DESIGN AND DEVELOPMENT OF SOLAR ELECTRIC TRICYCLE

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***Abstract**:* Physically challenged persons have several challenges when it comes to mobility in society. Physically challenged persons have been observed utilizing assistance equipment such as crutches, prosthetic limbs or legs, and manual wheelchairs or three-wheelers for their daily movements. However, the design of these wheelchairs or three-wheelers is primitive and inefficient, making them unsuitable for outdoor use or ordinary terrain in the countryside. This project focuses on the design and development of a solar-powered tricycle that will assist physically challenged persons in getting about. At critical speeds and higher, the vehicle's CG is behind the Neutral Steering Point (NSP), causing the rear wheel slip angle to be larger than the front wheel, resulting in a negative static margin for the tricycle. As a result, the vehicle responds to sideload by yawing, or turning the CG in the opposite direction of motion. The results of the study revealed that the tricycle is in good working order.

The Solar Electric Tricycle-based mobility assist wheelchair is designed to travel in all directions, including to and fro and sides. The vehicle's movement is controlled by the hub motor, which is utilized to commute from one location to another. The solar panel generates energy, which is stored in the batteries and used to power the motor. If there is not enough sunlight to run the vehicle, the tricycle is also equipped with a hand to peddle. For safety reasons, this tricycle is meant to go at a modest speed of no more than 20 km/hr. The tricycle maintains stability at a low speed below its critical speed, according to the center of gravity calculations.

Keywords: Solar Electric Tricycle, Hub Motor, Solar panels, Batteries, Chassis, Chain sprocket.

I. INTRODUCTION

The movement of physically challenged people in society is uptight with challenges. Physically challenged people have been seen utilizing crutches, artificial limbs or legs, and manual wheelchairs or three-wheelers to go around daily. Tricycles are divided into three categories: paddle tricycles, motorized tricycles, and electric tricycles. Tricycles aren't always the most popular mode of transportation. Hand-powered tricycles are currently being used in rural villages and other places to provide mobility for disadvantaged people. Mechanical paddle tricycles take a lot of energy from the rider, in the form of physical energy. After a given distance, this might become exhausting. Fuel is the primary source of propulsion for motorized tricycles. These motorized tricycles use non-renewable fuels that may or may not be cost-effective.

Solar power is a rapidly growing business in India. As of March 31, 2020, the country's solar installed capacity was 37.627 GW. **PV** stands for **Photovoltaic**, which is the conversion of light into electricity utilizing semiconducting materials that have the photovoltaic effect. Inventors, governments, and corporations have worked together since the 1970s to produce solar-powered automobiles, boats, bicycles, and even airplanes.

II. LITERATURE SURVEY

R. R. King et al. [1] Multifunction concentrator cells of several different types have demonstrated solar conversion efficiency over 40% since 2006 and represent the only third-generation photovoltaic technology to enter commercial power generation markets so far. The impact of 40% and 50% cell efficiency on cost-effective geographic regions for CPV systems is calculated in the continental US, Europe, and North Africa.

N. S. Hanamapure et al. [2] The solar-assisted bicycle developed is driven by a DC motor fitted in front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage will charge the battery & which in turn drive the hub motor. When the bicycle is idle, the solar panel will charge the battery. This arrangement will replace the petrol engine, the gearbox & the fuel tank in case of a two-wheeler or a chain sprocket, chain & gear shifting arrangement of a conventional bicycle being used by the most common man.

Rajendra Beedu. **et al. [3]** In this work, a solar-powered cycle is fabricated by modifying an all-geared bicycle. The discussion covers the design, assembly, and performance evaluation of the tricycle. The selection of electric motor, solar charger, and panels are dealt with.

Mahadi Hasan Masud et al. [4] The body of a tricycle, charging system, battery, and power transmission system is designed. After a performance study, it is obtained that the storage system can run the tricycle about 25 km and it gets back up about 24% power from a solar system which is equivalent to 6 km if the solar intensity is around 1150 w/m2 at the time of running of the tricycle. The maximum speed of the tricycle has been found at 26 km/h.

III. PROJECT OBJECTIVES

The following objectives can be used to fill the research gap identified in the literature review:

- ❖ To select a suitable solar panel for an inexpensive and ecologically friendly solar-powered tricycle.
- ❖ To create the tricycle's primary sections and components.
- ❖ To design and test a low-speed tricycle for physically challenged individuals.

These are the Expected Outcomes of our Project:

- ❖ A system that will allow persons with impairments to move about more easily.
- ❖ All of the tricycle's components are engineered to perform within safe stress limits.
- ❖ In comparison to existing tricycles, the current project effort intends to be cost-effective.

IV. METHODOLOGY

1. Literature Review
2. Design Calculations
3. Selection of Materials
4. FEA Analysis
5. Fabrication and Assembly of Tricycle
6. Performance Evaluation

V. DESIGN CALCULATION

Basic Calculation:

1.Torque Calculation: Diameter of wheel= 660.40 mm Radius of wheel = 330.19 mm Radius of wheel = 13*2.56 = 33.28cm = 0.33m Torque = force * radius Torque = 120*9.81*0.33 = 388.4N-m Torque = 388.4*10^3 N-mm	**2.Battery Calculation:** Taking 2 batteries of 12v each = 2*12 = 24V Current (I) = power / voltage I = 6729.4/24 = 280.391A Approximate run time/day = 2 hours Assuming overall losses as 20% Load current = 2*280.391*1.2 = 672.93 Ah/day
3.Speed Calculations: Power = mass*g*speed Speed = power/(mass*g) Speed = 6729.4/ (120*9.81) = 5.58m/s Speed = 5.58*(18/5) = 19.98km/hr i.e., 20km\hr	**4.Motor Calculation** Total weight = weight of the person + weight of the vehicle Total weight = 80 + 40 = 120 kgf Total weight = 120*9.81 = 1177.2 Kgf Speed assumed = 20 km/hr = 20 * (5/18) = 5.55m/s Assume slope = 3% Power = total weight (in kgf) *speed*slope Power = 1177.2*5.55*1.03 = 6729.46 watts Approximate power required per day = 6729.46watts = 6.7Kwatt motor

VI. DESIGNING OF MODEL

Assembly Modelling is a technology and method used by computer-aided design and product visualization computer software systems to handle multiple files that represent components within a product. The components within an assembly are represented as solid or surface models.

The designer generally has access to models that others are working on concurrently. For example, several people may be designing one machine that has many parts. New parts are added to an assembly model as they are created. Each designer has access to the assembly model, while a work in progress, and while working in their parts. The design evolution is visible to everyone involved. Depending on the system, it might be necessary for the users to acquire the latest versions saved of each component to update the assembly.

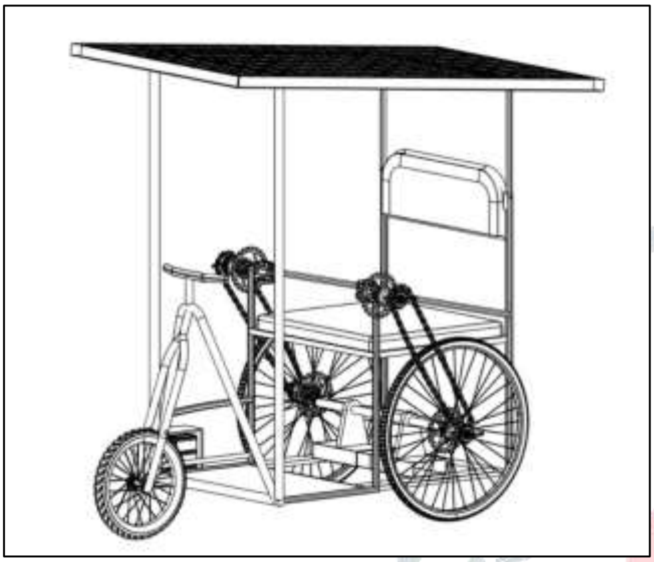


Fig.1. Assembled Model

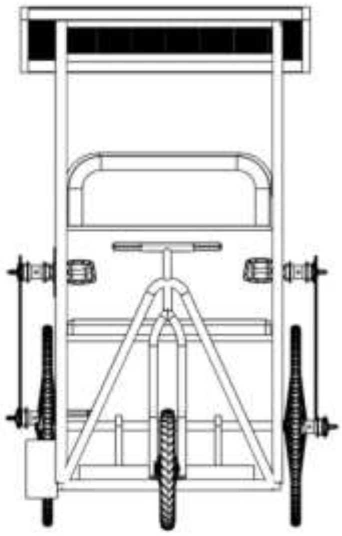


Fig.2. Front View

An **Exploded View** drawing is a diagram, picture, schematic or technical drawing of an object, that shows the relationship or order of assembly of various parts.

It shows the components of an object slightly separated by distance or suspended in surrounding space in the case of a three-dimensional exploded diagram. An object is represented as if there had been a small controlled explosion emanating from the middle of the object, causing the object's parts to be separated an equal distance away from their original locations.

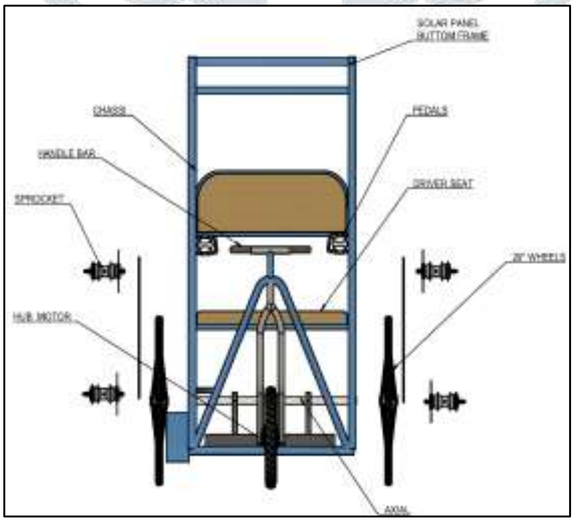


Fig.3. Disassembled View of Tricycle

VII.MESHED 3D CHASSIS MODEL FOR ANALYSIS IN COMSOL MULTIPHYSICS

Meshing is defined as the process of dividing the whole component into several elements so that whenever the load is applied to the component it distributes the load uniformly called meshing. A component is analyzed in two ways. One is with Meshing and the other is without meshing. COMSOL MULTIPHYSICS Meshing. COMSOL MULTIPHYSICS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient metaphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model.

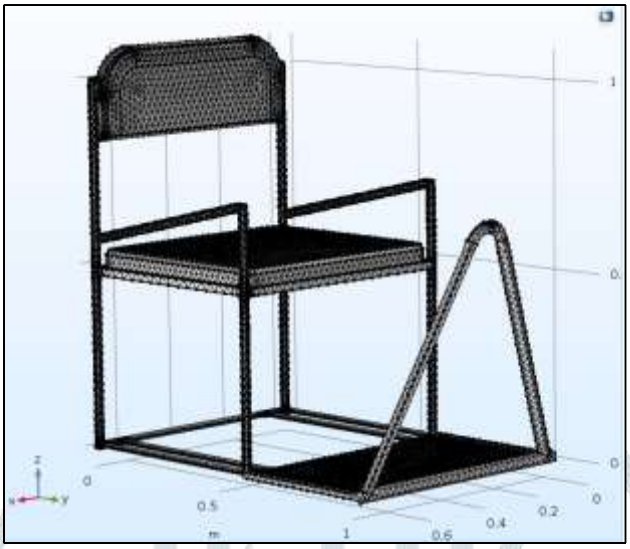


Fig.4. Complete Meshing was generated to fine quality

Meshing Details:

Mesh

Average Element Size (% of model size)	
Solids	10
Scale Mesh Size Per Part	No
Average Element Size (absolute value)	-
Element Order	Parabolic
Create Curved Mesh Elements	No
Max. Turn Angle on Curves (Deg.)	60
Max. Adjacent Mesh Size Ratio	1.5
Max. Aspect Ratio	10
Minimum Element Size (% of average size)	20

Mesh

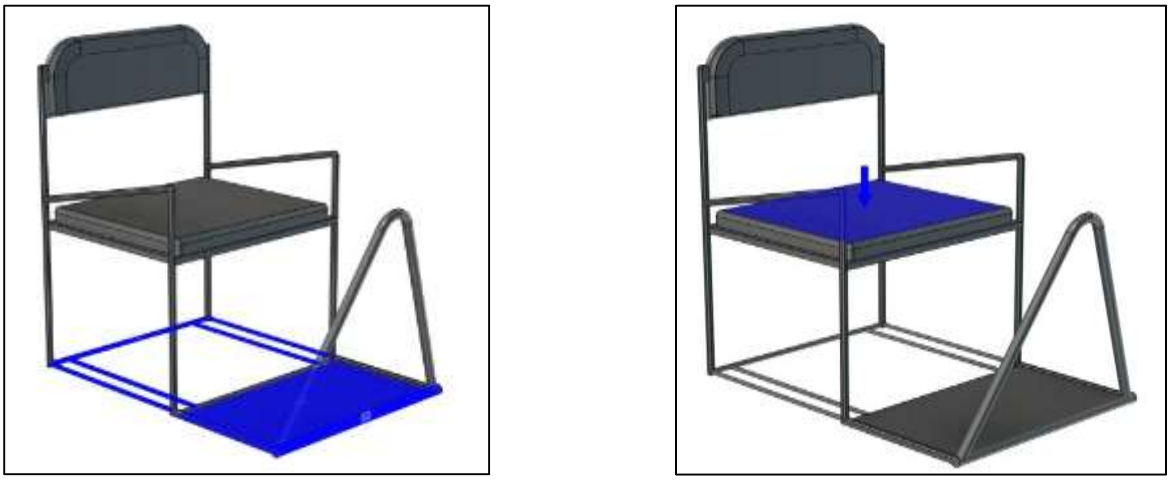
Type	Nodes	Elements
Solids	175888	95007

VIII.CONDUCTING STATIC STRUCTURAL ANALYSIS USING AUTODESK NASTRAN SOFTWARE

INTRODUCTION TO FEA: The vibrational or weighted residual techniques are used to generate the systematic approximation solution for FEA, which is based on the decomposition of the domain into finite sub-domains (elements). By splitting the domain into elements and defining the unknown field terms of the presumed approximation functions inside each element, FEA effectively reduces the problem to a set of unknowns. These functions (also known as solution functions) are specified in terms of the field variables' values at specified nodes.

STATIC STRUCTURAL ANALYSIS ON CHASSIS:

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. A static structural load can be performed using the AUTODESK NASTRAN, or ABAQUS solver.



(a) (b)

Fig 4. (a) (b) Applying boundary condition on the vehicle

The Three wheels are to be fixed, the load of 500N (52Kg) is applied on the Handle surface of the Vehicle Considering the surrounding temperature to be 22°C.

Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
22	1.93e+011	0.31	1.693e+011	7.3664e+010

The Factor of safety (FOS):

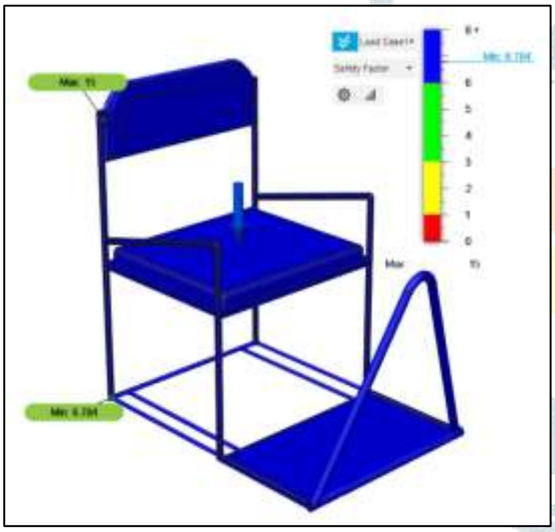


Fig.5 The factor of safety for the analyzed model is **6.784 Design is Safe**

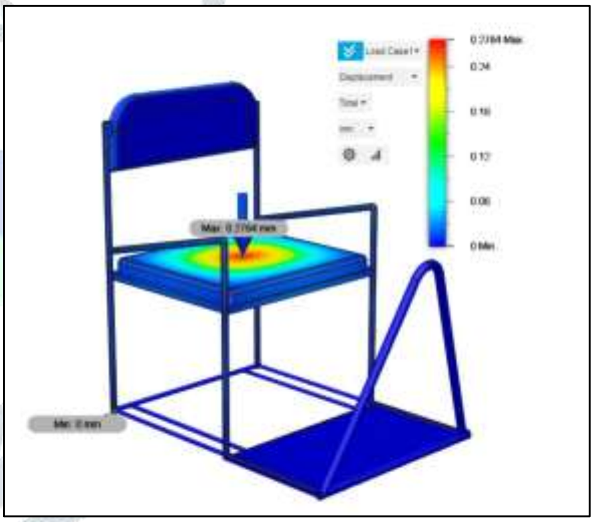


Fig 6. Total Deformation when subjected to load
Displacement Gives the Total Deformed Shape of The Model for An Experimental Load Of For **1500N(152.9Kgf)**

$$\text{Factor of safety} = \frac{\text{yield stress}}{\text{working stress}}$$

Total Deformation Result:

From Fig 6 the Total deformation along X-axis, Y-axis & Z-axis the max. deflection created is 2.764 e-005 mm and minimum deflection X-axis-axis & Z-axis is given as 0 mm that is the static structural deformation result on the X-axis, Y-axis & Z-axis for 1500N (152.9Kgf) under time interval of 15 seconds.

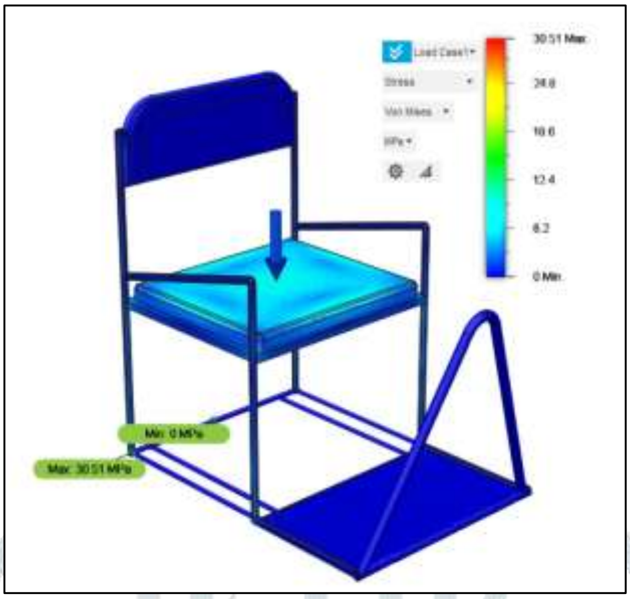


Fig.7.Von Mises stress

Stress concentration Throughout the chassis 1500N.

Von Mises stress result:

Von Mises stress result is a value used to determine if a given material will yield or fracture. It is mostly used in ductile materials, such as metals. The von Mises yield criterion states that if the von Mises stress of trial under load is equal or greater than the yield limit of the same material under simple tension. The max equivalent (von-mises) stress created is 30.51 MPa the minimum equivalent stress is found to be 0 MPa. That is the equivalent (von-mises) stress of the designed model for a load of 1500N (152 kg) under the time interval of 15 seconds.

Types of Cyclic Loading

1. Fully Reversed
2. Zero Based
3. Ratio
4. History Data

Fully Reversed cycle loading: One cycle of this type of loading occurs when a tensile stress of some value is applied to an unloaded part and then released, then compressive stress of the same value is applied and released. A rotating shaft with a bending load applied to it is a good example of a fully reversing load.

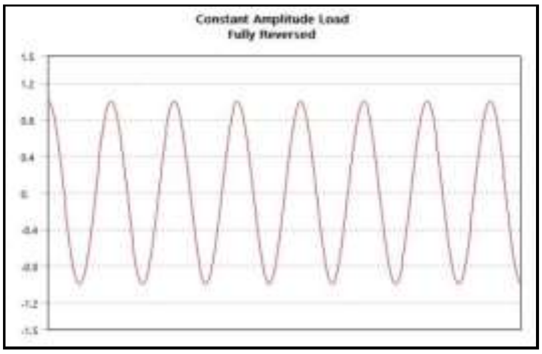


Fig.8. Constant Amplitude Cycle Graph

IX.RENDERED 3D MODEL OF THE PROTOTYPE

Rendering or image synthesis is the process of generating a photorealistic or non-photorealistic image from a 2D or 3D model utilizing a computer program. The resulting image is referred to as the render. The term "rendering" is analogous to the concept of an artist's impression of a scene.

Fig 9. Assembled and Rendered Modeled (Iso-metric view)

X. FABRICATION AND ASSEMBLY OF THE MODEL

1.Fabricated Chassis

- Type of welding arc welding.
- The material used M.s circular pipe. (18 gauge)
- Oxide coating and enamel spray painting were carried out.

Fig.10 Side view

Fig.11 Iso-metric view

2.Solar Panel Frame, Handlebar, Hub Motor & The Solar Panel Were Assembled

Fig 12. Assembled View

Fig 13. Solar Panel Frame

XI. RESULTS AND CONCLUSION

Therefore, the required tests were conducted and after evaluation of results it can be concluded that:

- The tricycle runs at a speed of 20Km/Hr.
- The tricycle provides a mileage of 50-60km, which also varies with the load.
- Maximum load 120-130 kg.
- The charging time of the solar panel is 8.5-9.5 hours.
- Type of tire used -Tube tire.
- Electric start.
- Due to better weight distribution, there is no imbalance in the tricycle.
- The tricycle is also provided with hand pedals to help commute when there is a shortage of power to drive the motor.
- There is enough space for the rider to get on and off the tricycle.
- It is built to provide safety, shelter, and comfort to the rider.

SCOPE OF FUTURE WORK

Following are the works that can be done on the present work to carry out further studies in the Design and Development of Solar Electric Tricycle:

- Flexible solar panels can be used.
- More aerodynamic designs can be adopted.

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