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INFLUENCE OF PROJECTILE BALLISTIC COEFFICIENT DISPERSION ON NON-LETHAL AND LIMITED RANGE WEAPONS' TACTICAL CHARACTERISTICS

The field of non lethal and limited range weapons engineering, as opposed to combat weapons, is still not sufficiently explored. These types of weapons can be used by security forces to carry out their fire missions usually demanding high accuracy firing. Projectile ballistic coefficient dispersion can essentially affect nominal characteristics of non lethal and limited range weapons. The influence of projectile ballistic coefficient dispersion on projectile target affecting parameters is researched in the article. Common dependencies and methods of external ballistics are applied. The way to determine maximal and minimal usage range declining due to projectile ballistic coefficient dispersion is defined. The results represented in the article can be used for the purpose of non lethal and limited range weapons designing and projectile ballistic coefficient demands creating.

Keywords: *ballistic coefficient, non-lethal weapon, limited range weapon, muzzle velocity, projectile.*

Introduction

As kinetic weapon is used, it should be distinct clearance about how target must be hit by projectile: weather it must be stopped, injured or shot through, etc. Target hitting effect of projectile depends on its characteristics such as projectile target meeting velocity V_t, kinetic energy and specific energy, etc.

V_t value can be declined towards increasing or decreasing due to natural dispersion of projectile velocity affecting factors.

In combat conditions shortage of projectile target meeting velocity can lead to fire mission failure. Excessive muzzle velocity and corresponding kinetic and specific energies, while firing within human settlements or buildings, can occur injuring of those near target or shooter himself, or those beyond shooter's vision due to ricochet. It can also make unreasonable material loses [1].

Excessive projectile velocity of non-lethal weapon (NLW) or limited range weapon (LRW) can cause inadmissible deadly injury [2–4]. Projectile target hitting velocity depends on muzzle velocity V_m and projectile velocity degradation dynamics. Last one is function of ballistic coefficient C [5–7].

Influence of muzzle velocity dispersion on kinetic weapon's characteristics and V_m demands was discussed in [8–9]. Meanwhile, influence of NLW and LRW projectiles ballistic coefficient dispersion on security forces fire missions' effectiveness is still not sufficiently explored.

The aim of the article is to define the influence of kinetic weapon projectiles' ballistic coefficient dispersion on security fire mission effectiveness.

Basic section

Projectile's ballistic coefficient shifting ΔC leads to projectile target hitting velocity declining in comparison with calculated value [10]. It can cause target affecting to be excessive or deficient as well as it depends on projectile kinetic E_k and specific E_{sp} energies which are determined by V_t.

As projectile hitting effect values are determined, it can be allocated certain section within projectile trajectory where these values are true. For the purpose of this article let's denote this projectile trajectory section as valid range of NLW (ΔX).

Projectile ballistic coefficient shifting also leads to valid range declining. The influence of ΔC declining on valid range ΔX of Fort-500 rifle compounded with Teren-12 cartridge is depicted on fig. 1.

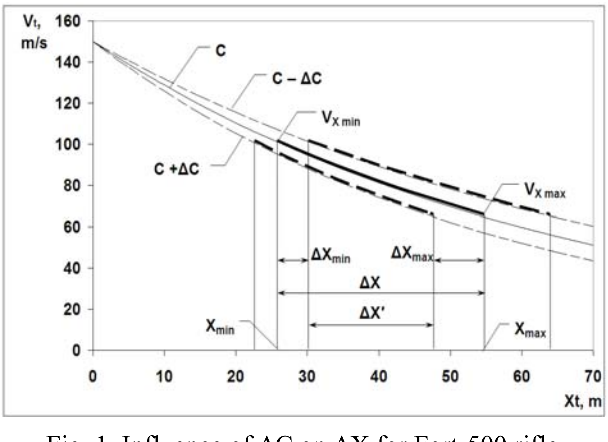

Fig. 1. Influence of ΔC on ΔX for Fort-500 rifle compounded with Teren-12 cartridge

The dependence of V_t on target range X_t with nominal projectile ballistic coefficient C is marked by solid line. V_t versus X_t plots are marked by dash line if C is 10% out of nominal. Plot sectors corresponding to valid range, where projectile's energy characteristics are in valid limits ($65 \le E_k \le 80$ J, $E_{sp} \le 0,5$ J/mm2 [11–12]), are highlighted by heavy lines.

As it is impossible to know C value and direction declining in every case of firing, only ΔX´ (as on the figure 1) can be considered as valid range.

Thus, while demands for NLW and LRW ballistic coefficient dispersion are creating, it is influence on valid range, not influence on accuracy, what should be considered first of all. Obviously, ΔX_{min} and ΔX_{max} values depend on projectile's velocity degradation dynamics determined by ΔC, and derivative of velocity with respect to distance at ΔX_{min} and ΔX_{max} points determined by C. Also ΔX_{min} and ΔX_{max} values increase corresponding to X_t growth. At that, $\Delta X_{min} \ne \Delta X_{max}$ due to probable essential difference between derivative dV/dX values at ΔX_{min} and ΔX_{max} points. It is especially essential if projectile ballistic coefficient values are large.

Projectile velocity values can be obtained by formula [5] at every point of the trajectory:

$$V_X = V_m \cdot e^{-kCX}. \quad (1)$$

Transforming (1), we get:

$$X = \frac{1}{k \cdot C} \ln \frac{V_m}{V_X}. \quad (2)$$

Based on (2) we obtain:

$$\Delta X = \frac{1}{k \cdot C}\left(\ln \frac{V_m}{V_{X\,max}} - \ln \frac{V_m}{V_{X\,min}} \right), \quad (3)$$

$$\Delta X_{min} = \frac{1}{k} \ln \frac{V_m}{V_{X\,min}} \left(\frac{1}{C - \Delta C} - \frac{1}{C} \right), \quad (4)$$

$$\Delta X_{max} = \frac{1}{k} \ln \frac{V_m}{V_{X\,max}} \left(\frac{1}{C} - \frac{1}{C + \Delta C} \right). \quad (5)$$

Considering (3–5) we get:

$$\Delta X' = \frac{1}{k}\left(\frac{1}{C + \Delta C} \ln \frac{V_m}{V_{X_{max}}} - \frac{1}{C - \Delta C} \ln \frac{V_m}{V_{X_{min}}} \right). \quad (6)$$

Influences of ΔX´ range on ΔC values for standard NLW cartridges projectiles are depicted at fig. 2. As it fig. 2 shows, while ΔC is growing, effective sector of valid range ΔX´ is getting narrow; further it becomes zero as ΔC riches certain values.

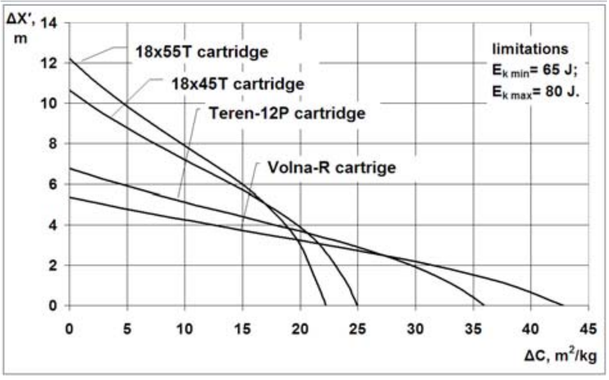

Fig. 2. ΔX´ versus ΔC for NLW cartridges (data obtained subject to X_{min} = 1 m)

Absolute C and V_m values essentially differ for projectiles mentioned. Therefore dependence ΔX´ on relative C value (δC), as it shown on fig. 3, would be more indicative.

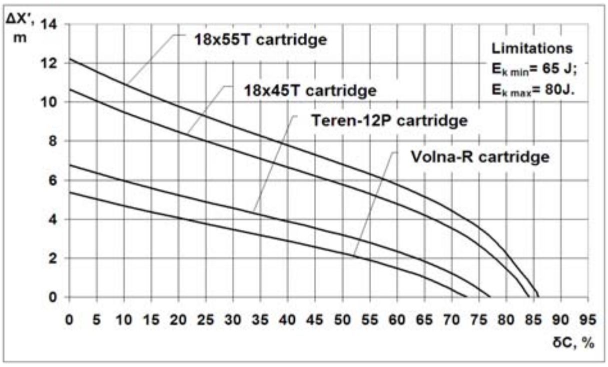

Fig. 3. ΔX´ versus δC for NLW cartridges (data obtained subject to X_{min} = 1 m)

Within these NLW cartridges the most extended valid range has 18×45T cartridge, and the less valid range has Volna-R cartridge. It can be explained by ballistic coefficient values. The 18×45T cartridge projectile has the smallest C value; the Volna R cartridge projectile has the largest one (tabl. 1).

Table 1

NLW cartridges ballistic coefficient values

NLW cartridges	C, m^2/kg
Teren-12P cartridge	47
with 18×55T cartridge	26
with 18×45T cartridge	34
Volna R cartridge	59

At the fig. 4 ΔX´(ΔC) dependences for the complexes NLW cartridges with appropriate weapons are depicted.

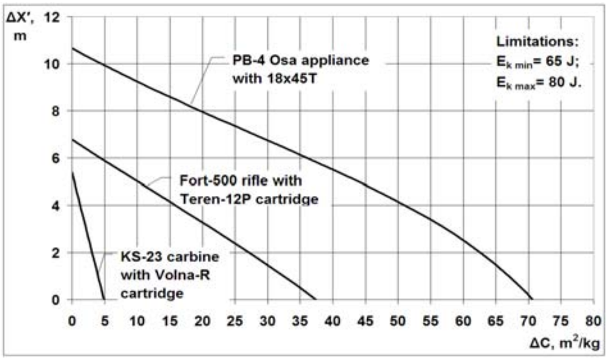

Fig. 4. $\Delta X'$ versus ΔC for NLW complexes

Fort-500 rifle with Teren-12P cartridge complex has the less valid range reducing dynamics with respect to C grows; KS-23 carbine with Volna-R cartridge complex has the largest one. It can be explained by valid range on trajectory allocation relative to the muzzle position. The farther is valid range allocation on trajectory the bigger ballistic coefficient dispersion influence on $\Delta X'$ width.

Concerning LRW weapons it can be indicated range section from muzzle to X_{min} (let's denote it as valid range of LRW). As it is impossible to know C value and direction declining in every case of firing, only $X_{min} - \Delta X_{min}$ (as on the fig. 1) can be considered as valid range of LRW. It can also be indicated another projectile trajectory section from $X_{min} - \Delta X_{min}$ to $X_{min} + \Delta X_{min}$ where projectile on target hitting effect can be lethal or deficient due to ballistic coefficient value. This trajectory section can be denoted as indeterminacy range ΔX_{idet}. Valid range and indeterminacy range of LRW can be defined by formulas

$$X_{min} - \Delta X_{min} = \frac{1}{k\left(C + \Delta C\right)} \ln \frac{V_m}{V_{X_{min}}}, \qquad (7)$$

$$\Delta X_{i\,det} = \frac{1}{k} \ln \frac{V_m}{V_{X_{min}}} \left(\frac{1}{C - \Delta C} - \frac{1}{C + \Delta C} \right). \qquad (8)$$

The indeterminacy range width is reducing while ballistic coefficient value is growing. Minimization of indeterminacy range width is important for LRW designing. Thus, projectiles having large ballistic coefficient values should be considered as rational for LRW cartridges.

Conclusions

1. Projectile ballistic coefficient declining from nominal leads to NLW and LRW valid range shortening and LRW indeterminacy range growing; it can affect negative on fire mission effectiveness.

2. The way to determine maximal and minimal NLW usage range declining due to projectile ballistic coefficient dispersion is defined. It can help to identify NLW projectile trajectory sectors with probable excessive or deficient target affecting.

3. It is obtained the dependences of valid range on projectile ballistic coefficient dispersion. They can be used for the purpose of NLW and LRW designing and projectile ballistic coefficient demands creating.

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ВПЛИВ РОЗКИДУ ЗНАЧЕНЬ БАЛІСТИЧНОГО КОЕФІЦІЄНТА МЕТАЛЬНОГО ЕЛЕМЕНТА НА ТАКТИЧНІ ХАРАКТЕРИСТИКИ ЗБРОЇ НЕСМЕРТЕЛЬНОЇ ДІЇ ТА ЗБРОЇ З ОБМЕЖЕНОЮ ВІДСТАННЮ ДІЇ

О.І. Біленко, Д.В. Павлов

Зв'язок технічних і тактичних характеристик зброї несмертельної дії та зброї з обмеженою відстанню дії, на відміну від бойової зброї, є недостатньо вивченим. Така зброя може використовуватись силами безпеки при виконанні вогневих завдань з підвищеними вимогами до точності стрільби. Розкид значень балістичного коефіцієнта метального елемента зброї несмертельної дії та зброї з обмеженою відстанню дії може призводити до суттєвого зсуву їх характеристик від номінальних. В статті досліджено вплив розкиду значень балістичного коефіцієнта метального елемента на характеристики його дії по цілі. Використано відомі залежності та методи зовнішньої балістики. Представлено спосіб визначення максимального та мінімального відхилення значень допустимої відстані застосування зброї у залежності від розкиду значень балістичного коефіцієнта метального елемента. Результати дослідження можуть бути використані для формування вимог до технічних характеристик зазначених видів зброї на етапах її проектування та виробництва.

Ключові слова: *балістичний коефіцієнт, зброя несмертельної дії, зброя з обмеженою відстанню дії, дульна швидкість, метальний елемент.*

ВЛИЯНИЕ РАЗБРОСА ЗНАЧЕНИЙ БАЛЛИСТИЧЕСКОГО КОЭФФИЦИЕНТА МЕТАТЕЛЬНОГО ЭЛЕМЕНТА НА ТАКТИЧЕСКИЕ ХАРАКТЕРИСТИКИ ОРУЖИЯ НЕСМЕРТЕЛЬНОГО ДЕЙСТВИЯ И ОРУЖИЯ С ОГРАНИЧЕННОЙ ДАЛЬНОСТЬЮ ДЕЙСТВИЯ

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Связь технических и тактических характеристик оружия несмертельного действия и оружия с ограниченной дальностью действия, в отличие от боевого оружия, недостаточно изучена. Такое оружие может использоваться силами безопасности при выполнении огневых задач с повышенными требованиями к точности стрельбы. Разброс значений баллистического коэффициента метательного элемента оружия несмертельного действия и оружия с ограниченной дальностью действия может приводить к значительным смещениям их характеристик относительно номинальных. В статье исследовано влияние разброса значений баллистического коэффициента метательного элемента на характеристики его действия по цели. Использованы известные зависимости и методы внешней баллистики. Представлено способ определения максимального и минимального отклонения значений допустимой дальности применения оружия в зависимости от разброса значений баллистического коэффициента метательного элемента. Результаты исследования могут быть использованы для формирования требований к техническим характеристикам обозначенных видов оружия на этапах его проектирования и производства.

Ключевые слова: *баллистический коэффициент, оружие несмертельного действия, оружие с ограниченным расстоянием действия, дульная скорость, метательный элемент.*