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Design and Analysis of Freedom Trike Chassis

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***Abstract*— A trike is a user propelled vehicle which is used by everyone who are not physically abled. The main objective of designing is to make the freedom trike light weight, good maneuverable and very durable. The phenomenon of finite element analysis has been extensively used to make sure that the chassis is rigid and it provides a safe place for the user in case of any miss happening. The trike should also be exquisite. The main aim is the user safety. Freedom trike's reliability is not compromised in the need of speed. Chassis is the combination of rectangular as well as L-shaped cross section pipe, of AISI 1020 grade. In this trike we have used AISI 1020 type tube of 2 mm thickness with 25mm widths. A front, rear and side impact test is done on simulation for the frame design to observe the stressful zones in it and their deformations.**

Keywords—Trike; Chassis; Modelling; AISI

1. INTRODUCTION

Freedom trike is an alternative for regular wheelchairs for using it outdoors. The users in them are not completely abled and they are bound to use wheelchairs for their daily commute. Chassis is one of the major part of these trikes as the safety of the user totally depends on it. The project is aimed for modelling and checking of the performance parameters while in case of any impact. Modelling and analysis is done on SOLIDWORKS 2016. The frame designed is made to absorb and spread the impact forces all around the frame rather than transferring them on the user. Wheelchairs and trikes have a very large and fixed markets which regularly wants improvements in safety. The frame should be strong enough to absorb shocks, vibrations and all the other stresses occurred during and off-road ride.

2. OBJECTIVES

The objectives of this project are as follows:

1. First, the selection of the material for the chassis is an important part to check the availability in market, its cost, machinability and it should be light weight.
2. To develop the right kind of chassis for the trike which requires less number of members and still absorb all the shocks during an impact.
3. To find out the stresses being developed of the frame during front, side and rear impact crash tests.

3. SCOPE OF THE TRIKE

The freedom trike is a wheelchair intended to move past walkways. For the handicapped individual living in a developing nation like India, customary push-rim wheelchairs miss the mark since they limit the user to smoother grounds. In contrast to regular wheelchairs, the Freedom trike utilizes the chain and sprocket drive train of a standard bike related to two stretched out push levers to enable the client to move 27% quicker on level ground and get 43% higher torque on off-road surfaces. In particular, it conveys a freshly discovered feeling of enthusiastic autonomy for its users.

In developing nations, the available structures & frames are uncommon and they aren't locally repairable at lost cost. The expense and framework for those are not reasonable. The freedom trike is evaluated as per the needs of users so that it could be used in rural areas and get repaired by local bi-cycle shops at very nominal costs. A regular indoor wheelchair costs around Rs. 8000 and their maintenance cost is high due to special parts, whereas the freedom trike costs Rs. 6000 with outdoor capability & easy maintenance.

4. ABOUT TRIKE

A trike is a 3-wheeled vehicle similar to a regular wheelchair but suitable for outdoors. It is manually powered by the user for their business purposes and travelling distances which are not possible with a wheelchair. A trike with levers reduces the risk of hands getting injured. In developing countries like India, Africa people require a vehicle which is reliable and have less expensive repairs. Trike helps to fulfill all the needs.

Parts of Trike:

- Chassis
- Rear shaft setup
- Front wheel setup
- Lever Mechanism
- Seat
- Braking System

5. DESIGN AND METHODOLOGY

The main intention of designing freedom trike:

1. It can be operated by a physically challenged person.
2. Low effort to propel on different terrain.
3. To make it light weight and easily repairable.

The basic idea behind the Freedom Trike is to provide a trike that contains all standard cycle parts to provide ease of maintenance and all these cycle part are equipped with the chassis that is specially designed for freedom trike. We decided AISI 1020 for its good weldability, light weight and to

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maintain the sufficient strength of trike for the safety of the user.

A very compact chassis is designed by considering load distribution, the center of gravity and structural properties. The modeling of the Freedom trike chassis is done in Solid Works V16 and A front, rear and side impact test is done by finite element method for the frame design to observe the stressful zones in it and their deformations.

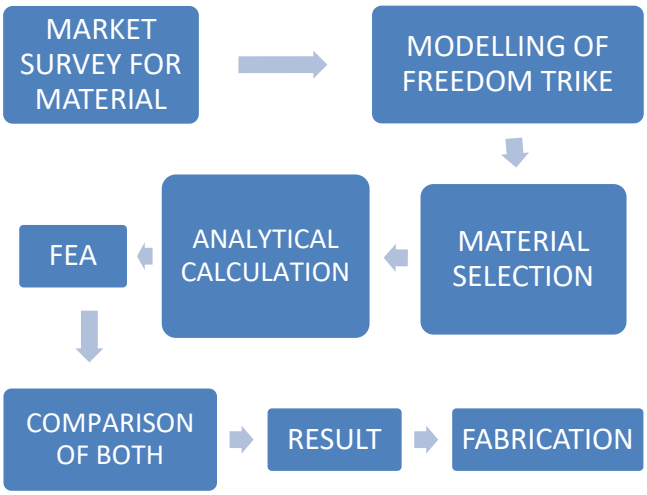

Fig. No. 1 Flow Chart of Design

5.1 Modelling: 3-D modeling was done using SolidWorks v16 software as shown in Fig.2

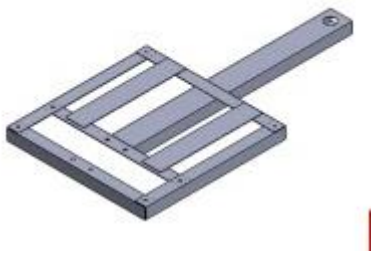

Fig. No. 2 Chassis Model (Isometric)

5.2 Material Selection:

The main goal of material selection is to reduce the cost and weight of trike while maintaining all other necessities like tensile strength, compressive strength torsional rigidity, various loading conditions, machinability, and availability in the market.

After modeling Freedom Trike chassis it is analyzed for various impacts and loading conditions that were really helpful in determining the effect of impact on the chassis to assure the user safety.

AISI 1020 contains carbon, iron, manganese, phosphorous, sulfur here sulfur improves the machinability, Manganese increases hardenability and tensile strength of steel, phosphorous provides surface finish to carbon steel and also increases strength and hardness

Composition of AISI 1020 steel is:

Element	Content
Carbon, C	0.17 - 0.230 %
Iron, Fe	99.08 - 99.53 %
Manganese, Mn	0.30 - 0.60 %
Phosphorous, P	≤ 0.040 %
Sulfur, S	≤ 0.050 %

The Properties of AISI 1020 steel are:

Properties	Metric
Hardness, Brinell	111
Tensile Strength, Ultimate	394.72 MPa
Density	7.87g/cc
Tensile Strength, Yield	294.74 MPa
Elongation at Break (in 50 mm)	36.5 %
Reduction of Area	66.0 %
Modulus of	200 GPa
Bulk Modulus	140 GPa
Poissons Ratio	0.290
Shear Modulus	80.0 GPa

5.3 Chassis:

The chassis of Freedom trike is a compact ladder frame with a front rectangular bar to reduce the space occupied by the trike.it is made up of L shape angles and rectangular bar .The entire frame is very rigid and strong to sustain various loading conditions as all the joints are efficiently welded by arc welding. The thickness of the angle and bar is taken 2 mm to `make it light weight with good machinability and weldability.the chassis is strong enough to support all the elements of the trike with ease. As this is the chassis of trike and used to carry a single user hence the testing parameter are taken upto 80 kg for user.

6. THEORETICAL CALCULATIONS OF CHASSIS

6.1. Chassis Dimension

Factors to consider are cost, durability and force distribution. The dimensions of the frame are according to the fitment of other parts on it. Extra support beams are used to provide integral strength to the chassis as well reduce the total cost of the frame.

TABLE I. SPECIFICATIONS

S. No.	Freedom Trike	
	Chassis Material	***Specifications***
1.	Grade	AISI 1020
2.	Thickness	3 mm
3.	Cross section	Rectangular & L-shaped

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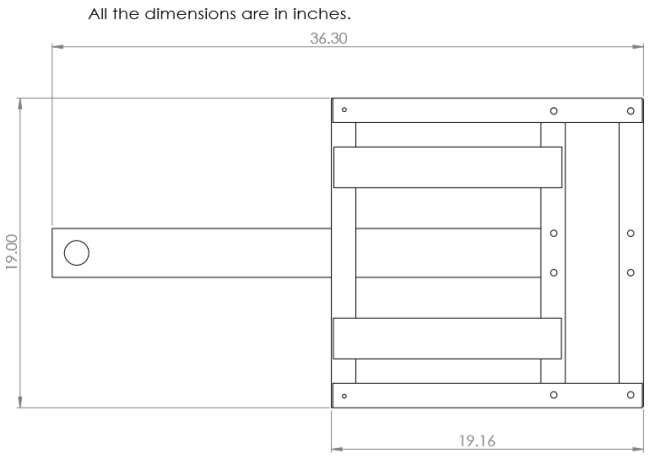

Fig. No. 3 Dimension of the frame

7. FINITE ELEMENT ANALYSIS

Finite Element analysis (FEA) is a methodology for predicting however a product reacts to real-world forces, vibration and alternative physical effects. Finite part analysis shows whether or not a product can break, wear out, or work the way it had been designed. Here we have a tendency to divide the part into tiny sizes called part and collective parts on the model form a mesh.

The computer analyses the forces and other parameters and gives a collective result. In the form of stress acting upon the part. The chassis was finalized then FEA was performed on it. It shows the stresses and deformation by the impact crash tests. Solid works 2016 is used for modelling and performing tests:

1. Front Impact 2. Side Impact 3. Rear Impact

7.1. Meshing

Meshing is defined as the process of dividing the whole component into number of elements so that whenever the load is applied on the component it distributes the load uniformly.

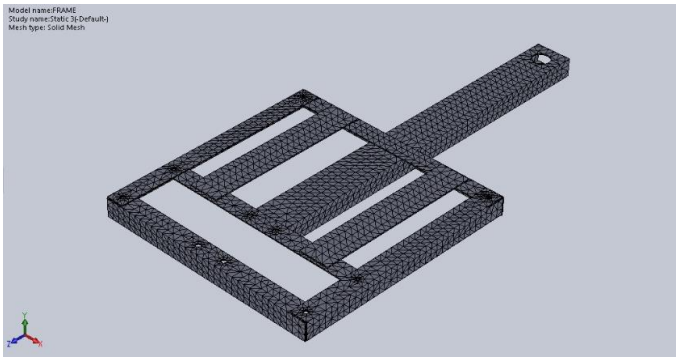

Fig. No. 4 Meshing

7.2. Front Impact analysis

During the front collision test the trike collides with a stationary wall and the impact is mainly absorbed by the front bar. As trike is a small vehicle, the acceleration will be 2g.

Vehicle + Driver mass = 105 kg
Acceleration = 2g
Impact Force= 105*2*9.81= 2060.1 N

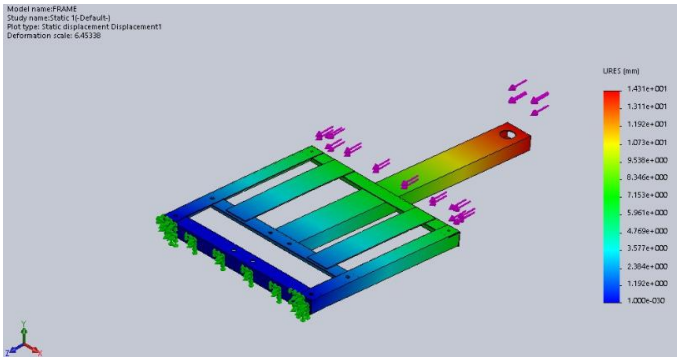

Fig. No. 5 Front Impact (Displacement Analysis)

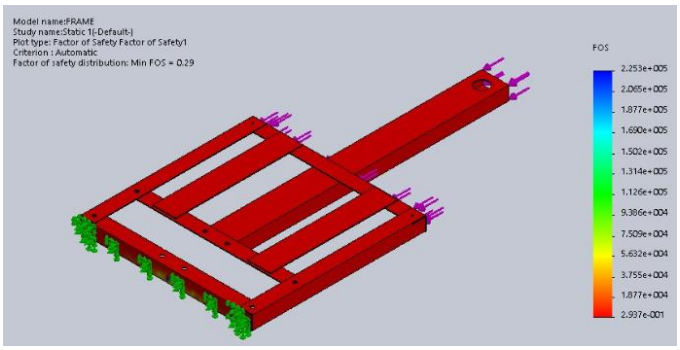

Fig. No. 6 Front impact (Factor of Safety)

Maximum Deformation= 6.45mm
Factor of Safety = 0.29

7.3. Side Impact Test

The load calculated for the front and rear impact test is used for side impact test, i.e. 2060.1 N. The load is applies from the right side of the chassis to simulate a side collision crash.

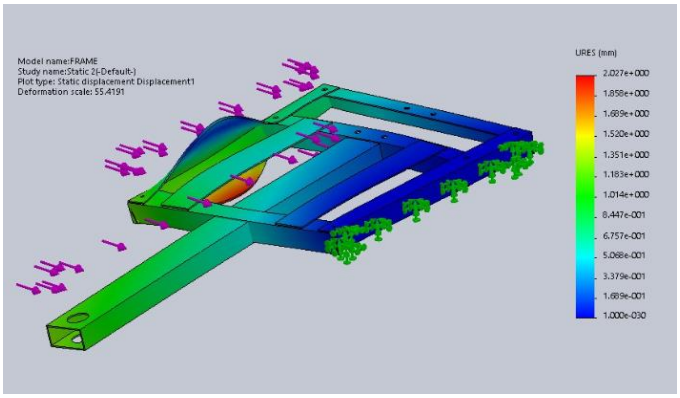

Fig. No. 7 Side impact (Displacement Analysis)

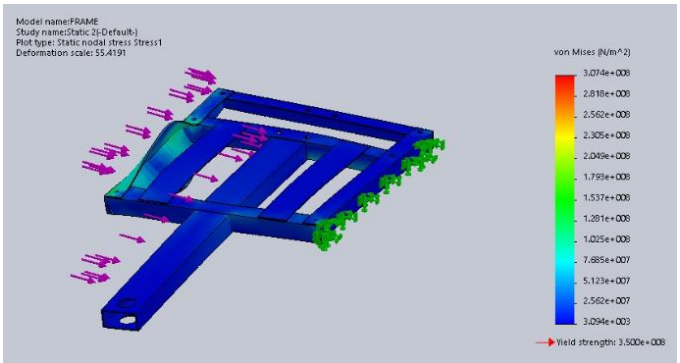

Fig. No. 8 Side Impact (von-Mises stress)

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Side Impact = 55.41 mm
Factor of Safety = 1.03

7.4. Rear Impact Test

The load applied to the rear is same as that od the front impact but this time the front nodes are of fixed geometry. The stress and deformation values are in the safe limit.

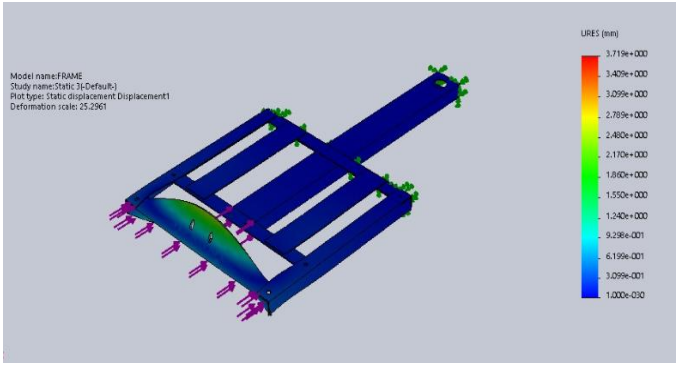

Fig. No. 9 Rear Impact (Displacement Analysis)

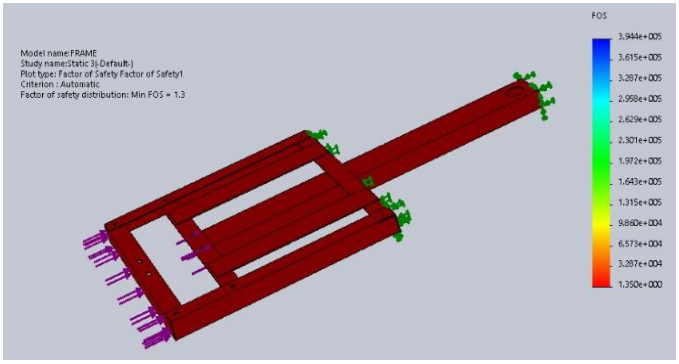

Fig. No. 10 Rear Impact (Factor of Safety)

Maximum Deformation = 25.29 mm
Factor of Safety = 1.01

CONCLUSION

The FEA analysis result show the chassis of Freedom Trike can withstand 2G force front, rear and side as well. The deformation & stresses are within the permissible limits, i.e., factor of safety greater 1. The basic requirement of the trike, which is to reduce the weight and increases the strength. Thus, it concludes that this chassis have good strengths against the collision from front, rear & as well as from side.

FUTURE SCOPE

Taking manufacturing into consideration, future works includes the reduction of members from the chassis which do not have major effect on the strength of the chassis.

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