

Design and Development of Solar-Assisted, Dual Charging Electric Scooter

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Abstract - The growing demand for sustainable and eco-friendly transportation has rapidly accelerated usage of electric vehicles powered by renewable energy sources in response to the growing demand for green means of transportation. This research consists on designing and fabricating of solar powered electric scooter for short-distance mobility. The main goal is to create an energy-efficient vehicle that has a total carry load of 120kg and can accelerate up to a max speed of 15km/h.

The study comprises in-depth engineering calculations to evaluate the forces acting on the scooter such as rolling resistance and aerodynamic drag.

Based on these calculations, we figured out how much power and tractive force the vehicle needed. Taking into account system losses, the right motor rating, battery capacity, and solar panel specifications were chosen.

To make sure it was possible to build, a full-size cardboard model was made to test the size and comfort of the design. Then, a 3D CAD model of the scooter was made, and structural analysis was done to make sure the frame was strong and safe. The last prototype was made and tested to see how it worked in real life.

Key Words: Solar Powered Electric Scooter, Electric Vehicle, Renewable Energy, Solar Energy, Photovoltaic System, Solar Panel, Battery Energy Storage, Lithium-ion Battery, BLDC Hub Motor, Motor Controller, Energy Efficiency, Power Requirement, Tractive Force, Rolling Resistance, Aerodynamic Drag, Vehicle Dynamics, Sustainable Transportation, Green Mobility, Eco-Friendly Vehicle, CAD Modeling, CATIA V5, ANSYS, Structural Analysis, Frame Design, Ergonomics, Prototype Development, Performance Evaluation, Energy Management System, Solar Charging, Clean Energy Technology

1. INTRODUCTION-

The rapid growth of cities and the population has led to a big rise in the need for transportation, which has caused more fuel use and pollution of the environment. Fossil fuel-powered cars and trucks are a major cause of air pollution, greenhouse gas emissions, and the loss of natural resources. Electric vehicles (EVs) have become a promising solution in recent years because they are very

efficient, cost very little to run, and don't pollute the air. But the fact that EVs need electricity from the grid, which is often made from non-renewable sources, makes them less sustainable overall.

To solve this problem, there has been a lot of interest in combining renewable energy sources, especially solar energy, with electric vehicles. Solar energy is plentiful, clean, and free, making it a great choice for powering electric mobility systems. Adding photovoltaic panels to electric cars makes it possible to use solar energy to charge the batteries. This cuts down on the need for regular electricity and makes the car more energy efficient overall. This project focuses on the design and development of a solar powered electric scooter intended for short-distance transportation. The scooter can carry up to 120 kg and go as fast as 15-20 km/h. The study calculates resistive forces like rolling resistance and aerodynamic drag, and then it figures out how much power the vehicle needs to run. Based on these calculations, the right parts, like the motor, battery, and solar panel, are chosen.

Along with theoretical analysis, practical parts of the design are looked at by making a full-size cardboard model to test ergonomics and dimensions. Then, a 3D CAD model is made so that the frame can be seen in detail and its structure can be analyzed to make sure it is safe and reliable. Finally, the scooter is made and tested in real-world conditions to see how well it works.

This project aims to create a transportation solution that is energy-efficient, environmentally friendly, and affordable by combining solar energy with electric vehicle technology. This will help make mobility more sustainable in the future.

2. METHODOLOGY:

The design and development of the solar powered electric scooter were carried out in a systematic and step-by-step manner to ensure accurate analysis and practical feasibility. The complete methodology adopted for this project is described below:

2.1 Problem Definition and Requirement:

At first, the basic requirements for the scooter were chosen based on how it would be used in real life. The total

weight of the vehicle and rider was 120 kg, and the maximum speed was set at 15 km/h. These numbers were used as the basis for all future calculations and design choices.

2.2 Calculation of Resistive Forces, Power Required, Wheel Diameter, Torque,

- Let mass of rider = 100 kg
- Mass of vehicle = 20 kg
- Total mass = 120 kg
 - Desired speed of vehicle = 15 km/hr Convert to m/s:
 $v = 15 \times 1000 / 3600 = 4.16 \text{ m/s}$

A. Traction (Resistance) force Calculation:

Total tractive force: $F_t = F_r + F_d$ (neglecting gradient slope force)

1) Rolling Resistance Force on wheels (F_r): $F_r = C_r \times N$, Where:

$C_r = 0.015$ (rolling resistance coefficient)
 $N = mg = 120 \times 9.81 = 1177.2 \text{ N}$ (Normal reaction force on wheels)
 $F_r = 0.015 \times 1177.2$
 $F_r = 17.658 \text{ N}$

2) Aerodynamic Drag
(F_d): $F_d = (1/2) \cdot \rho \cdot C_d \cdot A \cdot V^2$

Where:

- $\rho = 1.225 \text{ kg/m}^3$ (Air Density)
- $C_d = 0.9$ (Coefficient of drag)
- $A = 0.7 \text{ m}^2$ (frontal area for scooters)
- $v = 4.16 \text{ m/s}$ (Scooter velocity)

$F_d = 1/2 \times 1.225 \times 0.9 \times 0.7 \times (4.16)^2$

$F_d = 6.7 \text{ N}$

Total Tractive Force = $F_t = 17.658 + 6.7 = 24.358$

$F_t \approx 25 \text{ N}$

B. Power Requirement Estimation for motor:

$P = F \times V =$
 $25 \times 4.166 \text{ P} =$
 105 W

Now for safer side and considering acceleration, slope and motor losses.

The standard motor (BLDC for 90% effic.) available in market for power nearly 105W are 350W.

Hence, taking **350 W BLDC motor**.

C. Wheel Diameter Selection:

We have Peripheral speed or cutting speed formula:

$$v = \pi D N / 60$$

Let's assume motor of rpm 400

$$\text{Hence, } 4.166 = \pi D \times 400 / 60$$

$$D = 0.1989 \text{ m} \sim 7.83 \text{ inch}$$

The market available wheel sizes are- 6inch, 8inch, 10inch

D = 8inch hub wheel

D. Torque

Required: Wheel Dia

$$= 0.133 \text{ m} \approx 0.2 \text{ m} \text{ So,}$$

$$r = 0.1 \text{ m}$$

$$\text{Torque } T = F \times r$$

$$= 25 \times 0.1$$

$$T \approx 2.5 \text{ Nm}$$

For more safer side let's take F_{os} as 3

Hence **T required = 7-8 Nm**

Our 350W motor typically produces around 10 to 15 Nm torque

Hence our BDC motor is sufficient for producing torque of 8 Nm

E. Battery Voltage and Capacity:

1) Battery Voltage:

In market 350 w BLDC motor are available for 24 Volt. We have, $P = VI$

$$I = 350 / 24$$

$$I \sim 14.64 \text{ Amp}$$

Hence Taking 24-V battery system

2) Battery Capacity:

Battery energy needed:

Energy = Power \times (time for which) vehicle will run let take 30 min runtime i.e. 0.5 hr runtime

$$\text{Energy} = 350 \times$$

$$0.5 \text{ Energy} \sim 175$$

$$\text{Wh}$$

Battery capacity (Amp-hr) :

$$\text{Ah} = \text{Wh} / V = 175 / 24$$

$$\text{Ah} \sim 7 \text{ Ah}$$

Battery = 24 V, 7 Amp-hr

So, connecting two 12V lead acid batteries in series.

2.3 Selection of Components:

After determining the power requirement, suitable components were selected:

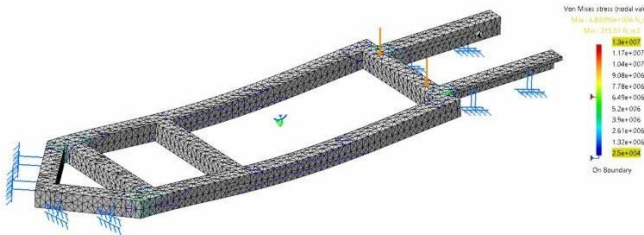
- A. 350 W BLDC Hub Wheel Motor
- B. Two Lead Acid Batteries of 12V & 7 Ah
- C. Two Solar Panel of 10W Capacity Each
- D. Rear Spring Suspension
- E. Motor Controller (Accelerator)

The distributive load of 120 Kg was applied at the center of the frame and both the ends of frame were clamped (fixed on both ends).

1. Von Mises Stress Distribution:

Maximum stress value was observed to be $6.8 \times 10^6 \text{ Nm}^2$ and yield strength of our material is $2.5 \times 10^8 \text{ Nm}^2$.

So, our frame is highly safe under the loading of 120kg approximately.

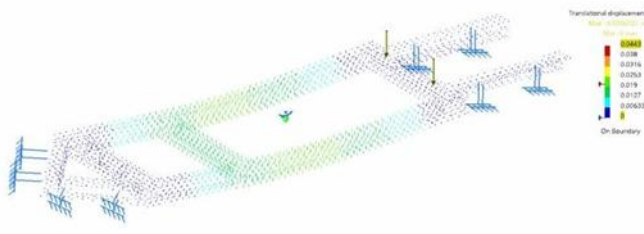


Von Mises Stress Distribution

2. Maximum Deformation:

For this loading the maximum value of displacement is 0.044mm. This value is negligible.

Hence deformation in our frame is under control and is very low.



Translation Displacement 2.6Fabrication and

Assembly:

After the calculations, design, analysis and parts selection were finished, the solar-powered electric scooter was made. Mild steel was used to make the frame by cutting and welding all the members (pieces) to the right size. The rear wheel had a BLDC hub motor, and the front wheel was connected to the handlebar to steer.

The Lead Acid battery (24V, 7Ah) was firmly attached to the frame to keep the weight balanced. A support structure was used to hold two 10 W solar panel in place so that it could get the most sunlight. Using the right wiring and a charge controller, all of the electrical parts, like the motor, battery, controller

After putting all the parts together, the scooter was checked

to make sure they were all in the right place, stable, and working properly.

The images are attached which depicts the assembly of scooter:



Base frame structure



Wheel and suspension assembly



Stand



Adjustable handlebar



Finished product



3. CONCLUSION:

This study outlines the design and development of a solar-powered electric scooter designed for short-distance transit. We figured out the needed tractive force and power by calculating at the vehicle's rolling resistance and aerodynamic drag. Based on these numbers, a 350 W BLDC hub motor, a 24 V Lead Acid battery and a solar panel were chosen as the best combination to meet the performance needs.

The results indicate that the integration of solar energy with electric mobility is feasible for short-distance applications. Although the contribution of solar charging is limited, it enhances energy efficiency and reduces dependence on conventional power sources. The developed system offers an eco-friendly, energy-efficient, and cost-effective solution for sustainable transportation.

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