter 7, two sets of sugar-HTPB composites were produced: one with fixed particle size distribution with varying particle separation, and the other vice-versa. Microstructural properties, including the distribution of intergranular separations, were measured using X-ray microtomography. Quasi-static and SHPB compression experiments were performed. Particle size and separation were found to be secondary to fill-fraction in governing material properties. A Porter-Gould modulus decay function was fitted to the stress-strain curves. The binder elastic modulus and crystal-binder adhesion energy were estimated at high and low strain-rates.