EXPERIMENTS AND CONSTITUTIVE MODELING OF THE HIGH RATE DEFORMATION BEHAVIOR OF POLYURETHANES AND POLYUREA

Mary C. Boyce and Jin Yi
Department of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

The thermoplastic elastomer polyurethane and the elastomeric thermoset polyurea are finding new applications in increasing the survivability of structures under impact loading, including those encountered in blast and ballistic events. However, the mechanical behavior of polyurea and polyurethane materials under these high rate conditions is relatively unknown. Here, the rate-dependent stress–strain behavior of one polyurea and three representative polyurethane materials is studied by dynamic mechanical analysis, quasi-static compression testing and split Hopkinson pressure bar (SHPB) testing. The polyurethane chemistries were chosen to probe the influence of the hard segment content on the mechanical behavior, where the volume fraction and the amorphous vs. crystalline structure of the hard segment domains were varied. The large strain stress–strain behavior of polyurea and polyurethane shows strong hysteresis, cyclic softening, and strong rate-dependence. The polyurethane with a non-crystalline well-dispersed hard segment morphology did not exhibit cyclic softening. The materials are observed to transition from a rubbery-like behavior under low strain rate loading conditions to either a leathery or glassy-like behavior under high strain rate loading conditions. The polyurethane constitituve model of Qi and Boyce (2005) is adopted and extended to capture the behavior of these materials from low to moderate to very high strain rate loading conditions.