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Foldable Scooter


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Abstract:

It is very difficult to reach the nearest public transport facility and in many cases the destination will be very far from the main roads where the public transport might not be able to commute or it might be very expensive. To overcome a common problem faced by the society, an idea is conceptualized to design and fabricate a foldable scooter. We already have seen some foldable scooters in the global market but the main idea of this project is to provide a foldable scooter which is light & sleek yet rigid & safe, easy to handle and easy to maintain. Unlike the conventional scooters, this scooter will occupy very less space and also is very easy to be carried around. The main objective is to design and develop a foldable scooter which is comfortable to ride and economical.

I. INTRODUCTION:

A folding bike is a bike designed to fold into a compact form, facilitating transport and storage. When folded, the bikes can be more easily carried into buildings, on public transportation (facilitating mixed-mode commuting and bike commuting), and more easily stored in compact living quarters or aboard a car, boat or plane. Folding mechanisms vary, with each offering a distinct combination of folding speed, folding ease, compactness, ride, weight, durability, and price. Distinguished by the complexities of their folding mechanism, more demanding structural requirements, greater number of parts, and more specialized market appeal, folding bikes may be more expensive than comparable non-folding models. The choice of model, apart from cost considerations, is a matter of resolving the various practical requirements: a quick easy fold, a compact folded size, or a faster but less compact model, There are also bikes that provide similar advantages by separating into pieces rather than folding. Military interest in bikes arose in the 1890s, and the French army and others deployed folding bikes for bike infantry use. I`n 900, Mikael Pedersen developed for the British army a folding

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version of his Pedersen bike that weighed 15 pounds and had 24 inch wheels. It included a rifle rack and was used in the Second Boer War In 1941, during the Second World War, the British War Office called for a machine that weighed less than 23 lb (this was not achieved - the final weight was about 32 pounds) and would withstand being dropped by parachute. In response, the Birmingham Small Arms Company (BSA) developed a folding bike small enough to be taken in small gliders or on parachute jumps from aircraft. This British WWII Airborne BSA folding bike was rigged so that, when parachuted, the handlebars and seat were the first parts to hit the ground (as bent wheels would disable the bike). BSA abandoned the traditional diamond bike design as too weak for the shock and instead made an elliptical frame of twin parallel tubes, one forming the top tube and seat stays, and the other the chain stay and down tube. The hinges were in front of the bottom bracket and in the corresponding position in front of the saddle, fastened by wing nuts. The peg pedals could be pushed in to avoid snagging and further reduce the space occupied during transit. From 1942-1945, the British WWII Airborne BSA folding bike was used by British & Commonwealth airborne troops, Commandos, and some infantry regiments; some were also used as run-about on military bases. The bike was used by British paratroopers, Commandos, and second-wave infantry units on the D-Day landings and at the Battle of Arnhem.

II. HINGE DESIGN:

The hinge being a very important member of the frame required utmost attention. The hinge is the load bearing member. After a long survey of the existing hinge mechanisms used in the foldable bicycles, it was found that most of the bicycles used similar kind of hinge and locking mechanism. The mechanism used was simple, but manufacturing something similar with available resources turned out to be expensive. But the hinge mechanism or the simplest hinge mechanism used in brompton bicycle caught our interest.

This mechanism was very simple and used a screw and spring loaded mechanism to lock the hinge. The design was simple yet strong and a chance of failure is minimal. The following figure shows the hinge mechanism used in the brompton bicycle

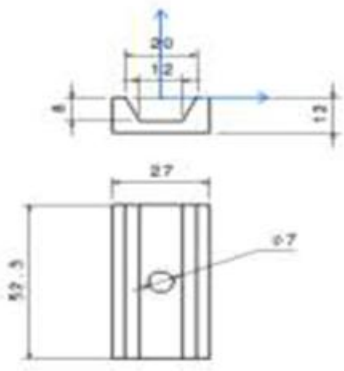

Fig 1: Draft of hinge clamp

Fig 2: HING MECHANISM

Fig 3: hinge clamp mechanism

III. TESTING FOR BENDING AND COMPRESSION LOADS

Bending Test- The tube used to fabricate the bicycle was subjected to bending test. A tube of outer diameter 1 inch, 16 gauge and length 10inches was used as the

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test specimen. The specimen was mounted on the UTM with necessary arrangements to perform bending test. The specimen was supported by two v-blocks and then the bending test was done. It was observed that the tube does not show much deflection till a load of 4 KN, but the since the tube is hollow first the outer surface of the tube was bent then the whole tube started bending. The bending test was carried out till a deflection of 8.5 mm was observed. The variation of the deflection with respect to the load is as shown in the graph below.

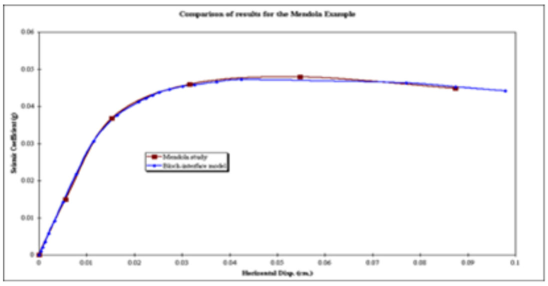

Fig 4: Graph of Deflection v/s Load for bending test

Compression Test- The mild steel tube was cut and welded to the angle as in the frame design and tested on the UTM till fracture. The mild steel tube of outer diameter 1 inch and 16 gauge was used to build the specimen as per the required dimensions. Compressive load was applied on the specimen. It is observed that there is very less deflection up to a load of 4 KN and then the joint shows plastic deformation at 5KN and then fractures at a load of 6.5 KN. The result of the test is plotted as a graph of deflection versus load and is as shown in the below figure.

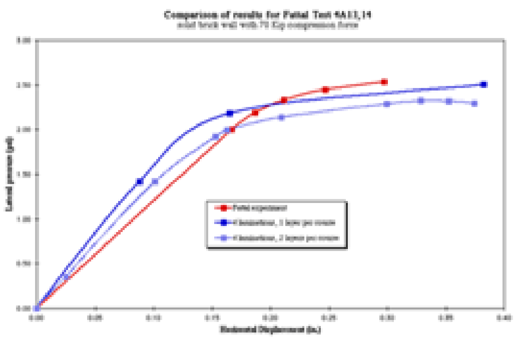

Fig 5: Graph of Deflection v/s Load for compression test

IV. THEORY OF OPERATION OF ELETRIC VEHICLE

When the driver accelerates the wrist throttle the potentiometer activates and provides the signal that tells the controller how much power it is supposed to deliver. The controller reads the setting of the accelerator pedal from the potentiometers, regulates the power accordingly, takes the power from the batteries and delivers it to the motor. The motor receives the power (voltage) from the controller and uses this power to rotate the wheel and causes the vehicle to move forward.

METHODOLOGIES

If the driver accelerates the full throttle, the controller delivers the full battery voltage to the motor. If the driver takes his/her hand off the accelerator, the controller delivers zero volts to the motor. For any setting in between, the controller chops the battery voltage, thousands of times per second to create an average voltage somewhere between 0 and full battery pack voltage. The specifications of compact two-wheeled foldable electric moped are:

Table 1: specifications table

motor	BLDC hub motor 250 w: Weight – 7kg Hub diameter -10
Battery	Lead acid: 2(12v, 7ah)in series Charging time -5h 27m
controller	BLDC hub motor controller
material	Mild steel (SAE1018): Uts :450mpa, Ys :250mpa, Poisson s ratio: 0.3
wheels	2 wheels of 10 inch dia each

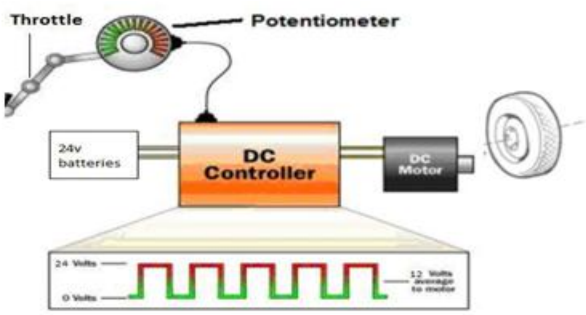

Fig 6: working principle diagram

V. Development and Construction of Scooter

Frame- The frame and thus keeping the mass to the lowest and most desirable value Frame is the most

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significant rigid structural member that carries the various components of the vehicle in proper orientation. Basic types of frames are:

- Tubular frame: Single cradle frame, double cradle frame, backbone frame.
- Pressed steel frame. Tubular frame is easy to fabricate as compared to pressed steel frame.

Our vehicle is designed using the simplest form of double cradle frame. This helped us in decreasing the number of member.

Material of Frame - Material selection of the chassis plays crucial part in providing the desired strength, endurance, safety and reliability to the vehicle. To choose the optimal material considering the properties good bending stiffness , minimum weight and maximum strength for the pipes from Mild Steel , Stainless Steel and Aluminum. Along these lines, post-retail investigation on cost, accessibility, and properties of these three materials. The material finalized was Mild Steel with the grade of M.S. IS1239 of the following dimensions: outer diameter 25.4mm and thickness 3mm.

Evaluation of Material for Frame- Based on results of Universal testing machine, availability, requirements and comparison between aluminum, mild steel and stainless steel we found mild steel to be the most appropriate material to be used for our vehicle, but even in Mild Steel there are many grades. Out of which we preferred to use MS IS1239.

Fork Steering- A fork connects a front wheel and axle to its frame. The upper part of fork is connected to the handle bar. The handle bar with fork steering is the simplest steering mechanism. There are a number of fork steering systems: Simple fork, Telescopic fork, Trailing arm fork, Leading arm fork Out of all these types of forks three forks excluding the first have suspension systems linked with it. Out of all these types of forks we have used the simple fork steering. The reason behind using this type of fork is reduced weight, ease of manufacture and reduced cost but only at the cost of suspension. In our vehicle, we do not Need the suspension at front as the vehicle is made for indoor purpose and other surfaces which are not rough, hence it possible to use simple forks

Brake- Brake is the most important control device of our vehicle. The main function of brake is to stop the vehicle within smallest possible distance which is done by converting the kinetic energy of vehicle into the heat energy which is dissipated in surrounding. In our prototype, we decided to use drum brake because of its various advantages such as light weight, high brake factor and easy actuation mechanism. As the speed of the vehicle is low thus we have only used drum brake in the front wheel containing hub motor.

Wheels and Tires- Wheels and tires are the most important components of an automobile because in the absence of an engine, a vehicle can be towed but towing is not possible in the absence of wheels and tires. The selection criteria for wheels and tires of our vehicle is lighter weight, lower cost, effective performance and longer life, so in order to fulfill the above requirements we selected one aluminum and magnesium alloy wheel with hub motor as front wheel and two solid wheels as rear wheels. In the trolley, we decided to use four solid wheels.

Trolley- A trolley is a permanent or detachable part of a vehicle which is used to carry load. In case if a trolley is detachable, it is hinged or pivoted at the rear of the vehicle. Commonly used trolleys are of rectangular shape and they are generally made of hollow circular or rectangular parts. Generally solid wheels are used in a trolley if its operation is to run on smooth roads and pressed steel disc wheels with radial tires are used if they are to be run on rough roads. In our prototype we decided to use solid wheels because our vehicle is to be used in workshop and in college premises which have smooth surface for rolling the wheels they are less expensive.

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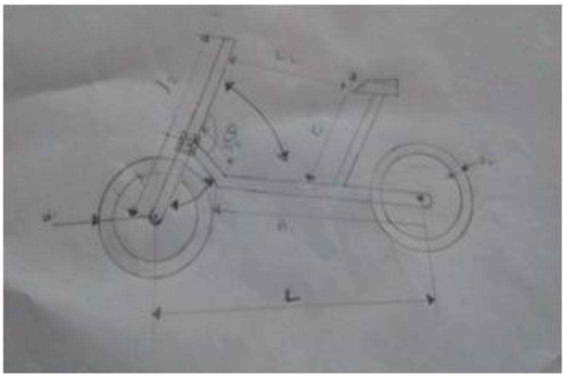

Fig 7: Dimensions of Modified frame

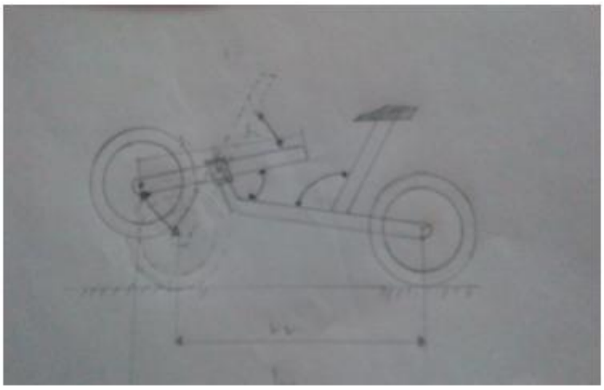

Fig 8: Angles between members in the modified design

Fig 9: Modified frame

Fig 10: Modified frame folded

VI. CALCULATIONS

Motor Calculations

Power output of motor = 320 watt

Efficiency of motor = 80%

Power input to motor Pi = 1000/0.8=1250 Watt

Load torque = (output power)/ ($2\pi N$) =1000*60/(2π*500) =19.098 N.m.

Load current = Pi/ V= 1250/48 = 26.04 A Speed = (π*D*N)/60= 3.14*0.4064*500/60 = 10.634 m/s = 38.282 kmph

Force = T/r= 19.098/0.2032= 93.986 N

Rolling friction= 31.49 N

Force – Rolling friction= mass*acceleration

Acceleration a= (93.986 - 31.49)/22.43= 2.787 m/s^2

Battery Calculations

When batteries are connected in series,

Terminal voltage V =12*4= 48 Volt

Ampere-hour of batteries Q = 33 Ah

Power input for charging Pi = 290 Watt

Time required for charging = (V*Q)/ Pi = (48*33)/290=5.462 hrs = 5 hr. 27 minutes

Total Power Consumption

We have only BLDC hub motor for power consumption in our vehicle so power consumption is 1250 watt only.

Discharging time for battery = (V*Q)/ (total power consumption) = (48*33)/1250 = 1hr 16 min

Brakes Calculations

Load distribution of our vehicle is 43:57 there for load on the both axles divided are:

Static load on front Axle =43% of 219 Kg= 43*219/100 =94.17 Kg

Static load on Rear Axle =57% of 219 Kg=57*219/100 =131.4Kg

Dynamic weight transfer of our vehicle while,

Braking condition

(mass of vehicle) *(Max. Dec) *(height of C.G from the Base)

=22.32*1*9.81*25/45=121.64 N =12.43 kg

Dynamic load distribution of the front axle and rear axle while the braking condition:

Dynamic Front axle load while braking: 12.43+94.17Kg =106.6kg

Dynamic rear axle load while braking: 219-106.6kg =112.4kg

Net braking force is produce while braking is: mass*deceleration= 219*1*9.81=2148.39N

Net power absorbed of the wheel during braking:

= (mass of vehicle /2) *((velocity^2)/ (time for change velocity))

= (219/2) *((11.112)/1.13)

= 11960.8 9 J/s

Time for velocity Change:

= Velocity/Maxi. Dec.= 11.11/1*9.81

= 1.13 seconds

Maximum Temperature rise

= (Kinetic energy in Ft.lbs)/ (weight of rotor in Lbs) = 1472.92/6.613

= 222.83°F = 106°C

Stopping distance:

= $v^2/2*\alpha$ = (11.11)2/2*2.37 =26.040m

VII. CONCLUSION:

As seen in this report, with 18 km range on a single charge, a top speed of 13 kmph and an ability to fold small enough to fit next to you in a train or a bus, it can act as an awesome last kilometer commuter vehicle and also it is great way of transport for short distance and crowdie areas. It has many beneficial features such as folding mechanism, shock absorbing seat for an extremely comfortable ride, two wheels for more stability and disc brakes for better braking performance. The electric moped has many advantages and it is cleaner and much more efficient. Electric mopeds also eliminate the dependency of foreign imported crude oil hence helps in developing the economy of the country. It also produces zero tailpipe emissions hence reduce the health hazards like cancer, asthma and various other respiratory problems.

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