DESIGN AND DEVELOPMENT OF DUALDRIVE ELECTRIC VEHICLE

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Abstract- The concern over the environment with respect to pollution, conservation of fuel resources in the world, the automotive industry has entered into a new dimension in production of more fuel efficient, low emission vehicles and new technologies. One of the greatest innovations is Hybrid Electric Vehicle. The hybrid electric vehicle consists of two or more energy sources for total propulsion of the vehicle. The invention of internal combustion engine is greatest of mankind. Though it has certain negatives along with it like ever increasing demand for petroleum oils, their high prices and exhaustible reserves and the associated environmental and health issues. Hence to find sustainable alternative for conventional internal combustion engine is the need of the hour. Adaptation of many alternatives with less carbon footprint has been emphasized among the different strategies. Among these alternatives Hybrid Electric Vehicle technology has emerged promising solution for ensuring improvement in fuel consumption and emission rates with a performance comparable to the conventional vehicles. Hence, the aim of our project is to implement the foremost efficient and less polluting vehicle. An electric power train is combined with the conventional IC engine power train resulting in twice the fuel economy of conventional engine and half the harmful emissions.

Keywords- ICE – Internal Combustion Engine, EV – Electric Vehicle, HEV – Hybrid Electric Vehicle, MS – Mild Steel, AQI – Air Quality Index, IDC – Indian Driving Cycle, PM BLDC – Permanent Magnet Brushless DC Motor.

I. INTRODUCTION

The air quality scenario of our country is a major concern now a days. Many major cities of India are in top 10 in the list of Air Quality Index. In 2021 survey, Mumbai is ranked 2nd with AQI 169 while Delhi is ranked as 4th with AQI 158. In 2019 Survey 21 cities of India among 30 were included in the AQI list. The major cause of degrading air quality is harmful emissions emitted in environment by burning fossil fuel by the vehicles. Hence to reduce the emissions by the conventional vehicle, electric vehicles were introduced, but as it is a newly popular technology and less developed infrastructure in India people gave a second thought while opting electric vehicles. Hence as an engineering student the above problem motivates us to use our engineering knowledge to develop a vehicle to meet the requirements of the user while limiting the pollution.

The objective of our project is to make the transition smooth from conventional internal combustion engine technology to fully electric vehicle technology by designing and developing a hybrid vehicle which gives the advantages of both the technology.

METHODOLOGY

The first part of the methodology is carrying out a detailed survey to know the coustomer's requirements for prospective hybrid electric two wheeler. From the analysis formed we obtain the rankings for various functional requirements as well as design requirements for the vehicle. From the design requirements, a suitable conventional two wheeler is selected for modification over which the changes for hybridization are to be carried out. The selected vehicle is also road tested. According to the tested results and calculated power requirements, a suitable Electric motor and a suitable electric storage device is selected and procured. Next, the theoretical design calculations and design of various necessary components like powertrain parts, battery frame etc. are made and are analysed for strength and performance. The designed parts are then modelled in modelling software and analysed for strength and failure criteria using design analysis software. Design is again studied in detail for the feasibility of implementation. In the Design phase concepts of various combinations of possible configurations are conceptualized and compared with each other. Then the possible configurations are analysed in detail for the feasibility of implementation. Once the finalized design is reached, then the fabrication phase can begin. In the Fabrication phase the design is processed into a working model and the same is tested at various levels to find out any flaws and reengineered to meet the expectations.

This methodology consists of two distinct phases:

1. Solving an optimization problem to detect the best powertrain components characteristics and to choose the components according to specifications.
2. Application and calibration of the control strategy parameters and adjustment of the whole drivetrain, and in particular of the powertrain components characteristics, final assembly is done then tested at various levels to find out any flaws and reengineered to meet the expectations.

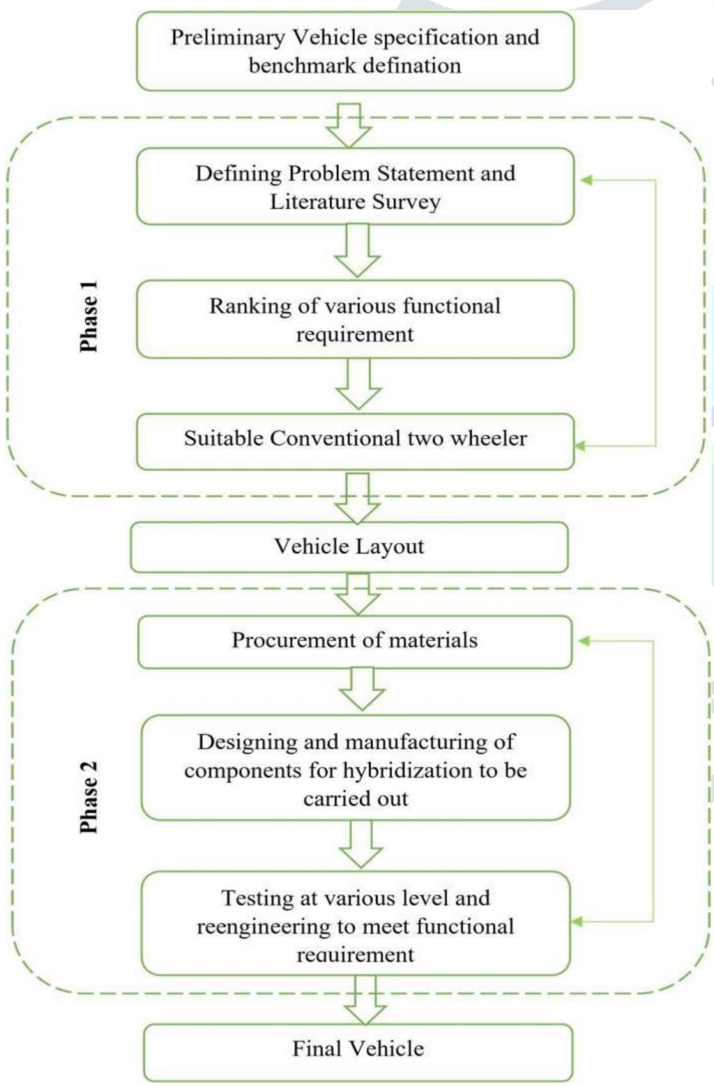

Fig 1 Methodology Flowchart

OBJECTIVE

- The main objective of our project is to design a vehicle which is able to combine the advantages of both, internal combustion engine as well as electric vehicle technology by balancing out each other's limitations.
- To limit the harmful emissions emitted by internal combustion engine.
- To increase overall fuel economy of the vehicle.

LITERATURE REVIEW

Design and Analysis of Two wheeler Hybrid Electric Vehicle for Optimized Performance with Indian Driving Condition: By Rushikesh Joshi, Kiran Wani, Sanjay Patil, Nagesh Chaughule, Manish Ingale.

In this research work various combinations of ICE, electric motor and battery are considered. The optimum component sizing is decided from the simulation results. The test vehicle is made HEV by the addition of electric motor, battery and powertrain components. Experimental testing is carried out on dyno test set up for conventional architecture as well as for HEV architecture. Simulation results are compared with experimental test results for validation. The pure Electric Vehicles (EV) are still not ready to conquer the market from the conventional vehicles due to high cost, low range of travel, lack of infrastructure for battery charging stations and high maintenance of batteries. The hybrid architecture combines the benefits of a conventional vehicle of higher range with the environmental benefits of low emissions of an electric vehicle. This improves the fuel economy of the vehicle and lowers the emissions. The main drawbacks with a Hybrid Electric Vehicle (HEV) are complexity in design and higher price than conventional vehicles. The research paper compares various combinations of electric motor, battery and other components required for HEV and optimizes the design. The simulation results are compared with experimental data by testing the HEV under Modified Indian Driving Cycle. The simulation result shows that after converting the conventional vehicle into HEV, downsizing of the engine is possible. The experimental result shows up to 47.96% reduction in equivalent energy consumption at lower gear and speed for combined power mode. The average variation of simulation result from dyno test result is found to be 8.4%. The driving cycle of any country is determined by collecting information about the usual driving scenario of the country which includes both the urban environment and the highways. The driving cycle is formulated by driving a vehicle over designated routes which have traffic density and driving pattern similar to the prevailing pattern in the country.

A graph of velocity of vehicle versus the time of travel is plotted and is used for various vehicle simulations.

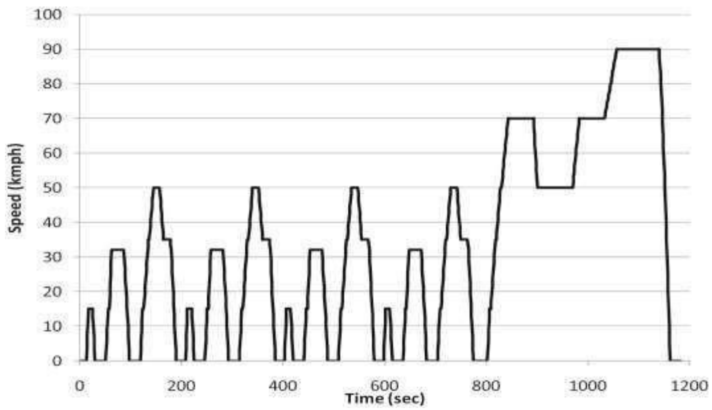

Fig 2 Indian Drive Cycle for hybrid two wheeler

The driving cycles are used in various propulsion system simulations to predict the performance of internal combustion engines, transmissions, electric drive systems, batteries, fuel cell systems, and similar components. In this research paper Modified Indian Driving Cycle (IDC) is used as per given in Central Motor Vehicle Rules (CMVR) Annexure II. Fig.2.1 shows Modified Indian Driving Cycle.

A Review on Electric Vehicles: Technologies and Challenges: By Julio A. Sanguesa, Vicente Torres-Sanz, Piedad Garrido, Francisco J. Martinez and Johann M. Marquez-Barja.

In this paper, a comprehensive survey of the most important aspects of EV technologies, charging modes, and the research carried out by different research teams and labs. Overall, the insight and contributions of our work are the following:

(i) They present an analysis of the existing surveys in the literature, motivating the need of our work, since we present some aspects that had not been dealt with before, and we cover the latest works that are presented in the literature, (ii) They analyse the current worldwide market situation of EVs and their prospects,

(iii) They make a thorough review of the battery technologies—from the lead-acid batteries to the Lithium-ion, including the latest technologies, such as graphene,

(iv) They review the different standards available for EV charge, as well as the types of connectors that are defined by them,

(v) They present the most relevant works related to Battery Management Systems (BMSs), thermal management, and power electronics, and

(vi) They conclude our work by discussing what is shortly expected in this field, as well as the research aspects, which, in our opinion, are still open for both industry and academic community.

Electric Vehicles: In this section, they present a classification of the different types of electric vehicles, commenting on their main characteristics. They also discuss the current market situation, analysing the sales data of this kind of vehicles and sales forecast in different countries in the world.

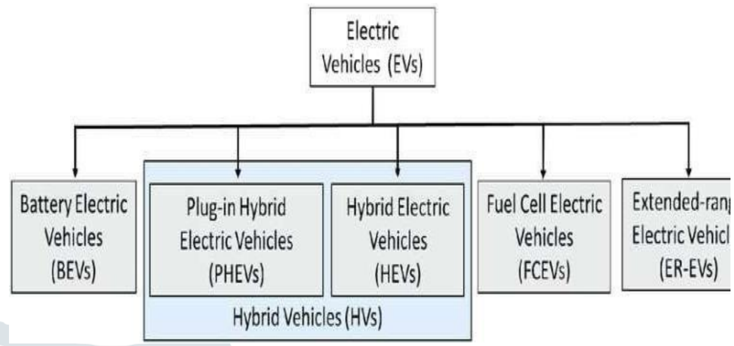

Fig 3 Electric vehicles classification according to their engine technologies and settings.

Characteristics of the Batteries

Concerning the main characteristics of batteries, we can highlight the following:

- Capacity. The storage difficulty and cost is one of the main problems of electric power. Currently, this results in the allocation of great amounts of money in the development of new batteries with higher efficiency and reliability, thus improving batteries' storage capacity.

- Charge state. Refers to the battery level with regard to its 100% capacity.

- Energy Density. Obtaining the highest energy density possible is another important aspect in the development of batteries, in other words, that with equal size and weight a battery is able to accumulate a higher energy quantity. The energy density of batteries is measured as the energy that a battery is able to supply per unit volume (Wh/L).

- Specific energy. The energy that a battery is able to provide per unit mass (Wh/kg). Some authors also refer to this feature as energy density, and it can be specified in Wh/L or Wh/kg.
- Specific power. The power that a battery can supply per unit of weight (W/kg).

- Charge cycles. A load cycle is completed when the battery has been used or loaded 100%.

- Lifespan. Another aspect to consider is the batteries lifespan, which is measured in the number of charging cycles that a battery can hold. The goal is to obtain batteries that can endure a greater number of loading and unloading cycles. • Efficacy. It is the percentage of power that is offered by the battery in relation to the energy charged.

Design and analysis of multiphase BLDC Hub motors for electric vehicles – By Gullu Boztas, Merve Yildirim, Omur Aydogmus:-

This paper presents a design and analysis of multiphase brushless direct current (BLDC) motor for electric vehicles (EV). In this work, hub-wheels having 110Nm, 900rpm rated values have been designed for the proposed EV. This EV can produce 440 Nm without using transmission, differential and other mechanical components which have very high losses due to the mechanical fraction structure. The motors to be used in the EV have been designed as 3, 5- and 7-phase by Infolytica /Motor Solve Software to compare their performances at the same load conditions. The same rotor geometry has been utilized for the motors. However, slot numbers and dimensions of the stator have been determined by considering the motor phase number. Performance curves of phase-currents, output powers, torques, efficiencies and power factors have been presented for these motors at the same operating conditions. It can be possible to use lower power switches in motor drive system thanks to the phase current reduction since the phase currents decrease proportionally to motor phase number. This work shows that the Multi-phase BLDC motors are a good alternative in order to obtain lower torque and lower power inverter structure than the 3-phase BLDC motors which are used as standard. Interest on electric vehicles (EV) has increased recently because of their environmental advantages, high energy efficiency, and low noise. Significant properties of brushless direct current (BLDC) motors for EVs are high power density and high efficiency. Besides, there are important advantages such as small size, high reliability, not having rotor copper losses and low maintenance cost due to not having brushes. Therefore, BLDC motors are commonly preferred in industry applications.The performance of the motor in terms of voltage/current ratings and energy conversion efficiency is compared with other conventional motors. It is seen that this motor is useful for vehicle propulsion applications. In a design of three phase PM BLDC (permanent magnet BLDC) hub motor which has high efficiency and power density and no cogging torque is realized for electrically powered two wheelers. It is seen that PM BLDC hub motor has high efficiency and it is convenient for different scooter load and speed conditions. The electromagnetic torque of the motor is calculated and analysed by finite element method (FEM).

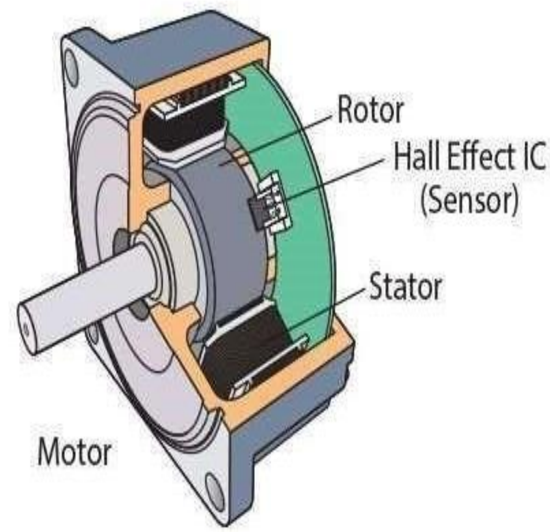

Fig 4 BLDC Hub Motor structure showing all the components

In this study three motors have been designed in order to focus on comparing the effect of the phase number on motor. These motors used as wheel in EVs are called hub motors. Firstly, a 3-phase BLDC hub motor is designed. As a base motor. This motor has inner stator and outer rotor structures. Then, 5-phase and 7-phase motors having the same rotor dimensions of the base motor have been designed. The number of the slots and dimensions of the stator have been determined by considering the motor solve software package. As the number of the phase of the motor increases, the phase currents reduce. This is allows the use of lower power switches in motor driving systems. This work shows that multi-phase BLDC motors are a good alternative in order to use lower power inverter structure compared with 3-phase BLDC motors that are used as standard. The other important characteristic for BLDC motors is the output torque curve. As the number of the motor phase increases, the torque ripple produced by the motors significantly reduces.

Brushless DC motor control with unknown and variable torque load By ljandra de la Guerra, LuisAlvarez-Icaza, Lizeth Torres.

This paper deals with the problem of controlling the rotor shaft speed for traction in a vehicle. The traction is responsible of converting electrical to mechanical energy in such a way that the vehicle is propelled to overcome aerodynamic drag, rolling resistance drag, and kinetic resistance. Therefore, the electric drive serves as an interface between the electrical and mechanical subsystems in a transportation system, where its job is to transfer energy in the needed direction with high efficiency. The electric machines normally considered for this kind of application are the Direct Current motor (DCM), the Induction motor (IM), the Brushless DC motor (BLDC) and the Switched Reluctance motor (SRM). To choose the right type of motor for a given application, it is important to define some qualifying factors related to power, range of speed, type of load and cost. Additionally, it is convenient to choose a motor that has a reasonable cost and market penetration, which relates with its availability and the cost of its associated power technology. The BLDC motor fulfills most of the requirements mentioned above with respect to the power density and efficiency as has been stated by Ehsani et al. and Zeraoulia et al. Moreover, this type of motors have good market availability and associated power technology cost. Nevertheless, its main drawback is that the BLDC motor has a short constant power region (the fixed permanent magnet limits its extended speed range). With respect to the velocity control of the BLDC motor several controllers have been proposed among them, the PID control has been the most used as in Pillay and Krishnan [1989], Lee and Ehsani [2003], AlMashakbeh [2009]. Another type of controllers proposed are those based on fuzzy logic as in Lee and Pang [1994], Lee et al. [1999], Rodr´ıguez and Emadi.

II. VEHICLE POWER LOAD CALCULATIONS

Before Starting further calculations let us assume certain functional requirement parameters which are necessary for the vehicle component design.

Maximum Load: Maximum Pay Load is the weight which vehicle can carry including the weight of rider and pinion. Here in this project we assume maximum pay load to be 180 Kg.

Maximum load =140Kg

Top Speed: Top speed the maximum speed achieved by the vehicle while carrying the load. We are assuming top speed for designing to be 40 kmph.

Top speed = 40 kmph = 11.11 m/s

Rolling Resistance: Rolling resistance sometimes called rolling friction or rolling drag, is the force resisting the motion when a body rolls on a surface. Here we consider the rolling resistance for asphalt road.

Radius of wheel = 0.4064/2 m = 0.2032 m

Power: In electric motor, Power is defined as product of total forceand velocity.

Power = Total Force * VelocityP = Ft × V

Rolling resistance =0.004

Area of vehicle = 0.7m^2

Density of air = 1.2Kg/m3

Wheel size (diameter) ~ 16 inch = 0.4064 m

Where,

Ft is the total force acting on the vehicleV is the velocity of the vehicle

Total three forces acts on the vehicle, F = Fh + Fr + Fd

Where,

Fh – Force due climbing hills.Fr – Rolling Resistance.

Fd – Aerodynamic Drag force. For Force due to climbing hills we have formula:

Fh = Wsin(Φ) = 140 × 9.81 × sin(2.5) --(Assume angle of inclination Φ = 2.5)

∴ Fh = 59.90 N

For Force due to rolling resistance we have formula:

Fr = CrWcos(Φ) = 0.004 × 140 × 9.81 × cos(2.5)

∴ Fr = 5.48 N

For Force due to Aerodynamic Drag we have formula:

Fd = 0.5pCdAV^2 = 0.5 × 1.2 × 0.5 × 0.7 × 11.11^2 - -----(Assume V = 40 kmph)

∴ Fd = 25.92 N

Hence, Ft = Fh + Fr + Fd = 59.90 + 5.48 + 25.92

∴ Ft = 91.3 N

Now, we have P = Ft × V = 91.3× 11.11

∴ P = 1014.343 watt ≈

1000 wattWatt hour = 1000 × 1 hr =

1000 whr

Battery watt hour = 1000 whr × 1.20 = 1200 whr

Take voltage = 48 V

Therefore, Current in battery = 1200/ 48 = 25 Ah

Now, V = 48 V, P = 1000W

N = V × 60/3.14 × d = 11.11 × 60/3.14 × 0.4064 = 522.1096 RPM

Also, Torque T = P×60/2×3.14×N = 1000×60/2×3.14×522.1096 = 18.28 Nm.

Assume,

V = 40 Kmph = 11.11 m/s

We know, V= πDN/60

Where, D is diameter of wheel

N_2 is rpm of rear wheel

$11.11 = \pi \times 0.4064 \times N_2 / 60$

∴ $N_2 = 522$ RPM

By above calculations we have motor speed 3500 RPM

∴ Velocity Ratio (N1/N2) = 3.7

We know,

N1/ N2 = D2/ D1

∴ To achieve this velocity ratio we design pulley's of diameter 25.4 mm & 95 mm.

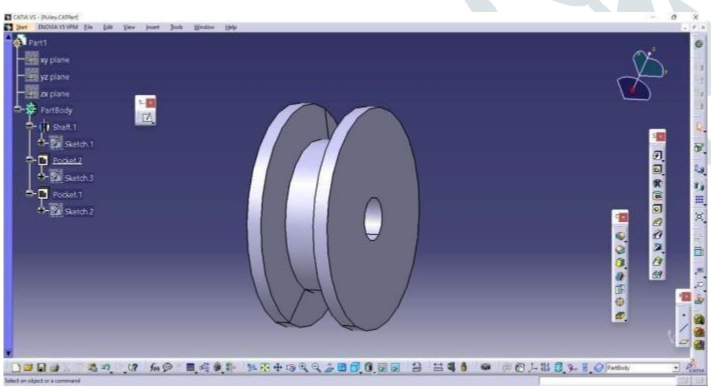

Fig 5 3-D Model of Driver Pulley

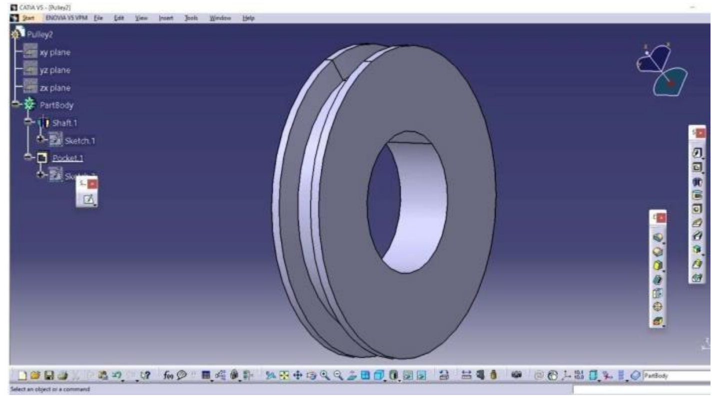

Fig 6 3-D Model of Driven Pulley

The belt length L for cross belt drive is given by

$$L = 2C + \pi(D + d)/2 + (D + d)^2/4C$$

C=343

∴L = 878.6546 mm

∴L = 34.59 inch

Fig 7 V - Belt

III. TESTING AND RESULTS

Fig 8 Final Vehicle Assembly

ACKNOWLEDGMENT

The final vehicle is tested on various parameters and conditions, so as to ensure that it won't fail during actual working. While testing the motive is that it should satisfy all the condition it is On the very outset of this report, we would like to extend our challenged for. sincere & heartfelt obligation towards all the personages who have helped us in this endeavour. Without their active guidance, help, 1. Speed cooperation & encouragement, we would not have made headway

The speed of vehicle on I.C. engine mode is found to be in the project.
around 70 kmph – 80 kmph and the speed while on
electric mode is found to be 40kmph – 50kmph. We highly indebted to Prof. A.M. Dharme for their guidance and constant supervision as well as for providing necessary

2. Distance Travel information regarding the project and also for their support in The vehicle travel completing the project. His constant guidance and willingness to

The vehicle travel 30km – 35km on single charge while share his vast knowledge made us understand this project and its on electric mode. manifestations in great depths add helped us to complete the assigned tasks on time.

3. Charging Time

battery pack of the vehicle takes 8hrs to full charge.

Advantages

1) It is environment friendly.
2) Less dependence on Fossil Fuels.
3) Increased Range.

Limitations

1) It is quite expensive.
2) It has high maintenance cost.
3) More Charging time.

IV. CONCLUSIONS

Unlike conventional internal combustion engine, hybrid electric vehicle uses two sources of power to propel the vehicle. It combines the advantages of both I.C. engine and electric motor. The I.C. engine is less efficient for less speed application, so in this condition the vehicle is propelled by electric motor. Whereas I.C. engines are efficient at high speed applications, so in this condition vehicle is propelled by I.C. engine. Hence hybrid electric vehicle's both mode of operation happens at their most extreme productivity.

By using above configuration in this project we conclude that the milage of the vehicle is increased as compared to the other conventional I.C. engine vehicle. Also, the pollutants emitted are this vehicles are minimum as compared to I.C. engine vehicle.

We also thankful to Prof. T.S. Sargar, Head of Department, The

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