EXPERIMENTAL RESEARCH ON THE VARIATIONS IN HIT DISTANCE AND DEVIATION ELLIPSE DURING THE USE OF DIFFERENT GUNPOWDER TYPES WHEN OPERATING THE 82MM MORTAR AND 82MM REUSABLE TRAINING MORTAR ROUND FOR SHORT DISTANCE ENGAGEMENT

Conuy G. Conev, Hristo A. Hristov

Artillery, Air Defense and CIS Faculty, National Military University "Vasil Levski"
Shumen, Bulgaria, coni19@abv.bg

Abstract: *This paper explores a completed experimental study on the variations in hit distance and deviation ellipse when different types of gunpowder are used. During the research, an 82 mm mortar is used. The issued ammunition is an 82 mm reusable training mortar round for short distance engagement.*

Keywords*: mortars, simulator*

Introduction

Over the last two decades, there has been an ongoing trend in the implementation of simulators (training simulator) for the training of military personnel. Part of these simulators are targeted towards practical preparations related to fieldwork in conjunction with the execution of military tasks and tactical operations during mortar fire missions [2].

One of the developments of such type in the Republic of Bulgaria is a training simulator for the mortar crews with an 82mm reusable training mortar round for short distance engagements. It is intended for training mortar crews in the preparation for mortar deployment, execution of fire missions and fire correction.

The main elements of the simulator are:

- 82 mm mortar;
- 82 mm reusable training mortar round for short distance engagement;
- dummy fuse; for short distance engagement
- main charge;
- the charge of the dummy fuse.

Training simulator consumables are the main charge and the charge of the dummy fuse.

The contents of the main charge of the dummy fuse include a smoke-forming substance with which a mortar detonation is imitated. The delivery of this element by different manufacturers wound not lead to any significant disruption of the simulators performance.

The contents of the main charge include two types of gunpowder (black gunpowder and smokeless gunpowder). Black gunpowder serves only for strengthening the explosive train produced by the ignition device. The main source of energy for the launch of the training mortar round comes from the smokeless gunpowder [1].

For the use of the simulator short distance firing tables are made, utilizing main charges armed with smokeless nitroglycerin, ballistic, strip gunpowder type NLB-11(НБЛ – 11).

The data gathered from the conducted research indicates that different manufacturers of the main charge for the 82mm mortar rounds use different smokeless gunpowder types which in turn have differ-

ent characteristics. Therefore further research needs to be conducted on the possibility of significant differences in firing distances when firing with different primary charges armed with various types of smokeless gunpowder.

2. Experimental research

A proper flow of the paper is to first set the related work, description of the problem context, followed by the presentation of the proposed solution. Then the verification part includes the analysis, simulation and experimentation. Finaly, an evaluation of the solution according to the verification results is made in the conclusion and future work.

2.1.Research objective

The objective of this research is the determination on the presence of deviations in firing distances and the deviation ellipse when using different gunpowder types. In this research, the following equipment will be used: the 82 mm mortar and the 82 mm reusable training mortar round for short distance engagement used for mortar crew training.

2.2. Research tasks

- To experimentally determine the presence of deviation in firing distance with an angle of elevation allowing for maximum firing distance. Two types of smokeless gunpowder will be used for the primary charge of the 82 mm training mortar round.
- To experimentally determine the presence of variations in the deviation ellipse on the maximum range of the system. Two smokeless gunpowder types will be used for the main charge of the 82 mm training mortar round.

2.3. Research location

The research was conducted on the artillery training range "Markovo".

2.4.Conditions under which the research was conducted

- ambient temperature 20° C; with a relative air humidity 65%;
- fire missions are conducted in clear and windless weather conditions to eliminate the effects of crosswind.
- fire missions are conducted with an elevation angle of 45^{o}, providing the maximum fire range;
- The fire mission was conducted with main charges, part of which (13 pc.) are armed with smokeless gunpowder, type PS-6642 (ПС-6642) and main charges (10 pc.) armed with smokeless nitroglycerin, ballistic, strip gunpowder type NBL-11(НБЛ – 11).
- The fire mission was conducted with 82mm mortar and 82mm reusable training mortar rounds for short distance engagement.

2.5. Restrictions

During the research, only the large axis of the deviation ellipse was noted.

2.6. Procedure for conducting the experimental research

A. Preparation of the weapon system and munitions.

Sequence::

- The bore of the mortar is cleared from lubricants, carbon and other contaminants before firing.
- The mortar is deployed;
- Dummy fuses are armed with their charges that imitate explosion on impact;
- The armed dummy fuses are then threaded to the training rounds;
- Distance indicators are deployed on the firing range with a distance of 10 meters in-between;

B. Execution of the experimental fire mission.

The experimental fire mission is conducted in the following sequence.

- 10 rounds are fired with the main charge armed with the smokeless nitroglycerin, ballistic, strip gunpowder type NLB-11 (НБЛ – 11) at an angle of 45^o and after each shot the distance between the barel bore and the place where the mortar has landed is measured.

- 5 rounds are fired with the main charge weighing 2,5g, armed with smokeless grain gunpowder type PS-6642 (ПС-6642) at an angle of 45^o and after each shot the distance between the barel bore and the place where the mortar has landed is measured;

- 4 rounds are fired with the main charge weighing 3g, armed with smokeless grain gunpowder type PS-6642 (ПС-6642) at an angle of 45^o and after each shot the distance between the barel bore and the place where the mortar has landed is measured;

3. Results of the experimental research

For the approximate determination of the required amount of smokeless nitroglycerin, ballistic, strip gunpowder type NBL-11 (НБЛ – 11) for the main charge a formula was used 1 [5]:

$$\omega = \sqrt[b]{\frac{V_0}{a}} \tag{1}$$

where:

ω – the mass of the smokeless gunpowder in the main charge [kg];

V_0 –the desired initial velocity of the training mortar round for maximal firing range of 100 m (desired initial velocity has a speed of ≈ 30 m/s) [m/s];

a - coefficient depending on the caliber and mass of the mortar (for the 82 mm training mortar the value of this coefficient is 20,601892) [5];

b - coefficient depending on the caliber and mass of the mortar (for the 82 mm training mortar the value of this coefficient is 0,60068571 [5].

The required amount of smokeless gunpowder type NBL-11 (НБЛ – 11), calculated from formula 1 is approximately 2,4 g.

The results gathered from the experimental research of firing the training mortar rounds with a main charge armed with smokeless gunpowder type NBL-11 (НБЛ–11) at an angle of 45^o are presented in table1.

Table 1

Results from the experimental research of firing the training mortar round with a main charge armed with smokeless gunpowder NBL-11 (НБЛ – 11) at an elevation angle of 45^o

Mortar shot №	Elevation angle	Expected hit distance	Hit distance	Error
	[deg]	[m]	[m]	[%]
1	45^o	100	86	-24%
2	45^o	100	90	-10%
3	45^o	100	97	-3%
4	45^o	100	106	+6%
5	45^o	100	111	+11%
6	45^o	100	115	+15%
7	45^o	100	89	-11%
8	45^o	100	92	-8%
9	45^o	100	103	+3%
10	45^o	100	105	+5%
Average hit and error values			99,4	9,6%

The average firing distance is 99,4 m. The average error results gathered from the experimental research from using the training mortar round with the main charged armed with smokeless gunpowder type NBL-11(НБЛ–11) at a firing angle of 45^{o} are 9,6% .

The big axis of the deviation ellipse is 29m.

Due to lack of data, the required quantity of smokeless gunpowder type PS-6642 (ПС-6642) for the main charge is not calculated. Therefore, main charges were made with a gunpowder mass of 2,5 and 3g.

The research from the conducted experimental fire mission are show in tables 2, 3 and 4.

Table 2

Results from the experimental research of firing the training mortar round with a main charge armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 2.5g at an elevation angle of 45^{o}

Mortar shot №	Elevation angle	Expected hit distance [m]	Hit distance [m]	Error [%]
1	45^{o}	100	82,00	-18 %
2	45^{o}	100	78,00	-22 %
3	45^{o}	100	75,00	-25%
4	45^{o}	100	84,00	-16%
5	45^{o}	100	80,00	-20%
Average hit and error values			79,80	-20,2%

According to the data presented in the above table it is clear that the average firing distance is 79,8m and the average error results gathered from the experimental research from using the training mortar round with the main charged armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 2,5g and an elevation angle of 45^{o} are 20,2% .

Due to the high error percentage accruing in firing distance, firing was ceased. The research indicates that the charges with mass of 2,5g do not meet the necessary requirements being - when firing at an elevation angle of 45 ° the training mortar round must reach a distance of 90 to 100 m.

Table 3

Results from the experimental research of firing the training mortar round with a main charge armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 3g at an elevation angle of 45^{o}

Mortar shot №	Elevation angle	Expected hit distance [m]	Hit distance [m]	Error [%]
1	45^{o}	100	84,60	-15,4 %
2	45^{o}	100	90,00	-10 %
3	45^{o}	100	107,00	+7,0 %
4	45^{o}	100	109,00	+9,0 %
Average hit and error values			97,65	10,35 %

Average firing distance is 97,65m. The average error results gathered from the experimental research from using the training mortar round with the main charged armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 3g and an elevation angle of 45^{o} are 10,35%.

The big axis of the deviation ellipse is 24, 4 m.

Table 4

Results from the experimental research of firing the training mortar round with a main charge armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 3g at an elevation angle of 83^o

Mortar shot №	Elevation angle	Expected hit distance [m]	Hit distance [m]	Error [%]
1	83^o	23	20,00	13,0 %
2	83^o	23	19,00	17,4 %
3	83^o	23	21,00	8,7%
4	83^o	23	21,00	8,7%
Average hit and error values			20,25	11,95%

Average firing distance is 20,25m. The average error results gathered from the experimental research from using the training mortar round with the main charged armed with smokeless gunpowder type PS-6642 (ПС-6642) with a gunpowder mass of 3g and an elevation angle of 83^o are 11,95% .

The big axis of the deviation ellipse is 2 m.

4. Conclusions

1. The conducted experimental research show that there are significant differences in the required amount of smokeless gunpowder for the main charge when manifactured from different types. This, in turn, does not allow the use of main charges manufactured by different companies for training mines since the firing tables will not be applicable.

2. A significant deviation in long distance hits was found. It is due to the presence of a small amount of gunpowder in the main charge (due to the requirement of maximum firing distance of up to 100 m). There is also a large passage of propellant gasses between the mortar round and the barrel bore. This, in turn, calls for the inclusion of an obturating band preventing the escape of propellant gasses.

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