Determination of main parameters of jet penetration into the homogenous steel obstacle

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The theoretical and experimental determinations of kinematic and dynamic parameters of the shaped charge jet necessary to analyze the process of jet penetration have been realized. The procedure of the experimental determination of jet penetration velocities is given as well as the critical jet velocity during the penetration into the homogenous obstacle. The procedure is based on the use of the logic analyzer and special captures to record the discrete data of the curve - the penetration length depending on time. A polynomial form of that mathematically fitted functional curve gives the possibility to determine the critical jet penetration velocity. Also, the results of the experimental determination of the penetration velocities of the copper shaped charge jet during the penetration into the homogenous steel obstacle are shown. The use of these results, obtained by the given procedure, in the program code for a numerical simulation of the shaped charge function and jet penetration, enables a more accurate calculation of jet kinematic and dynamic parameters (velocities, contact pressures, etc.) and penetrability in to obstacles of different mechanical properties.

Key words: **physics of explosion, shaped charge, jet penetration, critical velocity, contact pressure.**

Denotations and abbreviations

A
a_0
a_1
a_3
a_4
Cu
l
n
p_x
p_{cr}
r
r_m
t
t_{cr}
$u = v_j$
u_x
u_{x0}
v_0
v_x
v_{jcr}
α
α_m
α_p
ρ_0
ρ_x
$\rho_{m\,x}$
$\rho_{m\,0}$
$\rho_{p\,x}$
$\rho_{p\,0}$
HB
HRC
$HP\text{-}4$
GAO

Introduction

Theory

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$$u_x = u - \sqrt{p_x\left(\frac{}{\rho_m} - \frac{}{\rho_{mx}}\right)} = \sqrt{p_x\left(\frac{}{\rho_p} - \frac{}{\rho_{px}}\right)}$$

v_x v_0 -α

$$u_x = \frac{u}{+\sqrt{\frac{\alpha_m}{\alpha_p}\frac{\rho_p}{\rho_m}}}$$

$$p_x = \frac{\rho_m\ u}{\left(\sqrt{\alpha_m} + \sqrt{\alpha_p \frac{\rho_m}{\rho_p}}\right)}$$

$$p_x = A\left[\left(\frac{\rho_x}{\rho}\right)^n - \right]$$

α

$\alpha = -\rho_x/\rho$

$$\alpha = -\frac{}{\left(+\frac{p_x}{A}\right)^{\overline{n}}}$$

[ ]

r_{mp} *internal pressure in the obstacle material*

p_{cr}

u_{x0}

$$u_x = u\sqrt{\frac{}{\left(+\sqrt{\frac{\alpha_m\rho_p}{\alpha_p\rho_m}}\right)} - \frac{p_{cr}}{\rho_p}\frac{\alpha_p}{u}}$$

u_{x0} =0

p_x= p_{cr}

u u_{cr} v_{jcr}

u u_{cr} v_{jcr}

u_x u

$$u_{cr} = v_{jcr} = u\left(+\sqrt{\frac{\alpha_m}{\alpha_p}\frac{\rho_p}{\rho_m}}\right)$$

u_x u

u_x u

u_x

u_{cr}

p_x $p_x = p_{cr}$

$$p_{cr} = \frac{\rho_m\ u_{cr}}{\left(\sqrt{-\frac{}{\left(+\frac{p_{cr}}{A_m}\right)^{\overline{n_m}}}} + \sqrt{\frac{\rho_m}{\rho_p}\left(-\frac{}{\left(+\frac{p_{cr}}{A_p}\right)^{\overline{n_p}}}\right)}\right)}$$

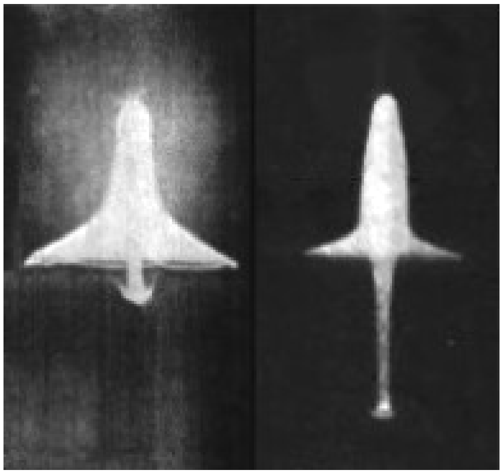
Calculation of the kinematics parameters of the shaped charge jet

τ μs τ μs

Figure 1.

Table 1.

i	v_j	Δl_j	Δm_j	v_n	Δl_n	Δm_n



τ μs τ μs

Figure 2.

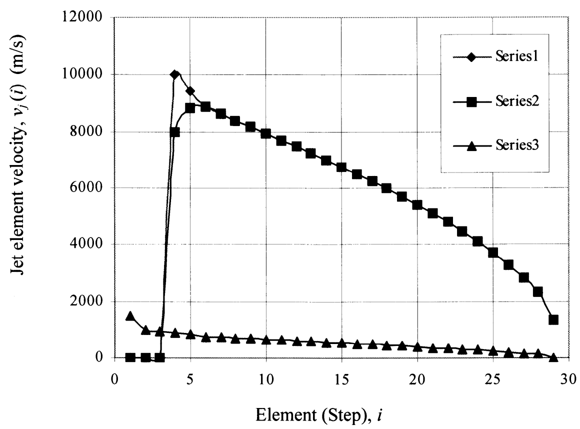


Figure. 3.

Figure 4.

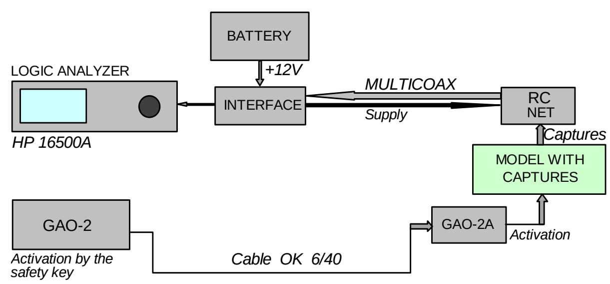


Figure 5.

Experiment

HP

r_m HB

u_{x0}

t t_{cr} μs

t_{cr} μs

v_{jcr}

l p_{cr}

$$l(t) = a\,t \;\; + a\,t \;\; + a\,t + a$$

a

a a a

r

$$u_x \;\; = \frac{dl(t)}{dt} = \;\; a\,t \;\; + \;\; a\,t + a$$

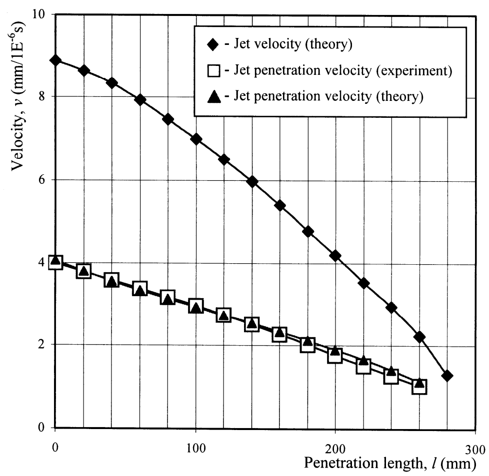


Figure 8.

v_j i c_{Steel}

Conclusion

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Sciences et techniques de l'armament,

Određivanje osnovnih parametara prodiranja mlaza kroz homogenu čeličnu prepreku

Rad obrađuje rezultate teorijsko-eksperimentalnog određivanja kinematičkih i dinamičkih parametara kumulativnog punjenja neophodnih za analizu procesa prodiranja mlaza. Izložena je metoda eksperimentalnog određivanja brzina prodiranja kao i postupak određivanja kritične brzine prodiranja kroz homogenu prepreku. Metoda je zasnovana na primeni logičkog analizatora i specijalnih davača koji se koriste za registrovanje diskretnih podataka krive - dužina probijanja u zavisnosti od vremena. Ovako dobijena matematički fitovana kriva polinomijalnog oblika omogućava određivanje kritične brzine mlaza. Takođe su prikazani rezultati eksperimentalnog određivanja kritične brzine mlaza formiranog dejstvom kumulativnog punjenja s bakarnom oblogom pri prodiranju kroz homogenu čeličnu prepreku. Korišćenje ovih rezultata u programu HYDRO za numeričku simulaciju funkcije kumulativnog punjenja i penetracije mlaza omogućava tačnije određivanje kontaktnog pritiska i probojnosti kumulativnog mlaza na preprekama različitih mehaničkih karakteristika.

Ključne reči: **fizika eksplozije, kumulativno punjenje, prodiranje mlaza, kritična brzina, kontaktni pritisak.**

Détermination des principaux paramètres de la pénétration du jet dans l'obstacle d'acier homogène

Les paramètres dynamiques et cinématiques du jet de la charge creuse, nécessaires pour l'analyse du processus de pénétration du jet, sont déterminés par la voie théorique et expérimentale. Le procédé de la détermination expérimentale des vitesses de pénétration est donné aussi bien que la vitesse criticale du jet pendant la pénétration dans l'obstacle homogène. Le procédé est basé sur l'application d'un analyseur logique et les capteurs spéciaux pour l'enrégistrement des données discrètes de la courbe – la longueur de la pénétration en fonction du temps. La forme polynômiale de cette courbe facilite la détermination de la vitesse criticale de pénétration du jet. Les résultats de la détermination expérimentale des vitesses de pénétration du jet d'une charge creuse en cuivre pendant la pénétration dans l'obstacle d'acier homogène sont également donnés. Ces résultats sont utilisés pour créer un programme pour la simulation du fonctionnement de la charge creuse et de la pénétration du jet facilitant ainsi le calcul des paramètres dynamiques et cinématiques du jet (vitesses, pressions de contact, etc.) et la pénétrabilité dans des obstacles aux propriétés mécaniques différentes.

Mots-clés: **physique de l'explosion, charge creuse, pénétration du jet, vitesse criticale, pression de contact.**