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Possibility of using a universal propellant charge for ammunition family fired from under barrel grenade launcher

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As part of the "21 Model pattern soldier" project, 40 mm ammunition family (FAM-40) was developed to be fired from under barrel grenade launcher.
According to the current requirements of our Armed forces, development FAM-40 was based on five new projectiles. To uphold tactical & technical requirements it was necessary to have a universal propellant charge for applicable for all, or at least the bulk of, projectiles, members of ammunition family. This paper deals with: theoretical analysis of the possibility to use universal propellant charge and analysing results of the performed experiments.
An projectiles from the ammunition family have the same muzzle velocity, same exterior ballistics characteristics, maximum pressure gasous products of propellant charge, under permitted limit and different weight.
General request for ammunition family are use universal constitutions and parts of projectiles.

Key words: **under barrel grenade launcher, ammunition, 40 mm caliber, projectile, propulsion, propellant charge, theoretical analysis, experimental results.**

Introduction

AS a part of "21 Model pattern soldier" project and the armament sub-system, automatic gun, under barrel grenade launcher (BGP-40) and 40 mm ammunition family (FAM-40) were developed. Under FAM-40 (Fig.1) project five projectiles for different purposes were designed. Every ammunition family has to meet general & special requirements of the particular weapon it is designed for. Among basic general requirements in case of FAM-40 projectiles, was to have the element design as unified as possible. This principle is equally important from tactical, technical and economic aspect.

Universal parts of the FAM-40 ammunition family are: fuse (UT M02 SP), shell with rotating band, base (for connection propellant charge), case (in function envelope) and propellant charge.

Propellant charge (Fig.2) is a subconstitution consisting of: case, foil pad, above pad, primer E-72S and nitrocellulose (NC) powder.

This paper aims to demonstrate for which spectrum mass of projectiles FAM-40, universal propellant charge may be used, satisfying the required tactical and technical aspect.

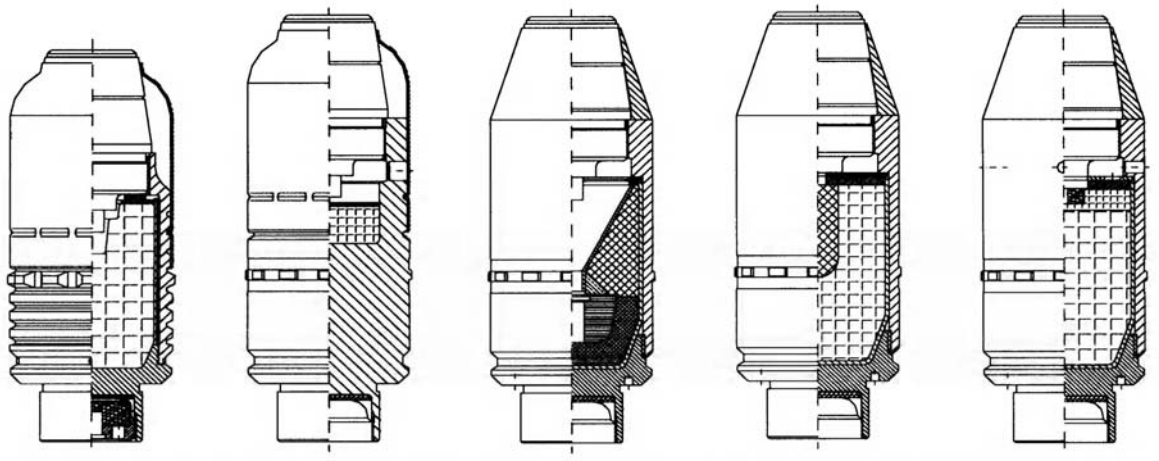

Figure 1. FAM-40 projectiles with unified positions (HE, practice marker, holow charge ,incendiary, smoke)

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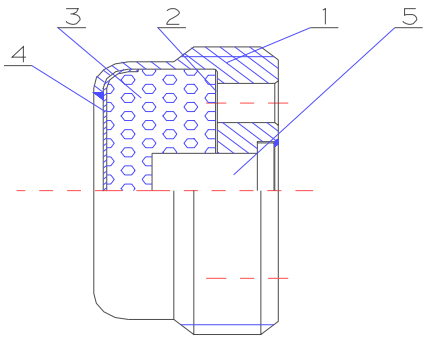

1. - case, 2. - foil pad, 3. - powder, 4. - above pad, 5. - primer E-72S

Figure 2. Propellant charge M02

It is worth stressing out that a difference in mass of the projectiles was noticed in the scatch-design phase. This problem couldn't have been avoided, preserving at the some time other design characteristics.

Theoretical analysis

Sight unit on BGP-40 has excellent characteristics enabling an infantry soldier to open direct and indirect fire.

Each projectile is meant to be fired from this sight unit, without any accessories present (additional unit, individual corrections ...)

Impulse effect – recoil of system weapon-projectile on soldier is limited by maximum permissive motion quantity of elementary projectile in FAM-40 (TF M02). Maximum permissive motion quantity is 22 kgm/s and recoil velocity of gun with under barrel grenade launcher is approximately 4 m/s.

Endurance of grenade launcher and system weapon-projectile must not be jepardize by maximum pressure gaseous products. The three tactical requirements specified allow a very limited zone of projectile design.

Analysing design FAM-40 development process, two groups of projectiles with different construction attributes were identified. The first group has the spectrum mass of 230 g - 280 g and the other 245 g - 265 g, further more, for all items of FAM-40 family identical exterior shape was allocated.

Collective attributes for this ammunitions type are:

- high combustion speed in the propellant charge,
- dynamic stability of projectile,
- coefficient stability oscillations are around one,
- the difference between ammunition and projectile mass is insignificant (less than 1g).

Ammunition does not have the usual cartridge case, since the propellant charge is wrapped into the ammunition base. Base of the propellant charge has 10 openings covered with a foil pad.

After primer ignition combustion of the powder begins, simultaneously perforating the foil pad and allowing the flow of gasous products of propellant charge in to the grenade launcher chamber.

At pressure exceeding $3x10^5$Pa, an axial force leading to projectile motion is generated.

Projectile has steel rotating band which induces rotation by moving through the barrel of the launcher. Projectile muzzle velocity is around 76 m/s.

Twist angle of groove barrel launcher produces a much lower value angular of velocity than in the case of fast-rotating projectiles.

For interior and exterior ballistic computation the existing program solution was used, utilizing a less complex variation of Serebrjakov method. The specific traits of this system demanded for the use of reduced barrel cross section surface, while due to the poroseousness of the propellant, the equivalent thickness of the propellant charge was used.

Computation was done for projectiles of 230 g, 240 g, 250 g, 260 g, 270 g and 280 g mass.

The calculated muzzle velocity and maximum pressure of the propellant gasses are given in the Table in Annex 1. The computed maximum range along with experimental results are given in Tables 1 and 2.

Experiment

In the first part of the experiment 6 groups (with 7 projectiles) were shoot on vertical target made of cloth 100 m away from the grenade launcher. Adapter under barrel granade launchers adapted for krusher i.e. pieso were used. 15 projectiles were used per group, with projectile mass between 230 and 280g. The projectile muzzle velocity was measured by dopler radar BS-850 ″OPOS″. Maximum propellant gases pressure was measured by krusher KSZ-5 and pieso ″Kistler″ 6201B gauges. The median palts coordinates on the target are given in Fig.3.

Table 1. Results of V_0, P_m and maximum range Xm computation, along with experiments results

ammunition 40 mm – grenade launcher 40 mm GP-25							
group	1	2	3	4	5	6	results
mass (g)	230	240	250	260	270	280	
Vo(m/s)	82.7	79.6	76.8	74.2	71.9	69.6	computation
Pm(bar)	823	842	861	879	896	913	
X(m)	453	430	409	389	372	355	
Vo(m/s)	82.2	80.1	78.4	76.4	73.0	73.5	experiment
Pm(bar)	815	707	664	-	734	876	pieso
Vo(m/s)	83.1	80.5	78.4	76.6	73.5	73.5	experiment
Pm(bar)	894	871	893	851	781	976	krusher
X(m)	431.6	435	450	431	390.4	366	experiment
X^*(m)	456	436	421	406	384	384	computation

In the second part of the experiment 6 groups (with 7 projectiles) were shoot on a flat section with elevation angle corresponding the maximum range of projectiles.

Muzzle velocity, maximum pressure (by pieso pickup) and coordinate on flat section (maximum range Fig.4) were measured.

Table 2. Results of shooting on the vertical target and maximum range

group	mass (g)	X(100m)		X(100m)		X(400m)	
		direction (cm)	height (cm)	*Vv* (cm)	*Vp* (cm)	*Vd* (m)	*Vp* (m)
1	230	-188	137	26,2	19,9	8,45	2
2	240	-172	54	9,4	9,0	21,6	3,55
3	250	-161	38	28,8	27,2	6,5	2,3
4	260	-165	75	23,3	13,4	8,0	1,7
5	270	-156	-34	42,8	25,3	8,5	3,6
6	280	-155	-45	42,2	13,8	8,0	3,2

Experimental results of interior ballistic attributes testing are given in Table 1 and velocity chart (Fig.5); exterior ones are given in Table 1 and 2. Calculated ranges are marked with X^* (Table 1) correspond the experimental results of muzzle velocities (krusher experiment).

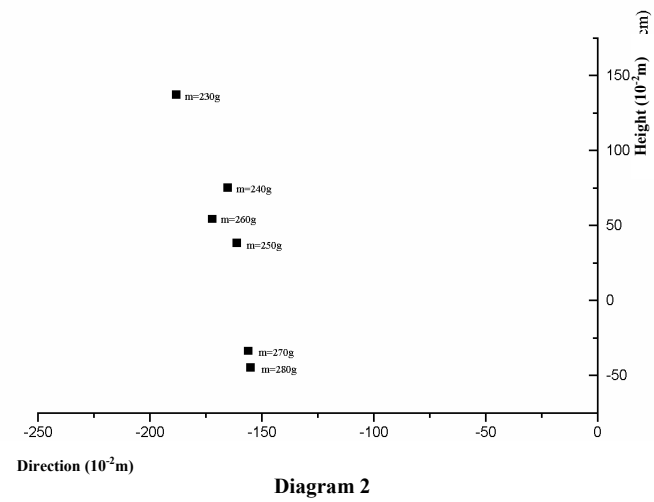

Figure 3. Summary median impact coordinate on vertical target in function of mass

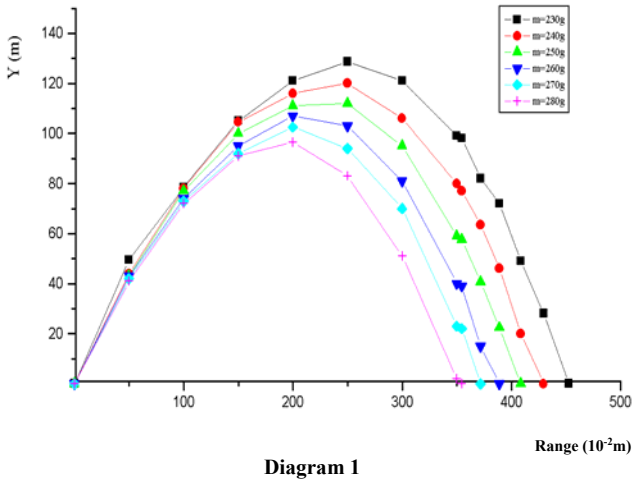

Figure 4. Experimental orbites of projectiles

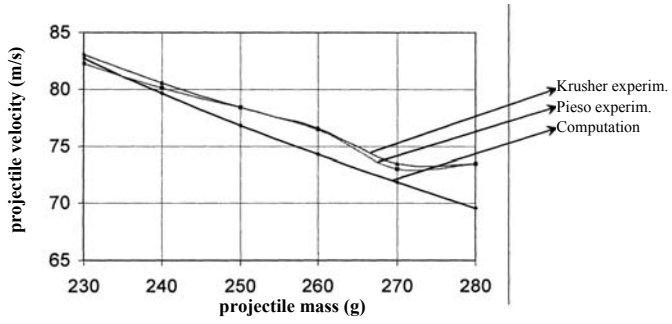

Figure 5. Velocity chart (V_0) in function of mass

Conclusions

Based on the calculations and experimental results which using functional projectile model the following interior and exterior ballistic performances were obtained:

- experimental muzzle velocity of 82,6 - 73,5 m/s, and computated 82,7 - 69,6 m/s,
- experimental maximum pressure gasous products (781-976) x 10^5Pa, and computated (823 - 913) x 10^5Pa,
- precision on vertical target, for all groups of projectiles included in the experiment satisfy the quality requirements ($V_v < 0{,}5$ m, $V_p < 0{,}5$ m),
- coordinate *median palts* on vertical target situated in a rectangle $X = 0{,}33$ m (direction) and $Y = 1{,}82$ m (height)
- maximum range is 432 - 366 m, and computated 456 - 384 m,
- dispersion on the maximum range is $V_d = 6{,}5$ m - 11,6 m, $V_p = 1{,}7$ m - 3,6 m, which satisfies the quality requirements ($V_d < 16{,}8$ m, $V_p < 8{,}4$ m).

The difference between the calculated and experimental values of muzzle velocities and pressures are partly due to the influence environmental temperature, since shooting was done over on extended period of time while ammunition was stored on the shooting spot. This is evident from velocity diagram (Fig. 5), especially with the group of projectiles used later (mass 0.25kg, 0.26kg and 0.28kg).

It can be concluded that, from the point of tactical and technical requirements set, to apply a universal propellant with all FAM-40 projectiles, provided that all 5 projectiles' mass is between 0.24 and 0.26 kg, which will be abided by in their design.

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Primena univerzalnog pogona kod familije municije za potcevni bacač granata

Familija municije, kalibra 40 mm (FAM-40), za potcevni bacač granata, čini deo podsistema naoružanje i razvijana je u sklopu složenog projekta "Model vojnika 21". U skladu sa trenutnim potrebama armije i njenim materijalnim mogućnostima, razvoj FAM-40 je baziran na osvajanju 5 novih projektila.

Pored osnovnih projektnih zahteva koji su definisani za svaki pojedinačni projektil, opšti zahtev za FAM-40 jeste izrada univerzalnih sklopova i delova, koji su primenjivi za sve ili bar veći deo projektila iz familije municije. U tom smislu kao univerzalni delovi koriste se: upaljač (UT M02 SP), košuljica sa vodećim prstenom, dno i čaura.

U ovom radu će se proveriti mogućnost primene jedinstvenog pogona, koji bi se koristio na svim projektilima. U tom cilju data je teorijska analiza mogućnosti primene univerzalnog pogona i analiza rezultata izvršenih eksperimenata u cilju potvrde postavljenog zahteva da se primeni isti pogon kod svakog metka iz FAM.

Ključne reči: **potcevni bacač, municija, kalibar 40 mm, metak, projektil, pogon, barutno punjenje, teorijska analiza, eksperimentalni rezultati.**

L'application de la propulsion universelle chez la famille de munitions pour le lance-grenades sous-tube

La famille de munitions du calibre de 40 mm (FAM) pour le lance-grenades sous-tube fait partie d'un sous-système d'armement ; elle a été développé dans le cadre du projet complexe « Modèle du soldat 21 ». En accord avec les besoins actuels de l'armée et de ses possibilités matérielles,le développement de FAM se base sur la réalisation de cinq nouveaux projectiles.
Outre les exigeances fondamentales du projet, définies pour chaque projectile, l'exige- ance générale pour FAM 40 consiste en élaboration des ensambles et des pièces unive- rsels, applicables à tous ou bien à la plupart des projectiles de cette famille de munitions. A cet effet sont utilisés comme les pièces universels : fusée (UT MO2 SP), douille à anneau de guidage, culot et cartouche.
Dans ce travail nous vériferons les possibilités d'application de la propulsion unique qui serait utilisée pour tous les projectiles. Dans ce but on a donné une analyse théorique des possibilités d' application de la propulsion uni- verselle et l'analyse des résultats d'essais effectués en vue de confirmer l'exigeance posée à l'égard de l'application de la même propulsion pour chaque cartouche de FAM.

Mots clés: **lance-grenades sous-tube, munitions, calibre de 40mm, cartouche, projectile, propulsion, charge de poudre, analyse théorique, résultats expérimentaux.**

Применение универсальной силовой установки у группы боеприпасов для подтрубной пусковой установке снарядов

Группа боеприпасов, калибра 40 mm (FAM-40), для подтрубной пусковой установке снарядов, представляет часть субсистемы вооружения и развивалась в рамках сложного проекта "Модель солдата 21". В соответствии с настоящими сегодняшними надобностями армии и её материальными возможностями, развитие FAM-40 основывается на овладении пять новых реактивных снарядов.
Кроме основных проектных требований, определённых для каждого реактивного снаряда отдельно, общим требованием для FAM-40 является выработка универсальных агрегатов, узлов и составных частей, применяемых для всех или по крайней мере для большей части реактивных снарядов из группы боеприпасов. В этом смысле в роли универсальных составных частей пользуются: взрыватель (UT M02 SP), рубашка с передним кольцом, дно и втулка.
В этой работе будет проверена возможность применения единственного привода, который пользовался бы на всех реактивных снарядах. С этой целью приведён теоретический анализ возможностей применения универсального привода и анализ результатов выполненых экспериментов с целью потверждения установленного требования применить тотже привод у каждой пули из FAM.

Ключевые слова: **пусковая установка снарядов, боеприпасы, калибр 40 mm, снаряд, силовая установка, пороховой заряд, теоретический анализ, экспериментальные результаты.**