Simulations on the Reactive Material Projectile Coated by Explosively Formed Penetrator

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Abstract

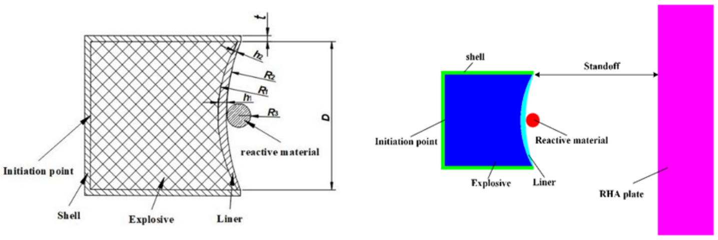
A typical shaped charge structure enhanced by reactive material projectile is established by AUTODYN-2D software. The formation and penetration processes of reactive inner core-wrapped compound EFP are simulated and analyzed. The results show that the segment liner with thick axis and thin edge becomes a penetrator with a lower velocity in the axis and a higher velocity in the edge under the shaped charge effects, which leads to EFP flipping forward and coating the reactive material projectile. The impacts between liner and reactive material projectile further increase the velocity difference between the axis and the edge, resulting in a better coating effect. The formation process is divided into three phases, including impact, coating and stretching. Then, the damage process contains penetration and deflagration of the following reactive material projectile. The liner thickness difference, curvature radius of the segment liner and radius of the reactive sphere all have important influences on formation and penetration of the reactive inner core-wrapped compound EFP.

Introduction

Explosively Formed Projectile (EFP) has been used widely in military to attack light and medium armored vehicles and can effectively penetrate these targets within limits of standoff , due to its high speed, high mass conversion and satisfied flight stability. However, feeble ability of second damage after EFP penetrating targets seriously restricts the development and improvement of the shaped charge warhead technology. In recent years, technology of the reactive material projectile coated by EFP has been extensively studied to solve this problem.

Simulation method

The shell thickness t=2mm, explosive diameter D=50mm, explosive length L=50mm, liner curvature radius R_1=50mm, liner thickness in the axial direction h_1=3mm, liner thickness in the edge h_2=0.75mm, reactive sphere radius R_3=4mm.



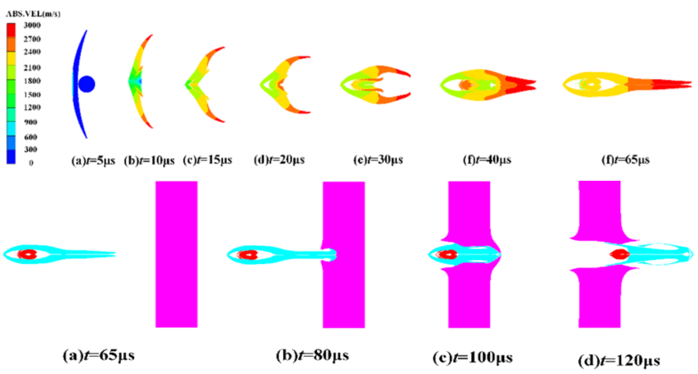
Parameters of 8701 explosive

ρ_0(g/cm^3)	D(m/s)	A(GPa)	B(GPa)	R_1	R_2	ω	E_0(GPa)	P_{CJ}(GPa)
11.71	8315	524.23	7.678	4.2	1.1	0.34	8.499	28.6

Parameters of copper, PTFE/Al and 45# steel.

material	ρ(g/cm^3)	A'(MPa)	B'(Pa)	C	n	m
copper	8.96	90	292	0.025	0.31	1.09
PTFE/Al	2.27	8.044	250.6	0.4	1.8	1
45#steel	7.83	792	510	0.014	0.26	1.03

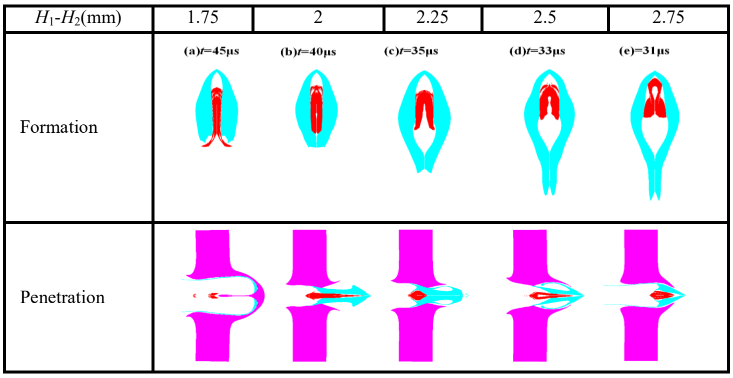
Formation and penetration process



Formation process is divided into three phases, including impact, coating and stretching. Penetration process produces penetration-deflagration behavior, chemical reaction behavior of reactive material cannot be simulated, but simulation has some guiding significance for further study.

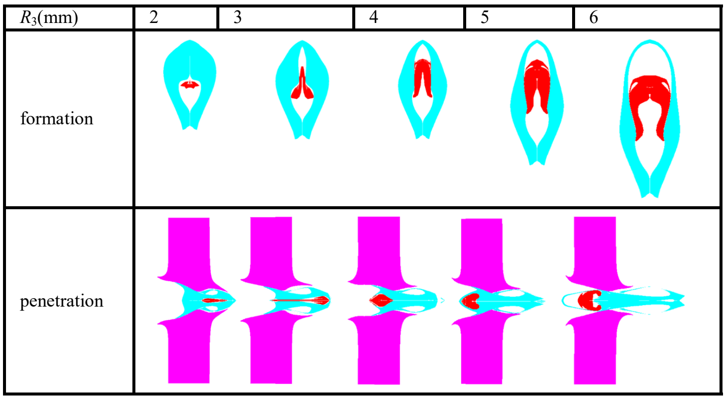
Influence mechanism

Liner thickness difference



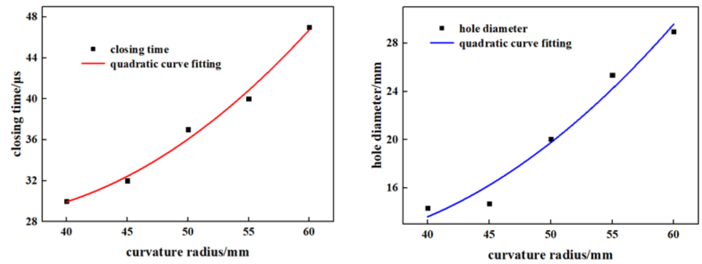
With increase of liner thickness difference (H_1-H_2), closing time of EFP is gradually decreasing, length-diameter and head of EFP increase. They have the same penetration diameters when H_1-H_2 varies from 2mm to 2.75mm, however, there are bigger hole diameter when H_1-H_2 =1.75mm.

Reactive sphere radius



Based on reactive sphere coated by EFP, improvement of reactive material can effectively strengthen this warhead penetration and detonation ability.

Liner curvature radius



With increase of liner curvature radius, EFP needs to spend more time coating reactive sphere, hole diameter of penetration also increases.

Conclusion

(1)The segment liner with thick axis and thin edge can coat reactive material under shock wave and form a projectile with penetration and detonation, it sharply improves shaped charge warhead mutilate ability.

(2)The formation process is divided into impact phase, coating phase and stretching phase. The damage process contains penetration and deflagration of the following reactive material projectile.

(3)The liner thickness difference, reactive sphere radius and curvature radius have important influences on formation and penetration of the reactive material projectile coated by EFP. The bigger liner thickness difference is, the larger the length-diameter of projectile is. Based on reactive material coating by EFP completely, bigger reactive sphere radius is good for second damage of projectile. In order to improve EFP coating and penetrating ability, curvature radius takes the median.