

Investigation of the ballistic performance of multi-material protection systems

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Ballistic protections usually result from an incremental and empirical approach and accordingly strongly depend on the experience and know-how of the manufacturer. Yet, in order to improve their specific ballistic resistance, current ballistic protections are more and more complex, based on functional, multi-layer and multi-material systems, and thus require the optimisation of a great number of parameters (e.g. layering order, thicknesses, number of layers, etc). In this context, numerical simulation-aided design has become indispensable.

An engineering ballistics-oriented methodology based on the correlation between experiments and simulations is under development. It has proven efficient for bi-layer protection systems, see Cosquer et al. (2021), and still needs to be applied to more complex configurations.

In this aim in view, an experimental campaign has been conducted on multi-material protection systems consisted of assemblies of plates made of ceramic, metal or/and fiber reinforced polymer fabric, each material having its own function in the protection system. In the framework of a calibration and V&V approach, impact tests were carried out employing ICA STIMPACT impact facility (3 gas launchers and their high-speed diagnostics) on ceramic/metal, metal/fabric and ceramic/metal/fabric protection systems. The interaction between the projectile and the protection systems was video-recorded using high-speed cameras, and residual velocity vs impact velocity curves were plotted for estimating the ballistic limit for each configuration.

A first attempt of numerically reproducing the experimental results was then made employing the finite element computation code Abaqus-Exp and using the engineering nonlinear constitutive models implemented by default in it.

Experimental results will be presented and commented and the limitations of the numerical simulations and ways of improvement will be discussed.

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