C.R. Siviour

High strain rate properties of materials using Hopkinson bar techniques

University of Cambridge (UK)

Contact : clive.siviour@eng.ox.ac.uk

This dissertation examines the high strain rate mechanical properties of polymers, polymer bonded explosives and solders. In addition, it examines experimental developments that will allow more detailed investigation of these properties in the future.

The split Hopkinson pressure bar is a standard apparatus used to measure the mechanical strength of materials at strain rates between 500 and 10,000 s^{-1}. Measurements are performed by dynamically loading a small cylindrical specimen between two rods that are instrumented with strain gauges. The data from these strain gauges are used to calculate stress and strain in the specimen as functions of time.

Chapter two contains an account of the Hopkinson bar system and its application. The advantages and limitations of the system are presented and discussed. Once of these limitations, the time taken for the specimen to reach mechanical equilibrium, is examined in detail in chapter three.

In chapter four the variation of strength with strain rate of two polymers, polycarbonate and polyvinyladine difluoride, is investigated. It is shown that at high stain rates their mechanical strength is increased by freezing out of low order molecular relaxations. Chapter five presents data from measurements made on polymer-bonded explosives. The effect of crystal size on the mechanical properties of the mixture is examined, and it is shown that the strength of the material varies as the inverse square root of crystal spacing. In chapter six measurements of the high strain rate properties of different solder materials are presented. These measurements were made to provide high quality experimental results for the development of material models for solder at high strain rates.

Chapter seven presents results from the application of speckle metrology, a well-established technique for making optical measurements of displacements, to the Hopkinson bar system. Along with a line laser device for measuring specimen radius this allowed accurate measurements of the Poisson's ratio of Hopkinson bar specimens. In addition, speckle enabled a high rate Brazilian test with measurements of tensile strain. Finally, data are presented on the deformation of PBS9501, a polymer bonded explosive stimulant. The evolution of damage in the material is investigated using both the speckle and line laser techniques.