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Design and Development of an Electric Scooter for Streamlined Personal Transportation

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ABSTRACT :

This paper presents the design and development of a cost-effective electric scooter aimed at providing streamlined personal transportation for everyday commuting. The project emphasizes simplicity, affordability, and customization, making it accessible to a broad audience, particularly in regions with financial constraints or limited access to advanced repair facilities. A PMDC motor is selected as the primary drive component due to its cost-efficiency, ease of control, and reliability in low-power applications. The design incorporates basic but essential features to ensure user-friendliness and ease of maintenance, allowing individuals to build, modify, and repair the scooter with minimal resources. By focusing on a DIY approach, this project seeks to empower users to take part in the development of sustainable and affordable transportation solutions. Through a detailed analysis of the electric scooter's design, components, and performance, the paper highlights how streamlined, affordable electric mobility can be achieved without compromising practicality or functionality.

INDEX TERMS Electric scooter, PMDC motor, affordable electric mobility, customization, cost-efficiency.

I. Introduction :

With the rapid pace of urbanization and increasing concerns about environmental sustainability, there is an urgent need for more efficient and eco-friendly transportation solutions. Among these, electric scooters have gained significant attention as a practical option for short-distance commuting, especially in densely populated cities. These vehicles are seen as a sustainable alternative to traditional gas-powered scooters and cars, helping to reduce air pollution and dependence on fossil fuels. Their small size, ease of use, and low running costs make electric scooters an attractive choice for personal mobility in both urban and semi-urban areas. Despite the growing popularity of electric scooters, many commercially available models come with limitations, particularly in terms of affordability and accessibility. A significant portion of the market is dominated by high-end models equipped with advanced features such as high-capacity batteries, regenerative braking systems, and smart connectivity. While these features may appeal to tech-savvy consumers, they often result in higher prices, putting electric scooters out of reach for individuals in lower-income communities or small towns. Moreover, the complexity of these systems can make the scooters more difficult to repair and maintain, especially in regions with limited access to specialized repair facilities. Considering these challenges, this project focuses on the development of a more accessible and affordable electric scooter. The goal is to create a vehicle that balances functionality and simplicity, making it ideal for everyday commuters who prioritize practicality and low-cost solutions. By opting for a straightforward design, we aim to offer a scooter that is not only easy to use but also easy to assemble, maintain, and repair. Central to this design is the use of a Permanent Magnet DC (PMDC) motor, which provides reliable performance while keeping costs low. PMDC motors are known for their simple construction and ease of control, making them an ideal choice for low-power applications like electric scooters. One of the key aspects of this project is the focus on empowering users to build and modify their scooters. By incorporating a DIY (Do-It-Yourself) approach, the project enables individuals to take an active role in the creation and customization of their personal transportation solutions. This not only lowers the overall cost of the vehicle but also promotes hands-on learning, making electric mobility more approachable for a wider audience. The DIY aspect ensures that users can adapt the scooter to their specific needs and perform basic repairs or upgrades without requiring advanced technical skills. Our design philosophy revolves around eliminating unnecessary complexities, ensuring that the scooter remains affordable without sacrificing essential functionality. The focus is on creating a vehicle that addresses the needs of everyday commuters in a practical and cost-effective manner. Throughout the paper, we will discuss the design process, the selection of key components such as the PMDC motor and battery system, and the overall performance of the scooter. We will also highlight the benefits of this streamlined approach, demonstrating how it can contribute to the wider adoption of electric mobility solutions in both urban and rural settings. By developing a scooter that is simple, affordable, and customizable, this project seeks to address the growing demand for accessible electric transportation. It aims to provide a viable solution for individuals seeking personal mobility options that are both environmentally friendly and financially attainable.

II. Literature Review :

The shift towards electric scooters (e-scooters) has grown significantly due to environmental concerns and demand for sustainable urban transport. Key research areas include design, energy efficiency, and motor selection. Structural innovations in e-scooters, like the self-standing model by Smitha et al. [1], enhance rider safety and ease of parking, while Biswa [2] developed a low-cost design targeting affordability in emerging markets. Daingade et al. [3] focused on material selection and assembly to reduce production costs without sacrificing durability. Energy efficiency research includes Yuniarto et al. [4]'s model for energy consumption under real driving conditions, aiding in battery optimization and extended range. Studies on technology integration, like Reddy et al. [5]'s IoT systems, show potential for smart diagnostics, while Jorge et al. [6] used simulations to enhance stability and energy management. Motor selection research compares PMDC, BLDC, and AC induction motors, with Jape and Thosar [7] highlighting PMDC motors for low-cost applications and BLDC for higher efficiency. Khande et al. [8] further explored motor-battery combinations for optimal energy use. Overall, advancements in design, energy efficiency, and motor selection contribute to affordable and efficient e-scooter solutions, supporting sustainable urban transport growth.

III. System design and components :

- **Motor Selection**

For the project, a PMDC motor has been selected.

FIGURE 1. PMDC Motor.

- **Calculations and specifications**

Forces acting on a vehicle:
Aerodynamic Drag Force,
Air density (ρ) = 1.225 kg/m^3
Coefficient of drag (c_d) = 0.5
Frontal Area (A_f) = 0.7 m^2
Velocity (v) = 30 km/hr = 8.33m/s
$F_A = 0.5 \times \rho \times A_f \times c_d \times v^2$
= 14.875 N
Gradient Force,
Assuming slope as zero,
F_g = M × g × sin θ = 0 N
Rolling Resistance Force,
Acceleration due to gravity (g) = 9.81m/s^2
Assuming, Total mass (vehicle + driver), M = 130 Kg
$F_r = C_{rr} \times$ M × g × $cos\,\theta$
= 19.129 N
Total Force required to drive a vehicle,
$F_{Total} = F_A + F_g + F_r$
= 14.875 + 0 + 19.129
= 34.004 N
Power required to propel a vehicle (or) Average power consumption,
P = F × V
= 34.004 N × 8.33 m/s
P = 283.25 w
Speed of motor in rpm,
k = Speed in kmph = 30
d = wheel diameter in cm = 20.3(8 inch)
N = $\frac{k}{d \times 0.001885}$ = 783 Rpm
Torque of the motor,
T = $\frac{P \times 60}{2 \times \pi \times N}$ = 3.45 Nm
which we can conclude that the motor power
rating must be more than 283.25 w, i.e., 350 w.
From the above calculations,
The motor must meet the following ratings,
Voltage = 24 volt
Power rating = 350 watt
Torque (T) = 3.45 Nm (>=)
The table below presents the ratings and specifications of the PMDC motor purchased based on the calculated requirements.

Table 1. Motor Specifications

Parameter	**Ratings**
Voltage	24V
Wattage	350W
Torque	22 Nm
No Load RPM	3850
Rated Load RPM	400
No Load Current	< 2.2 Amps
Rated current	18 Amps
Efficiency	78 %
Reduction Ratio	9.78:1
Dimension (Width*Length)	101*69
Weight	2.56 kg

- **Battery Selection**

For the project, a Li-ion battery pack has been selected.

FIGURE 2. Li-ion Battery pack.

- **Calculations and specifications**

Since the motor voltage is 24v, Battery voltage must match the motor voltage i.e., 24v.
For a range of about 1 hr, 350w power is consumed for 1 hr,
Total energy = 350w × 1 hr = 350wh

Battery capacity (Ah) = $\frac{E}{V}$

$= \frac{350wh}{24v}$

= 14.58 Ah

The battery must meet the following ratings,
Voltage = 24 volt
Battery capacity = 15 Ah

The table below presents the ratings and specifications of the Li-ion battery pack purchased based on the calculated requirements.

Table 2. Battery Specifications

Parameter	**Ratings**
Voltage	24V
Battery Capacity	15 Ah
Charge Cycle with full Capacity	1200 aprox
Battery Energy	360wh
Maximum discharge current	20A
Maximum charging current	10A
Battery full charge voltage	29.4v
Battery Low discharge voltage	22.4v
Dimension (Length*Width*Height)	28x7x7 cm
Weight	2.5kg
Total no of cells used	7x5=35pcs
BMS Specification	7s20A

- **Selection of Controller**

FIGURE 3. Motor Controller

The voltage rating of controller must match the motor voltage rating i.e., 24v. The controller's maximum current rating should be equal to or greater than the peak current that the motor will draw.

The Controller must meet the following ratings,
Voltage rating = 24 volt
Current rating >= maximum current draw of the motor

The table below presents the ratings and specifications of the controller purchased based on the calculated requirements.

Table 3. Controller Specifications

Parameter	**Ratings**
Rated Voltage	24V
Rated Power	350W
Weight	256g

- **Selection of Battery charger**

Let us assume, the current rating of charger is 3 Amp.
Voltage rating of charger = 24 volt
Charger Power = 24 volt × 3 Amp = 72 watt
Let us assume, If the charger efficiency is 85 % ,
Adjusted power = Calculated power / Efficiency
= 72 / 0.85
= 85 watt

FIGURE 4. Battery Charger

Battery charger must meet the following ratings,
Voltage rating = 24 volt
Current rating = 3 Amp
Power rating = 75 – 85 watt

The table below presents the ratings and specifications of the battery charger purchased based on the calculated requirements.

Table 4. Battery Charger Specifications

Parameter	**Ratings**
Charging Voltage	29.4v
Max Charging Current	3Amps

IV. Methodology and modelling :

- **E-Scooter Energy Flow Architecture**

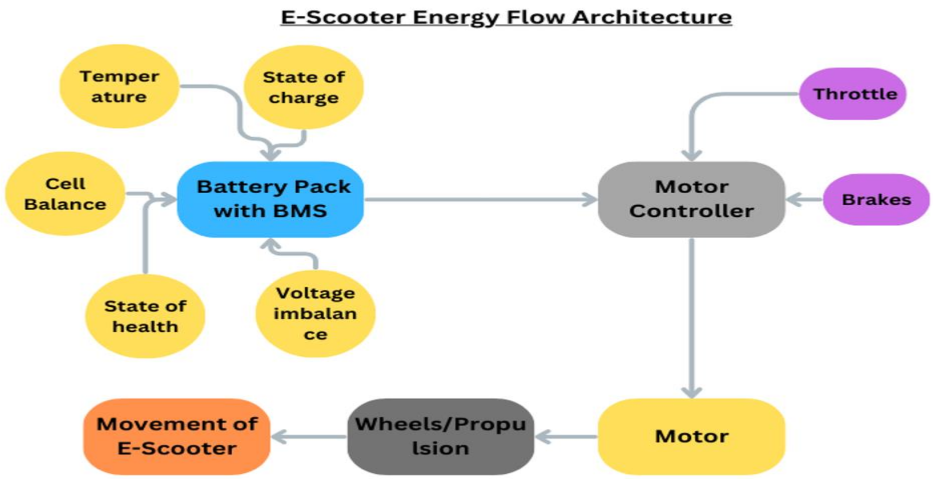

FIGURE 5. E-Scooter Energy Flow Architecture

The working of an electric scooter involves the coordinated function of multiple components, where the energy flow starts from the battery pack and is directed towards the motor that propels the scooter. The battery pack, equipped with a Battery Management System (BMS), is responsible for storing and supplying electrical energy. The BMS plays a vital role in maintaining the health and efficiency of the battery by constantly monitoring factors such as temperature, state of charge, cell balance, and voltage imbalance. These parameters ensure the battery operates optimally, preventing any potential damage due to overheating or uneven cell charging. The motor controller is the intermediary between the battery and the motor. It regulates the power sent to the motor based on the rider's input. Signals from the throttle determine the speed of the scooter, while the brakes instruct the controller to slow down or stop the vehicle. This dynamic control of power ensures that the motor runs efficiently and safely under different operating conditions. Once the motor receives the controlled power from the controller, it converts the electrical energy into mechanical energy, driving the wheels and propelling the scooter forward. The rider's control over the throttle and brakes is essential in modulating the speed and movement of the scooter. Throughout the process, the efficient use of energy, as well as the health monitoring of the battery, ensures a smooth and safe transportation experience for the user. This system design ensures that the energy flow is optimized for performance and longevity, resulting in a practical and reliable electric scooter solution for urban transportation.

- **Proposed Electrical Circuit Layout for E-Scooter System**

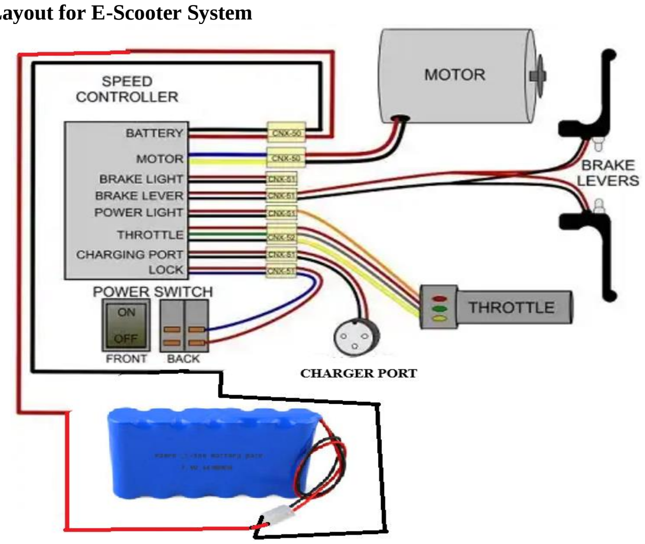

FIGURE 6. Electrical Wiring Diagram of E-Scooter System

- **How the System Works Together**
    - **Power On:** When the rider turns on the power switch, the lithium-ion battery is connected to the speed controller, which powers up the entire system.

FIGURE 7. Ignition Lock and Key Set

- **Throttle Control:** The rider adjusts the throttle to control the speed. The throttle sends a signal to the speed controller, which adjusts the current sent to the motor. More throttle means more power to the motor, resulting in higher speed.

FIGURE 8. Throttle

- **Braking:** When the rider pulls the brake levers, the switches within the levers send a signal to the speed controller to cut off power to the motor. This stops the motor's power output, helping the scooter slow down or stop.

FIGURE 9. Brake Lever

- **Battery Charging:** When the battery needs charging, the rider connects an external charger to the charger port. The charger provides a controlled voltage to recharge the lithium-ion battery.

FIGURE 10. Battery Charging Set

- **Modeling of E-Scooter using Onshape and Blender**

E-scooter project uses Onshape and Blender as the main modeling tools, with Onshape for precise CAD design and Blender for realistic rendering and visualization.

- **Designing the Frame**

The frame forms the foundation of the e-scooter, housing all the components such as the motor, battery pack, and wheels. Here's how to design the frame:

- **Sketch the Frame Base:** Start by creating a 2D sketch in the top view. Use the rectangle tool to outline the frame base. Define the dimensions of the frame based on the scooter's size requirements (e.g., width and length of the scooter's deck).
- **Extrude the Frame:** Once the sketch is complete, use the extrude tool to give the frame thickness. The thickness can be set to accommodate the weight of the rider and the components it will house.
- **Cutout for Battery Compartment:** Create a second sketch to make a cutout in the frame base where the battery will be installed. The size of the cutout depends on the dimensions of your battery pack. Extrude this sketch in the reverse direction to create the hole.
- **Additional Mounting Points:** Create mounting points for the motor, fork, and rear wheels by sketching holes or brackets in the appropriate places.

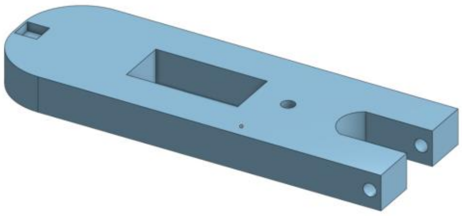

FIGURE 11. Base of an E-Scooter

- **Designing the Head Tube and Fork**

The head tube holds the front wheel assembly and is a critical part of the scooter's steering mechanism.

- **Create a Sketch for the Head Tube:** Switch to the side view and sketch a basic cylindrical shape for the head tube. The head tube should be designed at a slight angle to match the typical rake angle for scooters, which affects steering stability.
- **Extrude the Head Tube:** Extrude the sketch to the required length based on the design parameters.
- **Fork Design:** For the fork, create a U-shaped sketch to match the width of the front wheel. Once sketched, extrude this shape to give it thickness. Ensure the fork is dimensioned to hold the front wheel securely.

- **Handlebar Design**

The handlebar controls the scooter's direction and provides a place for the rider to hold on while riding.

- **Sketch the Handlebar in the Front View:** Create a simple sketch for the handlebar. This typically consists of a horizontal bar for the grip and vertical stems that attach to the fork.
- **Extrude and Mirror:** After extruding the handlebar, mirror it to create symmetry. Ensure the handlebar has ergonomic grips for better handling.
- **Handlebar to Fork Connection:** Create a cylinder at the bottom of the handlebar stem to ensure that it fits into the head tube. Add fillets at the joints for strength.

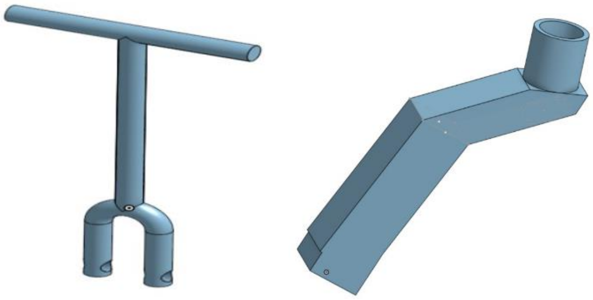

FIGURE 12. Head Tube, fork and Handle bar

- **Wheel Design**

The wheels provide the primary means of movement and support. In the case of electric scooters, the rear wheel often houses the motor in a hub or is connected to a motor via a chain or belt.

- **Sketch a Wheel:** Start by sketching a circular profile for the wheel in the front view. Use the revolve tool to create a solid, circular wheel.
- **Tire Detailing:** Add additional sketch details to represent the tire tread or create separate bodies for the rim and tire.
- **Hub Design:** For a hub motor, create a separate sketch for the hub area within the wheel. Extrude this section and add connection points for the motor.

FIGURE 13. Wheel

- **Motor and Mounts**

The motor, typically a PMDC motor for scooters, is either housed in the wheel hub (hub motor) or mounted separately.

- **Create Motor Housing:** Design the motor housing by creating a cylindrical enclosure that fits the dimensions of your motor. Use the extrude tool to give it depth.
- **Motor Mounts:** Create motor mounts on the scooter's frame using the sketch tool. Position the motor mount near the rear wheel for better power transmission. Add mounting holes for screws or bolts that will hold the motor in place.
- **Chain/Belt Drive System:** If the scooter uses a chain or belt drive, add sprockets or pulleys between the motor and the rear wheel. Use geometric constraints to ensure they align perfectly.

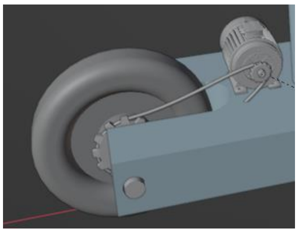

FIGURE 14. Motor mounting

- **Sitting seat support**

Each component of the seat, such as the mounting bracket, cushion, and support post, is designed separately using 3D sketches and extrusion features. The support post, as shown in your model, is crafted to fit securely into the scooter's frame, with enough strength to support varying rider weights. Key design features include rounded edges for safety, a slight contour for comfort, and a secure mounting structure that connects seamlessly to the scooter's frame.

FIGURE 15. Sitting seat

- **Assembly of Components**

Once all individual parts are modeled, the next step is to assemble the components into a functioning scooter.

- **Create a New Assembly:** In Onshape, switch to the assembly workspace. Insert all the parts (frame, head tube, fork, handlebar, wheels, motor, etc.) that have been created.
- **Mates and Constraints:** Use mates to connect parts properly. For example: Revolute mates for rotating parts, such as between the fork and the head tube or between the wheels and the frame. Rigid mates for fixed components, such as the motor to the frame or the handlebar to the fork.
- **Alignment:** Ensure all parts are aligned correctly. The wheels should rotate freely within the fork, and the handlebar should turn the front wheel as expected.

- **Additional Components and Detailing**

After the primary parts are assembled, additional components like the brake system, kickstand, and electrical routing for wires can be added.

- **Brake System:** Design the brake callipers and discs. The brakes will be attached to the wheel assemblies, so ensure that the mounting points on the fork and rear frame are in place.
- **Kickstand:** Model a simple kickstand and add it to the scooter's frame. Use mates to allow the kickstand to move between the deployed and stowed positions**.**
- **Cable Routing:** Add small clips or channels on the frame to show where the throttle and brake cables or electrical wires will be routed.

- **Rendering and Simulation**

Once the assembly is complete, you can apply materials and colors to the components to create a more realistic representation of the scooter.

- **Material Assignment:** Assign materials to the frame (e.g., aluminium alloy), wheels (rubber), and other parts. This gives a realistic look to the scooter and helps in analyzing the weight and balance of the design.
- **Simulation and Analysis:** Onshape also allows for basic simulations such as static analysis or motion simulation to check if the design is functional. Run a simulation to test the movement of wheels, handlebar rotation, and motor function. You can also run stress tests on critical parts like the frame and head tube to ensure that they can withstand loads.

- **Final Checks and Export**

- **Check Tolerances:** Before finalizing, check that all parts have appropriate tolerances, especially at joints and mates. Ensure that the wheels rotate freely and the frame provides enough clearance for all components.
- **Exporting CAD Files:** Once satisfied with the design, export the CAD files (in formats such as STL or STEP) for manufacturing or further analysis.
- **Documentation:** Create detailed engineering drawings of each part for reference during manufacturing or for team discussions.

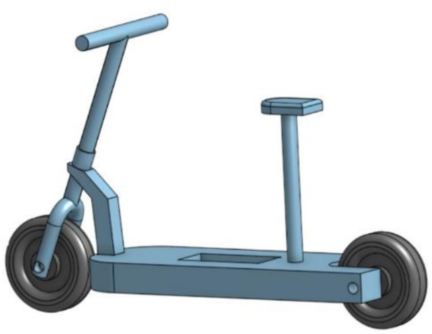

FIGURE 16. 3D Model of Proposed E-Scooter in Onshape

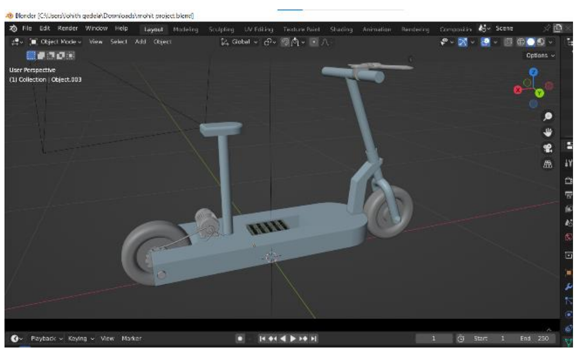

FIGURE 17. 3D Model of Proposed E-Scooter in Onshape

- **Physical implementation of the proposed project**

The physical development of our electric scooter (e-scooter) project is the culmination of extensive design, research, bringing together mechanical, electrical, and software elements to create a functional prototype. This process involves the fabrication of components, assembly, wiring, and integration of electrical systems, followed by testing and optimization. Here is a detailed breakdown of the development phases involved in your project.

- **Material Selection and Procurement**

The physical development of the e-scooter starts with selecting suitable materials for key components like the frame, motor, wheels, suspension, and battery housing. Lightweight yet strong materials like aluminum alloy or high-grade steel are used for the frame to ensure durability and maneuverability. Wheels incorporate rubber tires, alloy rims, and durable bearings for smooth, wear-resistant motion. Heat-resistant materials protect the battery housing and motor mounts, securing critical components against environmental factors.

- **Frame Fabrication and Structural Design**

With materials selected, the e-scooter frame is fabricated based on the precise Onshape 3D design. Cut and welded to specification, the frame serves as the scooter's core, supporting components like the motor, battery, and rider. Precision is key to prevent handling issues or safety risks. It includes mounts for the motor, gearbox, wheels, and subsystems, ensuring balanced weight distribution and structural integrity. The frame accommodates the 24V, 350W PMDC gear motor with a 9.78:1 reduction ratio for optimal performance.

FIGURE 18. Structural Hardware Development for E-Scooter Frame

Motor and Gearbox Installation

The PMDC motor and 9.78:1 gearbox are essential in driving the e-scooter, providing the torque needed for acceleration and hill climbing. The motor is securely mounted to ensure efficient power transfer to the rear wheels, with the gear reduction system lowering speed while boosting torque. Accurate alignment is critical to minimize energy loss and mechanical wear, ensuring smooth, efficient operation with optimal force for the rider.

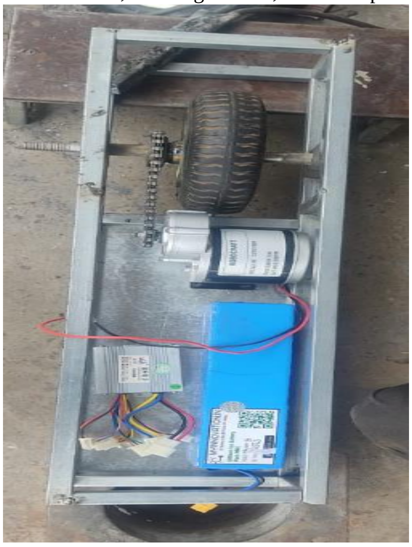

FIGURE 19. Motor Installation

- **Wheels, Suspension, and Steering Assembly**

The e-scooter's wheels, suspension, and steering components are mounted onto the frame. Pneumatic tires, which improve ride quality on rough surfaces, may be used for shock absorption. The suspension, if included, helps cushion the ride, especially important on uneven urban roads. The steering column connects to the front wheel, with handlebars that may include throttle, brake levers, and a display unit for speed and battery status. Precision alignment ensures responsive steering and reliable rider control.

- **Electrical Components Installation and Wiring**

The lithium-ion battery pack is securely mounted and connected to the motor via the motor controller, which regulates energy flow for safe operation. A Battery Management System (BMS) is included for protection, preventing overcharging, overheating, and voltage imbalance. The wiring layout is designed to avoid short circuits and facilitate maintenance. The motor controller, an essential component, manages power delivery based on throttle input, ensuring smooth speed and torque control. It may also enable regenerative braking, recovering energy during deceleration. Properly installed, the braking system combines mechanical disc brakes with regenerative braking (if applicable) for safe, efficient stopping. Accurate calibration ensures balanced braking force, preventing abrupt stops or insufficient deceleration.

FIGURE 20. Electrical Components Installation and Wiring

- **Final Assembly**

In the final assembly, all bolts are tightened, and electrical connections are secured, ensuring correct alignment of each component. Mechanical and electrical systems are inspected for issues, with wiring insulated and connectors double-checked for stability. Ergonomic testing is performed, with adjustments to handlebars, seat (if applicable), and controls to enhance rider comfort and usability.

FIGURE 20. Final Assembly of e-scooter system

V. Results and discussions :

The results obtained from the design and testing of the electric scooter provide valuable insights into the performance, efficiency, and practicality of the model. Through prototype trials, the scooter demonstrated effective functionality within the expected performance parameters. Key metrics analysed included speed, range, motor efficiency, and battery life under varied load conditions. On average, our scooter achieved a maximum speed of approximately 20-25 km/h, suitable for urban commuting. Range testing showed that the 24V, 15Ah battery provided an average travel distance of 20-25 km per charge, although this varied based on factors such as terrain, rider weight, and throttle usage. These results align well with the targeted specifications, affirming the battery's adequacy for short-distance travel. Motor performance was also evaluated, with the 350W PMDC motor exhibiting steady operation under typical load conditions. However, when subjected to inclines or increased rider weight, there was a noticeable drop in efficiency and torque, which limited performance on more demanding terrains.

This finding underscore one of the project's anticipated limitations, where the simplicity and cost-effectiveness of the PMDC motor come at the cost of reduced adaptability in varied environments. However, the PMDC motor's 75% efficiency and the absence of regenerative braking highlight areas for improvement. Future iterations could enhance adaptability, motor efficiency, energy recovery, and component durability. Overall, the design provides a strong foundation for advancing affordable electric mobility.

VI. Conclusion and future scope :

This project demonstrates the successful design and development of a low-cost, user-friendly electric scooter intended for short-distance commuting. By focusing on affordability, simplicity, and ease of assembly, we created a model accessible to individuals with limited resources and technical expertise. The scooter, powered by a 24V, 350W PMDC motor, meets essential performance targets, achieving an average speed of 20-25 km/h and a range of approximately 20-25 km per charge, suitable for urban environments. Key aspects of the design, such as the use of standard components and the absence of complex systems, make it straightforward to maintain, repair, and modify. The project's approach to motor selection, battery choice, and simplified braking systems reflects a practical balance between functionality and cost-effectiveness. Feedback and testing underscore the scooter's potential as an accessible solution for personal transportation in resource-constrained settings, although limitations in power and range highlight areas for further refinement. In conclusion, this project provides a foundation for affordable electric mobility, aligning with the needs of individuals in lower-income areas or regions with limited access to advanced repair services. Future iterations can explore enhancements such as regenerative braking, improved motor efficiency, and extended battery capacity, further expanding the scooter's adaptability and sustainability. This project serves as a valuable educational resource, fostering an understanding of electric vehicle technology and promoting sustainable urban transportation solutions.

REFERENCES :

[1] Smitha BS, Sabeel MS, Shaik AA, Riza M. Design and Modelling of Self standing Electric Scooter. InMATEC Web of Conferences 2024 (Vol. 393). EDP Sciences.

[2] Yuniarto MN, Wiratno SE, Nugraha YU, Sidharta I, Nasruddin A. Modeling, simulation, and validation of an electric scooter energy consumption model: A case study of indonesian electric scooter. IEEE Access. 2022 May 2;10:48510-22.

[3] Biswa B. Design and Development of Electric Scooter. International Journal of Academic Multidisciplinary Research (IJAMR). 2021 Aug;5(8):63-9.

[4] Daingade P, Shirolkar A, Singh S, Tamhankar S, Shelke MR. Designing and manufacturing of Electric Scooter. International Research Journal of Engineering and Technology (IRJET). 2020.

[5] Khande MS, Patil MA, Andhale MG, Shirsat MR. Design and Development of Electric scooter. Energy. 2020;40(60):100.

[6] Reddy YK, Sanju S, Roy SK, Rubiston MM. Electric Smart Scooter. International Research Journal of Engineering and Technology. 2020 Jun;7(06):1714-23.

[7] Jorge I, Mesbahi T, Théophile PA, Samet A. Study and simulation of an electric scooter based on a dynamic modelling approach. In2020 Fifteenth International Conference on Ecological Vehicles and Renewable Energies (EVER) 2020 Sep 10 (pp. 1-6). IEEE.

[8] Jape SR, Thosar A. Comparison of electric motors for electric vehicle application. international Journal of Research in Engineering and Technology. 2017 Sep;6(09):12-7.