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RELATIVELY ANALYSIS OF EXPERIMENTAL AND NUMERICAL RESULTS IN RESPONSE TO IMPACT BETWEEN PIERCING – INCENDIARY BULLETS AND ARMOURED SKIN

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ABSTRACT
This paper proposes the analysis of experimental and numerical results in response to accomplishment of some experimental tests. Experimental tests have consisted in executed experimental firing into a rifle range. Materials used to experimental firings are : armament, ammunition, armoured skin and ballistic protection equipment. Armament consist in Barinov ballistic barrel, Levaşov ballistic barrel and 14,5 mm calibre machine gun mounted on armoured amphibious transporter (MTB). Ammunition is represented by 7,62x54, 12,7x108 and 14,5x114mm calibre piercing – incendiary bullets. Armoured skin consist in 6 mm thickness armour plate. Ballistic protection equipment is constituted by bulletproof jacket. The impact process between 14,5x114mm calibre piercing – incendiary bullet and 6 mm thickness armour plate was moulded by „Ls-Dyna" support, which is a finite elements program for dynamics analysis of structures.
Keyword : piercing – incendiary bullet, bulletproof jacket, armoured skin

1. INTERACTION TYPES BETWEEN PROJECTILE AND ARMOUR
Failure modes of targets and projectile are dependent on impact velocity, angle of obliquinty, projectile shape, relative dimensions of projectile and target in addition to material properties and their fracture behaviors.
The failure modes of plates impacted may be complex, involving several modes.

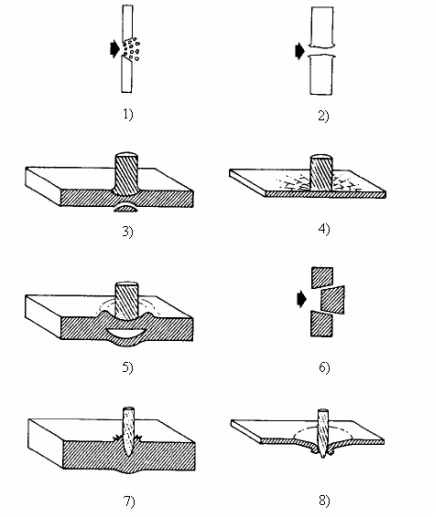

Figure 1. Typical failure (penetration) modes of impacted plates

Fig 1 shows typical failure modes of impacted plates used in this study :

1) Fragmentation ;
2) Ductile hole enlargement ;
3) Compression fracture ;
4) Radial fracture ;
5) Spal ;
6) Plug ;
7) Face petalling ;
8) Back-up petalling.

2. THE EXPERIMENTAL TESTS

2.1. The purpose of experimental tests

The purpose of experimental tests was the behaviour's analysis of some configuration constituted by armour and ballistic protection equipments, in response to firings execution by short calibre bullets.

2.2. The desciption of experimental tests

The experimental tests consisted in 7,62 x 54 mm, 12,7 x 108 mm and 14,5 x 114 mm calibre piercing incendiary bullets firings against some configurations consisting of 6 mm thickness armour plate and bulletproof jacket situated at 50 metres from firings arms.

First of all, firings have been executed against a 6 mm thickness armour plate. After bullets have penetrated the armour, the bulletproof jacket was fitted up on a device and placed at 300 mm distance from the armour.

The next 3 pictures show the effect of bullets used regarding configuration specified :

Figure 2. Impact between 7,62 x 54 mm calibre piercing incendiary bullets and configuration constituted by 6 mm thickness armour plate and bulletproof jacket

Figure 3. Impact between 12,7 x 108 mm calibre piercing incendiary bullets and configuration constituted by 6 mm thickness armour plate and bulletproof jacket

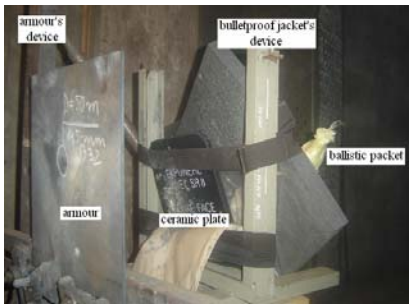

Figure 4. Impact between 14,5 x 114 mm calibre piercing incendiary bullets and configuration constituted by 6 mm thickness armour plate and bulletproof jacket

2.3. Materials used at experimental tests

Technical dates of the armament and ammunition used at experimental tests are presented in the following tables.

Table 1. Important technical dates of the armament used at experimental tests

Nr. crt.	Armament / Technical dates	Ballistic barrel Barinov	Ballistic barrel Levasov	M.T.B.
1.	Calibre	7,62 mm	12,7 mm	14,5 mm
2.	Barrel Lenght	755 mm	1.005 mm	1.276 mm
3.	Total lenght	900 mm	1.200 mm	1.480 mm

Table 2. Important technical dates of the ammunition used at experimental tests

Nr. crt.	Bullets / Characteristics	7,62 x 54 mm cal. piercing incendiary	12,7 x 108 mm cal. piercing incendiary	14,5 x 114 mm cal. piercing incendiary
1.	Velocity of barrel muzzle	830 m / s	820 m / s	945 m / s
2.	Energy of barrel muzzle	337 kgf m	1520 kgf m	2.910 kgf m
3.	Mass of bullet	9,6 g	51 g	64 g
4.	Core of bullet	Steel	Steel	Steel
5.	Mean mass of fling charge	3,00 – 3,30	16,00 – 17,00	31,00 – 33,00

The bulletproof jacket provide ballistic protection from bullets and fragments of conventional weapons. The components are ceramic plate and ballistic packet.

The ceramic plate protect the vital organs and abdomen and is composed from multi tile ceramic plates, covered with aramid fibres and resin, thicker to the human body to attenuate the impact with bullets or fragments.

3. ANALYSIS OF OBTAINED RESULTS

The experimental obtained results are presented in the next table.

Table 3. Obtained results in response to experimental tests

Ammunition used	7,62 x 54 mm calibre piercing incendiary bullet				12,7 x 108 mm calibre piercing incendiary bullet		14,5 x 114 mm calibre piercing incendiary bullet	
	Shot "1"		Shot "2"					
Target	Bulletproof jacket		Bulletproof jacket		Bulletproof jacket		Bulletproof jacket	
	Ceramic plate	Ballistic packet	Ceramic plate	Ballistic packet	Ceramic plate	Ballistic packet	Ceramic plate	Ballistic packet
Obtained results	Amprent	Unpenetration	Amprent	Partial penetration	Amprent	Partial penetration	Complete penetration	Complete penetration
Observations	-	-	-	11 penetrated fibres	-	21 penetrated fibres	-	33 penetrated fibres
Protection grade of each bulletproof jacket's component	50%	100 %	50%	66,7 %	50%	36,4 %	0 %	0 %
Protection grade of bulletproof jacket	75%		58,4%		43,2 %		0 %	
	67 %							

Even if armour doesn't offer maximum protection for the fighter from armoured vehicles, this mark has great enough importance, because, in response to the impact, it reduces the bullet's mass and penetration power.

Very grand importance of ceramic plate is remarked, because, containing high toughness ceramic plates, it sometimes stops the bullet to penetrate the target, or in other situations causes bullet's ricochet.

The ballistic packet has two very important tasks. First, to absorb shells sprinter formed in response to bullet-target impact and, second, to retain bullets ricocheted from the ceramic plate.

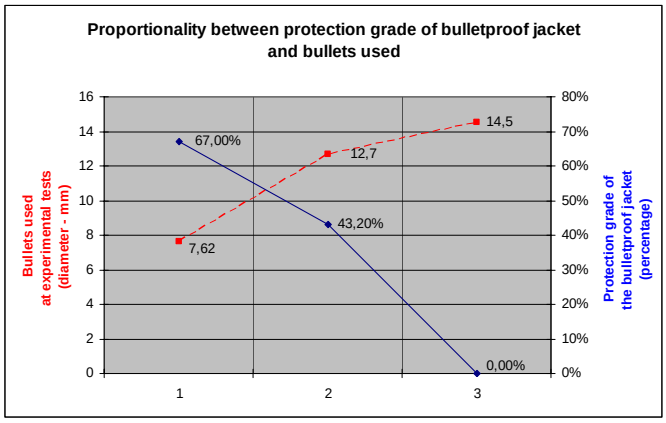

Figure 5. Proportionality between protection grade of bulletproof jacket and bullets used at experimetal tests

From the left figure, it can deduce that protection grade of bulletproof jacket, presented through the blue continue line is reverse proportional with bullets used at experimental tests, represented through the red dotted line.

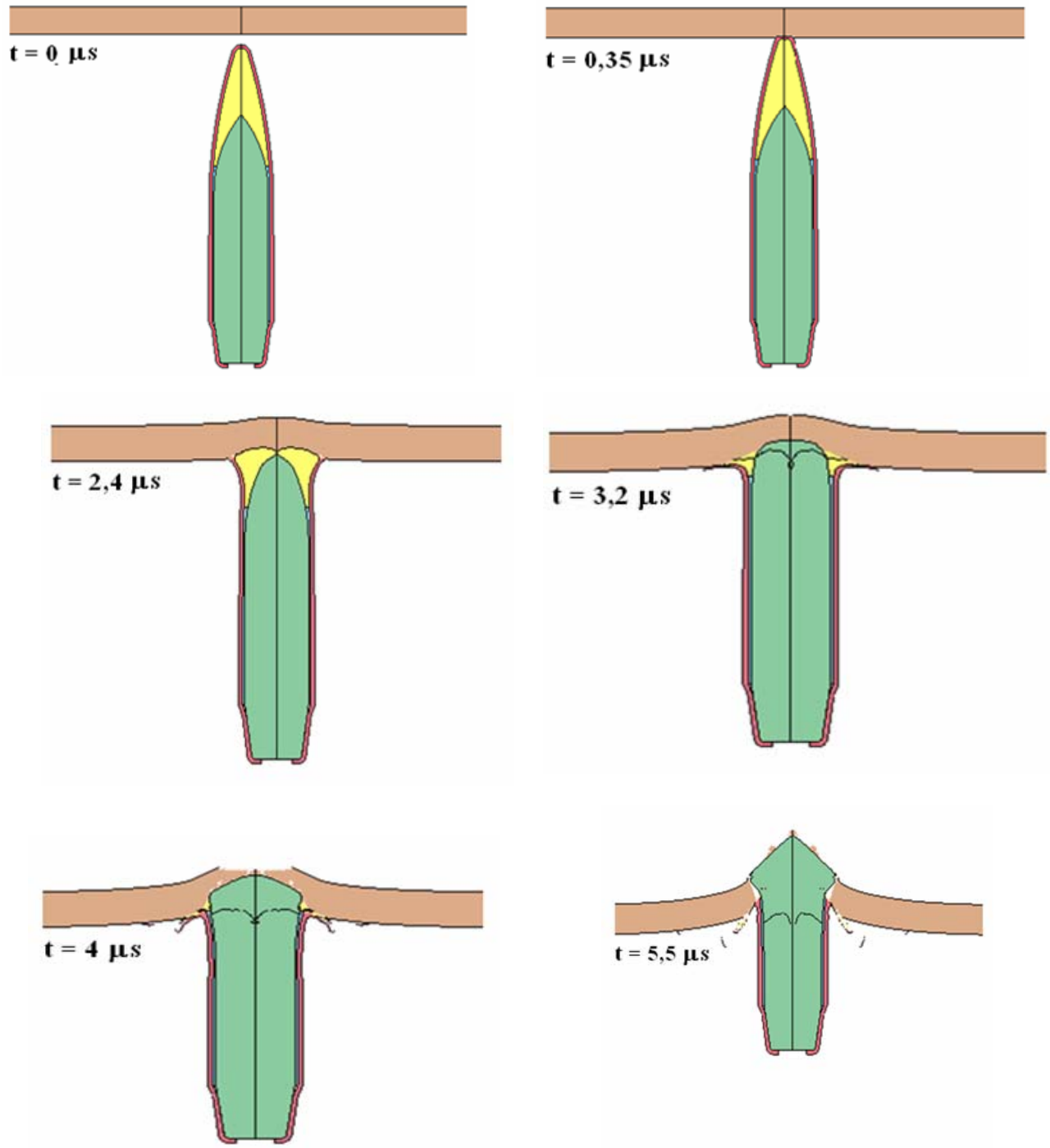

Figure 6. Important moments of the impact process between 14,5 x 114 mm piercing – incendiary bullet and 6 mm thickness armour plate

In the previous figure it can see some very importants moments of the impact process between 14,5 x 114 mm piercing –incendiary bullet and 6 mm thickness armour plate.
The first picture (t=0 µs) expresses the initial state of projectile and target. Projectile is represented by 14,5 x 114 mm piercing – incendiary bullet and target by 6 mm thickness armour plate.
The second picture (t=0,35 µs) presents the moment of impact, where both elements which generate the process start to deform.
The next three pictures (t=2,4 µs, t=3,2 µs, t= 4 µs) show steps of armour plate's fracture by the bullet. The last picture (t=5 µs) is dedicated to complete penetration.