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Design and Fabrication of Gauss Rifle with Mechanical Feeding System

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ABSTRACT: This project report presents the design and construction of an electromagnetic gun that uses electromagnetic forces to propel projectiles at high speeds. The aim of this project was to develop a prototype electromagnetic gun. The report begins with an overview of electromagnetic guns and their advantages over conventional guns, highlighting the potential for increased range, accuracy, and reduction. It explores the basic principles of electromagnetic propulsion, which are critical to understanding the gun's mechanism of action. The design phase involves thorough research and analysis to determine key components and their characteristics. This includes selecting suitable materials for the barrel, projectile, and electromagnets and designing the coil configuration and power supply system. Computer□Aided Design (CAD) tools were used tosimulate and optimize the design for efficiency and performance. The manufacturing process includes manufacturing, assembling, and integrating firearm components. The testing and evaluation phase focused on testing the performance and functionality of the electromagnetic gun. Experiments were conducted to measure projectile velocity. The results were analysed, and any inconsistencies or areas for improvement were identified. Finally, the report discusses the limitations and challenges faced during the project. Future research directions and potential improvements to the electromagnetic gun are explored, including implementing advanced control systems and using advanced materials. Overall, this project report comprehensively describes the design and construction of an electromagnetic gun. This contributes to the emerging field of electromagnetic propulsion technology and serves as a foundation for further development and refinement of electromagnetic guns for a variety of future applications.

Keywords: Electromagnetic Gun, Projectile Velocity, Electromagnetic Propulsion

I. INTRODUCTION

An electromagnetic gun is a type of particle accelerator consisting of coils used electromagnetically to accelerate a conductive projectile to a high velocity. It is an electromagnetic launch system, a fuel-free launch technology that is more advantageous than existing chemical launch systems, environmentally friendly (smoke- free), and its range can be controlled by controlling the velocity through varying currents. It has low recoil, silence, and low friction loss by adjusting all configurations of the gun. Experiments have been done to increase the velocity and its manufacturing characteristics. It is suitable for armed force use and has a future in newer weapons. The coils are arranged along a tube so that the path of the shot isalong the mid-axis of the coils. The coils switch precisely, causing the shot to accelerate rapidly along the tube because of forces. An AC electric current through the solenoid creates a magnetic field when it shoots, which causes the ring to bounce a few meters away from the core. This system is beneficial over the existing launching systems. Itis gun powder launch method. Instead of using an explosive charge, they use electromagnetism to propel the projectile. A coil gun is a type of shot ejector with coils that, when activated, operate electromagnetically that accelerates a shot to high velocity. The fabrication of the coil gun is easy but theoretically complex. Coil guns are further classified depending on their working principle, reluctance type, and induction type coil gun. Research on the induction coil gunis not extensive in the literature; however, there are some papers that provide a basic theoretical framework(Khandekar et al.). Coil guns use magnetism to fire the shot instead of using gunpowder. It can be used as a fireless weapon. The user may have a maximum ammo velocity. The propulsion of existing systems is the detonation of the ammunition, which causes fire on the back of the bullet placed in a barrel. With new findings and innovations in modern weapon systems, ammunition is expected to change.

II. PHYSICAL DESIGN

The following factors are involved in designing.

1. **Frame**: Based on materials properties, the best solution would be to use a plastic-based material. Despite the ease, we feel that since our weapon uses electromagnets to accelerate the weapon rather than gunpowder, that creates an explosive force, recoil shouldn't be a thing that we would have to worry about. Therefore, plastic use should not reduce weapon performance or accuracy. We also feel that the cost of creating a plastic frame should be cheaper than steel. Fabricating a plastic frame is also much simpler than creating a metal-based frame because we don’t need to use any machining tools, which can be expensive; we don't have access to it yet. But, if you want to create a plastic-based frame, we can use a 3-D printer,making it easier and faster to create.
2. **Barrel:** The barrel's internal surface must be smooth to minimize friction and facilitate the efficient acceleration of the projectile. Consider using a polished or coated surface to reduce friction losses. Provided electrical insulation between the coil and the barrel to prevent short circuits and to ensure efficient energy transfer to the projectile. Designing a barrel for a coil gun using polystyrene offers several advantages. Polystyrene is a lightweight and durable material that can withstand high stresses and forces generated during the firing process. Its insulating properties help reduce heat loss, allowing efficient energy transfer to the projectile. Polystyrene's low cost and ease of moulding make it an attractive choice for barrel design. However, it is important to ensure that the polystyrene barrel is properly reinforced to handle repetitive forces and prevent deformation or failure. Overall, by using polystyrene in the barrel design, a coil gun can achieve a lightweight, cost-effective, and efficientsolution.
3. **Magnetic Field**: Choose a shape for the coil, usually cylindrical or solenoidal, that maximizes the strength of the magnetic field and ensures uniformity in the trajectory of the projectile. And we used a cylindrical shape to fit properly over thebarrel of the gun. Then we determined the optimum number of turns for the coil based on the required magnetic field strength, energy transfer efficiency, and available power supply. We finalized the number of turns to 150 turns. A suitable wire gauge that can handle the required current without overheating was selected with a diameter of 0.8mm. Thicker wires reduce resistance and power loss but increase coil size and weight. Ensured coil dimensions and magneticfield configuration matched projectile shape and material.
4. **Projectile**: The material must be ferromagnetic tointeract with the magnetic field generated by the coil. Common choices are iron, steel, or nickel- based alloys. Materials with high permeability increase the effect of the magnetic field on the projectile, leading to better acceleration. Soft magnetic materials such as iron or certain steel alloys are often preferred. The projectile material should have low electrical conductivity to reduce eddy currents. Eddy currents can induce opposing magnetic fields that reduce acceleration efficiency. Non-conductive or weakly conductive materials such as plastics or ceramics can be used. It must bestrong enough to withstand the acceleration forces during launch and maintain structural integrity. Metals such as steel or aluminium alloys are usually chosen for their strength. The material must be appropriate for efficient acceleration within the coil gun. It should not be too light to reduce momentum or too heavy to hinder acceleration. Experimentation and optimization may be necessary.

III. CIRCUIT DESIGN

The following factors are involved in circuit designing.

1. **Circuit Designing for Electromagnetic Coil**: The circuit for the electromagnetic coils consists of three stages one for each coil and a circuit for receiving power from the battery unit. The circuit of the first stage consists of a push button, solenoid, resistor, 70 TPS 12 thyristor, 6A10 diode, and a 600 µf capacitor that powers thecircuit. Initially, the capacitor is fully charged by the battery at 300 V, and when the push button is pressed, a 12 V signal output is generated by the push button; this switch on the thyristor makes thecircuit close,

and the capacitor is made to discharge through the solenoid of the first coil, and thus the solenoid will be magnetised. And the projectile will be attracted by the magnetised coil.

In the second stage, the circuit is divided into two parts one for sensing the projectile and the second one to magnetise the solenoid. The circuit for sensing the coil consists of a photo transmitter and a receiver; when the projectile is passed in between the transmitter and receiver, it interferes with the transmission, which results in the formation of an input signal. This signal is then transferred to the second circuit, and when this signal is received, the second circuit becomes closed, and the capacitor will be discharged through the solenoid, thus producing a magnetic field. The second circuit for magnetising the coil is a replica of the circuit for the first stage, but the sensing circuit's signal replaces the push button. Circuit for the third stage is as same as the circuit for the second stage.

2. **Circuit Designing for Power Supply Unit:** The circuit consists of three 18650 batteries; the AC voltage 120 V is supplied from the power source is used to charge the batteries, each having a capacity of 500 mAh, through a battery management system. The circuit consists of a two-watt toggle switch to switch between a 12 V supply for the electronic components and a 300 V supply for charging the capacitors. The 300 V required for charging the capacitor is obtained using a step-up AC-DC converter that converts the 12 V supply to 300 V DC voltage for charging the capacitors. The circuit designs for the electromagnetic coils and for the power supply are given in Figure 1.a below

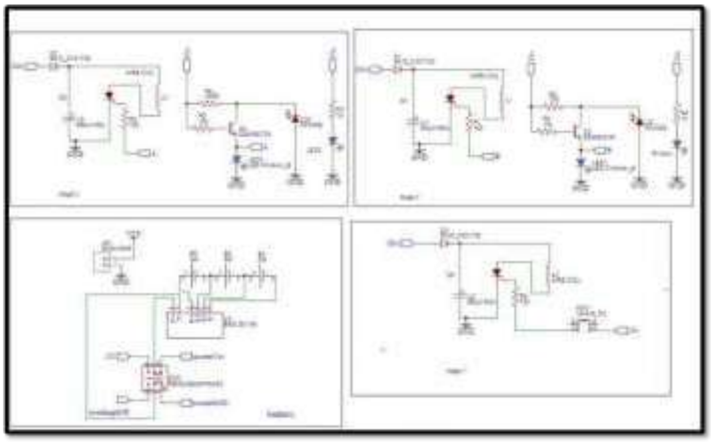

Fig 1.a

Table 1. List of items as per specifications.

Item Name	Specification	Quantity
Capacitor	450 V, 680 µf	3
Led	Red, blue	4
Copper wire	0.8 mm	5 m
Battery	18650 Battery, 500mAh	3
Socket	18650 socket	1

Push button		1
IR led emitter		2
Transistor	S8040 bjt transistor	2
Photo receiver	Pt334 phototransistor receiver	2
Thyristor	70tps12	3

IV. EXPERIMENT DETAILS

Table 2- Experiment Details

Location	9.9503733° N, 76.6309416 ° E
Conducted experiment on	21/04/2023
Distance	2 m
Velocity	8.69 m/s to 9.53 m/s
FPS	720

V. OBSERVATION TABLE

Table 3 – Observation Table of the experiment

Sl. No.	**Time Taken (seconds)**	**Exit Velocity (m/s)**
1	0.21	9.52
2	0.23	8.69
3	0.23	8.69
4	0.21	9.52
5	0.23	8.69

VI. CALCULATIONS

Calculations for the projectile velocity is given below:

1. <u>Velocity</u>

Time taken = 0.23m/s Distance= 2 meters

Velocity= Distance/Time
= 2/0.23
= 8.69 m/s

VII. RESULTS

The values measured for different parameters of the prototype are shown in the table below, Table-4 Values measured for different parameters

Parameter	Measured Value
Number f stages of coils	3 stages
Number of coil windings	150 rounds
Output of the inverter after AC to DC conversion	300v-320v
Time taken by the capacitor to charge	5 seconds
Time taken by batteries to full charge	90 minutes
Number of shots can be done from 1500 mAh battery	10 shots
Maximum exit velocity obtained	9.52 m/sec

VIII. CONCLUSIONS

In conclusion, the design and fabrication of an electromagnetic gun with a mechanical feeding systemhave been successfully completed in this project report. This project aimed to create a highly efficient and reliable electromagnetic gun that could be used in variousapplications.

The design phase involves thorough research, analysis, andconsideration of components such as electromagnetic principles, mechanical components, and power supply. By combining these factors, a well-optimized design was developed that ensured the effective operation of the electromagnetic gun.

The design specifications were translated into a physical prototype during the manufacturing phase. High-quality materials and precision manufacturing techniques were used to manufacture the electromagnetic gun and mechanical feeding system. Rigorous testing and evaluation are done to ensure the final product's functionality, performance, and safety.

An electromagnetic gun with a mechanical feeding systemhas demonstrated admirable results. It exhibited efficient acceleration and projectile launching capabilities, which were essential for its intended applications. A mechanical feeding system reliably fed projectiles into the gun, enabling uninterrupted continuous firing. It also incorporates safety mechanisms to prevent accidental discharge or accidents during operation, prioritizing user protection.

The success of this project highlights the importance of effective design and fabrication processes to achieve the desired results. The performance and reliability of the electromagnetic gun make it a potential candidate for applications requiring high-velocity projectiles, such as military defense systems or industrial material testing.

In conclusion, designing and constructing an electromagnetic gun with a mechanical feeding system yielded a well-engineered, efficient, and versatile product. This project has contributed to the field of electromagnetic propulsion systems by opening avenues for further improvements and applications in the future.

SCOPE OF THIS PROJECT

- The gun design can be refined to improve the portability of the gun.
- More power can be generated from the gun by changing the values of the components can make it possible to use in military applications.
- More work on the feeding system is to be done because, for military usage, high-speed feeding ofthe projectile is required.
- An automatic version of the gun can be made,which will increase the gun's firing rate.
- A solution for making the gun waterproof is notyet discovered

REFERENCES

[1]. Zhou, Y., Han, X., Zhang, D. and Bing, Z., 2023, March. Optimal Parameters Configuration of anInduction Coil Gun. In The Proceedings of the 17th Annual

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Conference of China Electrotechnical Society: Volume III (pp. 589- 595). Singapore: Springer Nature Singapore.

[2]. Kim, S., Jang, C. and Kim, J., 2023. Design and Experiment of Discharge Control Methods for Three-Stage Coil Gun Experiments. Applied Sciences, 13(3), p.1779.

[3]. Chen, D., Li, Z., Chen, Q., Ma, Y., Chen, C., Zhao, W. and Yan, S., 2023, April. Simulation and Analysis of Muzzle Velocity Accuracy of Synchronous Induction Coilgun. In The Proceedings of the 17th Annual Conference of China Electrotechnical Society: Volume II (pp. 1320-1328). Singapore: Springer Nature Singapore.

[4]. Baharvand, M., Kolagar, A.D. and Pahlavani, M.R.A., 2021. Design, simulation, and parameter optimization of a multistage induction coilgun system. IEEE Transactions on Plasma Science, 49(7), pp.2256-2264.

[5]. Lee, S.J., Kim, J.H., Song, B.S. and Kim, J.H., 2013. Coil gun electromagnetic launcher (EML) system with multi-stage electromagnetic coils. Journal of Magnetics, 18(4), pp.481486