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Ballistic performance of plasma treated Kevlar fabrics

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Abstract

Yarn pulling out and yarn slippage are regarded to have negative influence on performance of ballistic fabrics. In order to increase the between fibre friction, non-polymerising reactive plasma gas N_2 and chemical vapour $(CH_3)_2Cl_2Si$ were employed to modify Kevlar fabric surface. The surface morphology of the treated fabrics was studied. SEM observations yield information about the surface effect of the fabrics after the plasma treatments. EDX (Energy Dispersive X-ray) analysis was used to analyse the surface chemical properties of the treated samples. Yarn pulling-out test shows that the resistance to pull out a yarn from N_2 and $(CH_3)_2Cl_2Si$ plasma treated fabrics is increased 18% and 300% respectively, compared to the untreated Kevlar fabric. A FE model is also developed to simulate the projectile-fabric impact process and to predict the influence of surface friction of Kevlar fabric on energy absorption and backface deformation of the impacted fabric. The work shows that fabric with higher surface coefficient of friction absorbs more energy and in the meantime, the depth of backface deformation decreased with the increase of surface friction.

Key words: *Ballistic performance, Kevlar fabric, Plasma modification, SEM examination, EDX analysis, Yarn pulling-out, EF simulation and prediction*

1. Introduction

Fabrics made from high performance fibres have been widely used for flexible body armours, leading to better protection, lighter weight, and better designs. The ballistic performance of a manufactured fabric depends on the mechanical properties of the fibre, fabric construction including yarn counts and thread densities in the fabric.

The fibre friction properties along with the fibre physical properties play an important role in slowing down the projectile. Friction also helps to strip the jackets from bullets, deform the bullet and ultimately stop the bullet (Bhatnagar, 2006). One factor that influences the ballistic performance of a material is the friction between yarns and between the fabric and projectile. This is the reason that plain woven fabrics, which offer the maximum level of wrapping and friction between yarns, are mostly used in the ballistic body armours. However in order to increase further the ballistic performance of woven fabrics, measures to increase the yarn gripping are desirable as has been found by Sun and Chen (2009). Kevlar is made from a highly crystalline polymer, and coefficient of friction of Kevlar fibres is low (Briscoe, Motamedi, 1992). To achieve decent ballistic performance of the soft body armour made from Kevlar fibre, it is necessary to find

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