International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 4 (2019) pp. 930-935

Design and Fabrication of Hybrid Electric Bike

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Abstract

A 'gasoline-electric hybrid vehicle' or 'hybrid electric vehicle' is a vehicle which relies not only on batteries but also on an internal combustion engine which drives the wheels. 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 objective is to design and fabricate a two wheeler hybrid electric vehicle powered by both battery and gasoline. The combination of both the power makes the vehicle dynamic in nature. It provides its owner with advantages in fuel economy and environmental impact over conventional automobiles. Hybrid electric vehicles combine an electric wheel hub motor, battery and control system with an internal combustion engine to achieve better fuel economy and reduce toxic emissions. In HEV, the battery alone provides power for low-speed driving conditions where internal combustion engines are least efficient. In accelerating, long highways, or hill climbing the electric motor provides additional power to assist the engine. This allows a smaller, more efficient engine to be used. Thus the vehicle is best suited for the growing urban areas with high traffic.

Keywords: Hybrid Electric Vehicle (HEV).

I. INTRODUCTION

Several economic and environmental factors are contributing to increase interest in alternative vehicle technologies. These factors include rising global demand for oil, concomitant increases in fuel prices and anthropogenic climate change. Rising global demand for oil has both economic and political consequences. Increasing demand has a direct economic impact via increased commodity prices as well as a number of geopolitical implications that create political challenges for countries that rely on imported oil for economic activity. Moreover, evidence of the increasing dangers posed by climate change adds to the urgency to reduce the Green House Gas (GHG) emissions from all sources. GHG emission from the transportation sector is growing more rapidly than from any other economic sector and INDIA is accounted for 11.7 percent of total GHG emissions in 2017[1].

The internal combustion engine is one of the greatest inventions of mankind. The conventional vehicles with ICE provide a good performance and long operating range. However, they have caused and continue to cause serious problems for poor fuel economy, environment pollution and human life. Reducing fuel consumption and emissions is one of the most important goals of modern design. The hybridization of a convectional combustion engine vehicle with an advanced electric motor drive may greatly enhance the overall efficiency and achieve higher fuel with reduced emissions.

Considering the urban status in India, a well organized and fuel efficient motorcycle has to be designed and developed. Internal combustion engines are relatively less efficient in converting the on-board fuel energy to propulsion as most of the energy is wasted as heat. On the other hand, electric motors are efficient in converting the stored energy in driving a vehicle, and electric drive vehicles do not consume power while coasting. Some of the energy loss in braking is captured and reused by regenerative braking. With the help of regenerative braking one fifth of the energy loss can be regenerated. Typically, petrol engines effectively use only 15 percent of its fuel content to move the vehicle. Whereas an electric drive vehicle has an on board efficiency of about 80 percent. But due to reasons such as cost, inability to reach higher speeds electric drive vehicles failed to capture markets. Contrary to these petrol vehicles can cover longer distances with higher speed but it cannot cover shorter distance with slow speed (say in traffic) in an efficient way. By increasing the range of electric vehicles they could easily capture the automobile industry. Hybrid technology is the most promising technology that could be implemented for increasing the EV range as current electric vehicle industries are switching towards this concept for increasing the vehicle range [2] . The concept of Electric hybrid system which incorporates two separate Wheel hub motor for its propulsion.

A hybrid vehicle is a vehicle with multiple distinct energy sources. The energy sources could be separately or simultaneously operated to drive the vehicle. Over the years many hybridization configurations like fuel cell, gas turbine, hydraulic, pneumatic, ethanol, electric, solar etc., are proposed. Among these, the hybrid electric vehicles, integrating two technically and commercially proven and well established technologies of electric motors and I.C. engine, allowing drawing upon their individual benefits have been widely accepted by the technologies and users. This is the most commonly adopted hybrid vehicle which combines propulsion sources of an electric motor and an I.C. engine. The power supply to the electric motor comes from on board batteries. In a HEV, the I.C. engine cooperates with an electric motor which leads to a more optimal use of the engine. Driving in city traffic involves frequent starts and stops of the

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vehicle. During idling, the engine consumes more fuel without producing useful work thus contributing to higher fuel consumption, less efficiency and unnecessary emission from exhaust. The HEV solves the problem by switching to power transmission through the motor and shutting off the engine. This way no fuel will be consumed during idling with no exhaust emission. Another advantage of HEV is that when fuel tank gets empty while driving the engine, the vehicle can be driven on electric power within its maximum range. The Plug in Hybrid Electric Vehicle (PHEV) is one technology that is nearing commercial deployment and has the potential to address all three of these issues to varying degrees. PHEVs, like current hybrid electric vehicles are equipped with an internal combustion engine, an electric motor and a battery that can be charged both by a generator driven by the internal combustion engine.

II. LITERATURE REVIEW

Karen et al., 1999, [3] presented a simulation and modeling package developed at Texas AM University, V-Elph 2.01. V-Elph was written in the Mat lab/Simulink graphical simulation language and is portable to most computer platforms. They also discussed the methodology for designing vehicle drivetrains using the V-Elph package. An EV, a series HEV, a parallel HEV and a conventional internal combustion engine driven drivetrain have been designed using the simulation package. Simulation results such as fuel consumption, vehicle emissions, and complexity are compared and discussed for each vehicle.

Ma Xianmin (2002) [4] developed a novel propulsion system design scheme for EVs requiring high power density. The theory analysis mathematical models of EV are first set up based on the vehicle dynamic characteristics, then the whole system is divided into seven function blocks according to power flow, the simulation models are formed in the MATLAB language. The simulation results are verified in a PDM AC-AC converter, which shows that the suggested method is suitable for EV

Brian (2007) [5] created a model in MATLAB and ADAMS to demonstrate its fuel economy over the conventional vehicle. He used the Honda IMA (Integrated Motor Assistant) architecture, where the electric motor acts as a supplement to the engine torque. He showed that the motor unit acts as generator during the regenerative braking. He used a simple power management algorithm in the power management controller he designed for the vehicle.

Cuddy and Keith (2007) [6] performed a parallel and series configured hybrid vehicles likely feasible in next decade are defined and evaluated using a flexible Advanced Vehicle Simulator (ADVISOR). Fuel economies of two diesel powered hybrid vehicles are compared to a comparable technology diesel powered internal combustion engine vehicle. The fuel economy of the parallel hybrid defined is 24 percent better than the internal combustion engine vehicle and 4 percent better than the series hybrid.

Bauml and Simic (2008) [7] discussed the importance of vehicle simulations in designing the hybrid electric vehicles. A series hybrid electric vehicle simulation with the simulation language Modelica was developed. They explained the simulation approach. They concluded with some of the simulation results emphasizing the simulation importance [8].

Zhou and Chang (2008) [9] established powertrain dynamic simulation model of an integrated starter/generator (ISG) hybrid electric vehicle (HEV) using Simulink. The parallel electric assist control strategy (PEACS) was researched and designed. The analysis of dynamics performance and fuel economy of the model was carried out under the FTP drive cycle, which can provide a design reference for the setup of the powertrain test bench. The results show that the fuel consumption can be effectively reduced by using the designed PEACS with the state-of-charge of the battery maintaining in a certain scope.

Kuen-Bao (2008) [10] described the mathematical mod-elling, analysis and simulation of a novel hybrid power train used in a scooter. The primary feature of the proposed hybrid power train is the use of a split power-system that consists of a one-degree-of-freedom (dof) planetary gear-train (PGT) and a two-dof PGT to combine the power of two sources, a gasoline engine and an electric motor. Detailed component level models for the hybrid electric scooter are established using the Matlab/Simulink environment. The performance of the proposed hybrid powertrain is studied using the developed model under four driving cycles. The simulation results verify the operational capabilities of the proposed hybrid system.

Daniel (2007) [11] designed, developed and implemented a series hybrid electric vehicle. Though he proposed the architecture as hybrid electric vehicle architecture, he showed that the vehicle runs well in the electric mode and left the hybrid conversion as future expansion. Before developing the hardware part, he did a simulation using PSCAD/EMTDC and validated the simulated results using the hardware he developed.

Emadi et al., (2008) [12] focused more on power electronics as an enabling technology for the development of plug-in hybrid electric vehicles and implementing the advanced electrical architectures to meet the demands for increased electric loads. A brief review of the current trends and future vehicle strategies and the function of power electronic subsystems are described. The requirements of power electronic components and electric motor drives for the successful development of these vehicles are also presented.

III. DESIGN PROCEDURE FOR HYBRID ELECTRIC BIKE

Theme which we have chosen as our final project is HYBRID BIKE. The name itself depicts that it is something different from normal bike. In case of normal bike, it will operate in only one mode i.e., Gasoline mode but in case of hybrid bike it will operate in both Gasoline and electricity mode. Due to this advantage of running in the both the mode there will be less consumption of fuel then there will be a maximum reduction in the pollution.

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 4 (2019) pp. 930-935

Fig. 1. Bajaj Boxer bike(old)

For our project we are procuring an ordinary engine bike of model BAJAJ BOXER (OLD). The requirement what we are expecting is getting a speed of 25 KMPH in urban areas with less pollution. To get this requirement we are doing some minor changes in the normal bike. The changes what we have made Replaced normal rear wheel by wheel hub motor with the power rating of 800w and 48v.

Hub motor electromagnetic fields are supplied to the stationary windings of the motor. The outer part of the motor follows, or tries to follow, those fields, turning the attached wheel. In a brushed motor, energy is transferred by brushes contacting the rotating shaft of the motor. Energy is transferred in a brushless motor electronically, eliminating physical con-tact between stationary and moving parts. Although brushless motor technology is more expensive, most are more efficient and longer-lasting than brushed motor systems.

Fig. 2. Wheel Hub Motor without Chain Sprocket Assembly

A hub motor typically is designed in one of three con-figurations. Considered least practical is an axial-flux motor, where the stator windings are typically sandwiched between sets of magnets. The other two configurations are both radial designs with the motor magnets bonded to the rotor; in one, the inner rotation motor, the rotor sits inside the stator, as in a conventional motor. In the other, the outer-rotation motor, the rotor sits outside the stator and rotates around it. The application of hub motors in vehicular uses is still evolving, and neither configuration has become standard [13].

Electric wheel hub motors have their greatest torque at startup, making them ideal for vehicles as they need the most torque at startup too. The idea of ”revving up” so common with internal combustion engines is unnecessary with electric motors. Their greatest torque occurs as the rotor first begins to turn, which is why electric motors do not require a transmission. A gear-down arrangement may be needed, but unlike in a transmission normally paired with a combustion engine, no shifting is needed for electric motors.

At starting, we have taken a wheel hub motor with only disc type brake but it hasnt fulfilled our requirement that why we have assembled chain sprocket in the place of disc brake. The possibility of placing both disc brake and chain sprocket in the same slot is not possible because of the reason, we need to weld some part that may leads to damage of winding. So to overcome this problem we are replacing disc brake with chain sprocket i.e., fitting in the same hole. Hub motors are an interesting development which could offer benefits such as compactness, noiseless operation and high efficiency for electric vehicles. These motors have stators fixed at the axle, with the permanent magnet rotor embedded in the wheel. The traditional exterior rotor design has the hollow cylindrical rotor spinning around a stator axle. There is a radial air gap between the stator and rotor.

Fig. 3. Wheel Hub Motor with Chain Sprocket Assembly

The stator consists of stacked laminated steel plates with wound coils. Pulse width modulated current is used to supply current to the stator. Hub motors must run at relatively low speed equal to the actual rotation of wheel if there is no final gearing stage. The benefit is about a 10 percent increase in efficiency due to the lack of transmission. The main reason for choosing a hub motor is that it does not require a transmission system which helps in reducing the transmission losses. Since it has no brushes to wear out the life of motor is increased. It has a greater traction control. The back emf created by BLDC motor can easily be stored in the batteries.

The total assembly of wheel hub motor with chain sprocket is included in normal wheel position.

Controller is fitted in the available free space of normal bike battery. The controller connects the power source to the motor It controls the speed and optimizes energy conversion.

Fig. 5. Controller Position

Lithium ion battery with the power ratings of 48v and 12 Ah is used in this project. The reason behind using this type of battery is getting high energy density and self-discharge with the low maintenance. The slot which we have chosen to place the battery is, in the available free space below the seat.

The much greater energy density is one of the chief advantages of a Lithium-Ion battery or cell. With electronic equipment such as mobile phones needing to operate longer between charges while still consuming more power, there is always a need to batteries with a much higher energy density. In addition to this, there are many power applications from power tools to electric vehicles. The much higher power density offered by lithium ion batteries is a distinct advantage.

One issue with batteries and cells is that they lose their charge over time. This selfdischarge can be a major issue. One advantage of lithium ion cells is that their rate of selfdischarge is much lower than that of other rechargeable cells such as Ni-Cad and NiMH forms.

Fig. 6. Twist Throttle Position On Same Handle Bar

Fig. 7. Final assembly of electric hybrid bike

Coming to the throttle operation, it is totally based on variable speed resistance. In detail, the speed will be regulated by using the resistance. The throttle placement in hybrid bike is adjusted the engine throttle and placed the electric speed throttle on the same handle bar. Due to this arrangement their will reduction in extra fitting of another handle bar.

These are the minor changes we have made to fulfil our requirement for the HYBRID ELECTIC BIKE.

IV. RESULTS

Gross vehicle weight

GVW = 170 KG = 170*9.81 = 1667.7 N

Weight on each drive wheel (WW) = 1667.7/2 =833:85N

Radius of wheel/tire (RW)= 0.22 m

Desired top speed (V_{max})=25 Kmph=6.94 m/s

Desired acceleration time (t_a)= 40 sec

Maximum incline angle = 2 degrees

Working surface= concrete (good)

Total tractive effort (TTE) requirement for the vehicle:

TTE = RR + GR + FA

Where:

TTE = Total Tractive Effort [N]

RR = Rolling Resistance [N]

GR = Force required to Climb a Grade [N]

FA = Force required to accelerate to final velocity [N]

The components of this equation will be determined in the following steps.

V. STEP ONE: DETERMINE ROLLING RESISTANCE

Surface type to be encountered by the vehicle should be factored into the equation. Rolling Resistance (RR) is the force necessary to propel a vehicle over a particular surface.

RR = GVW x Crr

= 1667.8 x 0:01 (good concrete) = 16.67 N

= 1667.8 x 0.37 (mud) = 617.08 N

= 1667.8 x 0.55 (grass) = 917.29 N

= 1667.8 x 0.60 (sand) = 1000.68 N

where.

RR = Rolling Resistance [N] GVW = Gross Vehicle Weight [N] Crr = Surface Friction (value from Table.I)

Table 1: Rolling Resistance for Rubber Wheels

Contact Surface	Crr
Concrete (good / fair / poor)	.010 / .015 /.020
Asphalt (good / fair / poor)	.012 / .017 / .022
Wood (dry/dusty/wet)	.010 / .005 / .001
Surface Snow (2 inch / 4 inch)	.025 / .037
Dirt (smooth / sandy)	.025 / .037
Mud (firm / medium / soft)	.037 / .090 / .150
Grass (firm / soft)	.055 / .075
Sand (firm / soft / dune)	.060 / .150 / .300

A. Step Two. Determine Grade Resistance

Grade Resistance is the amount of force necessary to move a vehicle up a slope or grade. This calculation must be made using the maximum angle or grade the vehicle will be expected to climb in normal operation.

To convert incline angle, to grade resistance.

GR = GVW x sin (ϴ)

= 1667.8 x sin 2^0 = 58.20 N

where.

GR = Grade Resistance [N]

GVW = Gross Vehicle Weight [N]

α = Maximum Incline Angle [degrees]

B. Step Three: Determine Acceleration Force

Acceleration Force (FA) is the force necessary to accelerate from a stop to maximum speed in a desired time

FA = GVW x Vmax / (9.81 x ta)

= 1667.8 x 6.94 / (9.81 x 40) = 29.49 N

Where,

FA = Acceleration Force [N] GVW = Gross Vehicle Weight [N] V_{max} = Maximum speed [m/s]

t_a = time required to achieve maximum speed [s]

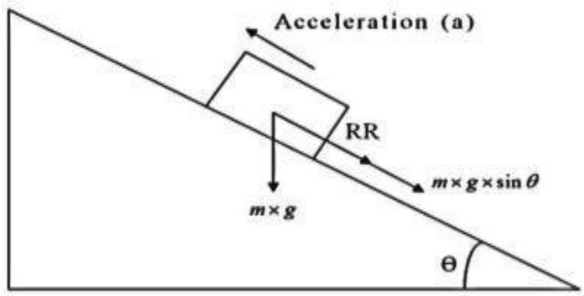

Fig. 8. Vehicle in Inclination

C. Step Four: Determine Total Tractive Effort

The Total Tractive Effort (TTE) is the sum of the forces calculated in steps 1, 2, and 3. (On higher speed vehicles friction in drive components may warrant the addition of 10 to 15 percent of the total tractive effort to ensure acceptable vehicle performance.)

TTE = RR + GR + FA

= 16.67 N + 58.20 N + 29.49 N = 104.36 N

D. Step Five: Determine Wheel Motor Torque

To verify the vehicle will perform as designed in regards to tractive effort and acceleration, it is necessary to calculate the required wheel torque (TW) based on the tractive effort.

TW = TTE x RW x RF

= 104.36 x 0.22 x 1.1 = 25.25 N.m

Where,

TW = wheel torque [N-m]

TTE = Total Tractive Effort [N]

RW = radius of the wheel/tire[m]

RF = Resistance Factor [-]

The resistance factor accounts for the frictional losses be-tween the caster wheels and their axles and the drag on the motor bearings. Typical values range between 1.1 and 1.15 (10 to 15 %)

E. Charging time Calculations

Time required to charge the battery by adapter 48 V 12Ah

P= 48 x 12= 576 W

T= (48 x 12) / 576 = 1 hrs.

VI. CONCLUSION

HEV is a vehicle that uses two sources of power- gasoline and battery. For low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. Gasoline drive is most efficient at high speed drive. Thus HEVs both mode of operation occurs at their maximum efficiency. But in gasoline engine low speed operation is not efficient. Its high speed mode is only efficient. Therefore, it gives twice the mileage given by a normal vehicle. As this hybrid vehicle emits 50 percent less emission than normal vehicle it plays an important role for reducing pollution to certain extent without compromising with efficiency. Thus it is most efficient in urban areas mainly in high traffic where gasoline engines are least efficient as the energy from gasoline is being wasted away and creates pollution.

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 utilizes 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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