COMPUTER AIDED ENGINEERING (CAE) REPORT

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➢ ABSTRACT

The main objective of this paper is to give detailed analysis of go-kart vehicles parts. The intention of this paper is modelling and analysis of go-kart vehicle parts according to their design calculation and simulation of parts. The modelling and analysis are performed by using 3D CAD design software tools such as SOLIDWORKS 2021 and subjected to simulation using ANSYS WORKBENCH 2021 R2 etc. where impact analysis was performed in front, rear, and lateral directions. Then we observed the flexural rigidity of structure and chassis deformation. The paper consists of design stresses and deformation result of different components of vehicle parts such as stub axle and stub arm of steering system, and temperature analysis of disc brake. Based on the result obtained from these tests the design is modified accordingly.

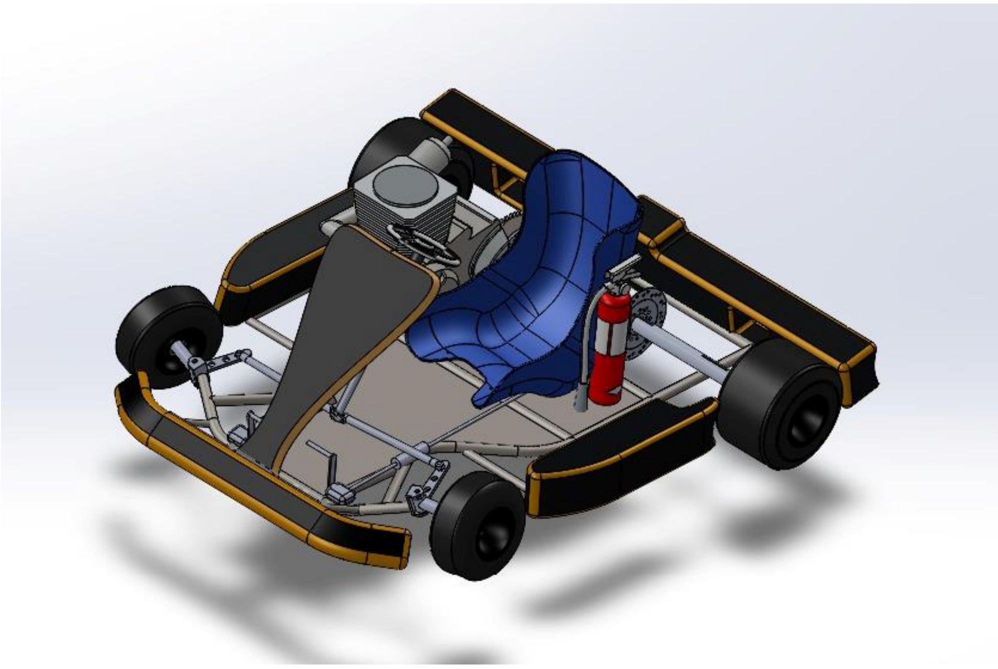

TABLE OF CONTENTS

➢ FACTOR OF SAFETY

SL NO.	COMPONENT	FOS
1	FRONTAL IMPACT	1.617
2	REAR IMPACT	1.965
3	SIDE IMPACT	3.055
4	C CLAMP	2.667
5	BRAKE PEDAL	1.3

➢ FRAME

MATERIAL DATA

MATERIAL	AISI 4130
TENSILE YIELD STRENGTH	460 MPa
POISSON'S RATIO	0.29
YOUNGS MODULUS	205 GPa
DENSITY	7.85 g/cm^3

TABLE 1: CHASSIS MATERIAL DATA

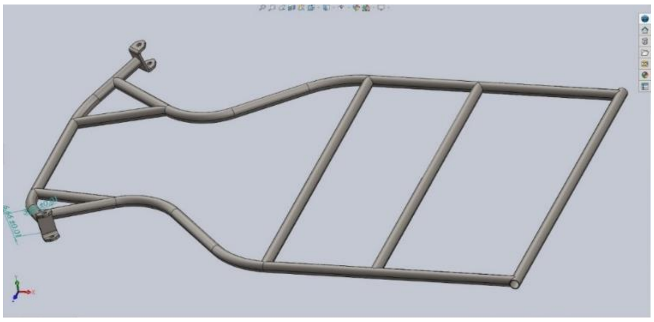

FIGURE 1 ANALYSIS MODEL OF CHASSIS

MESH QUALITY

This was done to obtain a solution with high accuracy. We have used mesh refinement in places where greater stress was expected like the bumpers and around the kingpin axis. The following data was found after meshing:

Element type	Tetrahedron
Element size	5mm
No. Of nodes	245885
No. Of elements	123460
Skewness	0.59695
Aspect ratio	3.1744

TABLE 2: MESH QUALITY OF CHASSIS

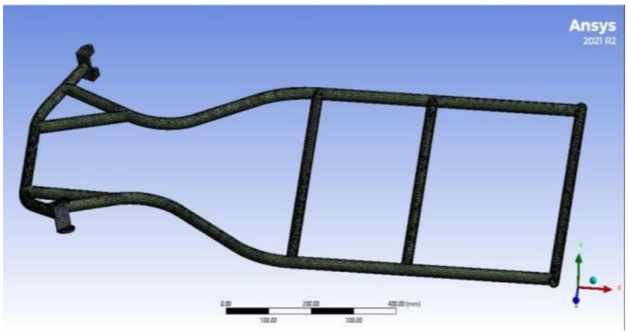

FIGURE 2 MESHED MODEL OF CHASSIS

FRONTAL IMPACT ANALYSIS

For the frontal impact analysis, the total weight of the kart was considered. The rear nodes and vertical axis of the c clap was fixed, and force was given to the foremost member of the chassis. Force was calculated for an optimal speed of 50 kmph. The driver would experience a G force of 5G.

$$Force\ F = m * g = 150 * 5 * 9.81$$
$$= 7357.5\ N$$

load	Deformation	Max. Stress	FOS
7375.5 N	1.605 mm	234.09 MPa	1.965

TABLE 3 FRONTAL IMPACT

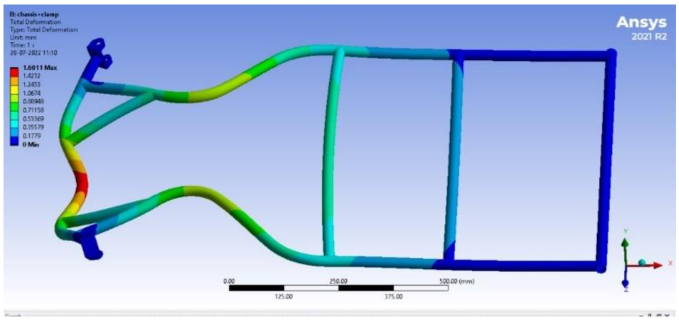

FIGURE 3 FRONTAL IMPACT TOTAL DEFORMATION

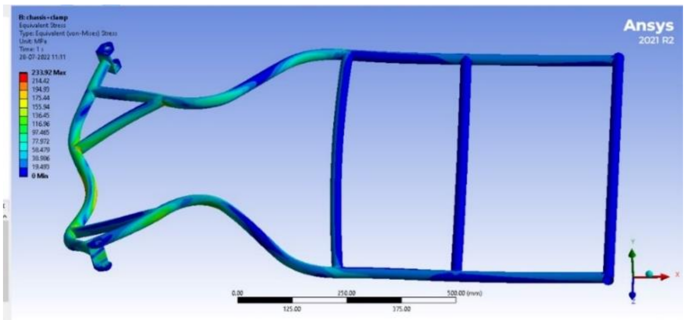

FIGURE 4 FRONTAL IMPACT EQUIVALENT STRESS

REAR IMPACT ANALYSIS

The analysis was carried out for collision from a vehicle travelling at 50kmph.Here, the front member is being fixed while load is applied at the rear section. The driver would experience a G force of 2G.

$$Force\ F = m * g = 150 * 2 * 9.81$$
$$= 2943\ N$$

load	Deformation	Max. Stress	FOS
2943 N	4.3018 mm	284.44 MPa	1.617

TABLE 4 REAR IMPACT

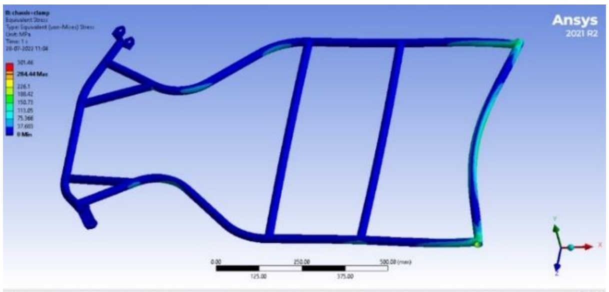

FIGURE 5 REAR IMPACT EQUIVALENT STRESS

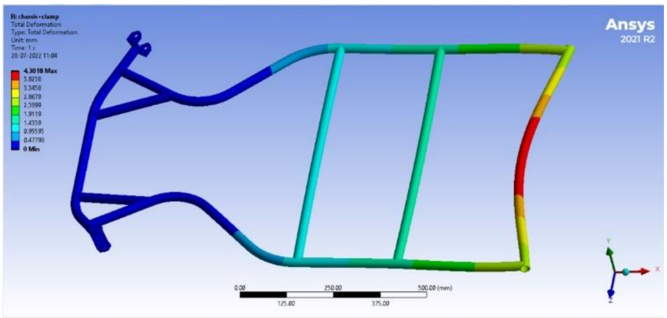

FIGURE 6 REAR IMPACT TOTAL DEFORMATION

SIDE IMPACT ANALYSIS

Here, the vehicle was fixed on the left side, while the right side was subjected to an impact from a vehicle traveling at 50 kmph. The driver would experience a G force of 4

$$Force\ F = m * g = 150 * 4 * 9.81$$
$$= 5886\ N$$

load	Deformation	Max. Stress	FOS
5880 N	0.5586 mm	150.53 MPa	3.055

TABLE 5 SIDE IMPACT

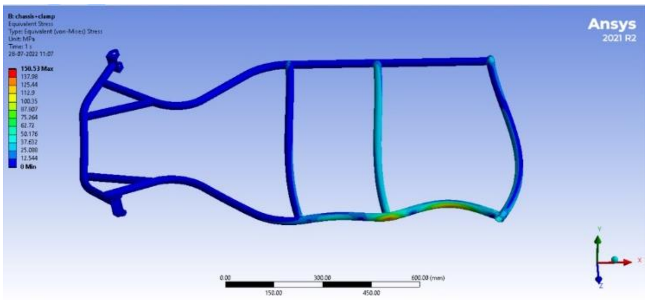

FIGURE 7 SIDE IMPACT EQUIVALENT STRESS

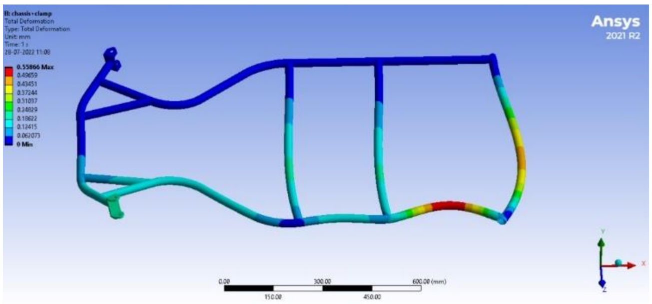

FIGURE 8 SIDE IMPACT TOTAL DEFORMATION

MODAL ANALYSIS

Modal Analysis gives us the natural frequencies of the body on which the analysis is being carried out.

If any external vibration has a frequency that matches the natural frequency of the body, resonance will occur.

Large deformation occurs due to resonance which is accounted for by this analysis.

The first mode occurs at 56.967 Hz as shown by the analysis report.

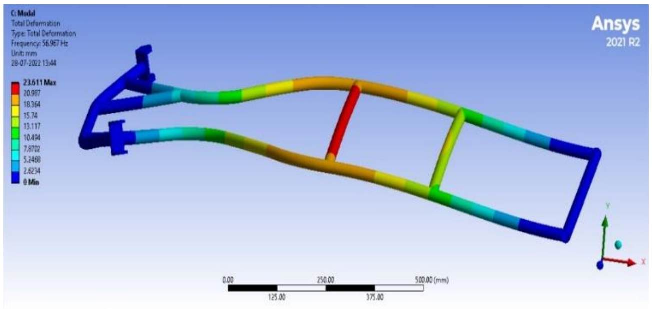

FIGURE 9 TOTAL DEFORMATION OF CHASSIS (MODE 1)

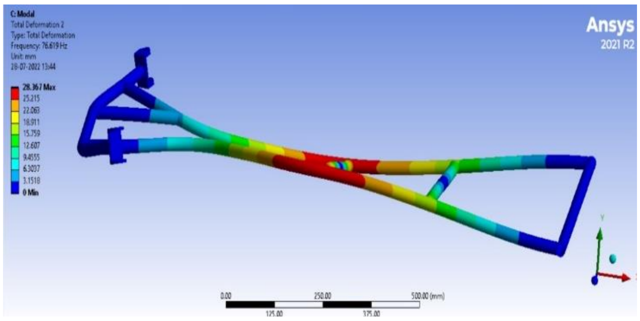

FIGURE 10 TOTAL DEFORMATION OF CHASSIS (MODE 2)

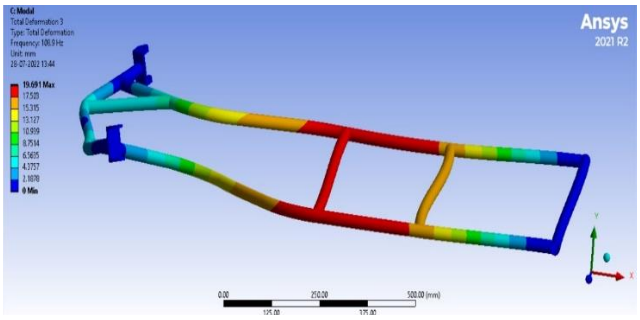

FIGURE 11 TOTAL DEFORMATION OF CHASSIS (MODE 3)

MODE	FREQUENCY (Hz)
1	56.967
2	76.619
3	108.9
4	132.23
5	178.26
6	180.23

TABLE 6 MODAL DATA OF CHASSIS

- ## C CLAMP

The C-clamp bears the load of the kart along with the driver. Therefore, analysis of the c clamp is mandatory.

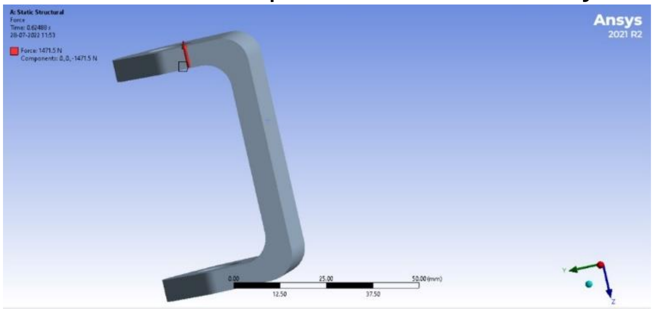

FIGURE 12 C CLAMP ANALYSIS MODEL

MESH QUALITY

Element type	Tetrahedron
Element size	1mm
No. Of nodes	30075
No. Of elements	16615
Skewness	0.38614
Aspect ratio	2-1998

TABLE 7 MESH QUALITY OF C CLAMP

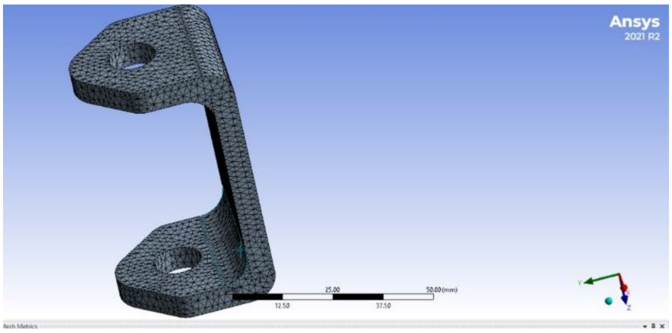

FIGURE 13 MESH QUALITY OF C CLAMP

STRUCTURAL ANALYSIS

The vertical axis was fixed while the load was added on to the surfaces bearing the weight of the kart and driver.

load	Deformation	Max. Stress	FOS
1177.2 N	0.0717 mm	172.43 MPa	2.667

TABLE 8 C CLAMP ANALYSIS

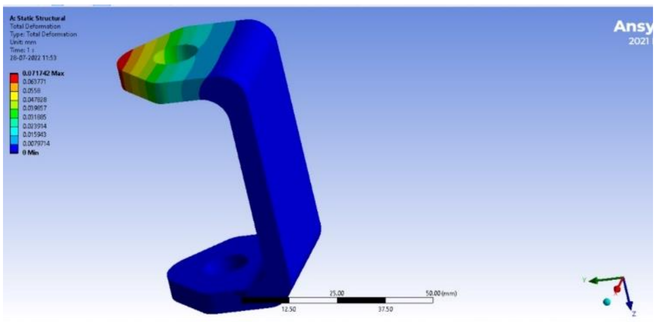

FIGURE 14 C CLAMP TOTAL DEFORMATION

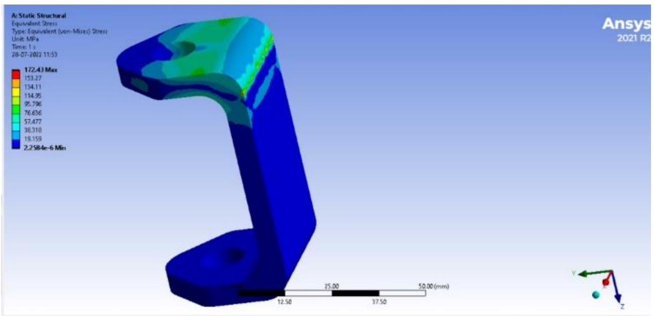

FIGURE 15 C CLAMP EQUIVALENT STRESS

- **BRAKING SYSTEM**

BRAKE DISC THERMAL ANAYSIS

MATERIAL DATA

Material	Grey cast iron
Density	7.15 g/cc
Thermal conductivity	46 W/m°C

TABLE 9 MATERIAL DATA OF BRAKE DISC

Mesh quality

Element type	Tetrahedron
Element size	1mm
Skewness	0.35
Aspect ratio	2.1667

TABLE 10 MESH QUALITY OF BRAKE DISC

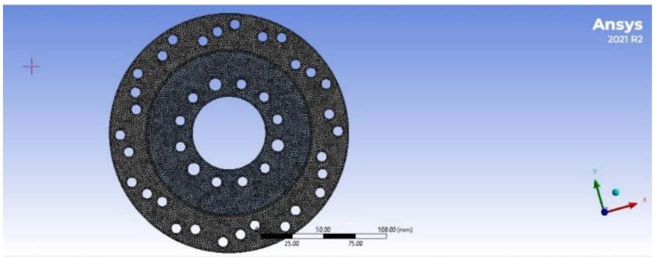

FIGURE 16 MESH QUALITY OF BRAKE DISC

Steady State Thermal Analysis

• Initial temperature: The initial temperature was set to 28° centigrade considering the temperature conditions in Bangalore in august.

• Convection: Convection is the dominant form of heat transfer seen and it was considered to act on the complete disc area. The value of film coefficient which was taken was 1.24 W/ m^2 °C. This was the film coefficient of the stagnant air obtained through research. (By referring to research papers).

• Heat flux: Heat flux basically signifies the amount of heat transfer through a given surface per unit time. The portion of the disc in contact with the disc calliper is the region which experiences the most amount of heat transfer. This was applied normally to both the opposite sides of the disc in contact with the pads.

Heat flux coefficient =0.001W/mm^2

• The rise in temperature due to friction of brake disc with brake pads was analysed and the following results were obtained

Max total heat flux	0.075666 W/mm^2
Max temperature	327°C
Min temperature	309.21°C

TABLE 11 THERMAL ANALYSIS OF BRAKE DISC

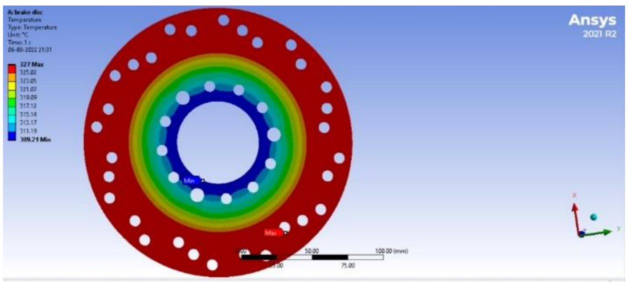

FIGURE 17 TEMPERATURE ANALYSIS OF BRAKE DISC

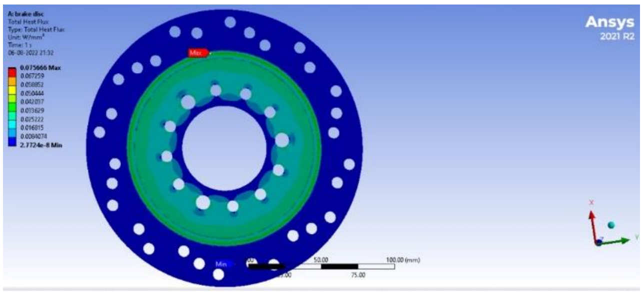

FIGURE 18 HEAT FLUX ANALYSIS OF BRAKE DISC

BRAKE DISC HUB

MATERIAL DATA

Material	Mild Steel
Density	7870 Kg/m^3
Poisson's ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 12 MATERIAL DATA OF BRAKE DISC HUB

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.41003
Aspect ratio	2.2569

TABLE 13 MESH QUALITY OF BRAKE DISC HUB

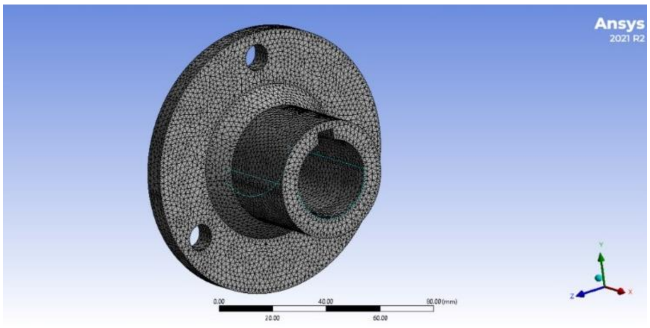

FIGURE 19 MESH QUALITY OF BRAKE DISC HUB

STATIC STRUCTURAL ANALYSIS

- The total applied force comprises braking torque and the driving torque.

Torque	Max. Deformation	Max. Stress
40KNmm	$6.3064*10^{-4}$ mm	4.1962 MPa

TABLE 14 STATIC STRUCTURAL ANALYSIS OF BRAKE DISC HUB

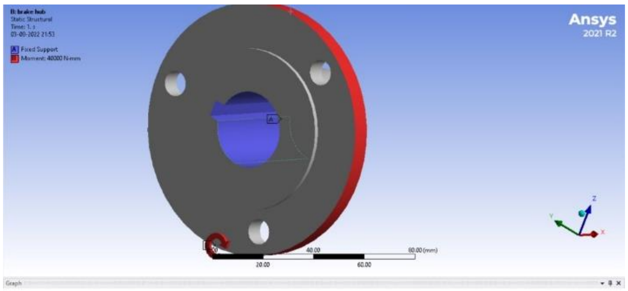

FIGURE 20 BOUNDARY CONDITIONS FOR BRAKE DISC HUB

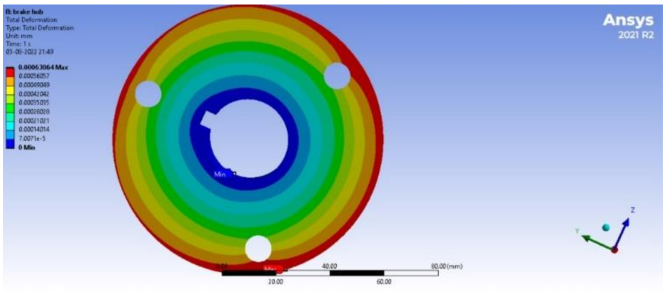

FIGURE 21 TOTAL DEFORMATION OF BRAKE DISC HUB

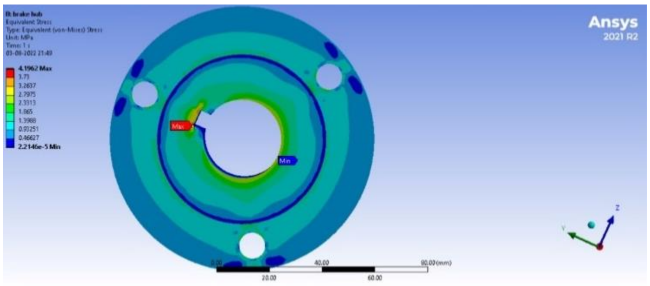

FIGURE 22 EQUIVALENT STRESS OF BRAKE DISC HUB

BRAKE PEDAL

MATERIAL DATA

Material	AISI4130
Density	7.85 g/cm^3
Poisson's ratio	0.28
Tensile yield strength	435 MPa
Tensile ultimate strength	670 MPa

TABLE 15 MATERIAL DATA OF BRAKE PEDAL

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.39234
Aspect ratio	2.2306

TABLE 16 MESH QUALITY OF BRAKE PEDAL

TABLE 17 MESH QUALITY OF BRAKE PEDAL

STATIC STRUCTURAL ANALYSIS

load	Deformation	Max. Stress	FOS
600 N	0.90837 mm	358.67 MPa	1.3

TABLE 18 STATIC STRUCTURAL ANALYSIS OF BRAKE PEDAL

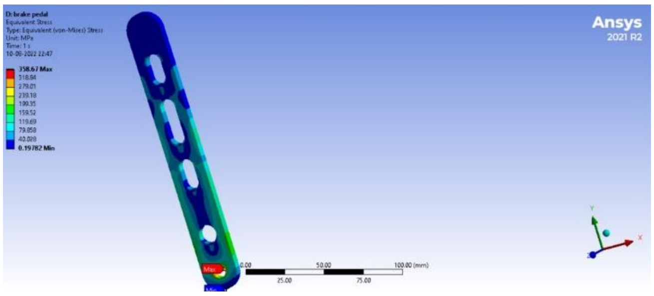

TABLE 19 EQUIVALENT STRESS OF BRAKE PEDAL

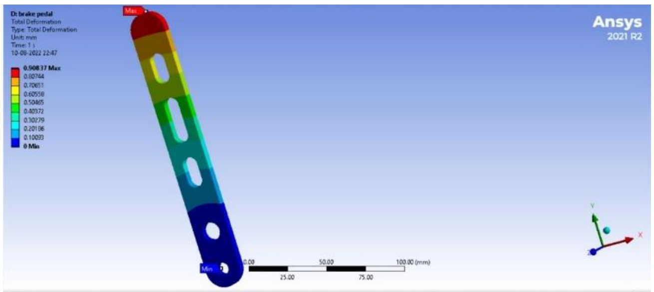

TABLE 20 TOTAL DEFORMATION OF BRAKE PEDAL

➢ TRANSMISSION SYSTEM

SPROCKET-1 (43 teeth)

MATERIAL DATA

Material	Mild Steel
Density	7870 Kg/m^3
Poisson’s ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 21 MATERIAL DATA OF SPROCKET-1

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.4
Aspect ratio	2.22

TABLE 22 MESH QUALITY OF SPROCKET-1

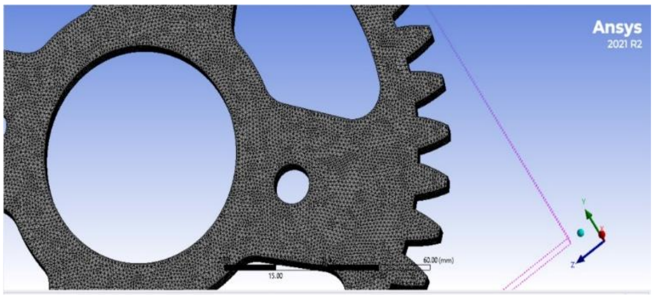

FIGURE 23 MESH QUALITY OF SPROCKET-1

STATIC STRUCTURAL ANALYSIS

Moment	Max. Deformation	Max. Stress
40KNmm	$8.8*10^{-4}$ mm	4.54 MPa

TABLE 23 STATIC STRUCTURAL ANALYSIS OF SPROCKET-1

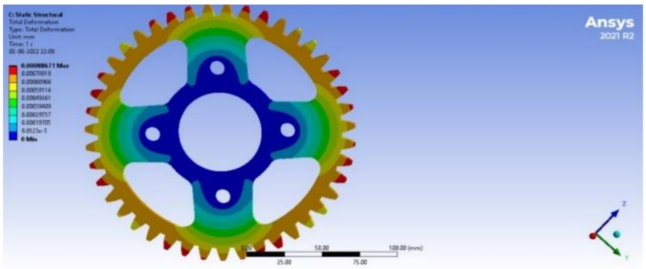

FIGURE 24 TOTAL DEFORMATION OF SPROCKET-1

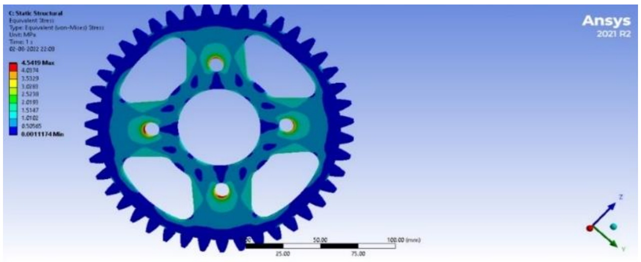

FIGURE 25 EQUIVALENT STRESS OF SPROCKET-1

SPROCKET-2 (26 teeth)

MATERIAL DATA

Material	Mild Steel
Density	7870 Kg/m^3
Poisson's ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 24 MATERIAL DATA OF SPROCKET-2

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.4
Aspect ratio	2.2

TABLE 25 MESH QUALITY OF SPROCKET-2

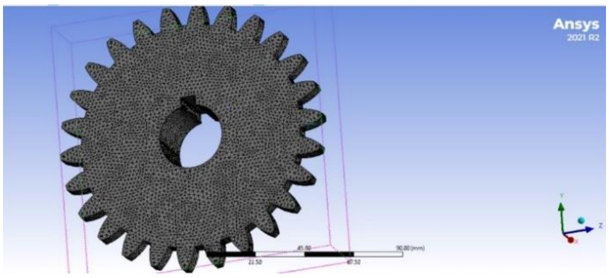

TABLE 26 MESH QUALITYOF SPROCKET-2

STATIC STRUCTURAL ANALYSIS

Moment	Max. Deformation	Max. Stress
40KNmm	1.22*10^{-3} mm	11.409 MPa

TABLE 27 STATIC STRUCTURAL ANALYSIS OF SPROCKET -2

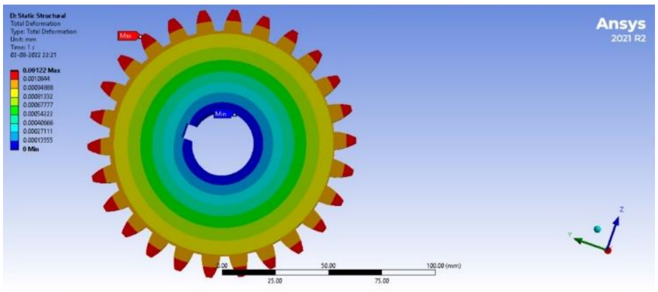

FIGURE 26 TOTAL DEFORMATION OF SPROCKET 2

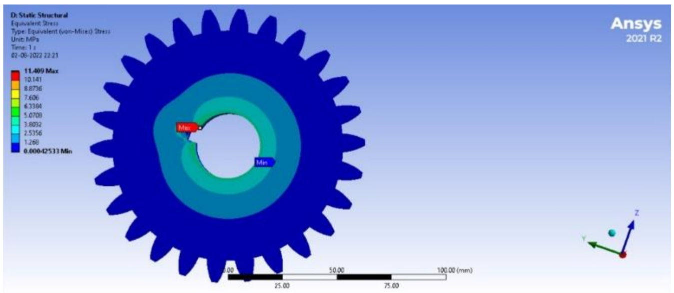

FIGURE 27 EQUIVALENT STRESS OF SPROCKET-2

SPROCKET HUB

MATERIAL DATA

Material	Mild Steel
Poisson's ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 28 MATERIAL DATA OF SPROCKET HUB

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.403
Aspect ratio	2.2358

TABLE 29 MESH QUALITY OF SPROCKET HUB

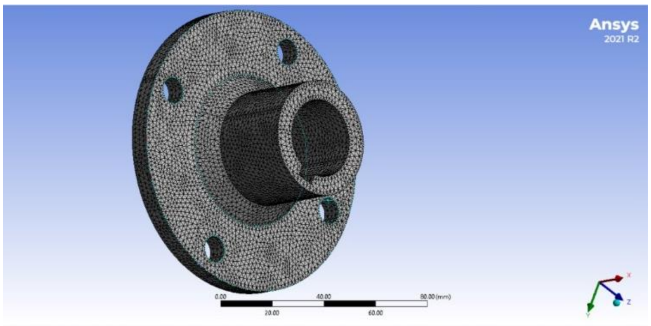

FIGURE 28 MESHING OF SPROCKET HUB

STATIC STRUCTURAL ANALYSIS

Moment	Max. Deformation	Max. Stress
40KNmm	$7.9615*10^{-4}$ mm	5.8967 MPa

TABLE 30 STATIC STRUCTURAL ANALYSIS OF SPROCKET HUB

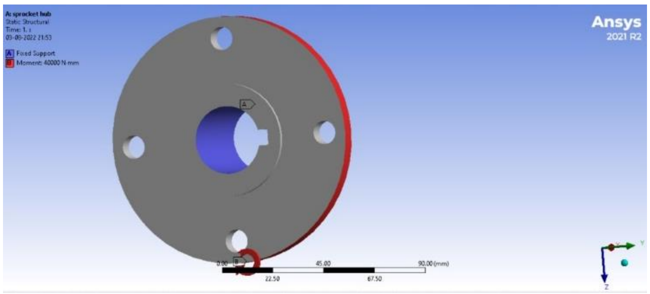

FIGURE 29 BOUNDARY CONDITIONS FOR SPROCKET HUB

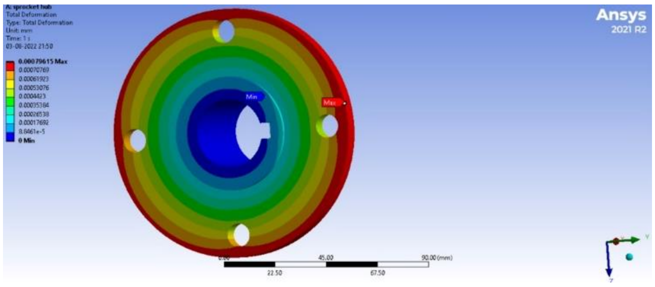

FIGURE 30 TOTAL DEFORMATION OF SPROCKET HUB

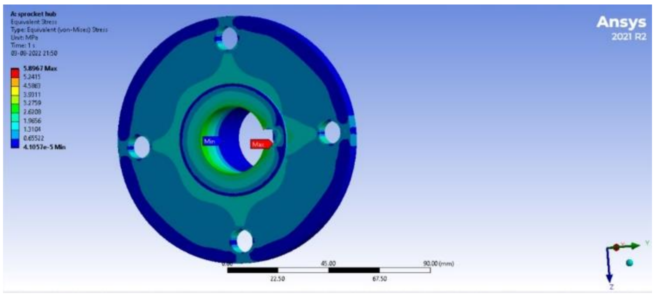

FIGURE 31 EQUIVALENT STRESS OF SPROCKET HUB

SHAFT

MATERIAL DATA

Material	Mild Steel
Density	7870 Kg/m^3
Poisson's ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 24 MATERIAL DATA OF SHAFT

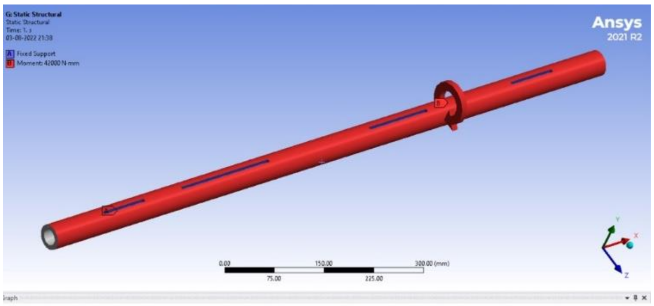

FIGURE 32 ANALYSIS MODEL OF SHAFT

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.36199
Aspect ratio	2.1761

TABLE 25 MESH QUALITY OF SHAFT

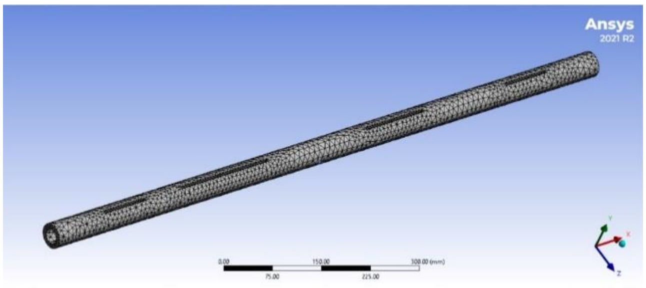

FIGURE 33 MESHING OF SHAFT

STATIC STRUCTURAL ANALYSIS

Torque	Max. Deformation	Max. Stress
42KNmm	$1.5319*10^{-3}$ mm	4.4856 MPa

TABLE 26 STRUCTURAL ANALYSIS OF SHAFT

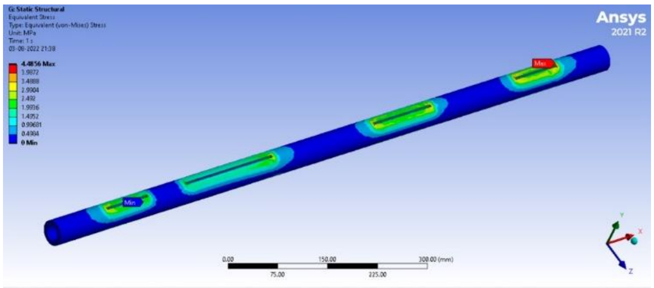

FIGURE 34 EQUIVALENT STRESS OF SHAFT

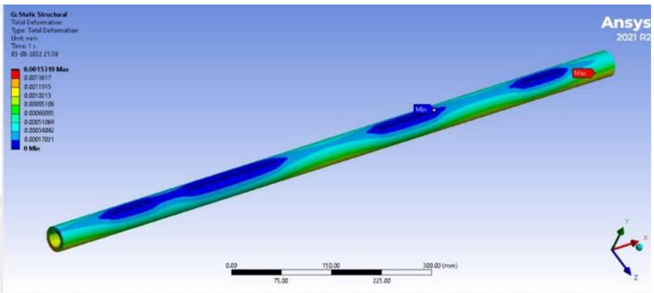

FIGURE 35 TOTAL DEFORMATION OF SHAFT

- **STEERING SYSTEM**

WHEEL HUB

MATERIAL DATA

Material	Mild Steel
Density	7870 Kg/m^3
Poisson's ratio	0.303
Tensile yield strength	370 MPa
Tensile ultimate strength	440 MPa

TABLE 31 MATERIAL DATA OF WHEEL HUB

MESHING

Element type	Tetrahedron
Element size	1mm
Skewness	0.40685
Aspect ratio	2.2545

TABLE 28 MESH QUALITY OF WHEEL HUB

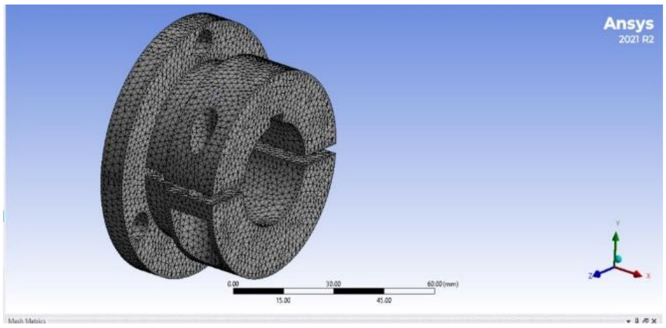

FIGURE 36 MESHING OF WHEEL HUB

STATIC STRUCTURAL ANALYSIS

Torque	Max. Deformation	Max. Stress
40KNmm	$1.3492*10^{-3}$ mm	18.875 MPa

TABLE 29 STRUCTURAL ANALYSIS OF WHEEL HUB

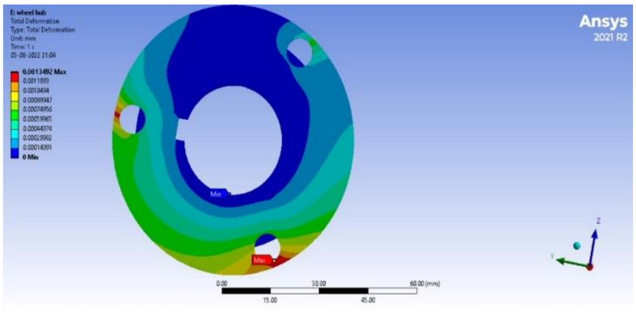

FIGURE 37 TOTAL DEFORMATION OF WHEEL HUB

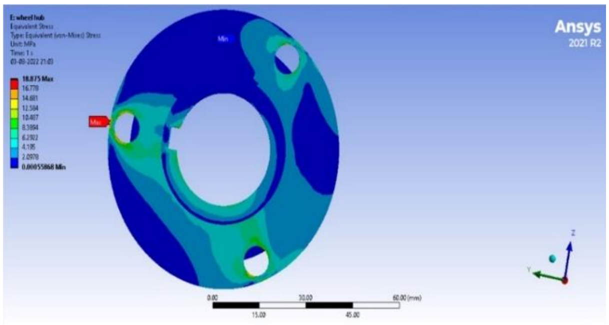

FIGURE 38 EQUIVALENT STRESS OF WHEEL HUB

STEERING KNUCKLE

MATERIAL DATA

Material	Plain Carbon Steel
Density	7,800 kg/m^3
Poisson's ratio	0.28
Tensile yield strength	2.2059*10^8 N/m^2
Tensile ultimate strength	3.99826*10^8 N/m^2

TABLE 30 MATERIAL DATA OF STEERING KNUCKLE

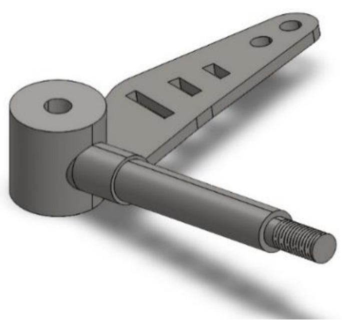

FIGURE 39 ANALYSIS MODEL OF STEERING KNUCKLE

NOTE: The knuckle, spindle and the steering arm were considered to be a single unit as they were going to be welded together, for more realistic results.

MESHING

Element type	Solid Mesh
Element size	2.869mm
Skewness	0.29498
Aspect ratio	1.8427

TABLE 31 MESH QUALITY OF STEERING KNUCKLE

STATIC STRUCTURAL ANALYSIS

Force	Max. Deformation	Max. Stress
343N	3.666*10^5 mm	1.906*10^5 N/m^2

TABLE 32 STATIC STRUCTURAL ANALYSIS OF STEERING KNUCKLE

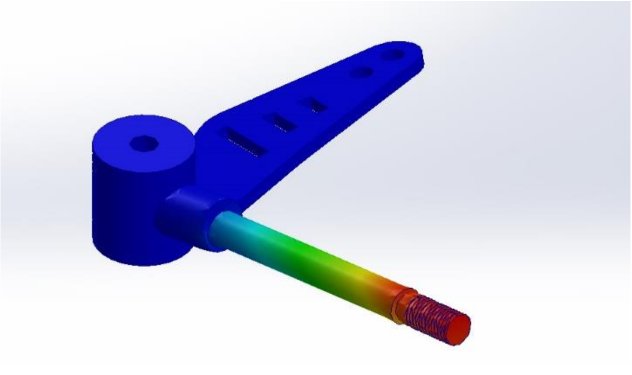

FIGURE 40 TOTAL DEFORMATION OF STEERING KNUCKLE

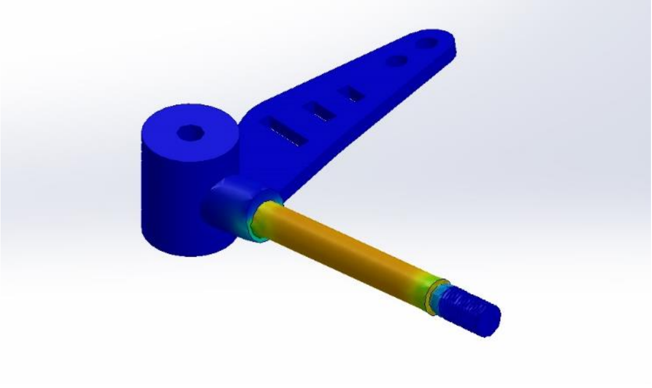

FIGURE 41 EQUIVALENT STRESS OF STEERING KNUCKLE

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