Optimization of the Electro-Magnetic Cannon

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1. Introduction

Electro-Magnetic (EM) guns (cannons) convert the electrical energy stored in a stationary power supply into kinetic energy of a moving projectile. The main superiority of such cannons on the conventional ones is that higher velocities can be achieved. So the development of electromagnetic gun construction is very actual.

The purpose of our investigation was to find out some directions in which the optimization of EM cannon construction can be achieved.

2. Method of the investigation

At first we investigated theoretically the parameters and construction principles that can play sufficient role in the simplest EM gun model efficiency. Then we constructed our model of EM cannon and observed the influence of mentioned parameters and construction principles on the obtained velocity of the projectile experimentally.

3. Investigation of EM cannon

3.1. Theoretical considerations

The simplest model of EM gun consists of a tube, solenoid, ferromagnetic projectile and an energy source - capacitors. Its acting principle is the following: when during the capacitor discharge an electric current passes through a solenoid, it creates a magnetic field, which magnetizes the projectile and attracts it towards the coil centre.

The force acting on the projectile can be expressed as [1]:

$$F \sim N \cdot I \cdot (d\Phi/dx), \qquad (1)$$

where N is the number of loops in the solenoid, I – capacitor discharge current and $d\Phi/dx$ – magnetic flux gradient at the projectile. Thus optimal construction of EM cannon assumes achieving maximal value of this product.

The other very important moment is the so called “solenoid middle-point problem”: after the projectile passes the centre of the coil, the acting force changes its sign, attracts the projectile back into the solenoid and slows it down thereby decreasing the final velocity. Thus the construction of EM cannon must avoid this problem.

3.2. Our construction of EM cannon

Analyzing construction of EM cannon it is known that among other parameters the Iron Shell around solenoid plays an important role. However, in difference to other investigations [1, 2] *we show that Iron shell must consist only of the front and the back washers* (Fig. 1). This helps to get higher gradient $d\Phi/dx$ at the place of projectile input without significant increasing of coil inductance L and thus without suppression of discharge current.

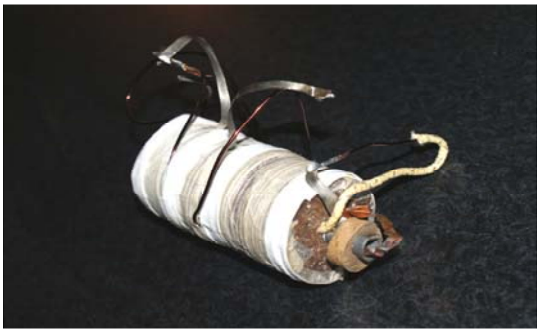
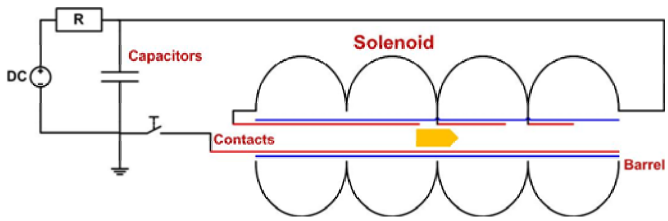


Fig.1. Our construction of EM cannon.

Also we offer our solution of the “solenoid middle point problem”. It is necessary to switch off the current flow when the projectile passes the solenoid center. It can be achieved if relevant part of EM cannon barrel contains conductor and the projectile itself is a part of the circuit.

We propose more advanced solution with *“consequent switching-off”* the solenoid parts behind the projectile (Fig. 2). In such case almost always exists the force acting on the projectile in the forward direction.

Fig.2. Circuit scheme.



3.3. Obtained results and conclusion

We observed that our construction of the shell gives much better results (~20% better than full-surround shell).

Our “consequent switching off” scheme also gave ~15% advantage over “switching off in the center” scheme.

With $C=900\mu F$, $U=300V$, $85mm*Ø42mm$ solenoid and $8mm*15mm$ projectile we got ***~42m/sec*** velocity.

For further investigations we think to develop the “consequent switching off” scheme.

References

[1] http://www.coilgun.eclipse.co.uk/coilgun_fundamentals_1.html

[2] http://www.coilgun.info/theory/externaliron.htm