CONSIDERATIONS REGARDING THE POTENTIAL OF ADD-ON ARMOUR WITH PERFORATED PLATES

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Abstract *The military vehicles are subjected to various threats on tactical field. Add-on amour made of perforated steel plates represents one solution used against small caliber kinetic threats. The working principle of such amour is analyzed and discussed.*

Keywords: *Add-on amour, perforated plates*

1. Introduction

Despite last decades with no traditional full scale war the world is far from being a peaceful place. Regardless of their nature, local conflicts or the new emerging hybrid war, are violent and take lives of both military forces and innocent civilians. The following (Fig. 1) is a list of ongoing armed conflicts that are taking place around the world and result in violence.

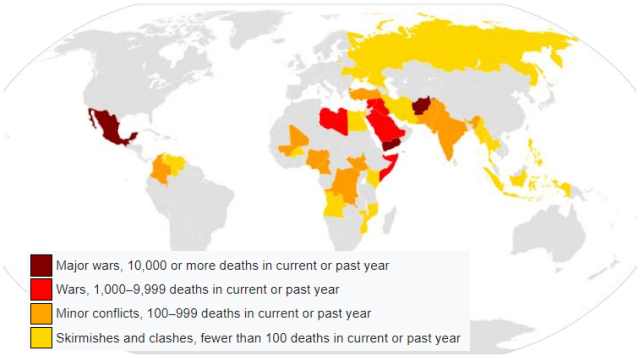

Fig. 1. Ongoing conflicts worldwide in 2019 [1]

During the missions or in tactical field, vehicles are subjected to various threats that may be able to come from all directions top, front, back or side and even from the bottom: armour piercing projectiles of small and medium caliber, shape charge and EFP ammunitions and missiles (eg. PG7 rounds), mines and improvised explosive devices. The need to protect lives is the main stimulating factor that drives continuously the research in the vehicle protection area.

In face of such threats, the monolithic metallic vehicle hull of simple shape is clearly obsolete, having no ability to mitigate the blast load and a low capacity to defeat armour piercing ammunition or high velocity fragments. In this situation the need to improve protection in all parts of the hull is obvious.

Currently, most of the work on the development of new passive solutions for light combat vehicles, beside the protection against blast threat, addresses the small caliber piercing ammunition threat.

2. Trends in vehicle ballistic protection improvements

The kinetic threat was usually address by replacing of traditional materials with new materials with superior mechanical properties. Thus new generation of steels (AERMET, ARMOX, FERRIUM, MIILUX, BAINITIC) have been made in recent years with yield and fracture limits between 1200 - 2000 MPa, respectively 1400 - 2300 Mpa [2-4]. Also the new aluminum alloys were introduced in protection solutions. Special attention was given to fabrics from performance fibers (eg. Kevlar, Tvaron, M5, Dyneema) [5] that have shown the ability to reduce the spalling threat, associated with close blast or kinetic impact.

UHMWPE fibers are some of the most resistant fibers, being 10 times stronger than steel and up to 40% more resistant than the organic fibers. The strength derives from its polymeric nature, Van der Waals weak links summation between molecules. Instead to be woven like other types of fibers in ballistic applications, the UHMWPE fibers of 10–20 μm diameter are glued in a thermoplastic polymer matrices and form unidirectional sheets containing ~ 85% by volume fibers [6]. The best ballistic results are obtained when these tapes are laminated in cross-ply [0°/90°] configuration [7]. These laminates are usually attached to the rear of an armor system or molded to form a protective structure (Fig. 3) [8]. The UHMWPE ballistic applications were studied at the national level too, namely the capacity of UHMWPE bare plate to stop the 7.62×39 mm lead core bullet [9].

Armor made with UHMWPE technology imposes a new standard in ballistic protection in a lighter, flexible solution that enhances comfort, mobility and efficiency. It can reduce armor weight up to 20% without reducing ballistic performance, which translates directly into an improved performance of vehicles, comparable to traditional materials [7].

Ceramics, like alumina, combined with metallic or composite support plates offer some of the best known protection/areal density ratio [10].

A specific category of armor with very good results is represented by add-on armour barriers, like reactive armour [11] and passive cage armour for shape charges [12] or hard steel perforated plates for armor piercing projectiles, which are designed to interact and disrupt the threat before the impact of main armour [10,13-14].

As a first conclusion of the above analysis is that there are many research directions to improve survivability of vehicles and of its occupants and is not a single path to an optimal solution, the numerous initiatives and innovative proposed approaches being usually orientated to defeat just one type of threat.

3. Perforated plates

As regards the perforated plates, the experimental and numerical studies dedicated to the add-on perforated armour plates manufactured from high hard steel have shown a ballistic protection capability against armour piercing projectiles similar to ceramic faced armour [15]. For example, Miilux Ltd Company has developed the perforated ballistic steel, Perforated Miilux Protection 500, used for add-on armor application to protect the vehicle and its occupants against 7,62 mm armour piercing ammunition.

Classical perforated steel plates used as add-on armour have a certain potential to defeat ballistic threats [16], the main identified mechanisms being [17]:

- asymmetric forces causing the projectile to deviate from incident trajectory,
- the projectile core fracture and
- the projectile core nose erosion.

Different holes configurations have already been studied: circular holes, triangular holes or other types of holes [18-20]. The effect and efficiency of the geometry, mechanical properties, thickness, obliquity, size and shape of regularly spaced holes on ballistic resistance of perforated high hardness steel plates has also been studied (Fig. 2) [21, 22]. Higher efficiency was observed for plates with hole sizes close to the projectile diameter and their presence inhibits shear band formation in the target plates [23].

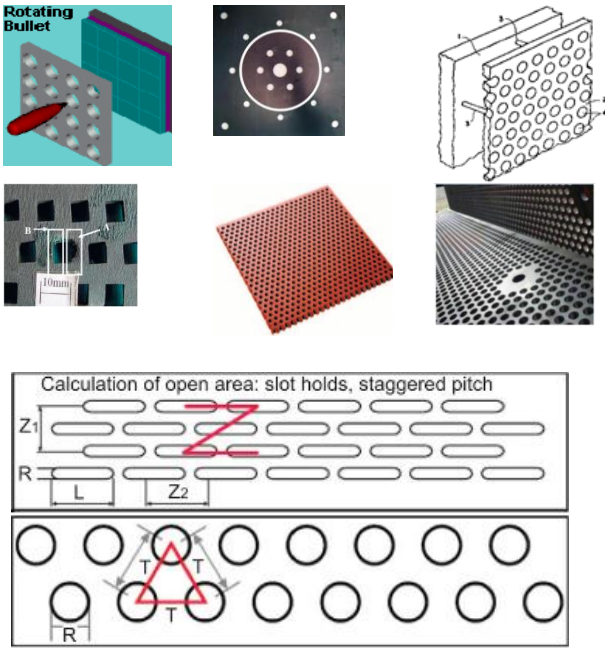

Fig. 2. Typical example of perforated steel armor plates developed in scientific community [18,24-27]

One major drawback of the current steel perforated add-on armor is the inconsistency of effects produced on the projectile [17]. Both core breaking and deviation are highly dependent on the projectile point and angle of impact [28]. At a normal impact on the center of a perforation the projectile it is affected to the smallest extent and no deviation occurs (Fig.3).

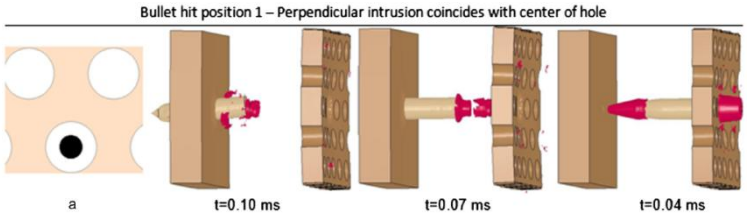

Fig. 3 Unaffected core passing through a hole [17]

4. Conclusions

Based on previous considerations, the following conclusions can be drawn:

- The add-on amour barriers made of perforated steel plates posses a ballistic protection capability similar to ceramic faced
- The potential of perforated amours is given by the ability to disrupt the amour piercing core
- One major drawback of the current steel perforated add-on armor is the inconsistency of effects produced on the projectile

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