Modification of Existing Vehicle to Hybrid Electrical Vehicle

Balla Siri Nagendra[1], Vishw Anand Bhatt[2]
[1,2]*Member, Department of Mechanical Engineering /BV(DU),COE, Pune*

Abstract **- In this modern-day world, human interventions have led to serious impact over the environment and climate. We list these as our top priorities to safeguard the environment and it has been a matter of discussion for over two centuries. The major portion of environment pollutant comes from the internal combustion engines in the form of COX, SOX, NOX, etc. which have led to serious effects over the climate change. In this paper we propose a model for the hybridization of conventional IC engine two-wheeler and have modified the same for the conversion. A Gasoline-hybrid electric vehicle or a hybrid electric vehicle is one which relies on dual power of an internal combustion engines and an electrical machine system to operate the vehicle. The proposed model is a parallel hybridized two-wheeler HONDA ACTIVA which can operate simultaneously on both battery and petrol. An extensive public survey was carried out for the project to get the insights from the customer perspective and then the parameters for the hybridization was decided. The fabrication was carried out in an effective manner so that the cost of conversion was brought down so that the converted vehicle results in a higher performance and more efficiency.**

1.INTRODUCTION

The IC engines are powered by mainly gasoline fuels (e.g. Petrol, diesel). The combustion of these petroleum fuels is a major source of environmental pollution as they emit harmful gases (e.g. CO2, CO, NOX, etc.) These harmful gases are a major source of health issues as they cause severe effects on human lungs and can lead to respiratory diseases, such as asthma. It has been a major domain of concern to reduce these emissions and engineers and lawmakers have spent decades of study and implementations of various emission norms have also been introduced in order to curb the emission from the conventional IC engine powered automobiles. Also, the fossil fuels will be depleted in the near future, we have to find other possible ways of sustainable power sources and recent years have seen development of various new technologies in this domain in order to reduce the dependency on the fossil fuels. The Hybrid Electric Vehicles are one of them.

A hybrid electric vehicle (HEV) is a modern-day engineering marvel in the field of automotive mobility. Its powertrain is a combination of both gasolines powered IC engines and an electrical machine which makes it dynamic in nature. The electrical machine is basically an electric motor which is powered by batteries. The use of a dual source of power (fuel and batteries) results in overall better performance and increased efficiency. The HEVs can also be charged whilst the vehicle is in operation because of the regenerative controller which is connected to the motor. When the driver applies brake the brake energy is utilized by the motor which acts as a generator to charge the batteries. This increases the vehicle performance as the vehicle need not be connected frequently to an electric source to charge the batteries.

The major drawbacks the electric vehicles and hybrid electric vehicles found is that of the high purchase cost to buy a new one. Through the extensive public survey that we carried out among 150 people, we got to know that people will prefer the hybrid conversion of their existing IC engine vehicle rather than buying a new one. In this paper we present a hybrid conversion model of a conventional CVT transmission vehicle to a hybrid electric vehicle through modifications and then testing the converted vehicle. We have chosen Honda Activa for the conversion and converted the vehicle in very cost effective and efficient manner.

2. METHODOLOGY

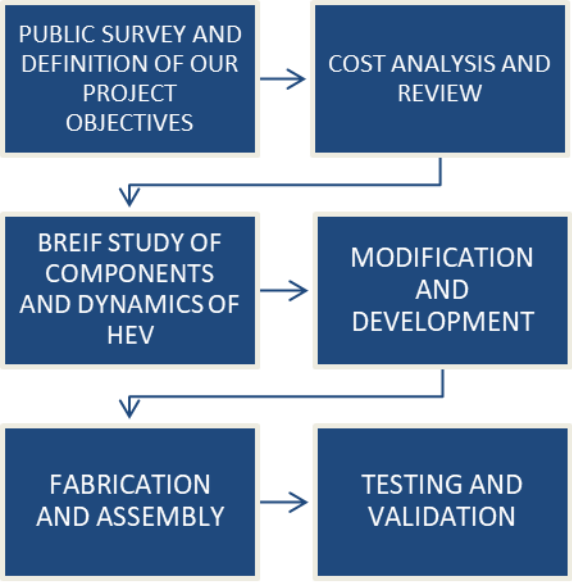
The first part of the methodology is carrying out a detailed survey to know the customer requirements from a prospective hybrid electric two-wheeler. From the design requirements, a suitable conventional two-

wheeler is selected for modification over which the changes for hybridization are to be carried out.

We start with a detailed public survey in which we tried to reach out to public in order to know the various insights about their perspective of an electric vehicle, and from that data we defined our objectives of the project.

Thereafter, we did a detailed cost analysis and reviewed with the existing setups regarding the modifications that are currently used as we wanted our product to be completed in the lowest cost possible.

After that we did a detailed component analysis in which we first defined what components we needed and then studied thoroughly about their different properties. Also we studied about the dynamics of electric vehicle through various journals and books. Thereafter we decided our strategies about how we were going to assemble all the components as various positions of the vehicle so that the centre of gravity of the body doesn't alter.



After that we will be proceeding for the assembling and fabrication stage in which we will be modifying the vehicle and placing the different components at the desired positions.

After that we will reach our final stage in which we will test our modified vehicle on various roads (i.e., urban roads, village roads, hill side roads, etc) on varios load conditions (i.e., with single passenger, with two passenger and some luggage).

3. LITERATURE REVIEW

- CARB (California Air Resource Board) introduced Clean Air Act and Zero Emission mandate (1970/1990) which laid down rules and regulatory restriction on emission norms, which led to a global reform in lowering the emission from IC engine powered vehicles and also encouraged heavy acceptance of electric and hybrid electric vehicles worldwide. [1]
- In this paper the authors Cuddy and Keith developed a configured series and parallel hybrid electric vehicle on ADVISOR (Advanced vehicle simulator) architecture in 2007. The caparison they did showed that the parallel hybrid is 24% more economical than normal IC engines and 4% better than the series hybrid. This showed us the advantages of the Hybrid Vehicle over conventional IC Engine powered vehicles.[2]
- Daniel had implemented the development of series hybrid electric vehicle architecture. He did studies based on simulation studies on EMTDC/PSCAD and validated the results and showed that the HEV architecture has better performance in the electric mode. A simulation using EMTDC/PSCAD was conducted and validated the simulated results using the developed hardware.[3]
- The author developed a model (2007) in MATLAB and ADAMS to discuss the fuel economy of the HEVs over the conventional IC engine vehicles. He evaluated that the motor of the hybrid vehicle acts as a generator and recharges the battery using regenerative braking system. The Honda IMA-Integrated Motor Assistant architecture was used, where the electric motor is supplementary to the engine torque. [4]
- The authors defined the advantages and importance of vehicle simulations using commercial software's in designing the powertrain of the hybrid electric vehicles. Discussion on the importance of vehicle simulations in designing hybrid electric vehicles. They developed a SHEV simulation with the help of Madelia simulation language and evaluated the results.[5]
- The author presented a simulation-based modeling package V-Elph which is written in MATLAB architecture and has been developed by developed at Texas AM University. They

discussed the various methods for designing vehicle drivetrains using the V-Elph. An electric vehicle, a series and parallel hybrid electric vehicle and a conventional IC engine powertrain have been developed using the simulation package. Simulation results of fuel economy and vehicular emissions have been compared and discussed for each vehicle.[6]

- Swagata Borthakur and Shankar Subramanian (2018) put forward a modified hybrid electric powertrain system which overcomes the shortcomings of SHEVs (series hybrid electric vehicle). The proposed powertrain system was compared and evaluated with SHEVs using AVL CRUISE.[7]
- The parallel hybrid electric two-wheeler developed (2015) has simplistic and unique cam clutch-based hybrid transmission system developed for the two-wheeler has distinctive benefits to offer in comparison to existing power split systems. The developed system is like a removable hybrid kit, which adds to the future possibilities in engineering design of HEVs.[8]
- This paper explains the mathematical modelling analysis and simulation of a plug used in hybrid electric motorcycle renovated from Honda Lead 110cc. The simulation results using MATLAB/Simulink environment show that fuel consumption of plug-in hybrid motorcycle is better than original one having similar performance characteristics.[9]

4. PUBLIC SURVEY

- We carried out a public survey through google forms platform and door to door questioning. The survey was carried out in urban as well as rural areas and one hundred five (105 + 50) people participated in the survey. We carried out this survey, as we wanted to get to the grassroots level and know the public opinion and awareness about electric and hybrid electric vehicles and the various factors indulged with it. We got the following questions.
- Firstly, we go with their age in this survey 57% people belong to under 25, 32% people belong to 25-39, rest 10% belong to 40-59. Going through survey we get to know 64% people never driven any electrical vehicle, 24% people have driven a pure electrical vehicle, rest 10% have driven a hybrid electric vehicle. 52% people are wish to own in future, 40% people never owned any electrical vehicle, rest 8% have owned electric vehicle. 67% people quite important in electric vehicle looks. 21% people most important in electric vehicle. 13% people are not important in looks.34% people disagree with buying electric vehicle cost the same amount of petrol vehicle.31% people can't say now about vehicle cost, 21% are agree with any cost, 14% are neutral about cost.30%people are definitely buying an ev in upcoming years, 29% are like to by one, 29% can't say now, rest 9% are happy with IC engine. The cost of charging electric vehicle is much less than the petroleum fuels 60%people are agree 34% can't say now. The maintains cost of an ev is much lower as compared to that of a normal petrol vehicle 54% people are agree and 27%people are don't know and rest 11% are neutral. Electric vehicle is much quieter another vehicle 89% are agree with this. 3% are disagree with this statement. 6%are neutral in this statement.2% are don't know regarding this statement. Electric vehicle has excellent acceleration 35% people are agree with this statement. 30% are neutral, 30% disagree and 5% are don't know regarding this statement. electric vehicle is environmentally friendly because they have zero emission 90% are agree with this statement, 5% are neutral ,3% are don't know and rest 2% are don't know regarding this statement. Electric vehicle technology has improved, and they have much better range 60% are agree with this statement, 25% are neutral on this statement, 5% are disagree and rest 10% are don't know regarding this statement. How quick it would full charge your battery 45% people are chosen 1-2 hrs., 26% are chosen 1hr, 14% are chosen 2-3 hrs., 5% chosen 3-4hrs. how much distance it would travel in one full charge 42% people are willing to travel 50-100km in one full charge, 26% are willing to travel 50kms in one charge, 22% are willing to travel 100-200kms and rest 10% are willing to travel 200&above kms. Cost of conversion electric bike 65% people are ready to spend 15k-20k, 30% are ready to spend 25k, and rest 5% ready to spend 30k.
- Google form link:

https://docs.google.com/forms/d/e/1FAIpQLSdWH-OmkDQK9vCr4JbsxbewU5DJyIXTCfLGzucpIaArNjLTXA/viewform?usp=sf_link

5. CALCULATIONS

1. Gross vehicle weight (GVW) = (Vehicle weight + component weight) *9.81
   {Vehicle weight = 109kg, component weight = 25 kg approx.}

Thus, GVW = 134*9.81 = 1314.54 N.

2. Weight on each drive wheel (WW) = 1314.54/2 = 657.27 N
3. Radius of wheel/tire (RW) = 5 INCHES = 0.254 m
4. Desired top speed (Vmax) = 40kmph = 11.11m/s
5. Desired acceleration time (ta) = 40s
6. Maximum incline angle = 6-8 degrees
7. Working surface= concrete (good) – CRR= 0.01
8. 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.

1. STEP ONE: -

ROLLING RESISTANCE: - Surface type to be encountered by the vehicle should be factored into the equation. Rolling Resistance (RR) is that the force necessary to propel a vehicle over a specific surface.

RR = GVW x Crr

APPROX WEIGHT OF VEHICLE ~ 134 KG

GVW = 134*9.81 = 1314.54 N

RR = 1314.54 * 0.01 = 13.1454 N

- RR = Rolling Resistance
- [N] GVW = Gross Vehicle Weight [N]
- Crr = Surface Friction

2. Step Two -

GRADE RESISTANCE – Grade Resistance is that quantity of force necessary to move a vehicle up a slope. This calculation should be made using the maximum angle. The vehicle will be expected to climb in traditional operation. To convert incline angle, to grade resistance,

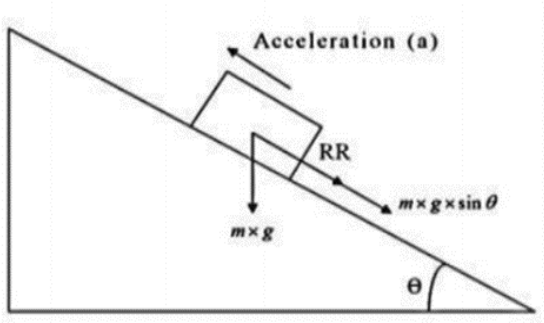
EXPECTED INCLINATION ANGLE – 5 degrees

GR = GVW * sin (Ɵ) = 1314.54 * sin (5)

{ GR = 114.56 N }

Where,

- GR = Grade Resistance [N]
- GVW = Gross Vehicle Weight [N]
- Ɵ = Maximum Inclination Angle [degrees]



3. Step Three: -

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

FA = [GVW x Vmax / (9.81 x ta)]

FA = [1314.54*11.11/ 9.81 * 40]

{ FA = 37.21 N **}**

Where,

- FA = Acceleration Force [N]
- GVW = Gross Vehicle Weight [N]
- Vmax = Maximum speed [m/s]
- Ta = time required to achieve maximum speed [s]

Fig. 8. Vehicle in Inclination

4. Step Four: -

Total Tractive Effort – The Total tractive Effort is that the addition of the forces calculated in steps one, 2, and 3. (On higher speed vehicles friction in drive parts might warrant the addition of ten to fifteen % of the overall rubbing effort to confirm acceptable vehicle performance).

a) RR = 13.1454 N,
b) GR = 114.56 N,

c) FA = 37.21 N
d) TOTAL TRACTIVE EFFORT (TTE) = 13.1454+114.56+37.21
{TTE = 164.91 N}
Where symbols have the usual meaning.

5. Step Five: -
Wheel Motor Torque – To verify the vehicle will perform as designed in regard to tractive effort and acceleration, it is necessary to calculate the required wheel torque (TW) based on the tractive effort.
TW = TTE * RW * RF N-m
TW = 164.91 * 0.254 * 1.1
{TW = 45.972 N-m}

- TW = wheel torque [N-m]
- TTE = Total Tractive Effort [N]
- RW = radius of the wheel/tire[m]
- RF = Resistance Factor

6. Charging time Calculations –
Time required to charge the battery by adapter 48 V 12Ah,

- BATTERY RATING = 48V 12 AH
- BATTERY POWER (P)=V * I = 48 x 12 =576 W
- TIME REQUIRED FOR CHARGING

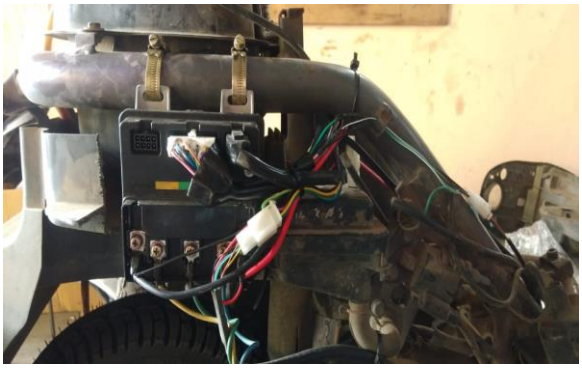
= (48 x 12) / 576 = 1 hrs.

6. MODIFICATION PROCEDURE

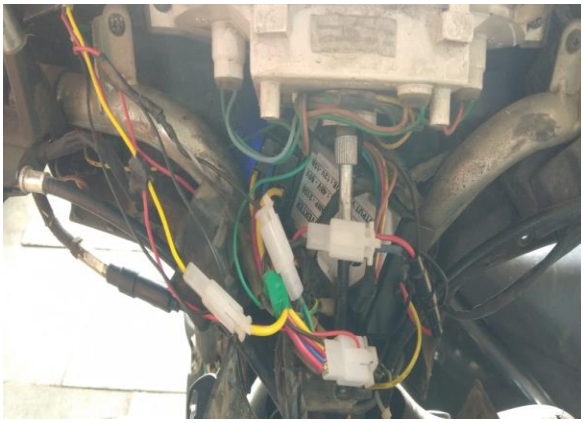
First, we have to change the accelerator cable, we have to fix another cable given the kit it will use for both hybrid electric vehicles and gasoline. First, we have to open the front panel, headlight, back body, leg space, we have to remove all parts of society, and so we can change the cable. Next, we have to remove the petrol cable. We have to replace the common cable we have to remove the spring and pin to the new cable and fix to the common cable. We have to check the cable whether it was working properly or not.

We have to fix the side motor to a rare wheel. First, we have to remove a rare wheel, and we have to change to a tubeless tire, we have to remove the hub from the wheel we have to change old bolts and replace new bolts given in the kit. In the kit we will get a plate in the circle plate we have to fix. We have to see all nuts will be in the level of the plate we fixed We have to fix the rare wheel in the same position, we have a side motor to the rare wheel first we have to fix the torque arm having two bolts in slots of side motor and we have to align then to the motor. With the help of a hexagonal bolt, we will fix the side motor to a rare wheel. We have fixed the torque arm in between the silencer rod.

Now we have to fix the controller fixed to the right side of the chassis. We have cut the plastic body of the scooty and we have to fix the controller to the chassis with the help of the clamps given in the kit. Next, we have to give wiring to the controller, we will connect with the side motor, common throttle, battery, starter button, dc-dc converter, and battery level indicator.



Next, we have to fix dc-dc converter, starter button, battery level indicator. From the controller three core wire was passed to the front panel, we will take 12v relay from the relay we have to connect led switch and dc-dc converter and scooter battery. With the help of a multimeter, we have to find by which wire we are getting 12v we have to connect one wire from the battery to the led switch. So, the wiring part will complete between all components.



Next, we have to connect the battery wire through the controller, we have to use MCB for the safety purpose of the positive terminal for MCB. We will use the compactable socket for the battery to connect a wire

7. CONCLUSION

- Hybrid Electric Vehicle is a vehicle that uses two sources of power: -gasoline and battery. The major drivetrain is a continuously variable transmission system (CVT) and an electrical machine system which operate simultaneously to give the driver a better performance and efficiency as compared to normal IC engine powertrain. The driver can switch to battery power whenever the power requirement is low and when the power load requirement is high the driver can switch on the IC engine. The most convenient factor in our hybrid converted vehicle model is that the switching between the two modes can be done only by the press of a button. This makes our modified vehicle more customer friendly and easy to use.
- The hybrid electrical vehicle in operation emits 50-70% less pollutant emissions as most of the time the driver runs on the battery mode wherever the traffic is high as the vehicle has to operate in low speed and the IC engines are least efficient in this case. This also makes the vehicle environment friendly. Also, the vehicle need not be connected to a power source for charging as the recharging is done when the HEV is running as the regenerative controller recharges the battery whenever the brakes are applied. The motor acts as a generator in this case. This also maximises the vehicle performance and saves the user time. Thus, in urban areas this vehicle is most suitable and sustainable for both the driver and the environment.
- People want to go for electric hybrid vehicle rather than pure Electric Vehicle. People want to switch to EV hybrid because they think that these vehicles are eco-friendly, produces low noise and save running cost.
- Design and aesthetics of the vehicle is of much importance for the audience. The most important consideration for the customers is the environment pollution that comes with normal petroleum powered vehicles.
- Safety and security are another important consideration for people to consider for an EV. The challenge that the people consider for the penetration of EV industry in India are - a) Shortage of charging infrastructure. b) Lack of skilled labours. c) Lack of electricity networked. d) Tough competition from petrol/diesel vehicles in terms of power, torque and durability

REFERENCES

[1] Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II)

[2] Hybridization, Of & Cuddy, Matthew & Wipke, Keith. (2001). Analysis of the Fuel Economy Benefit of Drivetrain Hybridization. 10.4271/970289.

[3] G. Frenette and D. Forthoffer, "Economic & commercial viability of hydrogen fuel cell vehicles from an automotive manufacturer perspective," International Journal of Hydrogen Energy, vol. 34, no. 9, pp. 3578– 3588, 2007

[4] B. S.-M. Fan, "Modelling and simulation of a hybrid electric vehicle using MATLAB /Simulink and ADAMS," Master's thesis, University of Waterloo, 2007

[5] T. Bauml and D. Simic, "Simulation and comparison of different energy management strategies of a series hybrid electric vehicle," in Vehicle Power and Propulsion Conference, 2008. VPPC'08. IEEE, pp. 1– 5, IEEE, 2008.

[6] K. L. Butler, M. Ehsani, and P. Kamath, "A matlab based modeling and simulation package for electric and hybrid electric vehicle design," IEEE Transactions on vehicular technology, vol. 48, no. 6, pp. 1770– 1778, 1999.

[7] Borthakur, Swagata & Subramanian, Shankar. (2018). Design and optimization of a modified series hybrid electric vehicle powertrain. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering. 233. 095440701875935. 10.1177/0954407018759357.

[8] Gopi Krishnan, N. and Wani, K., "Design and Development of a Hybrid Electric Two-Wheeler," SAE Technical Paper 2015-26-0118, 2015, doi: 10.4271/2015-26-0118.

[9] Nguyen Van Trang, Pham Tuan Anh, Huynh Thinh. A Simulation Study on Energy Consumption and Cost Analysis of Hybrid Electric Motorcycle. International Journal of Mechanical Engineering and Applications. Special Issue: Transportation Engineering Technology – Part IV. Vol. 6, No. 4-1, 2018, pp. 1-8. doi: 10.11648/j.ijmea.s.2018060401.11