DYNAMIC TENSILE BEHAVIOR OF GLASSY POLYMERS

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Amorphous polymers exhibit strong strain-rate sensitivity in many aspects of mechanical behavior including stiffness, yield, post-yield stress and failure. It is essential that their high-rate behavior be accurately understood and modeled to help develop better materials and also optimize their usage in impact-resistant applications, such as protective shields, safety glass windows and transparent armor. The mechanisms governing the mechanical behavior are further dependent upon the modes of loading. Though, the high-rate compressive behavior of polymers has received considerable interest recently, the dynamic tensile behavior has not been thoroughly examined due to the complexities in experimental techniques and data analysis.

In this study, the constitutive behavior of Polycarbonate (PC) was studied under dynamic tension at a range of loading conditions. The force-displacement behavior was examined at rates up to 1500 s-1 with a split-collar type split Hopkinson tension bar (SHTB). The effects of varying specimen geometry were studied to confirm the validity of the measured constitutive response. In some experiments, the severity of the loading and the geometry of the specimens were chosen such that failure was induced. The evolution of deformation including elongation and formation of necks, ultimately leading to failure, was examined through high-speed photography. The underlying stress-strain conditions resulting in inhomogeneous tensile deformation were examined with ABAQUS/Explicit finite element code, in which a constitutive model [1] for large-strain rate-dependent elastic-viscoplastic behavior was incorporated. Numerical simulations were also performed using a stretch-based failure criterion and compared against experimentally failed samples. The mechanics governing the phenomena of large inhomogeneous elongation, multiple necking, and failure will be explored.

References

[1] Mulliken A.D and Boyce M.C., “Mechanics of rate-dependent elastic-plastic deformation of glassy polymers from low to high strain rates,” Int. J. Solids & Struct. 43, 1331-1356, 2006

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