Design and Fabrication of Eco-friendly Vehicle for Physically Handicapped Person

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Abstract - *For A normal human being have plenty of resources available for mobility but when it comes to the physically handicapped person options are limited as very few form automobile industries put the focus on them. Majority of the physically disabled person uses hand operated tricycle or retrofitted scooters. Mechanical tricycle requires more human effort and it is a tedious task. Modified scooter is one of the best option which is powered by IC engine but cost of such vehicle high and requires periodic maintenance. So considering limitations of above options this project aims at design an ecofriendly tricycle powered by electric motor. This tricycle is convenient to a handicapped person as well as affordable to a poor person, as cost is major issue for them.*

Key Words: Tricycle, Electric motor, Retrofitted, Eco friendly, physically handicapped

1. INTRODUCTION

Mobility plays a vital role in social life of a human being. For that sake different vehicle have been developed but almost all of them produced for normal person. As far as a physically handicapped person is concerned, there are limited vehicles are available for personal use. Vehicles for a disabled person either of custom made or conventional hand operated tricycle. They meant to fulfill basic functional need and seldom put the emphasis on other factors. Most of listed options have poor aesthetics or cost issues. A conventional mechanical tricycle makes it hard to drive in poor road condition or on a gradient. A modified scooter require regular maintenance and operating cost is comparatively high. Smart wheelchairs also an option but it is suitable for short distance and cost associated with such chair is too much high.

Even though Previous options has given different design which are sophisticated but failed to consider many factors like weight, cost, simplicity, emission and operational cost.

This project aims to mitigate the above listed problems by designing and fabricating a tricycle which will be driven by an electric motor with simplified electric drive system eliminating chain and sprocket mechanisms.

2. LITERATURE REVIEW

There are different type of vehicle developed for physically handicapped person like Modified scooter driven by IC Engine, Solar operated tricycle, Hybrid Tricycle, Smart wheelchair etc. Cost of Modified scooter is around 65000. Solar tricycle requires photovoltaic cell which are expensive. Hybrid tricycle are bulky and sophisticated mechanisms.

Ajit Mohekar- He designed a retrofitted tricycle by modifying the existing scooter. He also design special platform arrangement so a wheelchair occupant can easily hold or leave the tricycle. This trike can be use for a long distance making it suitable for long journey too.

Ravikumar kandasamy- Ravikumar have developed solar operated tricycle for physically handicapped person and he made it especially for an NGO started by Baba Amate. Main components of tricycle was Solar panel (Photovoltaic cell) and frame to support panel, PMDC motor, Battery and charger controlling unit. Ravikumar developed a completely pollution free tricycle.

Andrew Schoenberg-A zero emission hybrid trike have been developed which have enclosed cabin. Powered by two 1HP motor and also equipped with a generator. Rear wheels are driven by motor and having suspensions and tilting capability.

 Jayaprabakar- She proposed an innovative design of battery powered vehicle. Vehicle equipped with three wheels at rear and one at front. Power is given to the rear middle wheel and remaining rear two wheels are for support and accommodate the suspension. In spite of all this feature it was a sophisticated design due to extra wheel.

3. DESIGN CALCULATION

3.1 Weight Estimation

Component	Weight (N)
Frame	346.35
Battery	121.72`

Rider	686.70
Front wheel	30.43
Wheel with hub motor	78.48
Wheel without hub motor	49.05
Handle	39.24
Luggage box	94.33
Accessories	35.03
Miscellaneous	49.05
Total	1530.49 (156 kg)

3.2 Running Parameters

As vehicle is being design for disabled person speed is limited to 25kmph and any vehicle having speed below 25kmph requires no RTO registration. Radius of vehicle is 203 mm (8 inch) thus rotational speed of wheel is limited to 327 rpm.

Motor must overcome following resistances while driving.

1. Air Resistance (R_A) = 7.06N

2. Gradient Resistance (R_G) = GVW×Sinθ

 θ=1 to 7 degrees

 GVW=1540N

 R_G = 1540×sin6.5=175N

3. Rolling Resistance (R_R) =μ×GVW

 R_R=0.023×1540

 R_R=36N

4. Acceleration (Fa) =m×a

 Taking acceleration as 2m/s^2

 (Fa)=156×2=312N

To overcome above resistances at maximum possible speed of 25 kmph tricycle needs a torque of 4-5 N-m. Motor selected for tricycle delivers running torque of 7 N-m at fully charged batteries and taking efficiency of motor as 0.85, motor overcomes all of above resistances.

3.3 Energy consumed by batteries

No of batteries used in the tricycle are four.

Battery has the following specification

- Type: Lead Acid
- Battery Rating: 20Ah
- Voltage:12V
- Total Voltage:12×4=48V

Energy consumption in 1 hour=Ah rating×Voltage

 =20×48

 =960Wh or 0.960KWh

Given Lead acid batteries take maximum 7hrs to full charging, Energy consumed during this hours is given by

 =Unit hour consumption×No. of hours taken to charging

 =0.960×7

 =6.72 KWh

Tariff of MSEB =6 rupees/unit for residential meter connection. (Average tariff)

Now charges for given energy consumption

 =unit rate×Energy consumption

 =6×6.72

 =40.32 rupees

In a single charge vehicle covers maximum distance of 65 km

Cost per km can be found easily

 =40.32/65

 =0.62 Rs/km

4. COMPONENT SELECTION

Tricycle consist of various components like motor and controller, chassis, batteries, Voltage converter and brakes and speed control.

4.1 Frame

Frame is the supporting member of the tricycle and subjected to static and dynamic load. It also takes various load like vertical load, Cornering load, side thrust, acceleration and brake dip. Various Accessories and components are mounted over the frame. A frame should have sufficient strength to stand against all the listed loads. Weight of the frame should be as minimum as possible to reduce the overall weight of tricycle. Cost of

the material of frame must be low. We selected the frame by considering available sizes of pipe, maximum stresses developed in the critical component and available factor of safety. Selected hollow pipe has the following specifications.

- · Material: AISI 1018
- · Outer diameter:25.4mm
- · Inner Diameter:21.4mm
- · Thickness:2mm
- · Sut:440 N/mm²
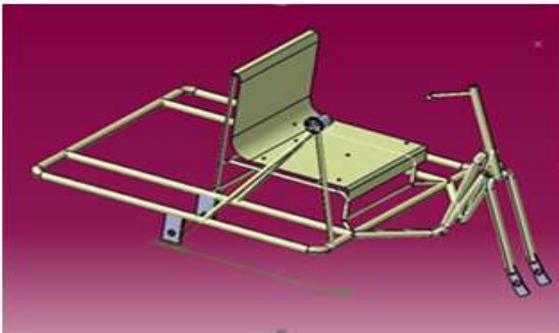
Fig- 1: Catia Model of Frame

4.2 Motor

To drive the vehicle at a speed of 25kmph and provide a rated torque about 5 N-m a motor having capacity above 200 watt is sufficient. Next Standard available motor is in capacity of 250 watt. Thus we have taken a Brushless DC motor of hero optima electric bike. The motor available in wheel itself i.e. hub motor. Hub motor of this kind is available in authorized workshop of hero motors. Cost of hub motor is below 5000 making it suitable for low cost application. Vehicle having electric power source of more than 250 watt requires RTO registration. Selected motor give us exemption from RTO registration.

Specification of selected hub motor.

- Type: Brushless DC Motor
- Power:250 Watt

4.3 Batteries

To run the motor at full load condition for 2-3 hours it requires energy about thrice of capacity of motor, along with this Batteries should provide high energy demand during starting without affecting the further performance. Battery power can be estimated by Voltage and current rating. Batteries must have high voltage in order to provide abundant energy supply and to maintain voltage drop as minimum as possible. Another requirement of batteries is low cost and low maintenance. Lead acid batteries fulfill the second condition. Voltage of system can

be increase by connecting it in series. Considering above parameters lead acid battery is suits best.

Selected batteries have following specification

- Current rating:20Ah
- Voltage:12V
- No. of batteries: 04
- Combination of batteries: Series
- Combined Voltage: 48V

4.4 Controller and Voltage Converter

Motor draw the current from batteries according the need of the driver. Controller takes different input like brake, acceleration and vary the power supply to the motor. We selected standard controller taken from the hero electric's bike and installed it with the given hub motor of same bike model. It has the following specification

- Operating current:19A
- Operating Voltage:48V DC
- Phase angle:120 degrees

Tricycle does have different accessories like horn, Headlight, Indicator lamp, Brake light and all of those operates on 12V. But combined voltage of system is 48V thus it is essential to convert 48V into 12V and DC-DC Voltage converter serves this purpose. Along with voltage conversion it also gives protection from overcurrent, short circuit and low voltage. The converter used in given tricycle has the following specification.

- Red wire/Input: DC 31V-59V
- Yellow wire/Output: DC 12V
- Black wire: Cathode(Earth)

4.5 Battery Charger

Battery get drains after running a distance of 60 km and it does requires to recharge it. For the sake of charging a charger is required. We cannot charge batteries direct from AC current supply. It requires to convert AC current into DC. Charger Convert AC to DC. It consist of step down transformer, rectifier and filtering circuit to supply constant voltage.

Specification of selected charger

- Input voltage: 170-300V
- Input current: 1A max
- Output voltage: DC 59V
- Output current: 2.7A

Fig-2 : Actual Tricycle

5. COST ESTIMATION

Component	Cost
Frame	3200
Hub Motor wheel	3520
Battery set	8350
Controller	1530
DC-DC Converter	730
Battery charger	460
Wheels	1250
Accessories	600
Fabrication	1700
Other	590
Total	21930

6. FUTURE SCOPE

6.1 Use of manual drive with gears

Tricycle is solely driven by the electric batteries. Although there are scanty chances of complete drain of battery but providing a secondary power source will make the tricycle more convenient to the driver. Secondary drive can be given by installing chain and sprocket mechanism. In case of failure or discharge of battery vehicle can be driven by manually like manually hand operated tricycle. To make ease of drive gears can be installed to obtain variation in torque and speed.

6.2 Use of batteries with more capacity

To increase the running distance in single charge batteries with more capacity can be installed. Installation of batteries of high capacity will allow to use motor of more power which will make it easy to take up more load. Use of Li-ion batteries instead of lead acid batteries gives lot of advantages as li-ion batteries are compact in size, high energy density, more life, and reduced charging time

7. CONCLUSIONS

[1]   Objective of the study was to design an eco-friendly vehicle which will be affordable to poor handicapped person.

[2]   Tricycle has been fabricated and tested successfully. Different parameters like running range, cost per kilometer, Discharge time of battery has been measured with actual running condition and it delivered better results.

[3]   We mitigated problems faced by previously designed model.

[4]   As compared to IC engine vehicle, running cost of tricycle is almost half.

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