

Design and Fabrication of Energy Conversion Vehicle

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Abstract- Energy Conversion Vehicle works on conversion of energy from one form to another. It consists of a power source which develops the power required to run the vehicle on its own. This can be achieved by combining the starting system and the charging system used in automotive vehicles. The BLDC Motor is powered by two self excited alternators, which can produce enough power to run the motor and are connected using belt drive system. The mechanical power from the motor is transmitted to rear wheel by using chain drive. Also the belt drive connects the motor and two alternators. This cycle of operation from one form of energy to another form will allow the vehicle to run the vehicle with self produced power. This results in reduction of emission which makes it eco-friendly vehicle. Since there is no need of any form of energy as an input, it is more economical.

Index Terms- Self charging vehicle, BLDC Motor, Charging System in Automobile, Regenerative Braking System, Motor and Generator.

I. INTRODUCTION

Number of vehicles is increasing day by day and most of them run on fuels which are extracted from non-renewable energy resources. Leading automobile companies are producing electric powered vehicle to reduce the use of fuels. I.C. Engines produces harmful pollutants which results in environmental pollution. Electric vehicles use rechargeable batteries, but it has limited distance range. It is essential to find a solution, so that we do not harm the environment and also not to run out of battery. Energy Conversion Vehicle works on conversion of energy from one form to another. It consists of a power source which develops the power required to run the vehicle on its own. This can be achieved by combining the electric drive train and the charging system used in automotive vehicles. The BLDC Motor is powered by two self excited alternators, which can produce enough power to run the motor and are connected

using belt drive system. The cycle of operation from one form of energy to another form will allow the vehicle to run the vehicle with self produced power. Ref [1] reviewed about “electric vehicle self charging system”. Ref [2] examined about “System and method for optimizing grid charging of an electric/hybrid vehicle”. Ref [3] reviewed about “Plug-in hybrid vehicle”. Ref [4] explained about “Fuel Cell Vehicles”. Ref [5] explained about “Engine operation for plug-in hybrid electric vehicle”. Ref [6] reviewed about “Hybrid electric vehicle regenerative braking energy recovery system”. Ref [7] Investigated about “Effectiveness of Regenerative Braking for EV and HEV”.

II. OBJECTIVES AND METHODOLOGY

Objectives

- The main reason behind this project is to build a eco-friendly vehicle.
- It can run long distance without worrying about refilling or recharging.
- This vehicle will run by a prime mover which can produce the power required to run the vehicle without using any kind of energy resource as an input.
- There is no limit for distance range of the vehicle.
- Successful implementation of this technology will result in a pollution free environment and guarantees a clean world to live in.
- This technology also reduces the maintenance of the vehicle.
- The battery will be self charged during working condition.

Methodology

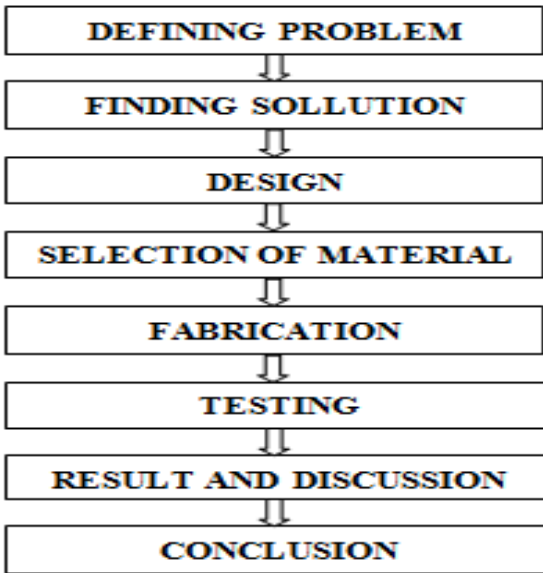


Fig 1: Methodology Flow Chart

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III. DISCRPTION OF COMPONENTS

1. BLDC motor

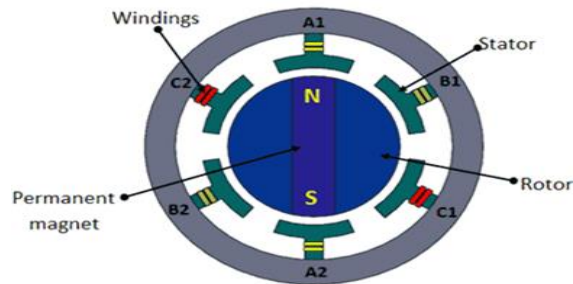


Fig 2: BLDC Motor

Brushless DC motor is a kind of permanent magnet synchronous motor. Permanent magnet synchronous motors are classified on the basis of the wave shape of their induced emf i.e., sinusoidal and trapezoidal. The sinusoidal type is known as permanent magnet synchronous motor; the trapezoidal type goes under the name of PM Brushless dc motor. Permanent magnet DC brushed and brushless motors incorporate a combination of Permanent Magnet and electromagnetic fields to produce torque resulting in motion. This is done in the DC motor by a Permanent Magnet stator and a wound armature or rotor. Current in the DC motor is automatically switched to different windings by means of a commutator and brushes to create continuous motion. In a brushless motor, the rotor incorporates the magnets, and the stator contains the windings. As the name suggests

brushes are absent and hence in this case, commutation is implemented electronically with a drive amplifier that uses semiconductor switches to change current in the windings based on rotor position feedback. In this respect, the BLDC motor is equivalent to a reversed DC commutator motor, in which the magnet rotates while the conductors remain stationary. Therefore, BLDC motors often incorporate either internal or external position sensors to sense the actual rotor.

Advantage of Permanent Magnet BLDC Motor

- Better speed versus torque characteristics
- Faster dynamic response
- High efficiency
- Long operating life
- Noiseless operation
- Higher speed ranges

2. BLDC Motor Controller



Fig 3:BLDC Motor Controller

Motor controller is a devise or group of devices that serve to govern in some pre determine manner the performance of electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation selecting and regulating the speed, regulating or limiting torque and protecting against over load and fault severy electric motor has to have some sort of controller. The motor controller will have different features and complex city depending on the task that the motor will be performing. The simplest case in a switch to connected to a motor to a power source such as in small appliances and power tools. The switch may be manually operated may be relay or contactor connected to some form of sensors to an automatically start and stop the motor. More complex motor controllers may be used to accurately control the speed and torque of the connected motor and may be part of close loop control system for precise position of driven machine.

3. Alternator

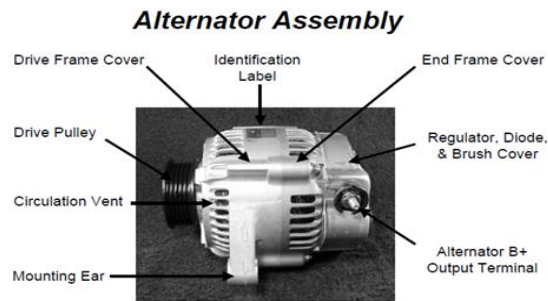


Fig 4: Alternator

Alternator is a device which produces alternating current by converting the Mechanical Energy into Electrical Energy.

The charging system has three major components; The Battery, Alternator, and the Regulator. This alternator works together with the battery to supply power when the vehicle is running. The output of an alternator is direct current; however AC voltage is actually created and then converted to DC as voltage leaves the alternator on its way to the battery and the electrical loads. The alternator contains a rotating field winding called the rotor, A stationary induction winding called the stator, A diode assembly called the rectifier bridge, A control device called the voltage regulator. The rotor winding assembly rotates inside the stator winding. The rotor generates a magnetic field. The stator winding develops voltage and current begins to flow from the induced magnetic field of the rotor. The regulator is the brain of the charging system. It monitors both battery and stator voltages and depending on the measured voltages, the regulator will adjust the amount of rotor field current to control alternator output. The Diode Rectifier Bridge is responsible for the conversion or rectification of AC voltage to DC voltage.

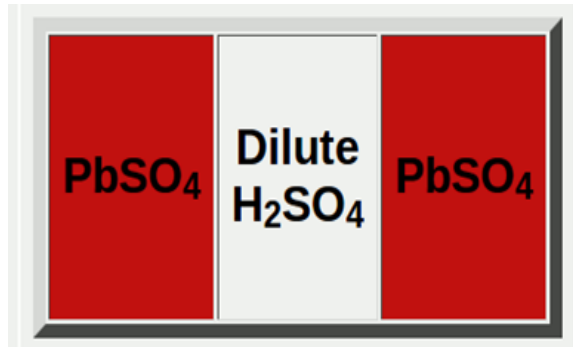
4. Battery



Fig 4: Battery

Lead acid batteries were invented at Gaston Plante in 1859. The technology of automotive starting, lighting and ignition they are robust and because of their low cost. They are bigger in size and heavier they suffer from short cycle life. The batteries consist of lead dioxide as cathode, a sponge metallic lead as anode and sulphuric acid solution as electrolyte. This heavy metal element makes improper disposal can be hazardous to environment. The standard cell voltage is 2volts.

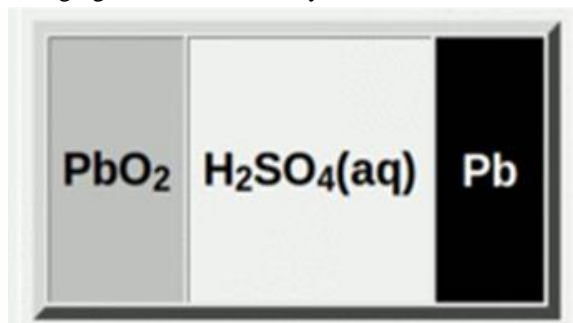
Discharging of lead acid battery



During this process, lead dioxide which is of positive plate and lead which is of negative plate react with sulfuric acid of electrolyte to form sulfate, water and energy.

Sum of molecular mass of reactants is 642.6g/mol so theoretically a cell produce two Faradays of charge from 642.6g of reactants.

Charging of lead acid battery



During this process the cycle is reversed. Where the water and lead sulfate are electrochemically converted to lead, sulphuric acid and lead oxide by an external charging source. Improvements are still being made to lead acid battery despite its shortcomings. Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water which is lost to the cell.

IV. CONSTRUCTION AND WORKING

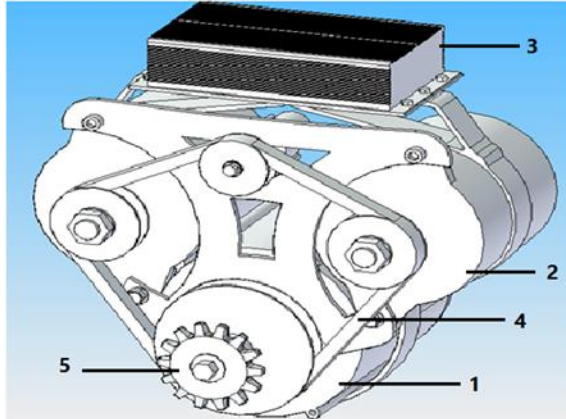


Fig 5: Design of Prime Mover

Parts

1. BLDC Motor
2. Alternator
3. Controller
4. V-Belt
5. Sprocket

This vehicle uses a BLDC (Brushless DC) Motor to run the vehicle. BLDC Motor is more efficient than the Brushed Motor. A controller is connected to the motor to vary the speed of the motor by altering the current supply. The mechanical power from the motor is transmitted to rear wheel using a centrifugal clutch system with chain drive. Here electrical energy is converted to mechanical energy. The motor is also connected to two alternators using belt drive which produces enough power to run the motor.

The above mentioned parts together form the powertrain. The mechanical energy is converted to electrical energy. This way the vehicle runs without using any kind of renewable or non-renewable energy as an input. Initially the alternators are cranked using a cranking mechanism.

All components of the powertrain is assembled together to a frame which is made up of mild steel flat bar; also G.I. pipe is used to increase the area for powertrain moutation. The powertrain is driven using belt drive mechanism and power is transmitted to rear wheels via chain drive. Two Plummer blocks are used to hold the shaft which acts as a mediator to transmit power from the powertrain to the rear wheel chain drive mechanism. The fuel tank is replaced with a flat bar frame which will carry the batteries.



Fig 6: Fabricated Model

V. CALCULATION

1. POWER:

Motor used: 48V 1500W BLDC Motor
 Rated input voltage(V): 48V
 Rated Input Current(I):40A
 Peak Input Current for Controller : 50A
 Rated Input Power = Input Voltage × Input Current
 = 48×40 = 1920W

Theoretical Peak Input Power = 48×50 =2400W
 Efficiency of the Motor (η) : >83%
 Peak Output Power from the motor = Efficiency ×
 Peak Input Power = 0.83 × 2400 = 1992W

2. TORQUE:

Mechanical Power = $2\pi NT / 60$ W Where,
 N = Speed of Motor in RPM
 T = Torque output from motor in Nm
 Maximum Speed of Motor = 3000RPM
 Therefore,

$$\text{Torque (T)} = (\text{Peak power} \times 60) / 2\pi N \text{ Nm}$$

$$= (1992 \times 60) / (2\pi \times 3000) = \underline{6.34 \text{ Nm}}$$

Gear Ratio or Velocity Ratio: $N_1 \times t_1 = N_2 \times t_2$

Where,

N_1 , Speed of Driving Sprocket = 3000RPM
 t_1 , Teeth on the driving sprocket = 14
 t_2 , Teeth on Rear Wheel (driven) Sprocket = 44
 Speed of Driven Sprocket, $N_2 = N_1 t_1 / t_2$
 = $(3000 \times 14) / 44 = \underline{954.5454 \text{ RPM}}$

Therefore,

Torque transmitted to rear wheel
 = $(1992 \times 60) / (2\pi N_2) = (1992 \times 60) / (2\pi \times 954.54)$
 = 19.928 Nm

3. OUTPUT POWER FROM ALTERNATORS:

Maximum rated output voltage: 24V
 Maximum rated output current: 45A

Maximum rated power from each alternator
 = $24 \times 45 = 1080\text{W}$
 Total rated power output = $2 \times 1080 = 2160\text{ W}$

4. TEST RESULTS OF PRIME MOVER:

Diameter of driving (Motor) pulley, $d_1 = 100\text{ mm}$
 Diameter of the driven (alternator) pulley, $d_2 = 62.5\text{ mm}$

Therefore, $\text{Gear Ratio} = \frac{\text{Speed of driving pulley}}{\text{Speed of driven pulley}} = \frac{\text{Dia. of driven pulley}}{\text{Dia. of driving pulley}} = \frac{d_2}{d_1} = 62.5/100$

Gear Ratio = 5 : 8

At 2500 RPM of motor,
 The speed of alternator = $2500 \times (8/5) = 4000\text{ RPM}$
 Power produced from alternators:

Output voltage: 65.5V

Output current: 11 A

Total power produced from alternators
 = $65.5 \times 11 = 720.5\text{W}$

5. SPEED:

Maximum Speed of Rear wheel = 954.5454 RPM
 Diameter of Rear wheel = 17 inches
 Diameter of Rear wheel with tyre (D) = 22 inches
 = $22 \times 2.54 \times 10^{-2} = 0.5588\text{ m}$
 Perimeter of the tyre = $\pi \times D = \pi \times 0.5588 = 1.7555$

Therefore,

Maximum Speed of Vehicle = $N_2 \times \Pi d$
 = 954.5454×1.755
 = 1675.7255 meter/minute
 = $1675.7255 \times 60 / 1000\text{ Km/hr}$

Theoretical Maximum Speed of the Vehicle = 100.5435 Km/hr

VI. ADVANTAGES AND LIMITATIONS

Advantages

- Since none of the fossil fuel is used in this vehicle, it does not emit any harmful green house gasses which lead to global warming.
- The running cost of this vehicle is negligible because, there is no need of refilling or recharging.
- Maintenance is very less when compare to other vehicles due to the elimination of complex mechanical parts.

- It produces less sound. So, there is a reduction in noise pollution as electric motor provide smooth running with high acceleration.
- It is safe to drive this vehicle and the procedure for fitness and testing procedure is like electric vehicle.

Limitations:

- Speed of the vehicle is limited as power is lost in belt drive system to run the alternators.
- Normally Electric vehicles are expensive. Since alternators are used together with the batteries it increases the price a bit more.
- The batteries used in the vehicle are heavy, which increases the overall weight of the vehicle.

VII. CONCLUSION

By combining the charging system and the electric drive train, we can produce a vehicle which can run without using any power from outside. Maintenance is very less when compare to other vehicles due to the elimination of complex mechanical parts. Noise pollution as electric motor provides smooth running with high acceleration The running cost of this vehicle is negligible because, there is no need of refilling or recharging. Normally Electric vehicles are expensive. But by combining the power train with charging system, it saves a lot of money in future. This results in reduction of emission which makes it eco-friendly and since there is no need of any form of energy as an input which makes it more economical.

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