High strain rate delamination of UHMWPE by laser induced shock waves

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Abstract

Nowadays, there is an increased need for studying high performance composite materials in order to use it for ballistic armour applications. Indeed, the three major issues for a ballistic protection are to be light, to be efficient and to be downsized. Therefore, high performance composite materials could be a reasonable candidate to answer to these issues due to their excellent strength to weight ratio and the associated potential for weight reduction. The material chosen in this study is a thermoplastic one, the Ultra High Molecular Weight Poly-Ethylene (UHMWPE) because this material demonstrates a very high penetration resistance for a given areal density. In the composite literature, there are numerous works about the mechanical strength at the impact of UHMWPE (Katz 2008, OMasta 2015, Zhang 2015, Lassig 2015, Lassig 2017, Nguyen 2015, Nguyen 2016, Alil 2017, Alil 2018). During a ballistic impact, kinetic energy brought by the projectile is spent on fiber stretching, breaking, melting and delamination. It has been evidenced that, in the case of thick composite materials, delamination is the most energy dissipative process (Zhang 2014). A way to study this damage mechanism is to use a laser induced shock wave testing procedure. Indeed, the delivered pressure is of the same intensity as the one generated during ballistic impacts. Laser induced delamination in composite materials brings a new insight for composite assessment in dynamic loading.

For an experimental study, several variant of UHMWPE are available and their efficiency may depend on process parameters. Among the process parameters, the pressing strength gives the material terminal resistance.

The presented work shows an experimental study using laser induced delamination on UHMWPE Tensylon HSBD 30 A provided by Dupont®, obtained with two pressing strengths. During this experimental study, the free surface velocity of the samples, in vis a vis of the laser impact, is measured thanks to Heterodyne Velocimetry. These tests permit to obtain the delamination failure stress threshold and to study the influence of the pressure strength on this parameter. These data can also be used for modelling delamination by cut-off fracture threshold in numerical modelling, by inverse approach for example. These data will be compared to results obtained in the works of Alil et al. 2018 for a pressure strength of 152 Bar.

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