ANALYSIS OF OBLIQUE PERFORATION OF CONICAL AND OGIVE PROJECTILES INTO THIN METALLIC TARGETS

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Abstract: In this note, a theoretical and analytical model of the conical and Ogive projectile penetration into metallic targets under oblique impact is presented .The failure is assumed to be asymmetry petaling and the analysis is performed by using the energy balance and work done .The done work consist of the required work for plastic transformation W_p, the work for transferring the matter to new position W_d and the work for bending of the petals W_b.
The analytical model can be predicated the value of final and ballistic velocity of the impact by using the energy balance.
In this present study, by assuming the crater formation, the value of work done is calculated during the oblique penetration of conical projectile into thin metallic targets.
The work done consist of the required work for plastic transformation W_p, the work for transferring the matter to new position W_d and the work for bending of the petals W_b.
In several studies [3,9], it has been shown that we can neglect the loss of energy by temperature (friction) .We also neglect the plastic work in dishing target plane. Although this loss of energy isn't important in speeds very higher than ballistic limit, but in speeds near to ballistic limit is considerable.
As will be shown, W_p, W_d, W_b for conical projectile are:

$$W_p = \frac{\pi}{2} b^2 Y \frac{h_\circ}{\cos\theta} \tag{1}$$

$$W_d = \rho h_\circ b^2 V_i^2 \tan^2\alpha(1-\tan\alpha\tan\phi)^2.\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{1}{[(1-\sin^2\phi\sin^2\delta)^{\frac{1}{2}}+\tan\alpha.\sin\phi\sin\delta]^4}d\delta\right)$$

$$+2\rho h_\circ V_i^4 \tan^4\alpha\left[\int_{t_2}^{t_3} t.\left(\int_{\delta^{***}}^{\frac{\pi}{2}} \frac{1}{[(1-\sin^2\phi\sin^2\delta)^{\frac{1}{2}}+\tan\alpha.\sin\phi\sin\delta]^4}d\delta\right)dt\right] \tag{2}$$

$$W_b = \frac{Y h_\circ^2 b}{2}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{[\frac{\pi}{2}+\sin^{-1}(\sin\phi\sin\delta)]}{(1-\sin^2\delta\sin^2\phi)^{\frac{1}{2}}}d\delta \tag{3}$$

The total work done during penetration is equal to:

$$W = W_p + W_d + W_b \tag{4}$$

The residual speed can be obtained by using the energy balance equation.

$$\frac{1}{2}m(V_i^2 - V_r^2) = W \quad \textbf{(5)}$$

Therefore:

$$V_r = (V_i^2 - \frac{2W}{m})^{\frac{1}{2}} \quad \textbf{(6)}$$

If V_r =0, the ballistic limit is computable.

$$V_b = (\frac{2W}{m})^{\frac{1}{2}} \quad \textbf{(7)}$$

For projectiles with ogive nose W_p , W_b are the same conical projectiles, but W_d is dependent to nose shape .profile of a ogive projectile is

$$y = \sqrt{\left(d\left(C^2 + \frac{1}{4}\right)\right)^2 - x^2} - \left(d\left(C^2 - \frac{1}{4}\right)\right) \quad \textbf{(8)}$$

A simpler approximation formula can also be used:

$$y = \frac{d}{2} - \left[\frac{x^2}{2 \times L \times C}\right] \quad \textbf{(8)}$$

Where:
L = cone length, d = cone base diameter, C= the caliber of the cone (C= L/d).
Therefore we can calculate the work for transferring the matter to new position ,W_d ,with numerical methods.