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PROCESSING TECHNOLOGY OF COMPOSITE MATERIALS FOR BALLISTIC PROTECTION AND ITS IMPACT ON THE FUNCTIONAL PROPERTIES OF GARMENTS

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To prevent perforation and serious blunt trauma, caused by high velocity riffle rounds, hard armour plates are added to the front and back of the protective vest in conjunction with the soft armour pack. In order to reduce the strike energy of a bullet, the armour plate is designed to blunt the incoming round and to absorb the impact wave and arrest the damaged projectile. More and more fiber-reinforced polymer composites made of a high-strength, fiber-embedded polymer matrix are used in body armour due to their outstandingly high strength and stiffness to weight ratios, which are essential for an application in reduced-weight ballistic armour.

The aim of this research was to study the influence of UHMWPE composite formation process for the mechanical and functional properties of hard armour plate. The plate – was composed of multiple layers of a thermo-plastic uni-directional UHMWPE laminate (Fig. 1) applying low-pressure membrane vacuum forming technique. With a vacuum approaching 1 bar, the sample was heated under vacuum to the polymer's processing tempera-ture (135 °C) which was maintained for full impregnation. After that, the sample was gradually cooled.

Fig. 1. Structure of one layer UHMWPE laminate (0/90/0/90° ply) [1].

Ballistic tests based on NIJ 0101.04 standard level III [2] were performed using 7.62×51 mm ammunition at an impact velocity of 838±15 m/s. Test results revealed no penetration for the investigated armour plates. The research was also carried out at the theoretical level, to develop a multi-scale ballistic-resistant composite model with a complex internal structure. The theoretical research was based on the formation of the composite structure by compacting it in a vacuum manner. In this process, the loads on the micro-scale model were presented as negative pressures on all internal surfaces of the micro-structure. This method was an alternative and required significantly lower pressure than the distributed load pressure added to conventional compaction only on the outer surface of the composite. The aim was to determine the most optimal internal structure of the composite in order to possibly reduce the uncompacted volumes due to the mutual slip resistance caused by the characteristic filament structure. The model was developed to integrally evaluate the influence of the volume and geometric shapes of the composite empty micro-cavities on both the static and ballistic strength of the composite. The numerical model is realized in LS-DYNA finite element method. The synergy of experimental and theoretical methods of investigation allows to manage processing technology of composite materials for ballistic protection.

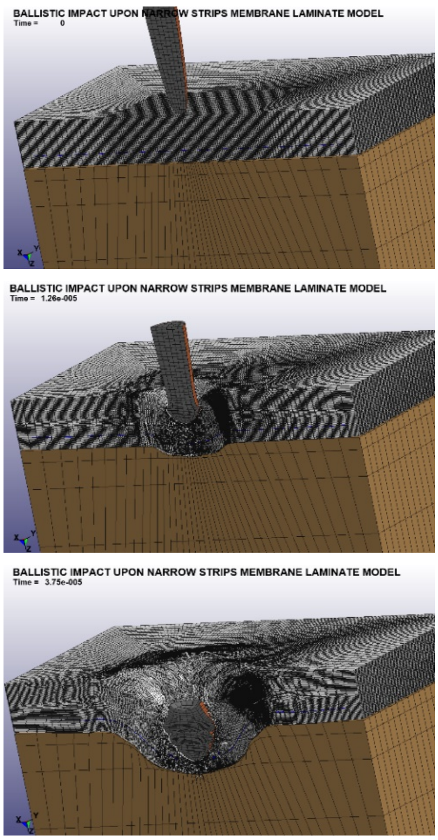

Fig. 2. Impact of high-velocity CuZn10 jacket bullet on multilayer UHMWPE package: a) initial position, velocity 800 m/s; b) intermedium position; c) final position, velocity 0 m/s.

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References

1. www.teijinaramid.com.
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