International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

# Design and Manufacturing of Battery Operated Drive System for a Three Wheeled Vehicle for Disabled

*Sanket C. Naik Nimbalkar[1], Nikhil Baldwa[2], Sumesh Navale[3], Devansh Khandelwal[4]*

[1234]*Dept. Of Mechanical Engineering, M.I.T, Pune, Maharashtra, India.*

---

**ABSTRACT:** Transportation *plays a vital role in today's fast moving world. Every human being is using one or the other form of transportation facilities available. As every normal human being a disabled person also has the right to use all these facilities to move around independently and to contribute to the society. Therefore a motorized tricycle for disabled person was designed previously. It was designed to suit a commonly available wheelchair. Existing tricycle for the disabled requires a disabled person to dismount from the wheelchair onto the tricycle. The previous motorized tricycle was designed to overcome this problem by allowing the disabled person to wheel up or down his wheelchair onto or down the tricycle. Even though the previous tricycle presented a promising design, it failed to take into consideration some important factors. The designed tricycle had an unbalanced design, large turning radius, large size and no means to move in reverse direction. This project aims at overcoming the drawbacks of the designed tricycle by redesigning a new model and a new electrical drive system.*

***Key Words***: **Motorized, tricycle, disabled, unbalanced, design, reverse, electrical.**

## 1. INTRODUCTION

Mobility is a crucial aspect in independence. It is sensitive to changes in health and psychological status and is one of the most crucial factors in determining one's functional capacity. Transportation is one of the important sources for increasing mobility of human. In transportation vehicles plays very crucial role. Normal human beings can use these vehicles very easily but things are different for the disabled. The disabled people also have the right to use all these facilities to move around independently Nowadays various hand driven tricycles are available for them but these are designed primarily for the basic functional use for moving on road without considering many important aspects of safety, human aspects and aesthetics. It induces inferiority complex of being disabled since odd designs are used in this special mode of transport. Among the various such designs available, some focused on improving the mobility of the wheelchair. These allow improvements in the use of the wheelchair but it is not a viable means for long distance travel. Motorized vehicles such as buses, vans, cars and motorcycles are usually customized for this purpose. Customized motorcycles such as the tricycles have been used by the disabled as a mean of transportation. However, existing tricycles are custom-made to suit individual requirements. These tricycles also require the disabled to get out of the wheelchair and onto the seat of the tricycle. These are some of the problems that the researchers are trying to solve with the new tricycle design.

Therefore a motorized tricycle for disabled person was designed previously. The tricycle was specifically designed to suit wheelchair occupants of healthy upper torso with pelvic to foot restraint. It was designed to suit a commonly available wheelchair. Existing tricycle for disable requires a disabled person to dismount from the wheelchair onto the tricycle. The previous motorized tricycle was designed to overcome this problem by allowing the disabled person to wheel up or down his wheelchair onto or down the tricycle. This was achieved using a specially designed platform that allows the wheelchair to be wheeled up or down.

Even though the previous tricycle presented a promising design, it failed to take into consideration some important factors. The designed tricycle had an unbalanced design, large turning radius, large size and no means to move in reverse direction.

This project aims at overcoming the drawbacks of the designed tricycle by redesigning a new model and a new electrical drive system. It is hoped that this new design will ease and improve mobility. In this project we will be following the scheme that has been approved by ARAI which specify the modifications that can be made to the vehicles, driven by physically challenged people. Then final design of the tricycle is done by attempting to tackle some of the major issues put forth by this scheme. Then the final product will be fabricated. An attempt has been made to provide unique, purpose serving indigenous Tricycle for Disabled person.

## 2. DESIGN CALCULATIONS

### 2.1 Estimation of weight

**Table 1**: Weight estimation

| | |
|---|---|
| Weight of chassis | **706.32 N** |
| Weight of gearbox | **137.34 N** |
| Weight of Motor | **137.34 N** |
| Weight of Batteries | **568.98 N** |
| Weight of ramp | **98.10 N** |
| Miscellaneous weight | **166.77 N** |
| Weight of wheel chair | **196.20 N** |
| Weight of rider | **637.65 N** |
| Total estimated weight | **2648.7 N** |

### 2.2 Running Parameters

As vehicle was designed for disabled people, speed was kept low for safety purposes. The maximum speed of the vehicle was set at 25 kmph. The selected speed gave rpm of 328 at wheel.

The motor overcame different resistances while driving the vehicle as follows:

Rolling Resistance = 39.73 N

Drag Resistance = 9.004 N

Grade Resistance = 277 N

Acceleration Force = 270 N

Let us assume, at any instant only 310 N resisting force acts upon the vehicle out of maximum possible 596 N.

Assuming 85% transmission efficiency, a motor of 3.5 HP was used to overcome the calculated resistance. Also a torque of 62.94 Nm will be requires to propel the vehicle at speed of 25 kmph.

## 3. SELECTION OF COMPONENTS

The drive train of the tricycle consists of various components like motor, batter, controller and gearbox. There are a variety of motors, batteries and gearboxes available in market. During this section we are going to see how various components of drive train are selected based on calculated parameters, cost and their discrete advantages and disadvantages.

### 3.1 Motor

Taking into account the pros and cons of various types of motors like Induction Motor, Brushless DC Motor and Permanent Magnet DC Motor, the best suited motor for the vehicle is BLDC motor. It is small in size and light weight. BLDC motors have high torque rating. The motor required to run the vehicle satisfactory should have a rating of 3HP. Therefore best suited motor for the vehicle is a 3HP, BLDC motor. According to market survey a 3HP BLDC motor with external control may cost up to INR 50,000/-. These types of motor are cost effective only in mass production. Taking into account the available cost for the project, such type of motor is not feasible. Therefore, a PMDC motor of 1 HP, 24 V, 1500 RPM and 4.7088 Nm rated torque is selected.

### 3.2 Battery

We wanted to run the vehicle for 2 hours continuously.
Motor to be operated:
Current Required: 39 Amps
Voltage: 24V
To run a motor for 2 hours continuously at a load of 39 Amps, we required
39 x 2 = 78 Ah rating battery
We selected 85 Ah rated battery. Maximum rated voltage battery available at local stores was 12V. We will require 2 x 12 V Batteries connected in series to supply current at 24V to the motor.
Taking into consideration advantages and disadvantages of various types of batteries, best suited battery for vehicle is Li-ion Battery. These batteries are up to 4 times lighter than conventional lead acid batteries. But taking cost into consideration, these batteries were very expensive and needed battery management system for their safe operation. This adds further cost to the overall battery system. Therefore, due to monetary constraints, lead acid battery is selected.

### 3.3 Controller

Speed control means intentional change of the drive speed to a value required for performing the specific work process. Speed control is a different concept from speed regulation where there is natural change in speed due change in load on the shaft. Speed control is either done manually by the operator or by means of some automatic control device. One of the important features of DC motor is that its speed can be controlled with relative ease. For controlling of the selected motor, a PWM speed controller is selected.

### 3.4 Gearbox

Gearbox is a power transmitting device which is generally used to reduce or increase the speed via an assembly of gears.

For our purpose we need to reduce input speed of motor i.e. 1500 rpm to required speed at wheels i.e. maximum 328 rpm. Therefore a gear box of 4.5 reduction ratio is selected.

### 3.5 Motor-Gearbox Assembly

Motor and gear box are assembled and mounted on the vehicle chassis using two mounting plates. The assembly along with mounting plates is shown below.

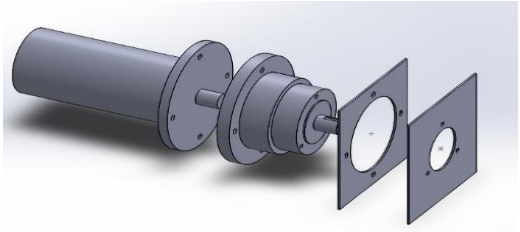

**Fig. 1**: Motor Gearbox Assembly with Mountings

## 4. CHASSIS DESIGN

Function of chassis is to make the vehicle robust and strong enough to withstand all the forces acting on the vehicle. To determine the desirable size of pipe we need to find out the critical component in the vehicle which is most likely to fail when impact is applied on wheels. Stresses developed in the pipe depend upon the area of cross section. Larger the area smaller the stress in the pipe. By considering available sizes of pipe, maximum stresses developed in the critical component and available factor of safety is found out. The size which gives maximum factor safety was selected.

| Pipe Material | Do Mm | Di mm | Thickness Mm | $F_{Bmax}$ N/mm$^2$ | FOS |
|---|---|---|---|---|---|
| M.S. | 25.4 | 23.4 | 1 | 336.41 | 1.19 |
| M.S. | 25.4 | 21.4 | 2 | 189.60 | 2.11 |
| M.S. | 25.4 | 19.4 | 3 | 142.62 | 2.80 |

**Table 2**: FOS for different chassis pipes

The frame basically consists of base platform and handrails on both sides of the platform. The function of the handrail is to assist the handicap in moving and adjusting wheelchair position on the tricycle. The handrail also acts as a safety fence.

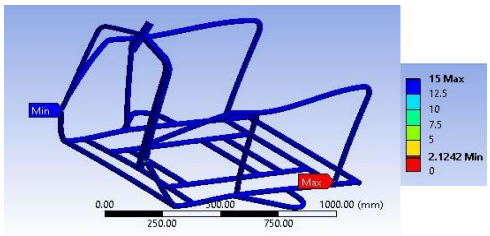


**Fig.2:** FOS Analysis

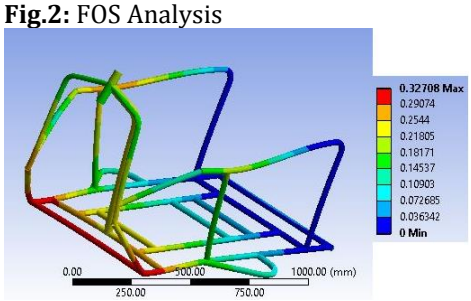


**Fig. 3**: Analysis for displacement in chassis

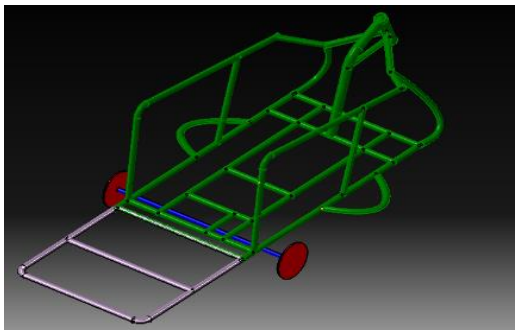

**Fig 4**: Chassis isometric view

Analysis showed that design of frame was safe against the reaction forces acting on it. The minimum FOS obtained is 2.12 which is an acceptable value of FOS.

## 5. STRESS ANALYSIS

The method of stress analysis includes detailed study of various forces and moments acting on the members of chassis during the actual working or travelling. This study is necessary for determining whether dimension of material and design of the assembly is feasible for proper functioning of the prototype. The forces acting are mainly due to reaction of vehicle weight and dynamic parts included in the prototype assembly. The path of force travel is from wheel assembly to chassis through axle. These forces result in various stresses acting in the member. Thus, in the stress analysis shown below, forces are applied on the Joints of the members having axle attached on their lower surface. The force considered for stress analysis is 3xg i.e. three times the weight of vehicle acts as the reaction force which ultimately gets transmitted to the chassis. The value of applied force is 7946.1 N. Based on this data the stress analysis is done. Following images show displacement of the

various nodes on the chassis and overall factor of safety obtained:

## 6. TESTING AND COMPARISION

Based on the various parameters a comparison was done between the newly fabricated vehicle and previous vehicle. The comparison is tabulated below:

| Sr. No. | Parameter | Previous Vehicle | New Vehicle |
|---|---|---|---|
| 1 | Turning Radius | 3.0 m | 1.1 m |
| 2 | Reverse Feature | NO | YES |
| 3 | Cost/Km | Rs. 5.41/km | Upto Rs.0.5/km |
| 4 | Dry Weight | 165 kg | 171 kg |
| 5 | Max. Speed | 40kmph | 25kmph |
| 6 | Max. Range | 72 km | 30 km |

**Table 3**: Comparison Table

## 7. CONCLUSION

1] This work discusses an attempt to design a battery operated tricycle for disabled people which can overcome the drawbacks put forth by previously designed tricycle.
2] A model is designed and fabricated that will be effective in providing mobility in both forward and reverse direction for persons who have disabilities.
3] Testing on the prototype is done which included parameters like turning radius, maximum range, cost per kilometre, etc. and the results obtained were quite satisfactory.
4] From the comparison table, we can conclude that although new model has low range and speed and higher weight, it provides an optimum solution to problems faced by previous design i.e. new model has reverse feature, compact size and better steering due to small turning radius.
5] The model which we have fabricated seems to have overcome the challenges faced by previous model.
6] This project provides scope to add advancement in various aspects of working and mechanism for future development.

## 8. FUTURE SCOPE

### 8.1 Use of More Advanced Technologies:

This project uses conventional low efficiency and bulky motor and batteries. Because of this the fabricated vehicle has drawbacks like high weight, low range, low speed and low power. This can be overcome by use of technologically more advanced components. Use of lithium ion batteries can decrease the weight of vehicle be considerable amount. Lithium ion batteries weigh up to 4 times less than the lead acid batteries used. Therefore more batteries can be installed to increase the range of the vehicle. Instead of using PMDC motor, BLDC motor can be used which occupies less space and is light weight. This will further reduce weight of vehicle.

### 8.2 Methods of Incorporating Rear Differential

Although the fabricated vehicle has successfully reduced the turning radius and improved the handling of vehicle as compared to previous design, it can further be improved by using rear differential. Use of rear differential will increase the height of the vehicle platform. But this can be compensated by using a hydraulic ramp which can lift the wheelchair up to the height of platform. The hydraulic ramp can further be automated using an electronic system which can be controlled by using a remote.

### 8.3 Final Information Construed

After the initial fabrication of the first prototype, any system developed always possesses an immense potential for future development and research. Further developments are only possible when considerable time and creativity is pumped into the progress of the project. The tricycle can tremendously reduce the effort to be put in on the part of the disabled and can improve and increase the mobility of millions of physically challenged human beings across the globe. Even on the sociological front, further work and promotion of the project can give confidence to such a section of the society that they are not neglected.

## REFERENCES

[1] "Establishing National Approval Scheme for modifications to Vehicles Driven by Physically Challenged", Rashmi Urdhwareshe, SIAT 2011.
[2] ADA Standards for Accessible Design, 2010.
[3] "Mobility Assistance Design of the Intelligent Robotic Wheelchair", Po Er Hsu, Yeh Liang Hsu, Kai Wei Chang and Claudius Geiser, International Journal of Advanced Robotic Systems, 2012, Vol. 9.
[4] "Review of Motorized Tricycle for the Disabled Person", Tatyaso A. Garande, International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064, 2013-2014.

[5] "Smart wheelchair control through a deictic approach", F. Leishman, O. Horn, G. Bourhis, Robotics and Autonomous Systems 58 (2010) 1149-1158.
[6] "The Motor Vehicles Act", 1988 and "Central Motor Vehicle Rules", 1989.
[7] "Design of Machine Elements", V.B. Bhandari, Tata McGraw Hill Pvt. Ltd.,3rd Edition
[8] "Machine Design I and II", R B Patil, Techmax Publications, 2013.
[9] Official website of Mahindra Corp. "www.mahindra.com".
[10] "Automobile Engineering", Kirpal Singh, Standard Publishers Distributors, Vol I And Vol II.
[11] "Electric Tricycle Project: Appropriate Mobility", Daniel Dourte, David Sandberg and Tolu Ogundipe, 2014.
[12] "Development Of Battery Powered Tricycle", Tilakiswaran A/L Samurgam, University Malaysia Pahang, 2007.
[13] https://www.wikipedia.com/
[14] https://www.youtube.com/user/ev4ucustomconversion/