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"DESIGN AND IMPLEMENTATION OF HYBRID ELECTRIC VEHICLE"

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Abstract - A hybrid electric vehicle (HEV), also known as a gasoline-electric hybrid, is a type of vehicle that uses both a battery and an internal combustion engine to operate. The internal combustion engine in an HEV drives a generator that provides electricity, and may also power one or more of the wheels. HEVs rely on a combination of both the battery and the internal combustion engine to function, and may offer advantages in fuel economy and environmental impact compared to traditional gasoline-powered vehicles. It has great advantages over the previously used gasoline engine that drives the power from gasoline only. It also is a major source of air pollution. The goal of this project is to design and build a two-wheeled hybrid electric vehicle that is powered by both a battery and gasoline. The use of both power sources makes the vehicle more versatile and adaptable to different driving conditions. The combination of electric and gasoline power also enhances the overall performance of the vehicle. It provides its owner with advantages in fuel economy and environmental impact over conventional automobiles. Hybrid electric vehicles (HEVs) combine an electric motor, battery, and power system with an internal combustion engine to improve fuel economy and reduce emissions. In an HEV, the battery provides power for low-speed driving conditions, where internal combustion engines are typically less efficient. When the vehicle needs additional power, such as when accelerating, driving on long highways, or climbing hills, the electric motor provides assistance to the internal combustion engine. This helps to optimize fuel efficiency and reduce emissions. The use of an electric motor to assist the internal combustion engine in an HEV allows for the use of a smaller, more efficient engine. In addition, HEVs utilize the concept of regenerative braking to optimize the use of energy. During braking, energy is normally dissipated as heat. In an HEV, this energy is captured and used to charge the battery. As a result, the vehicle is well-suited for use in urban areas with high traffic, where fuel efficiency and reduced emissions are important considerations. The process of designing and building an HEV typically involves creating a computer-aided design, simulating inverters and other components, conducting a cost analysis of equipment, assembling the internal combustion engine and its components, implementing an electric power drive and designing controllers, and improving the efficiency of the vehicle in cost-effective ways..

Key Words: Hybrid electric vehicles (HEV), Reduction of range anxiety, improvement in mileage, HEV - Hybrid Electric Vehicle AC - Alternating Current DC - Direct Current BLDC - Brushless DC IC - Internal Combustion CVT - Continuously Variable Transmission CAD - Computer-aided Design PWM - Pulse Width Modulation VSI - Voltage Source Inverter

1. INTRODUCTION

This project involves the development of a hybrid system that combines an electric power drive with an internal combustion (IC) engine to propel a vehicle. The front wheel is powered by a battery and the rear wheel is powered by gasoline through a single cylinder, air-cooled IC engine. A brushless DC motor is used as the electric power drive in this hybrid system. The controller is designed to switch between the IC engine and electric motor based on power needs and load conditions.

1.1 Proposed vehicle

The proposed vehicle is based on a scooty having displacement of 90 cc and max power of 5.36 bhp. Proposed add-on includes an hub motor of specifications 750 watts, rpm 400, rated voltage

1.1MOTIVATION

t he hybrid vehicle which are mainly known as 'hybrid electric vehicle' or 'gasoline-electric hybrid ' which not only work on batteries but also on the internal combustion engine which drives a generator to provide the electricity and also drive a wheel. The advantages of the hybrid electric vehicle over the gasoline based vehicle are gasoline only drives the power & not environment friendly which also do the major air pollution. The main purpose is to design and fabricate a two wheeler hybrid electric vehicle powered by both battery and gasoline. The mixture of gasoline and battery the power makes the vehicle dynamic in nature. Which gives the advantage in fuel economy and environmental impact over conventional automobiles. A hybrid electric vehicle is a type of vehicle that combines an electric motor, a battery, and a power system with an internal combustion engine. The purpose of this combination is to achieve better fuel economy and reduce toxic emissions The battery alone provides power for low-speed driving conditions where internal combustion engines are least efficient. During acceleration, on long highways, or when climbing hills, the electric motor in a hybrid electric vehicle provides extra power to help the internal combustion engine.. This allows a smaller, more efficient engine to be used. Besides it also utilizes the concept of regenerative braking for optimized utilization of energy. Energy dissipated during braking in hybrid electric vehicle is used in charging battery. With the areas of high traffic these vehicles are high suited. The process of manufacturing of a hybrid electric vehicle is

1) The designing of the vehicle in CAD
2) Simulations of inverter and other models are done.
3) Equipment and their cost analysis are done. Which deals with the fabrication of the vehicle.
4) Assembly of IC Engine and its components.
5) Implementing the electric power drive and designing the controllers.
6) Increasing the efficiency of the vehicle in economic ways is the final step of the process.

History:- Around 93% of the present vehicles run on petrol based products, which are assessed to be exhausted by 2050 . Only 25% of the energy set free from oil and rest is squandered into the climate . Not withstanding ongoing endeavors to further develop eco-friendliness and decrease harmful discharges in vehicles, outflows have kept on expanding consistently in the beyond twenty years. An electric vehicle can be a significant forward For conservation of fuel for future and expanding the effectiveness of vehicle an electric vehicle An electric vehicle is sans contamination and is effective at low speed conditions chiefly in high rush hour gridlock regions. However, battery charging is tedious. In addition, these vehicles can't give high power expected by drives during rapid circumstances or in slants of uneven regions. The Fuel motor demonstrates its effectiveness at higher rates in high ways and waste a ton of energy in metropolitan regions. A half breed vehicle tackles these issues by joining the benefits of both the frameworks and utilizations both the power sources at their effective circumstances. The ultimate goal of this venture focuses on better use of fuel energy and diminishes reliance on non-sustainable assets utilizing most recent innovation. The advancement of Hybrid electric vehicle which involves battery as well as fuel power for impetus of vehicle.

2. Objectives

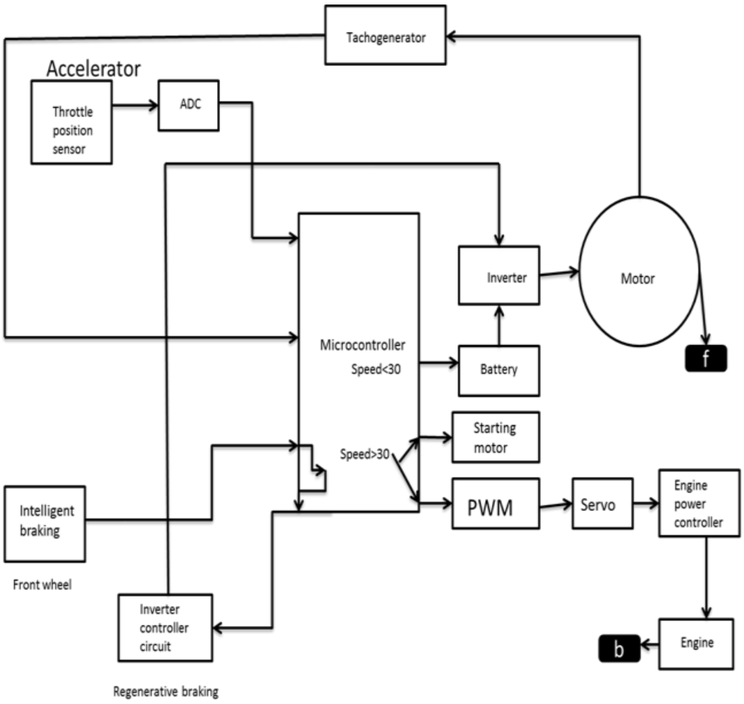
The following objectives are to be achieved at the end of the project.

- Design and virtual analysis of the vehicle.
- Designing & Assembling of IC Engine.
- Designing & Assembling of the Electrical Power Drive.
- Designing & Assembling a two wheeler vehicle design with front wheel powered by electric motor and rear wheel drive powered by an Internal Combustion Engine.
- A switching circuit used to switch from IC Engine to the electric power and vice versa
- Implementation of control algorithm by microcontroller
- Efficiency calculation of vehicle.

3.WORKING OF HEV:

In a hybrid electric vehicle, the internal combustion engine is least efficient at low speeds, and the battery is able to provide power on its own for these driving conditions.. While accelerating, passing, or hill climbing high power is required that time battery provides power to electric motor as an additional power to assist the engine. Which allows a smaller, more efficient engine to be usedThe throttle position sensor (TPS) is a sensor used to monitor the position of the throttle in an internal combustion engine.This contains a hall sensor. When the accelerator throttle angle changes magnetic field is created and it creates voltage across position sensor terminal. Thus for various angles, various voltages . Are obtained.It consists of a throttle position sensor, i.e, hall sensor. It gives voltage as output with respect to the angle displacement in the accelerator. The analog voltage generated is converted to digital through ADC and is given to microcontroller. If the speed corresponding to the angle deviation in accelerator is less than 30km/hr then the relay is switched onThe relay switching connects the circuit of the battery, inverter, and hub motor in a way that allows the vehicle to be propelled by electric power.If the speed directed by accelerator is greater than 30km/hr, then the engine is started by closing the circuit of starting motor through a relay. The starting motor circuit is activated for five hundred milliseconds such that the vehicle is started. Once the vehicle starts the valve of engine for gasoline intake opens by servo motor. The amount of opening is controlled by the PWM generated by the microcontroller as directed by the accelerator.

3.1 METHODOLOGY



4. DESIGN AND CALCULATIONS OF HEV.

- Length = 1735mm
- Width = 590mm
- Height = 1060mm
- gross Weight = 200kg
- Tyre size =90/90-10
- Tyre height = 90x.9=81mm
- Tyre diameter =254+81+81=416mm
- Tyre radius = 208mm
- Max speed = 60kmph

  - Tyre circumference = $2\pi x208=1306\cong1310=1.35m$
  - Bike frontage area = width×(total height)
    =590×(1060+600)
    Bike frontage area =0.9794m2
  - V =60kmph = 16.67m/s
  - RPM = $\frac{\text{speed in minutes}}{\text{circumference}}$
    $= \frac{16.67\times60}{1.35} = 740rpm$
  - Coefficient of rolling resistance = 0.02 (cr)
  - Air density = 1.2 kg/m3
  - Air drag = 0.82 (cd)

- Total force = rolling forces (fr) + drag forces (fd) + acceleration (fa) +gradient (fg)
  Fr = m.g.cr = 200×9.11×0.02
  $= 39.24 \cong 40N$

  Fd = $\frac{1}{2}$ Air density× cd× front area× V2

  Fd = $\frac{1}{2} \times 1.2 \times 0.82 \times 0.9794 \times 16.672$

  Fd = $133.9 \cong 135N$

  Fa = m.a = m × $\frac{v}{t}$ = 200 × $\frac{11.11}{1.5}$

  Fa = $148.133 \cong 150N$

  Fg= m× sinΘ

  Fg =170N

- Total force = rolling forces (fr) + drag forces (fd) + acceleration (fa) +gradient (fg)
  Assuming bike doesn't need high acceleration and not being used in uphill's, we can neglect fa and fg
  ∴ ft= 40+135= 175N

  Power = Ft × V = 175×16.67= 2917.25 watt $\cong$ 3KW
  $P= \frac{2\pi NT}{60}$
  $\therefore 3000= \frac{2\times\pi\times740\times T}{60}$
  ∴ T= 38.71 N.m
- Battery calculations
  Cc = cell capacity = 2.5 amp.hr
  Vc = cell voltage = 3.7 V

  Max speed to be achieved (m/s)
  V=60 kmph
  V= 60 × $\frac{5}{18}$ = 16.6 m/s
  Vehicle total mass (kg)
  M=200 kg
  Rolling force (Fr)= m.g.cr = 200×9.11×0.02

  ∴ = 39.24N

  Air drag = Fd = $\frac{1}{2}$ Air density× cd× front area× V2

  Fd = $\frac{1}{2} \times 1.2 \times 0.82 \times 0.9794 \times 16.672$

  Fd = $133.9 \cong 135N$

  Net force Fnet= Fd + Ff

  ∴ = 135+39.24 = 174.24N

  Power = Fnet× V

  ∴ = 175×16.67= 2917.25 watt

Energy used (E)= P×T

$T=\frac{D}{V}$ ……D= range, V= velocity

$\therefore T=\frac{70}{60}=1.66$

Energy used (E)= P×T = 2917.25×1.1666

∴ Energy used (E)= 3.4 kwh

COMPONENTS OF ELECTRIC DRIVE

3.3.1 BATTERY

Hybrid Electric Vehicle uses battery as one of its power source for vehicle motion during at low power conditions. Batteries are devices that consist of electrochemical cells and provide electrical energy converted from stored chemical energy [5]. Generally batteries are of two types: primary batteries that are disposable and secondary batteries that are rechargeable.

Secondary batteries are preferred for vehicles as they can be rechargeable.

There are six major rechargeable batteries available today. They are as follows: lead-acid (Pbacid), nickel-cadmium (NiCd), nickel-metal hydride (NiMH), lithium-ion (Li-ion), lithiumpolymer (Li-poly), zinc-air [5]. The basic performance characteristics of the battery which influence the design are as follows:

- Charge/discharge ratio (c/d ratio):

  The charge/discharge ratio is defined as the Ah input over the Ah output with no net change in the state of charge. Less the c/d ratio better is the battery.

- Round trip energy efficiency:

  The energy efficiency over a round trip of full charge and discharge cycle is defined as the ratio of the energy output over the energy input at the electrical terminals of the battery. More the round trip energy efficiency better is the battery.

- Charge efficiency:

  The charge efficiency is the ratio of the amount of electric charge stored within the plates of a device during charging, to the amount of electric charge delivered to the device's external terminals during the charging process.. More the charge efficiency better is the battery.

Internal impedance: Batteries have internal resistances. For the internal resistances present, the battery cannot operate in the full efficient condition. The power delivered at load decreases and hence less is the internal resistance of battery better is its performance.

➢ Temperature rise: Temperature rise is an important factor for batteries as beyond a certain temperature value the battery may lose its charge capacity. Thus, more the temperature sustaining value of the battery better is its efficiency and lifetime.

➢ Life in number of c/d cycles: Batteries have a particular life in number of c/d cycles. More the value better is the battery

TABLE 3.1: Average Cell Voltage during Discharge in Various Rechargeable Batteries

Electrochemistry Cell	Voltage
Lead-acid	2.0
Nickel-cadmium	1.2
Nickel-metal hydride	1.2
Lithium-ion	3.4
Lithium-polymer	3.0
Zinc-air	1.2

TABLE 3.2: Battery Characteristics Affecting Thermal Design

Battery	Operating temperature range °C	Overcharge Tolerance	Heat capacity Wh/kg-K	Mass density kg/liter	Entropic heating on discharge W/A-cell
Lead-acid (Pbacid)	−10 to 50	High	0.35	2.1	−0.06
Nickelcadmium (NiCd)	−20 to 50	Medium	0.35	1.7	0.12
Nickel-metal hydride	−10 to 50	Low	0.35	2.3	0.07
Lithium-ion	10 to 45	Very Low	0.38	1.35	0
Lithiumpolymer	50 to 70	Very low	0.40	1.3	0

Battery	Specific Energy Wh/kg	Energy Density Wh/liter	Specific Power W/kg	Power Density W/liter
Lead-acid (Pbacid)	30–40	70–75	~200	~400
Nickelcadmium (NiCd)	40–60	70–100	150–200	220–350
Nickel-metal hydride	50–65	140–200	~150	450–500
Lithium-ion	90–120	200–250	200–220	400–500
Lithiumpolymer	100–200	150–300	>200	>350
Zinc-air	140–180	200–220	~150	~200

Battery	Cycle life in full discharge cycles	Calendar life in years	Self discharge rate %/month at 25 °C	Relative cost $/kWh
Lead-acid (Pbacid)	500-1000	5-8	3-5	200-500
Nickelcadmium (NiCd)	1000-2000	10-15	20-30	1500
Nickel-metal hydride	1000-2000	8-10	20-30	2500
Lithium-ion	500-1000	-----	5-10	3000
Lithiumpolymer	500-1000	-----	1-2	>3000
Zinc-air	200-300	-----	4-6	------

The performance characteristics and properties of various electrochemistries presented in the preceding sections are summarized and compared . It is noted that despite of little advantages in all the factors, the overall cost of the lead-acid battery is low compared to NiCd, NiMH and Li-ion batteries. Because of its least cost per Wh delivered over the life, the lead-acid battery is best suited for vehicle application where low cost for customers are necessary.

BLDC motor is a closed loop synchronous motor. It has all the characteristics of DC Motor with some added features. It advantages are as follows:

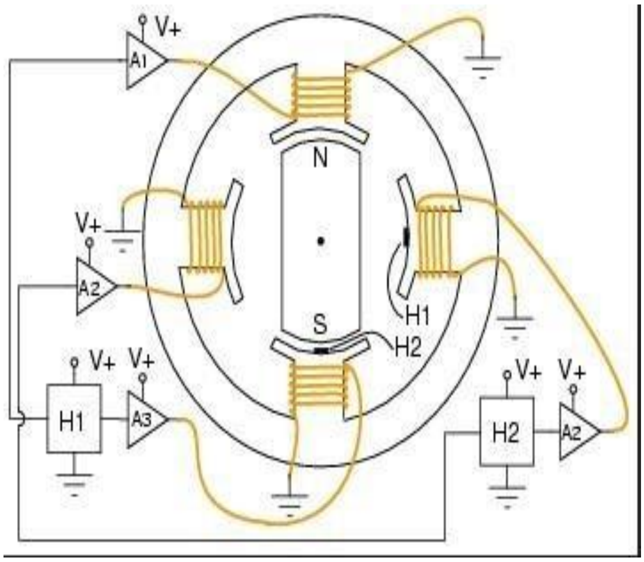
• It is cheap.

• It can save 30% to 50% of power consumed by a normal motor and has high efficiency of 80% to 90%.

• It is small in size. It can have high torque at low speed.

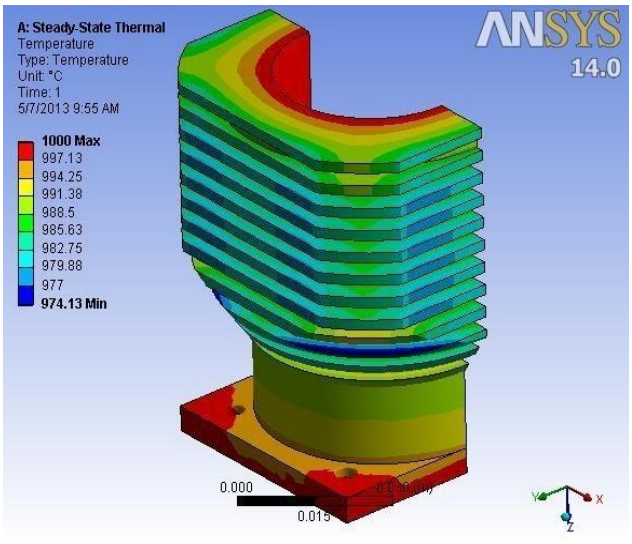
• Speed range can be customized

• Replace the AC + frequency equipment minimizing harmonics introduction to the circuit.

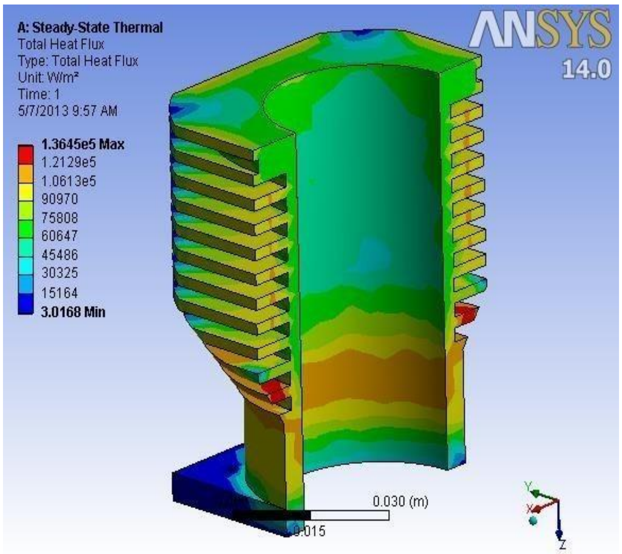


5. Results

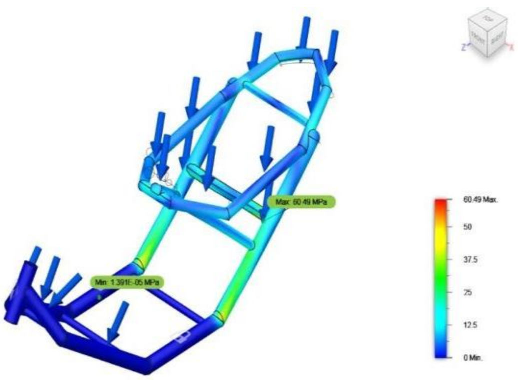
During the combustion of gasoline in an internal combustion engine, high temperature gases are generated, which can increase the temperature of the cylinder head. To dissipate this heat, the cylinder head is often equipped with long, conductive radiating fins. However, high temperatures can also affect the performance of the engine and can cause combustion of the lubricating oil. Figure 1.1 shows the temperature distribution of the cylinder head when the vehicle is running at higher speeds, with heat transfer occurring mainly through convection. The figure is color-coded, with red indicating higher temperatures and blue indicating lower temperatures. Figure 1.2 shows the heat flux distribution in a cylinder head, while Figure 1.3 shows the stress analysis of the chassis. The bluish areas experience less stress, while the reddish areas experience more stress, and the chassis must be designed with care in these areas. Figure 1.4 shows the inverter output of an electric vehicle, with the square wave produced being fed to the motor for maximum efficiency. Figure 1.5 shows the variation of torque, speed, output voltage, and armature current over time in the electric drive.



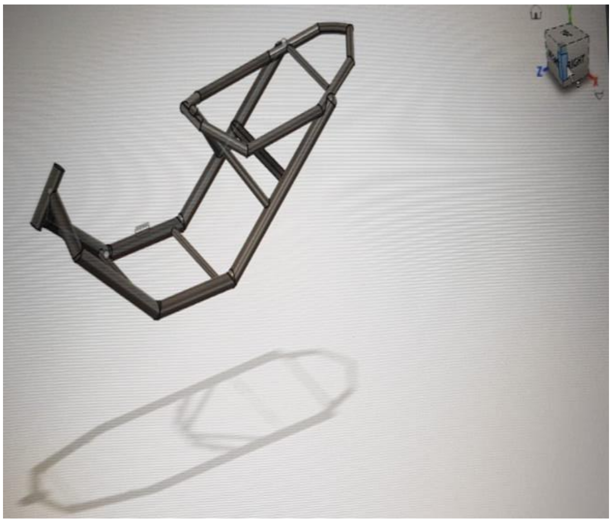
1.1Temperature Distribution of Cylinder Head

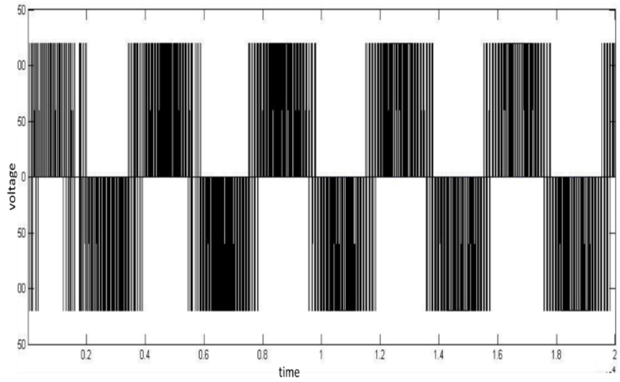


1.2 Heat Flux Distribution in a Cylinder

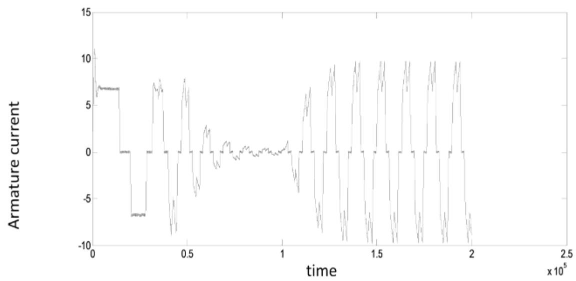


1.3 Stress analysis of chassis

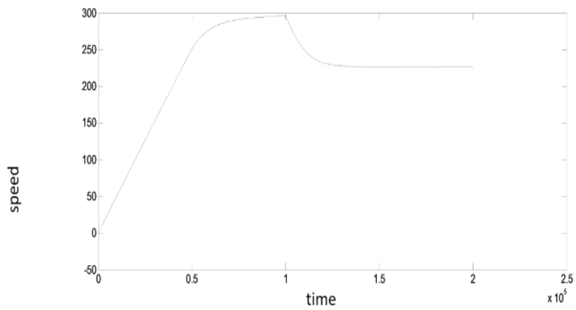




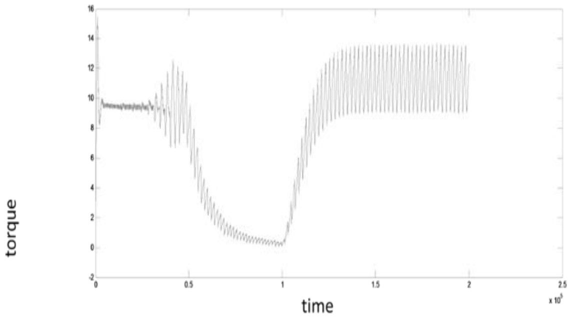
1.4 Output of inverter circuit



1.5 Armature current of electric drive circuit



1.6 Speed of motor at no load



1.7 Output torque of motor at no load

Equipment's used:

IC Engine

SI Engine			Justification
	Stroke	4-stroke	4 stroke engines have better efficiency and this engine commercially cheaper than other engines.
	Number of Cylinders	Single Cylinder	
	Displacement in cc	100c	
	Cooling	Air Cooled	
	Fuel Supply	Carburetor	
	Available Models	Pep	
Power Train			Its automation is much simpler than geared transmission.
	Transmission	Variomatic (CVT)	
	Availability	Comes with engine	

Electric Motor

BLDC Hub Motor			Justification
	Operating Voltage	48Volts	High efficiency and better load carrying capability.
	Power	750.0 watts	
	Max RPM	380.0 rpm	
	Max Current	15 amps	
Battery			High discharge capability
	Voltage	48volts	
	Capacity	15Ah	

Accessories

Tyre		
	Front	3.0x10
	Rear	3.0x10
Brakes	Front	130 mm Drum
	Rear	130 mm Drum
Suspension		
	Front	Bottom link with spring loaded hydraulic damper, 80mm travel
	Rear	Unit Swing with spring loaded hydraulic damper, 75mm travel
Clutch	Dry automatic	Centrifugal
Microcontroller	Atmega	1250
Servo Motor	PWM Controlled	15kg/cm
RPM Sensor	Hall Effect Sensor	5v operating voltage
Stirling Engine		
Electronics	Varo Board, Wires, transistors, etc	

Fabrication:

Component	Percentage Manufactured (Company made)	Percentage Fabricated in workshop
Engine	100%	-
Transmission	100%	-
Chassis	75%	25%
Hub motor	100%	-

Stirling Engine	100%	-
Suspension	100%	-
Tyre	100%	-
Motor Controller	0%	100%
Power Control System	0%	100%
Assembly of components	0%	100%

6. CONCLUSIONS

A hybrid electric vehicle (HEV) is a type of vehicle that uses both a gasoline engine and a battery as sources of power. In an HEV, the battery is used for low power applications, while the gasoline engine is used for high power applications where a higher level of power is required. The gasoline engine is most efficient at high speeds, while the battery is more efficient at low speeds. As a result, an HEV is able to operate at maximum efficiency in both modes of operation. However, the gasoline engine is not efficient at low speeds, so an HEV is able to achieve significantly better fuel efficiency than a traditional gasoline-powered vehicle. In addition, an HEV produces 50% fewer emissions than a traditional vehicle, making it an effective means of reducing pollution in urban areas, particularly in high traffic situations where the efficiency of a gasoline engine is typically low and emissions are a concern.

CONTRIBUTON OF THE PROJECT

The current society mostly depends on petroleum as the major source power for vehicle propulsion. The electric vehicle is not very efficient for all power conditions, i.e, it cannot provide power for high speed conditions. Through the project a hybrid method of both the vehicles is proposed which utilises the efficiency of both the vehicles. This method is implemented in two-wheeled vehicles that are mostly preferred by public. Thus proper manufacturing and cost analysis can make the vehicle a major breakthrough.

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