A Report
On

RETROFITTING OF CAR BIKE AND CYCLE

SUBMITTED TO: -

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Submitted By

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AND

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Electrical and Hybrid Vehicles

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TITLE

RETROFITTING OF CAR BIKE AND CYCLE

ACKNOWLEDGEMENT

I would like to covey my special thanks of gratitude to Dr Amiya Dash for giving us this great project on the retrofitting and hands-on experience of cycle , bike , car make them into electric and save the environment and we would like to thank other faculty Amit sir , Gora sir helped us.

We have completed this project successfully with our 2019 mech automobile specialization group great by sir guidance we have done. From this opportunity we learnt a lot about retrofitting and got to know new things regarding all types of retrofitting and motor sizing modelling battery sizing etc according to course we learned and implemented it.

Introduction

In this Era, we all have witnessed that an Automobile is something which is very crucial in our daily life and without a car or a bike few accomplishments would be difficult too. Here we all got the fuel powered internal combustion engines from the 1890's which has totally changed the industry demanding Diesel and Petrol Engines. But we do also know very well that these IC engines also have their disadvantages like releasing COx, NOx and HC gases into the atmosphere which degrades the quality of the air. So to reduce the dependence on fossil fuels and to control the environment pollution all the countries started to invest in electric vehicle technology. And then now, from the past decade, electric vehicle technology has been emerging very rapidly. People also started to like it as there is very minimal pollution when compared to the IC engine vehicles. One of the reports states that India's electric vehicle market is expected to grow at a CAGR of 90 per cent in this decade to touch $150 billion by 2030.

People have started to purchase the new model EVs released in the market and slowly the demand for electric cars has gone way higher than expected before. But we also can't easily put the IC Engine cars aside, though the engines would not be useful for the environment but the vehicle body will, and there's a chance for converting it into the EV. The process of converting petrol/diesel engine cars into an Electric Vehicle is called Retrofitting. In this process they generally remove the whole engine from the car. Take the dimensions and values from the car, make the battery sizing and motor sizing according to the vehicle, get the battery and motor fixed in the car and then the car turns into an Electric Vehicle once it starts moving while the motor is powered with the battery.

Nowadays a pure Electric Vehicle from the OEM directly is costing a little more when compared to IC Engines. So few people can't afford it and they are opting this Retro Fitting as a choice. This Retro Fitting is way more affordable when compared to the pure EV because we already do have the whole body with us and we get charged for only the battery and the motor. But the other con side of the Retro Fitting is that as the original can which we will be turning might be designed in such a way that the Auxiliary System, Drive Train and other wire harnessing is designed to as that of the IC Engine. But here you are making it get adopted as an EV so you'll be facing a few minor problems like designing the Battery Placement and Motor Placement well before the actual work.

Literature Review:

Retrofitting a used car with a hybrid electric propulsion system.

- This paper presents a design concept of converting a conventional used car to a hybrid electric vehicle (HEV). The existing propulsion system using an internal combustion engine(ICE) was replaced by an electric drive, which is supplied by batteries and an on-board generator.
- The propulsion system is configured as a series-hybrid concept. The input energy can come either from the on-board generator driven by a small combustion engine or from a battery charger powered by a household plug. The on-board generator is controlled manually. The driver can select to run in the hybrid mode or in the electric mode.
- In this work, a retrofitting concept for converting a used car to a series-HEV is reported. A prototype car was reconstructed with the designed hybrid electric propulsion. The field tests were carried out to verify the functions of the prototype in both pure electric and hybrid operations.
- The concept of converting a used car to HEV was successfully proven by the results of this work. There are further functions and components which should be developed in the future in order to improve the performance of the presented concept, e.g. battery management, electrical brake control, communication between components etc.

Eco fitting: design directions upgrading cars to zero emissions

- This paper presents the design directions for Eco fitting, a sustainable solution for the large UK fleet of internal combustion engine cars that will soon be rendered non-compliant with fast approaching initiatives for Ultra Low Emission Vehicles.
- Eco fitting circular economy strategy goes beyond just electrification, opening an opportunity for new approaches to automotive design, and to cater for generational shifts in desirability. State-of-the-art, taxonomic and trend mapping research have identified opportunities for retrofitting leading to four proposed design directions inspired and influenced by sustainable practices across other industries, that directly involve the consumer, and provide an alternative approach to the longstanding aesthetic of perfection historically seen in vehicle design.

Modelling and simulation of a retrofitted electric car in urban and extra urban driving cycles

- This paper presents a summary of the modelling and simulation carried out to evaluate the performances of a prototype of a retrofitted electric car in urban and extra urban driving cycles.
- The vehicle performances, including energy consumption and driving range, state of charge and current supplied by the battery pack, have been investigated over urban and extra urban driving profiles.
- To reproduce the EV power demand in some realistic usage conditions, the model has been also applied on a real-world driving cycle, diversified in terms of altitude.
- Based on the comparison between the two models developed, it must be noticed that the order-zero model overestimates the EV driving range and the state of charge of the battery pack at the end of the urban driving cycles, while for extra urban driving conditions the results are almost the same.
- In addition, the current supplied by the battery pack computed with the order-one model when the vehicle starts and accelerates is much higher, and more realistic than in the zero-order model, because the induction motor efficiency is evaluated with more accuracy.

Hong Kong Experience in Retrofitting In-use Diesel Vehicles

- Vehicle emission emissions are one of the main contributors to the air pollution in Hong Kong. Back in 1997, the exhaust from diesel vehicles accounted for almost all the particulates and 75% of the nitrogen oxides emissions. Since then, Hong Kong Environmental Protection Department (HKEPD) has implemented a set of control measures to abate vehicle emissions.
- This paper presents the progress of implementation of one of our control measures, the retrofitting of in-use diesel vehicles to reduce particulate emission.
- Since vehicle emissions are one of our main contributors of air pollution, we have implemented aggressive control measures to abate this problem. One of the effective control measures is the implementation of the retrofitting program for the in-use pre-1995 diesel vehicles. We began retrofitting the light duty diesels with traps or catalysts in 2000 with about 24,000 vehicles completed the installation.
- The implementation of the retrofit program together with other control measures is starting to generate positive results in reducing vehicle emissions. So far, the levels of particulates and nitrogen oxides on the street have reduced by 8 percent and 11 per cent respectively since 1999 and there are 50% less smoky vehicles running on the road.
- As a continuation of our effort, we have just expanded the retrofitting program to the heavy-duty diesels. Together with the retrofitting effort from the bus companies, we expect all the pre-1995 diesel vehicles; either light or heavy-duty diesels will be equipped with diesel oxidation catalysts or traps for the reduction of the particulate emissions.
- The quest of introducing new emission control technology continues. Like the trial of the passive particulate traps, we shall explore the application of advanced retrofitting technologies such as the nitrogen oxide traps or absorbers. We shall closely monitor the development of the new emission reduction technologies and will introduce them for our application when practical.

Development of a Retrofit Split-Axle Parallel Hybrid Electric Vehicle with In-Wheel Motors.

- This paper describes benefits of a hybrid drivetrain and presents development work of an experimental prototype of the retrofit hybrid system, implemented on a Proton WAJA. It explains operation of the retrofit vehicle's energy management system and describes a dynamic simulation model for the HEV. Preliminary simulation studies show a fuel reduction of 25% compared to the ICE only powered vehicle.
- Economic consideration requires further improvement of the fuel reduction, for the system to be commercially viable. This paper suggests for further research, an improvement to the simple retrofit system and investigation of various energy management strategies, to improve the fuel economy. Finally, this work describes experimental set-up for field testing and hardware-in-the-loop (HIL) simulation of the retrofit HEV.
- In the effort to reduce carbon emissions and dependence on fossil fuels as a source of energy, hybrid-electric vehicles (HEV) having more than one power source for vehicle propulsion provide a solution in the realm of transportation. HEVS combine the conventional vehicle power source - the internal-combustion engine (ICE) - with an electric motor, to form various possible configurations of the hybrid power train, allowing for different power-sharing schemes.
- There exist many variants of the HEV, and one specific configuration is the subject of this research the split-axle parallel hybrid configuration, in which the ICE and the electric motor operate on different axles. The split parallel layout enables existing ICE-powered vehicles to be retrofitted into a hybrid vehicle with minimal physical modification, achieved by placing electric motors in the hubs of the non-driven wheels.

Paper Citation: Nirmal A Kumar, Navaneeth M and Allan Sabu Joseph (2021) "Retrofitting of Conventional Two-wheelers to Electric Two-Wheelers".

This paper aim is to convert a standard Internal Combustion Engine (ICE) two-wheeler into a pure Electric bike. Tailpipe effusions in ICE are one of the most significant sources of air pollution. Rather of destroying existing ICEs, converting them to Battery Electric Vehicles (BEV) will lower the initial cost and reduce the carbon footprint of EVs. A 2KW BLDC motor and a 72V / 60Ah Li-ion battery were installed on this Bajaj Pulsar 220. To accommodate the new electric drivetrain without compromising the bike's structural stability, a design change was made. This document demonstrates the process of modifying a motorcycle. To comprehend India's road conditions, a regional drive cycle is established. In addition, power requirements for various driving cycles were analysed using reverse engineering-based powertrain modelling. The benefits of converting an ICE-based bike to an electric bike is also discussed towards the end.

Paper Citation: T. Deepak Varma, D. Sudhakar Reddy, N. Guru Vardhan and K. Chandra Mouli (2018) "DESIGN OF STEERING GEOMETRY FOR FORMULA STUDENT CAR'S"

The paper's major goal is to improve the effectiveness and sensitivity of the steering input or response between the driver and the wheels. Increasing interaction between the driver and the wheels while reducing driver effort. Ackerman set-up, steering effort, steering arm length, rack travel, turning radius, steering ratio, slip angle, castor, toe angles, kin-pin angle, and camber angle are all aspects to consider when determining sensitivity.

Rack and Pinion is the link between the driver and the wheels in this case. CATIAV5, Ansys 15, and Lotus are the softwares used in component design and analysis.

Paper Citation: Abolfazl Tahmasebi Inallu (2014) "Design of Steering Wheel Force Feedback System with Focus on Lane Keeping Assistance Applied In Driving Simulator", ISSN 1652-8557.

The purpose of this thesis is to give simulator drivers a more realistic steering experience. Increasing the realism of the steering improves the simulator driving experience. The work is split into two sections: the first is the creation of a steering wheel force feedback system, and the second is the development of a Lane Keeping Assistance System (LKAS), which includes the steering wheel force feedback system. The effect of the kingpin and caster angles on tyre forces and self-aligning torque, which have been proved to be essential elements in achieving good steering feel, are included in the steering force feedback system created. In the second section, a LKAS is presented, with the goal of minimising trajectory overshoot by applying an aid torque based on lateral offset and heading error. The steering system feedback torque is increased by the computed lane maintaining assistance torque. The suggested steering force feedback system and the LKAS are evaluated using the Chalmers simulator. The simulator results show that the LKAS minimises vehicle lateral offset and the requirement for the driver to intervene with the system, as well as improving steering sensation.

Paper Citation: Biao Ma, Yiyong Yang, Yahui Liu2, Xuewu Ji2 and Hongyu Zheng3 (2016) "Analysis of vehicle static steering torque based on tire–road contact patch sliding model and variable transmission ratio" , Advances in Mechanical Engineering 2016, Vol. 8(9) 1–11

Static steering torque when parking is a critical component in vehicle steering portability. The most widely used estimating approach at the moment is empirical formula calculation, which, however, cannot explain why the steering torque grows rapidly as the steering angle increases (over 300). This paper provides a static steering torque estimation approach based on a mathematical model of tire-patch sliding torque, which takes into consideration the variable torque transmission ratio from steered wheel to steering wheel. The tire-patch sliding torque, gravity aligning torque, and internal friction torque of the steering system are all modelled and studied as static steering torque components. The transmission ratio of steering torque is calculated using rack-suspension mathematical analysis to study the static steering torque at the steering wheel. The proposed method is used to estimate static steering torque and the results are compared to experimental data. The comparison reveals that the suggested method's estimation results are more in line with experimental results than other approaches.

Paper Citation: Ibraheem Raza Khan (2017) “Steering Effort Calculation Methodology & Study on Hydraulic and Electronic Power Steering” ISSN [ONLINE]: 2395-1052.

The steering effort of a vehicle is significant because it directly affects the driver's comfort. This study report is interested in steering effort and steering feel. In recent years, steering feel, or a driver's sense of steering characteristics, has become a hot topic. Effort to steer. The steering sensation and driving comfort are directly affected by vehicle speed and steer speed. The steering effort can be separated into two categories: parking manoeuvres and driving manoeuvres. Different processes generate steering effort during parking and driving actions. The elastic deformation of the tyre tread caused by friction between the tyre surface and the ground develops steering effort during a parking move. When analysing steering effort during a driving move, the slip angle idea is critical. The steering effort grows as the axel weight increases, and after a certain point, human muscle can no longer steer the wheel for longer periods of time. To combat this, power steering attachments, which can be either a hydraulic pump or an electric motor, are used to aid the steering gear box. In this study report, both steering gear attachments are discussed.

Paper Citation: Nitin C M and Santosh Patil (2019) “A retrofit design of safety and stability mechanism for two wheelers”

This paper proposes an idea for a retrofit design of a mechanism that aids in the two-wheeler vehicle's safety and stability. The mechanism's goal is to keep the two-wheeler from falling or skidding, as well as to serve as an attachment for physically handicapped drivers. The mechanism is a hydraulic system with linkages, with an extra two little wheels grounded to protect the two wheeler from falling and provide stability. The planned refit mechanism would take the place of the vehicle's double stand. These additional wheels move with the vehicle, providing the necessary stability. This is a cheaper alternative to the expensive accessories that physically challenged drivers put to their vehicles. The shock absorbers would be included in the mechanism as needed. Improvements in deploying the abovementioned mechanism on a two-wheeler are likely to make riding more comfortable, as the vehicle will self-stabilize when the little wheels are grounded. This allows less abled riders to effortlessly ride the vehicle without fear of their feet becoming grounded. A variety of ideas were created, researched, and three were chosen based on the mechanism's viability. Finally, a better design for future improvement and execution is offered.

Paper Citation: Rajlaxmi Darekar, Neha Gawande, Vispi Karkaria, P B Karandikar (2021) “Analysis of critical issues in retrofitting of ICE vehicles”

Vehicle population is growing at an alarming rate, resulting in air pollution from inefficient engines in cities and towns. Millions of automobiles are produced and trashed every year. Vehicle disposal or scrapping before their usable life is not a smart idea. A vehicle's parts and systems wear out at varying rates. Owners will be able to contribute to society by reducing input energy for big vehicle businesses by using this retrofit technique for the next 10 to 15 years. This study discovered a range of ages at which retrofitting can be done based on the life span of automobile parts. A cost analysis of automobiles was conducted in this study, which revealed a decline in performance when maintenance, repair, and replacement costs increased. For performance and cost, a mathematical model has been developed. Retrofit age is the mathematical model's minimum value. Due to insufficient recycling of vehicle parts, limited processing plants, and restricted scrap yards, our research has revealed that the time has come to implement this technology. Honda Activa 5G, Bajaj Pulsar 500, and Maruti Baleno were evaluated for this investigation.

Paper Citation: Alejandro Gabriel, Buena venturaa, Brian Azzopardi (2015) “Energy recovery systems for retrofitting in internal combustion engine vehicles: A review of techniques”

Energy recovery systems (ERSs) for internal combustion engine vehicles (ICEVs) are discussed in terms of fuel economy and retrofitability. The report includes technical information on the possible carbon emission reduction benefits of retrofitted ERSs. The energy sources are divided first, and then the harvesting and storage techniques are divided further. The accompanying qualities, such as weight, size, and cost, are evaluated critically. Finally, the paper reviews ERS systems using a set of common criteria and discovers that the most fuel-efficient ERSs are the ones that are the most difficult to retrofit. Further research is suggested to investigate the trade-off between fuel consumption reduction and investment cost of the system.

Thin Flexible Lithium-Ion Battery Featuring Graphite Paper Based Current Collectors with Enhanced Conductivity Hang Qu 1 , Jingshan Hou 1 , Yufeng Tang 2 , Oleg Semenikihin 3 , and Maksim Skorobogatiy

- The main component in the manufacture of a high-performance flexible lithium-ion battery is a flexible, light-weight current collector with good conductivity. We present a graphite-based lithium-ion battery that is thin, light, and flexible.
- · In this an ultra-thin flexible battery with overall thickness of less than 250 μm was manufactured by employing conductivity-enhanced metal-deposited GP current collector. We deposit this very flexible and conductive current collector to create it.
- · PVD method was used to deposit sub-micron thick metallic layers onto the GP. The suggested current collector has advantages over typical current collectors based on pure metal foils (such as Al or copper) because of its light weight, high flexibility, and increased surface adherence for depositing battery electrode materials.
- · The cathode and anode materials are $LiFePO_4$ and $Li_4Ti_5O_{12}$, respectively, with a separator made of PE membrane soaked in $LiPF_6$. Under normal 0.2C charge/discharge rates, the battery could achieve a rate capacity of 100 $mAhg^{-1}$. Furthermore, the battery's capacity may be preserved.

Toward Low-Cost All-Organic and Biodegradable Li-Ion Batteries N. Delaporte, G. Lajoie, S.Collin-Martin & K. Zaghib*

- This paper provides an alternate approach for producing Li-ion electrodes that does not require the use of expensive binders or aluminium/copper current collectors. As a binder and support for the electrode, low-cost natural cellulose fibres with a 2-mm length are used.
- The purpose of approach replaces traditional expensive binders with cellulose fibres and eliminates the use of heavy and inactive current collector foils as substrates. Furthermore, no hazardous solvents, such as N-methyl pyrrolidone, are used in the manufacture of films. Water-soluble carbons are also used to shorten preparation time and improve carbon distribution in the electrode, resulting in improved electrochemical performance. Active mass synthesis produces flexible and robust LiFePO4 (LFP), Li4Ti5O12 (LTO), organic 3,4,9,10-perylenetetracarboxylic dianhydride (PTCDA), and graphite electrodes.
- An alternate method for generating Li-ion electrodes based on the paper-making process is proposed in this research. This fabrication approach avoids the use of aluminium/copper current collectors, pricey binders, and hazardous solvents (NMP). Tees is substituted with non-modified cellulose, a plentiful, natural, and inexpensive polymer. The technique is simple and quick to scale, and it simply requires water as a solvent.
- A mixture of redox active substance, conductive carbon, and cellulose fibres A self-standing electrode film is created after several filtrations. It is made up of a cathode/anode material and carbon electrode composite that is coated over a 20-m thick strong carbon current collector. Water-soluble carbons and LFP are also manufactured to speed up the preparation process.

Design, simulation, and implementation of a PID vector control for EHVPMSM for an automobile with hybrid technology-Adeyinka O.M. Adeoye a, Bankole I. Oladipo a,∗, Adeyemi A. Adekunle b, Oyelowo J. Oladimeji c, Joseph F. Ka

When connected to the EHVPMSM's main supply, it charges automatically. From 0 Nm to 6.7 Nm, the electromagnetic torque can be raised. Nm in around 340 seconds The speed transient response was from 2100 rpm to +2100 rpm in 100 milliseconds at 6.7 Nm torque limit. This is a revolutionary method of reducing energy usage in a vehicle that saves space, weight, and money because it is done with low-cost components. mathematical model for the direct and quadrature axes of the current is proposed to control the engine's speed mechanism. With a percentage inaccuracy of 4.5 percent, computer simulation ensures experimental validation of the system.

The system was controlled using a variety of sensors and a software controller, which may be simply applied in industry and institutional laboratories of learning.

* Based on field-oriented vector control with PID control, a design simulation and implementation of a novel engine for an Electric Hybrid Vehicle of Permanent Magnet Synchronous Motor (EHVPMSM) is presented.

* A direct torque control was achieved by quickly matching the vector torque required by the load by altering the magnitude and phase angle of the stator flux linkage.

* To manage the engine's speed mechanism, a new mathematical model for the direct and quadrature axes of the current was established.

* The vehicle's battery was charged when it was linked to the EHVPMSM's main supply, eliminating the need for a separate charging process.

* The maximum electromagnetic torque of 6.7 Nm was attained in 340 seconds. The responsiveness of a speed converter from 2100 rpm to +2100 rpm in 100 milliseconds of 6.7 Nm torque limit was measured.

* A simple and cost-effective technique to reduce energy usage in a vehicle while saving space and weight for industrial applications and student learning

The Comparison of Control Strategies for the Interior PMSM Drive used in the Electric Vehicle -Yaohua LiP 1 P , Dieter GerlingP 2 P , Jian MaP 1 P , Jingyu LiuP 1 P , Qiang YuP 1 P

The internal permanent magnet synchronous motor (PMSM) has several advantages, including a high power-to-weight ratio, high efficiency, rugged construction, low cogging torque, and reluctance torque capability, making it a popular choice for electric vehicles (EV). PMSM drives use two control schemes: field-oriented control (FOC) and direct torque control (DTC). An improved DTC scheme based on the control of stator flux, torque angle, and torque was proposed, which used voltage vector selection strategy and space vector modulation (SVM) technology to generate the applied voltage vector instead of switching table to reduce current and torque ripple and fix switching frequency. examined the three control strategies using a Honda 15-kW indoor PMSM. 06 Civic My electric hybrid automobile. The stator current is more sinusoidal for the FOC employing the hysteresis current control, because of the shorter sample period.

However, it requires continuous rotor position data, and the VSI's switching frequency is not constant. Current ripple is larger and the VSI switching frequency is not constant when using a DTC with a switching table.

When we compare the experimental results of the interior PMSM drive utilised in electric vehicles under the management of various control systems, we can draw the following conclusions. The stator current is more sinusoidal in the FOC with hysteresis current control because to the shorter sample interval. However, it requires continuous rotor position data, and the VSI's switching frequency is not constant. Current ripple is larger in the DTC employing the switching table, and the VSI switching frequency is not consistent.

Except for the initial rotor position, it does not require rotor position information. When compared to the switching table, the voltage vector selection approach suggested in this study can reduce current and torque ripple while also fixing the Switching Frequency.

Permanent Magnet Synchronous Motor for Electric Vehicle Applications A.Loganayaki; R. Bharani Kumar

Permanent Magnet Synchronous Motors have the capability of delivering high torque-to-current ratios, high power-to-weight ratios, high efficiency, and ruggedness. PMSMs are widely employed in modern variable speed AC drives, particularly in electric vehicle applications, because to the advantages listed above. Electric vehicles are a nightmare for city traffic since they emit no hazardous emissions and are quiet. In high-performance drive systems like electric vehicles, permanent magnet synchronous motors have risen to the top of ac motors. For electric vehicle applications, this research offered a radial flux inner rotor PMSM architecture. The PMSM layout is The motor's design is created in Ansys Electronics.

Research on a PMSM control strategy for electric vehicles Guangliang Liao, Wei Zhang , Chuan Cai.

A rather complete non-sensor PMSM control approach for EV has been proposed in this , which includes an SFDCDF, an OBASE, an EBRAE, and a VLE. To begin with, the SFDCDF includes a decoupling item that eliminates the mutually detrimental influence of two system states. The disturbance feed-forward item can also help the system respond to disturbances more quickly. A new OBASE is proposed to deliver enough information to the controller. The observer and estimator, the two primary pieces, are designed separately. Lyapunov steady theory theoretically proves the OBASE's convergence. In addition, instead of integrating angular speed, an EBRAE is utilised to calculate rotor angle. And the OBASE is repurposed as a VLE with minor modifications to obtain vehicle load data. Simulations are run in each section to ensure that each algorithm works properly.

All recommended algorithms are coded in a "Freescale" controller for an HIL test in the fourth section. To begin, the HIL system is briefly discussed. Other necessary models, such as the battery model, wheel slip model, and tire-road model, are then discussed. The test results are provided and reviewed in order to assess the overall system's performance. All algorithms, for the most part, operate well together. This certifies the effectiveness of coding at the same time. However, one flaw in this study is that the controller is the only piece of hardware in the loop. More real physical pieces, such as a real engine and a real battery, would make the test more convincing.

To summarise, mechanical state measurements are replaced and estimated in PMSM control by easier, faster, and more reliable measurements of electric states like as currents. All the methods provided in this paper can reliably and effectively control the PMSM to drive an EV. However, more effort, such as adding more real hardware to the system, will be required.

Design Of Permanent Magnet Synchronous Motor for Electric Vehicle Application Using Finite Element Analysis Dr.A.Sheela, M.Atshaya Mohan

Magnet software is used to build a Permanent Magnet Synchronous Motor (Reference Model and Project Model) and perform FEA analysis. The design's performance was then verified. The goal of future work is to uncover potential issues with the traditional design approach by adding a new phase to the prototype stage. The interaction between different aspects of the system will be used to assess the machine's behaviour for the final application. The system simulator MATLAB SIMULINK and the finite element analysis programme MAGNET will be integrated to achieve this goal.

Retro fitting of Car

In this case, we have decided to take up a project on converting the IC Engine powered car into a fully electric vehicle. As part of this project, we have taken the model Tata Indigo eCS which is powered with a 1.5litre Diesel engine. Initially all the crucial parts like engine, bumper, bonnet, pedals, etc were taken out. Now, we have obtained the Car without any engine and here the original work starts. We do have few prerequisites to do before concluding the battery size, motor specifications and range of the vehicle. Those prerequisites are:

- Motor Sizing
- Battery Sizing
- Auxiliary Motor calculation for steering
- Wire Harnessing
- Engine Space Design
- Current profiles for different speeds

So here we'll be getting into each and every part and will be showing what we have done in the same

Motor Sizing:

Motor Sizing means picking up the correct motor for your application. We generally do this motor sizing because without any clarity if we go for any motor available in the market and by chance if that motor is too small for that Car, then we can't consider it as it won't be able to handle the load we give and we won't be getting the desired torque to move the vehicle. Hence by doing the Motor sizing we will be able to know a motor with which specifications will be suitable for our vehicle.

Few of the parameters which are crucial in calculating the Motor Sizing are :

- Frontal Area (A_f)
- Mass of the Vehicle
- Kerb Weight of the Vehicle
- Gear Ratio
- Radius of Wheel
- Drag Coefficient
- Density of Air
- Rolling Resistance

```
m = 1200 + 500;

A_f = 2.4;

R_w=0.292;

Gear_Ratio = 1 / 3.7;
```

Constants

Vehicle	C_D	A_f
Motorcycle with rider	0.5-0.7	0.7-0.9
Open convertible	0.5-0.7	1.7-0.9
Limousine	0.22-0.4	1.7-2.0
Coach	0.4-0.8	6-10
Truck without trailer	0.45-0.8	6.0-10.0
Truck with trailer	0.55-1.0	6.0-10.0
Articulated vehicle	0.5-0.9	6.0-10.0

0.001-0.002	Railroad steel wheels on steel rail
0.001	Bicycle tire on wooden track
0.002	Bicycle tire on concrete
0.004	Bicycle tire on asphalt road
0.008	Bicycle tire on rough paved road
0.006-0.01	Truck tire on asphalt
0.01-0.015	Car tire 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 tires on solid sand, gravel loose worn, soil medium hard
0.2-0.4	Car tires on loose sand

Table.2:- Coefficient of rolling resistance

```
mu_r = 0.02;
C_d = 0.4;
rho = 1.225;
```

Case-1: Maintain climb speed on an incline

Input

```
theta = 8;
V = (30) * 1000 / 3600;
```

Calculate Forces

```
Rolling_resistance = mu_r * m * 9.81 * cosd(theta);
Gradient_resistance = m * 9.81 * sind(theta);
Air_drag = 0.5 * rho * C_d * A_f * V^2;
Force = Rolling_resistance + Gradient_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (pi() * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
Torque_motor = 212.4590
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor = 1.0083e+03
Power_kW = Force * V/1000
Power_kW = 22.4343
```

Case-2: Maintain peak speed on a flat road

Input
V = (80) * 1000 / 3600;
Calculate Forces
Rolling_resistance = mu_r * m * 9.81 ;
Air_drag = 0.5 * rho * C_d * A_f * V^2;
Force = Rolling_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (pi() * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
Torque_motor = 49.2383
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor = 2.6889e+03
Power_kW = Force * V/1000
Power_kW = 13.8647
Case-3: Accelerate to Avg speed on a flat road
Input
V = (45) * 1000 / 3600;
t = 30;
a = V / t;
Calculate Forces
Rolling_resistance = mu_r * m * 9.81;
Air_drag = 0.5 * rho * C_d * A_f * V^2;
Inertia = m * a;
Force = Rolling_resistance + Air_drag + Inertia;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (pi() * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
Torque_motor = 89.4742
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor = 1.5125e+03
Power_kW = Force * V/1000
Power_kW = 14.1719

Battery Sizing:

Battery Sizing is defined as the calculating and obtaining the capacity of the battery we need for our application in terms of Energy it can store and the current it can offer. This is often measured in KwH. In case if we don’t do the battery sizing and go for the market batteries available outside, we can get into trouble where those outsourced batteries cannot give us the required power and current our application demands and this can also result in failure. Hence Battery Sizing is better and we can easily make our own customised battery according to the values we get and it will be beneficial for our Car.

Few of the parameters which are crucial in calculating the Battery Sizing are :

- Velocity
- Air Drag
- Force
- Power
- Range

We generally assume that the battery efficiency is 90% in these cases.

	gradient = 0 deg					rolling resistance in N	333.54		batery efficienty	90%
assumed that vehicle will be moving with a uniform velocity through out the range.						gradient = 0 deg				
velocity(kmph)	velocity(mps)	aero drag in N	force(N)	power(kw)	range(km)	time required(hr)	battery capcity required in kwh			
80	22.22222222	290.3703704	623.9104	13.8646749	210	2.625	40.43864			
75	20.83333333	255.2083333	588.7483	12.2655903	210	2.8	38.15961			
70	19.44444444	222.3148148	555.8548	10.8082881	210	3	36.02763			
60	16.66666667	163.3333333	496.8733	8.28122222	210	3.5	32.20475			
50	13.88888889	113.4259259	446.9659	6.20786008	210	4.2	28.97001			
45	12.5	91.875	425.415	5.3176875	210	4.666666667	27.57319			
80	22.22222222	290.3703704	623.9104	13.8646749	180	2.25	34.66169			
75	20.83333333	255.2083333	588.7483	12.2655903	180	2.4	32.70824			
70	19.44444444	222.3148148	555.8548	10.8082881	180	2.571428571	30.88082			
60	16.66666667	163.3333333	496.8733	8.28122222	180	3	27.60407			
50	13.88888889	113.4259259	446.9659	6.20786008	180	3.6	24.83144			
45	12.5	91.875	425.415	5.3176875	180	4	23.63417			
80	22.22222222	290.3703704	623.9104	13.8646749	150	1.875	28.88474			
75	20.83333333	255.2083333	588.7483	12.2655903	150	2	27.25687			
70	19.44444444	222.3148148	555.8548	10.8082881	150	2.142857143	25.73402			
60	16.66666667	163.3333333	496.8733	8.28122222	150	2.5	23.0034			
50	13.88888889	113.4259259	446.9659	6.20786008	150	3	20.69287			
45	12.5	91.875	425.415	5.3176875	150	3.333333333	19.69514			

MOTOR CONTROLLER TUNING:

A Motor Controller is something which controls the voltage and the input current for the motor. In the present car project we're doing, we have established a battery with a capacity of 96 Volts which will be constant. So, the Motor Controller will only be having the flexibility to change the amount of current it takes in but not the voltage of the battery because it's constant. So the amount of intake of this current depends on the load applied on the vehicle. As the demand of the vehicle load increases, the amount of current intake also increases.

Rpm, power, torque, current profiles for 4W

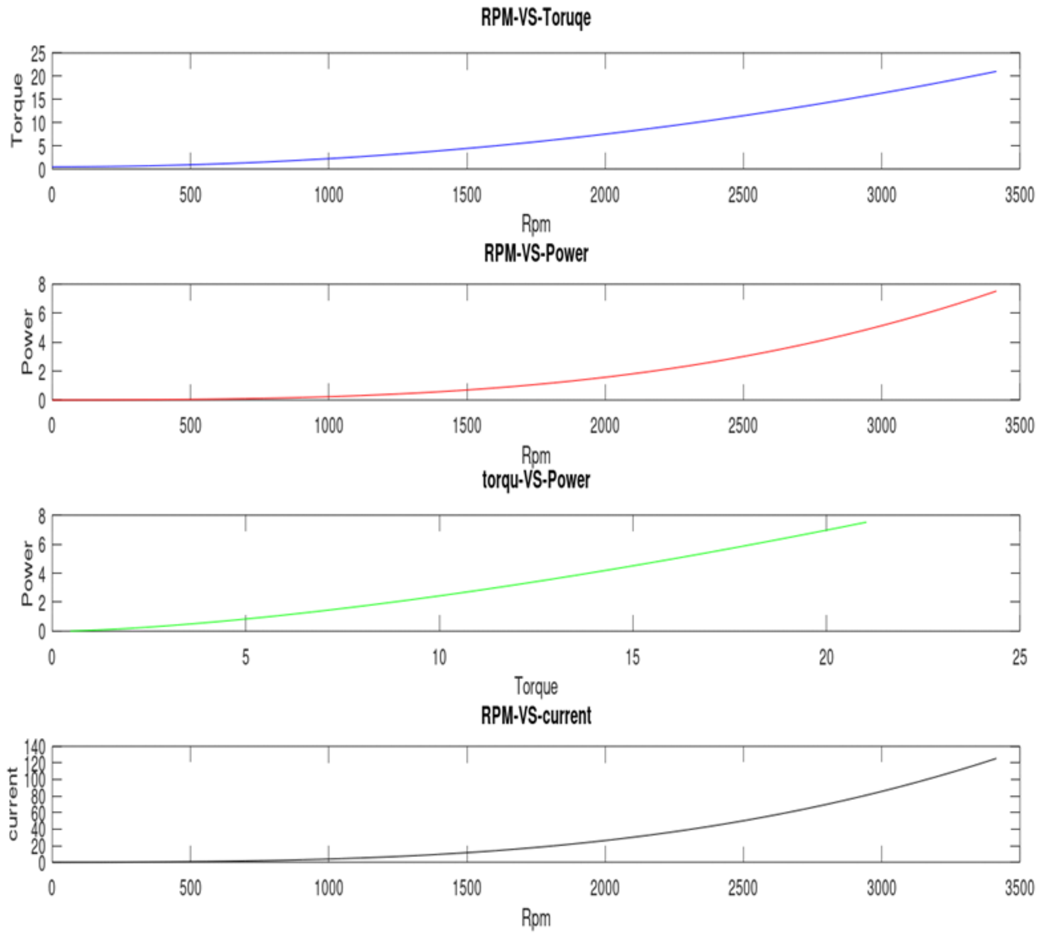
Data

v(kmph)	v(mps)	RPM_motor	Torque_motor	Power_kW	Current(A)
0	0	0	0.4632609	0	0

2	0.555556	69.68743815	0.471828194	0.003441492	0.057358
4	1.111112	139.3748763	0.497530078	0.007257921	0.120965
6	1.666668	209.0623145	0.54036655	0.011824223	0.19707
8	2.222224	278.7497526	0.600337611	0.017515335	0.291922
10	2.77778	348.4371908	0.677443261	0.024706193	0.41177
12	3.333336	418.1246289	0.7716835	0.033771734	0.562862
14	3.888892	487.8120671	0.883058328	0.045086895	0.751448
16	4.444448	557.4995052	1.011567744	0.059026611	0.983777
18	5.000004	627.1869434	1.15721175	0.075965821	1.266097
20	5.55556	696.8743815	1.319990344	0.09627946	1.604658
22	6.111116	766.5618197	1.499903528	0.120342465	2.005708
24	6.666672	836.2492578	1.6969513	0.148529773	2.475496
26	7.222228	905.936696	1.911133661	0.18121632	3.020272
28	7.777784	975.6241341	2.142450611	0.218777043	3.646284
30	8.33334	1045.311572	2.39090215	0.261586878	4.359781
32	8.888896	1114.99901	2.656488277	0.310020762	5.167013
34	9.444452	1184.686449	2.939208994	0.364453631	6.074227

36	10.000008	1254.373887	3.2390643	0.425260423	7.087674
38	10.555564	1324.061325	3.556054194	0.492816074	8.213601
40	11.11112	1393.748763	3.890178677	0.56749552	9.458259
42	11.666676	1463.436201	4.241437749	0.649673698	10.82789
44	12.222232	1533.123639	4.609831411	0.739725545	12.32876
46	12.777788	1602.811078	4.99535966	0.838025996	13.9671
48	13.333344	1672.498516	5.398022499	0.94494999	15.74917
50	13.8889	1742.185954	5.817819927	1.060872462	17.68121
52	14.444456	1811.873392	6.254751944	1.186168349	19.76947
54	15.000012	1881.56083	6.708818549	1.321212587	22.02021
56	15.555568	1951.248268	7.180019744	1.466380114	24.43967
58	16.111124	2020.935706	7.668355527	1.622045866	27.0341
60	16.66668	2090.623145	8.173825899	1.788584779	29.80975
62	17.222236	2160.310583	8.69643086	1.966371789	32.77286
64	17.777792	2229.998021	9.23617041	2.155781835	35.9297
66	18.333348	2299.685459	9.793044549	2.357189852	39.2865
68	18.888904	2369.372897	10.36705328	2.570970776	42.84951

70	19.44446	2439.060335	10.95819659	2.797499545	46.62499
72	20.000016	2508.747773	11.5664745	3.037151095	50.61918
74	20.555572	2578.435212	12.19188699	3.290300362	54.83834
76	21.111128	2648.12265	12.83443408	3.557322283	59.2887
78	21.666684	2717.810088	13.49411575	3.838591796	63.97653
80	22.22224	2787.497526	14.17093201	4.134483835	68.90806
82	22.777796	2857.184964	14.86488286	4.445373339	74.08956
84	23.333352	2926.872402	15.5759683	4.771635243	79.52725
86	23.888908	2996.559841	16.30418833	5.113644485	85.22741
88	24.444464	3066.247279	17.04954294	5.471776	91.19627
90	25.00002	3135.934717	17.81203215	5.846404726	97.44008
92	25.555576	3205.622155	18.59165594	6.237905598	103.9651
94	26.111132	3275.309593	19.38841433	6.646653554	110.7776
96	26.666688	3344.997031	20.2023073	7.073023531	117.8837
98	27.222244	3414.684469	21.03333486	7.517390464	125.2898



Steering system

Generally, for ic engines hydraulic power steering is used. As its name suggests, hydraulic power steering uses the force of pressurised hydraulic fluid to assist with the steering, working whenever the driver turns the steering wheel. The fluid is pressurised by a pump, which gets its power via a belt attached to the engine.

This mechanism is a combination of mechanical and hydraulic systems. But our vehicle does not contain an ic engine. So without an ic engine it cannot get power.

So to convert it into EHPS (Electro- Hydraulic power steering system) we need a motor to assist the hydraulic pump.

But it should also work while the vehicle is turned off so we cannot connect it to the main motor, So another motor is used which works on a 12 volts power line drawn from battery to auxiliary system

Steering pump Motor calculations

given,

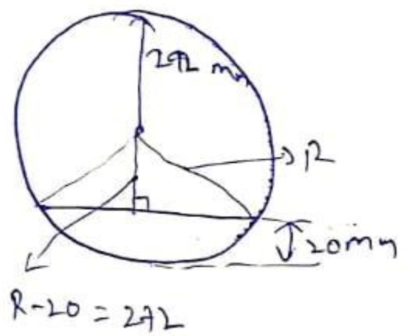
Nominal width = 175 mm (w)

Radius of tyre = 292 mm

Kingpin Excentrecity = 17.5 mm (Extreme)

13.5 mm (Nominal)

=> contact = Area contact



from pythagoreous theorem

$R^2 = x^2 + (R-20)^2$

$292^2 = x^2 - 272^2$

$x^2 = 292^2 - 272^2$

$x = 106.207\ mm$

=> $2x = 212.414\ mm$

Contact area = $2x * w$

$A = 212.414 \times 175$

$A = 37172.57\ mm^2$

$\boxed{A = 371.7257\ cm^2} = 0.0371\cancel{7257}\ m^2$

0.03717257

we know that Torque at king pin is as follows

$$T = wf\sqrt{\frac{A}{8} + E^2}$$

$M = 450\ kg$

$g = 9.81\ m/s^2$

$f = 0.8$

Case-ii)

$E = 17.5cm = 175mm$

$$T = 450 \times 9.81 \sqrt{\frac{0.03717}{8} + 0.175^2}$$

$$T = 450 \times 9.81 \times 0.1878$$

$$\boxed{T = 67.608 \text{ N.m}}$$

$T = f \times d$

$67.78 = f \times 0.115$

$$\boxed{F = 587.9 N}$$

$A = \frac{\pi}{4} d^2$

$= \frac{\pi}{4} (0.025)^2$

$= 0.00049$

$P = F/A = \frac{587.9}{0.00049}$

$= 11.9 mpa$

$= 118.9$ ~~bar~~

$\Rightarrow$ power = $\frac{\text{Pressure (bars)} \times \text{flow rate (Lit/min)}}{600}$

$$P = \frac{118.9 \times 10 \times 3.78}{600}$$

$P = 3.1 Kw$ (Extreme condition)

Note :-

In Hydraulic master cylinder the flow rate will be 3.78 Lit/min.

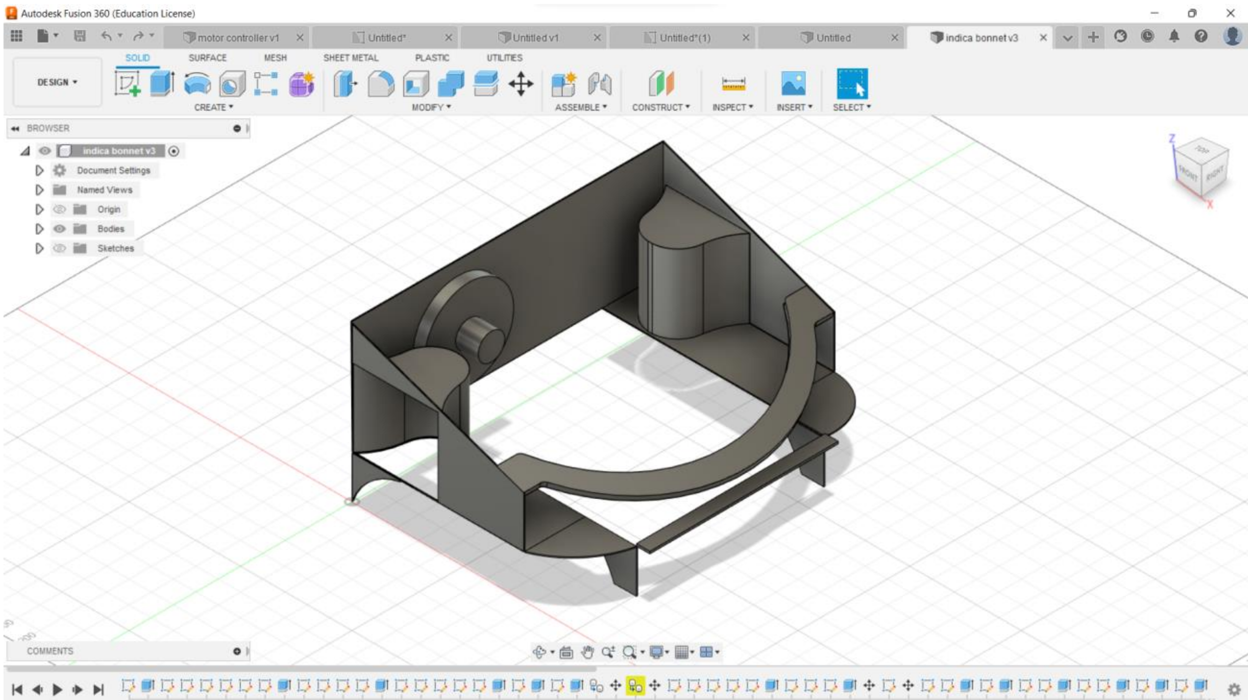
Bonnet design of tata indica

Bonnet is a place where the main components of a car are placed, the transmission, engine/battery, ECU, steering mechanism, suspension mountings and many more things are hidden under the bonnet.

So, In retrofitting we need to swap the engine with motors and battery system, as the previous bonnet space is designed for IC engines so to swap to the new system, we need to balance the new space with battery and motor. As there are many dimensions changes & different mounting points, we need to remodify the previous mounting points.

As to change, according to the new system, we must redesign the bonnet space for our retrofitting.so, we have redesigned the bonnet space according to the dimensions of the car, it has been modelled in fusion360 & NX for surface modelling.

For that we left the space to check where the motor and battery and all other systems will be mounted according to our retrofit.


Autodesk Fusion 360 (Education License)
motor controller v1
Untitled*
Untitled v1
Untitled*(1)
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indica bonnet v3
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SURFACE
MESH
SHEET METAL
PLASTIC
UTILITIES
DESIGN
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
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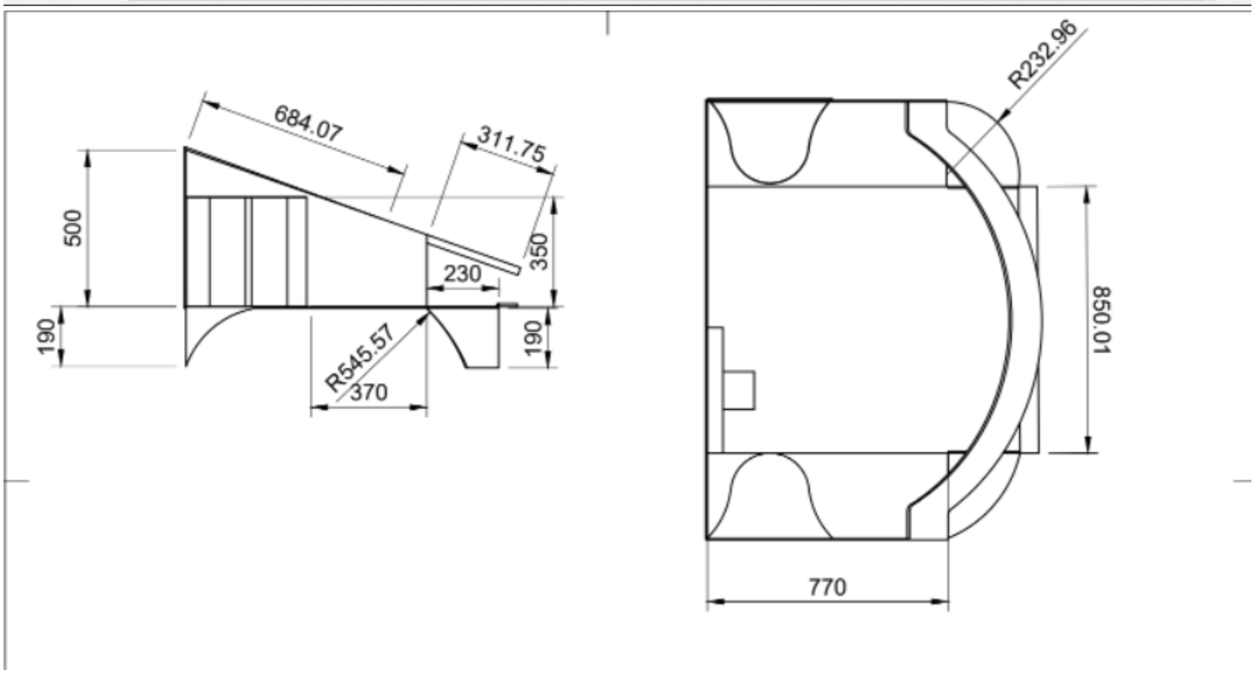
Named Views
Origin
Bodies
Sketches
COMMENTS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R545.57
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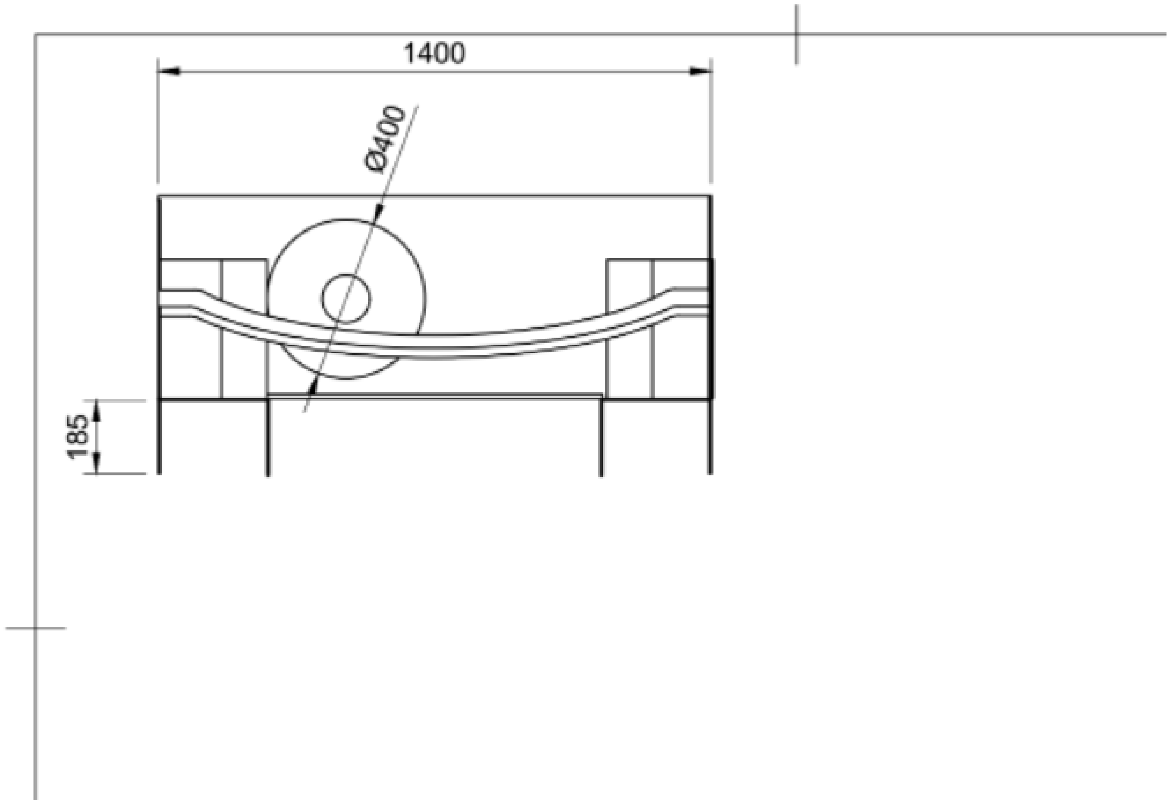
R232.96
850.01
770



POWER CONVERTOR

In our project we used 96v battery pack as main source of energy but to run auxiliary systems like lights, music system, dc ac compressor we need current at 12v volts, so we used Dc to Dc convertor
A DC-to-DC converter is an **electronic circuit** or electromechanical device that converts a source of **direct current** (DC) from one **voltage** level to another. It is a type of **electric power converter**. Power levels range from very low (small batteries) to very high (high-voltage power transmission).

BUCK CONVERTER:

A buck converter steps down the applied DC input voltage level directly. By directly means that buck converter is non-isolated DC converter. Non-isolated converters are ideal for all board level circuits where local conversion is required. Fax machines, scanners, Cellphones, PDAs, computers, copiers are all examples of board level circuits where conversion may require at any level inside the circuit. Hence, a buck converter converts the DC level of input voltage into other required levels.
AUXILLARIES:
1) Windshield viper motor (WSV).
2) Horn (H).
3) Power window (PW).

4) Air conditioner or Blower (AC/B).
5) Power socket (PS).
6) Head lights (HL).
7) Music system (MS).
8) Turn Single lamps (TSL).
9) Reverse lights (RL).
10) Battery level (BL).
11) Range indicator (RI).

COMPOUND GEAR RATIO CALCULATIONS:

As the manufacturer is only able to provide us the motor with torque of 120 Nm, we have added another gear to make the requirement of torque at the motor end equal to 120 Nm. The following calculations are for the same.

Date ___/___/______ Page No. ____

$F = 2688$

$T_q = 2688 \times 0.292$

$T_{qw} = 784.89$

$\text{Toorque motor} = 784.89 \times G.R$

$$GR = \frac{120}{784.89}$$

$GR = 0.152$.

$$0.152 = \frac{x}{\cancel{17}} \times \frac{\cancel{17}}{64}$$

$x = 9.728$

10 teeth for new gear

$\cancel{Rpm}\ 1008.3 \times 0.265625 = Rpm\ wheel$

$Rpm_{wheel} = 267.8296$

$$RPM_{motor} = \frac{267.82}{0.152}$$

$RPmotor = 1785.466$

$G_1 = 64$

$G_2 = 17$

$G_3 =$

$G_{12} = \frac{T_2}{T_1}$

$G_{23} = \frac{T_3}{T_2}$

$\Rightarrow G_{12} = \frac{17}{64} = \frac{1}{3.7} = 0.265625$

$T_{wheel} = 781.78$

$T_{motor} = 120$

$T_m = T_w \times GR$

$120 = 781.78 \times GR$

$GR = 0.15349587$

$GR = GR_{12} \times GR_{23}$

$0.15349587 = 0.265625 \times GR_3$

$\boxed{GR_{23} = 0.5778668}$

$\frac{T_3}{17} = 0.5778668$

$\boxed{T_3 = 9.8}$

RPM wheel = 267.829688

$\boxed{\text{RPM motor} = 1244.15 \text{ rpm}}$

< 3580 rpm

Retro fitting of BIKE:

In this case, we have decided to take up a project on converting the IC Engine powered motorcycle into a fully electric bike. As part of this project, we have taken the model Hero Splendour which is powered with a 100cc petrol engine. Initially all the crucial parts like engine, fuel tank, engine components, gear shifter, silencer, etc were taken out. Now, we have obtained the bike without any engine and here the original work starts. We do have few prerequisites to do before concluding the battery size, motor specifications and range of the bike. Those prerequisites are:

- Motor Sizing
- Battery Sizing
- Wire Harnessing
- Engine Space Design
- Current profiles for different speeds

So here we'll be getting into each and every part and will be showing what we have done in the same

Motor Sizing:

Motor Sizing means picking up the correct motor for your application. We generally do this motor sizing because without any clarity if we go for any motor available in the market and by chance if that motor is too small for that bike, then we can't consider it as it won't be able to handle the load we give and we won't be getting the desired torque to move the vehicle. Hence by doing the Motor sizing we will be able to know a motor with which specifications will be suitable for our vehicle.

Few of the parameters which are crucial in calculating the Motor Sizing are :

- Frontal Area (A_f)
- Mass of the Vehicle
- Kerb Weight of the Vehicle
- Gear Ratio
- Radius of Wheel
- Drag Coefficient
- Density of Air
- Rolling Resistance

Input Parameters

Vehicle Parameters

In [2]:

```
m = 120 + 190;
A_f = 0.85;
R_w=0.2285;
Gear_Ratio = 14/42;
mu_r = 0.002;
C_d = 0.7;
rho = 1.225;
```

Case-1: Maintain climb speed on an incline

Input

In [4]:

```
theta = 8;
V = (30) * 1000 / 3600;
```

Calculate Forces

In [8]:

```
import math
```

In [20]:

```
Rolling_resistance = mu_r * m * 9.81 * math.cos(theta * 3.14 / 180);
Gradient_resistance = m * 9.81 * math.sin(theta * 3.14 / 180);
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Force = Rolling_resistance + Gradient_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```

In [18]:

```
Torque_wheel
```

Out[18]:

103.82066046355257

In [21]:

```
RPM_wheel
```

Out[21]:

348.436912012711

In [22]:

```
Torque_motor
```

Out[22]:

34.60688682118419

In [24]:

```
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor
```

Out[24]:
1045.310736038133
In [25]:
```
Power_kW = Force * V/1000
Power_kW
```

Out[25]:
3.786311468400896
Case-2: Maintain peak speed on a flat road
Input
In [26]:
```
V = (80) * 1000 / 3600;
```

Calculate Forces
In [28]:
```
Rolling_resistance = mu_r * m * 9.81 ;
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Force = Rolling_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```

In [29]:
```
Torque_wheel
```

Out[29]:
42.5127302308642
In [30]:
```
RPM_wheel
```

Out[30]:
929.1650987005625
In [31]:
```
Torque_motor
```

Out[31]:
14.170910076954733
In [32]:
```
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor
```

Out[32]:
2787.4952961016875

In [35]:

```
Power_kW = Force * V/1000
print(Power_kW)
```

4.134474128943759

Case-3: Accelarate to Avg speed on a flat road

Input

In [36]:

```
V = (45) * 1000 / 3600;
t = 30;
a = V / t;
```

Calculate Forces

In [37]:

```
olling_resistance = mu_r * m * 9.81;
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Inertia = m * a;
Force = Rolling_resistance + Air_drag + Inertia;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```

In [38]:

```
Torque_wheel
```

Out[38]:

43.91592365052084

In [39]:

```
RPM_wheel
```

Out[39]:

522.6553680190664

In [40]:

```
Torque_motor
```

Out[40]:

14.638641216840279

In [43]:

```
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor
```

Out[43]:

1567.9661040571991

In [44]:
```
Power_kW = Force * V/1000
Power_kW
```

Out[44]:
2.402402825520834

In [ ]:

Battery Sizing:

Battery Sizing is defined as the calculating and obtaining the capacity of the battery we need for our application in terms of Energy it can store and the current it can offer. This is often measured in KwH. In case if we don't do the battery sizing and go for the market batteries available outside, we can get into trouble where those outsourced batteries cannot give us the required power and current our application demands and this can also result in failure. Hence Battery Sizing is better and we can easily make our own customised battery according to the values we get and it will be beneficial for our bike.
Few of the parameters which are crucial in calculating the Battery Sizing are :

- Velocity
- Air Drag
- Force
- Power
- Range

  We generally assume that the battery efficiency is 90% in these cases.

	gradient = 0 deg					rolling resistance in N	6.0230684		batery efficiency	90%
assumed that vehicle will be moving with a uniform velocity through out the range.						gradient = 0 deg				
velocity(kmph)	velocity(mps)	aero drag in N	force(N)	power(kw)	range(km)	time required(hr)	battery capcity required in kwh			
80	22.22222222	179.9691358	185.9922	4.13316009	210	2.625	12.05505			
75	20.83333333	67.78971354	73.81278	1.53776629	210	2.8	4.784162			
70	19.44444444	59.05237269	65.07544	1.2653558	210	3	4.217853			
60	16.66666667	43.38541667	49.40849	0.82347475	210	3.5	3.202402			
50	13.88888889	30.12876157	36.15183	0.50210875	210	4.2	2.343174			
45	12.5	24.40429688	30.42737	0.38034207	210	4.666666667	1.972144			
80	22.22222222	77.12962963	83.1527	1.84783773	180	2.25	4.619594			
75	20.83333333	67.78971354	73.81278	1.53776629	180	2.4	4.10071			
70	19.44444444	59.05237269	65.07544	1.2653558	180	2.571428571	3.615302			
60	16.66666667	43.38541667	49.40849	0.82347475	180	3	2.744916			
50	13.88888889	30.12876157	36.15183	0.50210875	180	3.6	2.008435			
45	12.5	24.40429688	30.42737	0.38034207	180	4	1.690409			
80	22.22222222	77.12962963	83.1527	1.84783773	150	1.875	3.849662			
75	20.83333333	67.78971354	73.81278	1.53776629	150	2	3.417258			
70	19.44444444	59.05237269	65.07544	1.2653558	150	2.142857143	3.012752			
60	16.66666667	43.38541667	49.40849	0.82347475	150	2.5	2.28743			
50	13.88888889	30.12876157	36.15183	0.50210875	150	3	1.673696			
45	12.5	24.40429688	30.42737	0.38034207	150	3.333333333	1.408674			
80	22.22222222	77.12962963	83.1527	1.84783773	100	1.25	2.566441			
75	20.83333333	67.78971354	73.81278	1.53776629	100	1.333333333	2.278172			
70	19.44444444	59.05237269	65.07544	1.2653558	100	1.428571429	2.008501			
60	16.66666667	43.38541667	49.40849	0.82347475	100	1.666666667	1.524953			
50	13.88888889	30.12876157	36.15183	0.50210875	100	2	1.115797			
45	12.5	24.40429688	30.42737	0.38034207	100	2.222222222	0.939116			

MOTOR CONTROLLER TUNING:

A Motor Controller is something which controls the voltage and the input current for the motor. In the present car project we're doing, we have established a battery with a capacity of 96 Volts which will be constant. So, the Motor Controller will only be having the flexibility to change the amount of current it takes in but not the voltage of the battery because it's constant. So the amount of intake of this current depends on the load applied on the vehicle. As the demand of the vehicle load increases, the amount of current intake also increases.

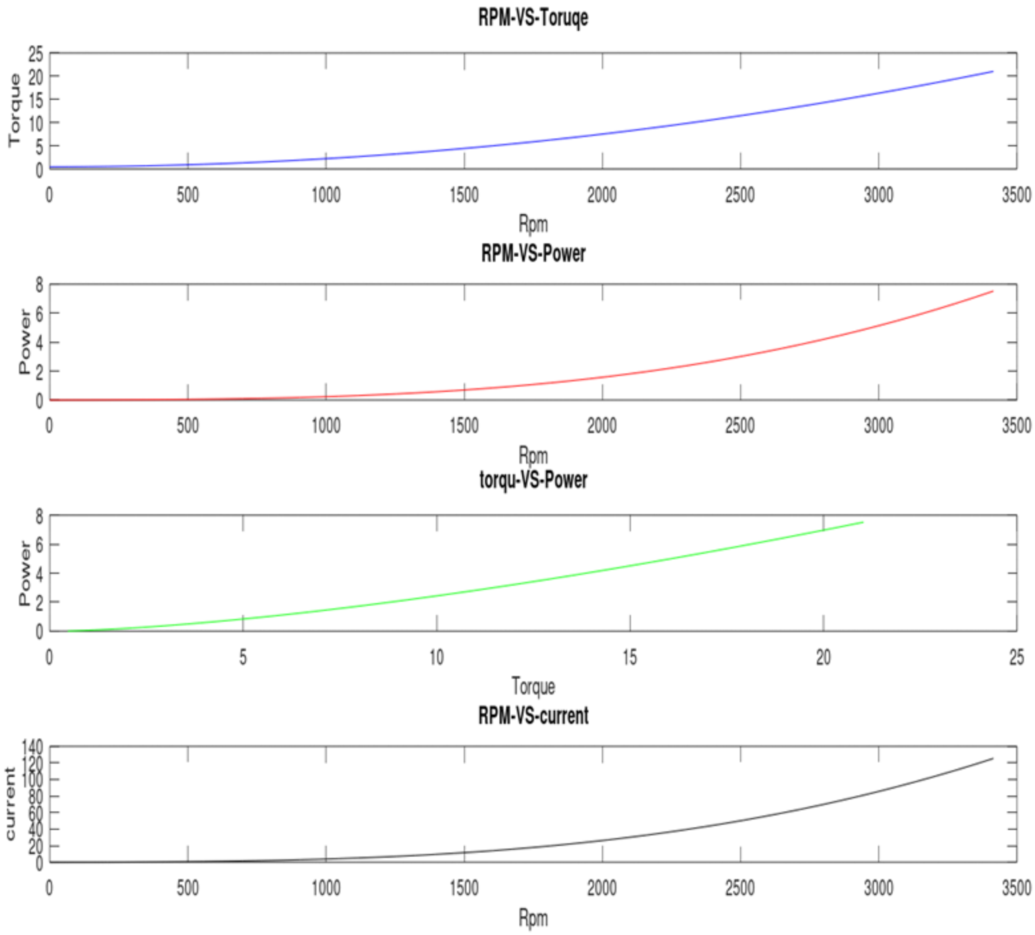
Rpm, power, torque, current profiles for 2W

v	RPM_motor	Torque_motor	Power_kW	current
0	0	26.32261622	0	0

2	67.25712852	26.33693856	0.18540097	3.090016
4	134.514257	26.3799056	0.37140688	6.190115
6	201.7713856	26.45151732	0.55862267	9.310378
8	269.0285141	26.55177374	0.74765328	12.46089
10	336.2856426	26.68067485	0.93910365	15.65173
12	403.5427711	26.83822064	1.13357872	18.89298
14	470.7998997	27.02441113	1.33168343	22.19472
16	538.0570282	27.23924631	1.53402271	25.56705
18	605.3141567	27.48272618	1.74120151	29.02003
20	672.5712852	27.75485074	1.95382477	32.56375
22	739.8284138	28.05561999	2.17249743	36.20829
24	807.0855423	28.38503393	2.39782442	39.96374
26	874.3426708	28.74309256	2.63041069	43.84018
28	941.5997993	29.12979588	2.87086118	47.84769
30	1008.856928	29.54514389	3.11978082	51.99635
32	1076.114056	29.9891366	3.37777456	56.29624
34	1143.371185	30.46177399	3.64544733	60.75746

36	1210.628313	30.96305607	3.92340408	65.39007
38	1277.885442	31.49298285	4.21224974	70.20416
40	1345.14257	32.05155431	4.51258926	75.20982
42	1412.399699	32.63877047	4.82502758	80.41713
44	1479.656828	33.25463131	5.15016962	85.83616
46	1546.913956	33.89913685	5.48862035	91.47701
48	1614.171085	34.57228707	5.84098468	97.34974
50	1681.428213	35.27408199	6.20786757	103.4645
52	1748.685342	36.0045216	6.58987395	109.8312
54	1815.94247	36.76360589	6.98760877	116.4601
56	1883.199599	37.55133488	7.40167695	123.3613
58	1950.456727	38.36770856	7.83268345	130.5447
60	2017.713856	39.21272693	8.2812332	138.0206
62	2084.970984	40.08638999	8.74793115	145.7989
64	2152.228113	40.98869774	9.23338222	153.8897
66	2219.485241	41.91965018	9.73819137	162.3032
68	2286.74237	42.87924731	10.2629635	171.0494

70	2353.999498	43.86748913	10.8083036	180.1384
72	2421.256627	44.88437564	11.3748166	189.5803
74	2488.513755	45.92990685	11.9631075	199.3851
76	2555.770884	47.00408274	12.5737811	209.563
78	2623.028012	48.10690332	13.2074424	220.124
80	2690.285141	49.2383686	13.8646963	231.0783
82	2757.542269	50.39847856	14.5461479	242.4358
84	2824.799398	51.58723322	15.2524019	254.2067
86	2892.056526	52.80463256	15.9840635	266.4011
88	2959.313655	54.0506766	16.7417374	279.029
90	3026.570784	55.32536532	17.5260287	292.1005
92	3093.827912	56.62869874	18.3375423	305.6257
94	3161.085041	57.96067685	19.1768831	319.6147
96	3228.342169	59.32129964	20.0446561	334.0776
98	3295.599298	60.71056713	20.9414662	349.0244


RPM-VS-Toruqe
Torque
Rpm
RPM-VS-Power
Power
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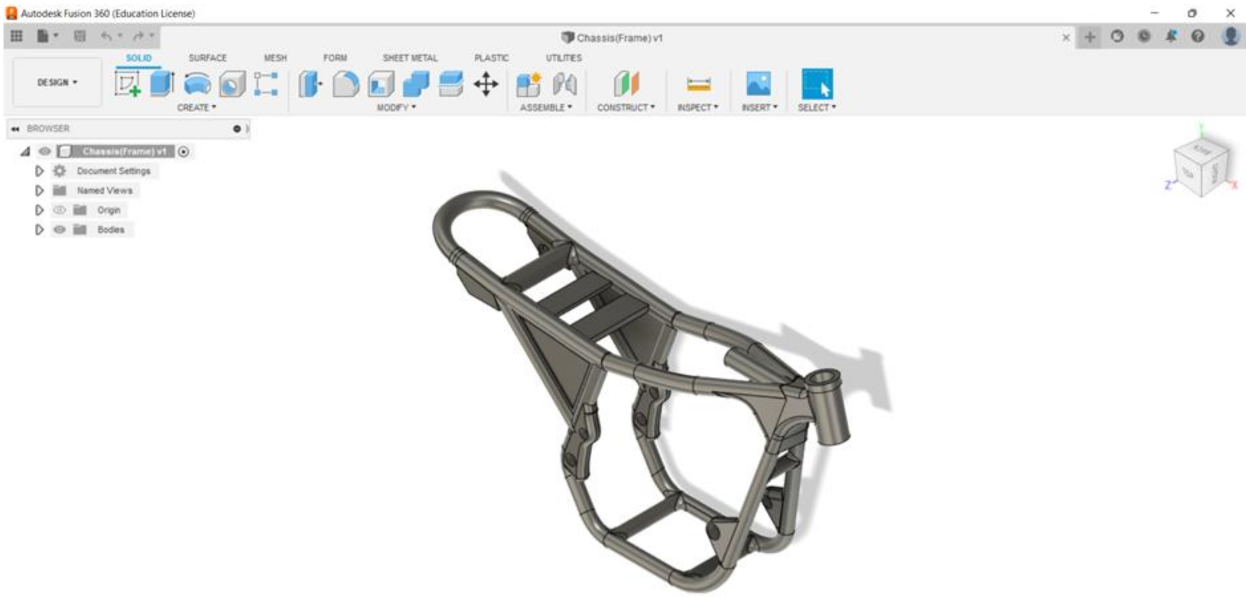
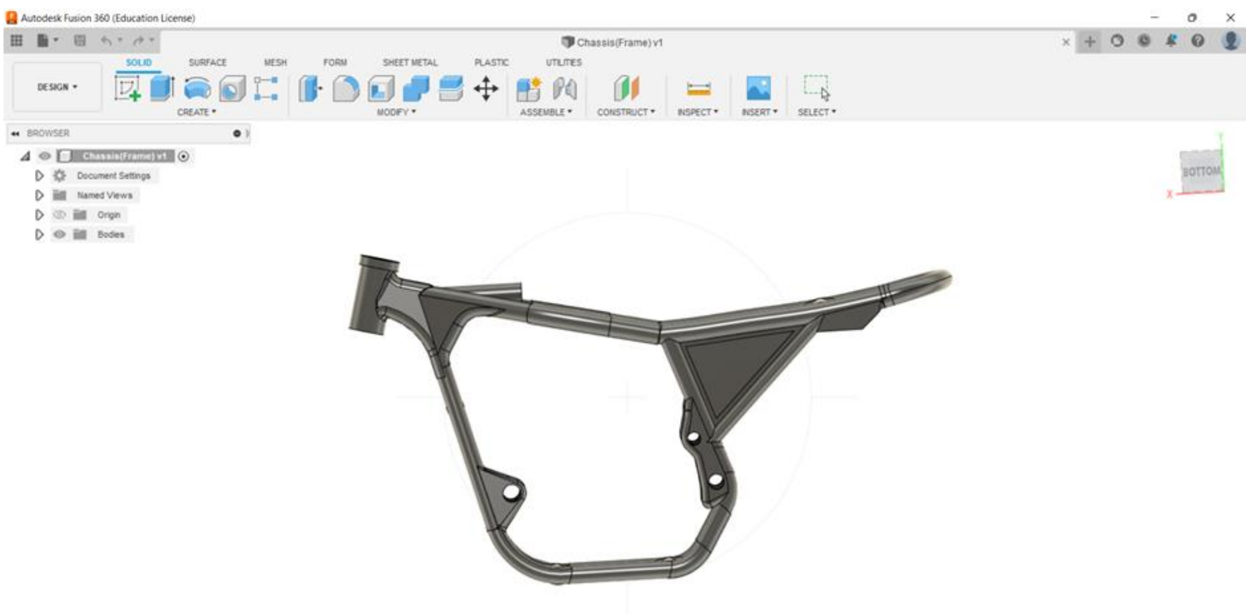
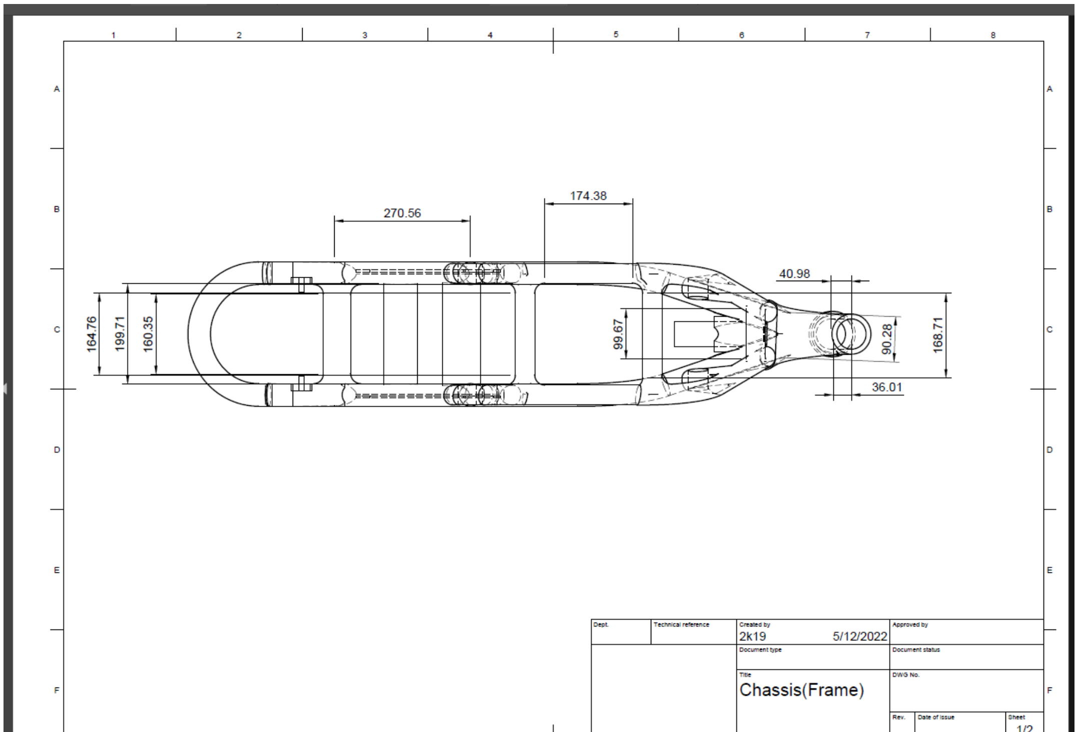
Power
Torque
RPM-VS-current
current
Rpm

Model of Bike chassis

From the following design of the motorcycle's frame we find the space and its shape available. So that we can design the motor housing and the battery's infrastructure. We have sent this cradle's space to the manufacturer. He designed the things according to our envelope size and delivered them to us.



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2k19
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Approved by
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Rev.
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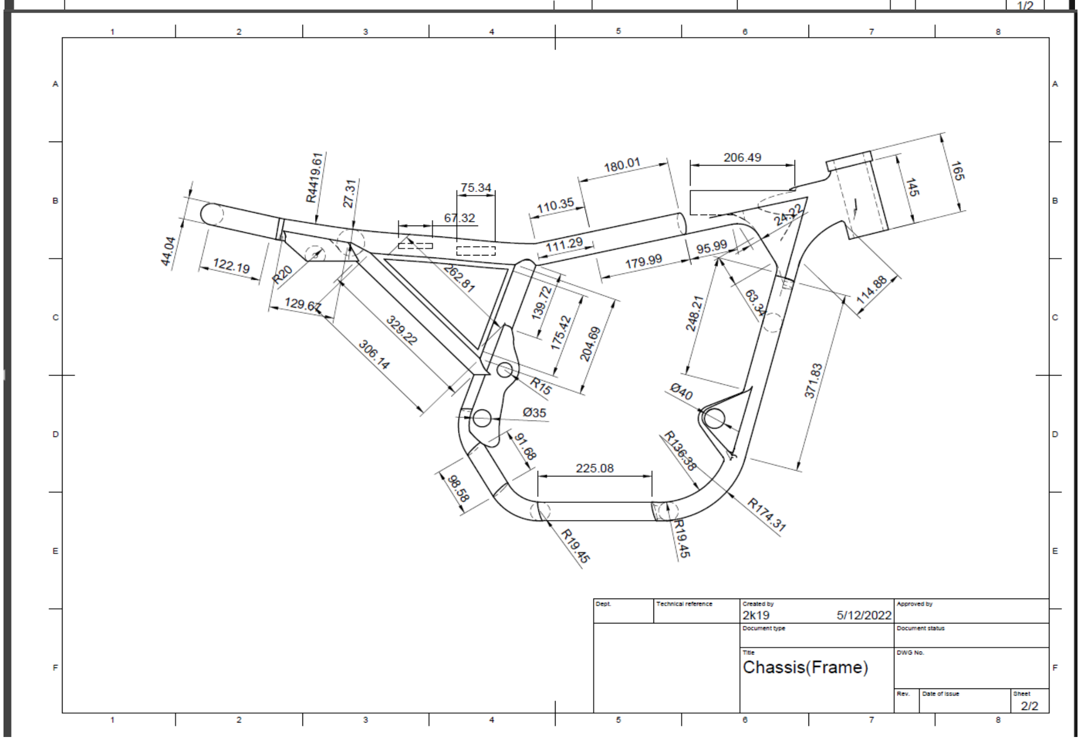
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329.22
306.14
262.81
139.72
175.42
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179.99
95.99
24.22
63.34
114.88
248.21
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R15
Ø35
Ø40
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Technical reference
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2k19
5/12/2022
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Document type
Document status
Title
Chassis(Frame)
DWG No.
Rev.
Date of issue
Sheet
2/2

CYCLE

In this case, we have decided to take up the project of converting a Normal Basic Cycle into a fully electric vehicle with a conversion kit. As part of converting, we have taken a normal mechanical cycle and dismantled the rear tyre, rim, axle and the sprocket. Now with the help of the conversion kit which is outsourced, we are taking the dimensions of the hub motor and rearranging the spokes of the rim. We do also have the prerequisites to do before concluding on the battery size, motor specifications and range of the vehicle. Those prerequisites are:

- Motor Sizing
- Battery Sizing
- Auxiliary Motor calculation for steering
- Wire Harnessing
- Engine Space Design
- Current profiles for different speeds

So here we'll be getting into each and every part and will be showing what we have done in the same.

Motor Sizing:

Motor Sizing means picking up the correct motor for your application. We generally do this motor sizing because without any clarity if we go for any motor available in the market and by chance if that motor is too small for that cycle, then we can't consider it as it won't be able to handle the load we give and we won't be getting the desired torque to move the cycle. Hence by doing the Motor sizing we will be able to know a motor with which specifications will be suitable for our cycle.

Few of the parameters which are crucial in calculating the Motor Sizing are :

- Frontal Area (A_f)
- Mass of the Vehicle
- Kerb Weight of the Vehicle
- Gear Ratio
- Radius of Wheel
- Drag Coefficient
- Density of Air
- Rolling Resistance

Input Parameters

Vehicle Parameters

In [1]:
```
m = 12 + 100;
A_f = 0.2;
R_w=0.35;
Gear_Ratio = 1; # as it is a bdlc motor
```
In [2]:
```
mu_r = 0.002;
C_d = 0.3;
rho = 1.225;
```
Case-1: Maintain climb speed on an incline

Input

In [12]:
```
theta = 8;
V = (5) * 1000 / 3600;
```
Calculate Forces

In [4]:
```
import math
```
In [13]:
```
Rolling_resistance = mu_r * m * 9.81 * math.cos(theta * 3.14 / 180);
Gradient_resistance = m * 9.81 * math.sin(theta * 3.14 / 180);
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Force = Rolling_resistance + Gradient_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```
In [14]:
```
Rolling_resistance
```
Out[14]:

2.176076307192823

In [15]:
```
Torque_wheel
```
Out[15]:

54.278777360801776

In [16]:
```
RPM_wheel
```
Out[16]:

37.91325447376403

In [17]:
```
Torque_motor
```
Out[17]:

54.278777360801776

In [18]:
```
RPM_motor = RPM_wheel / Gear_Ratio
```

```
RPM_motor
```

Out[18]:

37.91325447376403

In [19]:

```
Power_kW = Force * V/1000
Power_kW
```

Out[19]:

0.2153919736539753

Case-2: Maintain peak speed on a flat road

Input

In [20]:

```
V = (30) * 1000 / 3600;
```

Calculate Forces

In [21]:

```
Rolling_resistance = mu_r * m * 9.81 ;
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Force = Rolling_resistance + Air_drag;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```

In [22]:

```
Torque_wheel
```

Out[22]:

1.662333166666667

In [23]:

```
RPM_wheel
```

Out[23]:

227.4795268425842

In [24]:

```
Torque_motor
```

Out[24]:

1.662333166666667

In [32]:

```
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor
```

Out[32]:

2787.4952961016875

In [25]:

```
Power_kW = Force * V/1000
print(Power_kW)
```

0.03957936111111112

Case-3: Accelarate to Avg speed on a flat road

Input

In [26]:

```
V = (20) * 1000 / 3600;
```

```
t = 30;
a = V / t;
```

Calculate Forces

In [28]:

```
Rolling_resistance = mu_r * m * 9.81;
Air_drag = 0.5 * rho * C_d * A_f * (V*V);
Inertia = m * a;
Force = Rolling_resistance + Air_drag + Inertia;
Torque_wheel = Force * R_w;
RPM_wheel = 30 * V / (3.14 * R_w);
Torque_motor = Torque_wheel * Gear_Ratio
```

In [29]:

```
Torque_wheel
```

Out[29]:

8.425353999999999

In [30]:

```
RPM_wheel
```

Out[30]:

151.6530178950561

In [31]:

```
Torque_motor
```

Out[31]:

8.425353999999999

In [32]:

```
RPM_motor = RPM_wheel / Gear_Ratio
RPM_motor
```

Out[32]:

151.6530178950561

In [33]:

```
Power_kW = Force * V/1000
Power_kW
```

Out[33]:

0.13373577777777776

Battery Sizing:

Battery Sizing is defined as the calculating and obtaining the capacity of the battery we need for our application in terms of Energy it can store and the current it can offer. This is often measured in KwH. In case if we don’t do the battery sizing and go for the market batteries available outside, we can get into trouble where those outsourced batteries cannot give us the required power and current our application demands and this can also result in failure. Hence Battery Sizing is better and we can easily make our own customised battery according to the values we get and it will be beneficial for our cycle.

Few of the parameters which are crucial in calculating the Battery Sizing are :

- Velocity
- Air Drag
- Force
- Power
- Range

We generally assume that the battery efficiency is 90% in these cases.

	gradient = 0 deg					rolling resistance in N	2.1760763		batery efficienty	90%
assumed that vehicle will be moving with a uniform velocity through out the range.						gradient = 0 deg				
velocity(kmph)	velocity(mps)	aero drag in N	force(N)	power(kw)	range(km)	time required(hr)	battery capcity required in kwh			
30	8.333333333	2.977430556	5.153507	0.04294589	210	7	0.334024			
25	6.944444444	2.067660108	4.243736	0.02947039	210	8.4	0.275057			
20	5.555555556	1.323302469	3.499379	0.01944099	210	10.5	0.226812			
15	4.166666667	0.744357639	2.920434	0.01216847	210	14	0.189287			
10	2.777777778	0.330825617	2.506902	0.00696362	210	21	0.162484			
5	1.388888889	0.082706404	2.258783	0.0031372	210	42	0.146403			
30	8.333333333	2.977430556	5.153507	0.04294589	180	6	0.286306			
25	6.944444444	2.067660108	4.243736	0.02947039	180	7.2	0.235763			
20	5.555555556	1.323302469	3.499379	0.01944099	180	9	0.19441			
15	4.166666667	0.744357639	2.920434	0.01216847	180	12	0.162246			
10	2.777777778	0.330825617	2.506902	0.00696362	180	18	0.139272			
5	1.388888889	0.082706404	2.258783	0.0031372	180	36	0.125488			
30	8.333333333	2.977430556	5.153507	0.04294589	150	5	0.238588			
25	6.944444444	2.067660108	4.243736	0.02947039	150	6	0.196469			
20	5.555555556	1.323302469	3.499379	0.01944099	150	7.5	0.162008			
15	4.166666667	0.744357639	2.920434	0.01216847	150	10	0.135205			
10	2.777777778	0.330825617	2.506902	0.00696362	150	15	0.11606			
5	1.388888889	0.082706404	2.258783	0.0031372	150	30	0.104573			
30	8.333333333	2.552083333	4.72816	0.03940133	100	3.333333333	0.145931			
25	6.944444444	1.772280093	3.948356	0.02741914	100	4	0.121863			
20	5.555555556	1.134259259	3.310336	0.01839075	100	5	0.102171			
15	4.166666667	0.638020833	2.814097	0.0117254	100	6.666666667	0.086855			
10	2.777777778	0.283564815	2.459641	0.00683234	100	10	0.075915			
5	1.388888889	0.070891204	2.246968	0.00312079	100	20	0.069351			

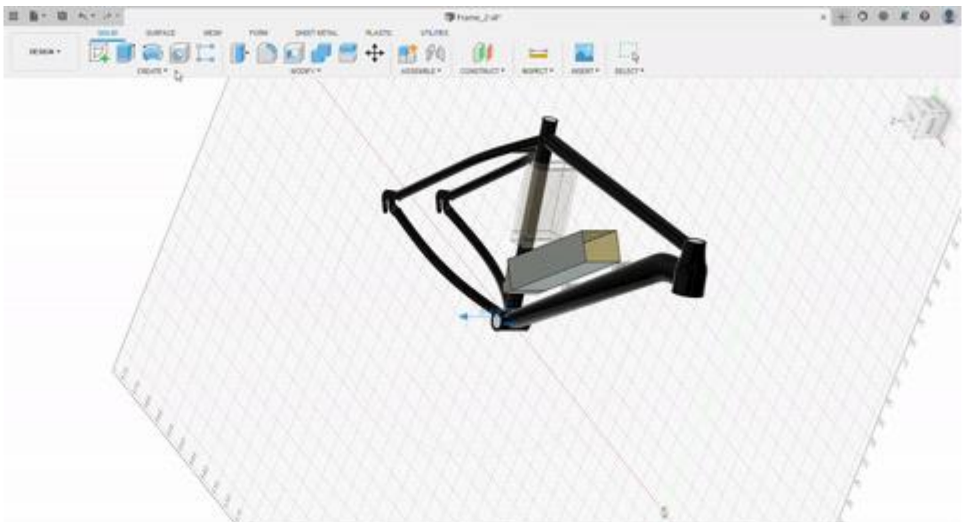
We have successfully completed the retro fitting process for a two wheeler bicycle. But when we look into the usage of the bicycle we found that it is used only for 2-3 hours in a day and for the remaining all the time the bicycle is parked outside, where the vehicle is subjected to different environmental conditions which affects the battery's performance and life.

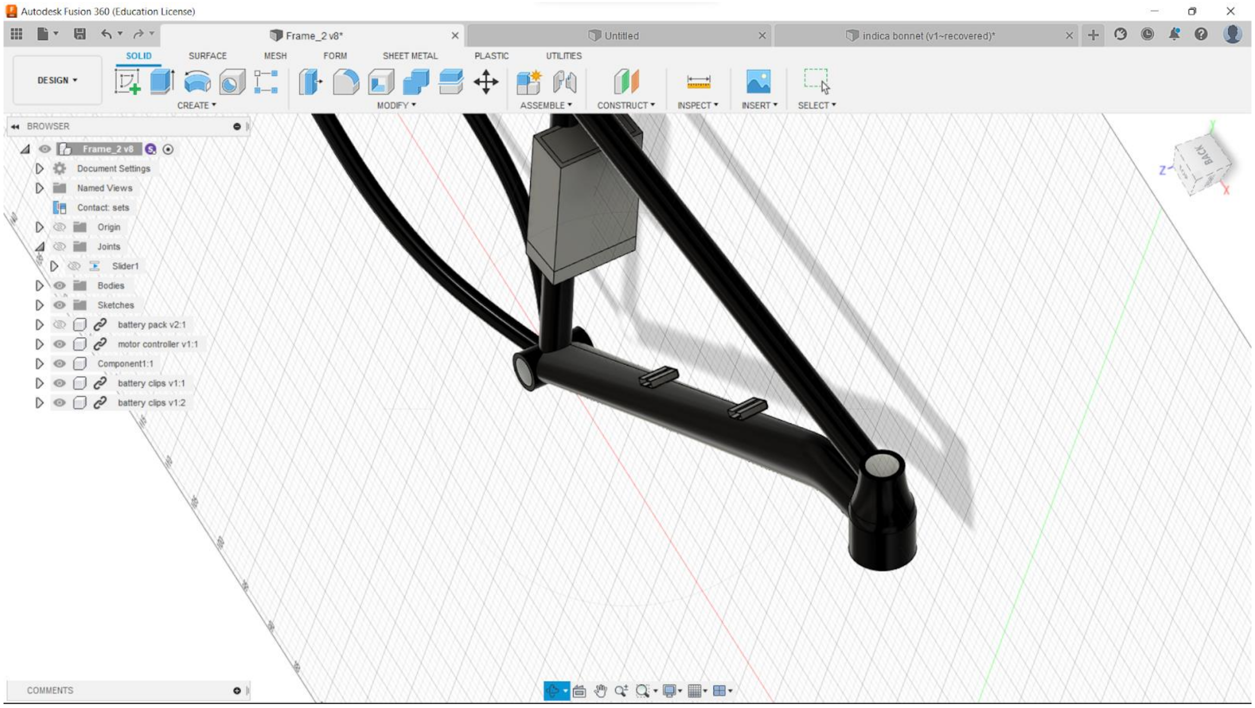
To avoid this we came up with a solution that will have a Detachable battery system where we can detach the battery from the vehicle and carry it with ourselves and keep it in a controlled environment. When the battery is in the controlled environment then it will have good performance characteristics along with battery life.

To develop the Detachable system for the bicycle we followed the following path.

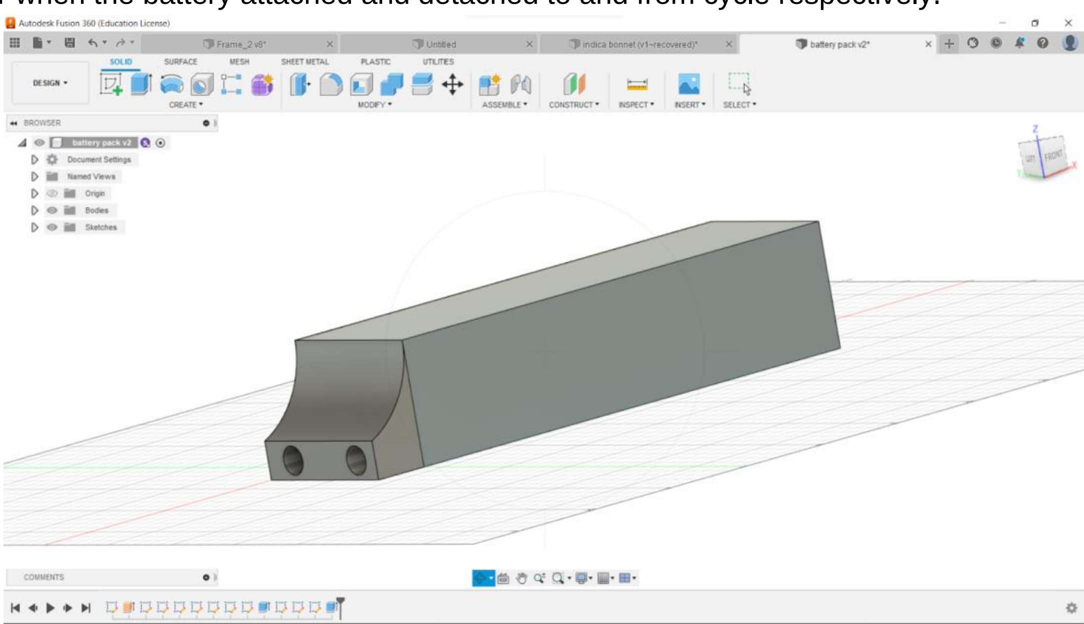
We modelled and simulated the detachable system as shown in the above system. So the battery which is covered with an envelope(closed) will have a slider with locks. The cycle's frame will also have a pair of sliders on which the pair sliders of the battery's envelope will slide. While we were turning to avoid sliding, we provided the locks on both sides to the slider with a hinge. When we want to detach the battery we can unlock the lock by rotating and then we can slide the battery's envelope towards the outside and remove it. We have provided the envelope for the motor controller as it should not be exposed to the external environment like a more sunny and hot environment, rain, humidity etc… This motor controller's envelope is rigidly mounted onto the cycle's frame.

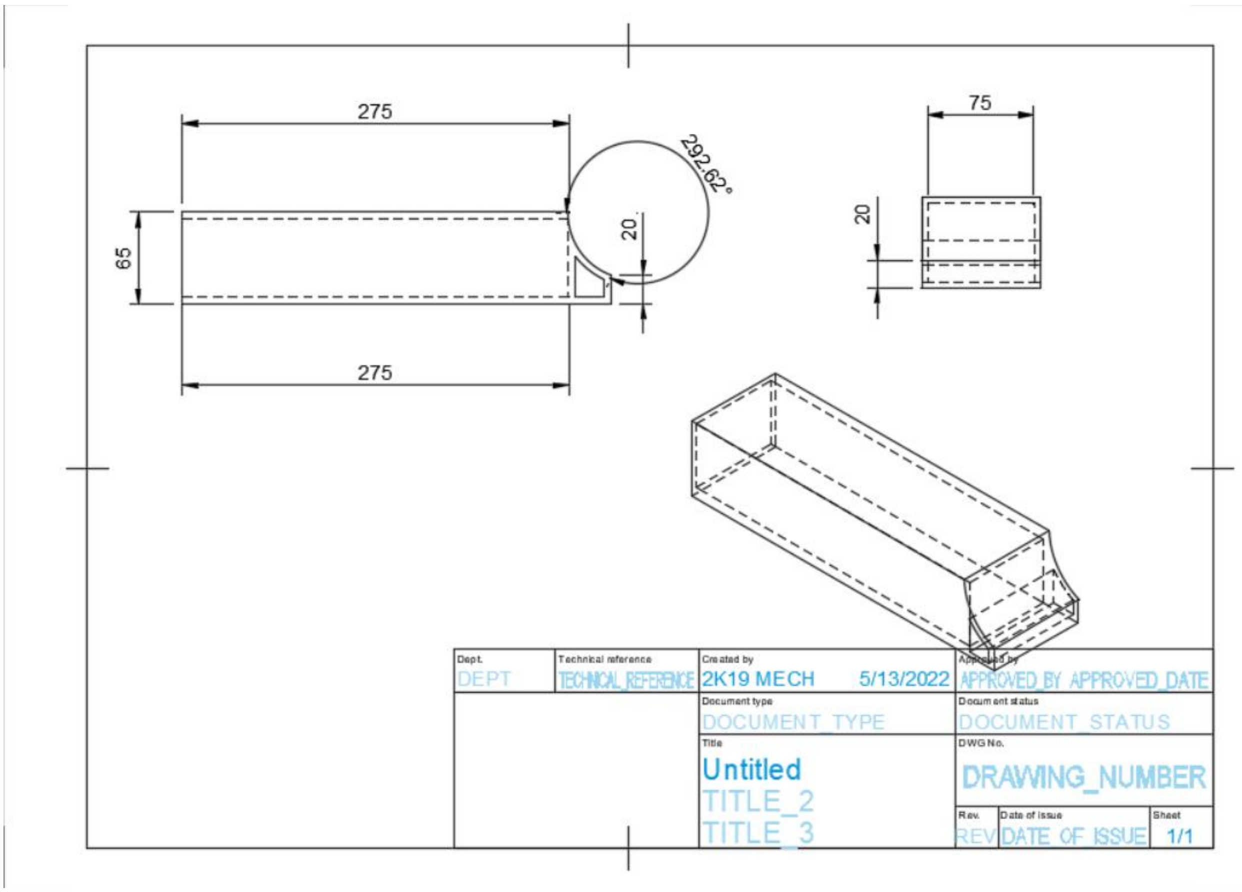
MODEL





There is a hole provided for the motor controller's envelope(shown above) from which the electrical links come out which should be connected to the battery and motor. There will be a holder attached at the end of the sliders. The electrical links coming from the motor controller envelope will come connected to the holder(as shown below). When the battery's envelope is fitted in the slider locked then this holder will get in contact with the envelope where the envelope will have pins on its surface which will be connected to the holder such that the circuit completes there. In this way the electrical link connected and disconnected in a requirement manner when the battery attached and detached to and from cycle respectively.

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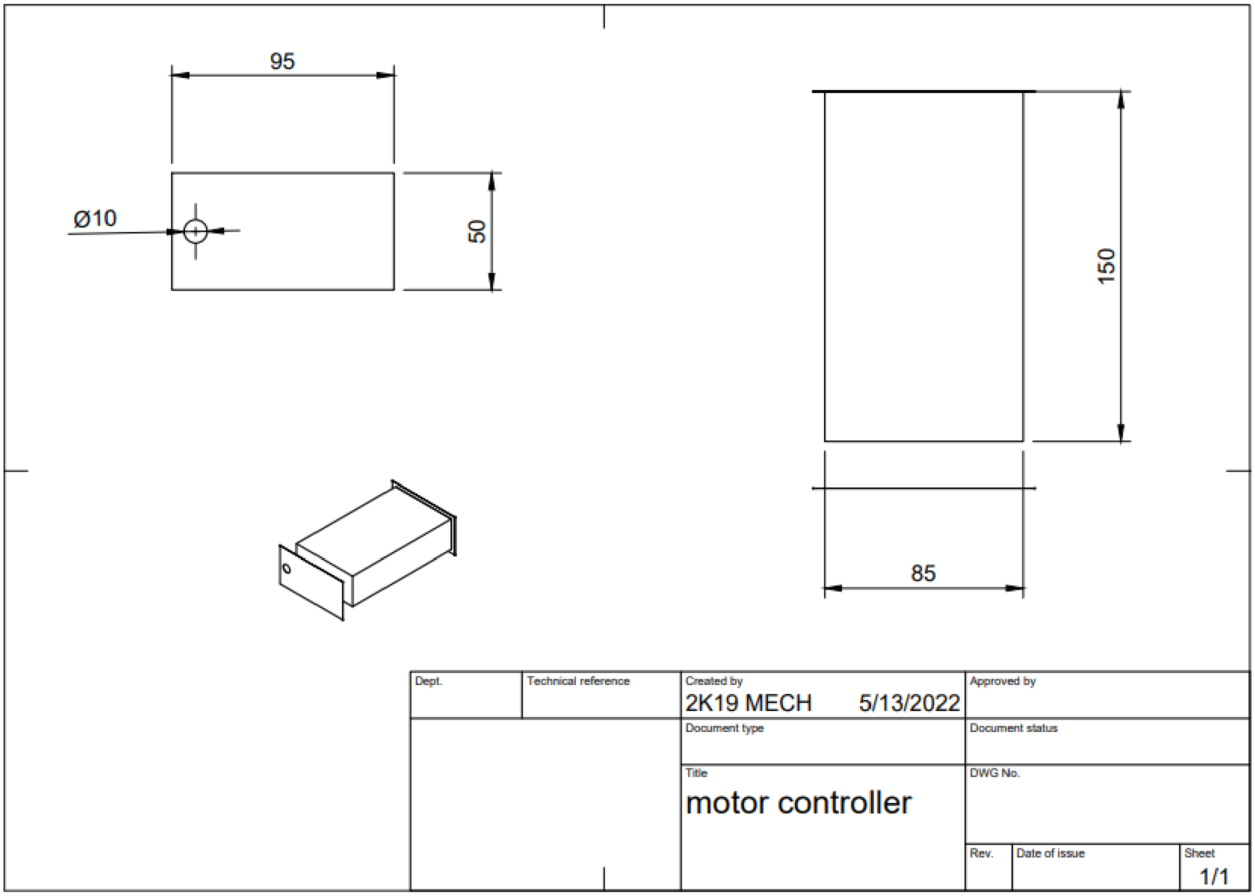

CONCLUSION

By this project I have so many things about retrofitting of the cycle, bike, car and for bike , car we will be converting the IC engine to Electric and it makes a huge a impact to decrease the emissions and make the pollution less so that we can protect the next generation people and make them not get disturb by this environment and if we compare the price of IC engine car and electric car current cost there is huge different and we can save lot of money the price of the diesel or petrol with unit of power cost these are things make impact to use retrofitting and I have learned about the modelling of bonnet etc and motor sizing ,battery sizing , motor controller tuning Rpm, power, torque, current profiles for 2W and 4W etc. This project made us more hand on experience. Thank you for giving this opportunity.

Thank You