Implementation of a DC Motor

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EEE 2204; Sec:A; Group 5

Abstract

This report presents a detailed study on the design, construction, and operational analysis of a direct current (DC) motor. The project aims to explore the fundamental principles of electromechanical energy conversion, providing a comprehensive guide to fabricating a functional DC motor from basic components. The methodology encompasses theoretical analysis, material selection, assembly procedures, and performance testing. Key concepts such as electromagnetic induction, magnetic fields, and motor efficiency are examined in the context of the motor's design. The construction process is meticulously documented, highlighting critical steps and potential challenges encountered during assembly. Experimental results are analyzed to evaluate the motor's performance, efficiency, and reliability. This project not only underscores the practical applications of electromechanical engineering principles but also serves as an educational tool for understanding the intricacies of DC motor technology. The findings offer valuable insights for future advancements in motor design and contribute to the broader field of electrical engineering.

Contents

1 Introduction

Now-a-days DC motors is the main mechanism in many devices we use daily, from small gadgets to large machines. This project aims to teach how to build a simple DC motor, helping to understand the basic principles of how these motors work.

The main goal is to provide hands-on experience in creating a working DC motor. Building the motor from scratch helps link theoretical knowledge to real-world application, covering areas like material choice, circuit design, and mechanical assembly. This report will guide you through the project step-by-step. First, it explains how a DC motor works. Then, it covers the materials and components needed and why they are chosen. The building process is detailed with clear instructions and pictures. Next, the motor is tested to see how well it performs. We measure things like speed discuss the results to understand what works well and what could be improved.

In summary, this project not only teaches about DC motors but also helps build practical skills in electrical engineering.

2 Project Objective

- Explore Electromagnetic Basics
- Build a Functional Motor
- Test and Evaluate

3 Design

The design of our DC motor incorporates several key components and follows a meticulous process to ensure efficient operation and functionality. This section outlines the design process, detailing each component and its role in the motor's overall performance.

Initially, we convert AC voltage to DC to power the motor. We then design the magnets to generate the necessary magnetic flux. Following this, we design the rotor with a two-pole configuration and proceed to design the commutator. The brushes are then assembled. The entire motor assembly is carefully aligned to ensure smooth operation. The rotor is mounted on a shaft that allows it to spin freely within the magnetic field created by the permanent magnets. The commutator and brush assembly are adjusted to ensure consistent contact and efficient current transfer. All components are securely fixed to minimize vibration and ensure durability during operation.

After assembly, the motor undergoes testing to evaluate its performance. Key parameters are measured, and adjustments are made as necessary to optimize performance. This includes fine-tuning the brush pressure and ensuring the commutator segments are clean and free of debris.

3.1 Components used for design

- SMPS Power Supply
- AV Meter
- Permanent Magnet
- Enameled Copper Winding Wire
- Aluminium Foil
- Aluminium Stick

3.1.1 SMPS Power Supply

To power our DC motor, we used a switched-mode power supply (SMPS) to convert AC to DC. The SMPS provides a stable and efficient DC output, which is essential for the consistent operation of the motor. The chosen SMPS is capable of delivering the required voltage and current to drive the motor effectively. [1]

Fig. 01:SMPS

General Specification of SMPS

Input Voltage	AC 85-265V
Output Voltage	0-15V
Current Max	12.5A
Size	128mm*98mm*40mm
Shell Material	Metal case / Aluminum base
Safety Compliance	CCC/ FCC / CE
Working Temperature	0 to 40°C
Storage Temperature	-20 to 60°C

3.1.2 AV Meter

An Ampere-Voltage(AV) meter, utilized in our setup, serves to measure both voltage and current, crucial for assessing the electrical parameters within our motor during operation.[2]

Fig. 02:AV Meter

General Specification of AV Meter

Power Supply	230V AC 50 Hz
Size(mm)	96 (H) x 96 (W) x 43 (D)
Panel Cutout (mm)	92 (H) x 92 (W)
Display	3-Digit , 2-Line , 7-Seg 0.56 Red, Blue LED
Working Temperature	0 to 55 °C
Storage Temperature	0 to 55 °C
Network Connection	1 Phase- 2 Wire (1P-2W)

3.1.3 Permanent Magnet

We used four permanent magnets in two sides to create the magnetic flux necessary for the motor's operation. These magnets are positioned opposite each other to form a two-pole magnetic field. The magnets are carefully aligned to ensure a uniform and strong magnetic field, which interacts with the rotor windings to produce motion.[3]

Fig. 03:Permanent Magnet

General Specifications: Permanent Magnet

Material	NdFeB
Configuration	Ring
Force Pull	100gm+
Size	10mm*4mm*1mm

3.1.4 Enameled Copper Winding Wire

The rotor is designed with windings appropriate for a two-pole configuration. We used copper wire to create the rotor windings, ensuring low resistance and efficient current flow. The windings are carefully wound around the rotor core and connected in a manner that allows them to interact with the magnetic field produced by the permanent magnets. We used 1mm copper winding wire and 55 turns each side.[4]

Fig. 04:Enameled Cu Winding Wire

General Specifications of used Cu wire

Diameter	1mm
Conductor Type	Solid
Wire Gauge	14SWG
Tensile Strength	550 MPa
Winding Turns each side	55

3.1.5 Aluminium Foil

The commutator is a crucial component that ensures the current direction in the rotor windings is switched appropriately to maintain continuous rotation. We constructed the commutator using aluminum foil segments, which are attached to the rotor shaft. The aluminum foil serves as the conductive segments, providing a lightweight and efficient solution.[5]

Fig. 05: Aluminium Foil

3.1.6 Aluminium Stick

To transfer current to the rotating commutator, we used a pair of aluminum sticks as brushes. These brushes are positioned to maintain constant contact with the commutator segments. The aluminum sticks are chosen for their conductivity and ability to withstand the wear and tear of continuous operation. The brushes are mounted on a fixed support that allows them to press lightly against the commutator, ensuring good electrical contact without excessive friction.

Fig. 06:Aluminium Stick

4 Diagram and Explanation

4.1 Diagram

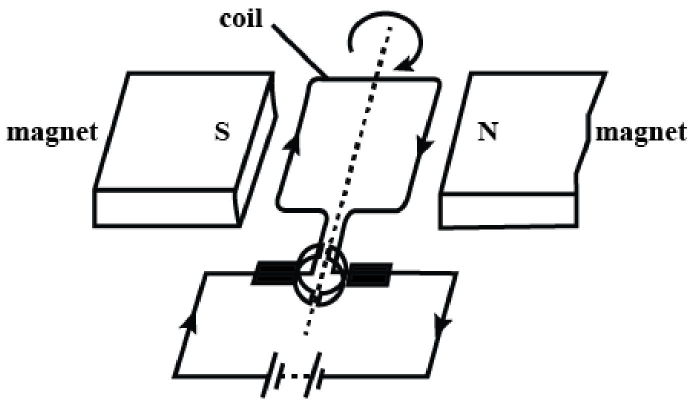

Fig. 07:Diagram

4.2 Working and Explanation

The working principle of a DC motor revolves around the interaction between magnetic fields and electrical currents to produce mechanical motion. Here's a detailed explanation:

Conversion of AC to DC: The first step involves converting alternating current (AC) to direct current (DC) using a switched-mode power supply (SMPS). This ensures a steady and consistent flow of electrical energy to power the motor.

Magnetic Flux Generation: Four permanent magnets are positioned to create a magnetic field within the motor. These magnets establish a stable magnetic flux, which is crucial for the motor's operation. The magnetic field created by the magnets interacts with the current flowing through the rotor windings, resulting in mechanical motion.

Rotor: The rotor, which is the rotating part of the motor, is designed with a two-pole configuration. This means that it has two magnetic poles, north and south, which interact with the magnetic field produced by the permanent magnets. The rotor windings are wound around the rotor core and connected to a commutator.[5]

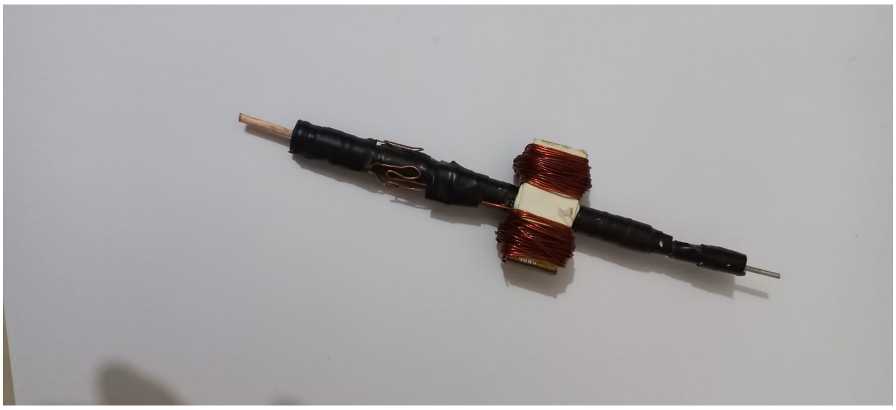

Fig. 08: Rotor Implementation

Commutation Process: The commutator is a segmented cylindrical structure attached to the rotor shaft. It serves to switch the direction of the current in the rotor windings as the rotor rotates. This switching action ensures that the rotor maintains continuous motion in the same direction. Brushes, typically made of conductive material such as carbon or metal, make contact with the commutator segments and transfer electrical current to the rotor windings.[5]

Electromagnetic Interaction: When electrical current flows through the rotor windings, it interacts with the magnetic field created by the permanent magnets. This interaction generates a force known as electromagnetic torque, which causes the rotor to rotate. The direction of rotation is determined by the direction of the current and the polarity of the magnetic field.

Mechanical Motion: As the rotor rotates, it drives the shaft connected to it, which can be used to perform mechanical work or drive other machinery. The speed and torque of the motor can be controlled by adjusting the voltage and current supplied to it.

In summary, the DC motor works on the principle of electromagnetic induction, where the interaction between magnetic fields and electrical currents produces mechanical motion. By carefully designing and assembling the components, we can create a reliable and efficient motor for various applications.

5 Project Demonstration

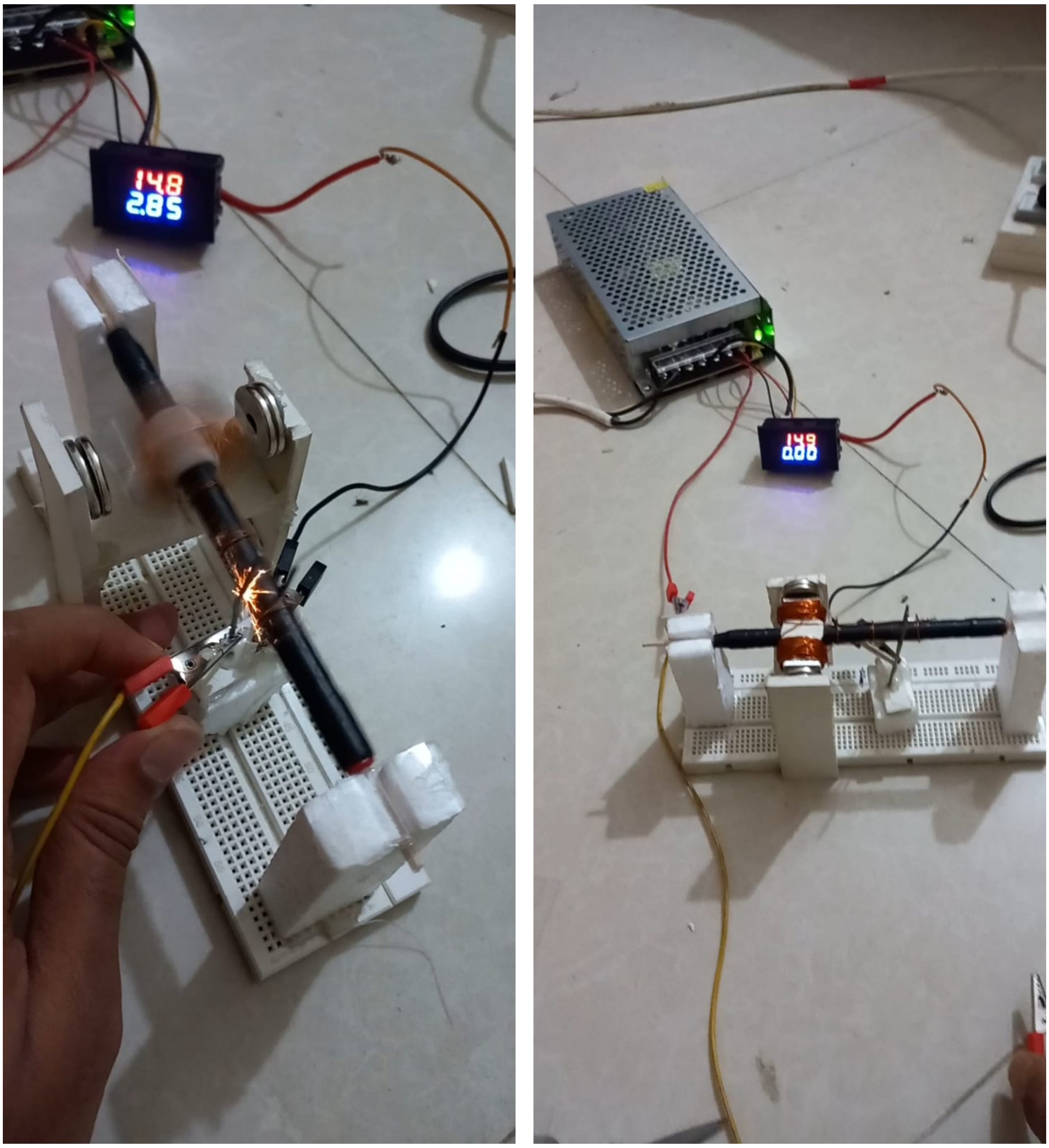

Fig. 09. Motor Demonstration

6 Voltage Control Testing

Voltage: The voltage supplied to the motor increases incrementally from 9.5 volts to 14.1 volts. Current: With the increase in voltage, the current drawn by the motor also increases, indicating a proportional relationship between voltage and current. Speed: As the voltage supplied to the motor increases, the speed of the motor also increases. This relationship between voltage and speed is consistent with the motor's characteristics, as higher voltage typically results in higher rotational speed.

Voltage(V)	**Current,Ia(A)**	**Speed,N(rpm)**
9.5	1.5	1045
10.0	2.1	1103
11.0	3.2	1230
12.1	3.3	1329
13.2	3.65	1404
14.1	3.9	1480

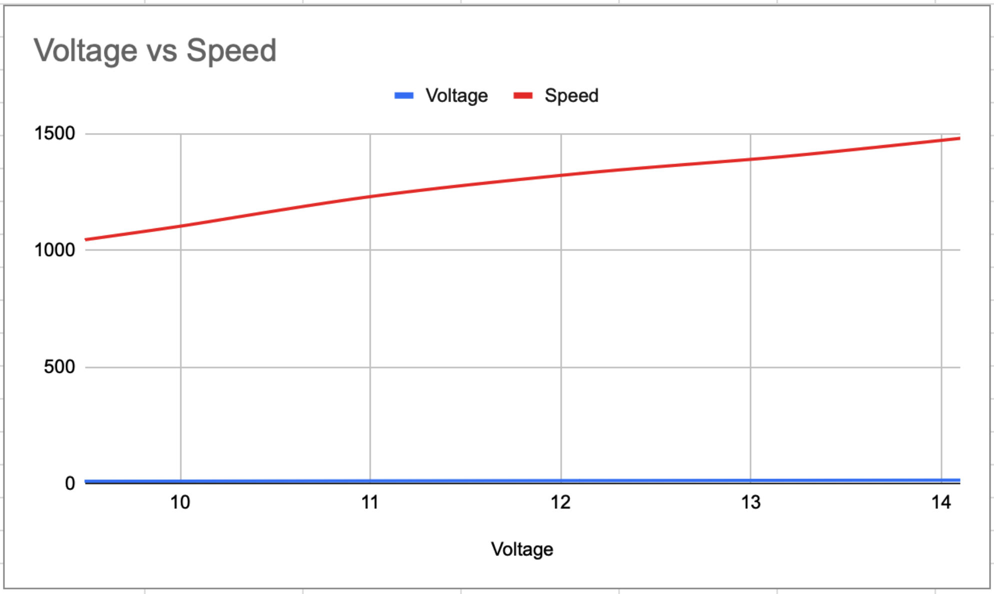

Fig. 10.Graph of Voltage vs Speed

7 Benifits

- Compact Size
- Efficient Operation
- Precise Control
- Easy to carry
- Low Maintenance
- Emergency Response
- Small Automotive Accessories

8 Application Areas

- Toy Industry
- Small Home Appliances
- Electronics Projects
- Cardiac Research
- Medical Devices
- Small Automotive Accessories

9 Limitations

- Brush Wear
- Limited Power Output
- Electronics Projects
- Cardiac Research
- Voltage Sensitivity
- Limited Temperature Range
- Limited Speed and Torque

10 Cost Estimation

The total cost of the project is estimated to be around 990 BDT. This includes the cost of the components, labor, transportation, and other expenses. The project is considered to be low-cost and can be easily replicated by others. The project uses readily available components, making it easy to obtain the necessary parts. The project is relatively simple to assemble, making it accessible to people with limited technical skills.

Component Cost table

Component	**Cost(BDT)**
SMPS Power Supply	600/-
AV Meter	130/-
Permanent Magnet 4x	200/-
Enameled Copper Winding Wire	50/-
Al.Foil and Al.Stick	10/-
Total	**990/-**

11 Conclusion

In conclusion, the construction and testing of the DC motor showcased the fundamental principles of electromechanical engineering in action. Through the assembly process, we gained insights into the interaction between magnetic fields and electrical currents, highlighting the importance of precise design and alignment. The performance testing provided valuable data on the motor's efficiency and reliability, underscoring its practical applications across various industries. Despite its limitations, the DC motor remains a versatile and indispensable component in numerous devices and systems.

References

[1] SMPS: https://leetechbd.com/product/12v-10a-dc-power-supply-smps/

[2] AV Meter: https://www.multispanindia.com/product-detail.php/ampere-volt-combined-meter

[3] Permanent Magnet: https://www.directindustry.com/prod/magengine-co-ltd/product-39403-1718246.html

[4] Cu Winding Wire: https://www.remingtonindustries.com/magnet-wire/

[5] Chapman, S.J.: Electric Machinary Fundamentals -5th Editon ISBN: 978-0-07-352954-7, p. 464. Chap 8: DC Motors and Generators