Design And Analysis of Powertrain for Electric Vehicle

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Abstract- The rapid growth of renewable energy, such as solar power, has led to a dramatic increase in the demand for engineers. Through our project, we will build and build the right vehicle capacity while gaining knowledge and experience in the growing industry. The powertrain is an integral part of any car, the Electric Vehicle powertrain design that emphasizes the cost-effective expansion by incorporating a gearbox with an electric motor thus reducing the need for torque in the car and reducing battery capacity.

The powertrain is designed to show the flexibility of the car by combining electric and mechanical models. In the study, vehicle power was assessed by looking at changes in vehicle speed and acceleration, battery charging status, and vehicle power.

The powertrain has a variety of features including battery pack, battery management system, converter, car and control system. In the mechanical system, it contains power transmission, axial shaft, car wheels and gearbox, a sophisticated gearbox designing method using the modern designing software's.

***Key Words*: Power train, electric motor, transmissions, design, Electric vehicle, electric transmission, battery calculation, solar.**

1. INTRODUCTION

Electric cars have higher transmission requirements than traditional cars. Cars require a lot of torque to start and go up, and the need for power, when they are moving fast and converting power at a high rate, must be met.

When charged for electricity generated by mineral and renewable resources, BEVs have the potential to provide a non-renewable energy category. BEVs provide high efficiency and no exhaust pipe emissions which is why regulations are considered to be neutral CO2 so far Motors relying on their current regulatory rating are far from meeting the automotive operating system. Proper comparisons of electric car signs can play an important role in increasing car power, economy, comfort ride, and endurance mileage.

The main technology of electric cars is the powertrain transmission system, and the performance of cars Gears, and gear drives are known and used for thousands of years as critical components of roads and equipment.

The project focuses on the construction of an electric car that can generate energy using renewable energy. Designing a powertrain to help with the initial difficulty. If this type of electric train becomes a standard, the need for fuel can be greatly reduced.

The powertrain should be lightweight to reduce the amount of vehicle needed to withstand the demands of urban transport, it should use renewable energy to reduce pollution and hit should be efficient enough to produce enough power to move power over a limited period of time. The powertrain is designed to handle one driver, there will be a need for additional space for other passengers and building materials.

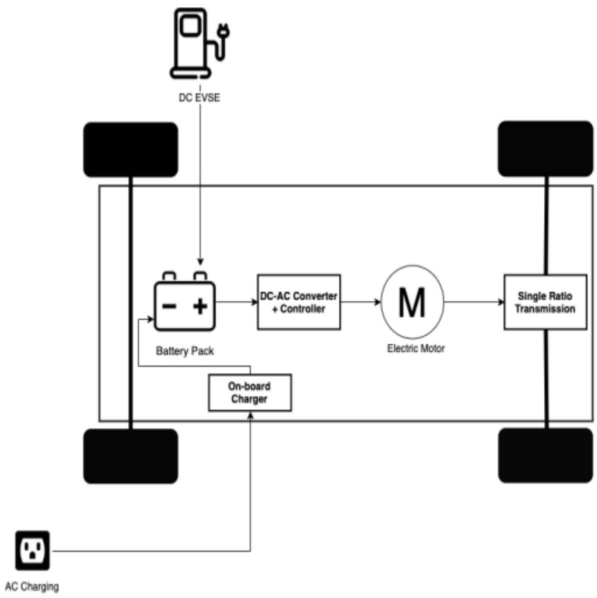
This leads to various decisions that need to be considered during the design process. Both mechanical and electrical engineering considerations should be considered for the project.

2. DESCRIPTION OF PROPOSED SYSTEM COMPONENTS

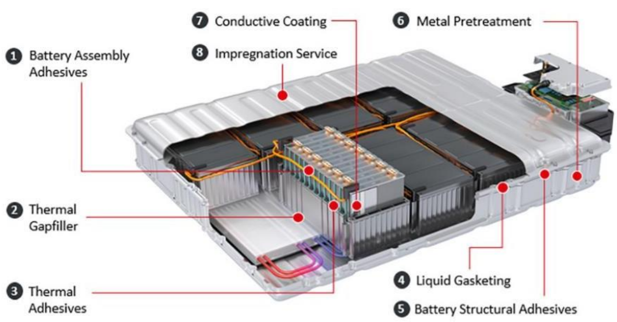
As the name suggests, the powertrain provides power to the vehicle. Powertrain refers to the set of components that generate the power required to move the vehicle and deliver it to the wheels

The powertrain of an electric vehicle is a simpler system, comprising of far fewer components than a vehicle powered by an internal combustion engine.

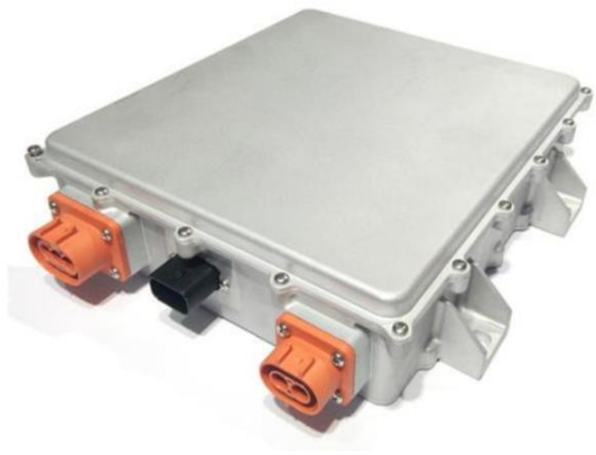
A vehicle has hundreds of moving parts. Main components of its powertrain are Engine, Transmission and Driveshaft. Power is generated by the engine and transmitted to the driveshaft. Other internal parts and components of the engine, differentials, axles, emissions control, exhaust, engine cooling system etc. are also included in the powertrain



Battery Pack: - The battery pack is made up of multiple Lithium-ion cells and stores the energy needed to run the vehicle. Battery packs provide direct current (DC) output.



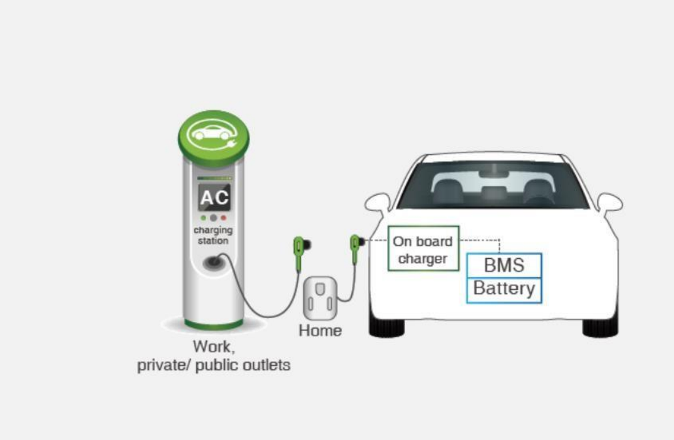
DC-AC Converter: - The DC supplied battery pack is converted to AC and supplied electric car. This power transmission is handled by a sophisticated vehicle control system (also called the Powertrain Electronic Control Unit) that controls the frequency and magnitude of the power given to an electric vehicle to control speed and acceleration as the driver's instructions are transmitted / accelerated



Electric Motor: - It converts electrical energy into Mechanical energy, which is transmitted to the wheels by a single transmission ratio. Many EVs using motor generators can do renewal.

On-board Charger: - Converts AC-acquired charging port to DC and controls the amount of current flowing in the battery pack

In addition to the above content components, there are many hardware and software components in the EV powertrain. Electronic Control Panels (ECUs) are basically software integrated with powertrain components to facilitate data exchange and processing, e.g., the Powertrain ECU mentioned above. There are several smaller ECUs in the EV that perform specific functions. Communication between different ECUs in a vehicle is usually carried over the CAN protocol.



Battery Management System (BMS): -
BMS continues to monitor the status of battery and is responsible for taking the necessary steps if it is not working properly. BMS makes cell balancing to deliver the highest performance on a battery pack. It is responsible for communicating with other ECUs and sensors, as well as EVSEs to control charging inputs, check current charging status and share details about battery specifications.

DC-DC Converter: - The battery pack delivers a fixed power supply, but the requirement for various access systems (e.g., wipers, lamps, infotainment system, mirror controller) on EV will vary. The DC-DC converter helps distribute power across various systems by converting the output power from the battery to the expected level. After conversion, power is transferred to smaller ECUs via a cable connection.

EVSE Type	Power Supply	Charging Power	Charging time for 24 Kwh Battery
AC Charging Station: Level 1 Residential	120/230 VAC 12A to 16A Single Phase	~1.44 KW to ~1.92 KW	~17 hrs
AC Charging Station: Level 2 Commercial	230 VAC 15A to 80A Single phase/Split phase	~3.1 KW to ~19.2 KW	~8 hrs
DC Charging Station: Level 3 Fast Chargers	300VDC to 600 VDC Max 400A (poly phase)	120 KW to 240 KW	~30 mins

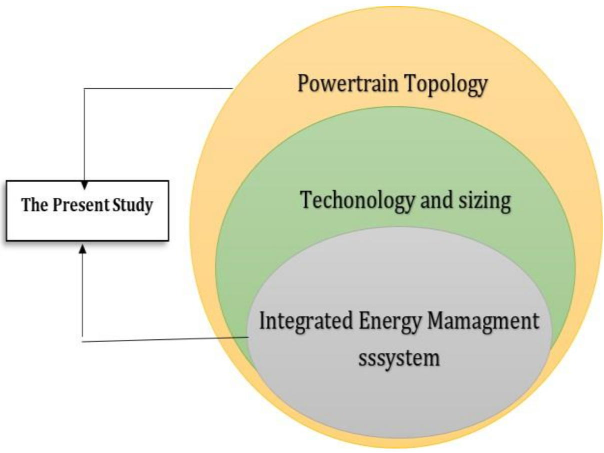
Thermal Management System: - responsible for maintaining a good temperature range for powertrain items.

Body Control Module (BCM): -
BCM is responsible for overseeing and controlling electronic equipment operations such as power windows, mirrors, security and access control for vehicles

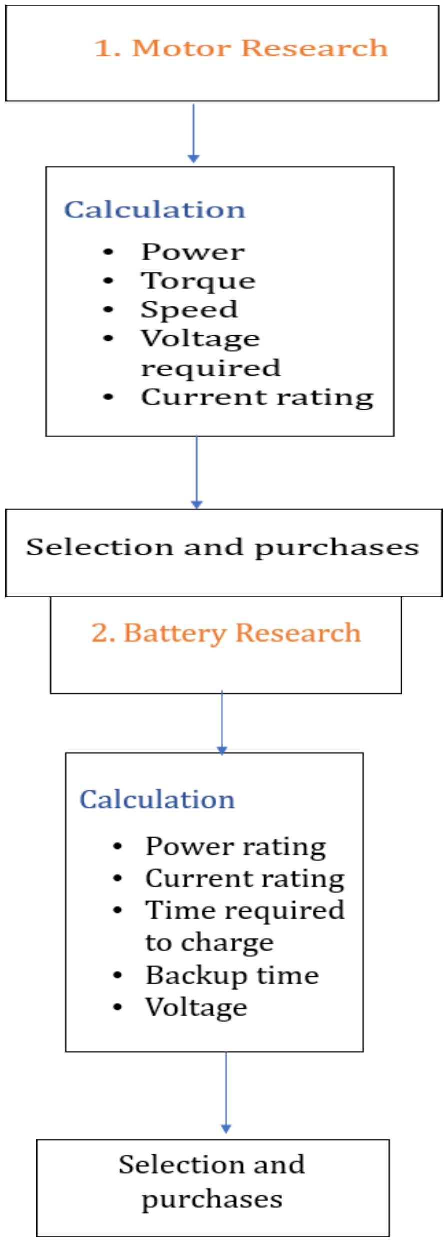
3. PROPOSED METHODOLOGY

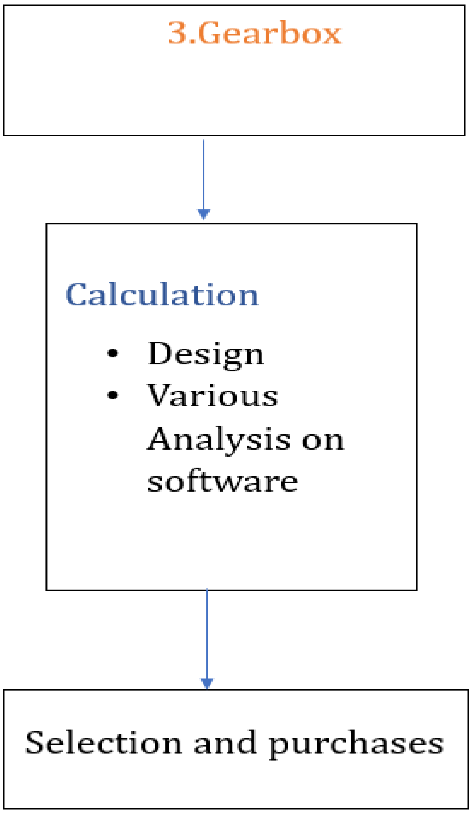
There are various features and components of the project that should have been developed or selected. The main ones are given below for each selection or construction process.

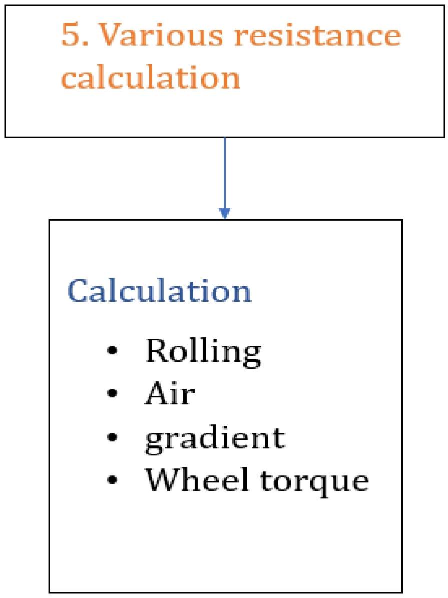
- Energy production from the sun
- Hourly electricity generation
- Loss power to charge the battery
- Loss of energy in transformation
- Battery storage capacity
- Time required to charge the battery
- Power lost in transmission
- Power generation from regenerative cracks

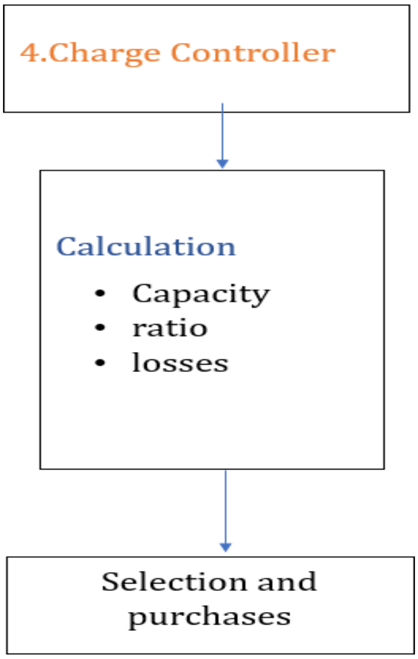


3.1 Powertrain parts and values to be calculated:




3.Gearbox
Calculation
Design
Various Analysis on software
Selection and purchases


5. Various resistance calculation
Calculation
Rolling
Air
gradient
Wheel torque


4.Charge Controller
Calculation
Capacity
ratio
losses
Selection and purchases

3.2 Weight Calculation:

SR. No		Quantity	weight(kg)	Total
1	Chassis	1	21.42	21.42
2	Battery	2	2	4
3	Fream (Roof & Support)	1	25	25
4	Seats	6	2	12
5	Passenger	4	80	320
6	Gearbox	1	20	20
7	Steering System	1	5	5
8	other electronic components	1	15	15
9	Suspension	1	40	40
10	Motor	1	12	12
11	welt/Rivets	1	15	15
12				0
13				0
14				0
15				0
SUBTOTAL(Kg)				489.42

3.3 Wheel calculation:

Linear Wheel Travel

- Linear Wheel Travel $= 2\pi r$

= 2 * 3.142 * 0.3

= 1.8852(m)

Where,
r = Wheel Radius(m)

Speed= 40 Kmph
= 40*(5/18)
= 11.11m/s

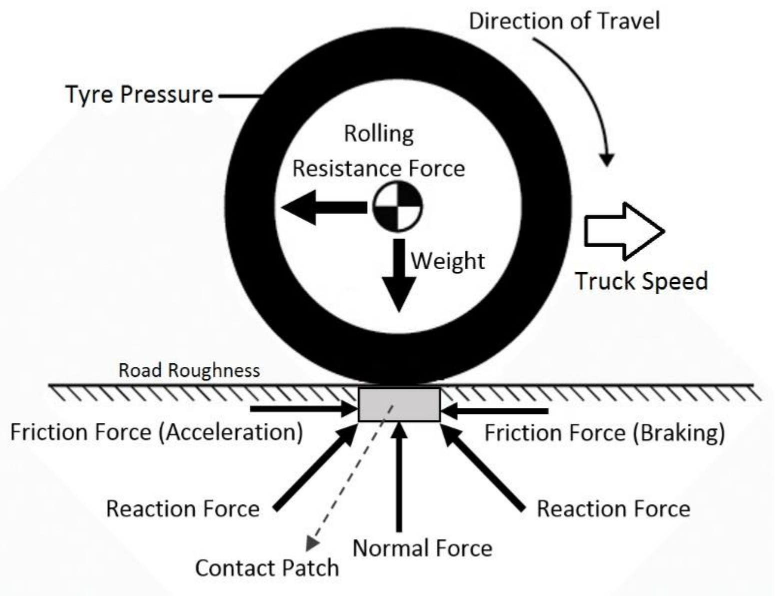
RPM Required=speed /wheel Travel
= (11.11*60)/1.8852
=353.6 RPM

power(p)= (m*g*V*Rolling Resistance*) +(Air density * Coefficient of drag *v3 * + |(m*g*sin30)

3.4 Parameters Affecting on Power Calculation

1. Rolling Resistance (*RR*)
2. Air Resistance (Air Drag) (*AR)*
3. Gradient Resistance (*GR*)
4. Total Resistance (*TR*)

1. Rolling Resistance (*RR*)



Fr = m * g * Cr

=489.42*9.81*0.02

=96.0242

Here

m = mass of car

g = gravitational Forces

Cr = coefficient of rolling resistance

Factor Affecting on coefficient of Rolling Resistance

- Weight of vehicle
- Speed of vehicle
- Tyre pressure
- Surface roughness of Road
- Car tyre rubber hardness

Coefficient of Rolling Resistance:

c	Type
0.001-0.002	Rail rods wheels on steel rails
0.001	Bicycle tire on wooden tracks
0.002-0.005	Low resistance tubeless tire
0.002	Bicycle tire on concrete
0.004	Bicycle tire on asphalt road
0.005	Dirty tram Rails
0.006-0.01	Truck Tyre on asphalts
0.008	Bicycle tire on rough paved Road
0.01-0.015	Ordinary car tires on concrete, new asphalt, cobbles small new
0.02	Car tire on tar or asphalt
0.02	Car tire on gravel rolled new
0.03	car tire on cobbles large worn
0.04-0.08	Car tire on solid sand, Gravel lose Worn, Soil Medium Hard
0.2-0.4	Car tire on loose sand

- Cr = 0.01 up to 500 kg weight
- Cr = 0.02 up to 500-1500 kg weight
- Cr = 0.03 up to 1500 kg weight

Air Resistance (Air Drag) (AR):

$$Fd = cd * \frac{1}{2} * d * v^2$$

$$=1/2*0.02*0.3*2*11.11*11.11$$

$$=25.9258$$

here,

Cd=coefficient of drag

d= fluid density

V=Frontage area of car

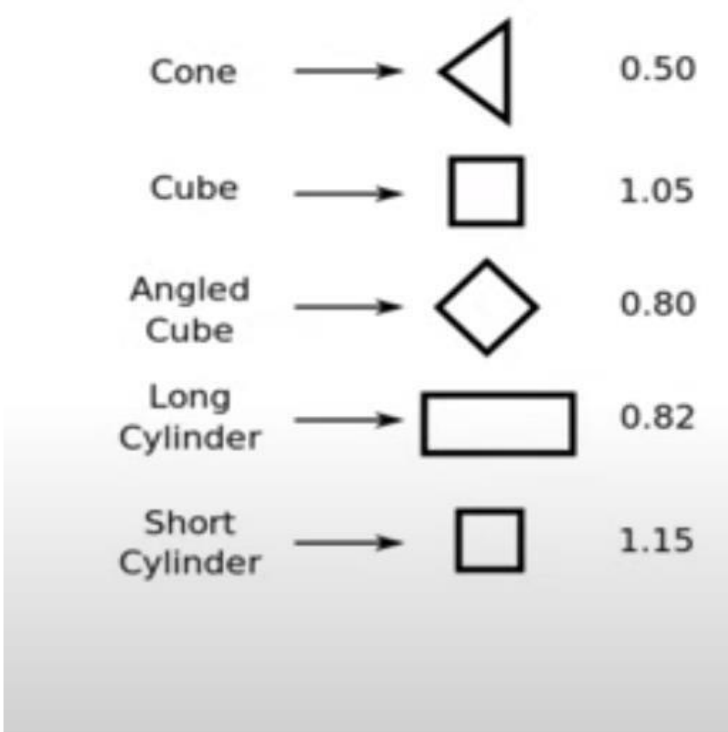
A=frontage Area of car,

3.2.2 Factor Affecting the cd

- Density of Air
- Frontage Area of Vehicle
- Velocity of car

Standard Coefficient of Drag Value

Common car like Opel Vectra (class C)	0.29	frontal area
Hollow semi-sphere facing stream	0.38	
Bird	0.4	frontal area
Solid Hemisphere	0.42	π / 4 d2
Sphere	0.5	
Saloon Car, stepped rear	0.4 - 0.5	frontal area
Convertible, open top	0.6 - 0.7	frontal area
Bus	0.6 - 0.8	frontal area
Old Car like a T-ford	0.7 - 0.9	frontal area
Cube	0.8	s2
Bike racing	0.88	3.9
Bicycle	0.9	
Tractor Trailed Truck	0.96	frontal area
Truck	0.8 - 1.0	frontal area
Person standing	1.0 – 1.3	
Bicycle Upright Commuter	1.1	5.5
Thin Disk	1.1	π / 4 d2
Solid Hemisphere flow normal to flat side	1.17	π / 4 d2
Squared flat plate at 90 deg	1.17	
Wires and cables	1.0 - 1.3	
Person (upright position)	1.0 - 1.3	
Hollow semi-cylinder opposite stream	1.2	
Ski jumper	1.2 - 1.3	
Hollow semi-sphere opposite stream	1.42	
Passenger Train	1.8	frontal area
Motorcycle and rider	1.8	frontal area



Gradient Resistance

Fg = m * g * sin (20)

=489.42*9.81*0.342

=1642.0138

Where,
Sin (20) = gradient Angle

Factor Affecting on Performance

coefficient of Rolling(cr)	0.02
Coefficient of Air Resistance	0.7
Gradient Andle sin (20)	0.342

Rolling Resistance (Fr)	Air Resistance (Fd)	Gradient Resistance (Fg)
m*g*Cr	1/2*Cd*d*sq(v)	m*g*sin20
96.024204	25.92592593	1642.013888

power(pr)	power (pd)	power(pg)	Total Power(watt)
Fr*v	Fd*v	fg*v	pr + pd + pg
1066.9356	288.0658436	1642.013888	2997.015332

3. 5 Total Power

- Power Pr = Fr * V

  =96.0242*11.1111
  =1066.9356

- Power Pd = Fd * V

  =25.92592593*11.1111
  =288.0658436

- Power Pg = Fg* v

  =1642.013888*11.1111
  =1642.013888

- Total Power = power Pr + power Fd + Power Fg

=1066.9356+288.0658436+1642.013888

=2997.015332 watt

- P= 2 *Pi*NT/60

3.6 Battery Selection:

Battery size calculation

$$Battery\ Size(Ah) = \frac{watt * hour}{voltage}$$

= (3000*8)/48

=500 AH

Where,

Watt= total load on battery

hour=backup time

Voltage=voltage rating of battery

- **Current required to run load**

$$I1 = \frac{load(watt)}{Voltage}$$

=3000/4 =62.5 A

Were,

Load=total load on Motor

voltage= voltage rating load

Battery Charging current

$$Battery\ charging\ current(I2) = \frac{Battery\ size(Ah)}{10}$$

=500/10

=50 A

Total current required

I=I1+I2

=50+62.5

=112.5 A

Where,

I1=current required to run load

I2= current Required to charge battery

Solar Plate Power:

= V*I

=62.5*112.5

=750 watt

Where,

V=voltage rating of solar panel

I=I1+I2

Total solar Plates Required:

$$= \frac{solar\ plate\ power}{st.solar\ plate\ wattage\ value}$$

=750/100

=7.5

Std. plate wattage and voltage	
watt	voltage
100	12
150	12
250	24
325	24/48

Sr. No	load	Quantity	watt
1	motor	1	3000
2			
3			
4			
5			
Total			**3000**

motor voltage	48
backup Time(h)	8
motor voltage	12
solar plate watt	100

current required to run load	battery size (Ah)	battery charging current	required current from solar panal	solar plate power
I1=(watt/V)	(W*h)/v	I2= (1/10) *battery size	I=I1+I2	v*I
62.5	500	50	112.5	750

4. Motor selection

BLDC Motor:

These types of motors are very effective in producing a large amount of torque at high speeds. In meters without brushes, permanent magnetic circles rotate the arm continuously and overcome the problem of the current connection to the armature. Electronic trading has a variety of capabilities and flexibility. They are known to work smoothly and have torque when suspended. In motors brushes, there are magnets that do not sit outside and a spinning arm that contains an electromagnet inside. These gases capture the magnetic field in the arm when the force is opened and helps to rotate the arm. Brushes around the shaft on the shaft to maintain rotation on the shaft. The basic principles of a DC brush and a brushless DC motor are the same eg, internal shaft response. The brushless DC motor has only two basic components: Rotor and stator. The Rotor is a rotating part and has a large Rotor and the stator is a straight and contained part

Motor Power calculation

- Torque

$$P = \frac{2\pi n t}{60}$$

$$t = \frac{P*60}{2\pi n}$$

=(3000*60)/2*pi*2400)

=11.93Nm

- Output Power

$$w = \frac{2\pi n}{60}$$

=251.3274

Pout= $T * w$

=251.3274*11.93

=2998.5368

approx.=3000 watt

Efficiency

Pin=V*I

=48*88.72

=4258.56kw

$$\%\eta = \frac{Pout}{Pin}$$

=70.44%

Pout=Pin* η

☐ Terminal Resistance

V=I*R

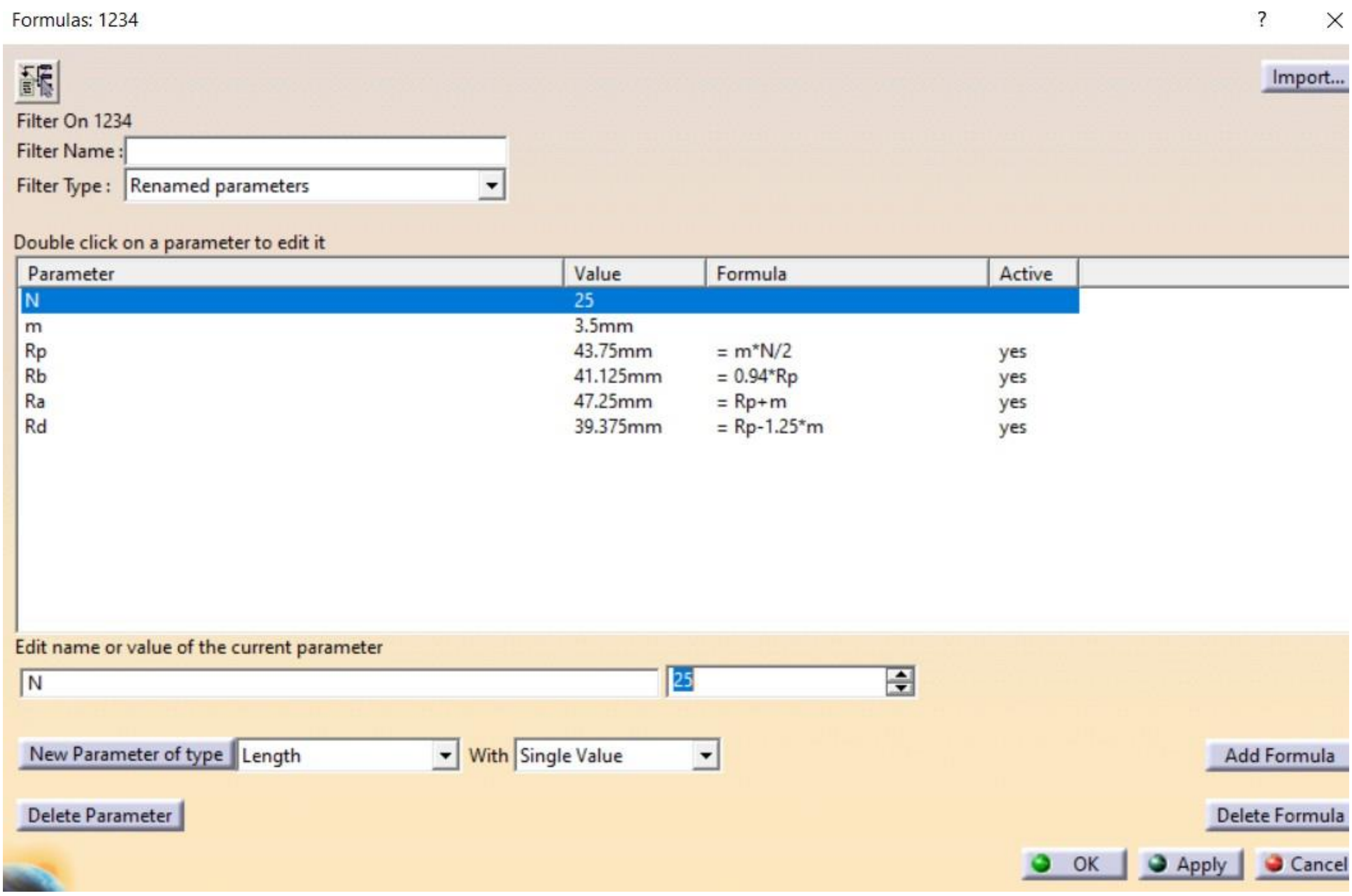
R=V/I

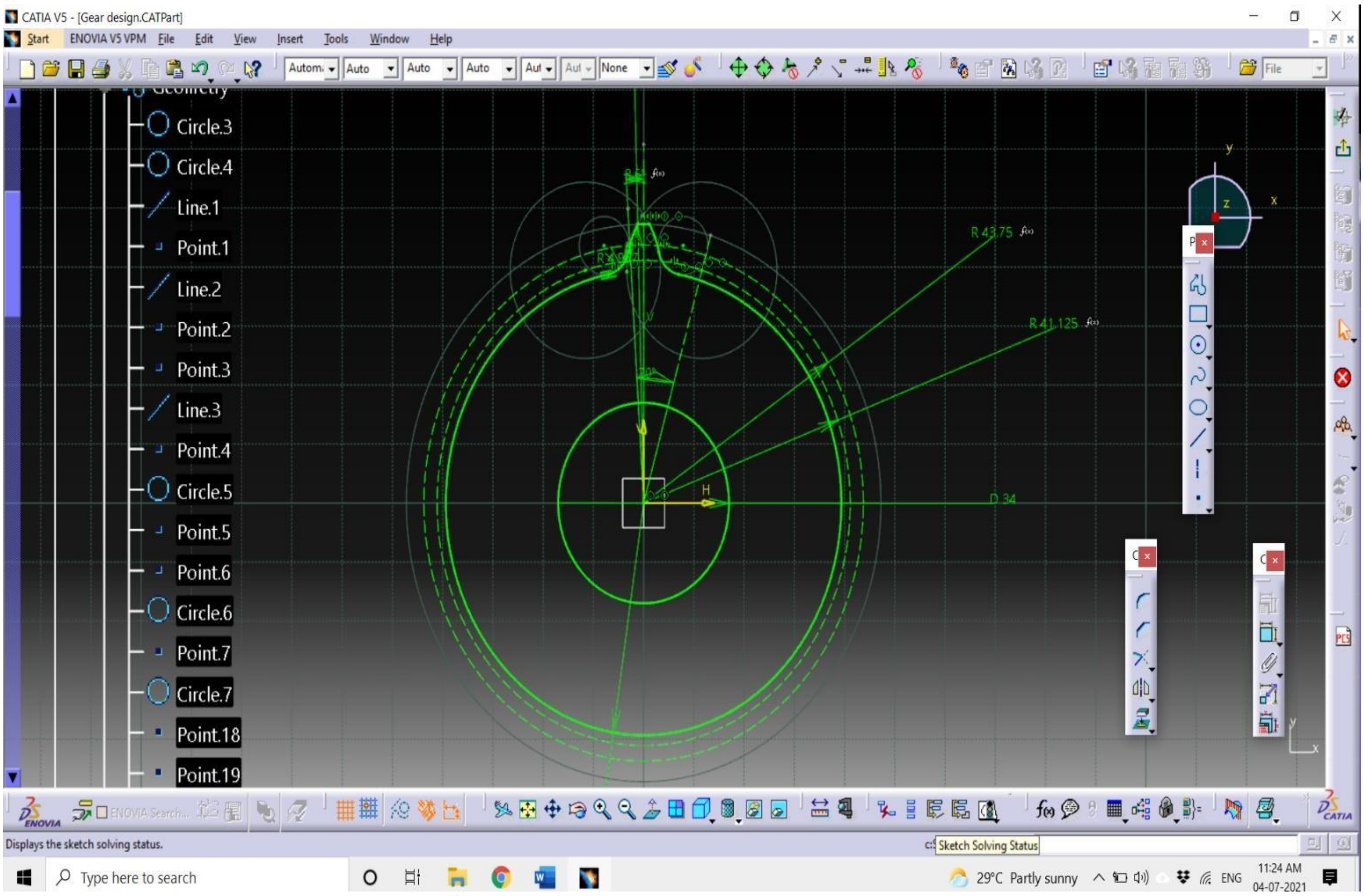
Motor Power Calculation

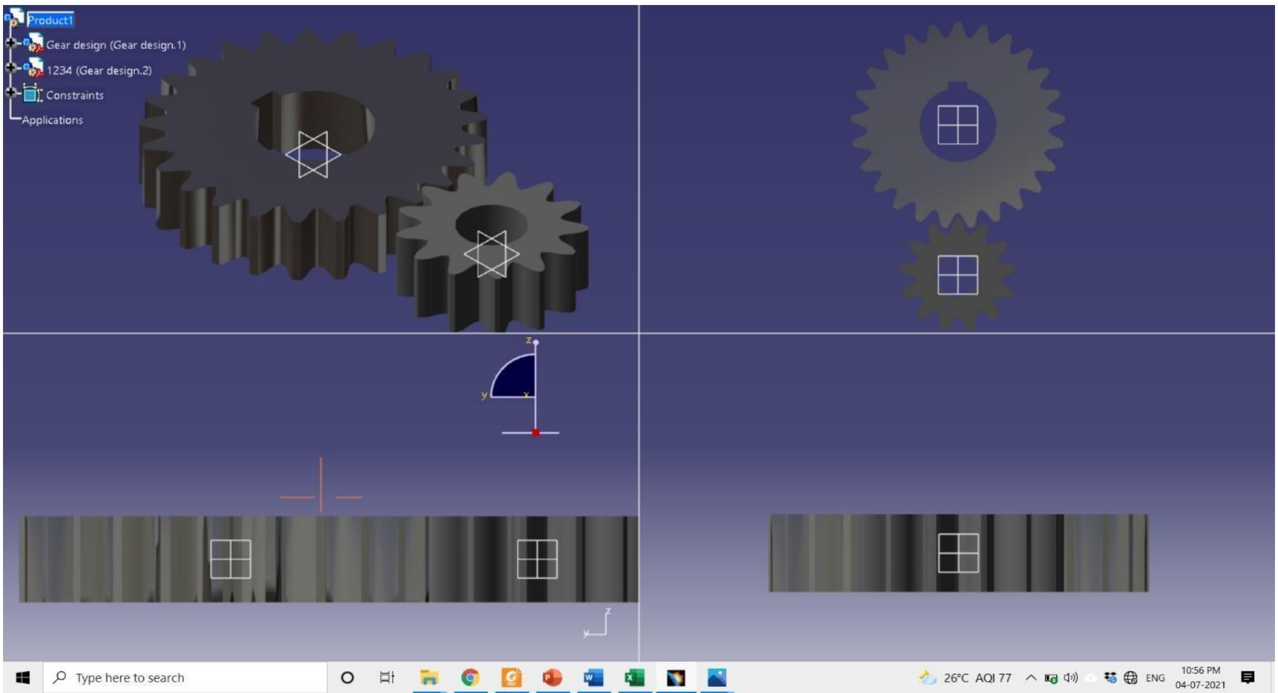
Torque (Nm)	Power out(watt)	Power Input(watt)	%Efficiency	Termonal Resistance
(P*60)/2πn	T*w	v*I	(Pout/Pinp)	(v/I)
9.5385593	2997.015332	4320	69.37535491	0.533333333

Std.power output watt	speed (rpm)	voltage (v)	Peak current (A)
3000	3000	48	90

Gear Design Calculation Sheet: -




CATIA V5 - [Gear design.CATPart]
Circle.3
Circle.4
Line.1
Point.1
Line.2
Point.2
Point.3
Line.3
Point.4
Circle.5
Point.5
Point.6
Circle.6
Point.7
Circle.7
Point.18
Point.19
R 43.75
R 41.125
D 34
Displays the sketch solving status.
Sketch Solving Status


Product1
Gear design (Gear design.1)
1234 (Gear design.2)
Constraints
Applications

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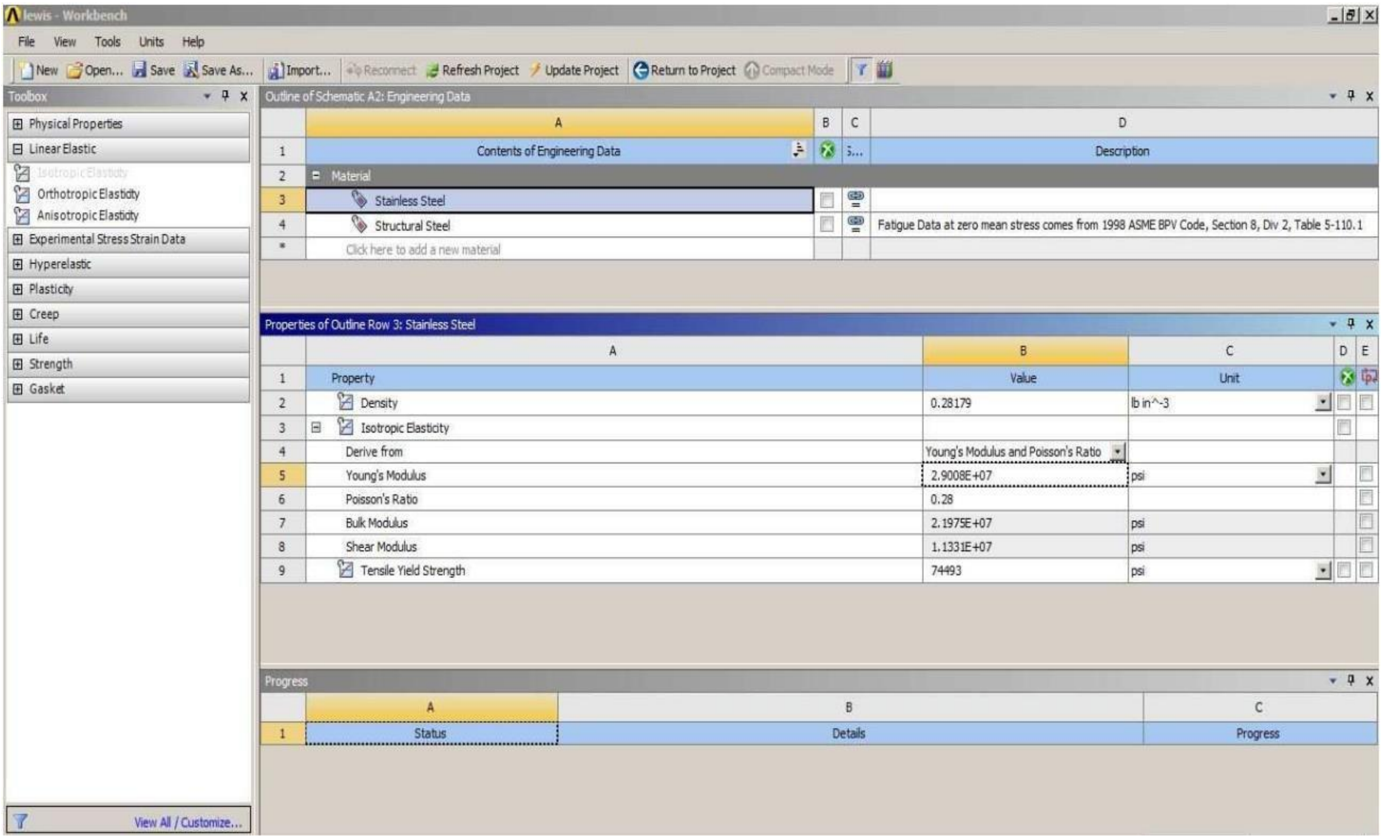
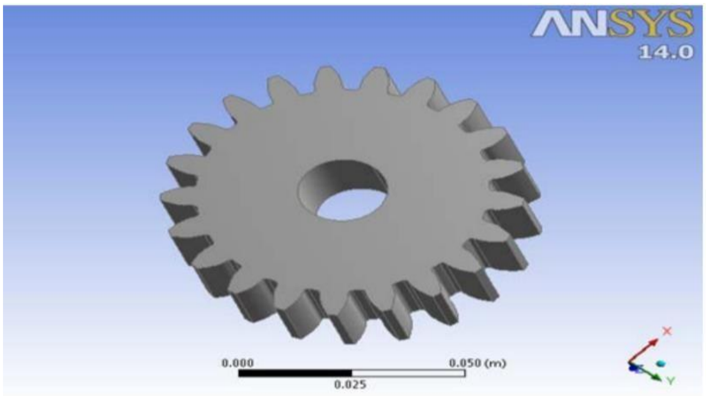
Volume: 08 Issue: 08 | Aug 2021 www.irjet.net p-ISSN: 2395-0072

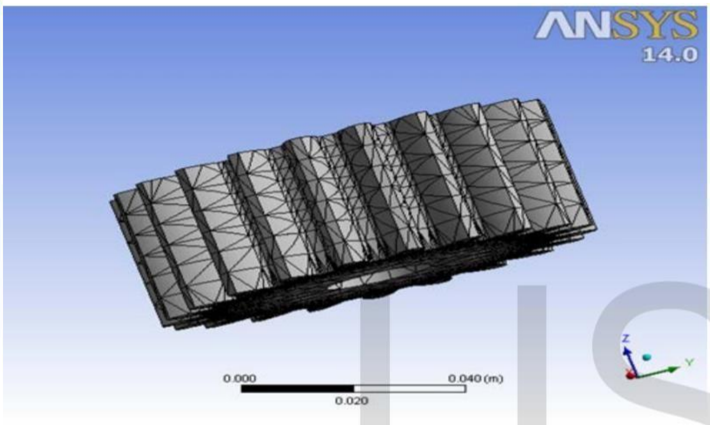
Various Physical Property of Gear:



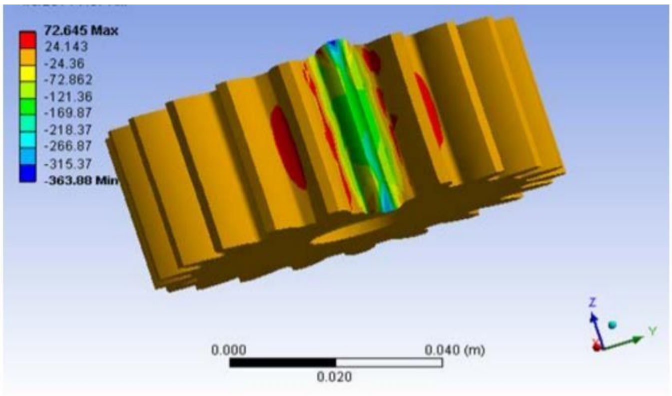
Part Design of spur gear

Mess of the gear



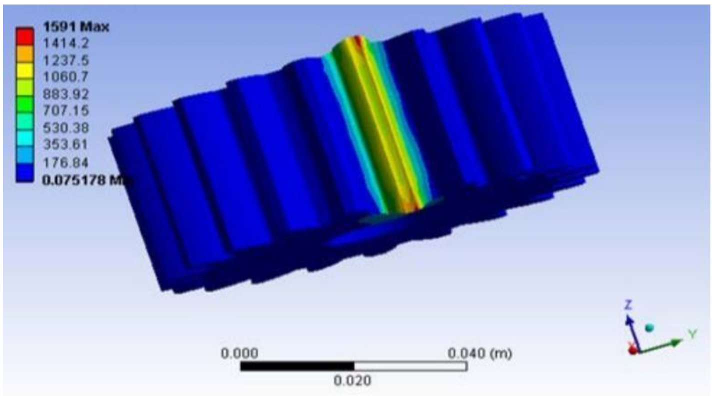


Static structural:

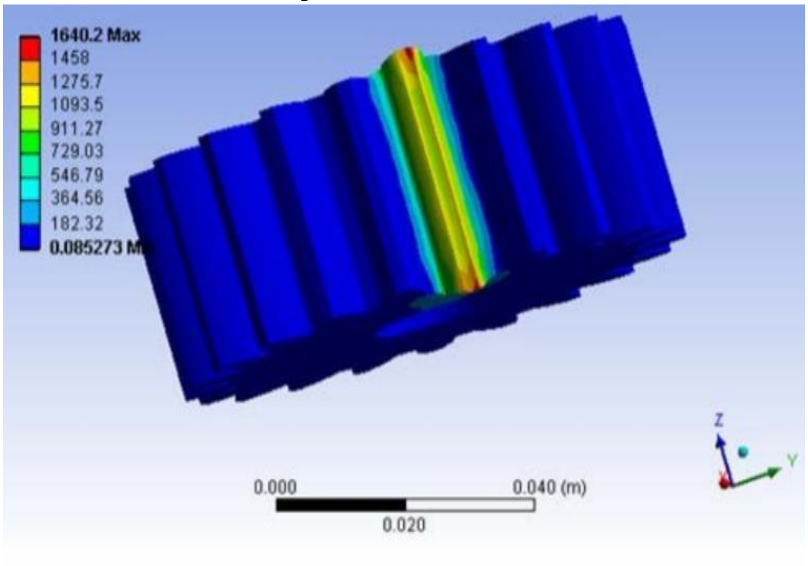


Middle Principal Stress

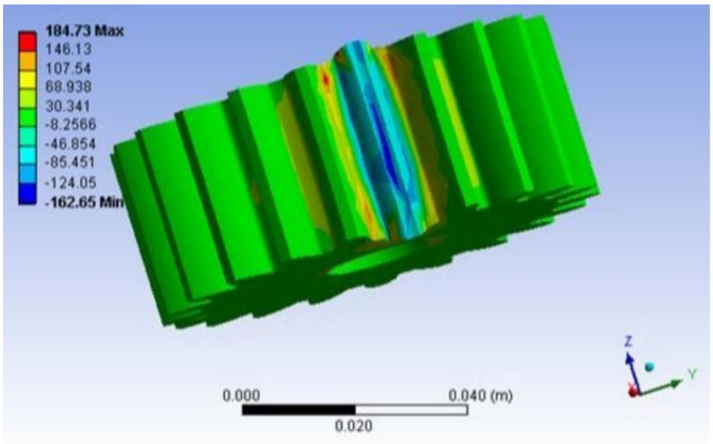
Shear Stresses



Stress Intensity



Directional Deformation



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