Design and computational analysis of chassis frame for electric bike

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Abstract

The main purpose of this project is to design a chassis of electric bike why because the world in the situation where the fossil fuels are running out so need to upgrade or else its time to change from the fuel to electric. Now a day's electric is the best possible way to save natural resources and environment. electric vehicles also give the safety measurements and comfort to the rider with modern techniques This project describes the design methodology of the frame. the design of vehicle in such a manner that it satisfies the maximum loading conditions, the safety and comfort of the driver. The vehicle designed in solid works CAD software and frame optimised using the software and analysis will be based on impacts on the Ansys workbench. The objective of this frame is to reduce the weight, cost and to increase the efficiency of the vehicle. ergonomics factor of the bike as 50% of Indian standards by keeping riders comfort. The calculations and analysis that are going to do in this project are, Dimension and material selection, Calculation of bending strength and bending stiffness, calculation of impact forces, Analysis of frame, Factor of Safety, Ergonomics.

Keywords: Ansys, chassis, electric bike, frame

1. Introduction

The major problem in today's world is energy crisis that is caused by depletion of natural resources like petrol, diesel to overcome this problem there must me a suitable alternative solution for world to make earth safe place for upcoming generation. Electric vehicle is a rechargeable battery operated vehicle which converts electric energy into mechanical energy with low maintenance and zero pollution. The batteries that are used here are either lead acid or lithium ion which can be recharged or replaced easily and the maintenance cost is very cheap. there are so many electric vehicles are there in present market based on complexity and price Although electric vehicles are not exact solution for this environment problems but it is a better alternative comparing to other vehicles. On average these bikes can travel up to 50 km based on the battery capacity without tail emission pollution and these don't make noise.

The basic components used in the electric vehicle are frame, battery, controller, motor, transmission, brakes, suspension

1.1 Components

Frame: Frame is the main structure of the vehicle which holds the battery, motor, driver weight and gives holding to various parts the vehicle. So it should be strong enough to with stand the impact forces.

Battery: Battery is the heart of the electric vehicle why because it stores the energy mainly there are two types of batteries that re lead acid and lithium ion which are rechargeable and replaceable and they are with bms and the travel time depends on the power rating of the battery

Fig: 1 battery

Motor: Motor is a device which converts the electrical energy to mechanical energy and the power is transmitted to rear wheel by chain drive .it gives high transmission efficiency and high speed ratio.

Fig: 2 motor

Controller: Controller is electric device which controls the electric power deliveries to various components depends on the input. It detects the higher voltages and do cut off the power when it is more than necessary and protects the circuit.

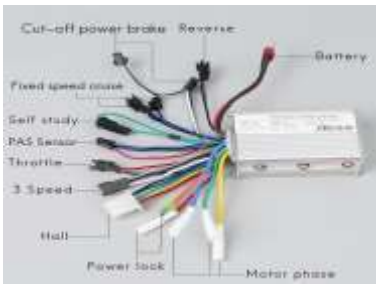


Fig: 3 controller

Suspension: Suspension is one of the main part in vehicles which reduces the jerks by converting the shock pulse into KE. there are two types of suspension used in bikes in front telescopic suspension is used it may be upside down or straight one and in rear suspension springs are used whether mono is twin.

Fig: 4 suspension

2.Literature review

Nigam et al. [1] has designed and developed the modern electric bike. Due to increase of automobiles the fuel costs are rapidly increasing to overcome the situation they designed an alternative electric bike. The model of bike frame was designed in CAD software and analysis in ANSYS workbench. The chassis of the frame was tested for its strength while carrying the driver. The project shows a study and development process of smart, affordable electric bike to reach the market standards.

Nikhil et al. [2] has developed a chassis of electric scooter that produces less pollution and eco-friendly. They developed the chassis made by AISI 1018, because of its less density and good strength and good price. Aluminium material used for weight reduction. They designed 3d model in CATIA V5 R17 and analysis in ANSYS WORKBENCH. The main objective of this paper is to design frame and perform analysis under various conditions and suitable for market standards.

Sushma et al. [3] The paper shows us the design of an electric bike which is useful for daily users. They designed the electric bike with 2kw BLDC 48volts motor with rotational speed 3000rpm. they chose material of AISI chromo 4130 and AISI Aluminium 6060 for front shock observers. They also considered the various factors like frame, stiffness, load paths and overall weight of frame. The analysis was done in various iterations and testing. They considered lithium-ion battery, because of high energy density of 100 why/kg and low risk of exploding.

Irfanudeen et al. [4] has studied about the frames of mountain bike and they designed the frame with low cost that satisfies all the conditions of user. They replaced the material with advanced composite materials to increase the strength and also reduce the cost. advanced Composite materials having high strength and low cost and consist of various mixtures like resin matrix, epoxy, Kevlar, polycyanate, vinyl ester. They designed in cero and did various structural and dynamic analysis.

Khurana et al. [5] The survey gives the result of adoption of electric vehicles in India. The pollution due to greenhouse gases are also increasing, so the country prepares to shift to electric vehicles by 2030 (IEA 2016). These results in reducing emissions to 37 per and reduce dependence on imports of fuels. The government also planning battery swapping option to adopt electric vehicles. government announced all cars to be electric by 2030 (SIAM,2017). The survey gives the information about usage of electric vehicles in future.

2.1 Research gap

As electric vehicles emerge as the better alternative for the conventional vehicles which runs on petrol, diesel and causes so many problems to nature so some ample amount of work is going on electric vehicles. As the name says electric most of the work is going on batteries and on their efficiency. Although it is electric vehicle its efficiency also depends on the mechanical members like frame. Frame is the main part of the bike which bears the total weight of the body, a room for battery motor, steering and the mountings for suspension. So there is a need to work on the frame of the electric vehicle which facilitates in the reduction of weight, cost and increase the efficiency of the vehicle.

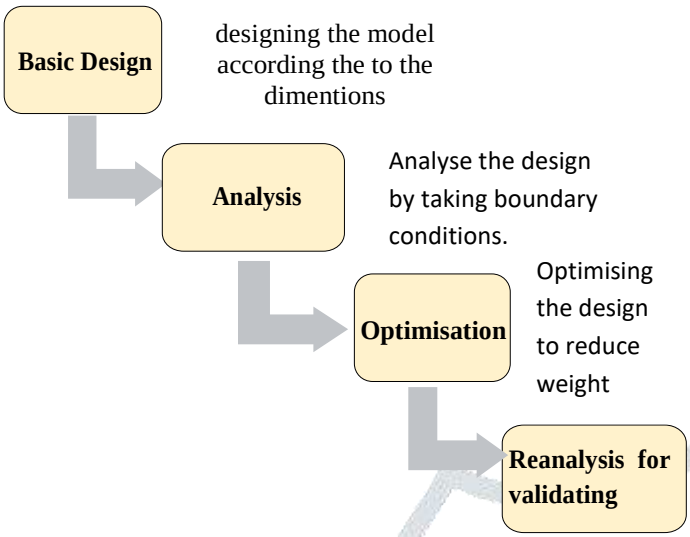
3.Objectives:

The main objective of the ebike is the efficiency and the good mileage which can be achieved by the two things the efficiency of the battery and the other side the design and the weight of the vehicle which will impact the mileage. The weight is inversely proportional means on increase in the weight will causes less mileage. We are going plan in such a way that by doing analysis we are going to remove the unwanted material from the frame design and make it lighter and increase the mileage.

The second objective is the cost factor where the decrease in the frame itself reduces the material which decrease 5-10% cost of the vehicle all including the cost of extra material removed and the welding's and labour cost of the parts removed.

The third objective is to make the simple and easy assemble frame which can be dis assembled and assemble even by a small mechanic and look it more easily for production. To make it sustainable by using the echo friendly materials and reducing the waste material and increased life time and make it reused after the motor becomes dead.

4.Methodology



5.Design:

5.1 Material selection

Material selection is important for the design of the frame as it would result in the F.O.S and the reliability and the deflection. So we selected the material according to the market availability, strength, chemical composition and the forces acting on the pipe. We selected two different materials after the hit and trail methods with carbon percentage more than 0.18% to get good strength like AISI1020 and AISI 4130. [5][6]

TABLE I physical properties of materials

Parameter	AISI 1020	AISI4130
Tensile strength	420 MPa	560MPa
Yield strength	350 MPa	460MPa
Poisson ratio	0.29-0.30	.27-0.3
Machinability	65%	70%
Modulus of elasticity	205 GPa	210GPa
Weld ability	Good	Good
% Elongation	15%	70%

TABLE II chemical properties of materials

Parameter	AISI 1020	AISI4130
Carbon “c”	0.17-0.23	0.28-0.33
Iron “Fe”	99.08-99.53	97.03-98.22
Manganese “Mn”	0.30-0.60	0.40-0.60
Phosphorous “p”	<=0.040	0.035
Sulphur “s”	<=0.050	0.040
Chromium “cr”	-	0.80-1.1
Silicon “si”	-	0.15-0.30

5.2 Dimension Selection:

Selecting the larger diameter and smaller thickness such that increasing the inertia moment of tubes by restricting even larger diameter and small thickness to avoid deformation of tubes due to concentrated loads.[7]

Primary member: 1.25inch 2mm

thickness (AISI4130)

Calculations of bending strength and bending stiffness:

Outer diameter d2=25.4mm

Inner diameter d1=23.4mm

Yield strength=460Mpas

C=distance from central axis to external fibre=12.70mm

$$M / I = C / Y = E / R$$

$$Momentofinertia = \prod(d2 * 4 - d1 * 4)/(64)$$

$$= 8073.81 * 10^{-12}\, m$$

$$BendingstrengthM = Sy * I /(c)$$

$$460 * 10 * 6 * 873.81 * 10 - 12/(12.70 * 10 - 3)$$

$$= 293.4372N / m^2$$

$$Bending\_stiffness = E * I = 1716.5001Nm^2$$

5.3Design of frame:

It describes the design methodology of the frame. The frame designed in such a way that it satisfies the maximum loading conditions and safety of the driver. The aim of the frame is to withstand, decrease the weight and cost of the frame.

The frame of the electronic bike is designed in solid works bench. The ergonomics of the bike as 50% of Indian standards. The design of the frame is optimised. Dimensions of the frame of the electric bike has taken from different bikes.

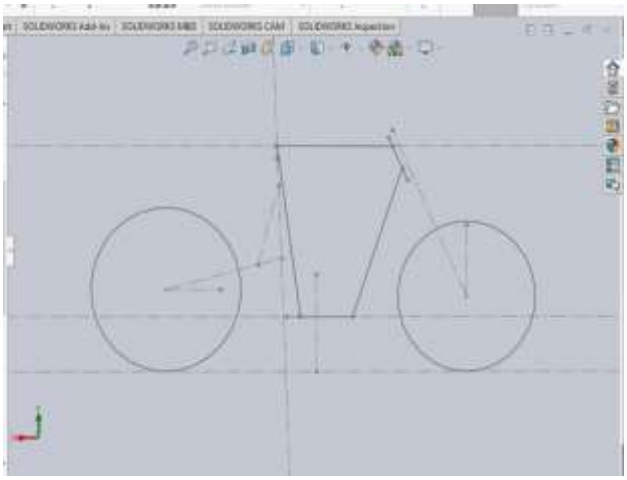


FIG: 5.3(a) 2d sketch of the frame

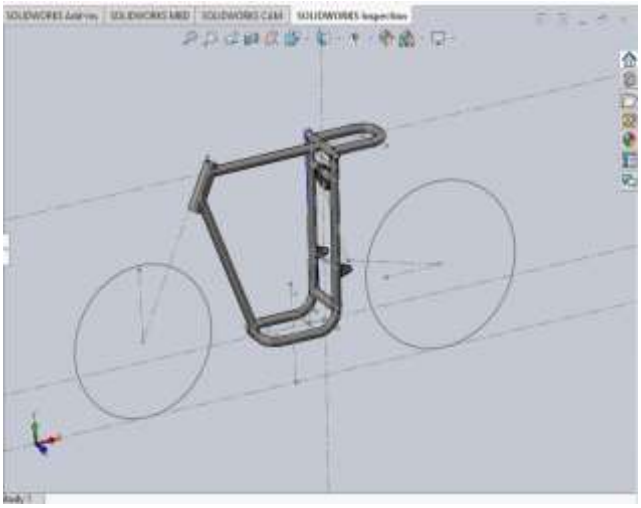


Fig: 5.3(b) isometric view of frame

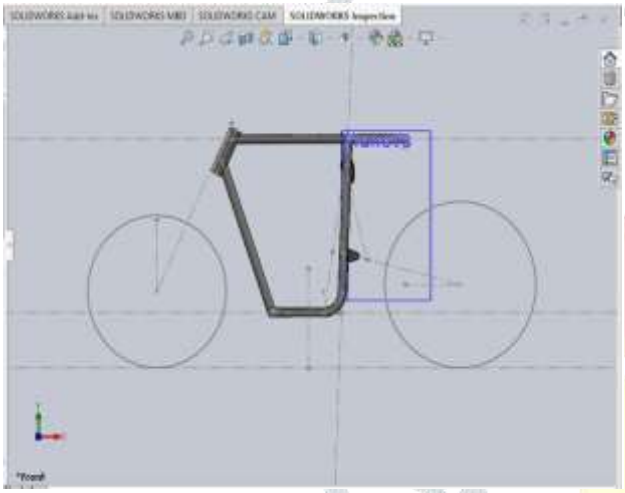


Fig: 5.3(c)- front view of frame

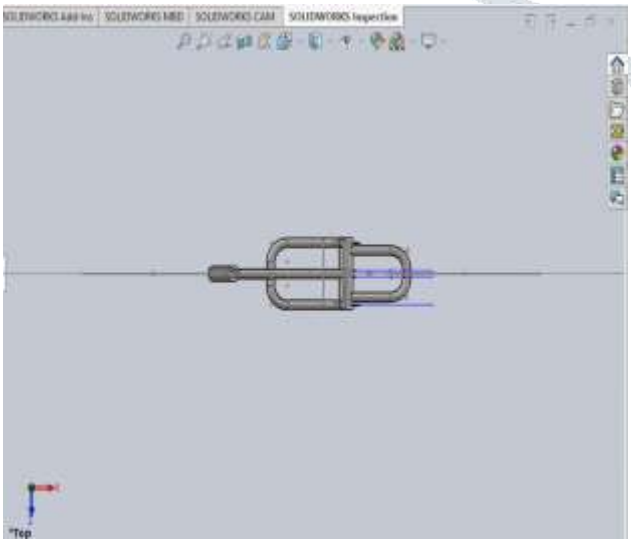


Fig: 5.3(d)- top view of frame

6.Analysis of the frame:

The analysis of the frame whether it withstand the maximum loads and vibrations was done on any work bench. The results of the analysis of the frame is satisfying and it ensures all requirements.

CAE Analysis of frame:

The frame is the main part of the bike which hold the entire weight of the body, a room for battery, motor, steering and the mounting for suspension. so the frame should be strong enough and have more safety for the driver for entire life cycle of it. Finite element analysis is a mathematical modelling technique to determine the response of real loads both external and internal. CAE analysis on the frame is performed to evaluate the safety offered by the frame to the driver in case of accidents in case of front impact or vehicle falling side wards.

6.1 Front Impact Analysis:

Material-AISI4130

Dia-1.25(outer)

Thickness-2mm

As the design of frame is made in solid works 2018while considering the Indian ergonomics 50% percentile and driver basis we made a frame. We use Ansys 16.0 work bench for meshing the whole model to get the result finite. For boundary conditions for front impact test, the frame is fixed from rear side of the vehicle and front member-1 will come across the applied load. From properly analysis for impact load. We need to find the deceleration of the vehicle after impact to approximate the worst-case scenario that the vehicle will undergo momentum equations are used to determine the deceleration of the vehicle.

Assumptions:

1. The vehicle is considered to be at maximum speed of 60 km/h.

2. The maximum or total weight of 160kg.

3. While hitting neglecting the forces damped by tires and front suspension and 100% forces are transferred to the head of the frame.

IMPACT FORCE:

Weight of the vehicle=160 kg (including driver weight)

Initial velocity before impact (U)= 16.66m/s

Final velocity after impact (v) = 0m/s

Considering the impact time as 0.15sec

Now we have standard theory that the one form of energy will be converted into another form.

So the work done is equal to change in kinetic energy

$$W = F * d$$

$$d = time * speed$$

$$soW = 0.5 * m * (v - u)^2$$

$$F = 0.5 * m * v^2 / t * v = 0.5 * 160 * 16.66 / 0.15$$

$$= 8885.333$$

Considering it as a 9000N we proceed further analysis

Analysis of AISI4130:

At 9000 N load

Front impact analysis results:

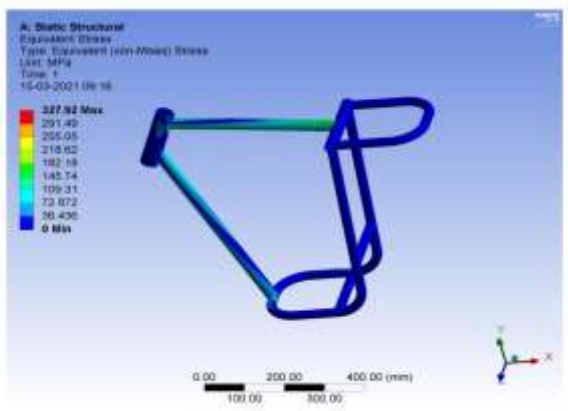


Fig: 6.1(a)equivalent stress

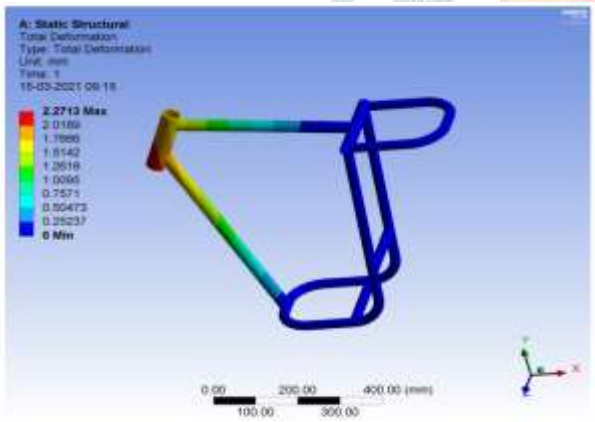


Fig: 6.1(b)total deformation

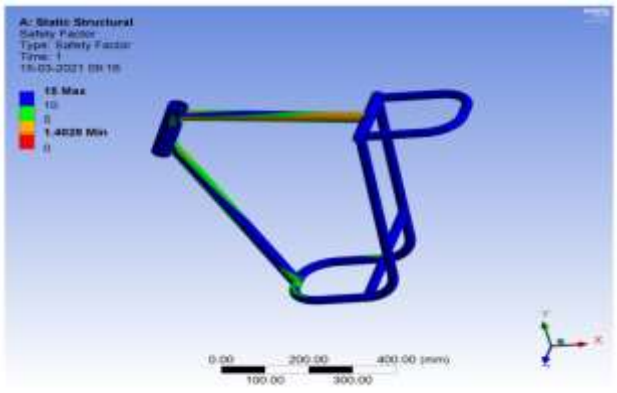


Fig: 6.1(c)- FOS

TABLE III front impact analysis results

Type	Equivalent stress	Total deformation	Factor Of Safety
Minimum	0	0	1.4
Maximum	327.92Mpa	2.27mm	15

6.2 Rear impact

Assumption:

By taking the half of the front impact force we proceed Further calculations and analysis.

1.Fixing the front part of the frame and applying load on back two members dividing the load uniformly.

2. The 100% load is transformed through swing arm through back members.

Rare impact analysis results:

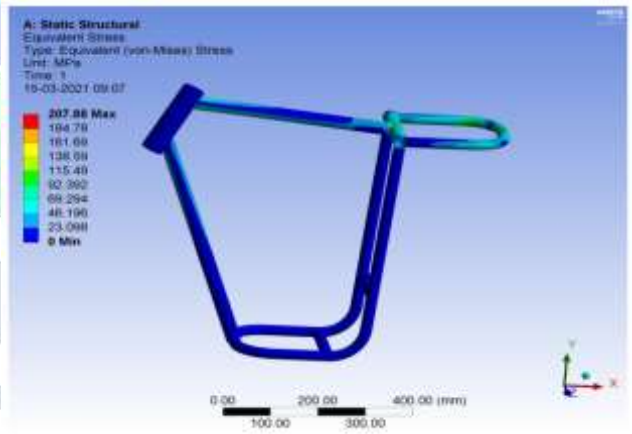


Fig: 6.2(a)equivalent stress

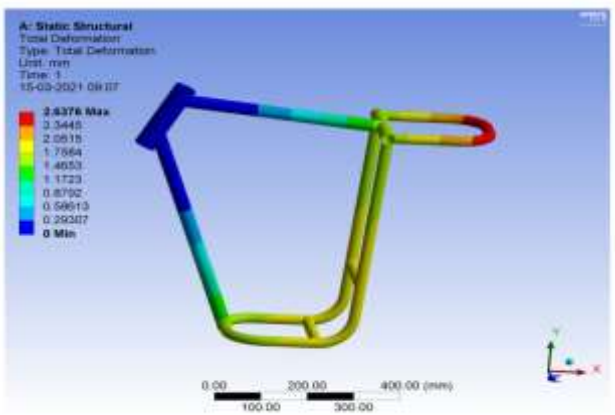


Fig: 6.2(b)total deformation

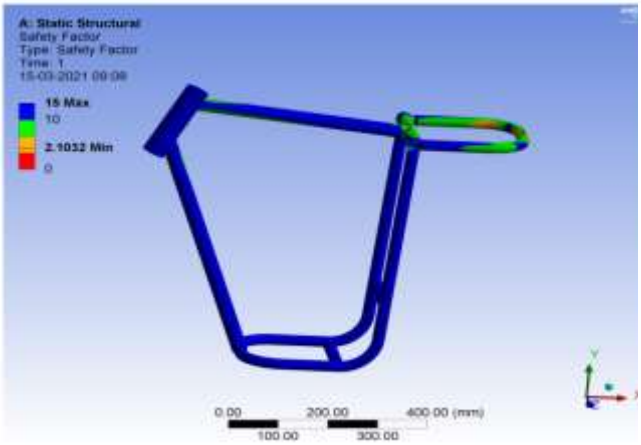


Fig: 6.1(c)- FOS

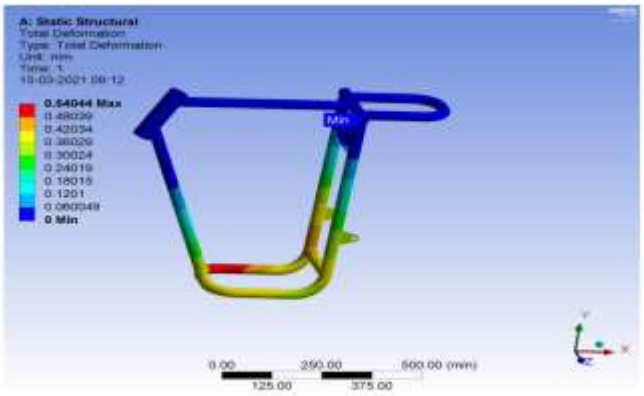


Fig: 6.3(b)total deformation

TABLE IV rare impact analysis results

Type	Equivalent stress	Total deformation	Factor Of Safety
Minimum	0	0	2.1
Maximum	207.88Mpa	2.63mm	15

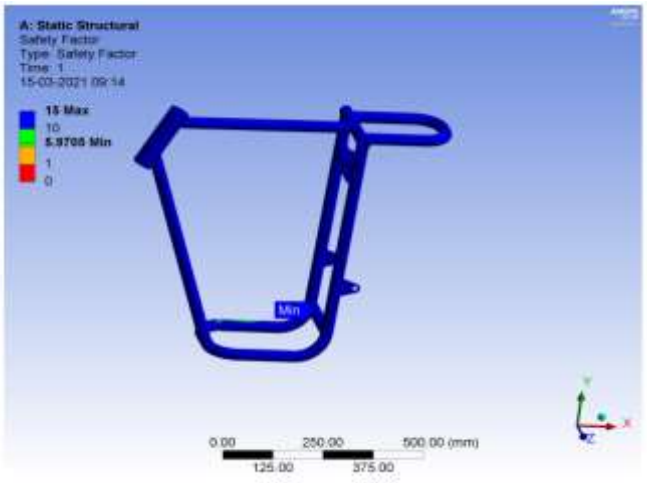


Fig**:** 6.3(c)- FOS

6.3 Drop down test

When vehicle passed through bumps or dropped from certain height mass (m) = 160 kg g (acceleration due to gravity) =9.8m/s2Drop height "h" =5 ft.

We considering maximum condition

Impulse time=0.1sec

From reverse condition:

Fixing the upper part and apply force downward members.

F=1955.35N Considering it as a 2000N we proceeded further analysis.

TABLE V DROP DOEN ANALYSIS RESULTS

Type	Equivalent stress	Total deformation	Factor Of Safety
Minimum	0	0	5.97
Maximum	127.57Mpa	2.86mm	15

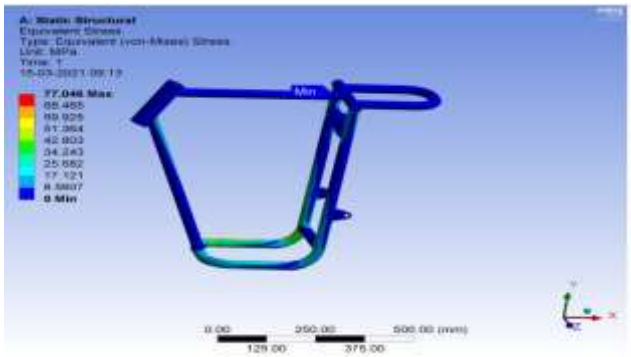


Fig: 6.3(a)equivalent stress

Conclusion:

- The main objective is to achieve the lightweight frame and from the above design and the analysis we have achieved the light weight frame by decreasing the unwanted material and we achieved it.
- The cost is reduced by decreasing the material and the additional welding's are also reduced which decreased the cost of labour and welding.
- The factor of safety is above 1.4 which is good to go for on road with all the impact forces and the frame sustained them.

- The frame was made very simple with easy assembly by have only three to four joins to make it fully assemble and any mechanic without prior knowledge can also assemble the bike so no need of skilled workers which reduces the cost.
- The frame was made in such a way that it can be used after its life cycle that it can be converted to simple bicycle frame and reuse it.

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