# Engineering Component Modelling and Analysis Showcase

Project synopsis submitted in partial fulfilment

for the Award of

*CERTIFICATION*

in

Electric Vehicle Course

by

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# CHAPTER 2

# PROJECT DESCRIPTION

## Objective

The objective of the project is to show case the models that are modelled using MATLAB and also the models that are modelled and analysed by using SolidWorks and ANSYS that have done in this course.

## Expected Result

The outcomes that are expected from the project are listed below:

- To understand importance of the Software which are used to design and analyse the models in this course.
- To ensure proficiency in creating models using MATLAB.
- Able to model the engineering components in SolidWorks.
- Able to analyse the components in ANSYS that are modelled in SolidWorks.

## Pre-requisites:

To complete this project, we need to have some basic knowledge on:

- MATLAB & Simulink environment.
- Knowledge designing components using SolidWorks.
- Knowledge on Analysing them using ANSYS.

# CHAPTER 3

## REQUIRED INPUT PARAMETERS AND CALCULATIONS

### 1. MATLAB – based Modelling

#### Assumptions:

The Assumptions made for MATLAB based modelling are:

- The vehicle which is going to be modelled is a rear wheel drive with single transmission.
- The Drive cycle used for the model is FTP75.
- The motor used is Permanent Magnet DC motor.

#### Input Parameters:

For Vehicle:

- Mass of the Vehicle: 317 kg
- Frontal Area: 1.33 $m^2$
- Drag Coefficient: 0.4
- Air Density: 1.225 $kg/m^3$
- Rolling radius of Wheel: 9 in

For Motor:

- Armature resistance: 9.3 milli ohm
- Armature inductance: 172 uH

By using the above data and assumptions an Electric Vehicle model is modelled using MATLAB – Simulink as Shown in the figure below.

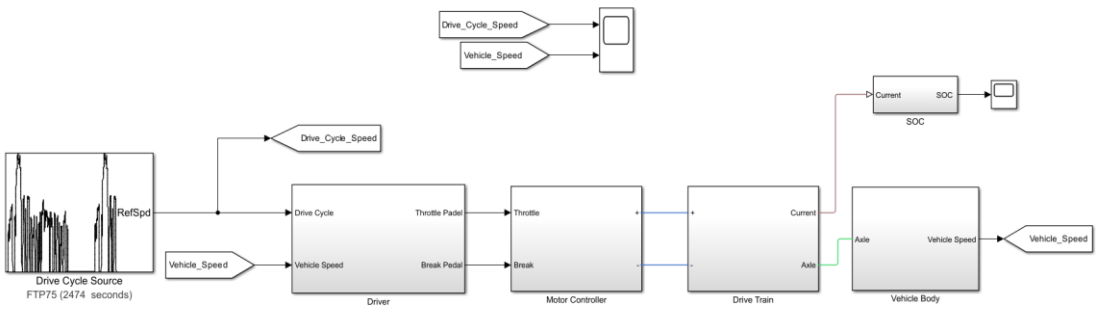


Fig - 1

The above Electric Vehicle model consists of Five major blocks:

1. Driver Block
2. Motor Controller
3. Drive Train
4. Vehicle Body
5. State of Charge

## Driver Block:

This block takes the reference speed or drive cycle and vehicle speed as input and gives throttle or break as output.

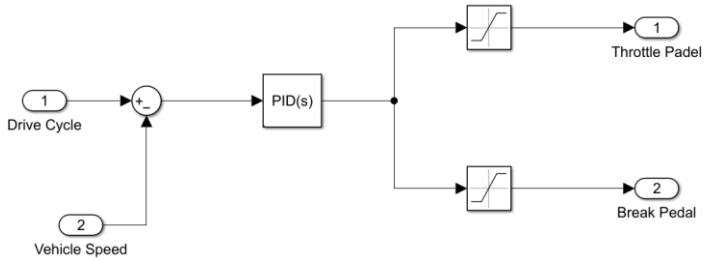


Fig – 1.1

As shown in the above figure, the Drive Cycle data and vehicle speed is fed to the sum block. The PID controller is used to give the output as throttle or break through the saturation blocks by analysing difference between Drive cycle and Vehicle speed.

If the vehicle speed is less than the reference speed the PID controller gives Throttle as output else it gives output as Break.

## Motor Controller:

This block will take input either throttle or break from the driver and according to that it transfers positive and negative signals to the motor in the Drive train block.

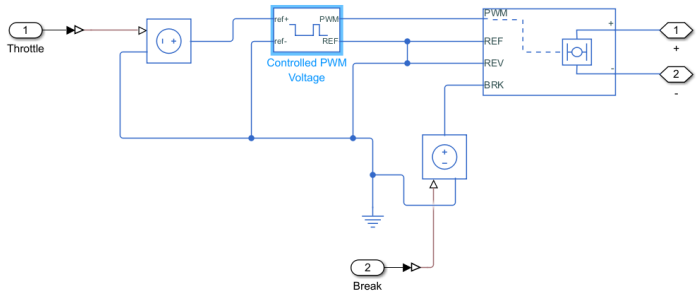


Fig – 1.2

When driver gives the Throttle, the signal is fed into the Controlled PWM Voltage as positive reference through controlled voltage source. Then the converted PWM signal fed into the H-bridge which gives positive output to the motor. Whereas the Break signal is sent by the driver then it fed into the H-bridge break reference which generates negative output.

## Drive Train:

This block will take either positive or negative signal from the controller which provides power to the motor and then to Axle.

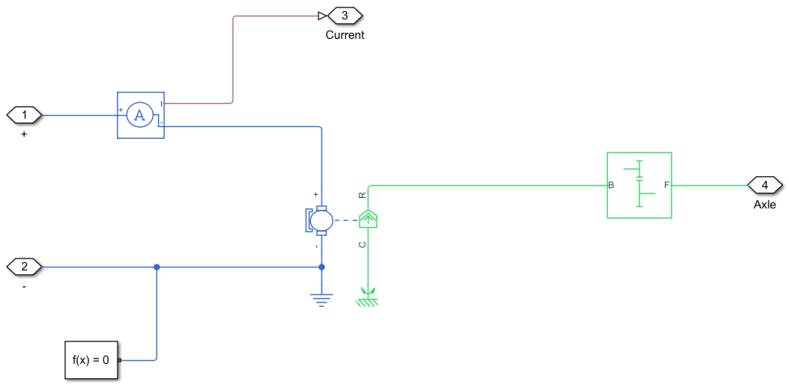


Fig – 1.3

As shown in the above figure, the positive signal from the controller is directly used to provide power to the motor through current sensor then the motor will supply the power through the single speed gear which is taken as output. Whereas no power is supplied by the motor for negative signal as it is directly connected to the ground.

## Vehicle Body:

This block will receive the power from motor to the axle of the vehicle and gives speed as output which is taken as input by the Driver block.

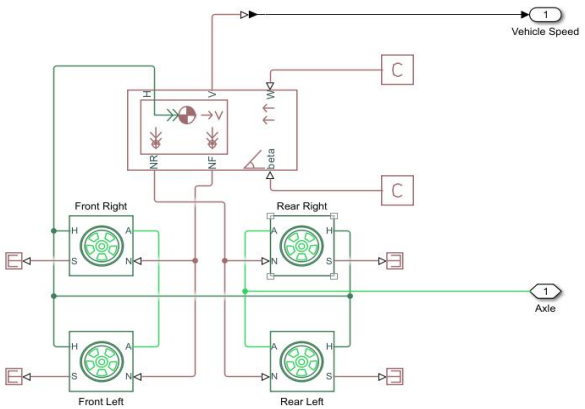


Fig – 1.4

As shown in the figure, the power supplied from the drive train block is received by the rear axle of the vehicle and supplies the power to the wheels which is used to move the vehicle. As a result, the vehicle speed is obtained as output which is used as input to driver.

**State of Charge:**

The current obtained from the drive train is fed into the SoC block which is used to find the remaining amount of the battery as shown in figure beow.

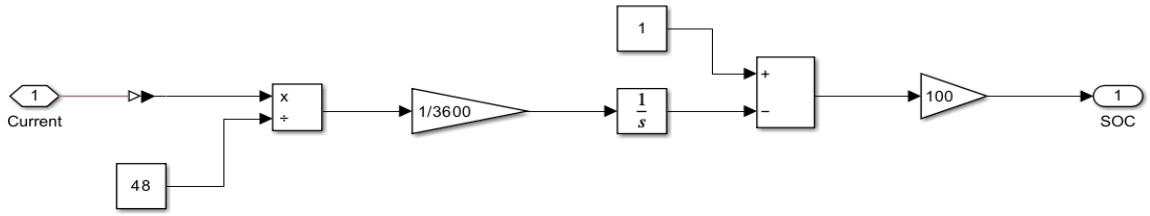


Fig – 1.5

## 2. SolidWorks & ANSYS based modelling and Analysis

The following components are modelled in SolidWorks and analysed in ANSYS through simulation:

1. Motor Shaft
2. Motor Mount
3. Bearing Adaptor
4. Sprocket
5. Eccentric
6. Tripod Housing
7. Axle
8. Differential Mounting

**Motor Shaft:**

It is a cylindrical component that extrudes from the motor and its housing. The main purpose of the motor shaft is to convert energy from the motor into end use application. The model of the motor shaft that was modelled using SolidWorks application was shown in below figure.

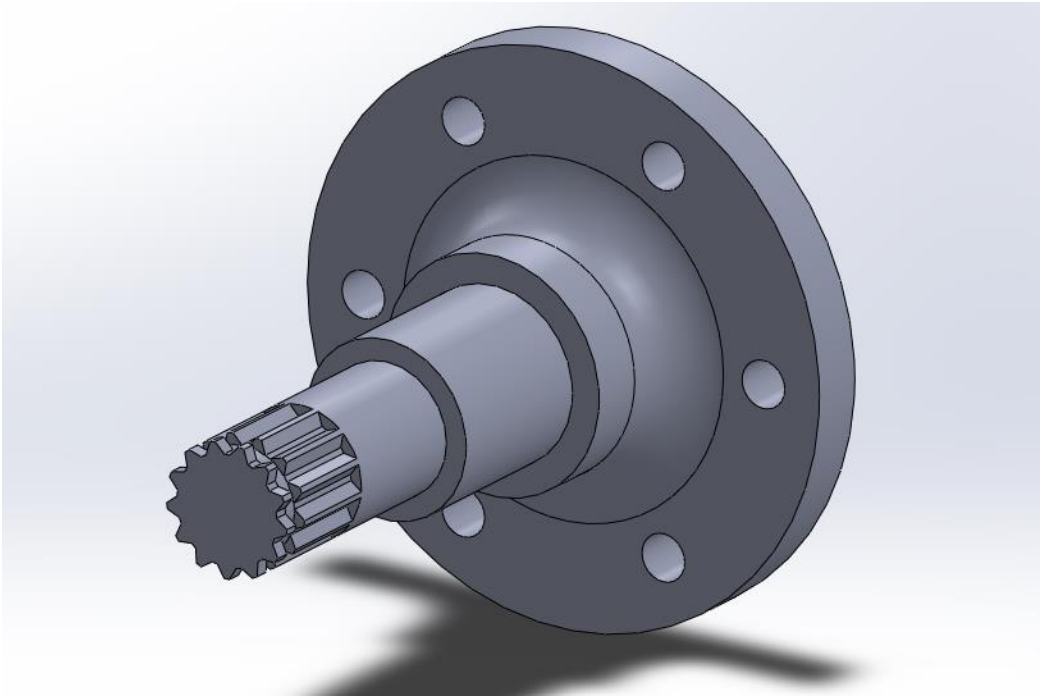

Fig – 2

After modelling the motor shaft, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

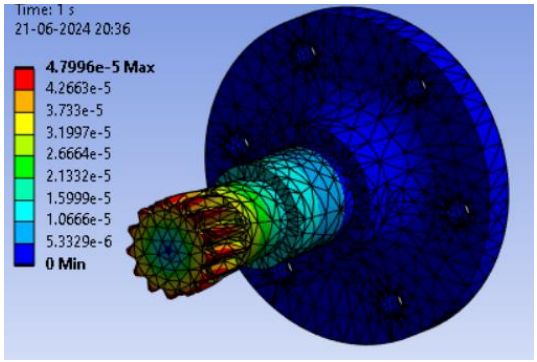


Fig – 2.1

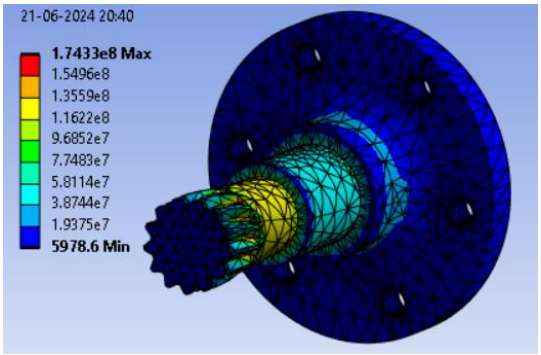


Fig – 2.2

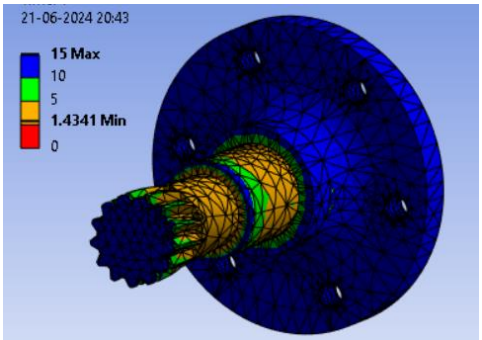


Fig – 2.3

The above figures are obtained after simulating the motor shaft model in ANSYS. To Analyse the model the base of the shaft was fixed by giving the fixed support. The splines of the shaft were given a force of magnitude 1500 N. The manufacturing material assumed for the analysis of motor shaft is EN24.

**Motor Mount:**

The motor mount is used to absorb the shocks and vibration of the motor when it is operating. It is used for the safe and secure operation of motor.

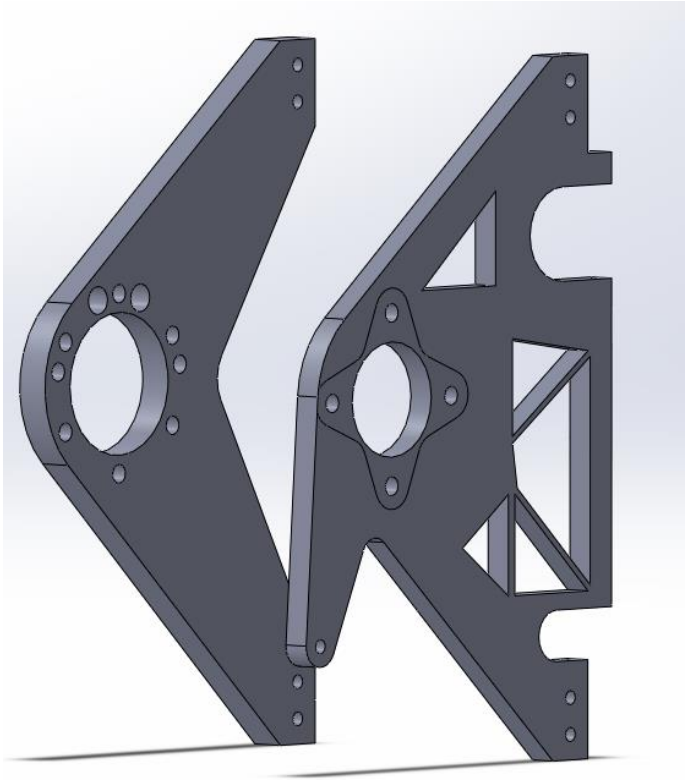

Fig – 3

The above figure is the assembly of the left and right mounts of the motor. After modelling and assembling the motor mounts, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

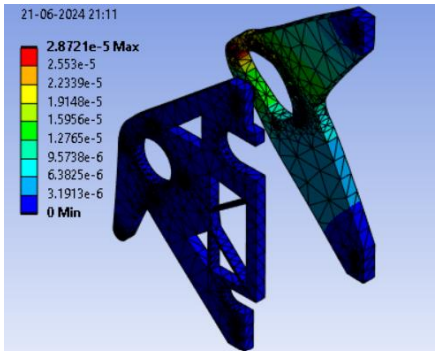


Fig – 3.1

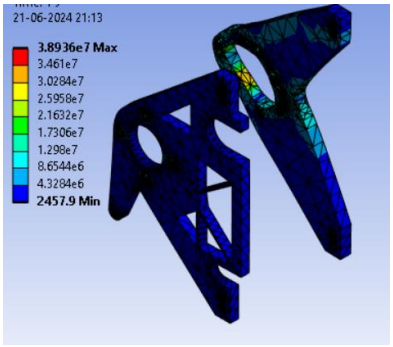


Fig – 3.2

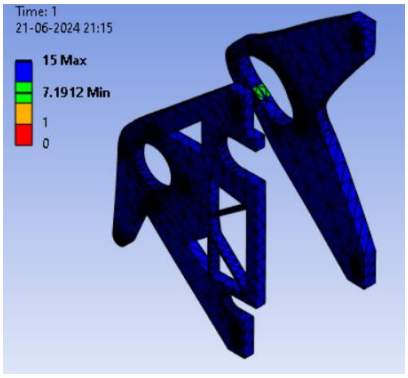


Fig – 3.3

The above figures are obtained after simulating the motor mount model in ANSYS. To Analyse the model the left mount was subjected to the force of 1600 N and the right bearing is subjected to the force of magnitude 1200 N where the motor is to be placed. The manufacturing material assumed for the analysis of motor mount is AL 7.

**Bearing Adaptor:**

The Bearing Adaptor is used to support the bearing when it is used for an application. The model of the Bearing Adaptor was shown in figure below.

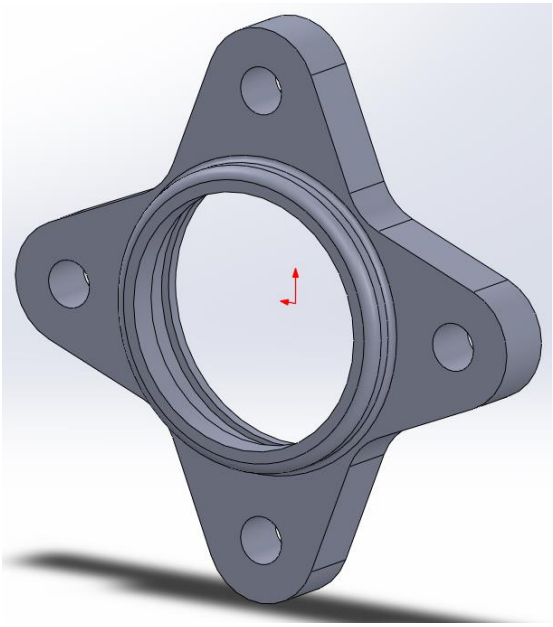

Fig – 4

Then the model was imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below. The manufacturing material assumed for the analysis of the bearing adaptor is AL 7.

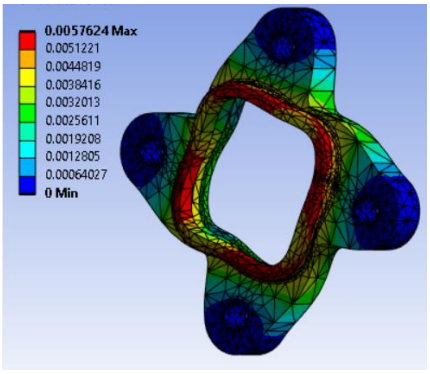


Fig – 4.1

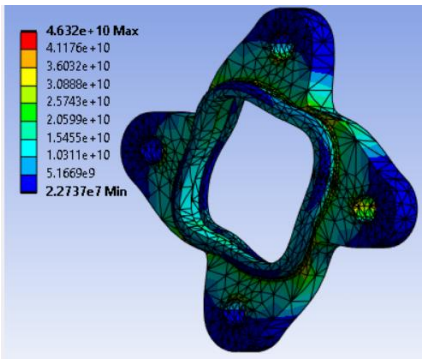


Fig – 4.2

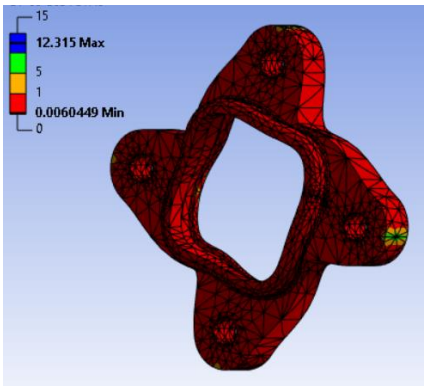


Fig – 4.3

The above figures are obtained after simulating the motor mount model in ANSYS. To Analyse the model the inner side of the adaptor was subjected to the force of 1600 N and moment of 250000 Nm simultaneously. The fixed support is given the four holes.

**Sprocket:**

The sprocket is a toothed wheel whose teeth engages the links of a chain. It is used to transfer the energy from one component to the other.

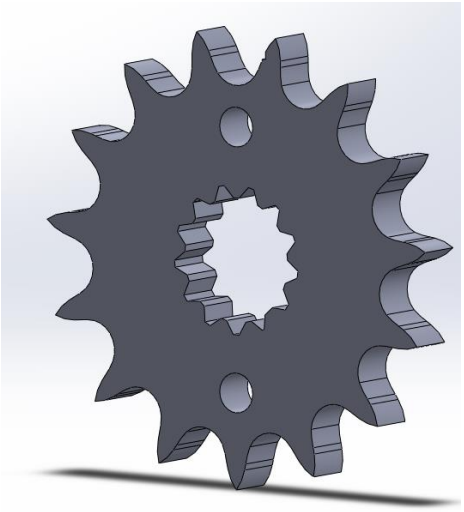

Fig - 5

After modelling the Sprocket in SolidWorks, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

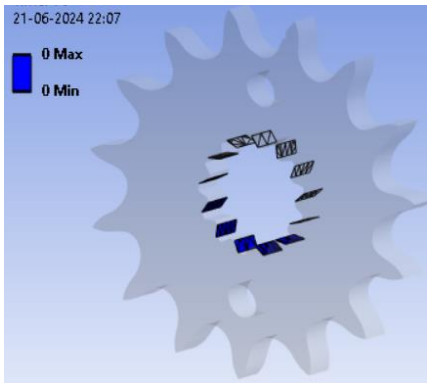


Fig – 5.1

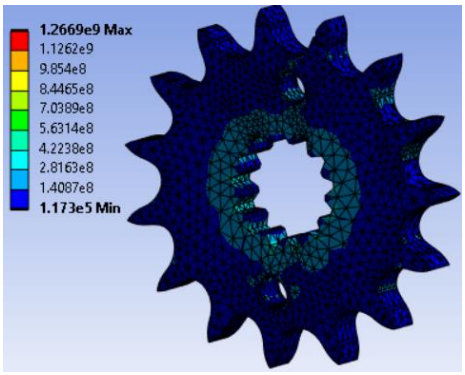


Fig – 5.2

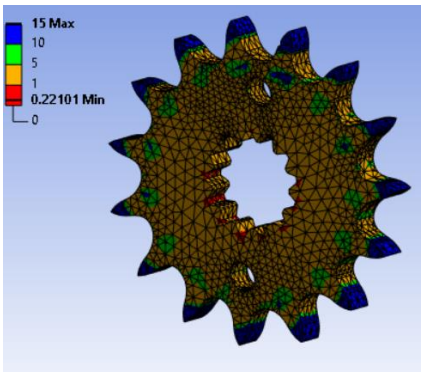


Fig – 5.3

To Analyse the model the inner splines were fixed and the outer splines were subjected to the force of 2300 N. The manufacturing material assumed for this simulation is AL 7.

**Eccentric:**

The eccentric is a circular disc which is solidly fixed to the rotating axle with its centre offset from that axle.

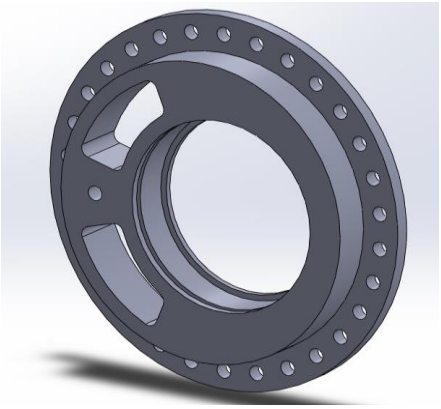

Fig – 6

After modelling the Eccentric in SolidWorks, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

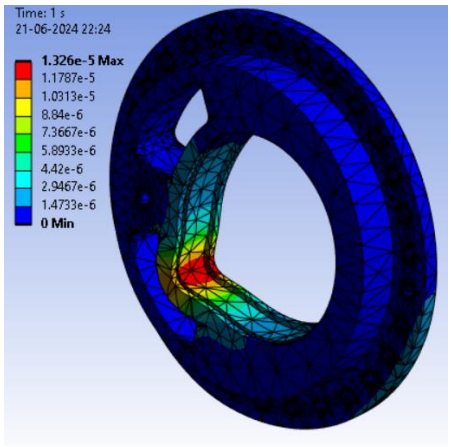


Fig – 6.1

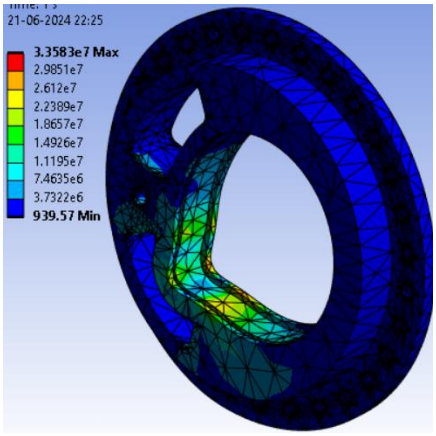


Fig – 6.2

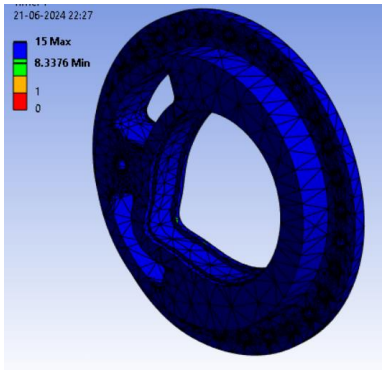


Fig – 6.3

To Analyse the model of the Eccentric the force of 6000N is given to the inner surface and outer surface kept fixed. The manufacturing material assumed for this simulation is AL 6.

**Tripod Housing:**

The tripod housing plays a crucial role in transmitting the power from the transmission system to the drive wheel. It consists of tripod which is used to enable the power transmission also when angle shifts. The model of a tripod housing is shown below.

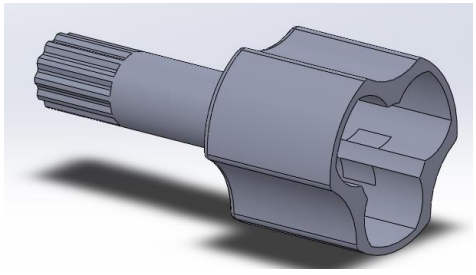

Fig – 7

After modelling the Eccentric in SolidWorks, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

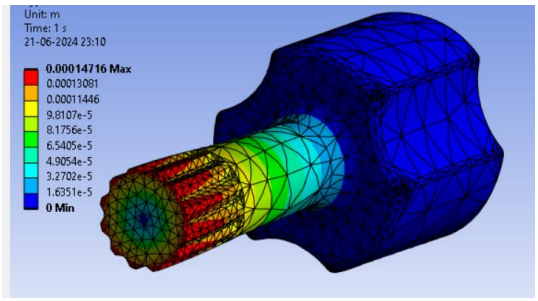


Fig – 7.1

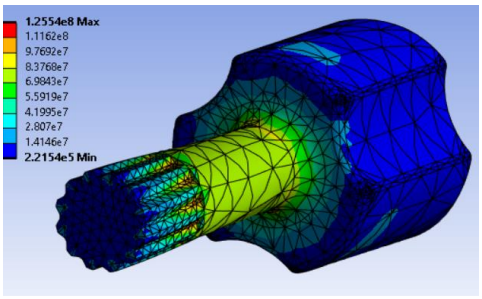


Fig – 7.2

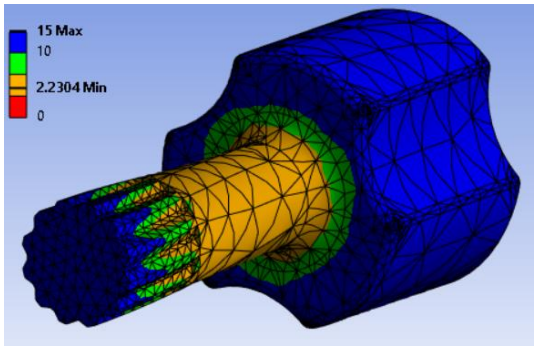


Fig – 7.3

To Analyse this model in ANSYS, the splines are subjected to the force of 2000N by keeping the inner side of the housing areas fixed where the contact takes place with tripod.

**Axle:**

The axle is a part of the vehicle where the wheels are mounted on its both ends. It is used to transfer the power from the power train to the wheel which intends vehicle movement. The model of Axle is shown below.

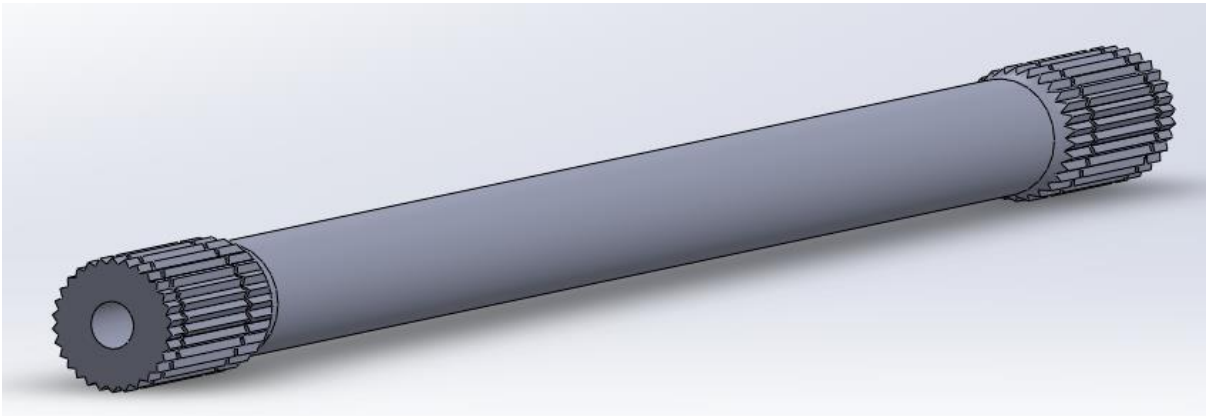

Fig – 8

After modelling the Axle in SolidWorks, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

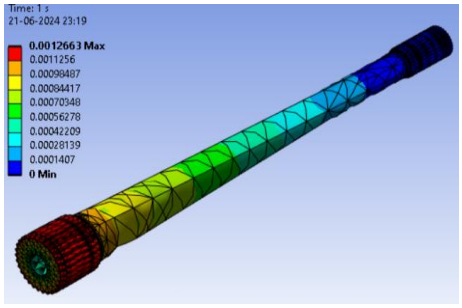


Fig – 8.1

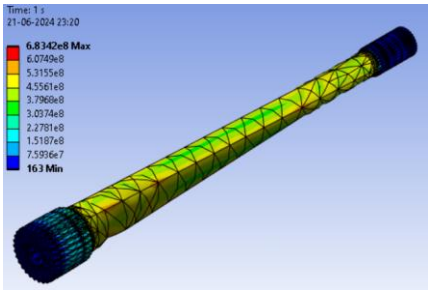


Fig – 8.2

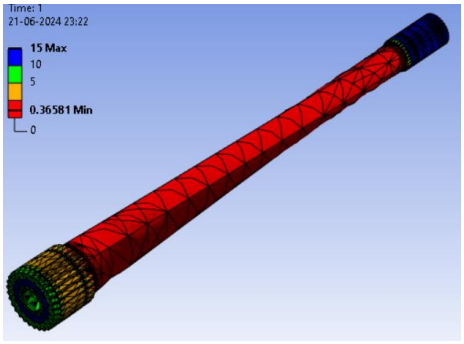


Fig – 8.3

To Analyse the axle in the ANSYS, the splines in the one end are subjected to the force of 1800N by keeping the splines on the other side fixed. The manufacturing material assumed for this simulation is EN24.

## **Differential Mounting:**

The purpose of the differential mounting is to support the differential which is used to transfer the power to the wheels and allow the wheels to move at different speeds. The model of differential mounting is shown below.

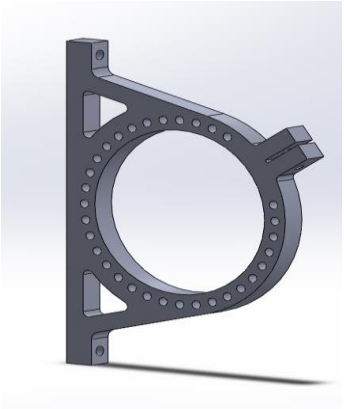

Fig - 9

After modelling the Differential Mounting in SolidWorks, it is imported to the ANSYS application where it is simulated under some conditions. The Ansys models after the simulation are is shown below.

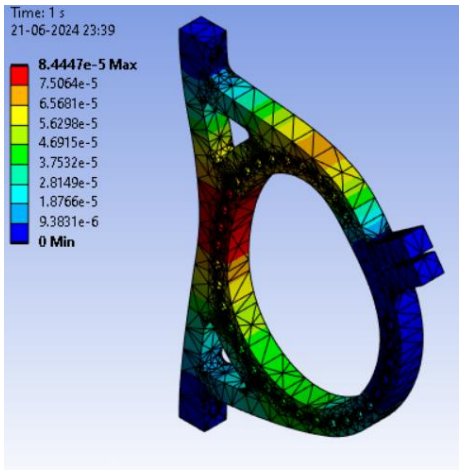


Fig – 9.1

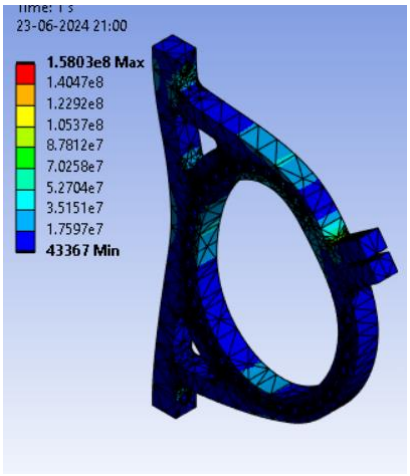


Fig – 9.2

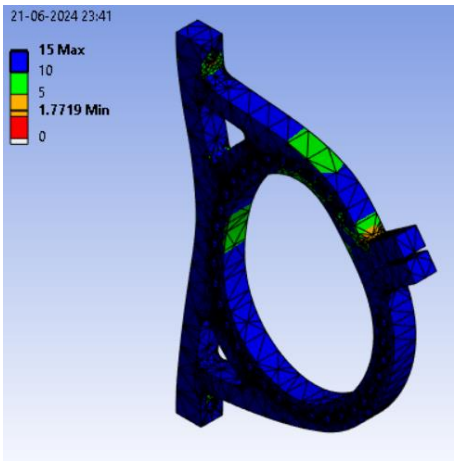


Fig – 9.3

To Analyse the Differential Mounting in ANSYS, a force of 60N is applied downwards and a force of 6000N is applied upwards. The fixed support is given at the top and bottom holes. The manufacturing material assumed for this analysis is AL7.

# CHAPTER 4

# OUTPUT PARAMETERS

The outputs that are expected from the project are listed below:

- To understand importance of the Software which are used to design and analyse the models in this course.
- To ensure proficiency in creating models using MATLAB.
- Able to model the engineering components in SolidWorks.
- Able to analyse those components in ANSYS that are modelled in SolidWorks.

# CHAPTER 5

# RESULTS

## 1. MATLAB-based model Results

The below graphs are belonging to the EV model which shows the variation in reference speed and vehicle speed.

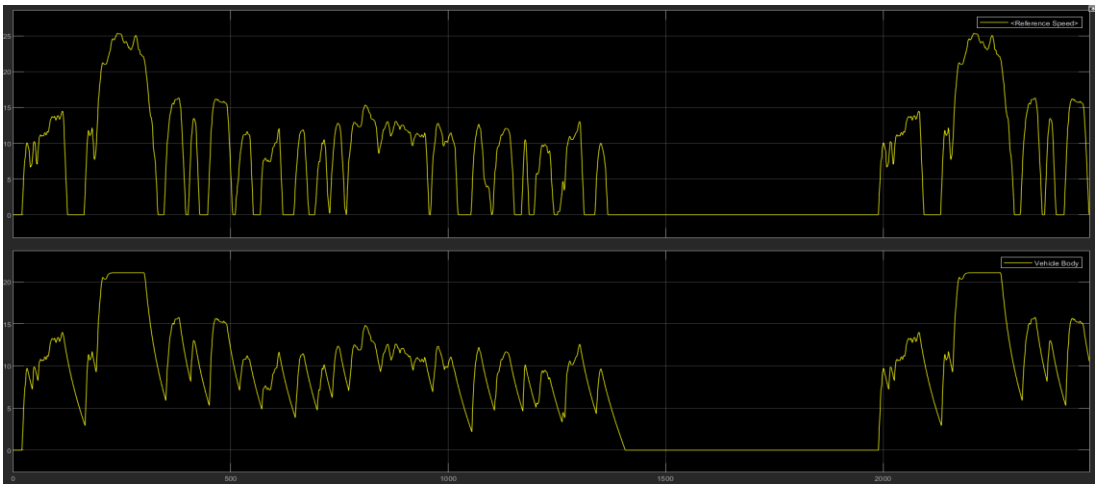


Fig – 10

Here we can observe that the speed of a vehicle almost equal to the given reference speed i.e. FTP75 which proves that the design of the EV model almost accurate.

The below figure shows the State of Charge of the battery after travelling one cycle.

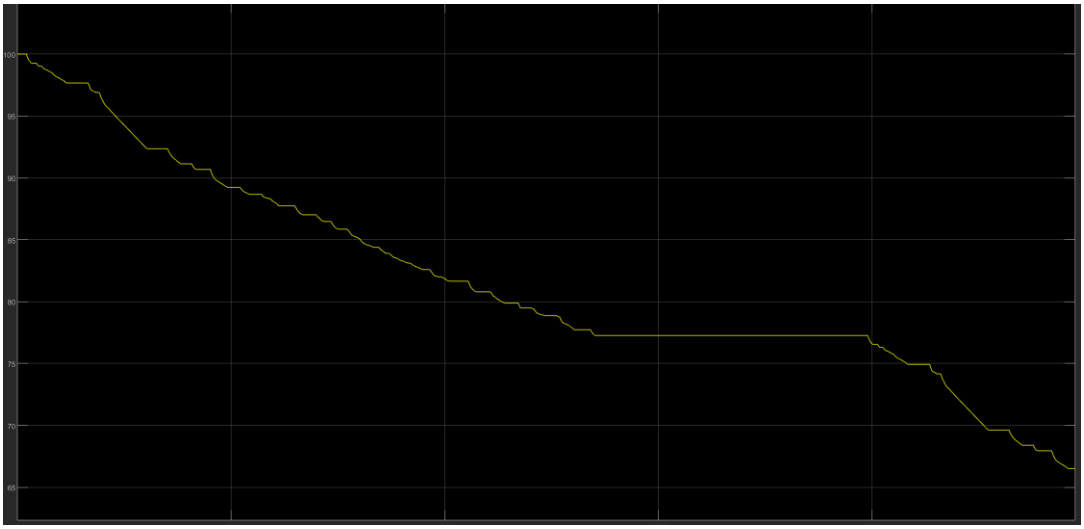

Fig – 11

The vehicle shows SoC of 66%(Approx.) after the simulation of 2474 seconds with 48Ah battery.

## 2. SolidWorks & ANSYS-based model Results

The Maximum Stress, Maximum Deformation and Factor of Safety of the Components which are modelled and analysed in SolidWorks and Ansys are given below:

| Sl. No | Name of Component | Maximum Stress (Mpa) | Maximum Deformation (mm) | Minimum Factor of Safety |
|---|---|---|---|---|
| 1 | Motor Shaft | 174.33 | 0.0048 | 1.43 |
| 2 | Motor Mount | 38.936 | 0.0028 | 7.19 |
| 3 | Bearing Adaptor | 46320 | 0.0000057 | 0.006 |
| 4 | Sprocket | 1266.9 | 0 | 0.22 |
| 5 | Eccentric | 33.583 | 0.0013 | 8.3 |
| 6 | Tripod Housing | 125.54 | 0.00000014 | 2.23 |
| 7 | Axle | 683.42 | 0.0000012 | 0.36 |
| 8 | Differential Mounting | 158.03 | 0.084 | 1.77 |

Fig - 12

# CHAPTER 6

# OBSERVATIONS AND CONCLUSION

By Observing the results which are stated above for the MATLAB-based model, it can be concluded that an Electric Vehicle model is designed in MATLAB with assumed battery capacity of 48Ah. By seeing the graphs of the actual speed of a vehicle and reference speed i.e. FTP75 for 2474 seconds in Figure 10, we can say that the Vehicle speed is almost equal to the given Drive cycle which makes this design is more suitable for practical road conditions.

From the results of SolidWorks and Ansys models, it can be concluded that the given models in the problem statement are successfully designed in the SolidWorks and also made some analysis on these components by applying load in Ansys after importing them into it. Through analysis some properties of the given materials are found like Max. Stress, Max. Deformation and Factor of Safety which are stated in the above Figure 12.

To sum up, the skills on the modelling of the components in MATLAB, SolidWorks and Ansys are demonstrated successfully.

## **References**


Al Halabi, M. and Al Tarabsheh, A., 2020. *Modelling of electric vehicles using Matlab/Simulink* (No. 2020-01-5086). SAE Technical Paper.

Jaiswal, R., Jha, A.R., Karki, A., Das, D., Jaiswal, P., Rajgadia, S. and Basnet, A., 2016. Structural and thermal analysis of disc brake using solidworks and ansys. *International Journal of Mechanical Engineering and Technology*, *7*(1), pp.67-77.

https://www.youtube.com/watch?v=gndU0CR8AIE



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