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Design and Development of Motorized Scooter

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Abstract— Two-wheeled vehicles play an important role in city transport in India thereby contributing considerably to city transport impacts and energy consumption. The increase in air quality issues and governments regulation towards pollution has created electrical vehicles as an ideal alternative. Advances in battery technology and enhancements in motor potency have created electrical vehicles a reputable variety of transportation, particularly for short-distance travel. These days in India, more individuals are choosing electric vehicles as a primary variety of transportation. In this project, we tend to develop a motorized version of a standard kick scooter.

Keywords - Dc Motor, Electric Scooter, Torque, Battery

Introduction

An electric scooter widely known as an e-scooter is a kick scooter that uses an electric motor for traction and a battery system that supplies power to the motor. New developments have been introduced to make the system efficiency flawless. These developments include the design and selection of motor, battery usage, modes of operation of motor etc. Apart from being convenient, when technological aspects are concerned, it is necessary to research the technical aspects for the design of such vehicles. Here we are proposing a scooter that is a cost effective solution for short-distance commuting with minimal carbon footprint.

I. MODEL DEVELOPMENT

1). Major Components in Electric Scooter

Following are the Major components present in an Electric Scooter

1. Battery
2. Battery Charger
3. Chassis
4. DC Motor
5. Motor Controller

A. Battery

Batteries are the power source for any electric vehicle. Electric vehicles are often limited to a speed of 25 km/h. A larger wattage increases the range and can increase the upward torque, however, a larger wattage does not increase the maximum speed. We need a batterywhich is compact in size to be fitted in the scooter.

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Table 1 Comparison between Different batteries

Parameter	Ni MH	Ni Cd	Ni Zn	Li-ion / Li-Po	Lead Acid
Specific Energy(Wh/kg)	60-120	40-60	100	100-265	35-40
Energy Density(WH/L)	140-300	50-150	280	250-730	80-90
Specific Power(W/kg)	250-1000	150	>900	250-340	180
Charge/Discharge Efficiency(%)	66	70-90	80	80-90	
Self-Discharge	30	10	13	8-5	
Cycle Durability	500 - 1000	2000	400-1000	400-1200	

Fig. 1 3D model of the E scooter

Based on the information listed in the table 1 Lead-acid is selected as it is Affordable and simple to manufacture Mature, reliable and well-

C. Chassis

The major frame or the chassis is the core structure that holds all the systems of the scooter. Thus, this being the foremost crucial part, it is to be designed and fabricated primarily. The chassis will have to contain the power unit, motor controller and all other electrical components of the scooter.

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known technology. It has the lowest self-discharge rate among rechargeable batteries which is Capable of high discharge rates.

Fig. 4 Chassis

B. Battery charger

Fig. 2 Battery

D. DC Motor

A DC motor is one of the categories of rotary electrical machines that converts DC wattage into mechanical power. The high beginning torque capability of the DC Series motor makes it an appropriate choice for
Simple AC-powered battery chargers usually have much higher ripple current and ripple voltage than other kinds of battery chargers because they are inexpensively designed and built. Generally, when the ripple current is within a battery's manufacturer recommended level, the ripple voltage will also be well within the recommended level. The maximum ripple current for a typical 12 V 100 Ah VRLA battery is 5 amps. As long as the ripple current is not excessive (more than 3 to 4 times the battery manufacturer recommended level), the expected life of a ripple- charged VRLA battery will be within 3% of the life of a constant DC- charged battery.

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Fig. 3 Battery Charger

traction application. the benefits of this motor are simple speed management and it can withstand a sudden increase in load. A DC motor's speed can be controlled over a broad range, using either a variable supply voltage or by changing the power of the current in its field windings. This makes it a feasible alternative for diverse applications. For our model, a DC motor with a rating of 24V 250W is selected.

Fig. 5 DC Motor

E. Motor Controller

The electric vehicle controller is the electronic module that operates between the batteries and the motor to control the electric vehicle„s speed and acceleration like a carburetor does in a gasoline-powered vehicle. The controller is used to connect all the electrical components of an e-scooter such as things like the battery, motor, throttle, display and various sensors. It takes energy from the battery and directs it to the motor. By twisting the throttle, the user can regulate the power that is being sent to the controller, which, in turn, controls the speed of the scooter. Unlike the carburetor, the controller can also reverse the motor rotation, and convert the motor to a generator. For our model a controller with voltage 24 V and rated power of 250W is selected.

Stature range(cm)	θ_1		θ_2		θ_3		θ_4		θ_5		θ_6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Under160	158.1	1.24	42.6	1.88	131.8	2.66	171.7	1.56	107.1	0.90	82.8	2.79
160 - 165	159.5	2.15	40.9	1.88	135.3	3.47	171.3	1.61	103.9	1.31	79.7	2.35
165 - 170	161.3	1.68	39.1	1.07	143.5	2.53	171.6	1.09	104.8	1.25	77.5	2.07
170 - 175	159.2	1.85	38.4	1.38	144.6	2.19	169.2	1.64	101.7	1.61	76.2	2.33
Over175	158.3	2.06	37.6	1.71	145.2	2.62	165.3	1.89	99.3	2.67	74.9	2.18

Fig. 7 Characteristic poimts and angles for anthropometric measurement

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As the scooter is thought to be a constrained workstation, for riders of various sizes to suit a similar workstation, the anthropometrical knowledge used for planning a scooter ought to be moderately representative of the population of scooter users. The below Tableshows the typical characteristic angles of scooter riding postures.

Table 2 Average angles of the riding postures

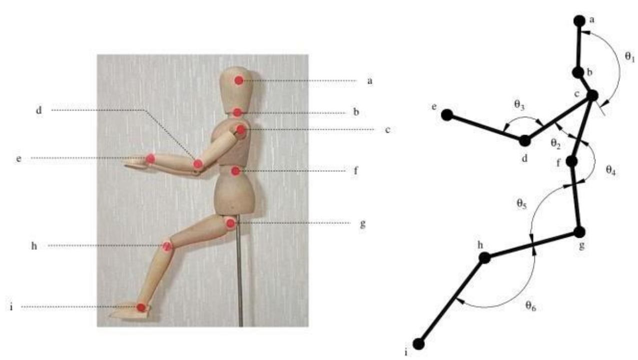
2).Material Selection

Fig. 6 Motor Controller

JFor the whole construction of the chassis of our model, mild steel is chosen for all the components. It is because the material used must havethe best properties of strength, should be low in price, with good malleability and weldability. Mild steel also has a long chassis life and reliable strength.

3).Anthropometry in Designing the model

Anthropometry is an analysis technique coping with the measure of the scale and bound physical characteristics of the frame. anthropometrical knowledge is employed in technology to specify the physical dimensions of workspaces, workstations, and instrumentality to make the human interaction around it simpler and easier.



The riding posture is additionally relevant to riders stature, which is oneof the vital engineering science issues in measuring moreover as a vital thought within the style of simple machine vehicles. In posture modelling, the body motion is commonly delineated in terms of angles shaped by body segments instead of trying to model the coordinates of the joints directly.

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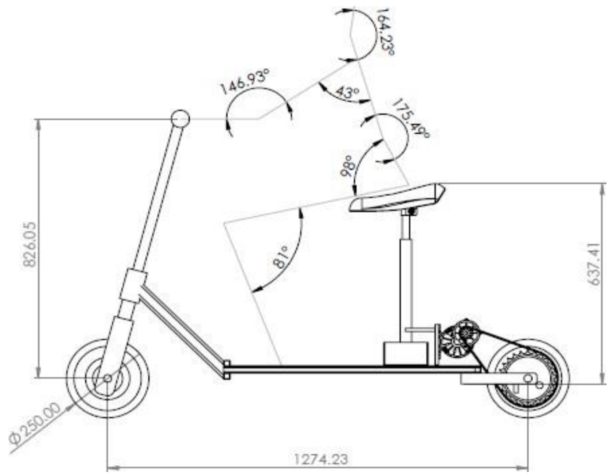

Fig. 8 The Physical Dimension of the scooter

III MODEL CALCULATION

1) Battery specification : 24V, 10Ah Lead Acid
2) Nominal voltage : 24V
3) Charge voltage : 36V
4) Frame material : Mild Steel
5) Motor : DC Motor
6) Power : 250W-350W
7) Voltage : 24V

A. No Load speed calculation

No of tooth on the Motor(T1) = 9No of tooth on wheel(T2)=36 Speed of N1=3300 rpm
Speed of N2=?

Using Gear ratio formula$N_1T_1=N_2T_2$
$N_2=N_1T_1/T_2$
Hence, N_2=825 under no load condition.

B. Calculation for motor rating

The performance of the motor varies with load given to the motor, it is essential to choose the motor rating according to the load given to the motor. We assumed that the weight being placed on the motor to be 110kg. This weight is that the whole weight of the scooter assembly which incorporates the weight of the motor, chassis, battery and additionally the weight of the rider.
The subsequent steps describe the calculations for selecting the motorrating.
Assuming that a mass of 110 kg is loaded.m = 110 kg
Speed changes from 0 → 15 km/hr in 10 sec.

Acceleration
a = (15-0)*(5/18)/10 = .416 m/sec^{2}Force is given by
F = m x a =110 x .416 = 45.83 N

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d = Wheel Diameter in metreWheel Diameter (d) is 8 inch

1 inch = 0.0254 m, So, d = 8 inch = .204 m Torque developed = force x radius of the wheel

= F x r

= 45.83 x .102 m

= 4.675 Nm

C. Selection of motor

When choosing drive motor for the electrical vehicle, a number of factors should be taken under consideration to see the maximum torque needed.

The factors are:

- Rolling resistance
- Gradient resistance
- Aerodynamic drag

$F_{total} = F_{rolling} + F_{gradient} + F_{aerodynamic\ drag}$

Where F_{total} = Total force

$F_{rolling}$= Force due to Rolling Resistance $F_{gradient}$ =Force due to Gradient Resistance

$F_{aerodynamic\ drag}$ =Force due to Aerodynamic Drag

F_{total} is the total tractive force that the output of the motor mustovercome, to propel vehicle.

1) Rolling Resistance

Rolling resistance is the force which resists the motion of the vehicle due to the contact of the tire with the road. The formula for calculating force due to rolling resistance is given by the equation:

$F_{rolling} = C_{rr} \times M \times g$

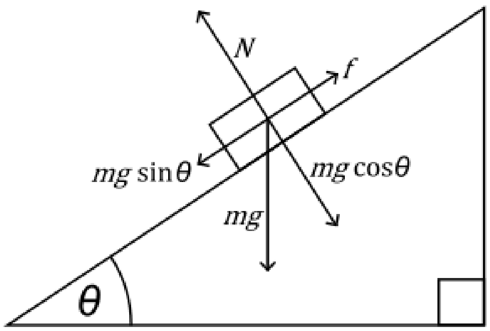
Table 3 coefficient of rolling resistance

Conditions	Rolling resistance coeffecient
Car tire on smooth tamacroad	0.01
Car tire on concrete road	0.011
Bicycle tire on concrete	0.002
Wheel on iron rail	0.001 – 0.002
Truck tire on asphalt	0.006-0.01
Car tire on gravel-rolledroad	0.02
Bicycle tire on asphalt road	0.004
Bicycle tire on concrete	0.002

M = mass in kg
g = acceleration due to gravity = 9.81 m/s^2
For application, puropose consider, C_{rr}= 0.004 as per the above table and weight of the scooter = 110 kg
Then, $F_{rolling} = C_{rr} \times M \times g = 0.004 \times 110 \times 9.81 = 4.3164$ N

2) Gradient Resistance

The gradient resistance of the vehicle is the resistance offered to the vehicle while climbing a hill or an inclined surface. The angle between the ground and slope of the path is represented as "θ" which is shown in the below figure



The formula for calculating the gradient resistance is given by equation below
$F_{gradient} = \pm M \times g \times \sin\theta$
Where, +(positive) sign is for moving up the gradient -(negative) sign is for moving down the gradient.
For application, In this illustration, let us consider electric scooter moves at an angle of θ (inclined angle) = 2.5°
$F_{gradient} = \pm M \times g \times \sin\theta = 110 \times 9.81 \times \sin 2.5° = 47.0696$ N

3) Aerodynamic Resistance

Aerodynamic drag is the resistive force offered due to viscous force acting on a vehicle. It is determined by the shape and size of the vehicle.
The formula for calculating aerodynamic drag is given by the below equation.

$F_{aerodynamic\ drag} = 0.5 \times C_D \times A_f \times \rho \times v^2$

Where, C_D =Drag coefficient, A_f=Frontal area
ρ = Air density in kg/m^3 , v = velocity in m/s

For application assume, maximum speed of our scooter is 15 kmph that is 4.166 m/s and air density is 1.1644 kg/m^3 at 30° temperature and drag coefficient is 0.5 , frontal area is 0.7 as per the table shown below.

Table 4 Drag coefficient and frontal area of vehicle

Vehicle	C_D	A_f
Open convertible	0.5-0.7	1.7-0.9
Limousine	0.22-0.4	1.7-2.0
Coach	0.4-0.8	6-10

Motorcycle withrider	0.5-0.7	0.7-0.9
Truck without trailer	0.45-0.8	6.0-10.0
Truck with trailer	0.55-1.0	6.0-10.0
Articulated vehicle	0.5-0.9	6.0-10.0

Then, $F_{aerodynamic\ drag} = 0.5 \times C_D \times A_f \times \rho \times v^2$
$= 0.5\times0.5\times0.7\times1.1644\times(4.166)^2 = 3.5376$ N
Then, The force required for driving a vehicle is, $F_{total} = F_{rolling} + F_{gradient} + F_{aerodynamic\ drag}$
= 6.2894 N + 47.0696 N + 3.5376 N
= 56.8966 N
Then, The power required for driving a vehicle is, Power = Force × Velocity × (1000 ÷ 3600)
= 56.8966 × 15 × (1000 ÷ 3600) = 237.06 watt.
Hence, the power required to propel the vehicle is 237.06 W, Which is just below our motor specification 250 W.
4).Battery Selection Power Equation
Power (P) = Current (I) × Voltage (V) Hence, I = P ÷ V = 250 ÷ 24= 10.41 Amp.
Voltage Rating = 24 v, Current Rating = 10 Ah
So, Wattage of battery =
Voltage Rating × Current Rating = 24 × 10 = 240Wh (watt.hr.)
As per the above calculation a battery with rating of 24V 10 amps will be suitable for our model.

IV RESULT

Nowadays, Most Conventional vehicles used are based on the fuel ignition principle powered by an Internal Combustion engine for long as well as short-distance commuting. Hence causing urban air pollution. Thus, the proposed paper researched on design and development of the two-wheeler motorized scooter with renewable power source. This given EV contains a lead-acid battery of capacity 24v, 10Ah. Thus the EV can be charged up to 200 to 250wh using a charger, which will run at an appropriate speed of 15 kmph.

V CONCLUSIONS

A motorized scooter is one of the simple variants of the electric vehicle category and as the demand for less polluted vehicles are growing with the advent of the greenhouse gas emission into the atmosphere this will provide a better means of transport for short distance commuting. The importance of these type of vehicles are gradually increasing due to increase in air pollution and the rapid burning of fossil fuels. So a motorized scooter will pose a better alternative for short distance commute in large campuses and institutions as well as on pedestrian roads. This study helps to provide outline of a motorized scooter and their various components.

REFERENCES

[1] Ji-Young Byung-Chul Woo,Jong-MooKim and Hong Seok Oh, “In-wheel Motor Design for an Electric Scooter”, Journal of Electrical Engineering And Technology , Nov.2017.
[2] ZhaiHaizhou Heze University, Heze, China, “Modeling of Lithium-ion Battery for Charging/Discharging Characteristics Based on Circuit Model” Article submitted 05 March 2017.

Published as resubmitted by the author 17 April 2017 .

[3] K.W.E Cheng, "Recent Development on Electric Vehicles", Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong. June 2009.

[4] Md. Rifat Hazari, Effat Jahan, "Design of a Brushless DC (BLDC) Motor Controller", Department of Electrical and Electronic Engineering American International University- Bangladesh (AIUB) Dhaka, Bangladesh. Oct 2017.

[5] Rajasree S R, Sithara Mohan, Kaleshan K R ,"Development of an improved low cost Electrically Assisted Bicycle with anefficient plugin charger" ,Oct 2018.

[6] Ian Vince McLoughlin,I. Komang Narendra, Leong Hai Koh, Quang Huy Nguyen, Bharath Seshadri, Wei Zeng, Chang Yao
, "Campus Mobility for the Future: The Electric Bicycle",Jan 2018.

[7] Srivatsa Raghunath, "Hardware Design Consideations for an electric bicycle using a BLDC Motor",2016 .

[8] David Jordan,Stacry Worley,Christopher Cherry ,"Electric Bike Sharing System Requirements and Operational Concepts" ,TRB 2011 Annual Meeting.

[9] Abdulkadir Baba Hassan, "Design and Fabrication of a Motorized Prototype Tricycle for the Disable Person" ,May. 2012.

[10] Mahesh S. Khande, Mr. Akshay S. Patil, Mr. Gaurav C. Andhale, Mr. Rohan S. Shirsat,"Design and Development of Electric scooter", May 2020.

[11] Ionuț Daniel Smărăndescu, Petre-Marian Nicolae, "About Electric Scooter Mobility. Aspects Regarding the Designing of a Brushless DC Motor for an Electric Scooter", May 2020.

[12] Patmont, steven J.Asuncion, R. B ,"Development of an Electric Tri-wheel Scooter", June 2015.

[13] Ganjapure Aditya, "Design and Development of CompactThree Wheeled scooter" , June 2016.

[14] Bharati Parmar , "Design of a Three Wheeler Electric Vehicle",May 2013.

[15] C.-L. Chiu, Y.-T. Chen, Y.-H. Shen, and R.-H. Liang, "An Accurate Automatic Phase Advance Adjustment of Brushless DC Motor,", Jan. 2009.

[16] Y.-C. Chiu and G.-H. Tzeng, "The market acceptance of electric motorcycles in Taiwan experience through a stated preference analysis", Mar. 1999.

[17] Jyh-Rong Choua, Shih-Wen Hsiao, "An anthropometric measurement for developing an electric scooter", August 2005.

[18] K Veeramanikandan, K Nikkhil, V Benny, KBBhuvaneshwaran, A Sundar, Design and Development of Electric Scooter, studies in Indian Place Names,40,74,(2020) 165-170.

[19] Veeramanikandan K,Naveen kumar M, ,Deepak bohra S,Vinoth kumar V, Vijay ananth G K, Investigation of Air conditioning system by vapour compression refrigeration cycle using waste heat energy from the engine exhaust, International Journal of Innovative Technology and Exploring Engineering, 8(8),2019 1581-1585.

[20] K. Veeramanikandan, S. Vignesh, B. Pitchia Krishnan, M. Mathanbabu, M. Ashokkumar, Investigation of Al2O3-water nano fluid flow through the circular tube, Materials Today: Proceedings, 2021, 2214-

[21] 7853.