

Design of Solar Powered Electric Four-Wheeler for Disabled People

Thirunavukkarasu M¹, Karthik Pandian A², Arun kumar R³, Karthick M⁴, Pradeep A⁵

Assistant Professor (SS), Department of Automobile Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India¹

Final Year UG Student, Department of Automobile Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India²

Final Year UG Student, Department of Automobile Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India³

Final Year UG Student, Department of Automobile Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India⁴

Final Year UG Student, Department of Automobile Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India⁵

ABSTRACT: This paper explains the design of solar powered electric four wheeler for physically challenged persons. At present considering the Automotive market in India, China and Vietnam there is no standard vehicle for the Physically Challenged people which can be driven on roads. Available models are modifications of current vehicles. The objective is to design a vehicle for Hands as well as legs impaired people which is least expensive and easily accessible

KEYWORDS: foot steering and hand steering, solar panel, WORKING MODEL

I.INTRODUCTION

The objective of this paper is to design and fabricate an electric four wheeler. To serve this purpose a field survey will be done which includes physically challenged persons. The design includes development of frame and other sub-systems of the vehicle which would be validated by softwares such as SOLIDWORKS, ANSYS and WORKING MODEL. The design of the vehicle will be in such a way that it will be easily accessed by the physically challenged people. The advantage of our vehicle is its compactness and accessibility. The design will aid the above purpose. The fabricated vehicle will be tested under several conditions. This is done to ensure the safety of the vehicle, so that vehicle can be used under any condition.

II. STEPS INVOLVED IN THE PROJECT

1. Field survey for need assessment
2. Design of the vehicle
3. Cost analysis

III. FIELD SURVEY

In order to know the needs of the vehicle, survey was taken up. The survey includes interviewing the person from medical field, physically challenged and a normal human. The result of the survey narrowed the design concept of the

vehicle concluding that the vehicle should have reduced wheel track for easy steering, minimum weight and minimum speed.

IV. GREEN MOTIVE IN PROJECT

The usage of electric motor for this vehicle is justified because of the lower power requirement. Electric motor has greater power-to-weight ratio compared to engine. Though solar panels can't supply the entire power required, it can supply part energy in recharging the batteries

V. DESIGN AND ANALYSIS OF FRAME

Factors considered for design of frame:

- Self-weight of vehicle
- Weight of the Passenger
- Weight of the power plant
- Weight of Battery
- Weight of solar panel

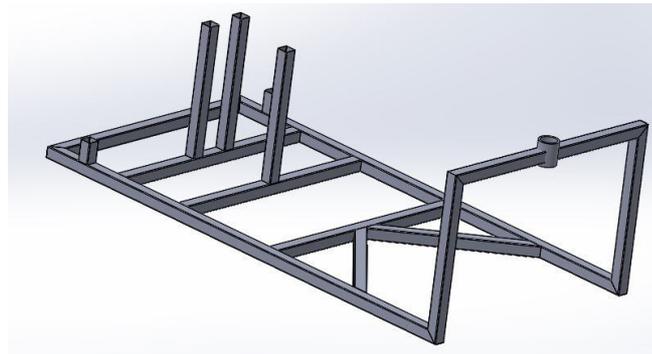


Figure1. Frame of previous vehicle

This is the frame designed for the three-wheeler fabricated before this vehicle. It was an electric vehicle powered solely by battery. In order to incorporate the solar panel and include foot-steering chain we re-modeled the frame. The reason for updating to four-wheeler is increased stability.

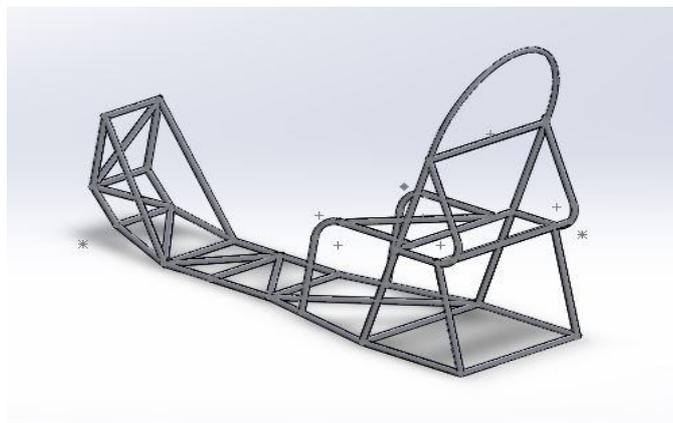


Figure2. Basic Frame design

The material which we have (AISI 1020) chosen. This material was chosen based on easy availability, Weldability and cost of material. Initially the frame was designed as closed-type but after suggestions from experts, we re-designed the frame as open-type in order to increase the ease of accessibility. Also redundant members were removed to reduce weight.

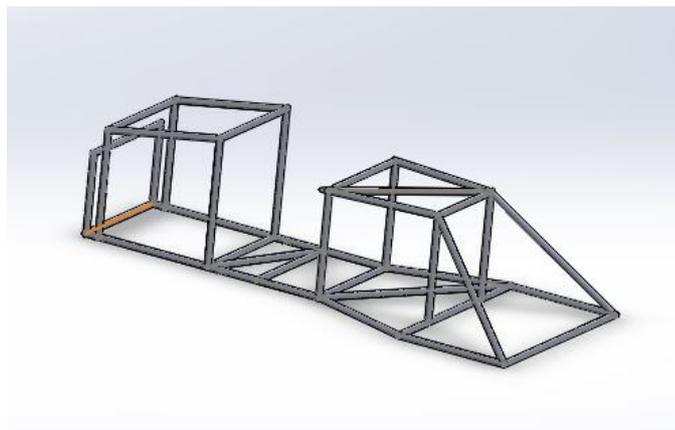


Figure3. Re-designed frame

Two types of circular pipes will be used in the frame. The pipe with 1.2mm thickness will be used for members with lesser loads. 1.6mm thickness pipes are used at critical loading areas. Even though 1.2 mm pipes are enough, 1.6 mm pipes are included to bear the dynamic loads which will be acting on the vehicle. The frame is not designed for all adverse situations because it will increase the complications and weight. Instead it is designed for minimum safety. The solar panels will be fitted in the front in order to minimize the shadowing effect which would reduce the efficiency of solar panels

Analysis of frame

The frame is analyzed in SOLIDWORKS and ANSYS softwares. The test result shows that the material (AISI1020) is safe for use. Also the frame is analyzed analytically by considering it as a 2-D overhanging beam. The shear force and bending moment diagrams are drawn. The maximum bending stress developed in static condition was calculated and it is found to be 99 MPa. The deviation of results is around 16% between softwares. The maximum deflection is found to be around 2 mm. In dynamic condition, it will be around ten times the static value which itself had a FOS of nearly 3.5.

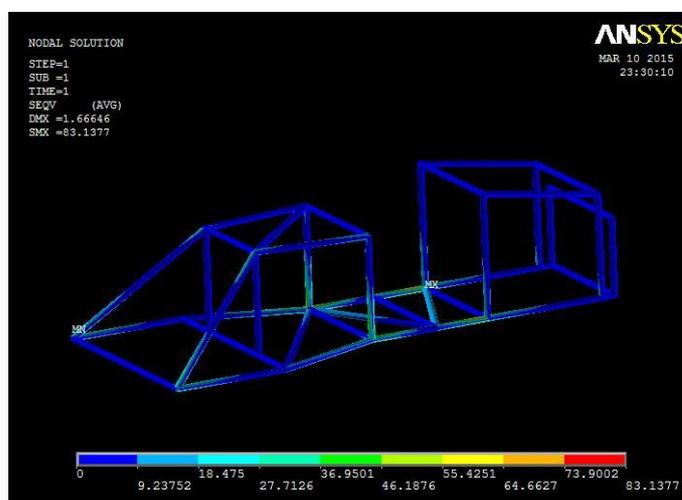


Figure4. ANSYS analysis of frame

VI. STEERING SYSTEM

This vehicle includes dual-steering. Steering by foot involves a kinematic linkage. This linkage does not follow the conventional Ackermann condition. So this linkage was tested for possibility in the software WORKING MODEL. Since the steering by foot will be difficult we have designed the lever for a mechanical advantage of 1.7.

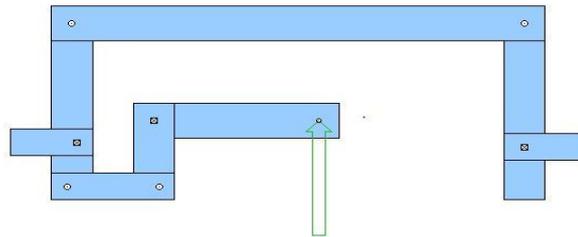


Figure5. WORKING MODEL image of steering linkage setup

The force applied by foot along Y-axis will be transmitted by the 90° bell-crank lever into linear motion along the X-axis which will turn the stub-axle. The reason for the mechanical advantage of the system is because of the location of the hinge points. This is illustrated in the figure shown below:



Figure6. Experimental setup

Since the output link is shorter than the input link, it tends to rotate faster covering greater angles. The effort will be applied by single leg as the driving controls will be operated by the other leg. The maximum output angle will be in the range 31°-33°. The stub axle will be fabricated by us. It will be supported on the frame by a C-bracket.

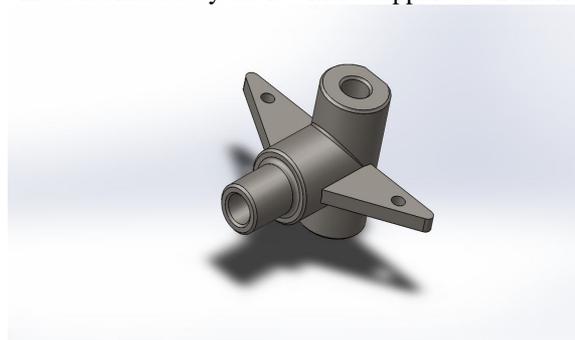


Figure7. SOLIDWORKS image of stub axle

The hand steering will be by a hand- lever which will be connected to the steering chain. Whenever the hand lever is oscillated the bell-crank lever will move to steer.

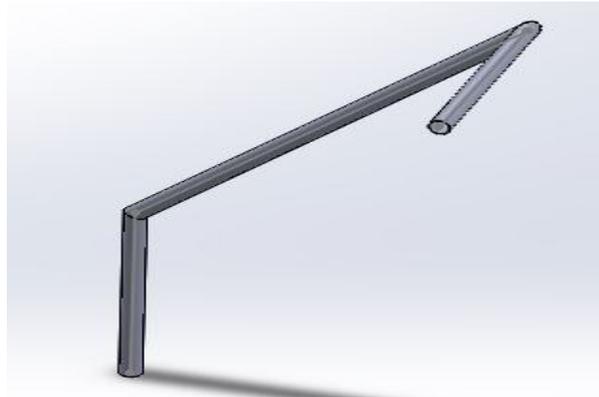


Figure8.Hand lever for steering

VII. BRAKING SYSTEM

This vehicle will incorporate dual-braking i.e., in hand and legs respectively. Since this is a low-speed vehicle, a single disc rotor brake will be employed mounted with dual callipers one for leg and hand.

The disc will be mounted on the rear axle arresting the rear wheels whenever braked. The brakes are designed for speeds far from the operating range making them extremely safe even in adverse conditions. The stopping distance in the worst case will be 7m whereas for operating range it would be around 3m. The normal pedal force exerted on the right foot is between the range of 445-489 N. In accordance with it, we have designed for a pedal force of 468 N. Also, the distance travelled by the pedal for complete locking should not exceed 150 mm. So we have included a leverage of 6 for greater force application.

VIII. POWER TRAIN

The vehicle will be driven by a 1-HP , 48 V Brush less DC motor. Chain drive will be used to run a solid axle. Since this is a low speed vehicle and also it does not include any gear box we have decided to have a reduction of 1.5 which will give optimal performance. The motor will be powered by a solar panel which supplies 350 W and a flooded lead-acid battery of 48 V, 40 Ah rating. The reason for choosing lead acid battery over Li ion battery is cost. But the advantage of Li ion is energy density and compactness. The main reason for not having solar panel alone to power the vehicle is because of the cost and space constraints associated with it. The solar panel will be fixed at an angle of 11° which is the optimum angle for maximum power output. The solid shaft will be made of C45 steel. The maximum diameter will be 15 mm. This is designed based on the Von-misses criterion and torsion equation. The solid shaft is expected to transmit torque alone because the driving thrust will be transmitted by the supporting bearings

IX. TOTAL COST OF THE PROJECT

The cost of the vehicle will be around Rs.60, 000/-. The high cost of the vehicle is mainly attributed to the cost of battery, solar panel and BLDC motor. They contribute to around 40,000. The cost analysis is purely based on the current design. If the vehicle is to be manufactured on large-scale there could be changes relating to the material and parts used which will reduce the cost at the same time will improve performance. When manufactured in large scale the costs of transportation and machining will be reduced because they are the main contributors of fabrication costs.

X. SPECIFICATION

Kerb weight	:70 kg
Gross vehicle weight	:160 kg
Length	: 1809 mm
Wheel base	:1309 mm
Wheel track	:850 mm
Rear brake: Single disc, 200 mm diameter	
Maximum load	: 200kg
Maximum speed	: 20 km/hr
Motor power	: 746 W
Battery type	: maintenance free Rechargeable flooded lead acid battery
Battery capacity	: 48 V 40AH
Charge time	: 4 hours
Solar panel power	: 350 W

XI. CONCLUSION

The project involves design of a solar powered four wheeler for the physically challenged people. To serve this purpose, a field survey has been taken which gave first hand feel of the physically challenged people about their need. Then a conceptual design has been made, to check how the vehicle looks on paper. This also gave some insight regarding design and functional parts that are to be assembled. A study has been made to know which electric motor best suits our purpose. A design calculation was done to know the power required for the motor to propel the vehicle.

The conceptual design was refined in order to accommodate some changes that improve the performance of the vehicle. The frame of refined design was subjected to static analysis, to check the loading condition and strength of the material that was selected for fabrication. The design stage was scrutinized to make sure that the vehicle to be fabricated would be safe in all aspects.



Figure9. Model view of vehicle

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