Electomagnetic Projectile Launcher

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***Abstract*— An upcoming weapon for highly accurate long-range shooting is the electromagnetic projectile launcher. Since it doesn't require any form of propellant to fire a projectile, this is a very cost-effective weapon. To create the force needed to hit the target, it uses a strong impulsive current. The US Navy intends to equip ships with railgun systems as a long-range firepower source. To provide the force required to fire the projectile to the designated target position, a coilgun must be charged to a specific voltage level. Because it reduces losses in the coilgun system, it is crucial that the projectile be fired at the target with the least amount of voltage necessary.**

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Keywords— Weapon, Long range, Electromagnetic projectile launcher, propellenty, Hardhat, Target, US Navy, CoilGun

I. INTRODUCTION

A projectile is propelled by an electromagnetic launcher, which transforms electrical energy into kinetic energy. Because it is stable and environmentally safe, it offers a big advantage in terms of storage and upkeep. Globally, a great deal of research and development is being done on EMLs. It is feasible to reorganise the development market for large-size satellites into a market for small-size spacecraft and employ an EML to use electromagnetic force to launch a small satellite into orbit. Accelerating a projectile by turning on many coils in succession is one technique to improve a coil gun's efficiency.In this study, we designed a two-stage coil with a greater efficiency than a single-stage coil gun based on this technology, and we tested its performance by building a prototype coil-gun system.

By supplying current to the coil in solenoid form, a coil gun uses the electromagnetic force produced by Fleming's right hand law to propel a projectile. Force travelling through the inside of the cylindrical coil and acting on the solenoid in all directions propels the coil cannon. Figure 1 illustrates the coil gun's workings. The solenoid separates the force operating on the projectile's circumference into two components: one component moves in the direction of the circumference, while the other component moves in the direction of the axis. Among these, the force acting in the axis' direction propels the projectile.

Furthermore, the projectile can be pushed from the flyway tube without experiencing any mechanical friction since the force in the direction of the circumference is balanced with the pivot point when the projectile's horizontal axis aligns with the flyway tube's horizontal axis. Consequently, the velocity has no theoretical limit. Controlling the operation time of each coil is necessary to find the ideal speed since the velocity of a coil gun is primarily dependent on the interval and operation duration. We created a coil gun system prototype in order to gauge the projectile's velocity. The power source, solenoid coil, guide tube, coil gun support fixture, projectile, and velocity-measuring infrared light sensor gadget make up the coil gun prototype. The velocity measuring infrared light sensor device positioned at the tube's end will measure the projectile's final velocity if it is launched along the guide tube after providing electric current to each coil.

Coil guns are a novel technological advancement in the search for effective, accurate, and adaptable projectile launch systems. These electromagnetic gadgets, sometimes referred to as coil accelerators or Gauss guns, use the laws of electromagnetism to accelerate projectiles rapidly. Coil guns, which use electromagnetic fields to accelerate projectiles instead of chemical combustion, are superior to traditional firearms in a variety of applications, including military, industrial, and scientific ones. Coil gun theory originated in the middle of the 1800s, when pioneers like as Faraday and Gauss established the foundation for knowledge of electromagnetic phenomena. But it wasn't until the second half of the 20th century that coil gun applications became feasible due to developments in materials science and electronics. An array of electromagnetic coils positioned along a barrel makes up the basic construction of a coil cannon. These coils create strong magnetic fields when electric current passes through them. Projectiles that are ferromagnetic—typically composed of steel or iron—interact with these fields to produce a Lorentz force that accelerates the bullet forward.

II. LITERATURE SURVEY

"Lunch to Space with an Electromagnetic Railgun," I. R. McNab Institute for Advanced Technology, University of Technology, Austin, TX, USA, published in IEEE Transactions on Magnetics. The electromagnetic antinuclear launcher for space shuttle and missile launches is described in this study. It operates on the magnetising and demagnetizing of coil concept. The object to be fired is put inside a wide-length tube. Coils are wounded over the tube. Upon receiving power, the first coil becomes energised and attempts to attract an object. Suddenly, the object is drawn towards it. Following attraction, the first coil de-energizes, and then the object is drawn to the second coil when it unexpectedly becomes energised. [1]

The process of energising and de-energizing is repeated until the object does not reach the last coil. During this running process, the object will receive a lot of force and energy, which will cause it to shoot out of the tube in the chosen direction and at a sound speed. "Reluctance Launcher Coil-Gun Simulations and Experiment," by Yafit Orbach, Matan Oren, Aviv Golan, and Moshe Einat from Ariel University in Ariel, Israel, was published in IEEE Transactions on Plasma Science. This paper discusses a particular kind of electromagnetic mass launcher that accelerates a projectile using the Lorentz force: the (induction) coil gun.[2]

In a coil cannon, a second, coaxial, single coil is pushed axially down a guide-way by a magnetic field created by a stack of outer coils that constitute the "barrel (stator)." The term "armature" refers to the moving coil. The shorted armature of a standard induction coil cannon induces current through changes in the magnetic flux from the outer coils. The armature is propelled down the guide-way by a Laplace force created when the induced armature current interacts with the magnetic field generated by the outer coils. IEEE International Conference on Industrial Control and Electronics Engineering published "Design and Implementation of Electromagnetic Rail gun Simulation System based on HLA and VR" (2012). By Yuwei Hu and Ming Yang.[3]

"Magnetic Journey of Space Shuttle," by Praveen Raj, Rishabh Bana, Priya Garg, and Ravi Kumar Shakya from Aerospace University, SRM University, Chennai, India, was published in Advances in Aerospace Science and Applications. This study outlines the launch of a space shuttle that is guided towards either the North or South Poles using the principle of magnetic levitation. [4]

III. DESIGN METHODOLOGY

From the beginning of the electrical current to the projectile's acceleration, there are multiple sequential steps involved in the operation of an electromagnetic projectile launcher that uses a coilgun. Here is a thorough rundown of how things operate:

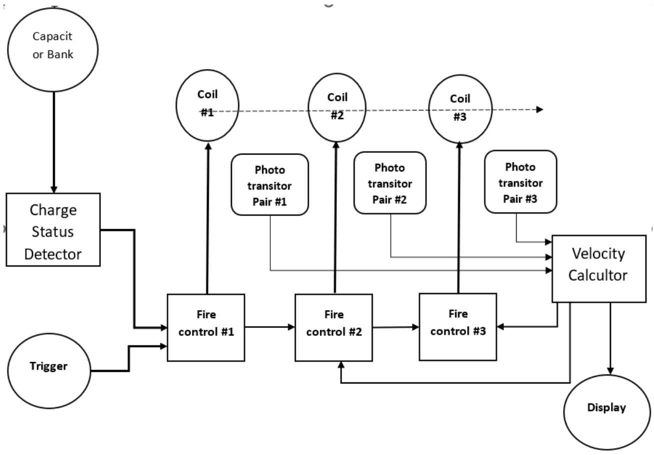

Fig1.Block Diagram

Initialization: After making sure every part is present and working, the coilgun system is ready. This covers the control circuitry, power supply, coils, and safety precautions. [6]

Capacitor Charging: High voltage must be applied to capacitors if they are to be utilised as the power source. Usually, a charging circuit or external power source attached to the capacitor bank is used to do this. Coil preparation: In a coilgun, the coils are usually placed in a sequence down the barrel. Every coil is linked to the control circuitry by means of an insulated wire winding.

Projecting the projectile: The projectile is positioned at the barrel's entrance once the coils and capacitors have been charged.

Current Flow Initiation: The control circuitry starts the electrical current flowing through the coils. Depending on the exact design of the coilgun, this can be accomplished by different methods or by rapidly discharging capacitors. [7]

Creation of Magnetic Fields: Every coil has a magnetic field surrounding it when current passes through it. When the

current rises, the magnetic field gets stronger, and when the current falls, it gets weaker.
Projectile Attraction: The ferromagnetic bullet is pulled towards the closest coil by the magnetic fields produced by the coils.
Sequential Coil Activation: The control circuitry rapidly activates each coil in turn to move the projectile along the barrel. The bullet is propelled forward by a travelling magnetic field created as a result.
bullet Acceleration: The bullet accelerates progressively with each coil it passes as it moves through the barrel. The velocity increases cumulatively as a result of this.

III. SPECIFICATIONS AND HARDWARE COMPONENTS

1. DC Supply: A coilgun system's DC power supply is a crucial component that provides the electrical energy required to move a projectile around the coil at a fast pace.

This power source usually consists of an energy storage device, usually a bank of capacitors, which is charged prior to each firing sequence using specialised electronics.

Fig. Dc Supply

Power conversion mechanisms can be utilised to convert the incoming power into the necessary voltage and current levels for the Coilgun, hence ensuring regulated and efficient operations.

2.Capacitor Bank

Fig.Capacitor Bank

A capacitor with a capacitance of 680 microfarads (uF) and a voltage rating of 450 volts could be suitable for use in a coilgun project, depending on the specific requirements and design considerations. A prototype coilgun's capacitor bank, which acts as the main energy source and gives the projectile incredible force, is the system's beating heart. This essential part, which is engineered for quick energy discharge, is meticulously created to satisfy the unique requirements of coilgun technology. A prototype coilgun's capacitor bank, which acts as the main energy source and gives the projectile incredible force, is the system's beating heart. This essential part, which is engineered for quick energy discharge, is meticulously created to satisfy the unique requirements of coilgun technology.

3.70TPS12 Thyristor :
Synthetic semiconductor firms produce the 70TPS12, a silicon-controlled rectifier (SCR), a kind of thyristor. Below is a summary of its features and specifications:
Reference Number: 70TPS12
Type: Thyristor or Silicon-Controlled Rectifier (SCR)
Rating for Voltage (Vdrm): 1200 volts (V)
Present Rating: 70 Amperes (A) (Itav)
A few milliamperes (mA) is the typical gate trigger current (Igt).
Usually a few volts (V) is the gate trigger voltage (Vgt).

Fig. 70TPS12 Thyristor

4.Diodes:

Rectifier diodes of the FR607 and 6A10 varieties are frequently used in a variety of electrical circuits. Here is a quick synopsis of each:

- **FR607 Diode**:

The FR607 diode is a rectifier diode with quick recovery.
Six amperes (A) is the maximum average forward current.
Maximum Repeated Peak Voltage in reverse: 1000 volts (V)
Forward Voltage Drop (VF): At a forward current of 6A, the typical value is 1.3 volts (V).
Recovery Time: Quick recovery time, appropriate for applications that need to transition between tasks quickly.
Package Type: Usually offered in a DO-201AD (DO-27) package, which is a two-lead, cylindrical container.

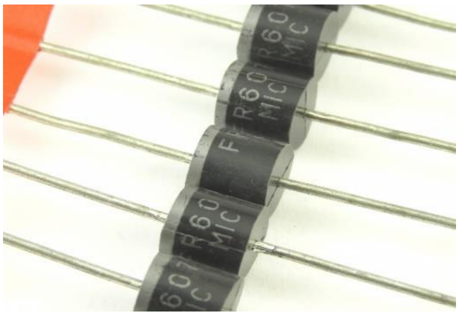

Fig.FR607 Diode

- **FR607 Diode**

A general-purpose rectifier diode is the 6A10.
Six amperes (A) is the maximum average forward current.
A maximum of 1000 volts (V) is the repetitive peak reverse voltage. Forward Voltage Drop (VF): At a forward current of 6A, the typical value is 1.1 volts (V).
Recovery Time: Typical recovery time, appropriate for rectification applications in general.
box Type: This product is usually offered in an R-6 (G-4) box, which is a moulded plastic container including axial leads.

The diodes FR607 and 6A10 are both extensively accessible and often utilised in electrical circuits. Specific needs like switching speed, forward voltage drop, package size, and cost determine which option is best. To guarantee dependable and effective functioning, it's critical to choose the diode that best meets the needs of the application.

5.S8050 BJT transistor

A popular NPN bipolar junction transistor (BJT) for amplification, switching, and other uses in electrical circuits is the S8050. Here are some fundamental details regarding the S8050 BJT transistor:
Bipolar junction transistor of the NPN (negative-positive-negative) type

Polarity: The S8050 is an NPN transistor, which consists of two layers of N-doped semiconductor (the "emitter" and "collector") layered on top of a P-doped semiconductor layer (the "base").
Pinout: The emitter (E), base (B), and collector (C) are the three leads or pins that normally make up a S8050 transistor.
Maximum Points:
40 volts (V) is the collector-base voltage (VCBO).
25 volts (V) is the collector-emitter voltage (VCEO).
5 volts (V) is the emitter-base voltage (VEBO).
700 milliamperes (mA) is the collector current (IC)
625 milliwatts (mW) is the power dissipation (PD).

Utilising and Preserving Temperature: Typically between -55°C and +150°C.
Features: Affordable and compact in size.
ideal for switching and low- to medium-power amplification applications.
is suitable for use in a variety of electronic circuits, including as switching circuits, voltage regulators, audio amplifiers, and signal amplifiers.

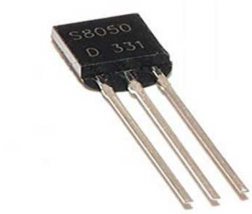

fig. S8050 BJT transistor

6.Projectile

The projectile is driven by electromagnetic forces rather than conventional chemical propellants in an electromagnetic projectile launcher, commonly referred to as a railgun or coilgun. Due to their ability to produce projectiles with high velocity and extended ranges, these launchers are frequently employed in military applications. A variety of parameters, such as mass, conductivity, and form, influence the projectile selection in an electromagnetic launcher. Source: The projectile must be constructed from a ferrous substance, like steel, or a conductive material, like aluminium. Interacting with the electromagnetic fields produced by the launcher requires this. When calculating the force needed for acceleration, the projectile's mass is a crucial consideration. An electromagnetic launcher's projectile selection is influenced by a number of parameters, including as mass, conductivity, and form. Content.

IV.ADVANTAGES

Compared to a powder gun, the projectile launcher might have a far greater potential power. With the projectile launcher, we can already achieve speeds of about 9 km/s; in contrast, the greatest speed of a powder gun is less than 8.5 km/s. The projectile launcher's maximum estimated speed is 140 km/s. ¬ There is no requirement for fuel or explosives because the projectile launcher is only dependent on a strong current. This is more effective in the ways listed below:
1. High Velocity and Range: Compared to conventional projectile launchers, electromagnetic launchers have the ability to drive projectiles at incredibly high velocity, giving them a greater effective range. They are therefore appropriate for uses where accuracy and range are crucial.
2. Lessened Propellant Dependency: Electromagnetic launchers employ magnetic fields to drive projectiles as opposed to traditional rifles, which rely on chemical propellants. As a result, less conventional propellants are required, which makes the system safer to operate and more ecologicallyfriendly.
3. Minimal Recoil: In general, electromagnetic launchers have less recoil than conventional rifles. More accuracy and quicker follow-up rounds may result from this, particularly in situations when recoil control is essential.

4. Projectile Variety: Electromagnetic launchers are capable of firing a wide range of projectiles, from conventional ammunition to specialised payloads. Because of its adaptability, the launcher may be used for a variety of purposes, including anti-armor and anti-missile defence.
5. Less Wear and Tear: The launcher and the projectiles experience less wear and tear as a result of the lack of chemical propellants and the smooth acceleration offered by electromagnetic fields. This may result in less expensive upkeep and greater longevity all around.
6. Potential for Fast Fire: Electromagnetic launchers have the ability to fire at a fast rate of fire when they are designed and powered properly. This can be helpful in situations when a large number of projectiles need to be delivered rapidly, such in some defence or military applications.

V.APPLICATIONS

Often called a railgun or coilgun, an electromagnetic projectile launcher uses electromagnetic forces to propel projectiles at high speeds. These sophisticated projectile launchers have a wide range of possible uses in several industries. Here are a few of them:
1. Military Uses: High-Velocity Projectiles: Railguns can fire projectiles at incredibly high velocities, which provides a considerable advantage in terms of impact energy and range. Because of this, they may find utility in military applications such as anti-ship and long-range artillery. Decreased Logistics: Because electromagnetic launchers do not require explosive propellants, handling and transporting the systems is safer and there are fewer logistical issues.
2.Systems for Space Launch: Satellite Deployment: Compared to conventional chemical rocket propulsion systems, electromagnetic launchers provide a more affordable and ecologically benign way to send tiny payloads into orbit.

3. Research and Testing: High-Speed Impact Studies: High-speed impacts, the behaviour of materials in harsh environments, and the effects of projectiles on different surfaces may all be studied using electromagnetic launchers inscience.
4. Uses in Aerospace: Hypersonic Research: By offering a way to test and examine materials and components at incredibly high speeds, railguns and coilguns can aid in the development of hypersonic technologies.
5. Metal Forming in Industrial Manufacturing: Electromagnetic launchers can be utilised in industrial settings to shape and compress metal workpieces.

VI.FUTURE SCOPE

Weapons: It is a weapon of the future that can hit targets at a great distance with extreme precision.
Ships can use this technology as a long-range firing weapon.
High-Speed Transport: The development of high-speed transport systems, such as electromagnetic trains or ideas resembling the hyperloop, may involve the exploration of electromagnetic launch technology.

VII.CONCLISION

This study proposes a finite element modelling approach for wear prediction in electromagnetic projectile launchers. The study looks at friction wear and launcher testing, and it provides us with helpful information. The practical implications of these results lie in their potential to increase the lifespan and utility of electromagnetic projectile launchers. Consider a modification that improves, lowers the cost, and consumes less fuel for rocket launches. That's what the suggested system is based on. How? By implementing the railgun technology, we can increase projectile speed and launch system reliability. Using Earth's magnetic field to launch space shuttles might revolutionise the industry and increase confidence and efficiency. These days, the magnetic levitation concept plays a major role in space travel and rail transportation. This provides astronauts with an innovative, new means of space travel. And the way with the rail gun? Projectile and rocket velocity are significantly increased by it.

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