Electric Autorickshaw: Custom Designed for Physically Challenged People

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Abstract:- *The research project mainly focuses on modifications on an autorickshaw to make it suitable to be used by physically challenged people. Certain modifications such as an additional ramp for placing the wheelchair, a motorized ramp for transporting the wheelchair in an out of the vehicle are made. In addition to this, design and analysis of a custom wheelchair is done to accommodate it in the autorickshaw. Finally, the paper also discusses possibilities of future research work in this area such as conversion to an electric drivetrain, adapting the system for use in other vehicles etc.*

Key Words: Electric Vehicle, Autorickshaw, Wheelchair

1. INTRODUCTION

Providing a reliable, feasible and easy means of transport to the physically disabled has been a problem that has challenged engineers and inventors worldwide. In a survey conducted by National Organization on Disability (NOD), almost a third of those with disabilities reported that inadequate transportation was a problem for them; of those individuals, almost half said that it was a major problem (Institute of Medicine, 2007). More was the severity of the disability, more severe was the difficulty reported in transportation (National Organization on Disability-Harris Interactive, 2004). This not only prevents them from using a convenient transportation, but also hinders them from pursuing occupations in the transportation service industry.

Autorickshaw is a popular mode of transportation, as well as a source of livelihood for people in rural and urban areas. Thus, a possible way to help people with disabilities would be to design an autorickshaw in a way that allows them to use it as a means of transportation as well as for livelihood. The project modifies an existing autorickshaw to accommodate a wheelchair as well as provide a method to drive the wheelchair out of the vehicle without external assistance. The vehicle is intended to help people with disability in the lower torso.

The research work also provides recommendations for future modifications. This includes technicalities in conversion of the IC engine drive train to an electric drive train and few other suggestions. Thus, a convenient, safe and cost effective vehicle is designed for physically disabled people with the aim to provide them with a reliable means of income and transportation.

2. RESEARCH METHODOLOGY

The research was done in collaboration with a team from Sree Chitra Thirunal College of Engineering from Kerala. The team researched the possibility of implementation of a wheelchair into the autorickshaw and the provisions required for that modification. This research work explores further possibilities in research work that can be done on the project. The project was awarded a grant from the Kerala State government and was given a period of two years of completion.

3. DESIGN METHODOLOGY

There are various factors and parts of the project that either had to be designed or selected. The major ones are given below with criteria for selection or design of each.

3.1 SELECTION OF AN AUTORICKSHAW

The main factors that had to be considered while selecting an autorickshaw was the size. Three autorickshaws were initially consider i.e. the Piaggio Ape, Bajaj RE Maxima and the Mahindra Alfa Champion. The size had to be large enough to accommodate a wheelchair and to also provide a door wide enough for the wheelchair to be driven out. Another factor was easy availability of the autorickshaw. Considering these factors, Mahindra Alfa champion was the vehicle selected (Mahindrasmallcv.com, 2018).

3.2 Wheelchair Design

Although mobility is an essential element in daily life, its importance is usually only then recognized when it is for some reason (temporarily) limited, as is the case in those who are wheelchair dependent (Woude et al., 2006). The main criteria for design of the wheelchair was the size of the driver cabin. The design should provide a facility to easily take the wheelchair out of the autorickshaw. Other necessities were an efficient hand-powered mechanism and a locking mechanism for safety.

3.2.1 Modeling

The wheelchair frame is designed in accordance with the dimensions of the cabin. The frame is made of mild steel plate of 5 mm and 7 mm thickness. Two slots are provided for attaching the two support wheels. The width of the frame is limited to 700 mm in order to suit the driver cabin. Also, a turn table type support is provided for the chair with a locking mechanism. This allows adjustment of the wheelchair while entering the vehicle. Figure 1 and 2 show the frame design and the final design of the wheelchair respectively.

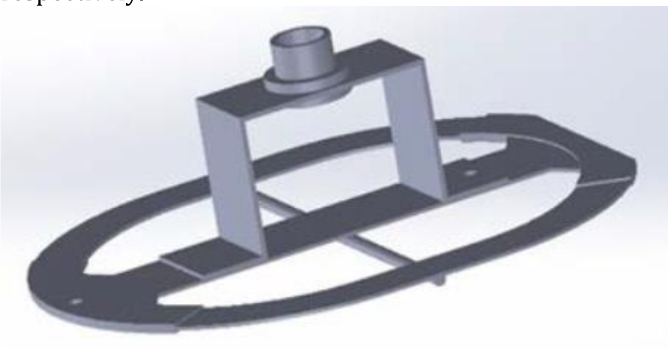

Fig -1: Wheelchair Frame

Fig -2: Wheelchair Final Design

3.2.2 Design Verification

The frame design was verified using ANSYS 16 Workbench software. A load of 85N was applied on the frame to check the maximum deformation and equivalent stress on the frame. The deformation was found to be 0.52 mm and the maximum equivalent stress was 13.796 Mpa. This was much below the safe limit for mild steel (Austenknapmancouk, 2018). The obtained results can be seen from figure 3 and 4 respectively.

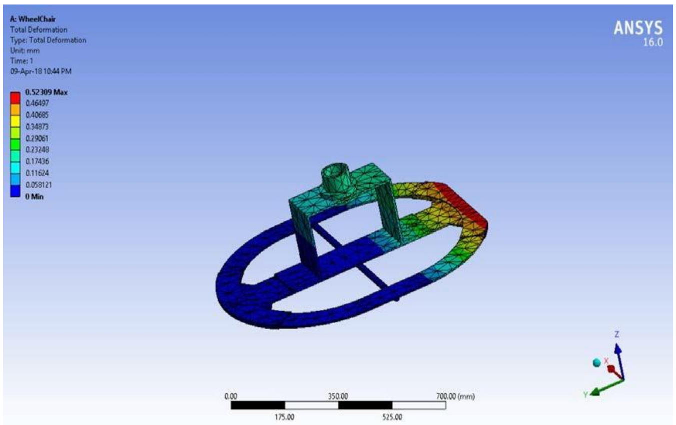

Fig -3: Wheelchair Total Deformation

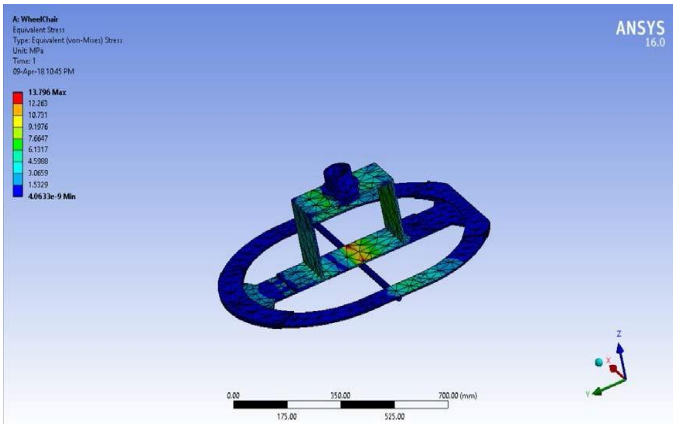

Fig -4: Wheelchair Equivalent Stress

3.2.3 Wheelchair Calculation

The overall dimensions of wheel chair are limited to: Width = 70cm
Length = 90cm
Overall height = 55cm

Tyre Dimensions.

Diameter D = 19" = 48 cm
Angle of Tilt of the Wheel = 65°
Overall Height of the Wheel (h) = D - sin 65 = 43.73cm
Minor Diameter from Top View = D - cos 65 = 20.4cm

Support wheels.

Total height of front wheel = (h/2) – 0.4 = 21.5cm
Total Height of Rear Support Wheel =
21.5 - 21*tan 25 = 11.2 cm

3.3 Ramp Design

The ramp is designed in order to allow the wheelchair to have access to the driver cabin. One end of the ramp is pivoted to the platform with two hinges. The material used for the ramp is Aluminium checkered plate and MS angle plate frame. In order to operate the ramp using an electric motor a pair of hooks are provided on the outer edge. The ramp also serves as a door and a manual locking mechanism is provided for safety purposes. The ramp is at an angle of 25 degree with the ground while providing access to the wheel chair. There are two ramps located on either side of the driver cabin. The ramp design can be seen in figure 5.

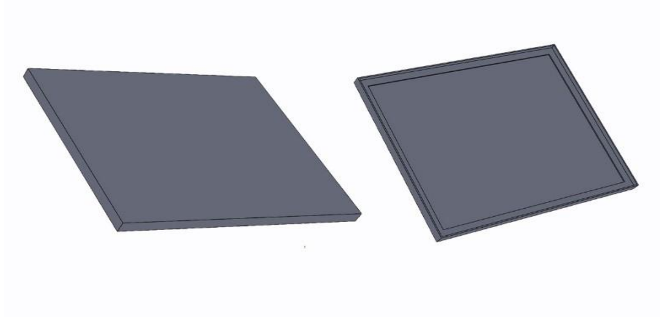

Fig -5: Ramp Design

3.3.1 Ramp Dimensions

Width = 73cm
Length = (45/Sin (25)) = 106cm
Material = Aluminium
Density = 2700kg/cm^3
Thickness = 4mm
Weight = 8.2kg
Total Weight = 8.5kg

3.3.2 Ramp Operating Mechanism

A DC Motor and Rope assembly is used to lift the ramp through a certain angle. Motor is operated by a three-way switch which enables forward and reverse rotation of motor allowing opening and closing of the ramp. The motor is simply powered by a 12 V, 2 Amp DC power supply. Rope selection was done on the basis of maximum tension developed to lift the ramp. Maximum tension developed in the rope is found out by considering the equilibrium about the point at which ramp is hinged and it is found to be 85.51 N. Nylon rope is selected due to its high breaking strength compared to the tension developed on the rope.

3.3.3 Ramp Operating Mechanism Calculation

Tension on rope = m * (g + a) = 8.5 * (9.81 + 0.25)
Where g is the acceleration due to gravity and a is the acceleration of the ramp.

Power required to pull the ramp = F *V
= 85.51*0.25 = 21.5W
Where F is the tension on the rope and V is the velocity of the ramp.

Thus, on the basis of the calculations, a motor is selected with specifications as follows:

Type: DC geared motor
Required Power Supply: 12 Volts 2A
Average Torque: 1.91Nm
Average Power: 25W

3.4 Platform Design

The platform is designed to accommodate the wheel chair in the driver cabin and to avoid the restrictions that the older cabin had in its base. The dimensions of the platform are such that it perfectly fits inside the driver cabin. The materials used are an aluminium checkered plate of 5mm thickness and a frame of MS angle plate. The platform is mounted to the base using bolts on either side. Slots are provided in the platform so that they serve as tracks for the wheelchair. The structure of the platform can be seen from figure 6.

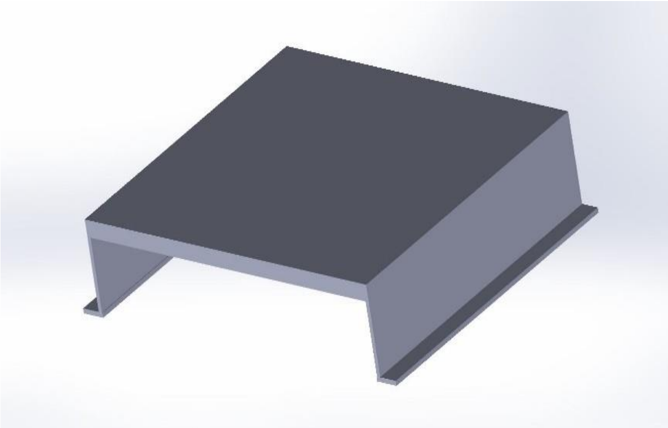

Fig -6: Platform Design

3.5 Locking Design

A newly designed locking mechanism is used for securely locking the wheelchair in the driver cabin. It consists of a male part provided on the wheelchair and a female part mounted on the separation wall between the driver and passenger cabins. The lock can be easily unlocked upon pressing the release button. A pair of these locking mechanisms are there to provide maximum safety. They help in securing the wheelchair inside the cabin while the vehicle is moving. The design and different positions of the locking mechanism can be seen from figures 7, 8 and 9.

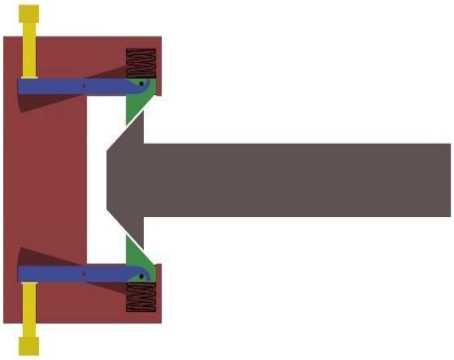

Fig -7: Locking Mechanism Free Position

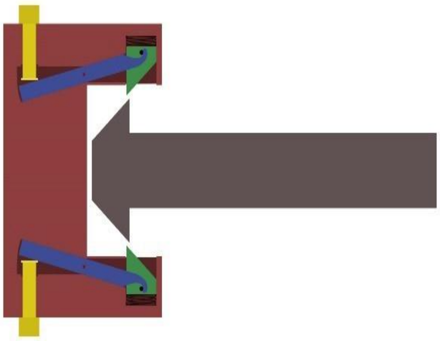

Fig -7: Locking Mechanism Open Position

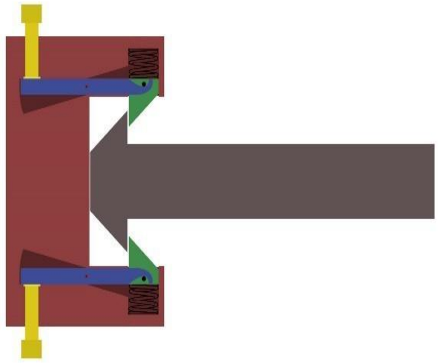

Fig -7: Locking Mechanism Locked Position

4. Recommendations for Future Research

4.1 Conversion of IC Engine to Electric Drive Train

Electric vehicles carry numerous advantages over IC engine vehicles. The main advantage would be zero tail-pipe emissions. Other benefits are reduction in noise, health benefits and much lower cost of running (Palinski, 2017). The calculations for conversion of the IC engine drive train to an electric drive train are provided in the section below.

4.1.1 Drive Train Calculations

The specification of the vehicle is given below

Weight of the vehicle (including passenger); W = 850 kg
Tyre radius, r_w = 0.16m
Torque produced by motor, T = 7.6Nm
Maximum speed of motor; N = 3000 rpm

Air resistance

Air Resistance $R_a = K_a AV^2$
K_a = co-efficient of resistance = 0.031 for Autorickshaw
Area of impact = $1210*1773*10^{-6} = 2.145m^2$
V = 20 km/hr
Ra = 26.6N

Rolling resistance

Rolling Resistance, R_r = K*W
K = co-efficient of friction for good road = 0.02
R_r = 0.02*850*9:81 = 166.7N

Gradient resistance

Gradient Resistance, R_g = W*sinΘ
= 8338.5 * sin (10)
= 145:5N

Considering air and rolling resistance only,

Total Resistance; $R_a + R_r$ = 26.6+166.7 = 194N
Torque required = Force*Tyre Radius
=194*0.16 = 31.04Nm

Consider a gear reduction of 6 units
The torque available at wheels, T_w = 6*7.6 = 45Nm
Force available at wheels = T_w / R_w = 45/0.16 = 285N
Power required for propulsion at 20 km/hr
= (167.14*20/3600) = 0.93KW

But electric motor with output power rating of 0.93 KW should not be used, because efficiency of motor is generally 80%.
The calculated motor power = $\frac{PV}{\eta}$ = 1.16KW
The motor power should be > 1.16 KW
Maximum speed up to 30 km/hr is obtained.
Battery capacity can be calculated after selecting a motor of 2 KW.

4.1.2 Calculation of battery Capacity

The calculated motor power = 2 KW
Desired range = 100 km
Speed of vehicle = 30 km/hr
Working duration= Range / Speed of the Vehicle
= 100/30 = 3.33hr

Therefore, Total Energy = motor power*working duration
= 2*3.3 = 6.6KWhr
Consider one battery with nominal voltage of 48 V
Therefore, Ampere hour rating = Energy/Voltage
= 6.6/48 = 137.5Ah
Thus, a battery with approximately 140 Ampere hour rating is required to obtain a range of 100Km with a maximum speed of 30Km/hr.

It is to be noted that conversion to an electric drivetrain is only one of the possibilities and there are innumerable other possibilities of future research in this field. Possibility of implementation of lithium ion battery in order to replace the existing lead acid battery and its effect is a possibility to be explored. Another area to be explored is to increase the safety in three-wheeler vehicles which is partially explored in this project. This technology and implementation can also be expanded to other modes of transportation to expand the horizons available for physically challenged people.

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