Design and Modelling of Self standing Electric Scooter

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Abstract: This work focuses on the compact design of a self-standing electric scooter, specifically engineered to require minimal parking space. The paper details the design and modelling of an innovative electric scooter that possesses the unique ability to stand on its own, utilizing a footprint smaller than that of a typical umbrella stand when parked. Employing a minimalist design approach, the scooter achieves an aesthetically appealing, simple, and futuristic appearance. The primary objective of this project is to propose a practical and compact electric scooter design by utilizing CATIA V5 software for modelling and ANSYS for required calculations and SolidWorks for visualization, a design that not only enhances efficiency for short-distance travels but also effectively mitigates issues related to traffic congestion and limited parking space.

Keywords: Self-Standing, CATIA V5, Modelling, Electric scooter.

1 INTRODUCTION

An electric scooter is a battery-operated vehicle for carrying a single rider which is specially designed for people who have low mobility. Scooters are available in three common designs, those intended for indoor use, those for outdoor use, and those that are used for both. A typical electric scooter requires a pair of batteries, but the batteries are rechargeable. The length of time an electric scooter can run on each charge depends significantly on its battery type, rating and capacity.

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The most common batteries are advertised to run for about eight hours, and for around 30-60 kms on a charge and totally depends upon battery capacity and the terrain in which it is being driven, before having the need to be charged again. The problem is, most of these scooters are not flexible although if they are already small. Even though some manufacturers make it in such a way that it can flip, but there are only few parts like seat, handle, and sometimes arm bar which can flip. Some of the scooters are not so ergonomic and cannot be used for a long time. Even for an electric scooter, most of them can’t be flipped. Usually just their seat and handle can be put up and down to flip. Sometimes this will cause a lot of space for storage and is difficult to bring far from house or put it in a car. Majorly lack of availability of parking spaces in campuses hinder the adoption of these light mobility vehicles within campus.

So to overcome these problems and add convenience to commute within short distances, a design of electric scooter which gets folded vertically and can stand on its own without any support consuming very less parking space is modelled, it does it by virtue of its position of centre of gravity that lies between the vertical frame and the supporting footboard, battery is placed in footboard and a hub-mounted motor is at the front wheel which propels the scooter, these two components make up the major portion of weight of electric scooter, there is a clamp on the vertical frame which upon releasing aids the scooter to get folded, there are rubber grips on the front most portion of the electric scooter’s footboard which comes in contact with ground upon folding and to balance the weight of scooter, a balancing mass is added to the vertical frame and the scooter is able to stand on its own.

2 METHODOLOGY

A literature review is done for the necessary considerations and insights, then the conceptual design is done by keeping dimensions in mind. Modelling of parts is done and assembled using CATIA V5 software, then the calculations are performed and finally the model is visualized using SolidWorks software.

Fig. 1. Methodology
3 LITERATURE REVIEW

The Robo scooter is an urban, electric, folding scooter developed by the MIT Media Laboratory in conjunction with Sanyang Motors of Taiwan (SYM) and the Industrial Technology Research Institute (ITRI). Designed with mobility and portability in mind, the scooter must be both safe and light. The Roboscooter currently has several design characteristics that distinguish it from typical electric scooters. The drive elements of the scooter are contained entirely in the wheel assembly, including brakes, suspension, and gearing. This configuration of the drive system is commonly referred to as a wheel-robot. The advantage of the wheel-robot configuration is an increase in simplicity and modularity of the scooter’s drive system [1]. Frame design is done according to an Average Human Being. As per space availability and clearance for reduction of friction, frame size is (1090*410)mm. They considered a Human being of about 6feet tall and having weight of 70kgs max [2]. Dimension all are referred from Currie Folding Scooter EZIPE400 [3].

4 DESIGN & MODELLING

4.1 Conceptual Design

The rubber padding at the forward-most point of footboard assists in getting grip when standing and the weight of scooter is balanced in such a manner that it can stand on its own without any external support while parked, it is due to the fact that motor is placed at front wheel, and battery is at foot board and remaining balancing mass is added within the vertical frame to enable proper balancing and bring centre of mass at the centre while being parked. Folding is achieved by releasing a clamp that locks up the scooter in respective parking condition.

Fig. 2. Front view of Design
Fig. 3. Side view of Design
Fig. 4. Standing condition

4.2 Dimensions of Scooter
The final drafted dimensional model is as shown below.

![Dimensions of scooter](image)

**Fig. 5.** Dimensions of scooter

### 4.3 Modelling of Parts

The major parts are the footboard and vertical frame, their dimensions are as shown below which are modelled in CATIA.

i. **Vertical frame:** Vertical frame is of 750mm height which is considered to be best suited for any rider height, it has clamps that enables folding and connects to holding as well as handle.

ii. **Foot Board:** Foot board is of 200mm width which enables the rider to place his legs without hinderance and it is designed to fit in with vertical frame and it the one where the rider stands and rides the scooter, upon folding it supports the scooter to stand.

![Vertical Frame](image)

**Fig. 6.** Vertical Frame

![Dimensions of scooter](image)

**Fig. 7.** Dimensions of scooter

### 4.4 Modelling in Various Conditions

Riding condition and the standing condition are major working conditions along with a intermediate transition condition which is folding.
4.5 CG for Standing

Riding To balance the scooter in its parked condition, the centre of gravity must lie at the contact of the contact surface or supports with the ground upon which the gravity is supposed to be acting. ‘Ansys’ software is used to determine the centre of gravity by importing the model to ansys and applying the gravitational force upon it which is acting from the point of centre of gravity. It is highlighted by yellow color as we could see that the distance between point of contact on ground is approximately 200mm and the CG lies on 100mm distance from either point of contact with ground under parking condition.
4.6 Calculations

The necessary calculations for the electric scooter to propel is as discussed below which primarily focuses on Motor and battery.

4.6.1 Motor Specifications:

Max Motor power = 700W
Nominal Motor power = 350W

4.6.2 Motor Calculations:

\[ \text{Power} = \text{Torque} \times 2 \times 3.14 \times N / 60 \] \hspace{1cm} (1)

Where, rpm of motor shaft \( N = 500 \text{ rpm} \)

Hence, Torque at motor shaft = 13.37 Nm

4.6.3 Battery Specifications:

Amp-h Rating = 12.8A-h (460 Whr)
Voltage Rating = 36V

Battery Calculations:

Voltage Supplied, \( V = 36V \)
Power of motor, \( P = 350W \)
Capacity of battery = 12.8Ah

Current drawn from battery, \( I = P / V \) \hspace{1cm} (2)
\[ = \frac{350}{36} = 9.7A \]

Li-Ion battery generally drains at 60%

So, effective capacity of battery = 0.6*12.8Ah = 7.68Ah

Now runtime, \( t = \text{effective capacity of battery} / \text{current drawn from battery} \)
Runtime, \( t = 0.7917\text{hr} \)

Therefore, battery can run for 0.79 hr with these specifications under given conditions.

4.6.4 Weight Calculations:

Considering material to be 7075 Aluminium alloy with density 2810 kg/m³

Weight=2810*751*10⁻⁶ = 2.11Kg

Vertical Frame=(750*30*70)-(750*22*62)= 552*10⁻⁶m³, considering material to be 7075 Al alloy

Weight=2810*552*10⁻⁶ = 1.55 Kg

Weight of Wheel & Tyres= 1.2 Kg

Weight of Battery= 1 kg (Between 380 Whr - 460 Whr)

Weight of Motor = 2.98 Kg (for 350W Motor)

Weight of other Auxiliary systems = 1 Kg

Total weight = 2.98+1+1.2+1.55+2.11+1=9.84 Kg
5 RESULT & CONCLUSION

Riding To balance the scooter in its parked condition, the centre of gravity must lie at the contact of the contact surface or supports with the ground upon which the gravity is supposed to be acting. ‘Ansys’ software is used to determine the centre of gravity by importing the model to ansys and applying the gravitational force upon it which is acting from the point of centre of gravity. It is highlighted by yellow color as we could see that the distance between point of contact on ground is approximately 200mm and the CG lies on 100mm distance from either point of contact with ground under parking condition.

<table>
<thead>
<tr>
<th>Motor</th>
<th>Power</th>
<th>350 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque</td>
<td></td>
<td>13.37 Nm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Battery</th>
<th>Capacity</th>
<th>460 Whr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td></td>
<td>36 V</td>
</tr>
<tr>
<td>Runtime</td>
<td></td>
<td>0.79 hr</td>
</tr>
<tr>
<td>Weight</td>
<td>Total</td>
<td>9.84 Kg</td>
</tr>
</tbody>
</table>

An eco friendly and compact electric scooter is designed and modelled which can stand on its consuming very less parking space. It could change the way of transportation and make it ease for short commutes such as for offices as well as colleges. A feasible design of a simple scooter which is totally unique and the concept of being folded and standing in its vertical position is something out of the box way of parking which is completely new and conceived in this report. Project was primarily designed for enhancing green mobility thus it will also help to control the pollution which is one of the major crises now a days. The unique idea of folding that enables the scooter to stand on its own, supported by its base frame is a whole new concept of design. This scooter has only two wheels, front wheel has hub mounted motor that propels the scooter and is its power train, the scooter looks modern and futuristic. Minimalist approach is used in design so it looks more appealing and simple. The incorporated design is drafted using CATIA V5 and shown isometrically. Solidworks software is utilized for visualization of the scooter and make it look more attractive. This concept will bring easy & greener mobility in a compact package which could be deployed in college and office campuses.
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