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Alternator Charging System for Electric Motorcycles

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ABSTRACT- *The following project deals with modelling and testing of a battery electric motorcycle with a self-charging system for obtaining better utilization of the energy. An attempt to fabricate a regenerative system for a BEV which utilises the rotational energy of wheels to restore the energy to the batteries, thereby introducing a system which makes the most of the power produced by the electric motor. The chassis of a commercially available motorcycle is modified as per the requirements of the battery sizes and the self-charging system. The components like alternator, motor and DC-DC converter was arranged in a manner to transfer the rotational energy being experienced by the chain sprockets through the chain to the alternator. The alternator here has the capacity to produce 14.4V DC, which is directed to DC-DC converter through a battery source. Here in DC-DC converter the voltage source is stepped up to 54V, which is enough to charge the 4 batteries in series which yields to 48V usage. Thus the batteries which are used to provide the rotational energy to the shaft through a motor is receiving back the sufficient voltage source to recharge it. The vehicle is tested for the supply of source to the batteries using multi-meter, distance travelled with and without the recharging circuit is also studied and is found to be effective*

Key Words: *Alternator, Battery Electric Vehicles, BLDC Motor, Battery, and DC-DC Converter*

I. INTRODUCTION

Electric vehicles are powered by batteries that are contained with the vehicle and usually provide an adequate charge for the propulsion of the vehicle through city traffic. The batteries are mounted within the vehicle and are used to propel the motorcycle as an alternative to using an internal combustion engine.

The efficiency of an electric vehicle is far greater than all other forms of propulsion currently in use. Whenever there is employment of electricity, the vehicles using it tend to produces zero emission at the tailpipe. Also, EVs offer great performance and are far from being slow. An electric vehicle operates differently from a vehicle with an IC engine. An all-electric vehicle is powered by electricity with a large rechargeable battery, an electric motor, a controller that sends electricity to the motor from the driver's accelerator pedal, and a charging system. These parts of an electric vehicle replace the IC engine, fuel tank, fuel line, and exhaust system in a traditional bike. While the IC engine is central to the operation of a traditional vehicle, it is the rechargeable battery that is central to the operation of an electric vehicle. All-electric vehicles recharge their batteries by plugging them into a household electrical outlet or a special charging station. The major components used in existing battery electric vehicles are motors, motor controller and battery.

Some of the earlier designs of electric bikes included a means to

charge the vehicle using kinetic energy generated by the vehicle itself. Electric bikes are being introduced on the market to completely eliminate the use of internal combustion and make use of In-wheel motor system on rear wheels for small electric vehicle, the combination structure of each component. The key point of In-Wheel motor system to be applied in small electric vehicle is the integration capability to meet the

requirements such as wheel space, power performance, strength of components .One drawback to electric bikes is that batteries must be recharged and there are limitations in the range that the battery may propel the motorcycle without recharging.

One solution to this recharging problem is to install an alternator of a car to retrieve the unused rotational energy of the wheel to recharge the batteries while still in motion. The alternator works on the principle of electromagnetic induction and hence produces electricity when rotated about its axis. Such a device installed on a modern electric bike may therefore increase the range of the battery and provide an effective means to recharge the battery while the vehicle is in motion.

II. OBJECTIVES

i. The prime objective of experimenting and fabricating the proposed vehicle is to revive the unused rotational energy of the wheels which is accomplished by using an Alternator.

ii. The defined work is to develop an energy regeneration system which helps in restoring the energy from the batteries which in turn results into the increase in the overall range of the bike in 1 charging cycle.

iii. Reduction in the frequency of the plug in charging thereby covering a larger distance as compared to the conventional electric motorcycles.

iv. Eco friendly mode of commutation can be obtained with desirable functions for various day to day activities hence obtaining a zero emission vehicle.

v. Optimum utilization of the rotational energy from the wheels in order to achieve greater outputs using the law of physics like Electromagnetic Induction.

vi. To propose existing alternator systems that are present in the modern day cars, to motorcycles in order to revolutionize the BEV industry.

VII SELECTION OF COMPONENTS

1) ***Chassis Frame***- It is the frame on which the motor, alternator assembly and the batteries of vehicle body is supported. It is designed such that the weight of the batteries, motor and the alternator is properly distributed throughout the motorcycle in order to produce smooth effortless movements with minimum losses on the entire body.

Figure 1. CHASIS OF TVS VICTOR

2) ***Motor-*** BRUSHLESS DC MOTORS also known as electronically commuted motors, which are the motors which are powered by a DC electric source via an integrated inverter/ switching power supply, which provides an AC electric signal to drive the motor. In this context, alternating current does not imply a sinusoidal waveform. Additional sensors and electronics control the inverter output amplitude and waveforms.

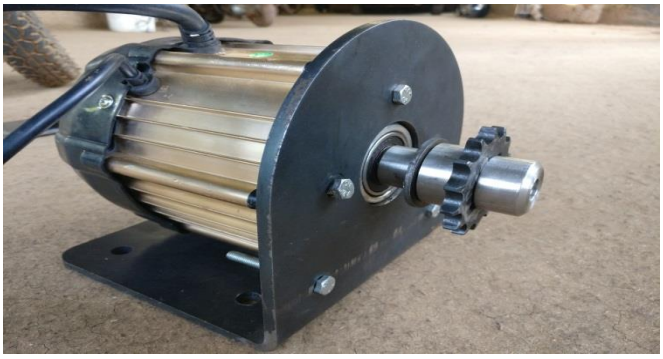

Figure 2. BLDC MOTOR

The equations for motor are,

1. Kinetic energy, E= (1/2)*mv2

Where m= mass of the vehicle

V= velocity of the vehicle

2. Braking distance, S

$v^2 = u^2 + 2aS$

3. Vehicle stopping time

$v = u + at$

4. Braking force, F

$F = m*a$

5. Brake torque = brake force * effective radius of rotor

***S**pecifications* -

a) Type : Permanent magnet Brushless DC motor
b) Voltage (V) : 48 Volts
c) No Load current : 3 Amp
d) Rated current : 33 Amp
e) Rated Speed : 3000 ± 100 RPM
f) Rated Torque : 5.2 Nm
g) Max. Output Torque : 18 Nm
h) Rated Power : 1500 Watts
i) Max. Output Power : 2500 Watts
j) Efficiency : > 83%
k) No. of Poles : 8
l) Motor Diameter : 145 mm
m) Insulation Class : B

Modifications –

A chain sprocket is fitted on to the motor shaft with the help of machined bushes, a key and a grub screw to keep this sprocket fixed to the motor shaft. This will result into optimum transmission of the power from the motor to the driving sprocket (on the motor shaft) to the rear wheel sprocket to obtain mobility.

3) ***Motor controller-*** A device that serves to govern in some pre- determined manner of performance of an electric motor. A motor controller includes an automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, limiting or regulating the torque, and protecting against overloads and faults.

Figure 3. VOLTAGE REGULATOR (R) AND MOTOR CONTROLLER (L)

Specifications of the controller-

a) Rated Voltage : 48 Volt
b) Peak Protection current : 50 Amp
c) Rated Power : 2000 Watt
d) Under Voltage Protection : 42 Volt
e) Throttle Voltage : 1 Volt – 4.5 Volt
f) Phase Commutation Angle : 120 Degree
g) Brake De-Energize : High
h) Heat Dissipation : Natural cooling
i) Ambient Temperature : 20 Degree to 60 Degree Celsius

4) ***Batteries –*** Selected batteries are Trontek Valve Regulated Rechargeable non-spill able gel batteries

Specifications-

a) 4 Batteries of 12 Volt each

b) Cycle use : 14.4 V- 15.0 V

c) Standby use : 13.5 V – 13.8 V

d) Charging time : 6-8 Hours with standard charger.

5) ***Battery Charger-***

Specifications :

a) Model : EBC-4827

b) Input Voltage : AC 170 V–300 V 47- 63HZ

c) Input Current : 1.0 Amp Max.

d) Output Voltage : DC 59 V ± 0.5 V

e) Output Current : 2.7 A ± 0.5 A

6) ***Chain Drive –***

a) Transmission from motor to the Rear wheel of the motorcycle.

The transmission of the power from the electrical motor to the wheels is done by the chain drive of the motorcycle. Selection of the speed reduction ratio is dependent on the no of teeth on the driving as well as driven sprockets of the chain drive.

Number of teeth on the driving sprocket = 13

Number of teeth on the driven sprocket = 43

Therefore,

Speed reduction ratio = 43/13

= 3.3

Hence, for every 3 revolution of the driving sprocket, the driven sprocket will undergo 1 revolution.

b) Transmission of rotational energy from the rear wheel to the alternator for regeneration.

The chain drive is again used to drive the alternator using the rotational energy of the rear wheel which is propelled by the electrical motor. Therefore, by modifying the number of teeth on the driving and driven sprockets according to the desirable output is done which in turn rotates the alternator coils in order to produce Electromagnetic field in order to recharge the batteries used to consume power.

Therefore, the maximum desirable output is achieved at the speed ratio 3. Hence, another chain drive is provided on the framework in order to transmit power to the alternator simultaneously beginning the charging process.

7) ***Alternator -*** There are two concentric wound coils of wire within the alternator: a stator coil (the outside coil which does not rotate) and a rotor coil (the inside coil, attached to the alternator's pulley, which does rotate). The rotor is also referred to as the alternator's "field.

Figure 4 CAR ALTERNATOR (MARUTI ZEN)

An electromagnet is created when current flows through the field coil. The strength of the magnet is directly proportional to the amount of current flowing through the field. As the rotor moves clockwise, the resultant magnetic field sweeps clockwise through the outer coil of wire, and electricity is generated in the stator coil. Since the magnetic field sweeps back and forth through the stator coil, an alternating current is

produced. The alternating current has a frequency equal to the frequency with which the alternator's pulley is rotating.

8) ***Miscellaneous-***

1. *Digital Battery Status Indicator :* Installed for the monitoring of the speed, battery level, distance covered, left and right indicators.
2. *Voltage Converter :* Electrical power converter which changes the Voltage of a power source according to the input and output requirements of the motor and batteries.
3. *Motor Mount Plate :* To mount the motor on a firm base so as to attach it according to the design specifications of the chassis frame.

IV. INTERCONNECTIONS AND WORKING

All the above mentioned electrical components in combination with the mechanical drive are assembled on the chassis of the bike as shown in the figure below. The figure below is the outline of the whole assembly of the bike according to the specific dimensions and proper weight distribution. The bike frame is modified according to the fittings and alignment of the motor, alternator and batteries. The brake wire is connected from the controller and fitted to the front brake of the bike. Shown below is the assembly.

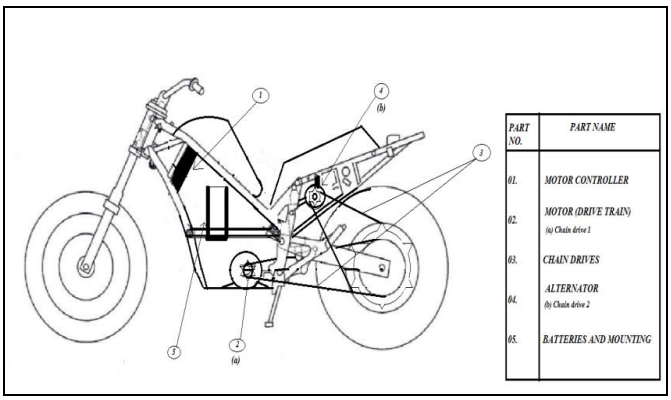

Figure 5 OUTLINE ASSEMBLY OF ALL COMPONENTS

- *Construction of battery case and motor mounting plate -*

This is done using strips of Mild Steel which are cut and welded on to each other to form a casing according to all the considerable dimensions of all 4 batteries. This is done considering minimum clearance between the batteries and the casing so that they fit perfectly on to the frame without the possibility of the batteries falling off.

- *Modification of the chain drive –*
  - The number of links on the chain are increased in order to obtain an in-line alignment of the driving sprocket (mounted on the motor shaft) and the driven sprocket (rear wheel).It is necessary to have proper alignment of the chain drive with the motor as it plays a pivotal role in mobility of the vehicle; i.e., transmission of rotational energy from the motor. Fig A (2a).
  - Another chain to transmit power from the rear wheel of the motorcycle (run by the motor) to the car alternator which is mounted at the position as shown in Fig A (4b). Here, a sprocket, of the same type as the original is cut and machined to match the inner diameter of the rim of the wheel which is then bolted to the pinion sprocket of chain drive 1 (motor – wheel). Hence, both sprockets rotate together while in motion.
- *Installation of Motor Controller –*

The controller is installed on the frame as shown in the figure A(1). All the connecting wire are connected to the controller as it controls the working of the motor, and hence all components.

TRIAL NO.	INITIAL SUPPLY VOLTAGE (VOLT)	FINAL VOLTAGE (VOLT)	DISTANCE TRAVELLED IN 1 CYCLE (KMS)	TOP SPEED ACHIEVED (KMPH)
1	12.6	11.0	24	56
2	13.0	11.0	25	55
3	13.0	11.1	25	55

- *Wire connections and integration of all parts of the assembly –*

Controls are present in the controller for various functions and accessories. Like headlight, brake lights, indicators, horn etc. A connection is provided to connect the batteries to the controller. The voltage regulator which adjusts the voltage of the system is also connected to the controller.

An electronic display is fitted at the front which indicates the battery level, speed of the motor, indicators, etc. as shown in the figure.(6)

Figure 6 ELECTRONIC DISPLAY AND SWITCH

V. RESULTS AND DISCUSSIONS

- *Testing of the actual range WITHOUT Alternator-*

The testing of the motorcycle is first done to check the total running range in one complete plug in charging cycle. It is done by fully charging the batteries and then driving the bike till the batteries are completely exhausted.

Table 1

Testing of the range WITH Alternator –

This is done after charging the batteries once fully, i.e., 13.0 Volt so that proper output can be obtained.

The Alternator receives a starting current from the batteries in order to create an electromagnetic field within the coils. The pulley, when starts rotating, disturbs the magnetic flux and hence produces

Table 2

TRIAL NO.	INITIAL VOLTAGE (VOLT)	FINAL VOLTAGE (VOLT)	DISTANCE COVERED (KM)	TOP SPEED (KMPH)
1	13.0	11.1	28	50
2	13.0	11.0	31	50
3	13.0	11.0	30	52

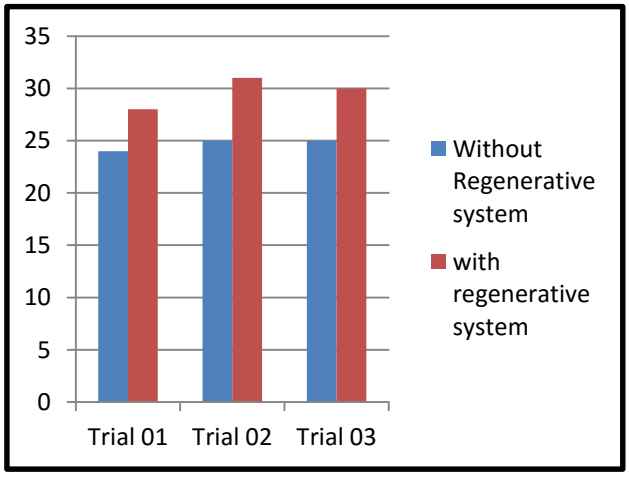

Chart 1- Comparison chart

The outcome of the vehicle was expected to supply the source continuously to charge the battery when the battery falls below a certain percentage while the motorcycle is moving forward. The connections made so far, provided the supply source based on the need and it is observed in many numbers of trials.

A set of 4 Lead acid batteries with specifications as 12V and 24Ah is used in the work. The supply from these batteries is found to be useful in moving the vehicle for a distance of around 25 km considering all loses in the motorcycle assembly. During the motion, the rotational energy is extracted by the alternator and transferred to a DC to DC converter where it is stepped up. This is finally supplied to battery source to recharge making it as a closed circuit.

The power source which is expected to reach the battery source from the alternator through DC-DC converter is observed using Multimeter. The parameter to be considered during the test, are Voltage source and Ampere.

VI. CONCLUSIONS

- The work is defined to develop a battery electric vehicle for daily commutations in the cities in order to reduce the pollution factor and utilize eco-friendly modes of commutation for a daily short distance basis within the cities.
- The concept of plug in charging which is found in conventional battery electric vehicles was targeted to replace by the concept of self-charging in the proposed work. The work started with the study on technology, components utilization and the future of battery electric motorcycles. Based on the study the outline of electric vehicles, this design for 2 passengers around 120 Kg is made.
- The alternator system, motor, motor controller, DC-DC converter were selected based on their wide applications used in the field of automobiles. From the results we can conclude that the vehicle travels for longer distance when the charging system has been adopted.
- The vehicle was tested for the source supply from the DC-DC converter to the batteries for many numbers of trials. This depicted the successful results in extracting the rotational energy from the wheels through an alternator to charge the batteries arranged in series.
- The alternator generates 12V – 14V using the rotational energy from the wheel under forward motion. The DC-DC converter steps up the source from 12V DC to 54V DC, which results in charging the batteries

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