A study of the ballistic protection mechanism of two kinds of structure against 7.62×54 mm ball ammunition

Guofei LI
E-mail: L_guofei@126.com
Inner Mongolia Metal Material Research Institute

Introduction

- The 7.62×54 mm ball ammunition is an important threat for the military used vehicle, shelter and soldier itself.
- Most of the work published focused on the penetration mechanisms of the steel-cored armor piercing bullets. In this work, the penetration behavior of the 7.62×54 mm mild steel core ball ammunition was studied.
- Two kinds of structure was studied here, which one is consisted with silicon carbide (SiC) ceramic and Ultra High Molecular Weight Polyethylene (UHMWPE), and the other is UHMWPE only.
- The purpose of this work is to find the better one of the two tested structure and to find the usually defeating mechanism of this type ammunition.

Experimental set up

Target materials

- **SiC:** hexagon, edge length 17.5mm; thickness: 3mm, 4mm, 5mm; Flexure strength: 400Mpa; Vickers hardness: 2.4Gpa.
- **UHMWPE laminate:** fiber tenacity was 38CN/dtex; water-based polyurethane resin.
- Two structure was used. Areal density was from 20.3 to 27.9kg/m^2.

Projectile

- 7.62×54 mm ball ammunition
- Nominal mass: 9.6 g
- Core hardness: HRB 95

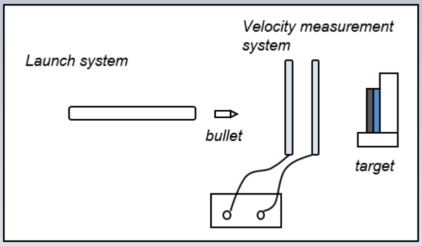
Ballistic experiment

- Firing distance: 10 m
- normal angle: 0°

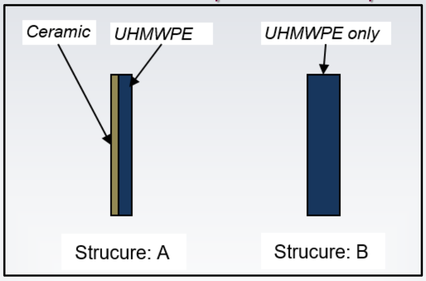
Core recovery and measurement

- The core was recovered from UHMWPE back plate
- The final length and mass was measured

bullet used in the experiment



Schematic of experimental set-up



Tested two kinds of structure

Computational modeling

Material Model

- SiC: JH-2 material model. Material data was from AUTODYN material database.
- UHMWPE laminates: Orthotropic material model. Material data proposed by Lassig T et al. [1] was used.
- Bullet (including steel core, jacket, lead filler) : Johnson-Cook strength and failure model. Material data published by Carbajal et al. [2] was used

Computation Model

- ANSYS AUTODYN was used
- The core, jacket, lead filler and ceramic were modeled using SPH (smooth particle hydrodynamics) dynamic.
- The UHMWPE laminate back plate was modeled using Lagrange dynamic.
- A 2D axial symmetrical set-up was used with particle size of 0.1 mm.

Impact event	Impact variables				Damage*	Measured parameters		
	Target ID	Ceramic thickness [mm]	UHMWPE thickness [mm]	Areal density [kg/m^2]		Impact Velocity [m/s]	Core length [mm]	Core mass [g]
1	C3+12-1	3mm	12mm	23.4	PP	836	17.5	4.56
2					CP	842	NA	NA
3	C3+12-2	3mm	12mm	23.5	PP	845	17.9	4.65
4					CP	839	NA	NA
5	C4+12-1	4mm	12mm	26.7	PP	834	17.2	4.56
6					CP	838	NA	NA
7	C5+10-1	5mm	10mm	27.9	PP	850	15.2	3.8
8					PP	835	16.2	4.2
9					PP	845	15.0	3.8
10	C0+20-1	0	20mm	20.3	PP	830	17.5	4.7
11					PP	832	17.2	4.7
12					PP	824	18.0	4.7

Recovered cores from ballistic tests, (a) original core; (b) recovered from C3+12; (c) recovered from C5+10; (d) recovered from C0+20

RESULTS

Ballistic experiment results

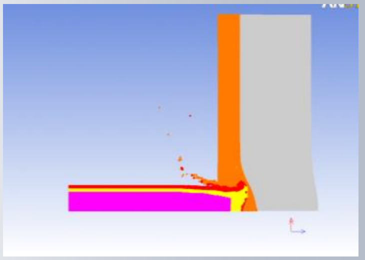
- The ballistic result of tests was list in the table above.
- UHMWPE plate was more effective than Ceramic/UHMWPE composite with a lower areal density

The effect of ceramic thickness

- It was found that the thicker the ceramic, the greater level of erosion.
- The core was mainly mushrooming but erosion by the target with ceramic thickness with 3 mm and 4 mm. Otherwise it was highly erosion by the ceramic for the thickness with 5 mm.
- The core was nearly erosion with the UHMWPE target.

The effect of the jacket and filler

- The computational result indicates that the presence of the lead filler and the jacket pre-damages the ceramic and acts to penetrate into ceramic before core arrival.



Penetration of the projectile into 3 mm SiC backed by the UHMWPE laminate plate

CONCLUSIONS

- The main effect of ceramic strike face was eroding the steel core, rather than breaking the core in the scene of defeating AP round.
- The presence of the lead filler and the jacket tends to pre-damage the ceramic face plate. So there is a critical thickness with the ceramic strike face to erode the steel core in the ceramic/ UHMWPE structure.
- UHMWPE laminate composite is more effective than the ceramic faced structure to defeat the 7.62×54mm ball ammunition.

REFERENCES

1. Lassig T et al. INT J IMPACT ENG 75 110-22
2. Carbajal L et al. 2011 Experimental and Applied Mechanics, Volume 6 pp 651-68