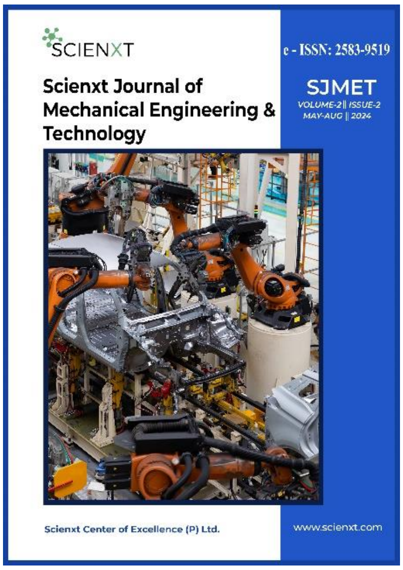

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Design analysis and fabrication of electric all-terrain vehicle for E-baja

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Abstract:

An all-encompassing engineering project, the Design Analysis and Fabrication of an All-Terrain Vehicle (ATV) aims to provide a flexible off-road vehicle that can reliably and efficiently traverse a variety of terrains. The main steps in the design process—the stages of conceptualization, analysis, and fabrication—are described in this abstract. In the initial stages, goals for the project are established, design elements are conceived, and feasibility studies are carried out to make sure the vehicle satisfies performance standards. Next, in-depth engineering evaluations are carried out to enhance the robustness and user comfort of the ATV's design. These analyses include structural, dynamic, and ergonomic assessments. In order to achieve high-quality construction, the fabrication stage includes material selection, component manufacture, and assembly processes. It makes use of sophisticated fabrication techniques and manufacturing technologies. Safety, sustainability, and economy of cost are all taken into account during the project's design and production phases. The culmination of these efforts results in the development of an innovative All-Terrain Vehicle optimized for the E-Baja competition, poised to deliver exceptional performance and reliability in off-road environments while showcasing the potential of electric propulsion in motorsport applications. After all of this work, a cutting-edge all-terrain vehicle that can function superbly and dependably in a variety of difficult conditions has been created.

Keywords:

All-Terrain Vehicle (ATV), Design Analysis, Fabrication, Off-road Vehicle, Engineering, Feasibility Studies, Structural Analysis, Dynamic Analysis, Ergonomics, Material Selection, Electric ATV.

1. Introduction:

An important engineering project, the Design Analysis and Fabrication of an All-Terrain Vehicle (ATV) aims to provide a multipurpose vehicle that can go through many terrains with ease and effectiveness. Because of their prowess in navigating off-road conditions, all-terrain vehicles have become a popular choice for use in industrial, agricultural, and recreational contexts. An overview of the main factors and goals involved in the conception, evaluation, and construction of an ATV is given in this introduction. The first step in developing an all-terrain vehicle is establishing the project's goals and specifications, which include performance indicators like payload capacity, speed, and manoeuvrability. The conception stage, which involves exploring design elements and configurations that satisfy the given criteria, is guided by these aims. In order to make sure that the finished product complies with the project objectives, feasibility studies are carried out to evaluate the technical and financial viability of different design options. After the establishment of a conceptual design, comprehensive engineering evaluations are carried out to assess the ATV's dynamic performance, ergonomic factors, and structural integrity. While dynamic analysis analyses a vehicle's stability, grip, and ride comfort over a variety of terrains, structural analysis procedures determine a vehicle's capacity to handle the stresses and strains experienced during off-road operation.

Figure. 1: a b c Shows the Initial Fabrication of ATV and D the Final One by Using PVC Pipes

The goal of ergonomic evaluations is to maximize user comfort and accessibility while improving the vehicle's overall usability and safety. During the fabrication stage, components are manufactured, materials are chosen, and assembly procedures are used to turn the design concept into a real prototype [1-4]. High-tech production processes and fabrication methods are used to provide the best possible construction and exact assembly of the ATV components. To provide a reliable and ecologically friendly vehicle solution, safety, sustainability, and cost-effectiveness are incorporated throughout the design and construction process. To put it briefly, a multidisciplinary approach integrating engineering concepts, real-world issues, and cutting-edge technology is used in the Design Analysis and Fabrication of an All-Terrain Vehicle to build a vehicle that can successfully navigate off-road terrain. E-Baja championships stress the use of electric propulsion systems, encouraging sustainability and environmental sensitivity in racing engineering, in contrast to traditional Baja races that employ gasoline-powered vehicles. The resulting ATV is a flexible and dependable solution that can be used for a wide range of applications since it caters to the unique needs of users and optimizes performance across different terrains. Through the application of advanced technology and engineering concepts, groups can create electric ATVs that can flourish in the demanding world of off-road competition, encouraging the use of electric engines in motorsports by the SAE BAJA 2021 rulebook [5-8].

2. Materials and methods:

2.1. Materials:

AISI 1020 steel was the principal material used in the construction of the main structure of the All-Terrain Vehicle (ATV). Low-carbon steel with good weldability, machinability, and moderate strength characteristics, AISI 1020 is appropriate for structural applications.

2.2. Methods:

2.2.1. Design conceptualization:

Based on the goals and specifications of the project, the primary framework of the ATV was developed during the conceptualization phase of the design process. To generate precise design models, CAD software was utilized, taking into account various aspects such functional component integration, load distribution, and shape optimization.

2.2.2. Electric propulsion system:

Including an electric motor, battery pack, motor controller, and related power electronics, the electric propulsion system is the beating heart of the E-Baja ATV. While the battery pack is selected to offer adequate energy density and power delivery for lengthy off-road operation, the electric motor is chosen based on performance requirements, such as torque output and efficiency.

2.2.3. Structural analysis:

To assess the primary structure's performance and structural integrity under various loading scenarios, Finite Element Analysis (FEA) simulations were carried out. Critical stress areas were found, material distribution was optimized, and safety standard compliance was ensured thanks to this study.

2.2.4. Fabrication methods:

A variety of methods, such as laser cutting, CNC machining, and welding, were used in the construction of the primary structure. The steel components were accurately shaped using laser cutting in accordance with the CAD design criteria. Tight tolerances and fine details were achieved with the use of CNC machining. Metal Inert Gas (MIG) welding was one of the welding processes used to fuse the assembled parts of the structure together.

2.2.5. Assembly:

To guarantee structural integrity and dimensional precision, the manufactured components had to be carefully fitted and aligned throughout the assembly process. Jigs and fixtures were employed to speed up the assembling procedure and preserve alignment while welding.

2.2.6. Quality control:

To ensure dimensional correctness, weld integrity, and material qualities, quality control procedures were followed during the fabrication process. To find any flaws or imperfections, non-destructive testing methods like visual inspections and ultrasonic testing were used.

2.2.7. Testing and validation:

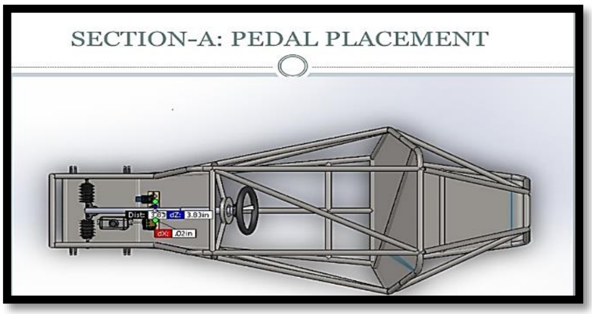
To assess the primary structure's performance in real-world scenarios, extensive testing and validation processes were carried out after it was constructed. To evaluate the load-bearing capability, durability, and stability over a range of terrains, both static and dynamic tests were carried out.

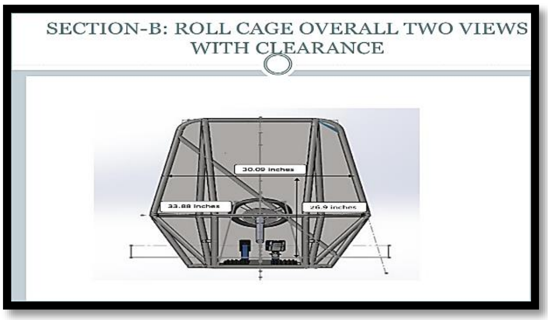
2.2.8. Optimization:

Based on input from testing and validation outcomes, the primary structure was continuously improved and optimized. Enhancements in performance, dependability, and user experience were achieved through iterative design changes.

Teams can effectively design, evaluate, and construct an All-Terrain Vehicle optimized for the E-Baja competition by using these materials and techniques, showcasing creativity, sustainability, and performance superiority in the field of electric vehicle engineering [1-8].

3. Design of E-baja atv:





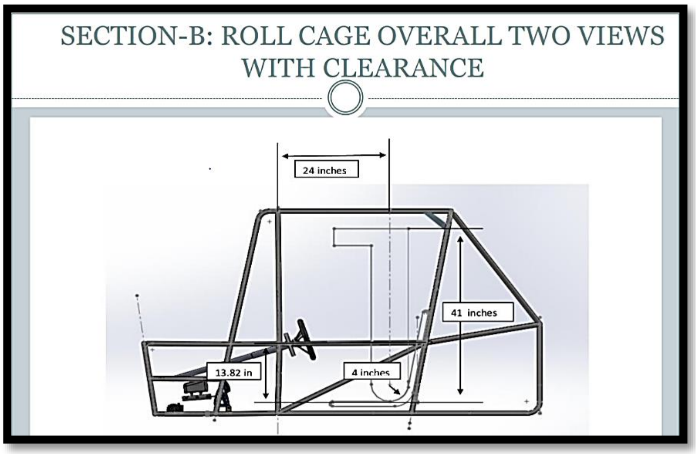


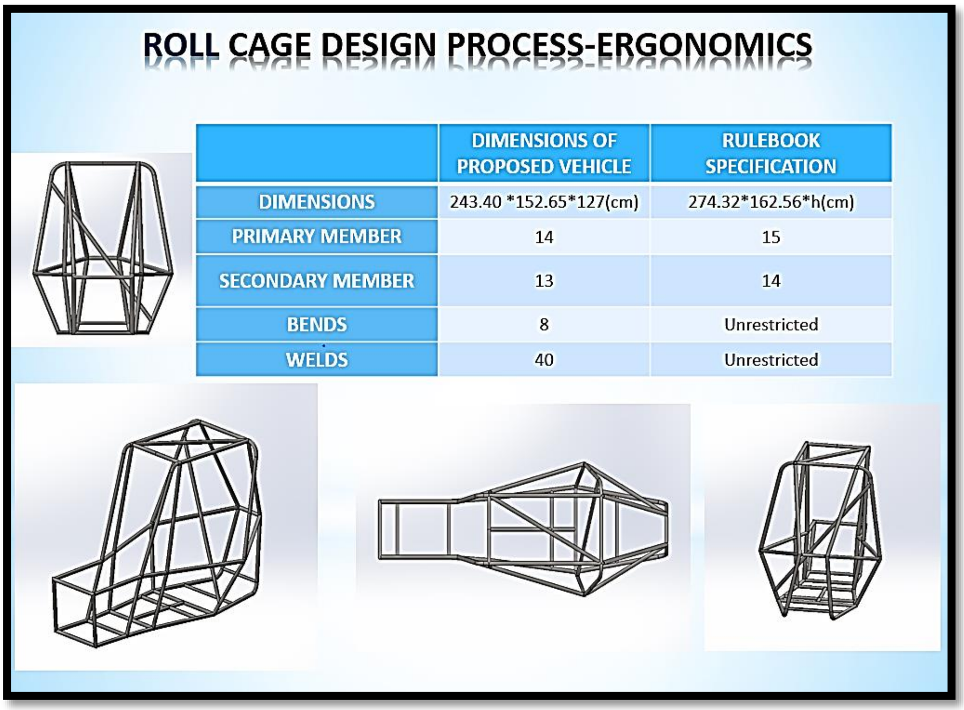
Figure. 2: A B and B Pedal Placement, Roll cage with clearance

4. Tech specs and performance specs of proposed vehicle as shown in Fig. 3 45678910 and 11[9-11]:

OVERALL DIMENSIONS	
Overall Width	152.654 cm
Overall Length	243.408 cm
Front Track Width	139.7 cm
Rear Track Width	144.78 cm
Ground Clearance	32 cm
WHEELS/ TIRES	
Diameter	53.84 cm
Width	12.95 cm
TRANSMISSION	
Electric Motor	BLDC, 5kW
Battery	5.77kW
FRONT AND REAR SUSPENSION	
Double Wishbone Suspension System	
BRAKES	
Front Rear	Disc Brake Type
STEERING	
Ackerman Steering Mechanism	

OVER ALL TARGET PERFORMANCE	
Max. Speed	50kmph
Max. Acceleration	0-40 kmph in 8 sec
Gradeability %	57.73%
Stopping Distance from 45kmph	35.89 m
Vehicle Speed	40kmph
Weight and its pie chart	400kg
Kerb weight	325kg
Ratio FAW to RAW	40:60

Figure. 3: Shows the overall dimensions and overall performance of the E-ATV



	DIMENSIONS OF PROPOSED VEHICLE	RULEBOOK SPECIFICATION
DIMENSIONS	243.40 *152.65*127(cm)	274.32*162.56*h(cm)
PRIMARY MEMBER	14	15
SECONDARY MEMBER	13	14
BENDS	8	Unrestricted
WELDS	40	Unrestricted

Figure. 4: Shows the Roll Cage Design Process and Ergonomics

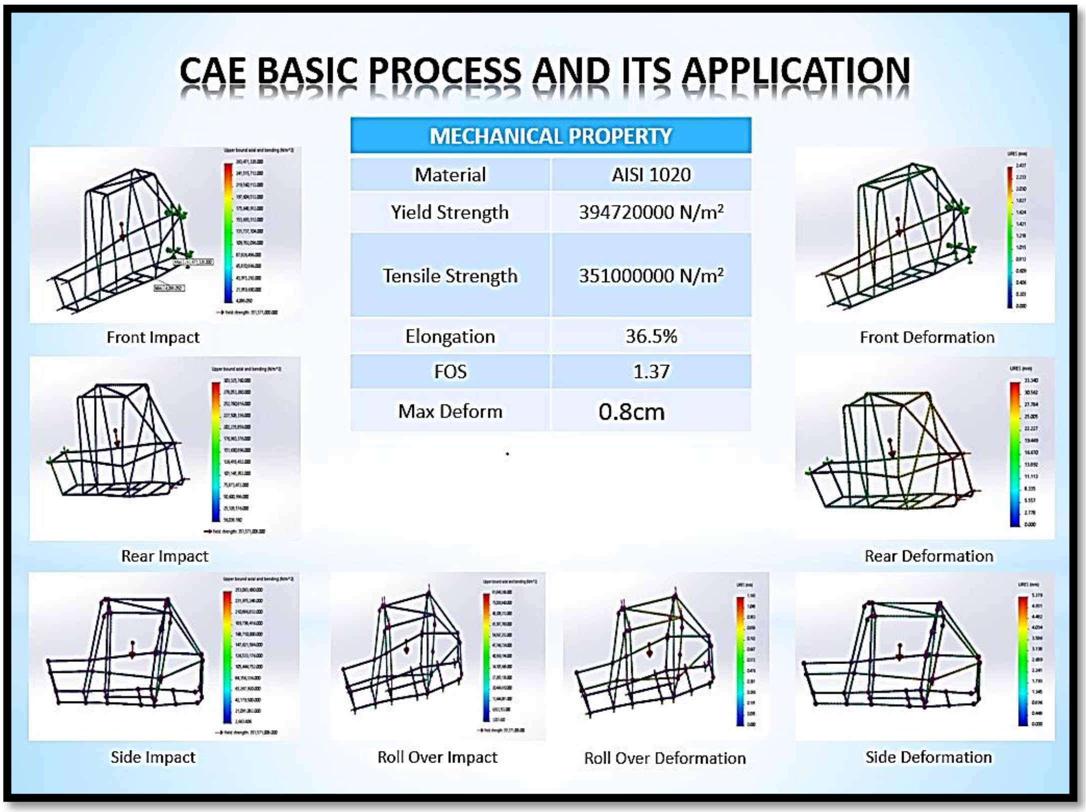


Figure. 5: Shows the CAE Basic Process and its application

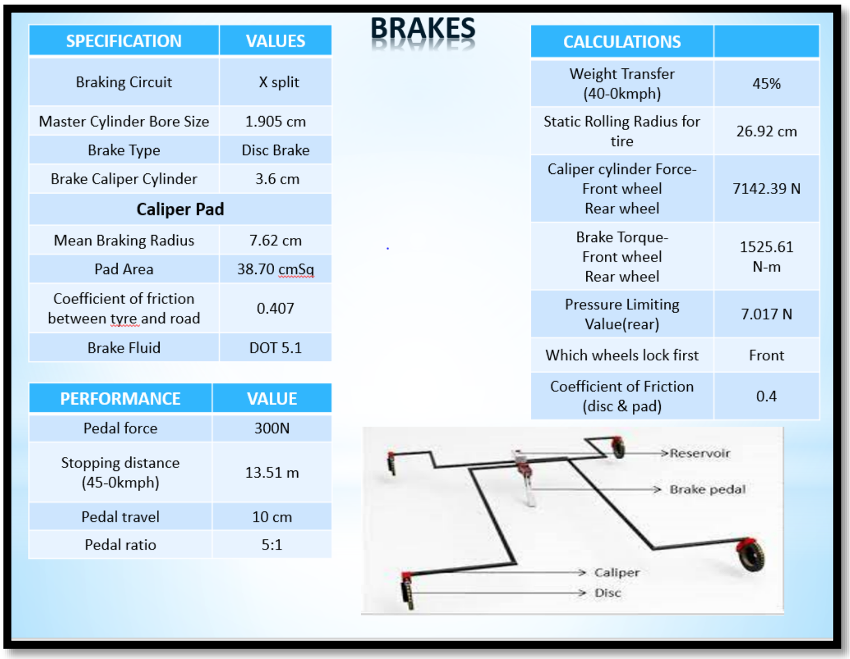


Figure. 6: Shows the Brakes Calculations

STEERING

STEERING SYSTEM	
Steering Mechanism	Ackerman Steering Mechanism
Ackermann Steering Percentage	99.99%
Rack Travel	15.95
Steering Ratio	9:1
Steering Torque Needed	4427.65N-m
Steering Column Type	Collapsible Steering Column
Lock to Lock Travel	$2\frac{11}{180}$ turns
Steering Wheel Diameter	29.97 cm
Turning Circle Radius	306 cm

STEERING ANGLE	
Inside	42.4898deg
Outside	29.685deg

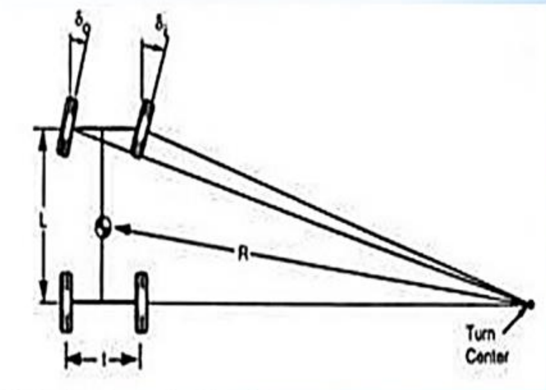


Figure. 7: Shows the Suspension / Front / Rear complete details

SUSPENSION-FRONT/ REAR

PARAMETER	FRONT	REAR
Suspension	Double wishbone, Damper to lower wishbone	Double Wishbone , Damper upper wishbone
Linkage Type	Eye ball	Eye ball
Natural Frequency	1.8Hz	2Hz
Spring Stiffness	54N/mm	43N/mm
Ride Rates	9.32N/mm	9.42N/mm
Scrub Ratios	25mm	18mm
Motion Ratios	0.68	0.7
Roll Center Height	10.5 inches 266.7 mm	11.5 inches 279.4 mm

FACTORS	STATIC VALUES
Camber	3deg (cornering)
Caster	4-5deg (self centering)
King Pin Inclination	8-10deg
Sprung Mass Targets	350Kg
Un-sprung Mass Targets	50Kg
Toe in & Toe out	1-2deg

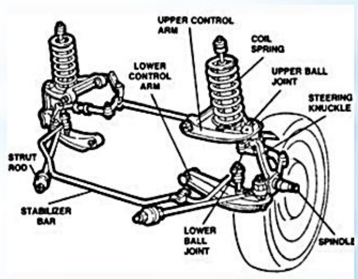


Figure. 8: Shows the Steering calculations

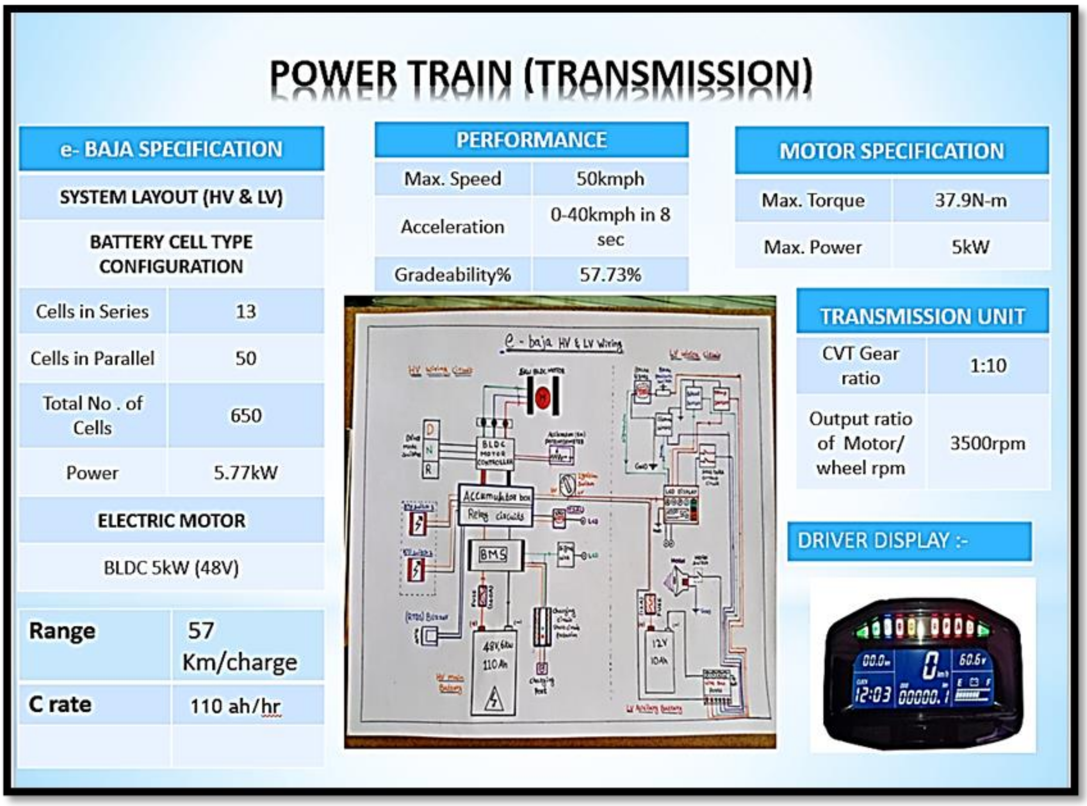


Figure. 9: Shows the Design and performance of the power train

DFMEA

Parts where chance of failure are more	Potential Failure Mode	Potential Effect of Failure/ Decrease in performance	Severity	Potential cause of failure	Occurance	Current Design control type	Detection	RPN	Recommended actions	S	O	D	RPN
Frame (roll cage)	Structural failure , Improper welds , Cracks	Damage to the roll cage , Frame breaks or bends, Internal parts get damaged	9	Axial stress exceeding the yield stress of material, Inclusions in welds	5	More safer design	8	360	Using better material having good FOS , Proper welds , constant analysis	9	3	4	108
Brake System	Mechanical failure, leakage of brake oil	Brake failure , may lead to damage of vehicle	8	No proper mounting and heating at uneven surfaces	4	Rigid mounting of master cylinder	2	64	High FOS material, Rigid mounting constant testing	8	2	2	32
Electrical components	Electrical connection and insulation failure	Endangers drivers safety and may lead to explosions	9	No proper insulation, water damage, circuit failure	5	Circuit and insulation review	2	90	Proper Insulation , proper wiring	9	3	2	54
A arms and trialing arms	Bending, breakage Fatigue	Damage to the suspension , non operable	7	Excess off load on welds,high axial stress	5	Use safer material	7	245	High FOS material, design analysis	7	3	4	84
Tires	Wear and over inflation	Puncture of the tires, instability, tire life reduces	7	High camber and caster angle	6	Proper wheel alignment	4	168	Good stiffness of A arm	7	3	3	63

Figure. 10: Shows the Design failure mode and effect analysis of all the parts [9-11]

a

DESIGN VALIDATION PLAN

	DESCRIPTION	ACCEPTANCE CRITERIA	PERSON RESPONSIBLE	TEST RESOURCE	START DATE	END DATE
1	Welding Test	The tensile strength should be 401Mpa and Bending strength should be 427Mpa	B. Harish Nair	UTM	21/10/21	22/10/21
2	Spring Test {Stiffness}	Should take the entire mass of the Vehicle	B. Harish Nair	UTM	23/10/21	24/10/21
3	Brake Test	All the wheels should lock at the same time	Gnana Tejus B	Braking Test Track	25/10/21	26/10/21
4	Steering Test	Turning the vehicle with full steer of radius less than 5m	Gnana Tejus B	Steering Test Track	27/10/21	28/10/21
5	Top speed/ Acceleration Test	Top speed of 40kmph	Gnana Tejus B	Chassis dynamometer/ Acceleration Track	29/10/21	30/10/21
6	Egression test	The circuits should disengage and driver should out within 5 secs	Sai Shravani SV	Pressing the kill switch when vehicle is running	31/10/21	1/11/21

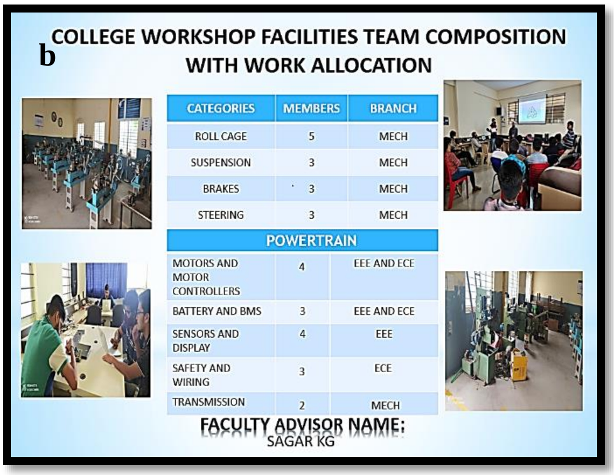


Figure. 11: a and b Design validation and facilities in the college

5. Brakes calculation [9-11]:

- Condition; v=45kmph
- Pedal force = 100N
- Brake pedal force = force on pedal * ratio of pedal
  - F = 100*5 = 500N

- Master cylinder pressure (P_{mc}) = F/A
- Area of the Master cylinder = π/4 $(19.05)^2$ – 285.02mm^{2} = 1.75 N/mm^{2}.
- Force on caliper piston = p*a
- Area of caliper piston = pie/4*(25.4)2 – 506.70mm2 = 286.72
- Caliper clam load = f.2*f N = 1773.4 N
- Frictional force = 1773.4*0.4 = 709.36N.
- Torque of rotor = T*F*R = 709.36 * 114.3 = 81.07Nm.
- Force on tires F = T/R (radius of the tires) = 81.07/0.2690 = 301.37 N
- Force on all tier = 4*301.37 = 1205.5N
- Deceleration of vehicle = 1205.5/400*9.81 = 0.3072 m/sec2
- Stopping distance at 45kmpm at a pedal force of 100N is 5.17m.
- Stopping time s2 v/a = 12.5/0.3072 = 40.69 sec.

6. Steering calculations [9-10]:

- Steering principle- Ackerman percentage
- Outer turning angle = θo =25.67°
- Inner turning angle = θi =37.68°
- Turning circle radius = 3.394m
- Ackerman percent = 100%
- Steering ratio = 9.5:1
- Lock to lock travel = 1.98 turns = 149/50 turns
- Rack travel = 6.283 inch
- Steering wheel diameter = 11.8 inch
- Steering torque = 4 N-m
- Tie rod length = 15 inch
- Tie rod diameter = 2 cm
- Rack length = 15 inch
- Steering column type – Collapsible steering column

7. Frame / rollcage calculation [9-11]:

Objective: To know the static, dynamic and torsional analysis of Roll cage/frame

Method used: FEA

Modelling software used: Solid works 2020

7.1. Pre-processing:

1. Geometry: Designed on solid works design software platform
2. Mesh: Beam mesh
3. Nodes: 825
4. Element quality-
5. Element type – circular tubular
6. Element size- 5mm (741 elements)
7. Order – program controlled

7.2. Constraints:

7.2.1. Static analysis:

1. Front impact:

Force - 4000N

Point of action- frontal members

Direction -x axis towards CG

Max displacement: 7mm

Max stress: 345.5 MPa

Yield strength: 351.5 MPa

Min FOS:1.017

2. Rear impact:

Force – 4000N

Point of action – Rear members

Direction- x axis towards CG

Max displacement – 6.15mm

Max stress- 186.8 MPa

Yield strength- 351.5 MPa

Min FOS- 1.881

3. Side impact:

Force- 4000N

Point of action- side profile members

Direction – z axis towards CG

Max displacement – 6.8mm

Max stress- 316.1MPa

Yield strength: 351.5 MPa

Min FOS- 1.112

4. Rollover impact:

Force: 4000N

Point of action: top roof points

Direction: y axis towards CG

Max displacement: 1.3mm

Max stress: 99 MPa

Yield strength: 351.5 MPa

Min FOS: 3.547

(Strongest part of frame)

8. Cae analysis:

1. FOS: Average of all
2. Deformation: respective
3. Max stress: respective
4. Life: 10^6 cycles

8.1. Properties:

8.1.1. Mechanical properties:

- ✓ Yield strength- 352 MPa
- ✓ Ultimate strength – 394.72 MPa
- ✓ Poison’ ratio: 0.29

8.1.2. Thermal properties:

- ✓ Specific heat: 420 J/kg K

- ✓ Conductivity – 47 W/m k

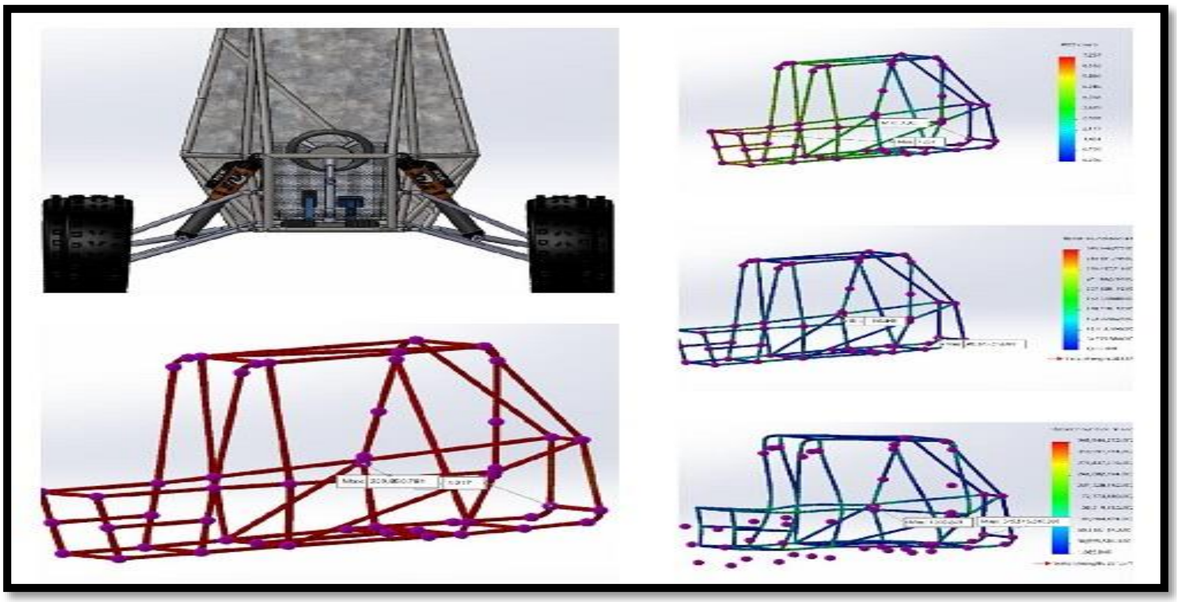


Figure. 12: Shows the CAE Analysis FRONT IMPACT

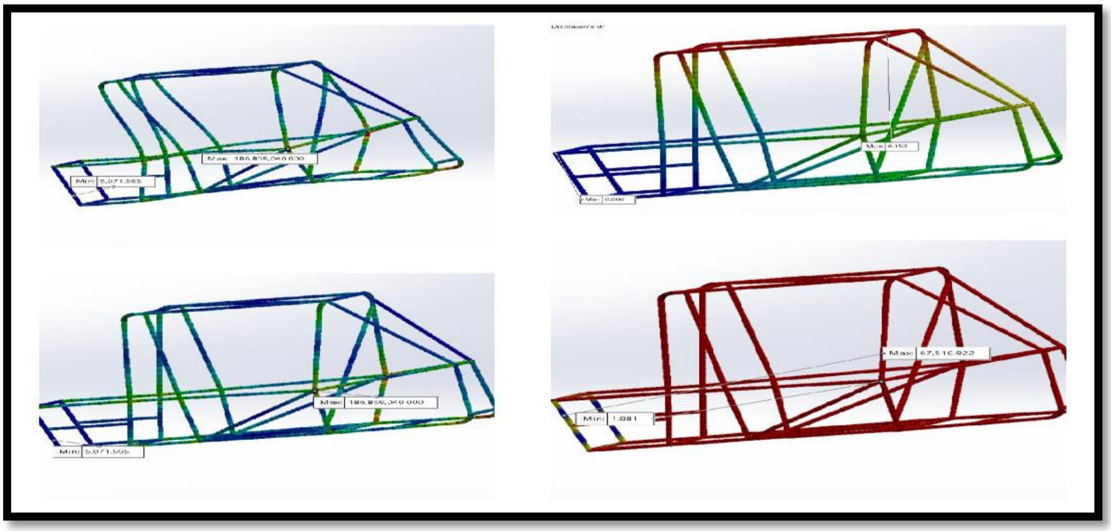


Figure. 13: Shows the CAE Analysis of REAR IMPACT

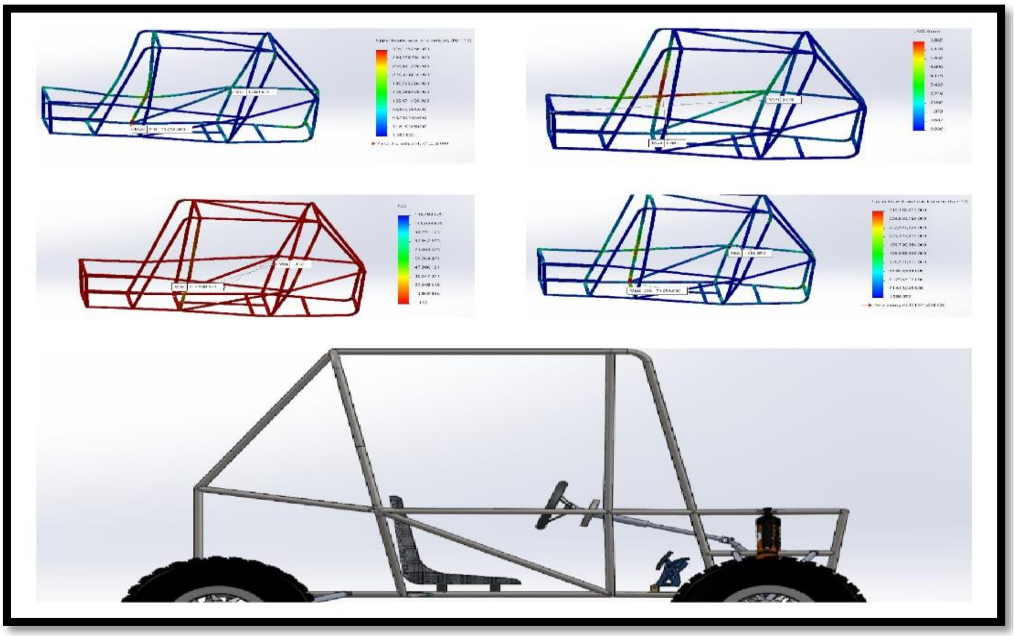


Figure. 14: Shows the CAE Analysis of SIDE IMPACT

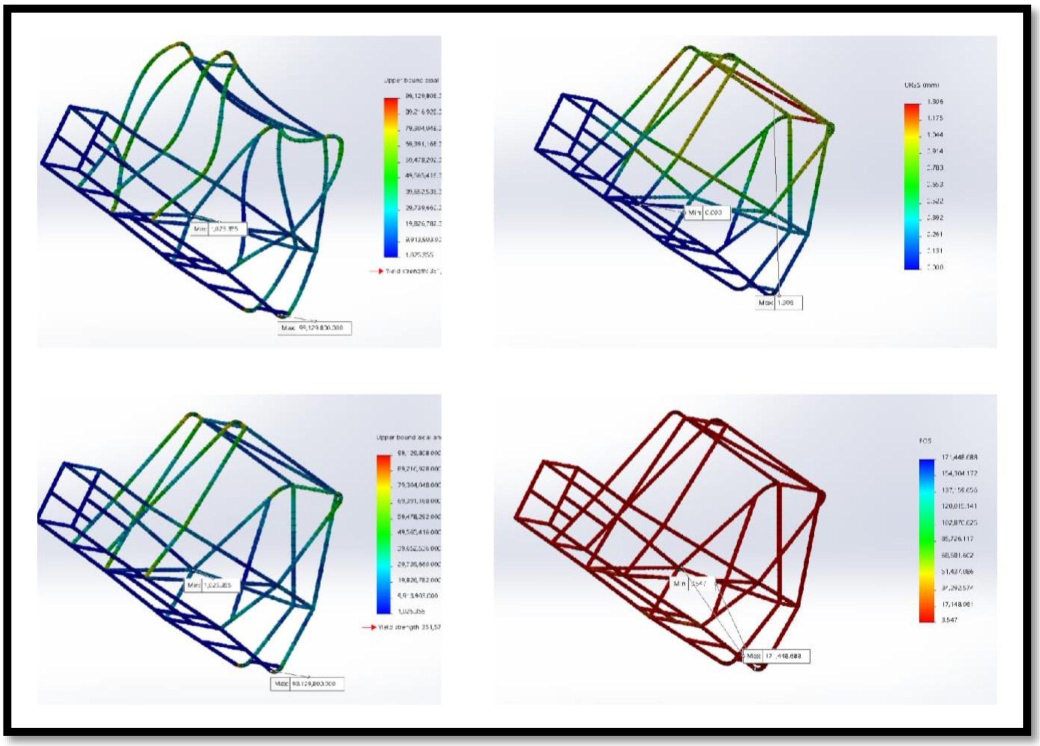


Figure. 15: Shows the CAE Analysis of ROLL OVER IMPACT

8.1.3. Analysis of tie rod [8-10]:

Objective: To know the static, dynamic and torsion of tie rod.

Method used: FEA

Modelling done using: solid work software

Preprocessing:

1. Geometry: Imported from solid work design model
2. Mesh
3. Nodes: 8318
4. Element quality :0.577
5. Element type: Tetrahedron
6. Element size :5mm
7. Order: programme controlled

Constraints:

Static analysis:

➢ Force: 4440N

a) Direction: x axis

b) Point of action: Tie rod end

➢ Moment: 8043N

a) Direction: x axis

b) Point of action: Tie Rod end

➢ Torsion:

➢ Displacement: 90

a) Direction: y axis

b) Point of action: Tie Rod end

Dynamic analysis:

➢ Force: 1000N

a) Direction: Z axis

b) Point of action: tie rod end

9. Results: All the analysis below are well with the prescribed limits as per the rule book 2021 [1-11]:

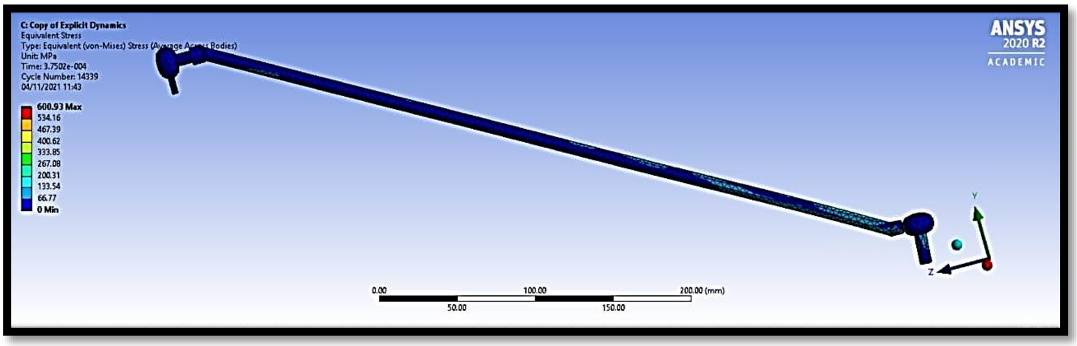


Figure. 16: Shows the Dynamic Analysis of the Tie Rod

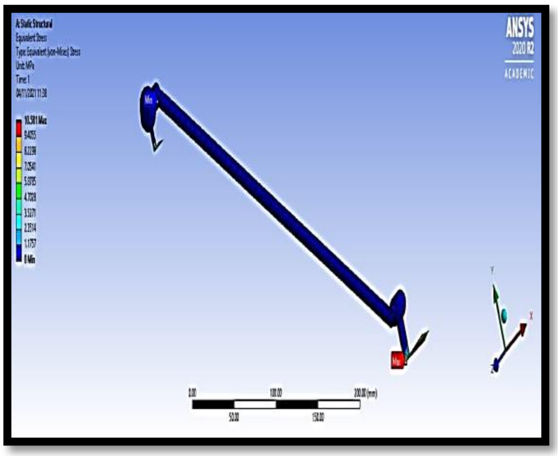


Figure. 17: Shows the Static Analysis Tie Rod

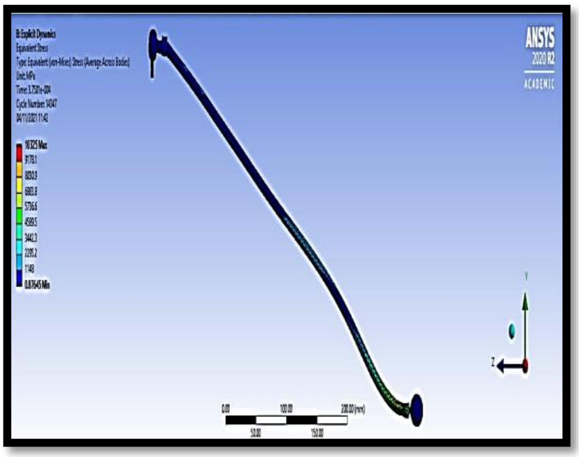


Figure. 18: Shows the Torsional Analysis of the Tie Rod

9.1. Cae analysis:

1. FOS – 15
2. Deformation – 1.48 *10-4 mm
3. Max stress -10.881 MPa
4. Life – 10^6 cycles

9.2. Properties:

Mechanical properties

1. Yield strength – 250 MPa
2. Ultimate strength – 0 MPa
3. Poisson's ratio-0.3

Thermal properties

a) Conductivity -0.0605 watts per meter-kelvin

b) Specific heat – $4.34x10^5$ j $kg^{-1}K^{-1}$

9.3. Fatigue graph:

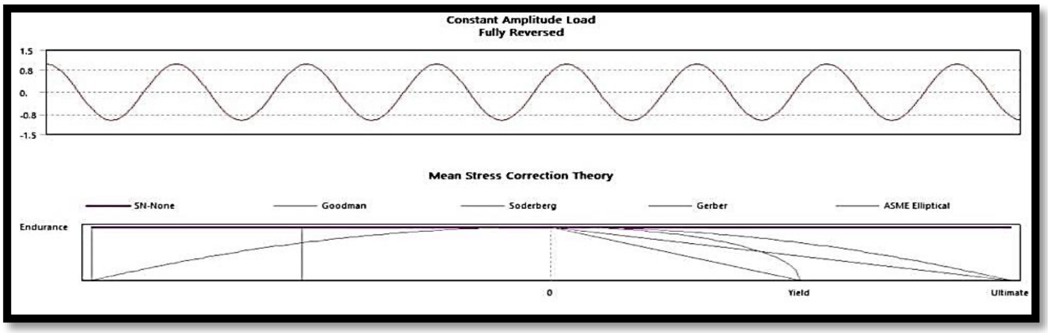


Figure. 19: Shows the Fatigue analysis of Tie Rod

9.4. Hub analysis [7-11]:

- **Objective: To know the Static analysis for hub.**
- Method used: FEA
- Modeling done using: Solid work Software
- Preprocessing:
- Geometry- Imported from solid work design model
- Nodes – 23069
- Element quality – 0.569
- Element Type – Triangular
- Element size – Default
- Order – Program Controlled
- Static Analysis
- Moment – 40675 N-mm
- Direction – Z Component
- Point of moment – Hub
- Fixed Support – Spindle
- Bearing Load on – bolt holes
- Magnitude – 667.23 N
- Direction – Y axis

10. Results:

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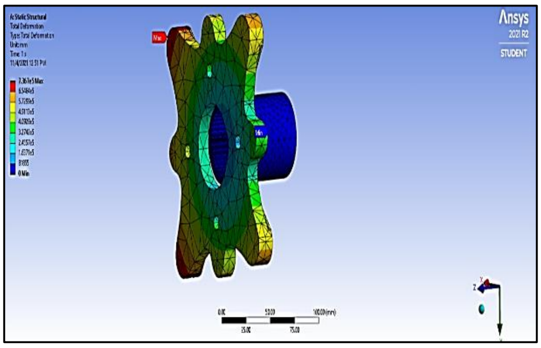


Figure. 20: Hub Analysis showing the Total Deformation

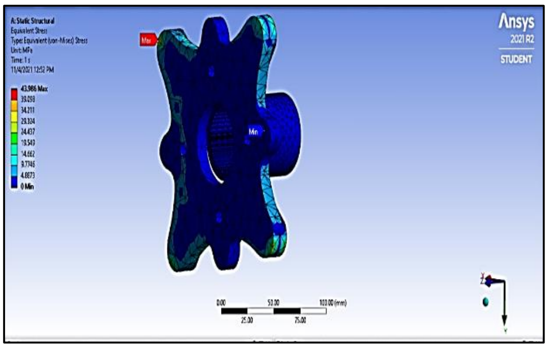


Figure. 21: Hub Analysis showing the Equivalent Stress

10.1. CAE Analysis:

- FOS – 5
- Max Deformation – $7.367*10^5$ mm
- Max Stress – 43.986 MPa
- Life – 10^6 cycles
- Properties:
- Material – Structural steel
- Mechanical Properties:
    - Yield strength – 250 Mpa
    - Ultimate strength – 0 Mpa
    - Poison's Ratio – 0.3
- Thermal Properties:
    - Conductivity – 0.0605 watts per meter-kelvin
    - Specific Heat – $4.34*10^5$ j $kg^{-1}K^{-1}$

10.2. Fatigue Graph:

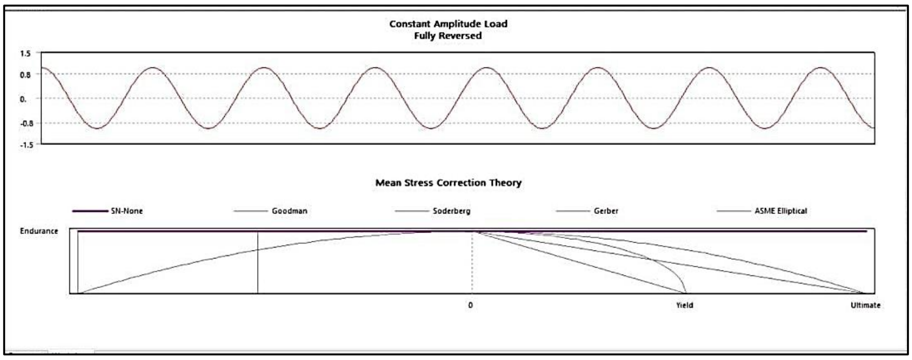


Figure. 22: Shows the Fatigue analysis of Hub

10.3. Upright analysis:

- Objective: To know the Static & Dynamic analysis of Upright
- Method used: FEA
- Modeling done using: Solid work Software
- Preprocessing:
- Geometry- Imported from solid work design model
- Mesh:
- Nodes – 125392
- Element quality – 0.829
- Element Type – Triangular
- Element size – Default (In Ansys Software)
- Order – Program Controlled

10.4. Constraints:

- Static Analysis
- Moment – 804483 N-mm
- Direction – y Component
- Point of action– At tie rod connection point
- Fixed Support – Bolt holes
- Pressure – 10000 Mpa
- Direction – X component
- Point of action – Hub center
- Dynamic Analysis
- Fixed support – Bolt holes
- Force – 1000 N
- Direction – Z component
- Point of Action – Tie rod connection point

11. Results:

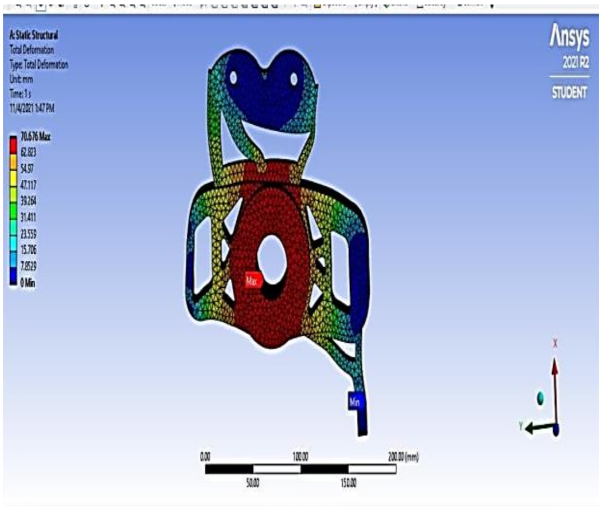


Figure.23: Showing the Static Total Deformation

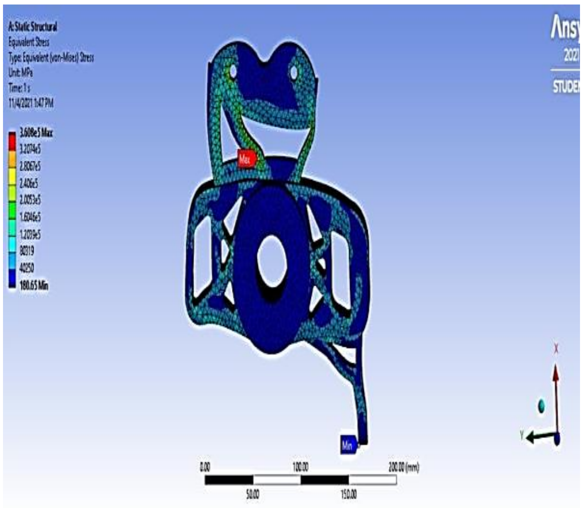


Figure. 24: showing the Static Equivalent Stress

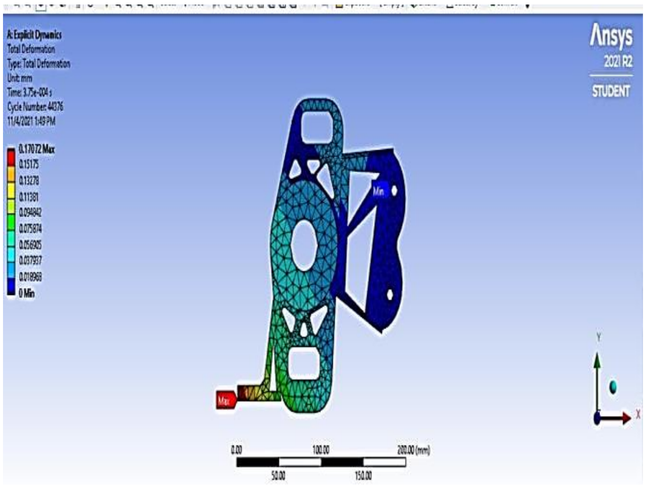


Figure. 25: Showing the Total Dynamic

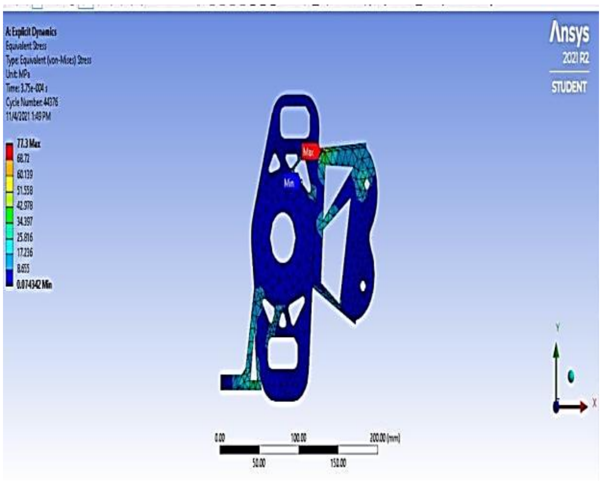


Figure. 26: Showing the Dynamic Equivalent stress

11.1. Cae analysis:

FOS – 1.38

Deformation – 70.676mm

Max Stress – $3.608*10^5$ MPa

Life – 37,237 cycles

11.2. Properties:

11.3 Mechanical properties:

- ✓ Yield strength – 250 MPa
- ✓ Ultimate strength – 0 MPa
- ✓ Poisson's ratio-0.3

11.4. Thermal properties:

a) Conductivity -0.0605 watts per meter-kelvin

b) Specific heat – 4.34×10^5 j $kg^{-1}K^{-1}$

11.5. Fatigue graph:

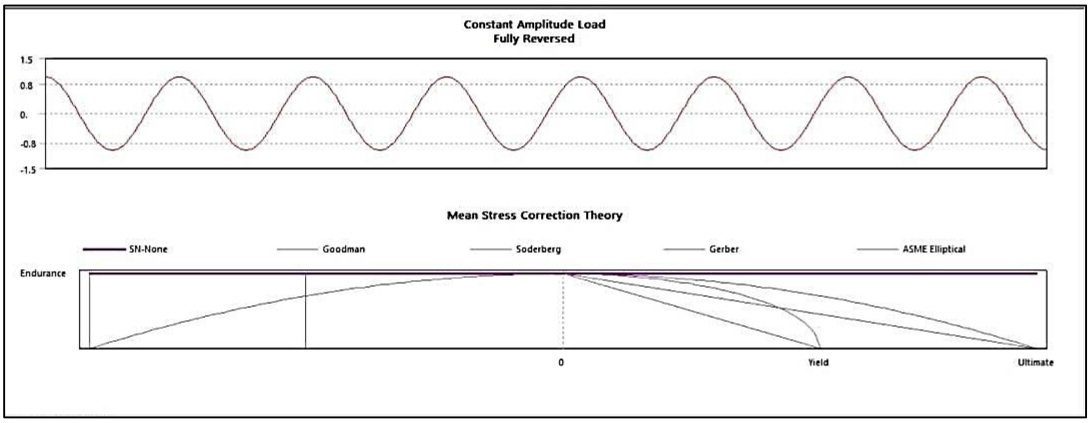


Figure. 27: Shows the Fatigue Analysis

12. Black disc analysis [6-10]:

- Objective: To know the static and thermal analysis for disc
- Method used: FEA
- Modelling used: solid works software

Pre-processing:

- **Geometry**- imported form solid work design model

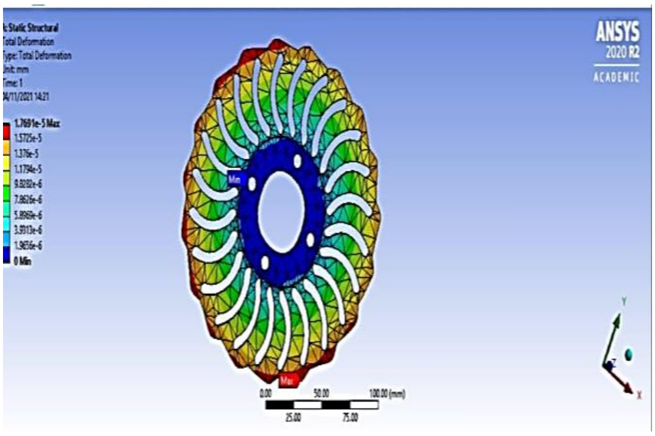
Mesh

- Nodes- 7989
- Element quality- 0.5182
- Element type- Triangular
- Element size – default
- Order- program controller

Constraints

- static analysis:
- Force- 1773.2 N
- Force2 –1773.
- Directions – 2 faces
- Fixed support- 4 bolts holes
- **Thermal analysis:**
- temperature
- convection(air)

13. Results:



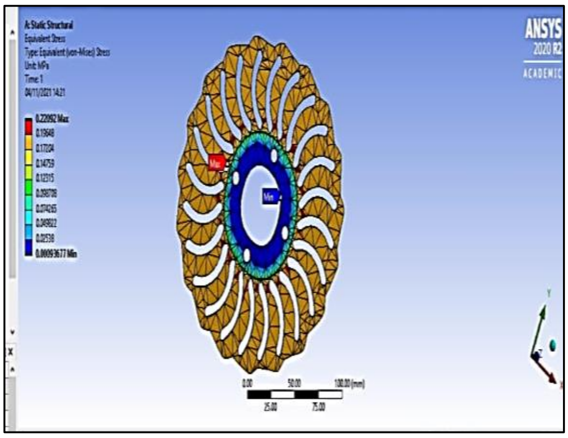


Figure. 28: Shows the Total Deformation of the Blank Disc Figure. 29: Shows the Total Equivalent Stresses

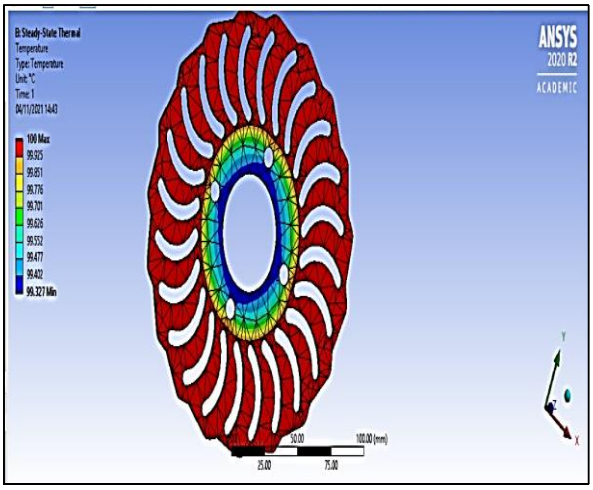


Figure. 30: Shows the Thermal Analysis Black Disc

CAE ANALYSIS

- FOS -2
- Max deformation -3.05x10^$^{-5}$
- Max stresses- 0.220 MPa
- Life – 10^^{6} cycles

<u>Properties</u>

- Material – Cast Iron
- Yield strength- 1.1x10$^{\wedge 5}$ MPa
- Ultimate strength – 240 MPa
- Poisson's ratio – 0.25

Thermal properties

- Conductivity – 0.052 watts per meter-kelvin
- Specific heat – 4.47x 10$^{\wedge 5}$ j kg^{-1}K^{-1}

FATIGUE GRAPH

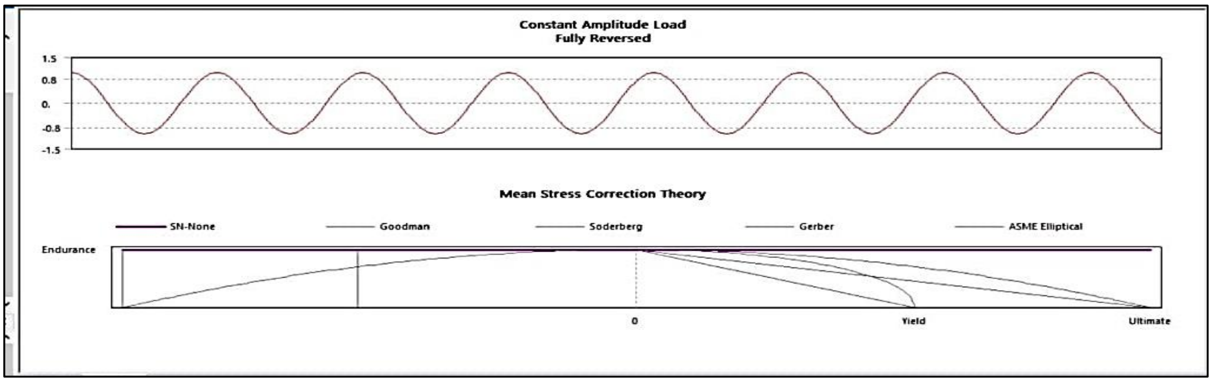


Figure. 31: Shows the Fatigue Analysis

TRAILING ARM

- Objective: To do the static analysis of training arm
- Method used: FEA
- Modelling used: solid works software

Pre-processing

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- Geometry- Imported from solid work design model
- Mesh
- Nodes-6521
- Element quality-0.9
- Element size- default (In Ansys software)
- Element type- rectangular and tetrahedron
- Order- program controlled

Constraints:

- Static analysis
- Fixed support- At bolt holes
- Force – 4440 N (x axis), 3290N (y axis)
- Point of force – At Rear wheel joining

14. Results:

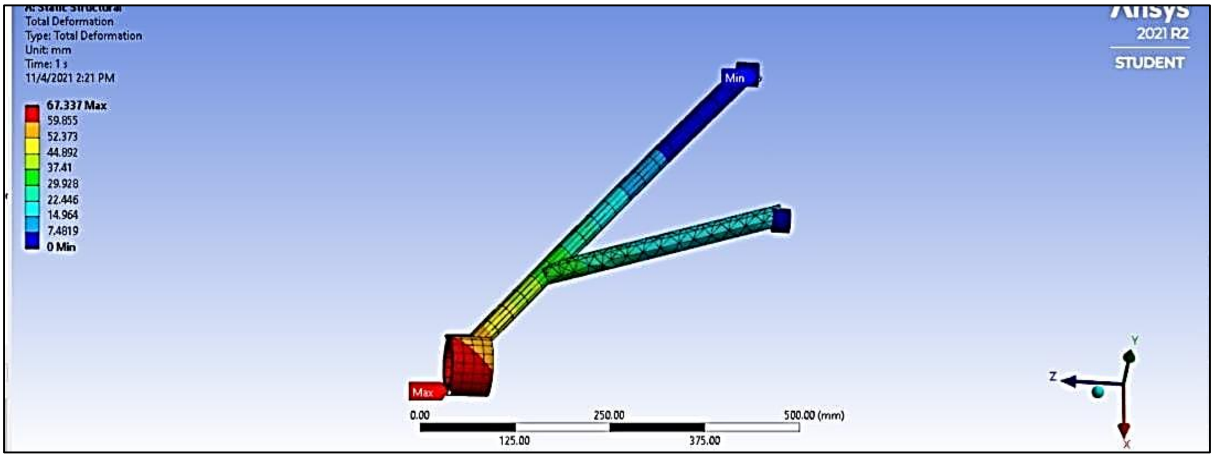

Figure. 32: Shows the Total Deformation of the Trailing Arm

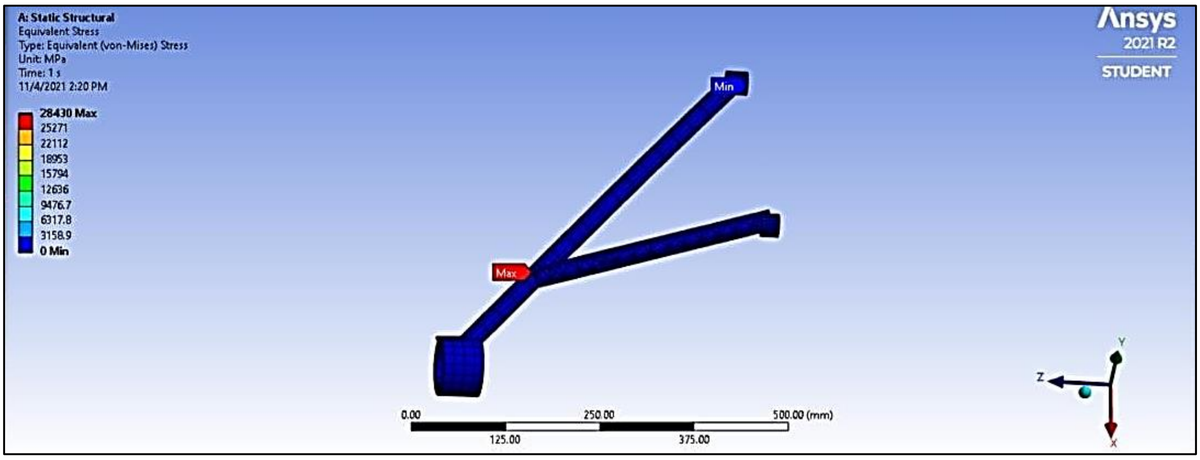

Figure. 32: Shows the Total Equivalent Stress of the Trailing Arm

Cae analysis:

- FOS – 1
- Max deformation- 67.337 mm
- Max stress – 28430 MPa
- Life -10^6cycles

Mechanical properties:

- ✓ Yield strength – 250 MPa
- ✓ Ultimate strength – 0 MPa
- ✓ Poisson's ratio-0.3

Thermal properties

- ✓ Conductivity -0.0605 watts per meter-kelvin
- ✓ Specific heat – 4.34x10$^{\wedge 5}$ j kg^{-1}K^{-1}

Fatigue graph:

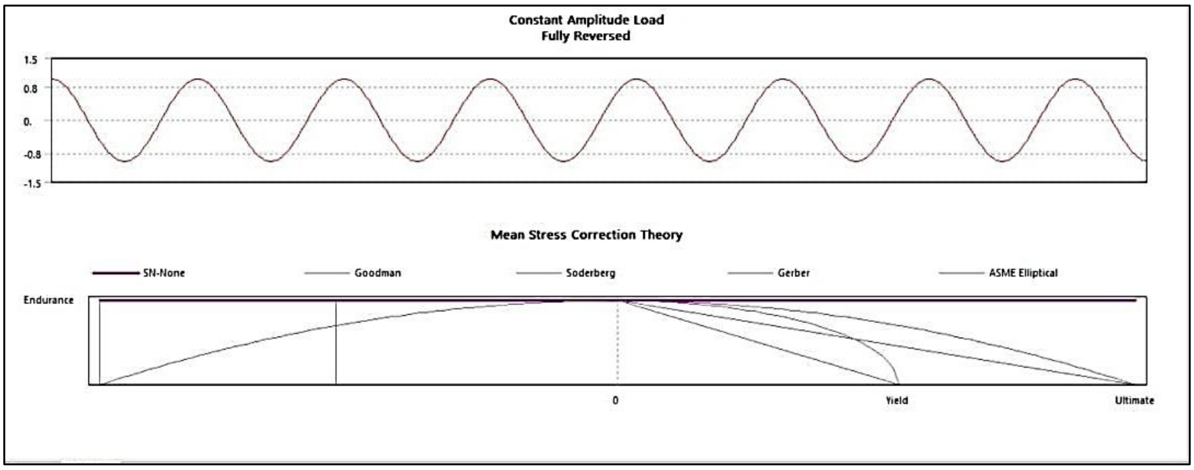

Figure. 33: Shows the Fatigue Analysis

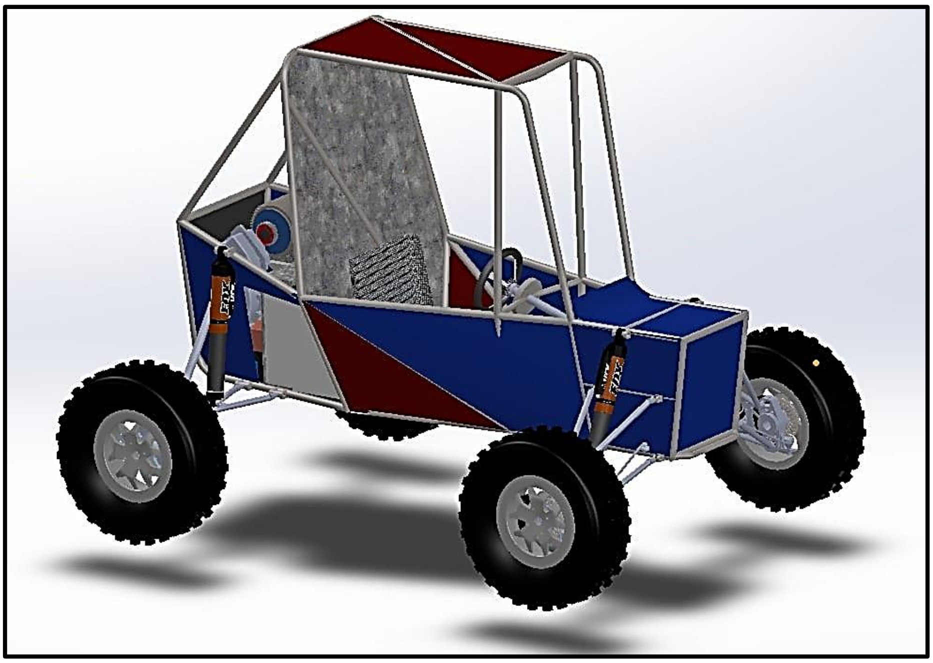

Figure. 34: Shows the Final Design of Electric ATV [9-11]

15. Conclusion:

For the E-BAJA competition, this project successfully designed, evaluated, and built an electric all-terrain vehicle (E-ATV). The E-ATV combined a number of important characteristics with meeting the competition's requirements:

1. Lightweight and robust chassis: The use of [AISI 1020] for the chassis construction ensured a balance between weight reduction and structural integrity, crucial for off-road performance and maneuverability.
2. Efficient electric drivetrain: The chosen electric motor and battery pack provided adequate power and torque for navigating challenging terrains while maintaining desired range and energy efficiency.
3. Suspension and drivetrain optimization: The suspension system effectively absorbed impacts and maintained vehicle stability, while the drivetrain configuration offered efficient power transmission to all wheels, enhancing handling and control.
4. User-centric design: The ergonomic considerations in the design, such as as per the rule book given by the SAE E-BAJA, ensured comfortable and safe operation for the driver during competition as per the rule book.

16. Scope for future work:

Several areas can be targeted for additional development in subsequent versions of the E-ATV based on the project's findings:

1. Material optimization: Looking for substitute materials with even higher strength-to-weight ratios may help cut down on total weight and boost efficiency.
2. Advanced battery technology: By utilizing more recent battery technologies with greater energy density, the range and recharge times of the E-ATV may be increased.
3. Sensor integration: By adding more sensors, it may be possible to monitor a variety of vehicle metrics in real time, giving useful information for improving performance and soliciting input from the driver.
4. Autonomous driving capabilities: Adding autonomous driving features to next E-BAJA tournaments may improve efficiency and safety as per the rule book 2021.

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17.1. Conflicts of interest:

No Conflicts of Interest

18. References:

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