

ABSTRACT

Lightweight, soft body armour is the current requirement for security forces due to increased terror attacks, civil war and cross border casualties. This research area has become a hotspot for protective textile researchers. For the last five-decade, *p*-aramid and ultra-high molecular weight polyethylene (UHMWPE) fibre is prominently used for bullet resistance material. New high-performance materials and techniques are required, which give better ballistic protection and are eco-friendly. Shear thickening fluid (STF), surface treatment and growth of nanostructures, hybridisation of material and stacking sequences are being explored for impact resistance material. The present research focuses on improving the impact performance in terms of back face signature (BFS) of soft body armour by using hybridisation techniques, STF impregnation and introducing new high-performance material, i.e., disentangled polyethylene (DPE) tape.

In the first part of this research, an attempt was made to develop a hybrid soft armour panel (SAP) using commercial high-performance material such as *p*-aramid woven fabric and UD laminates, UHMWPE UD laminates and polycarbonate sheet. The work shows the role of textile structure for bullet resistance materials. The developed hybridised SAPs were cost-effective solutions with improved ballistic performance.

In the second part of the research, an attempt was made to understand the role of STF impregnation on *p*-aramid woven fabric for SAPs. The areal density of SAP can be reduced further by 10 % ($4.5 \text{ kg}\cdot\text{m}^2$), while keeping the BFS comparable to or lower than that of an STF impregnated homogenous panel by judiciously placing the STF impregnated fabrics at the rear side while neat fabrics are placed at the strike face of the panel. It was also noted that STF impregnated panels were found to stop the impacting bullet earlier than the neat panel.

In the third part of the research, an attempt was made to understand DPE tapes physical, thermal, and mechanical properties from polymer to highly drawn tape. Thereafter find the possibility of DPE tape as a replacement of existing commercial high-performance material such as *p*-aramid, gel spun UHMWPE fibre. DPE tape has comparable mechanical properties as existing high-performance materials. Basic advantage of DPE, it is manufactured by solvent-free techniques, which is economical and eco-friendly compared to gel spun fibres.

In the last part of this research, an attempt was made to develop the various laminates structures of DPE tape and low-density polyethylene (LDPE), such as woven twisted tape (WTT) based UD laminates, cross-ply laminates at different process parameters and conditions. Thereafter, single layers of various laminates structures were optimised in terms of resin content, structures

and process parameters. The prepared laminates structures evaluated for mechanical and low velocity dynamic impact performance. After that, Optimised DPE based structures used for homogeneous SAP configuration using the optimised laminates. Cross-ply laminates-based SAP gives the highest ballistic resistance compared to woven based laminates. Overall, DPE based laminates can be used to produce SAP having areal density of $4.5 \text{ kg}\cdot\text{m}^{-2}$ which is comparable with the commercial solutions available in the market.