Effect of inner liner material on penetration behavior of reactive material double-layered liner shaped charge

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Abstract: To improve the insufficient penetration depth of the traditional single reactive liner shaped charge, the penetration enhancement behaviors of a reactive material double-layered liner (RM-DLL) shaped charge are investigated. This RM-DLL consists of an inner liner with metal materials and an outer liner with (polytetrafluoroethylene) PTFE/Al reactive materials. Based on the platform of AUTODYN-2D code, the influence of inner liner material on the jet formation of RM-DLL shaped charge and its penetration performance of multi-layered space plates were conducted. The numerical results indicated that, during the jet formation stage, the inner metal liner mainly formed a high-velocity precursor jet and the outer reactive liner became a major part of the slug. With increasing the material density of inner liner, the jet tip velocity and tip diamater decreased, and the effective mass of precursor jet also dropped off. For a given penetration time, with the increase in the material density of inner liner, the penetration capability of the RM-DLL shaped charge increased, whereas the mass of reactive materials entering the penetrated steel target decreased significantly. This RM-DLL shaped charge, incorporating the penetration capability of a precursor metal jet and the deflagration effects of the follow-thru reactive materials, will produce extremely damage to the desired target, typically such as the armored fighting vehicles.

This paper presents such a research, firstly, the metal liner material affecting on the jet formation is investigated based on AUTODYN-2D code. Then, a series of simulations are carried out to discuss the influence of the metal liner material on penetration behavior of the RM-DLL shaped charge against a multi-layered target. We expect that this work would have potential guidance and reference in the design of shaped charge with reactive material liner.

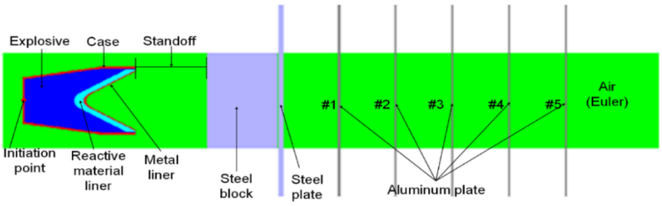


Figure 1. Penetration schematic of the RM-DLL shaped charge against a multi-layered target

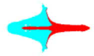
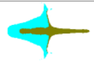
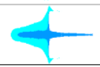
Material	Jet characteristics before penetrating	Jet tip velocity (m/s)	Jet tip diameter (mm)	Jet length (mm)	Jet formation time (μs)
Reactive material-aluminum jet		7279	7.8	110	24.2
Reactive material-titanium jet		6754	6.2	109.5	25.4
Reactive material-steel jet		5637	4.2	109.2	28.2
Reactive material-copper jet		5600	4.0	108.6	28.9
Reactive material-tantalum jet		5289	2.2	108.5	31.1

Figure 2. Jet formation characteristics of RM-DLL shaped charge at standoff of 1.0 CD

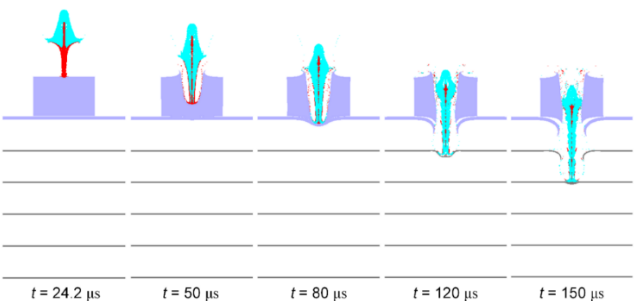


Figure 3. Numerical results of reactive material-aluminum jet against a multi-layered target

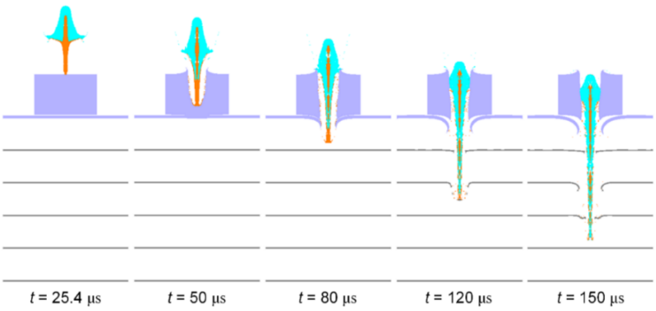


Figure 4. Numerical results of reactive material-titanium jet against a multi-layered target

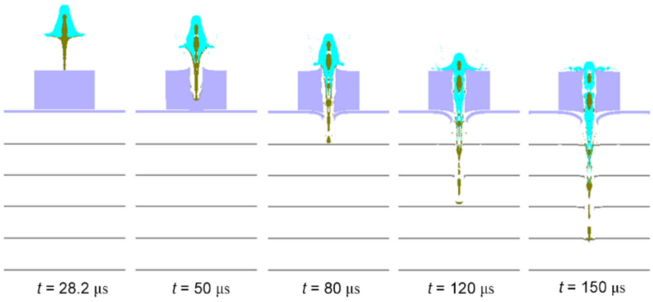


Figure 5. Numerical results of reactive material-steel jet against a multi-layered target

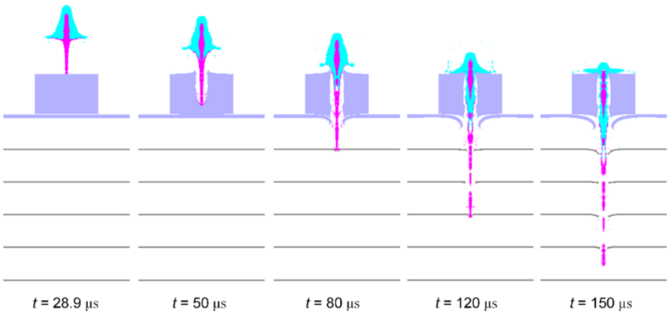


Figure 6. Numerical results of reactive material-copper jet against a multi-layered target

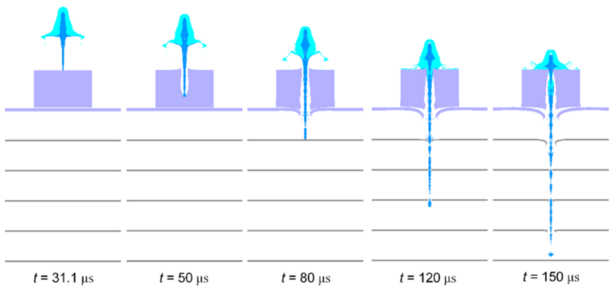


Figure 7. Numerical results of reactive material-tantalum jet against a multi-layered target

Conclusions：(a) Numerical simulations of the jet formation indicated that, for the RM-DLL shaped charge with different metal liner materials, the high-velocity precursor jets all were formed by the inner metal liners, and the major parts of the slugs were developed with the outer reactive material liners.

(b) For a given thickness of reactive material liner and metal liner, with increasing the material density of metal liner, the composite jet tip velocity and average jet tip diameter decreased dramatically while the time of jet formation increased.

(c) The material of metal liner significantly influenced on penetration performance of the RM-DLL shaped charge, with increasing the material density of metal liner, penetration performance increased while the enhance hole-diameter on the steel block decreased, eventually resulting in a dramatic reduction in the mass of reactive materials entering the spaced aluminum plates.