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Identification of armour technological solutions following experiment-simulation correlation

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Abstract

In the context of numerical simulation-aided design of armour technological solutions for ground vehicles regarding terminal ballistics, the work presented in this communication is focused on the validation of a numerical model applied to a three-layer armour solution, consisting of two metal alloy plates as front and rear layers, and air as an intermediate layer.

A ballistic test campaign was conducted using ICA STIMPACT impact platform, notably by varying the projectile geometry, the impact velocity, the plates and air layer thickness, and the boundary conditions. Impact velocity-residual velocity curves are obtained and protection limit velocities (VPL) are estimated. Depending on the configuration, two failure modes are observed: plugging and petalling.

At the same time, numerical simulations were carried out using the commercial finite element computation code Abaqus/Explicit. The deviatoric part of the metal alloy behaviour is described by the engineering-oriented rate- and temperature-dependent Johnson-Cook model [1], and its hydrostatic part by a Mie-Grüneisen equation of state (see for example [2]). The failure is tentatively driven by a critical strain which depends on strain rate and stress triaxiality.

Knowing that material data available in literature are often incomplete or/and not adapted to the materials under consideration, the objective is here to calibrate a set of constants by coupling Abaqus/Explicit computation code and ISIGHT optimization module from a series of impact tests on mono-layer armours. The set of constants is then applied to impact configurations involving three-layer armours in order to validate the numerical model.

From the comparison between experimental and numerical results for the three-layer armour configuration under consideration, one can conclude to a qualitatively fair experiment-simulation agreement. In addition, the method makes it possible to find a good approximation of the impact velocity-residual velocity curves, and to assess the effectiveness of the tested technological armour solutions.

Works in progress consist in enriching the experimental database and in improving the description of the failure mechanisms (plugging vs petalling).

[1] Johnson, G. R., & Cook, W. H. (1983). A constitutive model and data for metals subjected to large strains, high strain rates and high temperatures. Proc. 7th Int. Sympo. Ballistics. Proc. 7th Int. Sympo. Ballistics.

[2] Anderson, C. E., Cox, P. A., Johnson, G. R., & Maudlin, P. J. (1994). A constitutive formulation for anisotropic materials suitable for wave propagation computer programs—II. Computational Mechanics, 15(3), 201-223.

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