*Research Article*

# Design And Analysis Of Chainless Transmission Electric Bicycle

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**Abstract:-**With increasing in an air pollution and scarcity of fuels (petrol and diesel), electric bikes were playing an important role in this new era. E-bikes were eco-friendly and cost effective for transportation. The demand and constantly increasingly of petrol and diesel cost has made engineers to think for new source of energy for transportation. Electric vehicles gave a breakthrough solution to satisfy the needs required but the cost of electric bikes or e-bikes were too high that normal people cannot afford it easily. In order to fill that gap that everyone to afford an electric bike, this project aimed to design an electric bike. In this project, mainly to reduce the manufacturing cost the electric bike is converted the normal bicycle to an electric bike; the project work designed it in the manner it can be propelled through both manual and electric drive called as e-cycle or hybrid bicycle. In addition to this conversion, an attempt has been done to design this hybrid bicycle without chain, i.e.: gear and shaft mechanism for transmitting the power. Own frame has been designed for the e-cycle which can be used for load carrying purpose also. Frame was designed using solid works and with the help of analyses this project came to the conclusion to use AISI 4130 as a frame material for this hybrid cycle.

## I.INTRODUCTION

An Electric Bike or Scooter could also be electric battery operated vehicle that is very economical with low maintenance worth and cipher pollution. electrical a pair of wheelers use the electrical technology of reversible battery that converts the facility into energy. The battery of associate energy unit is charged merely using an influence affiliation. There area unit many accomplishable kinds of electrical motorized bicycles with several technologies gettable, varied in worth and complexity; direct-drive and double-geared motor units area unit every used. associate degree electrical power-assist system is {additionally} additional to nearly any pedal cycle pattern chain drive, belt drive, hub motors or friction drive. the power levels of motors used area unit influenced by gettable legal categories and area unit generally restricted to below 700 watts.

Electric bicycles use reversible batteries, electrical motors and a few sort of management. this could be a straightforward as associate degree electric switch however is a lot of sometimes associate degree electronic pulse breadth modulation management. electrical bicycles developed in European nation within the late Nineteen Eighties for the Tour de Sol star vehicle race came with star charging stations however these were later fastened on roofs and connected therefore on feed into the electrical mains. The bicycles were then charged from the mains, as is common nowadays. Battery systems in use embrace lead-acid, NiCd, NiMH and Li-ion batteries. electrical motorized bicycles are often power-on-demand, wherever the motor is activated by a bar mounted throttle, and/or a pedelec (from pedal electric), conjointly referred to as electrical assist, wherever the electrical motor is regulated by pedalling. These have a detector to discover the pedalling speed, the pedalling force, or both. associate degree electronic controller provides help as a operate of the detector inputs, the vehicle speed and therefore the needed force. Most controllers conjointly give for manual adjustment.

## II.MODELLING OF HYBRID CYCLE

Model of an electric bicycle has divided by two sections which are frame design and chainless transmission mechanism.

### Frame design

Frame is the base part of every vehicle, so designing of frame is very important in the aspect of safety, comfort, cost effective.

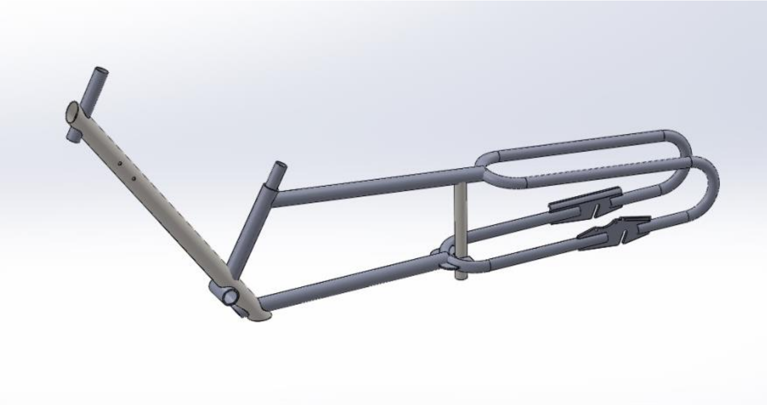


Fig.5 Designed frame of the E-cycle

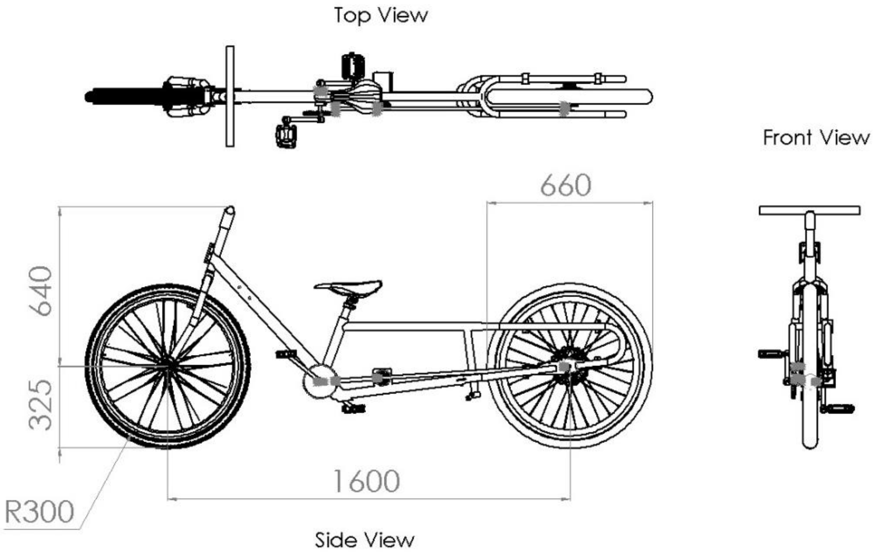



Fig.6 Different views of E-cycle (With line sketch)

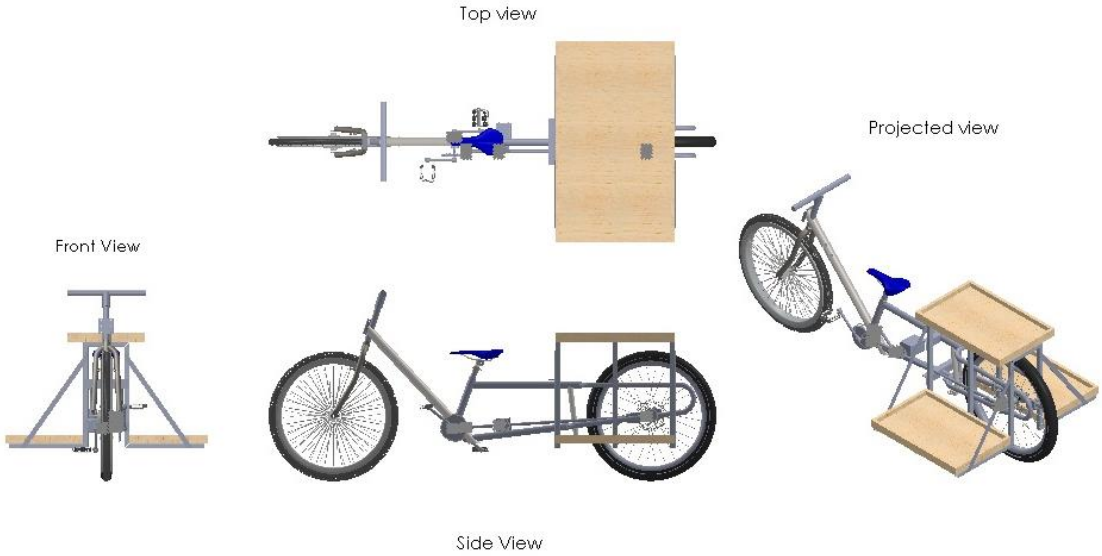



Fig.7 Different views of E-cycle (with solid part)

**4.2. Chainless Transmission**

Transmitting power from source to end can be done in many ways such as chain drive, belt drive, gears, etc., So in our design we designed our frame with bevel gear mechanisms.

Fig.8 Chainless Transmission working model

**III.SPEED AND TORQUE CALCULATION**

Any vehicle have its own speed based on its given parameters such as motor rating, load, self-weight, etc., and the speed indirectly depends on the torque required to move the vehicle. Thus we calculated the speed and torque of our designed e-cycle considering with some assumptions.

a). No load calculation

Given Motor power = 600 watts
Speed of the motor = 500 rpm
Diameter of the wheel = 622 mm

Gear ratio between the motor and the wheel sprocket is 1:1 so the same speed is transferred from motor to wheel.

Assumption: No load including driver and self-weight is neglected.

Wkt, Power (P) = 2 * 3.14 * N * (T/60)
600 = 2 * 3.14 * 500 * (T/60)
Therefore, T = 11.46 Nm
Where, T = Torque
N = Speed of the motor

Speed of the vehicle = Speed of the wheel * Circumference of the wheel
= 500 * (Diameter of the wheel * 3.14)
= 500 * (622 * 3.14)
= 976540 mm/min
Speed of the vehicle = 58.59 Km/hr

From the above calculation found that, during zero loads or no load the torque produced from the motor will be 11.46 Nm and the speed of the e-cycle is 58.59 Km/hr.

b). With load calculation
Given Motor power = 600 watts
Speed of the motor = 500 rpm
Diameter of the wheel = 622 mm

Gear ratio between the motor and the wheel sprocket is 1:1 so the same speed is transferred from motor to wheel.

Assumption: i). Driver weight = 60 kg
ii). Cycle self-weight = 5 kg
iii). Additional load = 10 kg
Total load = 75 kg
= 75 * 9.81
= 735.75 N

So the total load acting on the cycle will be 735.75 N, this can be divided into two loads for front wheel ($F_f$) and rear wheel ($F_r$).

$F_f = F_r$ = (735.75 / 2)
= 367.875 N

Where the reaction on each wheels,
Rf = Rw = Co-effiectioent of the friction * weight on the each wheels
= 0.2 * 367.875
= 73.575 N

To find the torque on rear wheel,
Torque (Tf) = Rw * (Diameter of the wheel /2)
= 73.575 * (622/2)
= 22881.825 Nmm
T = 22.88 Nm

Wkt., Power (P) = 2 * 3.14 * N * (T/60)
600 = 2 * 3.14 * N * (22.88/60)
Therefore, N = 250 RPM
Where, T = Torque
N = Speed of the motor

Speed of the vehicle = Speed of the wheel * Circumference of the wheel
= 250 * (Diameter of the wheel * 3.14)
= 250 * (622 * 3.14)
= 489246.54 mm/min
Speed of the vehicle = 29.5 Km/hr

Thus, from the above calculation we understand that when the load is applied, the torque required is increasing and the speed of the cycle is decreasing. So, speed may reduce depends on increasing of load on the cycle.

**IV.ANALYSISOF FRAME**

**a). CAE Analysis of Vehicle/Frame**

CAE Analysis on the frame was performed to evaluate the safety offered by the frame to drivers in case of any accident during Frontal Impact, Rear Impact and Side impact and in addition to these vertical bending of frame was analyzed to know the impact. The CAE analysis was done for all materials considered in the frame material option as mentioned in table. no.1 below.

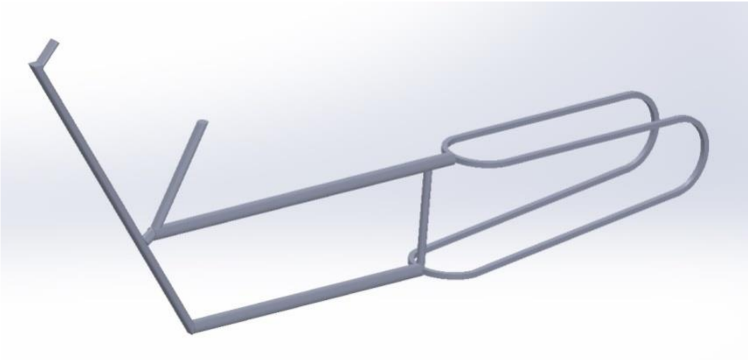


Fig.1. Re-designed frame for analysis

1. Frontal and Rear Impact Analysis

Assumption & Considerations

a). Front Impact: We applied the calculated force on the front member of the frame, considering the cycle is moving at the mentioned velocity and collide in the front portion of the frame and by constraint the motion on the rear member of the frame.

b). Rear Impact: We applied the calculated force on the rear member of the frame, considering the cycle is at rest and some other vehicle or object hit the cycle in the rear portion of the frame with the same velocity and by constraint the motion on the front member of the frame.

Calculation of Impact Forces

Our vehicle specifications:

Mass M = 100 kg (with driver, motor and battery)

Higher speed (V) = 25km/hr

= 6.94 m/s

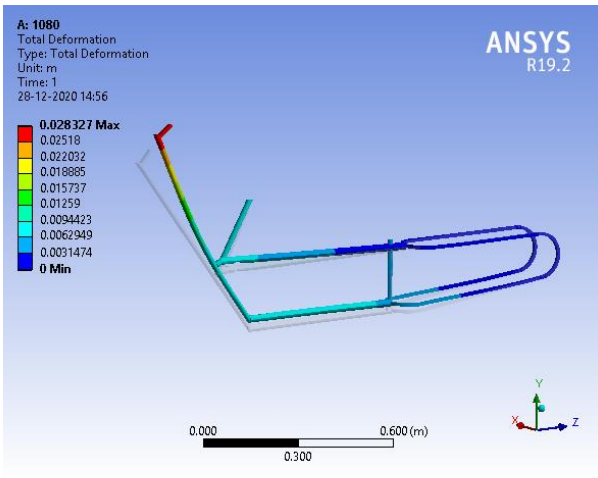
Time taken to velocity zero (t) = 0.4 s

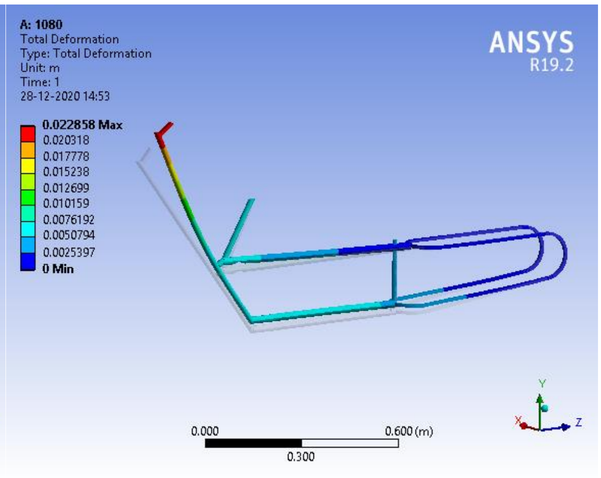
Front and Rear impact analysis:

$$F = M*(dv/dT)$$

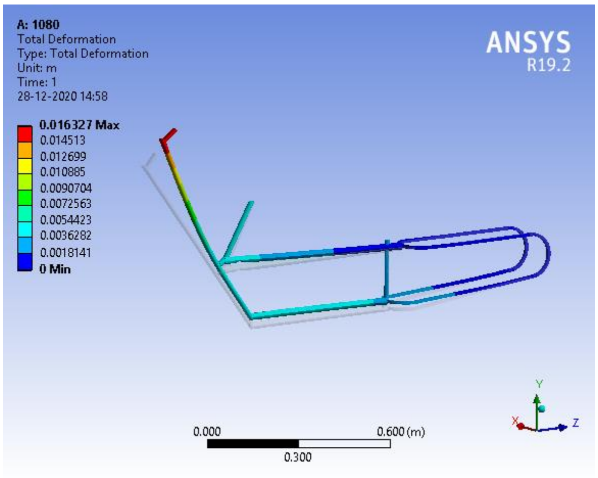
$$F = 100*(6.94 / 0.4)$$

$$F = 1735 \text{ N}$$

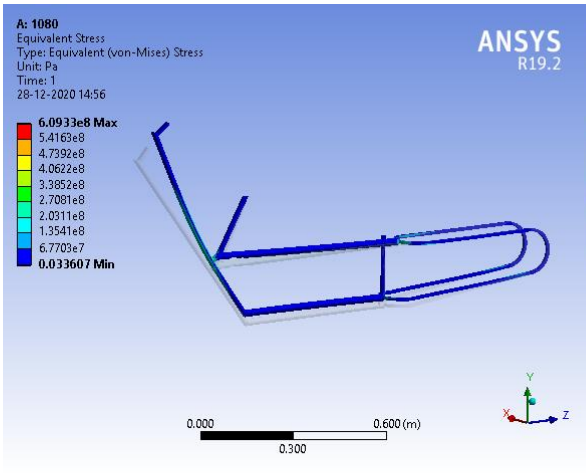


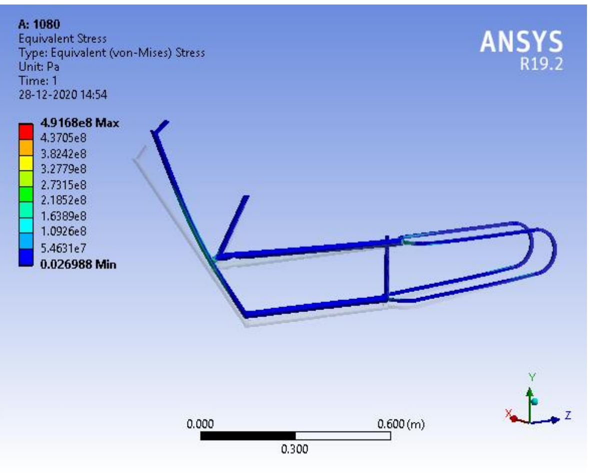




a). Front Impact Deformation of 1018 b). Front Impact Deformation of 1060

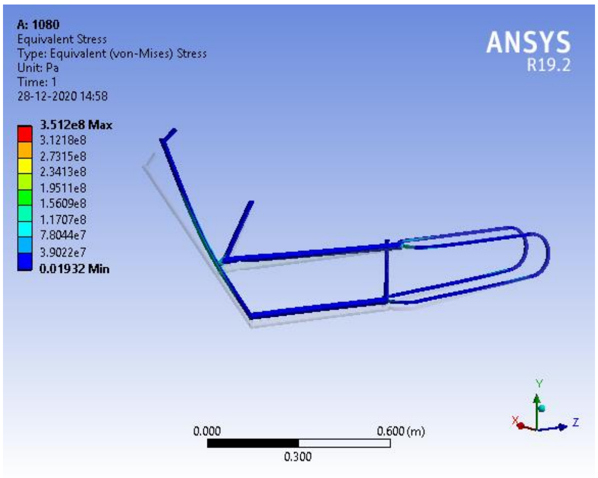



c). Front Impact Deformation of 4130

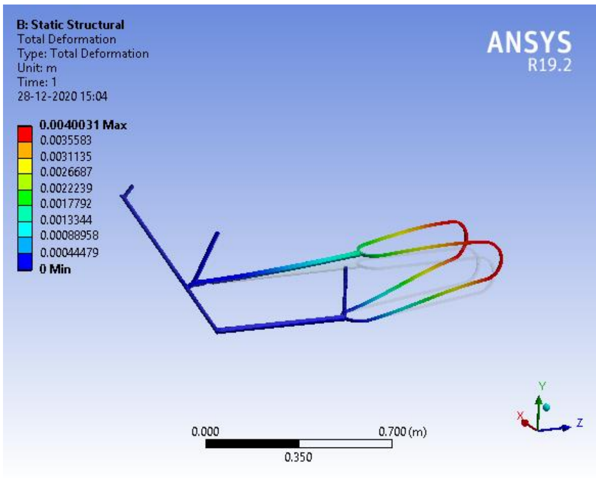


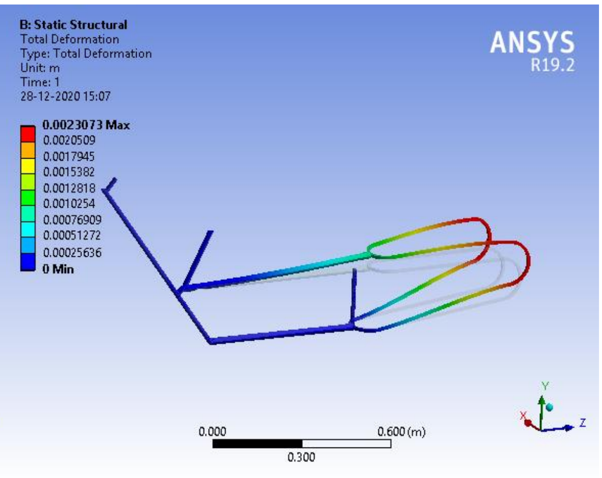

a). Front Impact Stress of 1018 b). Front Impact Stress of 1060



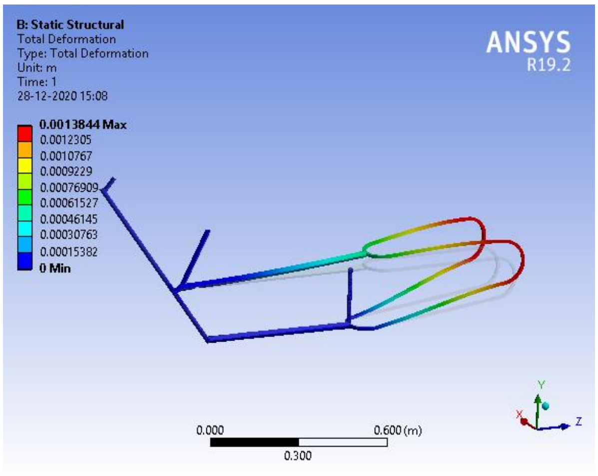

c). Front Impact Stress of 4130



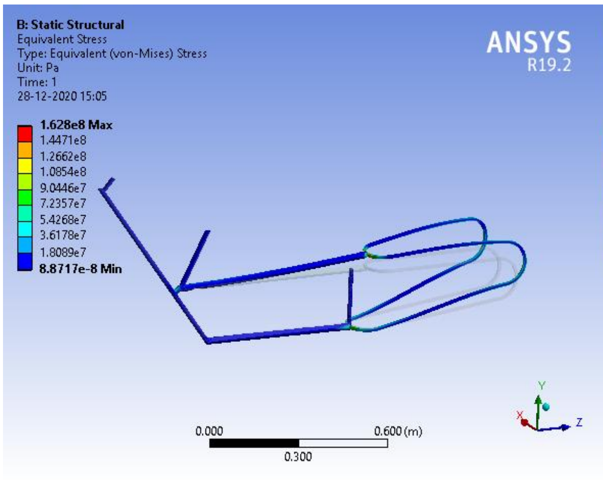

a). Rear Impact Deformation of 1018

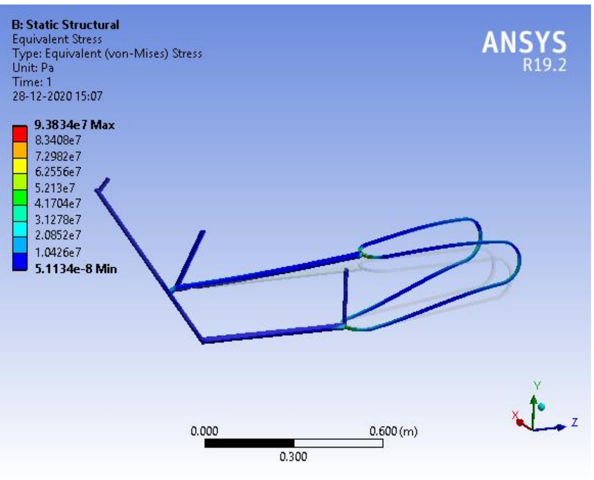



b). Rear Impact Deformation of 1060

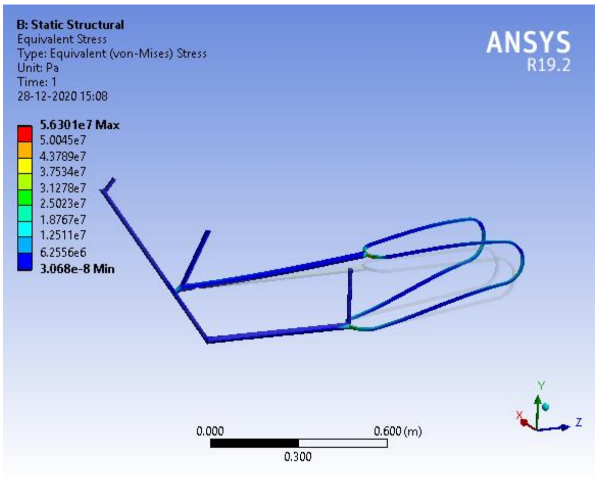



c). Rear Impact Deformation of 4130




a). Rear Impact Stress of 1018 b). Rear Impact Stress of 1060




c). Rear Impact Stress of 4130

2. Side Impact Analysis

Assumption & Considerations:

We applied the calculated force on the left side member of the frame, by constraint the motion on the right side member of the frame.

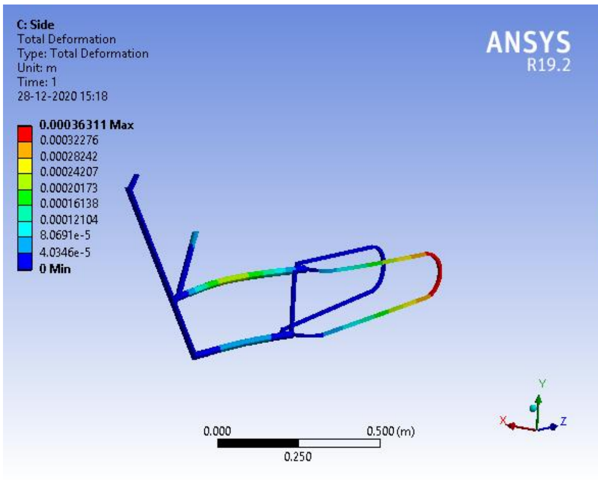
Calculation of Impact Force

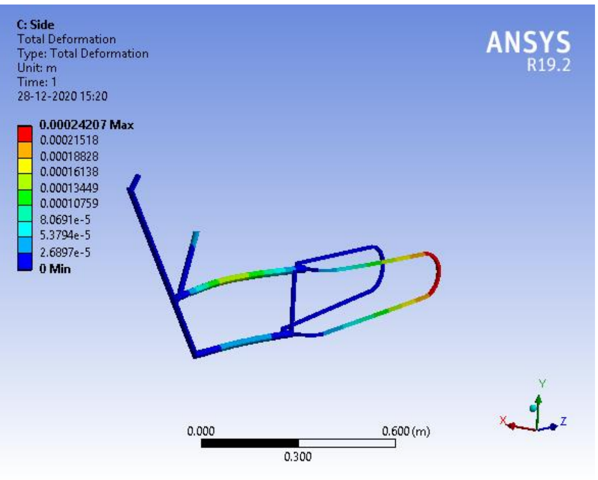
Total momentum charge was taken 1s

$$F = M * (dv/dT)$$

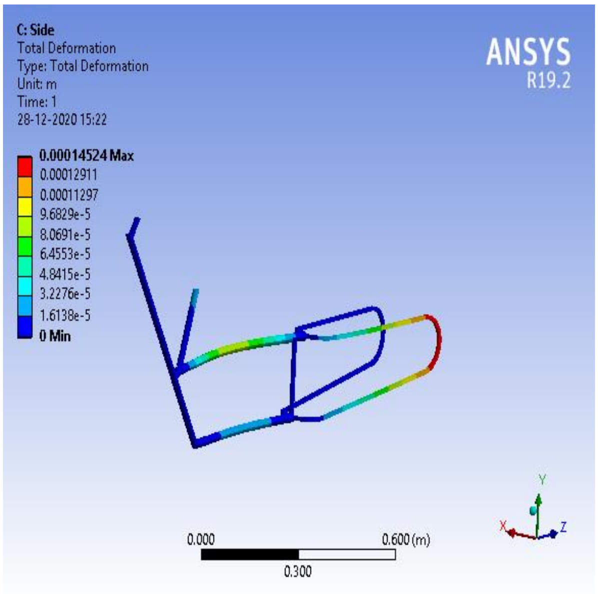
$$F = 100 \times 9.72/1$$

$$F = 972 \text{ N}$$

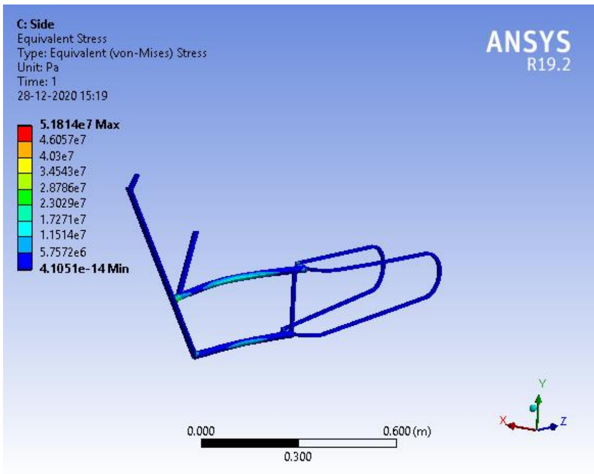


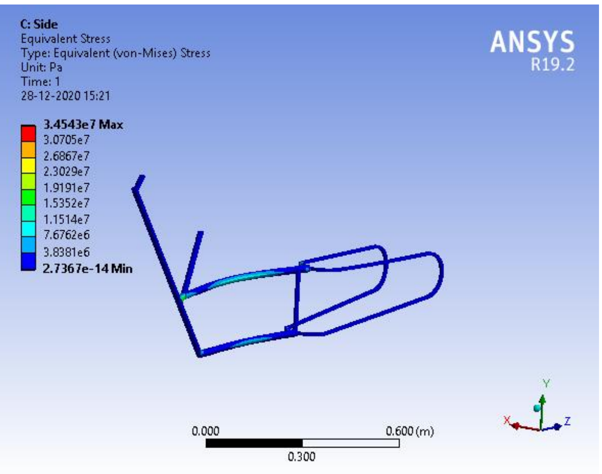




a). Side Impact Deformation of 1018 b). Side Impact Deformation of 1060

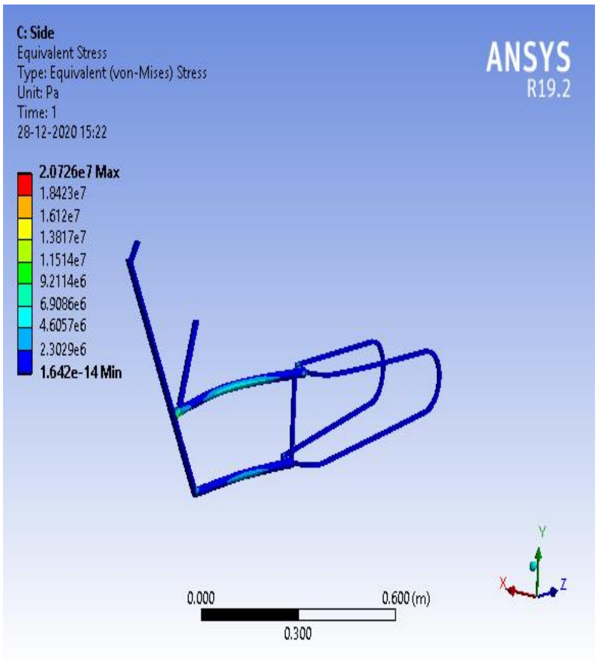



c). Side Impact Deformation of 1060




a). Side Impact Stress of 1018 b). Side Impact Stress of 1060



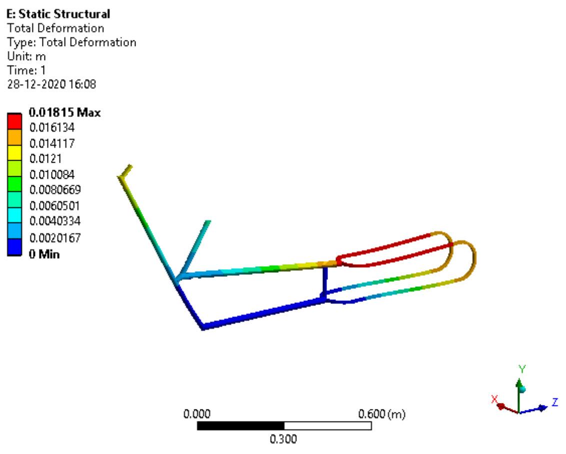

c). Side Impact Stress of 4130

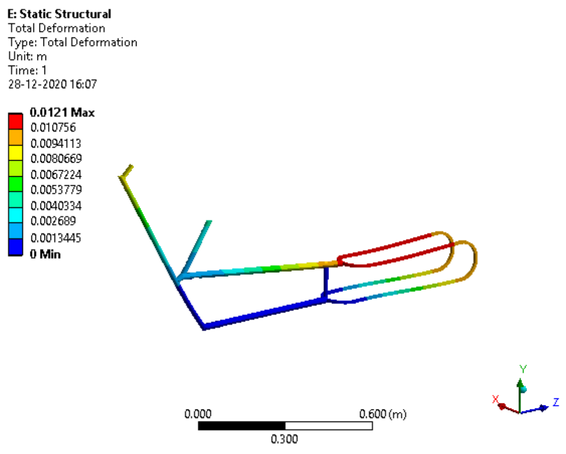
3. Vertical Bending

Vertical bending is to check the frame strength and deformation for the given force in vertical direction; this shows how much weight the frame can withstand.

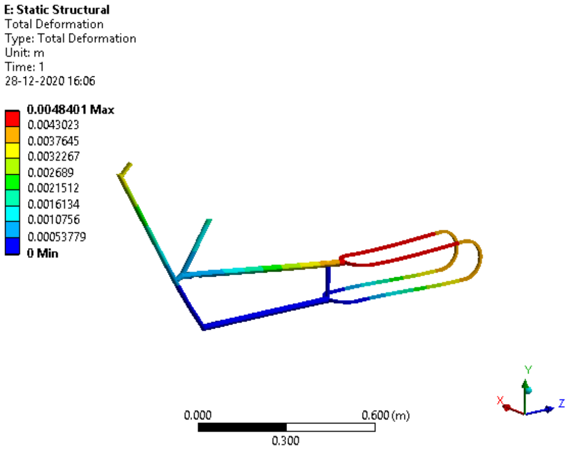
Assumption & Consideration:

Vertical force is considered as driver weight and maximum load. (i.e. 100N) and the load was applied to the upper surface of the frame as a distributed load.

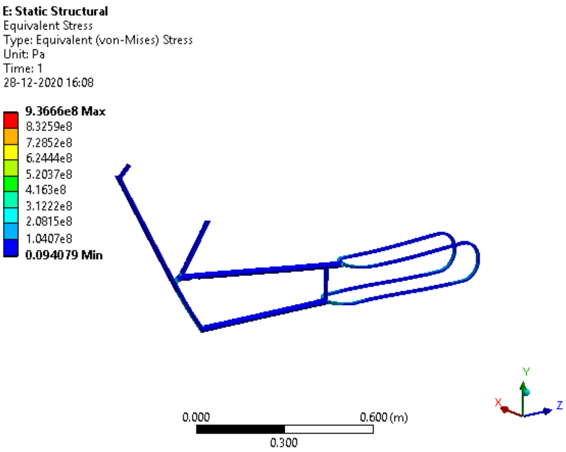


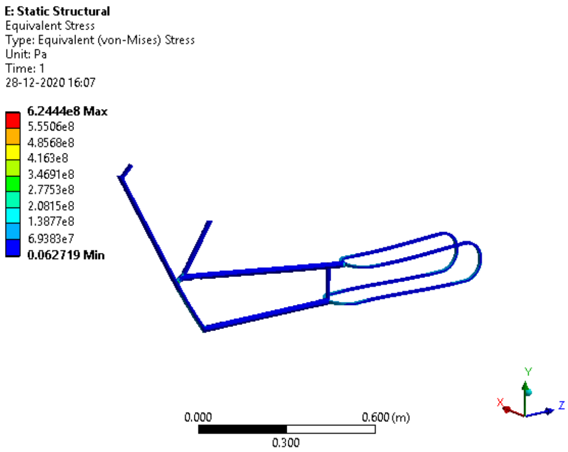

a). Vertical Bending deformation of 1018 b). Vertical Bending deformation of 1060



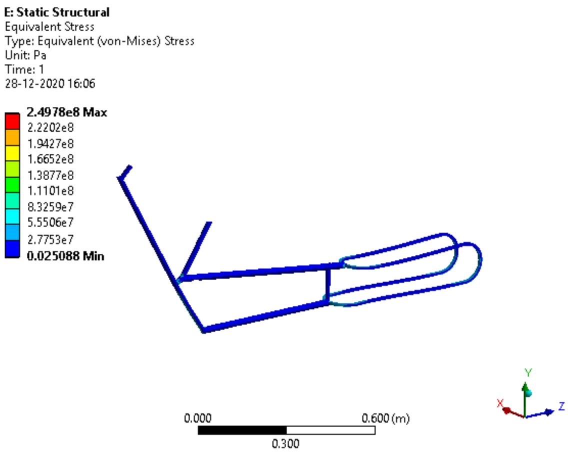

c). Vertical Bending deformation of 4130




a). Vertical Bending Stress of 1018




b). Vertical Bending Stress of 1060




c). Vertical Bending Stress of 4130

**b). Material selection**

Frame Material options

The material selection was based on the strength, availability and cost.

i). Material 1- AISI 1018
Circular hollow section; 26mm x 21mm x 2.5mm

ii). Material 2- AISI 1060
Circular hollow section; 26mm x 21mm x 2 mm

iii). Material 3- AISI 4130
Circular hollow section; 26mm x 21mm x 2.5mm

Where;

**A =** Outer dia. for circular section, Bigger side for Rectangular section, Major axis in case of elliptical section etc. (all dimensions in mm or inch)

**B=** Inner dia. for circular section, Smaller side for Rectangular section, Minor axis in case of elliptical section etc. (all dimensions in mm on inch)

**t=** wall thickness in mm or inch.

Table.No.1: Various materials with their properties

**V.**

| S.No | Material selected | Yield strength (MPa) | Ultimate strength (MPa) | % of elongation |
|---|---|---|---|---|
| 01 | AISI 1018 | 365 | 440 | 2.0 |
| 02 | AISI 1060 | 485 | 620 | 1.5 |
| 03 | AISI 4130 | 560 | 460 | 2.0 |

**Calculation of bending strength and bending stiffness**

1. MATERIAL 1: AISI 1018

Bending moment and bending stiffness calculation for AISI 1018:

Modula's Of Elasticity (E) = 205 Gpa

Second Moment of Area of Circular Cross

Section (I) = $(3.14/64)*(D^4 - d^4)$

$= (3.14/64) * (25.4^4 - 21.4^4)$

$I = 10118.69\ mm^4$

Yield Strength (Sy) = 365 MPa

Distance between Neutral Axis to Extreme Fiber = 10.7 mm

M = (Sy*I)/C

= (365*10118.69)/10.7

M = 345170.266 N-mm

Bending Stiffness (X) = E*I

= 205000*10132

$X = 2.07*10^{09}$ N-$mm^2$

2. MATERIAL 2: AISI 1060

Bending moment and bending stiffness calculation for AISI 1060:

Modulus of Elasticity (E) = 207 GPa

Second Moment of Area of Circular Cross Section (I) = $(3.14/64)*(D^4 - d^4)$

= $(3.14/64) * (25.4^4-21.4^4)$

I = 10118.69 $mm^4$

Yield Strength (Sy) = 370 MPa

Distance between Neutral Axis to Extreme Fiber = 10.7 mm

M = (Sy*I)/C

= (370*10118.69)/10.7

M = 349898.626 N-mm

Bending Stiffness (X) = E*I

= 207000*10118.69

$X = 2.09*10^{09}$ N-$mm^{\wedge 2}$

3. MATERIAL 3: AISI 4130

Bending moment and bending stiffness calculation for AISI 4130:

Modula's Of Elasticity (E) = 190 GPa

Second Moment of Area of Circular Cross Section (I) = $(3.14/64)*(D^4 - d^4)$

= $(3.14/64) * (25.4^4-21.4^4)$

I = 10118.69 $mm^4$

Yield Strength (Sy) = 560 MPa

Distance between Neutral Axis to Extreme Fiber = 10.7 mm

M = (Sy*I)/C

= (560*10118.69)/10.7

M = 529576.299 N-mm

Bending Stiffness (X) = E*I

= 190000*10118.69

X = $1.9*10^{09}$ N-mm$^2$

Table.No.2: Bending moment and stiffness for various materials

| | **AISI 1018** | **AISI 1060** | **AISI 4130** |
|---|---|---|---|
| **Bending moment (N-mm)** | 345170.266 | 349898.626 | 529576.299 |
| **Bending stiffness (N-mm$^2$)** | $2.07*10^{09}$ | $2.09*10^{09}$ | $1.9*10^{09}$ |

FINAL MATERIAL SELECTION

Table No.3: Comparison of CAE analysis results

| **Materials** | **Front / Rear** | **Side** |
|---|---|---|
| **AISI 1018** | Poor | Poor |
| **AISI 1060** | Good | Good |
| **AISI 4130** | Excellent | Excellent |

Table No.4: Comparison of the materials based on the following criteria's

| **Materials** | **CAE** | **Manufacturability** | **Weight** |
|---|---|---|---|
| **AISI 1018** | Poor | Excellent | Excellent |
| **AISI 1060** | Good | Good | Poor |
| **AISI 4130** | Excellent | Poor | Good |

## VI. Material Selected for Frame:

- AISI 4130, circular hollow pipe, 26mmx21mmx2.5mm

Based on the CAE analysis, stiffness calculation, cost and ease of availability the material AISI 4130 was selected because of its better rigidity under all impacts loads comparing to other materials taken in account.

**VII. Conclusion**

In this paper, a chainless electrical bicycle has been accomplished with the intermixture of the electrical equations of the motor, the generator, the battery and also the power converters with the physics of the bicycle and also the rider. Moreover, fast, perfect to step inputs and reliable controllers are designed adapting the strategy accustomed the hardware specifications. Then, it's all been deeply tested along to confirm it's behavior and performance once employed in realistic conditions. Obviously, this is often a abstract paper, and every one the conclusions drawn are obtained once simulating the model, that is shut however not reality. To confirm nice performance and to create final changes, a model ought to be designed and tested in real use conditions.

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