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A NOVEL TESTING APPARATUS FOR INVESTIGATING DYNAMIC COMPRESSION RESPONSE OF POLYMERIC FOAM AT INTERMEDIATE STRAIN RATES

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ABSTRACT

Polymeric foams have a ubiquitous presence in several industries due to their low densities, high energy absorbing potential and generally excellent mechanical and thermal properties. Securing a comprehensive knowledge of the mechanical response of such materials, especially under dynamic loading, is crucial for engineering design and optimization. Therefore, significant research efforts were conducted to investigate the rate sensitivity of polymeric foams. Split Hopkinson Pressure Bar (SHPB) apparatuses have been widely utilized in dynamic experimental testing of polymeric foams. These machines are capable of testing thinner foam specimens at higher strain rates, typically greater than 1000 s^{-1}. However, conventional SHPBs require significant modifications to become suitable for testing polymeric foams at intermediate strain rates, ranging from 50 s^{-1} to 500 s^{-1}. Alternatively, drop tower testing machines can be utilized for testing at these rates, however, consistent loading speeds (and strain rates) were rarely achieved utilizing these systems. These technical challenges have led to a lack of high-quality dynamic material characterization data for polymeric foams subjected to large compressive deformations at intermediate strain rates. This range of strain rates is crucial to the transportation industry, where material deformation under crash conditions often occurs. In this study, the dynamic compression of PVC foams at a constant intermediate strain rate was achieved utilizing a drop tower machine, equipped with a massive dropping entity and a novel cutting-based sacrificial energy dissipation system. The significant kinetic energy provided by a 45.45 kg dropping entity ensured full compression of the foam specimen at a near-constant strain rate. Following specimen deformation, the remaining kinetic energy of the dropping entity was safely dissipated, ensuring no overload to the force transducer and/or any supporting apparatus. The rate sensitivity of PVC foams with densities ranging from 80 kg/m^3 to 200 kg/m^3 was investigated at the strain rate range of 0.005 s^{-1} to 100 s^{-1}.