EXPERIMENTAL AND NUMERICAL STUDY OF BODY ARMOR OF ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE

Abstract

The quest for lightweight, high-performance ballistic protection has accelerated the adoption of Ultra High Molecular Weight Polyethylene (UHMWPE) laminates in modern body armor systems. This study presents an integrated experimental and numerical investigation into the ballistic behavior of UHMWPE-based armor panels under both single and multiple projectile impacts. Material modeling strategies were established to capture the orthotropic plasticity behavior of UHMWPE laminates, while Smooth Particle Hydrodynamics (SPH) was implemented to simulate realistic projectile deformation under impact loading. The findings of low velocity impact on hard armor panel (HAP) and soft armor panel (SAP) highlight the dominant role of plastic deformation in influencing the behavior of UHMWPE during impact. These results underscore the necessity of incorporating plasticity into the constitutive modeling of UHMWPE composites for accurate prediction of impact behavior.

Numerical modeling and ballistic evaluation of a multilayer UHMWPE-based body armor system consisting of HAP, SAP, foam and clay is carried out to meet Level 3 ballistic protection standards. Simulations closely matched experimental results, with backface signatures of 14.8 mm (simulated) and 15.6 mm (experimental). The multi-hit response of the ceramic/UHMWPE armor against steel core projectiles is analyzed, with simulations predicting BFS values closely matching with experiments. The use of hexagonal ceramic tiles wrapped in Kevlar epoxy effectively localized damage, preventing radial cracks and confining failure to individual tiles is also examined. The energy absorption by each component of the armor is also discussed.