Mechanics of Taylor Impact Tests of Polymeric Materials

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Polymeric materials encounter extreme dynamic loading conditions and undergo complex deformation during their usage in impact-resistant applications. Particular designs of the split-Hopkinson pressure bar have enabled the evaluation of the high rate stress-strain behavior of polymers. However, these homogeneous deformation conditions do not subject the polymer to the inhomogeneous deformation and stress fields and complicated progression of these fields induced during common impact phenomena. The Taylor impact test has been of invaluable use in testing metals at very high rates under large gradients of stress and deformation. However, only a handful of studies have been performed on polymers using the Taylor test.

Taylor impact experiments were conducted to study the dynamic behavior of polycarbonate (PC) under impact loading conditions leading to inhomogeneous deformation at strain rates exceeding $10^5 s^{-1}$ [1]. High-speed photography was used to monitor the chronological sequence of progressing deformation fields within the samples. Numerical simulations were performed using a three-dimensional large-strain rate-dependent elastic-viscoplastic constitutive model [2, 3], which describes the high-rate behavior of glassy polymers and was incorporated into ABAQUS/Explicit finite-element code through an user-defined material subroutine. The simulated progression of deformation fields during the dynamic loading events are compared directly with experimental images for a range in initial conditions. Final deformed shapes are found to correspond with those obtained experimentally, demonstrating the ability to predict progression of complex inhomogeneous deformation events during impact loading scenarios. The dependence of the observed behaviors on the various features of the polymer stress-strain behavior are presented in detail revealing the roles of rate-dependent yield, strain softening and strain hardening in governing the manner in which deformation progresses in a polymer during dynamic inhomogeneous loading events.

References

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