Original Contribution

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SHAPING THE PROCESS OF PENETRATION IN THIN TARGETS

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Abstract: *An analytic model is created describing the process of hitting thin targets. Mathematical expressions for determining the work for forming a stopper, for plastic expansion of the opening, work for friction and work done for heating are suggested.*

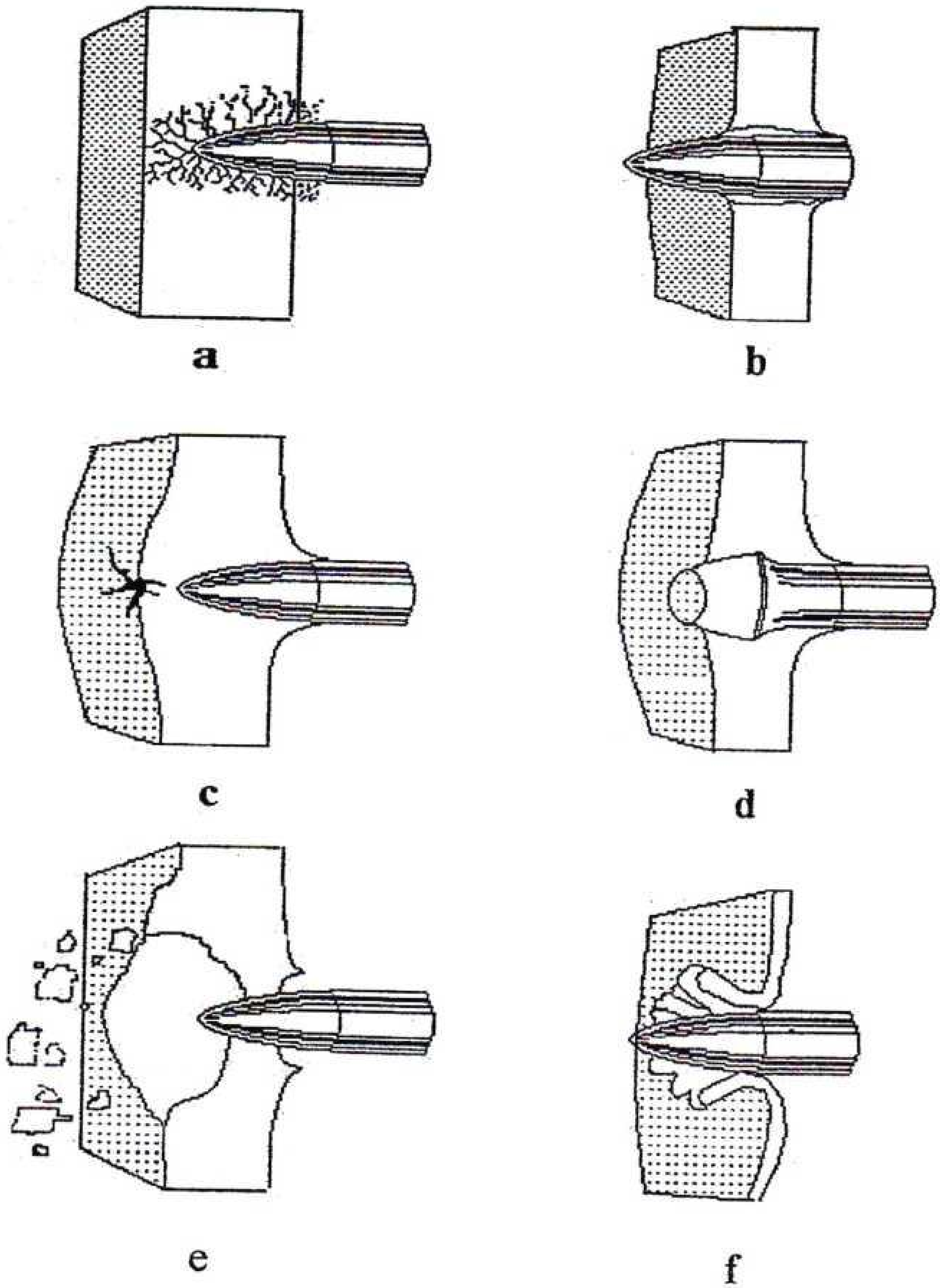
The basic destruction types of thin targets are showed in picture 1.

Usually one of the types may be dominating but they are often met in combination. In the present research 5,45 mm bullets are used with prolonged front part the central core of which is made of: steel 10, AÃ 13, 38XH3MÔA, 38XC - Ø, 65Ã, P6A2Ì5. The shooting is made with a ballistic tube from 50 m towards a target made of steel 20; 4; 6; 8 and 10 mm thick. The process of penetrating passes through three common stages and the forming of a stopper and its ejecting from the target is regarded to be a basic mechanism of the penetrating. During the first stage the moving may be ignored and it is considered as a stage of compactness in which the bullet feels the effect of the inertia strength and the strength of compactness.

The strength of compactness acting upon the bullet is determined by the strength of compactness of the target which is in contact with the bullet. Besides that it is supposed that on this stage of penetrating the mass of the

The second stage of penetrating comes with the moving of the forming stopper along the surface. The stopper will be ejected from the material. On this stage the power for moving the stopper emerging on account of the movement of a part of the material of the target fastened by the bullet is added to the acting strength of the bullet.

During the third stage the bullet and the stopper move together as a solid object overcoming the strength of the tangential tension which acts on the side surface of the stopper and along its whole length



Picture 1: Basic destruction types

a/ brittle destruction
b/ destruction with forming of radial leaks
c/ breaking to pieces
d/ plastic expansion of the opening
e/ ejecting a stopper
f/ forming an opening with a ring

It is necessary to import corrections in the model marking the plastic deformation in the smooth central cores and the brittle destruction of a part from the highstrong central cores. Besides that together with the ejecting of the stopper a plastic expansion of the opening combined with destruction by sagging is received. Similar model is developed in Tailor's and Vetne's works.

Connection between the penetrating and the expansion may be obtained only numerically. That is why it is interesting to know how good with Tailor's results the characteristics of the material of the barrier may be predicted, and these characteristics determine the armour piercing and the firmness against hitting.

From the models describing the destruction by sagging which is a basic kind of destruction in slim targets the further developed by Thomson Tailor's model is preferred. The work necessary for penetrating in conformity with this model is:

$$W = \frac{1}{2}\,\pi . a^2 . \sigma_s . h_o$$

σ_s- level of drawling of the material of the barrier

h_o- first thickness of the barrier

a- expansion of the opening from 0 to radius “r”

From the analysis of the existing theories it is obvious that still there isn't a full description of the process of penetrating. This is the reason for involving some other factors influencing this process.

If we mark the full work with A which is done during hitting of the steel barrier with A1 - work done for forming the stopper

A2 - work for expansion of the opening

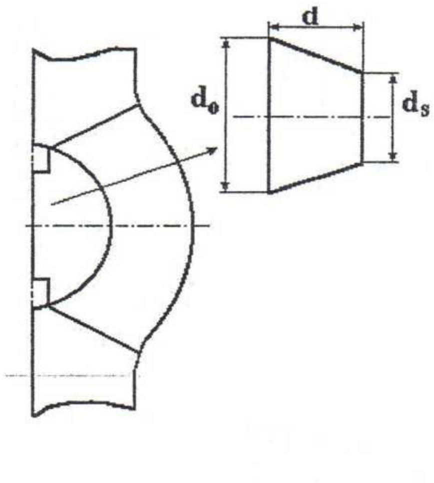
A3 - warmth used for heating the lead mantle

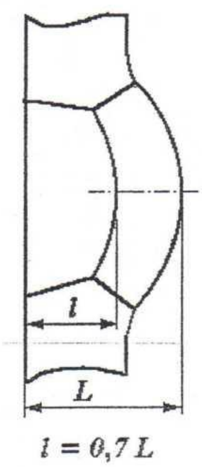
A4 - work for overcoming the friction strength appearing in the process of penetrating

A5 - warmth used for heating the central core

then: $\grave{A} = \grave{A}1 + \grave{A}2 + \grave{A}3 + \grave{A}4 + \grave{A}5$

where: $\grave{A}1 = n . rp^2 . \boldsymbol{\sigma}_s . lp$





Picture 3 Picture 4

rp - radius of the astopper

σ_s - level of drawling of the respective metal from which the target is made

lp - length of the stopper

À$_2$= $\sigma_0.(V_0'-V_s')= \sigma_0.\pi.(r_0^2-r_s^2).l$

$\sigma_0 - \sigma_s$ - the tension in which appear plastic deformations

V_0' - volume of the opening

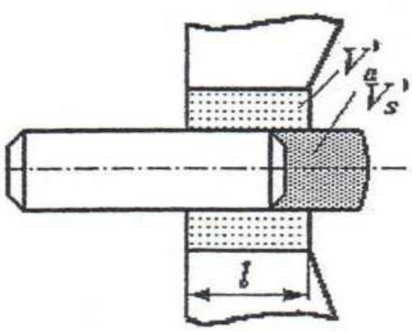
V_s' - volume the opening with diameter corresponding to the diameter of the central core

r_o - radius of the opening received plastic expansion

r_s - radius of the central core

$l \approx 0,7.$ L

L L - full thickness of the stable including the swelling that is obtained by forming a ring entrance+exit



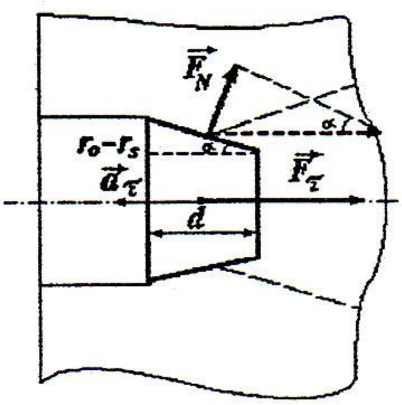
Picture 5

À$_3$=Ň$_{\text{Õâ}}$. m_r . ΔÒ

Ň$_{\text{Õâ}}$ -specific heat - capacity

m_r - mass of the lead mantle

ΔÒ - changing the temperature in the process of penetrating in the lead mantle ΔÒ = 300°C



F_τ - friction strength
F_N - normal strength
k- friction coefficient ê = 0,8... 1
a_τ – acceleration

Picture 6

$$|\vec{F}_\tau| = k \, . \, |\vec{F}_N|$$

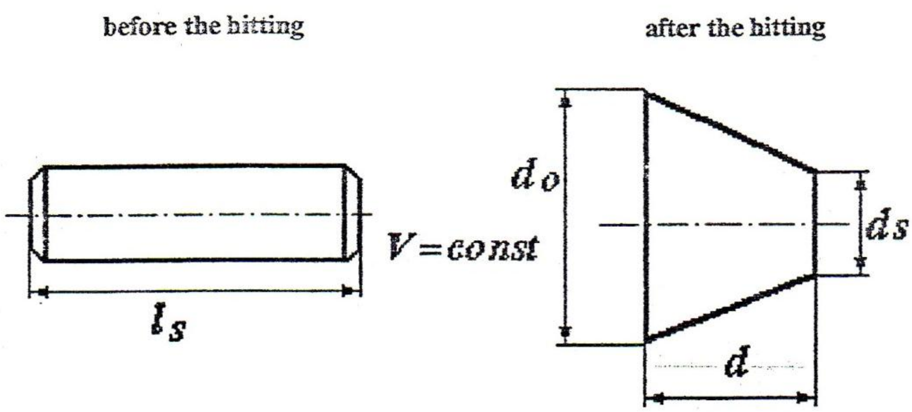
The acceleration a_τ of the stopper is determined from the formulas:

$$l_{st} = Vi \, . \, t - a.t^2/2$$
$$Vk = Vi - a \, . \, t$$
$$t = (Vi - Vk) / 2.a$$
$$l_{st} = (Vi^2 - Vk^2) / 2.a$$
$$a = (Vi^2 - Vk^2) / 2. \, l_{st}$$
$$m = ms + mp$$

ms - mass of the central core
mp - mass of the stopper
Vi - speed before the hitting Vi = 850 m/s
Vk - speed after the hitting

$$F_\tau = m.a; \qquad F_\tau = (ms + mp) \, . \, (Vi^2 - Vk^2) / 2. \, l_{\text{ïë}}$$

$$F_N = F_\tau \, . \, \sin\alpha$$



Picture 7

$$\pi . r_s^2 . l_s \approx \pi . d . (r_0 + r_s)^2 / 4$$
$$d \approx 4 . r_s^2 . l_s / (r_0 + r_s)^2$$
$$tg\ \alpha = (r_0 - r_s) / d \approx (r_0 - r_s) . (r_0 + r_s)^2 / (4. r_s^2 . l_s)$$

$$À4 = F_N . l_{st} = F_\tau . \sin\alpha . l_{st} = (ms + mp).(Vi^2 - Vk^2) . \sin\alpha . l_{st} / 2. l_{st}$$

$$À4 = (ms + mp).(Vi^2 - Vk^2) / 2 . \sin[arct\ (r0 - rs).(r0 + rs)^2 / (4. rs^2 . ls)]$$

l_S - length of the central core
lst - thickness of the stable
d - length of the central core after the hitting
$A5 = CFe. m_S . T$
CFe **-** specific heat - capacity of the iron CFe=500[J/°Kl
The kinetic energy when the bullet meet the barrier is:

$Å1 = m. Vi^2 / 2$

m - total mass of the bullet and after the hitting it is:
$Å2 = [(ms + mp). Vk^2]/2$
Knowing Å1 and Å2 we can determine what part of the bullet's energy is used for hitting the target

$\Delta Ò = Å1 - Å2 = m . Vi^2 / 2 - (ms + mp). Vk^2 /2$
Comparing the used work A and the loss of energy
formula (ΔT - A)/ ΔT. 100% we can determine the relative
result of the suggested model
In creating the analytic model of hitting the next limitations are made
- the diversion of the speed before the hitting in all experiments is ±5ì
- the lead mantle and the cover remain in the barrier
- after the penetration of the central core on 0,7 ***Lïë*** depth the stopper is
exit.

REFERENCES:
1. Grigoryan C.C, Dynamics Shot, World, M, 1986.
2. Dmitrievsky AA, external balistika, Engineering, M, 1982 ..
3. Woodward R. L., Int. J. Mech. Sci, 20, 349 (1988)
4. Woodward R. L., bit. J. Mech. Sci, 20, 599 (1988)