THERMAL AND FRACTURE BEHAVIOUR OF ROCKET MOTOR MATERIALS

by

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Abstract

The thermal and fracture behaviour of the polymeric materials employed in the manufacture of the PICTOR rocket motor has been studied for inclusion into a finite element analysis approach to service life prediction. Both as-received and aged specimens were tested at each of three temperatures and strain-rates, including an ambient, sub-zero and elevated temperature. The materials were aged by subjecting them to various thermal loads (accelerated ageing, thermal cycle and thermal shock) designed to expose them to conditions similar to that experienced by a rocket motor during its service life.

The change in the thermal expansion behaviour of the propellant, inhibitor, epoxy and insulation was investigated. Values of thermal expansion coefficient for both the unaged and aged inhibitor and propellant were found to diverge over the range of test temperatures, the consequence may be the development of a stress state capable of causing crack initiation and/or propagation in either material or at a bondline during thermal loads.

The fracture behaviour of the propellant and a propellant/inhibitor bimaterial specimen was found to be similar. The bimaterial specimen failed in the propellant adjacent to the propellant/inhibitor bondline. The deterioration of the mechanical properties of the propellant depended on the severity of the thermal loads. In each case the accelerated aged specimens became harder and more brittle whilst the thermally cycled and thermally shocked specimens were only marginally affected. A marked decrease in hysteresis ratio, critical stress and critical strain, an increase in crack velocity and a distinct difference in the mechanism of crack growth was observed for the accelerated aged specimens. This deterioration will have a significant impact on the modelling process with its inclusion yielding greater accuracy in predictions of rocket motor service life.

At –40°C the inhibitor specimens exhibited glass-like behaviour due to the proximity of the glass transition temperature. The stiffened inhibitor underwent brittle failure at substantially increased stress levels. The accelerated aged inhibitor was hardened without becoming more brittle and as such the critical stress increased above that of the unaged specimens. The deterioration of the inhibitor as a result of thermal cycling and thermal shocking was marginal. A much more severe set of ageing conditions would be required to cause a substantial degradation in mechanical properties.