DESIGN AND MANUFACTURING OF ELECTRIC VEHICLE (2W) TEST RIG

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Abstract— Currently, EV are prominent option to reduce the global warming. Green gas effect was mainly due to use of fossil fuel in IC engine. In electric vehicle, battery operated vehicles are largely used everywhere. In battery electric vehicle, battery, electric motor, AC-DC charger, power trains are the major components. Battery is said to be heart of BEV. For highly effective performance battery has to work in a temperature range of 15˚C- 35˚C. But as we run the electric vehicle, under different condition the heat generation in the battery is going to vary which makes detrimental effect on the battery life. The major reason for heat is Joule's heat with this test rig, the current fetched by motor under varying load, rolling resistance and road gradient can be easily find out.

Keywords— *Electrical vehicle, Lithium ion Battery, Battery Management System, Electrical Motor, Joule's Heat, Rolling Resistance, CAD Modeling, Structural Analysis.*

I. Introduction

In recent years, electric vehicles (EVs) have been massively used in our society. Battery is the main energy source of EVs and has a significant influence on the driving range, reliability and safety issues. Among the various types of batteries like Lead acid battery, Nickel-Cadmium battery, Nickel-metal Hydride battery, Lithium- ion battery (LIB) is widely used due to its high energy density, high efficiency, long life and low self-discharge rates. However, the main problem with these batteries is that, especially for high discharge speeds, heat generation increases the battery temperature, reducing its efficiency and durability. The motor converts electric energy from the battery into mechanical energy in order to run the motor torque is required, it is the twisting force that will make the motor running and the torque is active from 0% to 100% operating speed. Increase in battery pack width drag coefficient increases and the lift coefficient decreases and changes the pneumatic resistance of the vehicle. Increased tire rolling resistance reduces the recovery energy that can gain during regenerative braking during deceleration. Increased tire rolling resistance reduces the recovery energy that can gain during regenerative braking during deceleration. The higher the kinetic energy recovery of the tire with the low rolling resistance coefficients, the higher the charge level of the battery during driving cycle.

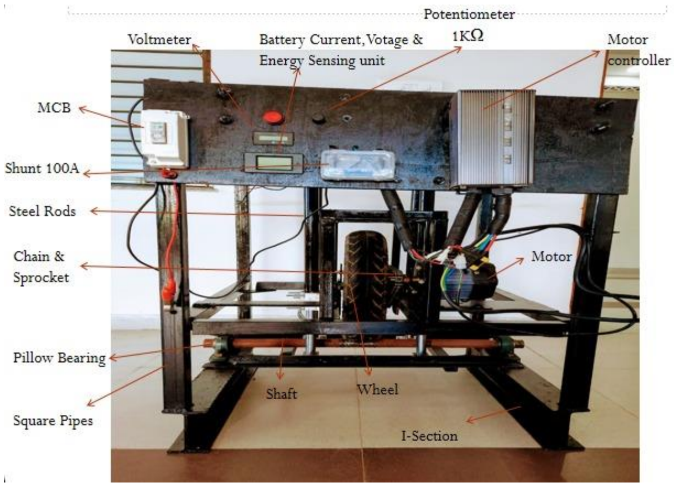


Fig.(1)

II. LITERATURE REVIEW

All the literature reviews which we have gone through, we have found out that in the field of batteries and electric vehicles there are many areas which needs more research and have insufficient information like different types of-

- Cooling system of batteries.
- Voltage capacity and size of battery cells.
- Electrochemical cell chemistry.
- Performance of battery in different environmental conditions.

III. METHODOLOGY

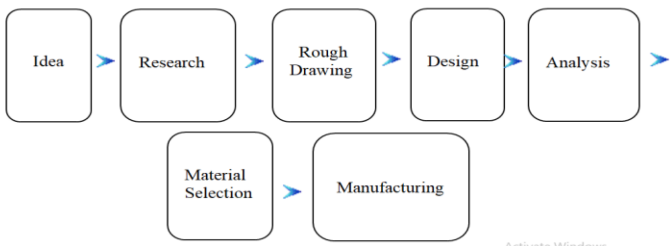


Fig.(2)

Selection of Components

A. AISI 4130 Alloy Steel

- It is used in shaft.
- According to design and analysis material with high strength and durability and also consider the cost we have chosen AISI alloy steel as material for

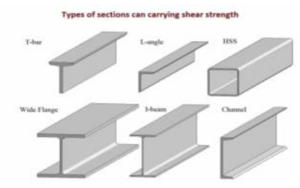
shaft.

- AISI 4130 alloy steel contains chromium and molybdenum as strengthening agents. It has low carbon content, and can be welded easily.
- Welding of AISI 4130 steel can be performed by all commercial methods.
- Some of the major applications of AISI 4130 alloy steel are in aircraft engine mounts and welded tubing.

B. ASTM A500 Mild Steel Square Pipes

- A500 cold-formed tubing comes in four grades based on chemical composition, tensile strength, and heat treatment.
- The yield strength requirements are higher for square and rectangular than for round tubing.
- The minimum copper content is optional.

C. ISMB 150 I-Section



PROPERTY	VALUE
Name	ISMB 150
Common Name	Indian Standard Medium Weight Beam 150
Weight per Meter (w)	14.90 Kg/m
Sectional Area (a)	19.00 cm2
Depth of Section (h)	150 mm
Width of Flange (b)	80 mm

D. Type of pack-Lithium-ion phosphate battery (LiFePO4)
Battery type: Li-ion
Charging Temperature: 0~45˚C
Discharging Temperature: 20˚C ~ 60˚C
Nominal voltage-3.6V
Max charge voltage: 4.2±0.03V (cut off charging current 24mA)
Dimension of cell 65.1*18.5 (mm) MaxStandard charge current: 0.2C

E. Motor with capacity of 48V
An electric motor is an electrical machine that converts electric energy into mechanical energy. A motor with capacity of 48V is used and this motor is connected to the wheel with the help of chain sprocket to run the wheel.

F. Chain Sprocket
A sprocket wheel or chain sprocket is a profiled wheel with teeth, or cogs, that mesh with a chain, track or other perforated or indented material. . The name sprocket applies generally to any wheel upon which radial projection engages a chain passing over it. A chain sprocket is used to connect the motor and the wheel. Gear ratio is 3.308:1.

G. RPM Sensor
It is used to measure the rotational speed of a mechanicalcomponent. RPM sensors are used for order analysis in rotor balancing system, for bearings diagnostics and for other research purposes.

H. Temperature Sensor
A temperature sensor is an electronic device that measures the temperature of its environment and convertsthe input data into electronic data to record, or signal temperature changes. We have used K type thermocouple
.

I. Wheel
The wheel here used is basic active wheel.

J. Frame
Motor, wheel, sprocket are mounted on the frame it is a rigidstructure that provide support. Dimensions: length and breadth are 750mm, width is 1200mm.

K. Motor Controller
A motor controller is a device or group of devices that can coordinate in predetermined manner the performance of an electric motor.

L. Sliding Bearing
Sliding bearing is used for the up down movement of wheel.

M. Pillow Bearing
Pillow bearing is a pedestal used to provide support for rotating shaft with the help of compatible bearings.

N. Data Logger

Data logger records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors
Sunsui-32 channel

O. Load
Load up to 250kg is used in the set up.

Fig.(3)

P. Types of Shaft

- There are three types of shaft used this are given bellow.
- Plane Shaft- It is used in tar road.
- Knurling Shaft- It is used in cement road.
- Spot Welded Shaft- It is used in terrain road.

IV. EQUATION

Data	Length	Width	Height	Speed	Weight (mg)	Density (ρ)	C_d	R_R for concrete	Wheel Size
Given	750mm	500mm	1000mm	60km/h	250kg	1.2kg/m^3	0.88	0.02	350mm
Required	0.750m	0.5m	1m	16.66m/s	250kg	1.2kg/m^3	0.88	0.02	0.35m

Power Calculation

- Aerodynamic force

Aerodynamic force = $\frac{1}{2}*\rho*A_F*V^2*C_d$
ρ = Air density = 1.2kg/m^3
A_F = Frontal area = 0.5m^2
V = Velocity of vehicle
C_d = Drag force = 0.88
Aerodynamic force = ½*0.88*1.2*(0.5*1)*16.66^2
Aerodynamic force = 73.27N
Power = 73.27.13*16.66
Power = 1220.75W

- Road Gradient

Different angles with respect to the wheel form by the Shaft at different heights:
At 8° angle from center of wheel height will shift to 19.45mm for shaft
At 30° it will be 48.05mm
At 23° it will be 34.86mm
At 15° angle height will shift to 25.27mm

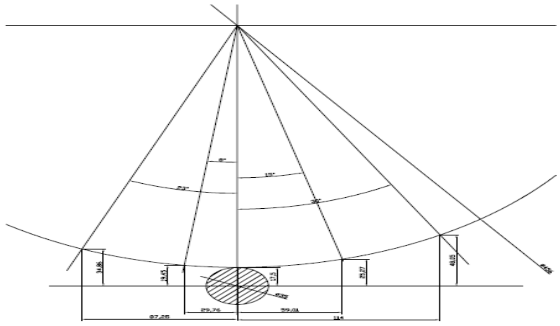


Fig.(4)

- Gradient force = M*g*Sinθ
  g = Gravitational acceleration
  M = Mass of vehicle + person
  Gradient force = M*g*Sinθ
  θ = 0° (for city road)
  Gradient force = 250*9.8*Sin0°
  Gradient force = 250*9.8*0

  Gradient force = 0
  Power = 0*16.66
  Power = 0

- Rolling resistance

  Rolling resistance force = $M*g*R_R$
  M = Mass of vehicle + person
  g = Gravitational acceleration
  R_R = Rolling resistance
  Rolling resistance force = 250*9.8*0.02
  Rolling resistance force = 49N
  Power = F*V
  Power = 49*16.66
  Power = 819.34W

- Linear distance = 2πr
  Linear distance = 2*3.14*0.175
  Linear distance = 1.102m
  RPM = (60000/60)/1.102
  RPM = 907.44rpm (minimum required rpm)

- Total Power

  Total Power = Rolling resistance Power + Gradient Power + Aerodynamic force
  Total Power = 816.34 + 0 + 1220.75
  Total Power = 2037.09W

- Gear ratio

  Gear ratio = rpm of motor/rpm of tyre
  Gear ratio = 3000/907.44
  Gear ratio = 3.308

- To find teeth of wheel sprocket

  Gear ratio = teeth of wheel sprocket/ teeth of motor sprocket
  3.308 = teeth of wheel sprocket/13
  Teeth of wheel sprocket = 43.004 ≈ 43

- To find RPM at N_2

(Driving sprocket)
N_1 = 3000rpm
T_1 = 13 teeth
T_2 = 43 teeth
$N_1 * T_1 = N_2 * T_2$

$N_2 = N_1 * T_1 / T_2$
N_2 = 3000*13/43
N_2 = 907.44rpm

- Torque of the motor

Power = 1500W
η = 90%
RPM = 907.44rpm
η = (O/P)/(I/P)
0.9 = (O/P)/1500
O/P = 1500*0.9
O/P = 2*π*N*T
Torque = (1500*0.9*60)/(2*3.14*907.44)
Torque = 14.42N-m
Torque at hard surface = Torque of the motor* Gear ratio*BLDC motor
Torque at hard surface = 14.42*3.308*0.9
Torque at hard surface = 42.31N-m

- Torque at 250kg weight

W = F = 250kg
V = 60km/h
r = 0.127m
ω = V/r
ω = 16.66/00.175
ω = 95.2rad/sec
Torque = F*r
Torque = 250*0.175
Torque required to move a weight of 250kg = 43.75N-m
So, the motor selection for this purpose should have torque around 40-45N-m.

- Battery Selection

Bench marking of battery: 1.15 hrs to run.
Motor of 48V
Comparison for different types of batteries

Sr. No.	Types	Charge efficiency (%)	Cycles durability	weight
1	Nickel cadmium battery	70-90	Up to 500	Heavy
2	Nickel metal hydride battery	66	300 to 800	Middle
3	Lithium ion phosphate battery	90	2500 to 12000	Light
4	Lead acid battery	50-92	50 to 100	heavy

Maximum speed = 60km/hr
Distance covered in 1.15hrs = 75km
Power required = 1875W
Power = voltage* current
1875 = 48* current
Current = 39Ah
By comparing different types of batteries we have chosen lithium ion phosphate battery according to our requirement.

- Yield Strength
- For Shaft

The following formula can be used to estimate yield strength
Ys = fs * Ds
Where Ys is the yield strength
fs is the safety factor
Ds is the design stress
By calculating it for original working load on shaft
D = 2844.66Psi
fs = 6
Ys=17064Psi or 117.652MPa which is less than the standard Ys of shaft which is 460MPa
So, it is safe to use the shaft at that much load.

- I-Section

By calculating it for original working load on I-section
Ds=3186Psi
fs = 10
Ys=31860Psi or 219.66MPa which is less than the standard Ys of I-section which is 500MPa.
So, it is safe to use the beam at that much load.

- For Square Pipes

By calculating it for original working load on square pipe.
Ds=2958.560Psi
fs = 4
Ys=11884.342Psi or 81.594MPa which is less than the standard Ys of square pipe which is 360MPa.
So, it is safe to use the square pipe at that much load.

- Chain Selection

Link pitch = 0.395inches
Small sprocket teeth =13
Large teeth = 43
Chain links = 65
Length of the chain = 652mm
Gear ratio = 3.308:1

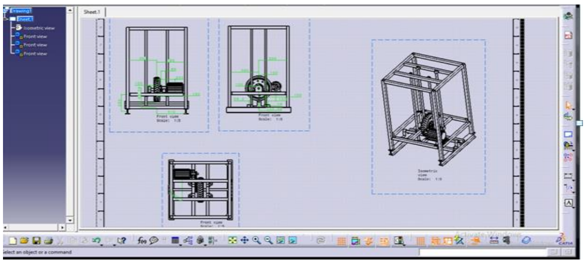
V. DESIGN & ANALYSIS

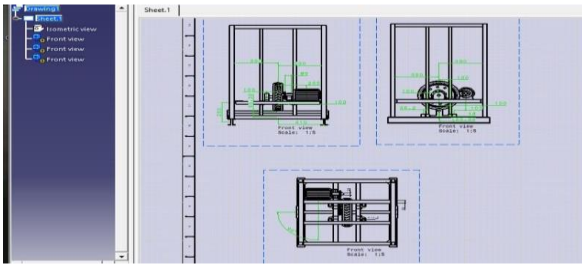
At first we draw the rough sketch of the overall planned model going to create in CAD software. The software used for 2D drafting and 3D modeling was Catia V5 R20, Ansys 2020 R2 was the software for the

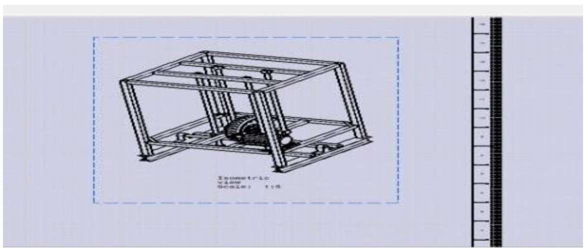
analysis part.
2D drafting plays major role in product design and manufacturing, it provides a good understanding and helps to communicate in easy way during manufacturing of parts.
While 3D modeling helps the designer and the end user to visualize space requirements and improves drawing efficiency and accuracy, also helps the designer to understand what they won't see in 2D drafting.

Here,
The overall dimension of the CAD model is 750 X 500 X 1200 mm.

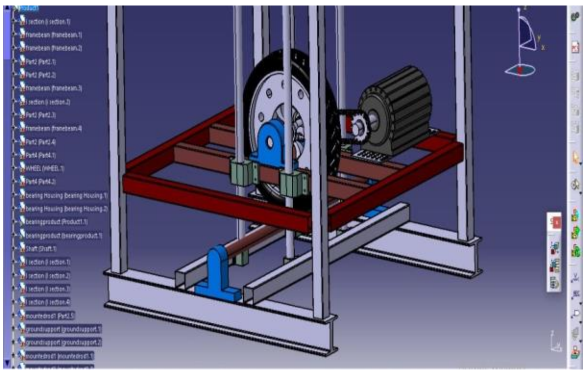
2D Drafting of 2W test-rig

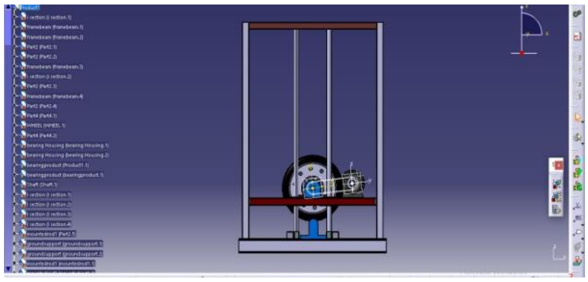


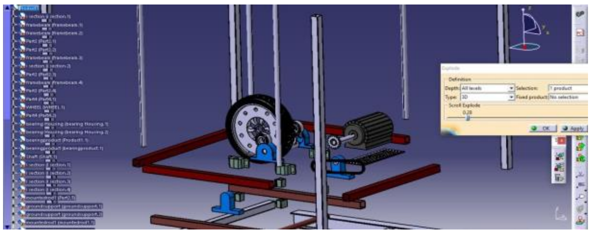


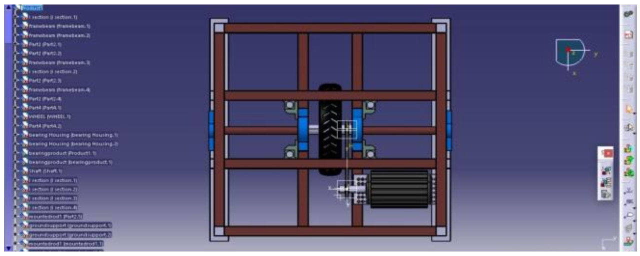


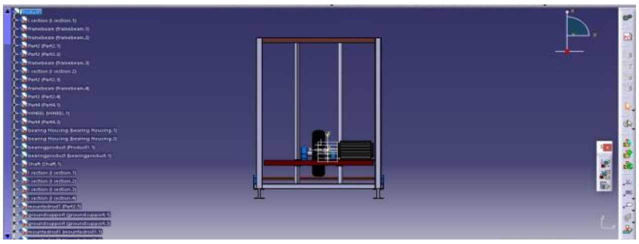
3D Modeling of 2W test-rig









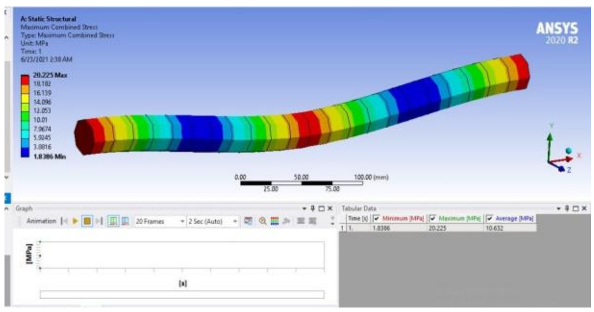


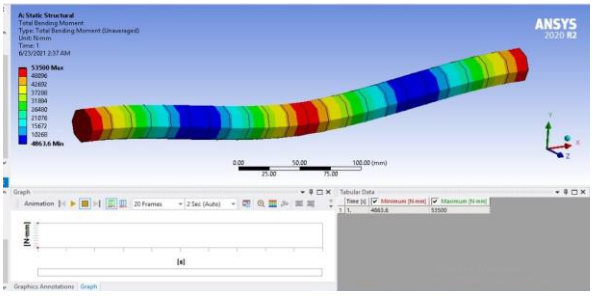
Analysis

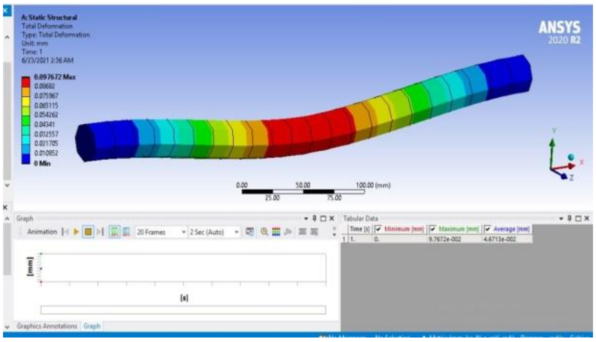
Analysis of 2W test-rig

- Base rod (support for the frame and wheel)

FORCE= **1000N**
Tensile Stress= 20.225MPa
Compressive stress= -1.83MPa
Total bending moment= 53500 N-mm
Total deformation= 0.0097 mm

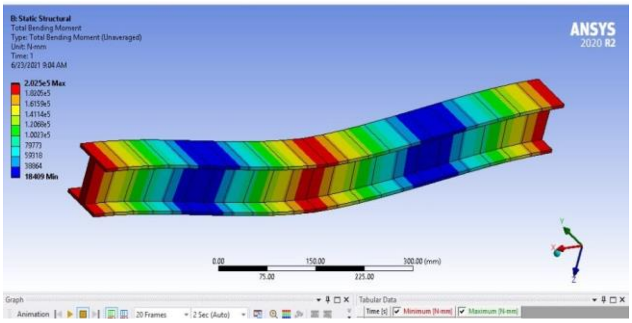


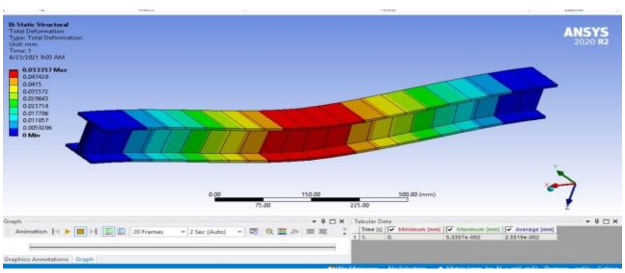




- -SECTION (support for the overall frame)

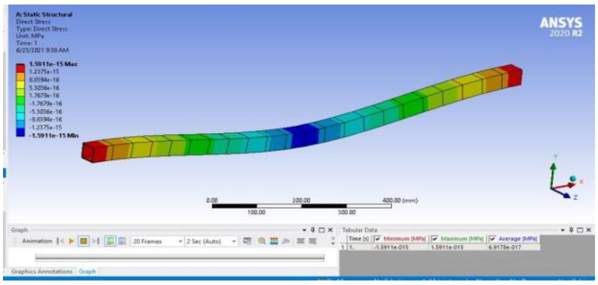
FORCE= **1800N**
Tensile Stress= 5.726MPa
Compressive stress= -0.520MPa
Axial stress= 1.866MPa
Total bending moment= 2.025 N-mm
Total deformation= 0.053357 mm

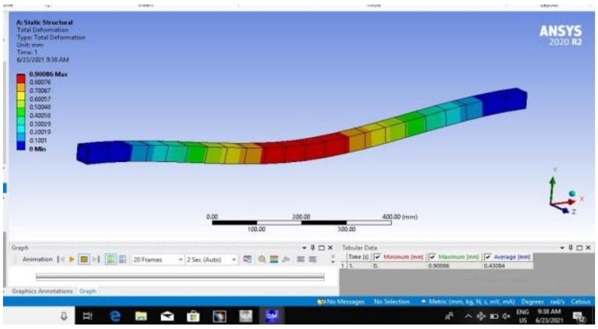




- Square Pipes (where wheels are assembles)

FORCE= **735N**
Tensile Stress= 30.556MPa
Compressive stress= -2.7778MPa
Axial stress= 1.59MPa
Total bending moment= 1.1209 N-mm
Total deformation= 0.9008 mm





VI. Acknowledgement

We would like to thank our professors and parents for there guidance. Their patience and technical expertise that help us to overcome obstacles during this project.

VII. Conclusion and Future Scope

In the introduction the idea of design and manufacturing of electric vehicle 2W Test Rig was introduced based on the calculated information, we finally came up with the electric 2W Test Rig which is working thoroughly and deftly on electric power.
In this electric 2W Test Rig we have deliberated current values at varying load, road gradient and rolling resistance of various surfaces.
The reason behind the manufacturing of this electric 2W Test Rig is to lower the carbon emission by using efficient and durable battery pack.
The literature on this topic reinforces the importance of electric vehicles in our future for clean and green environment.
In future by modifying the test rig battery we can increase the running distance of the vehicle.

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