Abstract

Advanced composites find appositeness in a variety of pertinences relative to conventional materials due to high specific strength, ease of manufacture, tailor-made properties and the possibility of enhancing its features by fillers or modifications. These materials find importance in many defence applications including armours, helmets, gloves and bomb blankets. The requisites for developing advanced polymer matrix composites for hard armour applications include materials with an increased impact resistance without compromising the increase in weight. This can be achieved by the incorporation of high performance, rheologically engineered fluids in the structure of the composites. Rheologically engineered fluids such as shear thickening fluids (STFs)possess dilatant properties which can enhance the impact resistance of the advanced composites. A major challenge in this endeavor is to formulate STFs which would provide an optimum combination of relatively low viscosity at rest, a marked shear thickening rheological character and a high post transition viscosity. Another challenge is to incorporate the prepared STF in the core of the advanced composites. Thus, this research work focusses on the development of an optimized process for the formulation of STFs having desirable rheological characteristics. The effects of parameters such as nanoparticle loading %, nanoparticle size and viscosity of the carrier fluid on the rheological parameters have been analyzed. The rheological data has been fitted to existing apparent-viscosity models to achieve a shear thickening fluid with tunable rheological characteristics. This research work also investigates various methods for the incorporation of STFs in the structure of the advanced composites. After a series of pre-ballistic screening tests, the most promising method for the incorporation of STFs in the advanced composites was identified. The identified method included development of 3D-mat composite panels. The core of the panels were filled with a high-performance STF and sandwiched between layers of KevlarR mat to develop 3D-mat-sandwich composite panels. These panels were subjected to ballistic impact using a 0.380-caliber projectile (average velocity:150 m/s) and a 9mm projectile (average velocity:400 m/s). It was found that the STF-incorporated sandwich composite panels could exhibit a much higher impact resistance to the ballistic impact in comparison to the hollow sandwich composite panels. This substantiates the STF-incorporated sandwich composite panels as a promising material for enhanced energy absorption.

Keywords: Advanced composites, shear thickening fluids, rheology, sandwich composite panels, ballistic impact, energy dissipation, 3D-mats, %energy absorbed