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POLISH PRACTICE AMMUNITION WITH REDUCED RICOCHETTE ABILITY

Some issues connected to 7,62 mm practice ammunition development are presented in this paper. Internal and external ballistic phenomenon let to determine demands for practice ammunition and reduce range of possible bullets designs, which could fulfil Polish Army requirements for 7,62 mm practice rounds. After preparing models of such developed rounds and conducting tests with them, it was possible to choose appropriate variant as well to verify simplifications used in mathematical models.

1. Introduce

During soldiers training and tactical exercises, the shooting training acts the crucial role. Traditional training model with live ammunition only provides high degree of realism, however bullets killing ability create serious problems. Established law regulations [5] cause necessity to provide huge dimensions safety zones; this increases costs of preparing firing ranges and often makes impossible to use existing objects. In 2006 more than 110 small arms firing ranges from the total number of 197 (56%) needed expensive modernizations and 33% (65 objects) were decided to be closed down due to too wide range of works necessary to do.

To solve these problems, the works with the aim to develop among others the 7,62 mm practice rounds were undertaken in Electromechanical Institute of Military University of Technology. Basing on the live ammunition characteristics it was necessary to develop such practice rounds which would characterize at least three times less bullets kinetic energy at the distance of firing range length and with more then a half reduced maximum range. Simultaneously, accuracy should be similar as in the live ammunition. According to assumptions [6] a difference between mean points of impacts for live and practice rounds couldn't be more than 80 mm on 100 m distance, while accuracy parameter R_{50} on 300 m couldn't be higher than 90 mm (for assault rifle) or 120 mm (for machine gun).

2. Modelling and tests on internal ballistics

During initial period, the main task was to choose appropriate propellant. For gas-operated weapon a very important characteristic is an overall impulse of gas pressure in gas chamber, which influence the weapon operating. From the other hand, the overall impulse of gas pressure in barrel influences the bullet velocity. For light bullets of practice rounds it was necessary to use propellant which ensures low bullet initial velocity (to fulfil energetic criteria) and properly weapon automatic operation.

Solving numerically equations of gases inflow and bullet movement in the barrel bore [3,4] a shoot processes were modelled for given propellants. After simulations for propellants available in Poland it was occurred that no one of them could be used in practice ammunition.

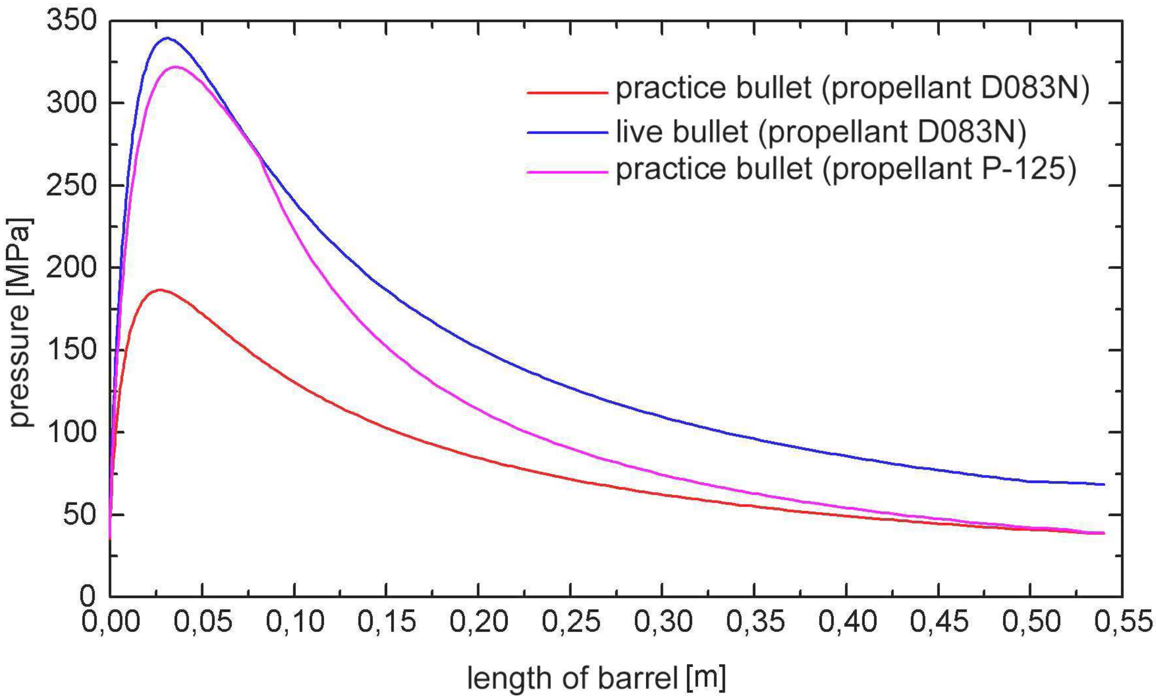

Fig. 1. Modelling results of shoot process for 7,62x51 mm round with propellants available in Poland

Further modelling of shoot process let to determine propellant characteristics ranges, which could ensure appropriate bullets characteristics as well weapon operation. According to these demands the imported propellants were bought. These propellants were tested in manometric chamber. After measuring necessary characteristics of delivered propellants, further simulations were provided which let to reduce propellants number to just few types. Chosen in these way propellants were used during tests with weapon systems. Results are shown in Table 1. Provided shooting test confirmed simulations results and let to determine chosen propellant masses for different round types, appropriate for light practice bullets (Fig. 2).

Table 1. Some results of internal ballistics researches for 7,62x51 mm rounds

Round characteristics	Mean velocity V_{25} [m/s]	Mean muzzle pressure [MPa]	Mean max. pressure in cartridge chamber [MPa]	Mean max. pressure in gas channel [MPa]	Overall impulse of gas pressure in barrel [%]	Overall impulse of gas pressure in gas channel [%]
live (m=9,5 g; $m_{prop.}$=0,33 g N340)	803,5	80,0	359,5	80,9	100,0 (54,0*)	100,0 (36,6)
practice (m=5,8 g; $m_{prop.}$=2,88 g N530)	924,2	77,4	263,1	76,5	66,5 (36,3)	86,3 (19,7)
practice (m=2,6 g; $m_{prop.}$=2,85 g Wufl)	1206,4	63,4	250,8	58,7	54,6 (27,2)	71,9 (16,4)
* - proportional part in overall impulse of gas pressure from start of burning to the muzzle						

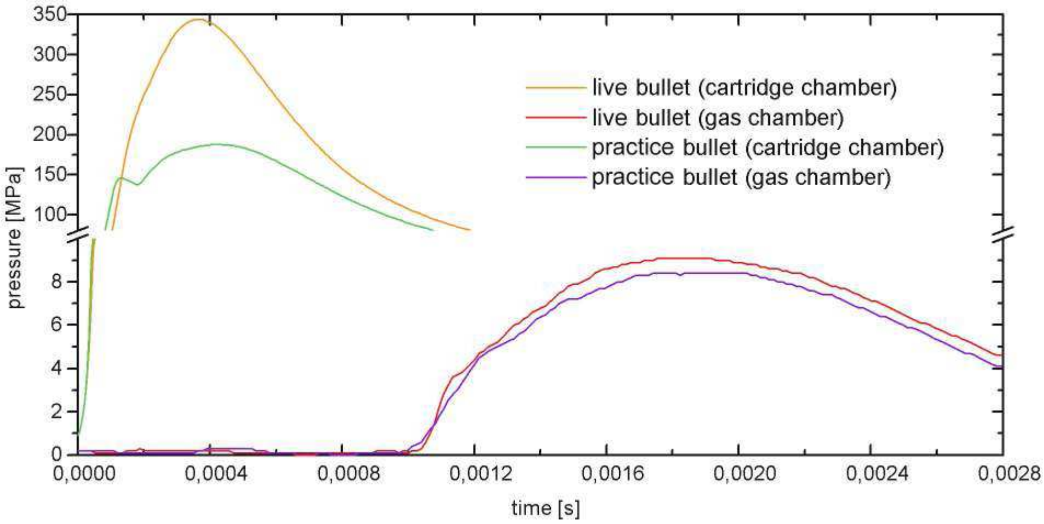

Fig. 2. Results of pressures measuring for 7,62 mm PKT machine gun (feed with 7,62x54R mm rounds)

3. Modelling and tests on external ballistics

For bullets of different masses and shapes, according to equations presented in [1,2], basic aerodynamic characteristics necessary to simulate theirs movement in an atmosphere were determined. All bullets were regarded as rigid solids and during modelling the complete system of movement equations were used. The aim of trajectory simulation of such bullets was to determine such bullet shape and its mass distribution, which would provide practice bullet trajectory as similar as possible to the live bullet trajectory [fig.3].

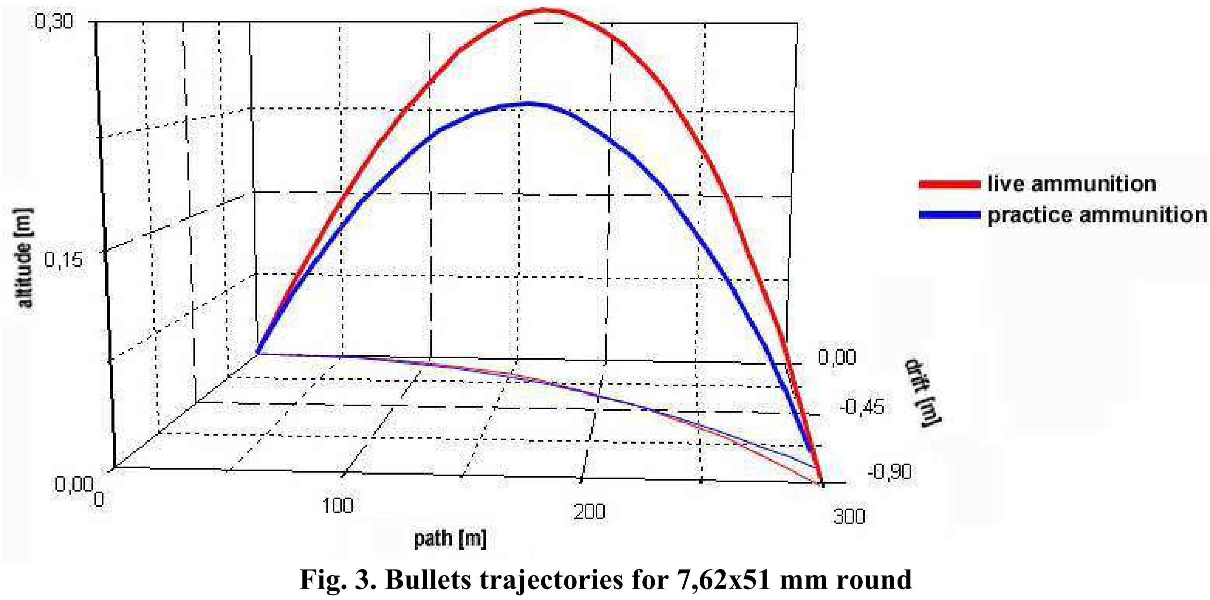

Fig. 3. Bullets trajectories for 7,62x51 mm round

Obtained results let to develop few bullets designs, which could fulfil demands [6]. Manufactured models were tested in details with ballistic radar. Tests results confirmed in significant degree simulations results. Developed rounds were characterized with high air drag force within supersonic velocities range (fig.4.). In this way it was possible fulfilling demands regarding low kinetic energy [6]. Simultaneously the high value of drag coefficient for subsonic velocities caused maximum range reducing, comparing to live ammunition.

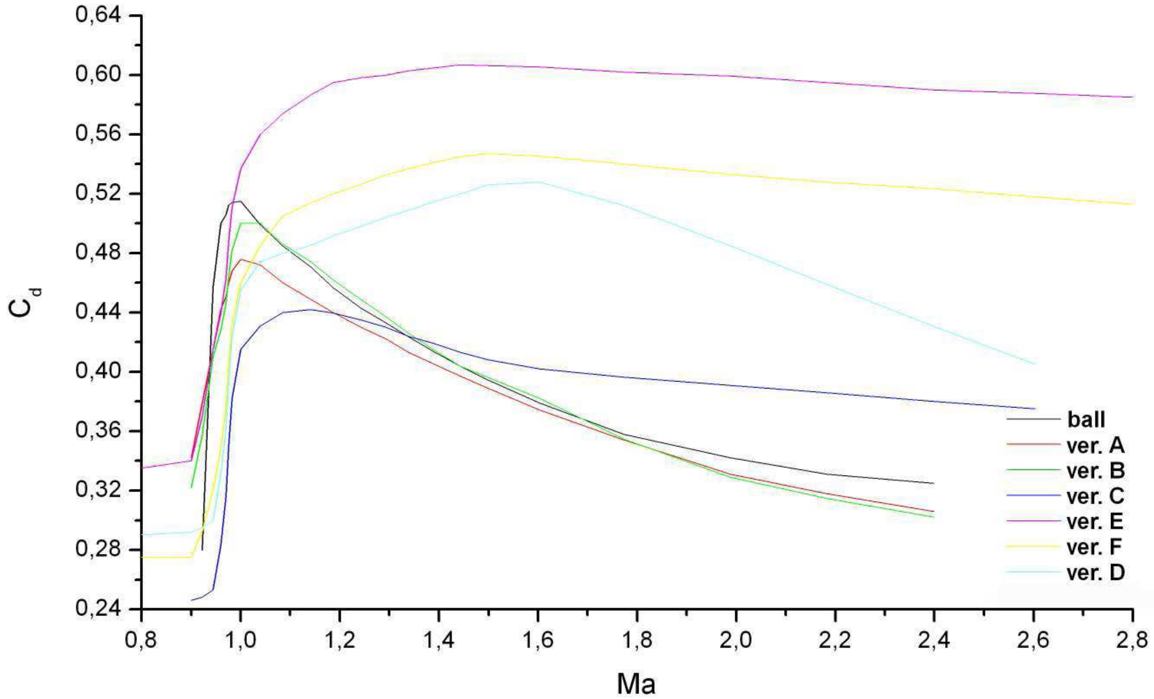

Fig. 4. Air drag force coefficient curves depending on Mach number for different 7,62x51 mm practice bullets, compared with live round (ball)

Unfortunately further researches showed that bullets designed from ballistics point of view do not operate properly in the real launching systems of existing weapon. Many stoppages while feeding were occurred. Also during sustained fire the low accuracy was observed because bullets tips were often damaged during chambering. Symmetry disturbances in such cases caused unacceptable bullets spread.

Because of this reason, the next modelling attempts with other materials and bullet shapes were done. Due to the small differences between trajectories of examined bullets, instead of rigid solid, the mass point was used during simulations. For example, trajectories of well stabilized in flight practice bullets differed only 50-120 mm from normal bullets trajectories at the distance of 300 m. The biggest observed differences regard heights of trajectories (fig.6). Thanks this simplification, the time needed to collect data and provide computations was significantly shortened, but without greater influence on results reliability.

After numerous simulations were done it was possible to choose bullets designs fulfilling demands (fig. 5). For 7,62 mm ammunition it was especially time-consuming process because it was necessary to regard some detailed parameters, which depend one on another, and to make the matter worse – they were often contradictory. For example the means ensuring accuracy increasing and low kinetic energy caused problems while chambering. On the other hand the shape appropriate from feeding and chambering point of view gave not correct mass distribution and then – low accuracy. More detailed tests (with ballistic radar) of developed ammunition let to estimate velocity (kinetic energy) curves (Fig.7a) and maximum ranges.

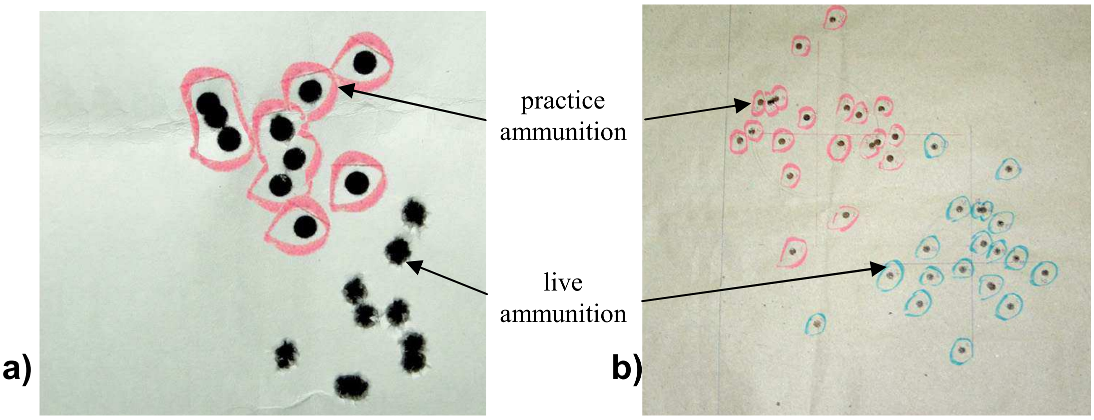

Fig. 5. Tests results of firing 7,62x54R rounds at distance 100 m (a) and 300 m (b)

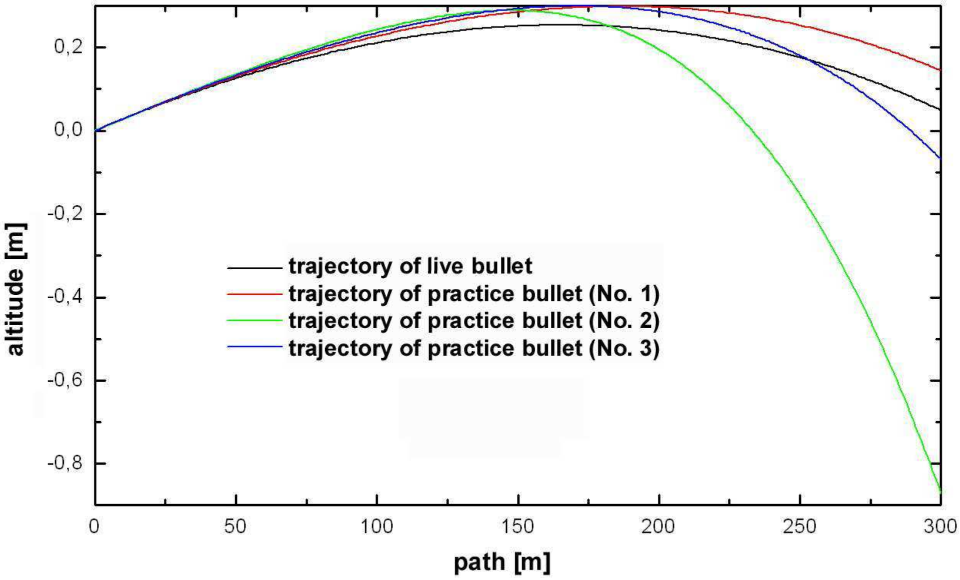

Fig. 6. Results of trajectories simulations for 7,62x54R rounds' bullets

Ricocheted bullets velocity continuously measurement let to estimate energy lost during different targets meeting for numerous input data sets and air drag coefficient changing for bullets particles. Knowledge of air drag coefficient after ricocheting let to simulate bullet flight after impact for any given input data. This knowledge is significantly important during determination safety zones around firing ranges (Fig.7b).

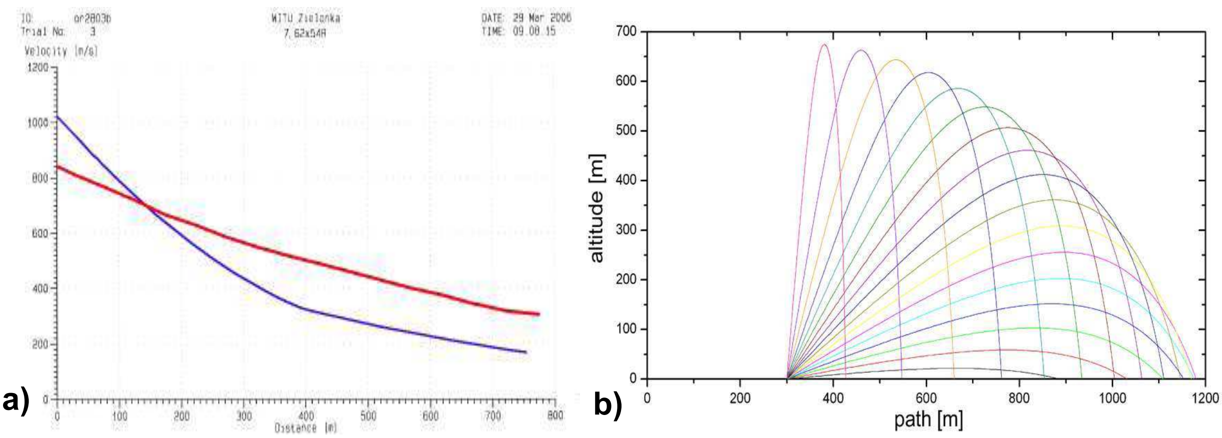

Fig. 7. Bullet velocity curves (red – live round, blue – practice round) for 7,62x54R rounds – a and bullet flight simulation after hitting the main backstop of firing range (without lost energy and shape changing) – b

4. Conclusions

Modelling of internal and external ballistics made possible to determine basic objects characteristics (bullets, propellants), which could fulfil demands formulated by customer [6]. Due to this fact, the time necessary to develop ammunition models was reduced and conducted detailed tests let to verify some computed/measured characteristics values and simplifications. Summarising as the most important advantage of this work, it can be stated that developed ammunition ensures:

- Danger zone radius reducing comparing to live ammunition. It is more than twice lower (1650 m) than for live ammunition (5100 m);
- Bullet kinetic energy reducing close to the firing range rear end; this factor mainly determines bullet killing ability. Practice bullet energy was reduced more than three times.
- Reopening a lot of existing firing ranges, temporary closed due to safety reasons; in some cases even without any modernisation works.

References

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