CONTRIBUTIONS TO THE INTERACTION AND ENERGY TRANSFER STUDY BETWEEN MEDIA SUBJECTED TO BLUNT IMPACTS SPECIFIC PHENOMENA

PhD supervisor: col.(r) Ioan VEDINAȘ, eng., PhD
PhD student: Laviniu-Octavian HALLER, eng.

The thesis approaches the interaction and energy transfer problematics between projectiles and the human torso, for both kinetic energy non-lethal rounds and behind armour blunt trauma. The results of the experimental trials conducted for the evaluation of the terminal effects were analysed from an energetic and criterial point of view. It was assessed and emphasized how the shape, the mass and the impact velocity of the projectiles, together with the potential body armour, influence the mechanical loadings and the overpressure that may be generated inside the human body.

The first two chapters of the thesis are dedicated to introducing the reader into the field of the paper by presenting the blunt impact phenomena, the means for assessing them and by establishing the assumed objectives.

The third chapter presents a mathematical model established in finite deformations theory in order to describe the behaviour of shape memory alloys for uniaxial loadings in real-like situations. This model could constitute the foundation for the subsequent development of related ballistic systems that can offer a greater protection using shape memory alloys.

The fourth chapter analyses the interaction and energy transfer between non-lethal kinetic rounds and human body simulants. It is described the interaction between non-lethal rounds and a soft tissue surrogate made out of ballistic gelatine in 10% concentration. The evolution of the volume of the temporary cavity inside the gelatine block was determined by using interpolation polynomials that relate to the observed evolution on the high-speed camera images. Following these tests, the manner and the velocities related to dilatation, in longitudinal and radial directions, while the temporary cavities are formed, were determined as means of energetic transfer. It is, also, described the interaction and energy transfer between non-lethal rounds and a rigid wall, used as a mean for assessing the potential kinetic energy that may be transmitted towards the human target. Following the experimental trials, the impact force, the ceded impulse and the absorbed energy were measured. These values were compared to the transported impact energy value. It was observed that, for a high energetic efficiency, the materials consisting the rounds play an important role.

Within the fifth chapter, the simulation of the terminal effect generated by non-lethal kinetic rounds was emphasized for an over-calibre assembly adapted to a 9 mm calibre lethal handgun and launched into a rigid wall. Evan if the initial kinetic energy of a 9 mm round transports lethal capacity, the initial velocity and energy of the over-calibre assembly, together with its initial energy density, qualifies the assembly for the non-lethal weapons category.

The sixth chapter comprise data obtained from the experimental trials, taken onto a human torso surrogate, conducted for the assessment of behind armour blunt trauma. The results from trials involving 5.56x45 mm and 7.62x39 mm calibre ammunition, fired onto the surrogate protected with two body armours and a ceramic ballistic plate, din not produce any trauma according to the confronted criteria. As for the 9x19 mm calibre ammunition, fired onto the surrogate protected only by the two body armours, there is a chance that the assessed generated overpressure inside the torso may produce trauma. While the Compression Criterion and Viscous Criterion approximated a 10% chance of inducing an AIS 2-3 trauma, the Chest Wall Velocity Predictor Criterion determined important chances for AIS 2-4 trauma. The energy absorbed by the intrathoracic region of the torso may lead to high severity trauma, which could also generate a temporary incapacitation of the victim.