The Analysis of Electromagnetic Accelerator

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Abstract

The electrical and mechanical construction of cheap and simple laboratory model of electromagnetic accelerator is presented. The system was operated at low energy of about 1.5KJ, producing a projectile velocity of about 50 m/sec. The system analysis based on a developed mathematical model shows the .variation of the current and the velocity as a function of the time

.**Key world:** Electromagnetic Accelerator , Rail Gun , high speed lancher

I. INTRODUCTION

A continuous interest has been carried out in the development of the electromagnetic accelerators to achieve a high velocity for the low weight insulator projectiles [1., 2] . The potential of the very high velocities can be used for many applications such as the generation of strong magnetic fields (>107 Gauss) and the possible production of a useful materials such as industrial diamond dust formed under pressure of (1018 dynes/cm2) .

The most interest has been concerted on the electromagnetic rail gun, because of this system to exceed the range of the muzzle velocities which can not be achieved with the conventional systems [3,4]. This type of accelerated is essentially a linear DC motor consisting of a pair of parallel bars (rails) carrying the current to and from a small interconnecting movable conductor (the armature). The Lorentz force resulting from the interaction of the current with magnetic field generated by the rail current accelerates the projectile [5].

In this work we are going to describe a simple laboratory model electromagnetic accelerator, which can be used to explain the principles of this type of accelerators for the young students and to study damage mechanism of the rail material in the laboratory. In the same time this minimize model can be used to test the theoretical models describing the principle work of such devices.

II. THE EXPERIMENTAL SETUP

The laboratory experimental setup is shown in Fig1. and the circuit diagram of the power source is shown in Fig. 2. The rail accelerator model is consists of two copper strips of (0.3×31×0.5cm) dimension. The copper strips were fixed in parallel by the help of grooved Perspex plates of (100cm) length as shown in Fig. 3. This combination (the copper plates and the Perspex plates) was mounted inside a Teflon channel which was inserted inside a cheap iron tube of (10cm) diameter and of (100cm) length. The alignment of the parallelism of the rails was down by the help of (10) compressed bolts. To best alignment of the rail a Perspex cube of dimension (1cm×1cm×1cm) was passed along the rail smoothly.

The charging unit consists of a DC power supply of output voltage of about (1KV) and rated current of (100mA) .The power source was used to charge the capacitor bank consisting of three electrolyte capacitors of (1000μF) which were connected in parallel. The electrical energy stored in the capacitor bank discharged to the load by the help of the switch S1. the switch was a simple home made three electrodes spark gap, evacuated to about (60-10torr) to be fired at the appropriate applied voltage of about (1KV) . The switch was triggering by a simple triggers circuit

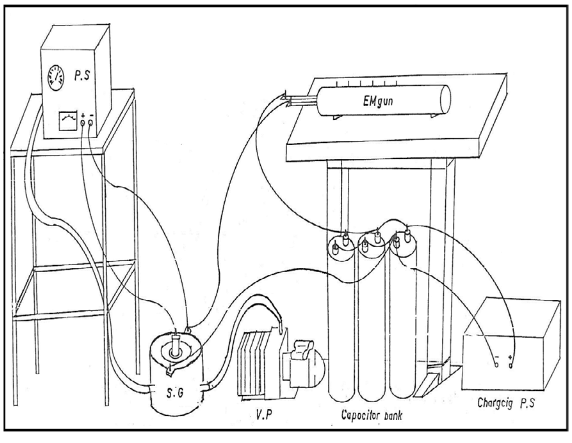


Figure 1.Laboratory setup of the EM launcher

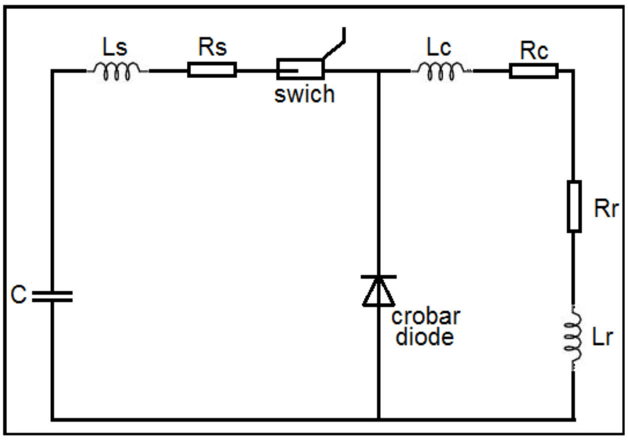


Figure 2. Circuit diagram of the operational launcher

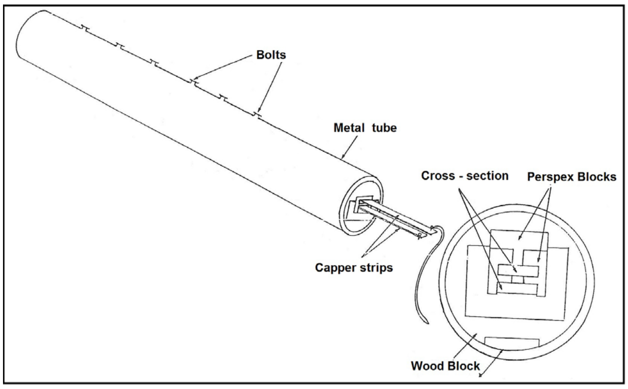
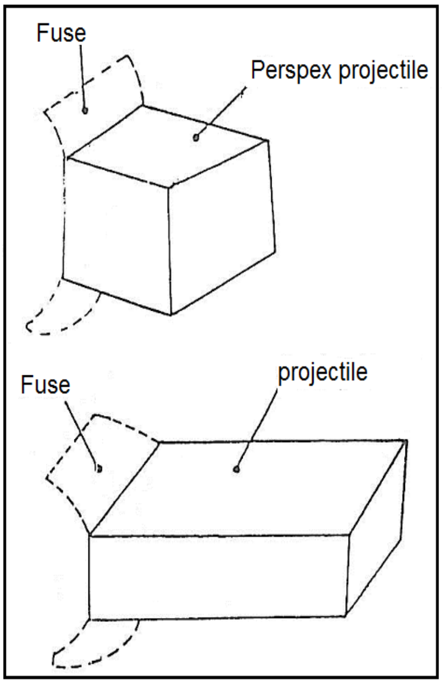


Figure 3. Launcher strips cross- section in side the cylindrical Perspex cover .

The projectiles were designed to be Perspex blokes with square cross-section of (1cm×1cm). The copper strip fuse (the armature) of (0.3mm) thickness was sealed to projectile by the help supper glue. The recommended projectile mass for this system was about (0.5gm), whereas the copper strip fuse is about (0.3gm) or less. The projectile and the fuse is show in Fig.4. Before triggering the switch, the projectile with its copper fuse is pushed between the rails to about (10cm) inside and the copper strip is in contact with the rail., this end is blocked by designed the plasma puffing produced by the evaporation of the thin armature when the high current passing through it .The produced pressure helps in the start movement of the projectile between the rails and then the projectile accelerates by the electromagnetic force.



I II. RESULT AND DISCUSSION

The discharge current assign in the rail measured by a calibrated Rogowski coil found to be about (60 KA) and its variation with time is shown in Fig.5. This result was compared with result extracted from a theoretical model developed by the same group as shown in Fig.6. The current passing in the rail can be given as :

$$I = \frac{2V_o.e^{-r}.\sin\sqrt{r^2-1}.\tau}{(R_s+R_{L_v})\sqrt{r^1-1}} \quad (1)$$

Where Vo is the charging voltage =1KV, r = 4L/R2 .C is the damping factor L= 80 μH, C= 3mF, and R= R s+ RL ≈134mΩ. Rs is the source resistance, RL is the load resistance, and τ is the reduce time which is given by:

$$\tau = \frac{R}{2L}.t \quad (2)$$

it can be noticed from the above results that the experimental results in not far away from the theoretical value.

The Lorentz force applied to the projectile is given by:

$$F = \frac{1}{2}L.I^2 \quad (3)$$

Where L is the circuit inductance (80 μH). Thus the projectile velocity can be given as: of this system

$$V = \frac{1}{2m}.L.\int I^2.dt \quad (4)$$

The variation of the velocity with time is shown in Fig.7. which is not far away from the experimental results measured by using an optoelectronic device. The results showed that the velocity was about (50 m/sec) for payload of mass of (0.5gm).

IV. CONCLUSION

The electromagnetic accelerator, which same time called the rail gun, can be demonstrated in the laboratory. The simplicity of construction of such unit makes it possible to test the theory of such technique and the basic principles of this system student. This approach can help the laboratory equipment supplies to develop a commercial experiential setup to demonstrate the type of accelerators in the university laboratories.

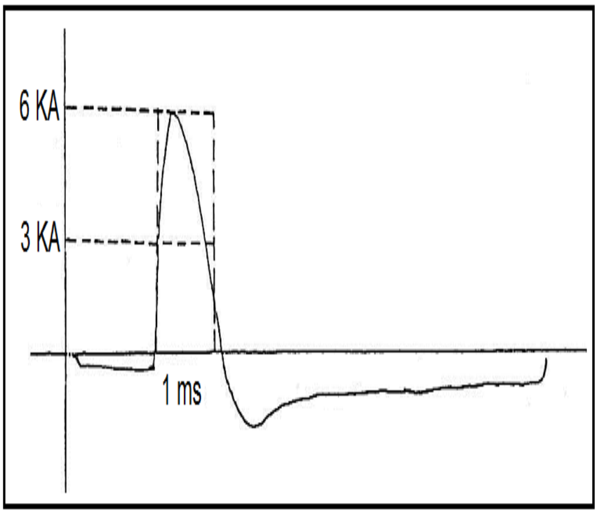


Figure 5. the out put current pulse variation with the time registered by Rogowski coil.

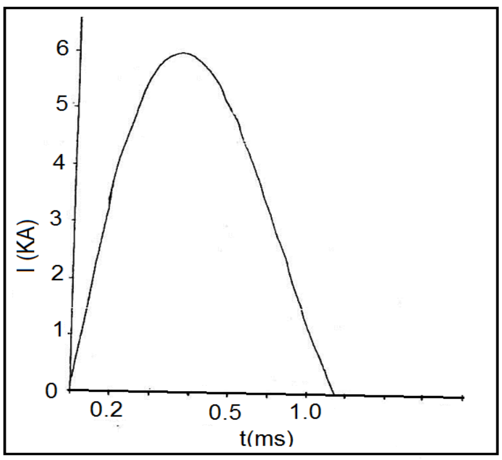


Figure. 6. theoretical current pulse shape of the operated system.

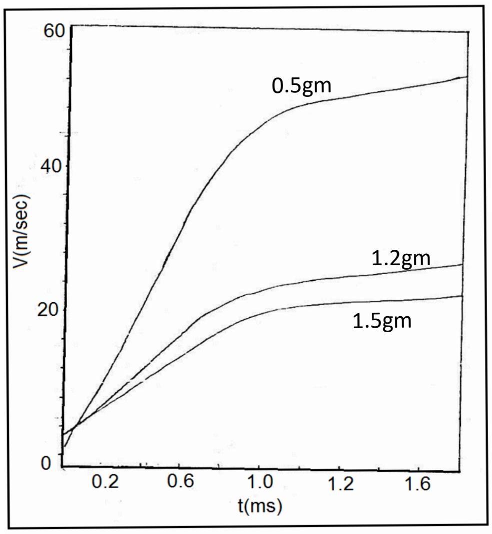


Figure 7. The nozzle velocity changing with time for different projectiles

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