Effect of the Cover Sheet at Ballistic Performance of the Composite Structures

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Objectives and goals

- The process of the interaction of the fast projectiles with composite structures is extremely complex multi-stage and multi-parametric process. Quantitative prediction of the performance of such systems needs intensive computational modeling.
- Interpretation of numerical models is not always simple. Particularly, it is not simple to extract information about the influence of the material properties of different structural constituents on the overall structure performance, which attracts significant attention of scientist and engineers and can have sufficient practical applications.
- Here we will focus on the effect of the ceramic confinement on the early stages of the ballistic event .

The model of the acoustic stage

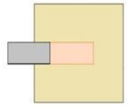
Integral mass conservation law: *Accumulated mass loss*

$$\pi R^2 \rho_0 X = \pi R^2 \rho^* (X - H) + \int_0^t J dt$$

Integral momentum conservation law: *Accumulated loss of the momentum with mass*

$$M_p V_o = \pi R^2 \rho^* \dot{H} (X - H) + \int_0^t J V^* dt - \int_0^t F dt$$

Impulse of the force

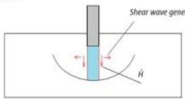


Equation of the shock front motion:

$$\dot{X} = C_0 + S\dot{H} \qquad X = C_0 t + SH$$

Model of the force:

$$F = -2\pi R z (X - H) \dot{H}$$



$$z_S = -i\rho c_S \frac{H_1^{(2)}(kR)}{H_0^{(2)}(kR)}$$

Model of the momentum loss (parametrization of openness):

$$V^* = \alpha \dot{H} \qquad \begin{cases} \alpha = 0 & \text{- Closed cavity case} \\ \alpha = 1 & \text{- Open cavity case} \end{cases}$$

Shock front conditions:

Final equations and the results.

$$\frac{d\eta}{dt} = p \qquad \eta = \frac{H}{R} \quad p = \frac{V_p}{C_{Cl}} \quad t = \frac{t_{phys} C_{Cl}}{R} \quad m = \frac{M_p}{\pi R^3 \rho_C} \quad \alpha = \frac{V^*}{\dot{H}} \quad \nu = \frac{C_{CS}}{C_{Cl}}$$

$$\frac{dp}{dt} = -\frac{(1+(S-1)p)^2 \left((1+Sp)p + Z\nu(t+(S-1)\eta)\right)}{m(1+(S-1)p)^2 + (t+(S-1)\eta)(1+\alpha p + S(S-1)p^2 + 2Sp)}$$

$\rho_C = 4000$ kG/m^3 $\quad C_l = 8660$ m/s $\quad C_S = 5000$ m/s $\quad S = 0.1$

$Hh = 0.025$ m $\quad M_p = 0.025$ kG $\quad R = 0.01$ m $\quad V_{p0} = 1000$ m/s

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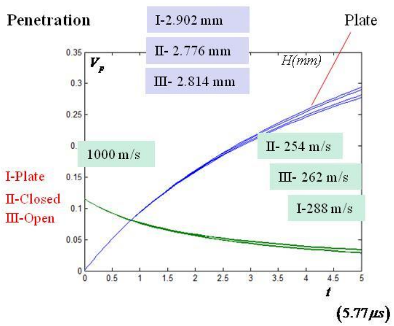
$\rho_C = 4000$ kG/m^3 $\quad S = 0.1$

	Scenario	[illegible]	[illegible]
	Plate a=0 (closed)	[illegible]	[illegible]
Worst case	Plate a=1 (open)	2.942	297
	Projectile a=1 (open)	2.814	254
Best case	Projectile a=0 (closed)		245

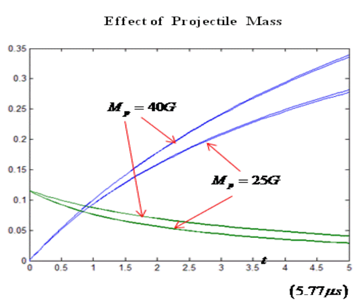
Maximal effect in terms of residual velocity~((297-245)/245)*100%=21%

$$p \sim 0.025kG * \frac{1000 \text{m/s}}{5*10^{-6} s} = 15.9 \text{ GPa}$$

Penetration as a function of the scenario



Effect of projectile mass



Effect of Confinement. Conclusions

•On the acoustic stage of the ballistic event the effect of confinement provides under considering parameters of construction potential 12-17% increase in decelerations force, the residual velocity of projectile decreases at least at 3-4% (21%-in the best case).

• The major effect has the creation of the added mass in front of projectile by the emission of shear waves due to moving of the cylindrical "pre-plug".

• Thus, the major properties of the material on this stage are: acoustic impedance and ability to withstand stress, which defines the duration of effect of impedance.

ACKNOWLEDGEMENTS

Authors are grateful for the ARL team and personally T. Bogetti for support and fruitful discussions.

Reviewed & Approved – (Type name upon approval)

Advisor __J. W. Gillespie Jr.____ Sponsor__ARL____________