RESEARCH ARTICLE OPEN ACCESS

Analysis of Packaging issues in current Electric vehicles.

*Rahil Patel[1], Sunil Kumar[2]
[1](*UG Student, Department of Mechanical Engineering, Universal College of Engineering, Gujarat Technological University, Gujarat, India)*
[2](*UG Student, Department of Electrical Engineering, Ahmedabad Institute of Technology, Gujarat Technological University, Gujarat, India)*

ABSTRACT
The decade of 2020 is the decade for development of electric vehicle in automotive industries. The future of transportation is Electric vehicle as we are running out of Fossil fuels. The Global automotive industries are working to implement projects on the production and development of electric vehicle. There are various companies which had developed a far more advanced vehicle than conventional combustion engine vehicles. As there is no harmful emission from electric vehicle and development of the electric vehicle will help to reduce the issues such as Global warming and environmental pollution. The major issues in designing an electric vehicle isthe packaging of various components into chassis of the vehicle. The work is on the requirement of space and optimization of the packaging inside the chassis of electric vehicle. Also the work is more focused on the comparison between power transmission equipment used in conventional combustion vehicle and current electric vehicle.
Keywords- Current Electric Vehicle,Electric motor, Ergonomics Optimization, Packaging Issues.

I. INTRODUCTION

In late 90's many nations realized the need of alternatives for combustion engine vehicles to reduce issues from exhaust emissions and dependency on imported crude oil. Till now, numerous attempts have been done to roll out practical electric vehicles. This report is to showcase the technology adopted to manufacture an electric vehicle, difference between (performance, efficiency and carbon emissions) a combustion vehicle and an electric vehicle. And why EVs as better then IC engine vehicles. It consists the reasons behind the sudden growth in Electric Vehicles and Hybrid Vehicles and it is a demand for better world.

Electric vehicles are ninety-five percent cleaner, release no emissions that particulate matter into atmosphere. Gas powered vehicles release carcinogens, particulate matter in air which can lead to cause asthmatic condition and irritation to respiratory system too. Firstly, history of electric vehicle shows the ups and downs in manufacturing and upgrades in technologies. Then it is followed by the section consisting comparison between combustion vehicles and electric vehicles on the basis of manufacturing cost, parts involved, carbon emission by vehicles, emission y production plants and upgrades that has been done for improving working efficiency. Next section gives technical details of an electric vehicle, its parts, their functions, and operation. Next section includes the packaging issues that are faced by the startups and other manufacturers for setting up motor, powertrain and battery package while considering the size and weight of the chassis. Then it is followed by the types of motors that are now used in low to high powered electric vehicles to increase load carrying capacity, power consumption and reliability. And lastly there's the need of ergonomics in electric vehicles has been shown as to show that they are nevertheless than combustion vehicles and can look better and can perform better too. A final conclusion has been drawn on electric vehicles, impact on peoples, its future and how it will change the world in upcoming years.

1.1 HISTORY

The Robert Anderson built the first crude electric carriage vehicle between 1832 and 1839 in Scotland. In preceding year 1895, A.L. Ryker made an electric tricycle and a six passenger wagon was built by William Morrison which made America to pay attention to the electric vehicle. In 1902 Wood created the Electric Phaeton, which was more than an electrified horseless carriage and surrey. "The Phaeton had a range of 18 miles, a top speed of 14 mph and cost $2,000".

In 1920s electrical vehicles faced reduction in its use and production. The major reason behind that declination was improvement in road system, reduction in gasoline price because of discovery of crude oil in Texas, addition of the electric starter and production of internal combustion engine vehicles at larger scale. A data record says that, during 1910s a gasoline car was sold at less than half price of an electric roadster. Near about in 1935, Electric vehicles disappeared completely. Internal combustion engine vehicles having good time in industry had cons too. In America during 1960s Electric vehicles showed up again due to the creation of unhealthy environment for the people by internal combustion vehicles.

1.2 Comparison between CV and EV

In case of combustion vehicle the engine is rigidly mounted with the chassis with necessary damping provision. But the size of engine is much higher than the motors hence it is the advantage in packaging in electric vehicles. While the battery is equivalent to the fuel tank of combustion vehicle and also it is too bulky as compared to the fuel tank. Also both combustion and electric vehicles are equipped with the final drive hence the overall power unit of both kind of vehicles are same.

1.3 TECHNICAL DETAILS OF ELECTRIC VEHICLE

An electric vehicle is propelled by an electric motor, takes power from rechargeable battery package and its control unit. It looks same as a general vehicle. The only thing that differs an electric vehicle from others is due to very less noise during operation.

An electric Car or Moped has:

- An electric motor
- Battery package(rechargeable)
- Battery management system
- Control unit

Battery package is the power source for the vehicle. It gives power to the control unit and other electronic accessories.
Battery Management System is the set of embedded electronics and set of programs which maintains the working parameters of the vehicle. It keeps a track on voltage, current drawn, temperature of the batteries and prevents it from overheating, overcharging and also prevents the load from getting overloads during peak working conditions.
Control Unit takes the data from the driver/rider in terms of throttle position or brake pedal position then it gives transmits power to the electric motor of the vehicle.
The electric motor is connected to the transmission which can be direct drive or indirect drive.
Basically an electric vehicle consists of a potentiometer, batteries, direct current (DC) controller and motor

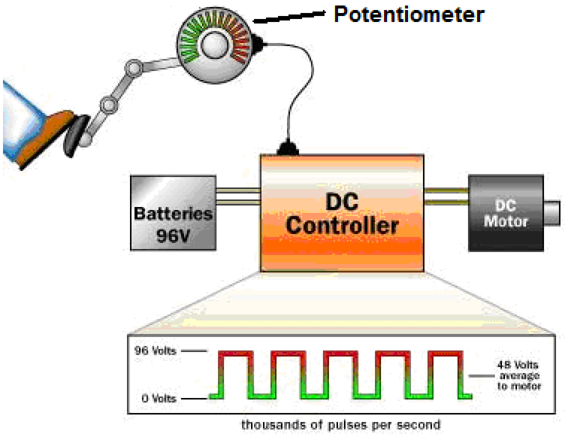


Fig. 01- EV control system

Potentiometer: it is a variable resistor which changes its resistance as its shaft is rotated or linearly moved. The potentiometer is connected to the throttle pedal or lever of the vehicle which sense the throttle position and sends it to the controller which in turn supply power to the electric motor accordingly.
Batteries: these are the power unit to the vehicle. Mainly lead-acid, lithium ion, nickel-metal hydride batteries are used. But nowadays, lithium ion batteries are preferred for making the battery package due to its high current density and lower losses. Many years later they were not to be considered for the use in vehicles due to its high manufacturing cost. But due to advancement in technologies its production took a greater hive and are preferably getting used in electric vehicles.
DC controller: it delivers power to the electric motor by taking power from the batteries. It manages the whole power supply system from steady condition of the car when the throttle pedal is at ideal position to the power delivery when the pedal is fully pressed to get the electric motor to its maximum working condition.
Motor: This unit converts the electrical input into mechanical rotating power.

1.4 Packaging issues in current EV

As the above section completely describes various components and subsystems of an Electric vehicle that it is not as complex as Combustion vehicles but the main issue with which require the main focus is the bulkiness of subsystems like battery package and powertrain unit.
The battery package requires a rigid mechanical mount with a functional cooling system. It is critical to decide the location and mounting type of the battery package. Battery package are generally mounted with the chassis rigidly but in some modern era EVs like GOGORO, a quick removable battery

package is provided which can be directly removed from vehicle. Also while designing a Battery management system one has to select an optimum battery current rate, voltage and lifecycle.
Also Final drive and motor should be closely packed in the rear section of an EV in order to obtain desired body work and overall length.

II. SUBSTITUTES AND SOLLUTIONS

2.1SELECTION OF POWERTRAIN EQUIPMENT

Selection of Powertrain equipment mainly includes selection of motor and final drive.
Various kind of motors and final drive are discussed below which are most commonly used in Electric vehicles.
However the selection of powertrain equipment is mostly depends on End user requirement as well as the primary use of vehicle.
Selection of powertrain equipment may highly affect the overall performance of the vehicle. Hence while deciding the subsystem designers take care of the torque requirement and product lifecycle.

2.1.1 TYPES OF MOTORS

EV industry mainly uses BLDC,Induction and DC series motor in production.every motor has its own operating characteristic and response to the load.

BLDC

Brushless DC motor is also known as electronically commutated motors (ECMs, EC motors). DC power source is used with an inverter/switching power supply which converts the DC into AC/bidirectional electric current to run each phase of motor with the help of a control closed controller.
A permanent magnet is used for the motor's structural element. the main parameters of BLDC are motor constants Kt and Ke

$$K_e = \frac{\text{VoltSecond}}{\text{Radian}} = \frac{\text{KilogramMeter}^2}{\text{AmpereSecond}^2}$$

The maximum power output which can be applied to a BLDC is almost limited exclusively due to heat. These are more efficient motors than the brushed motors which is due to frequency at which current is switched which is determined by the feedback of the position sensor. Their efficiency is comparatively better than the other Brushed motors and the rotation is controlled by the electronic circuit that smoothens the speed control.

SERIES WOUND MOTOR

In this motor the speed decreases as the load is increased on the motor. The current rises and torque increasesin proportional to the square of the current as the same current flowing in both armature and the field windings.in a case if motor get stalled, the current is limited only by the total resistance of the windings and torque can be very high. The notable characteristics of the series motor are totally dependent on the torque required to drive the load. So this motor can accelerate from maximum torque. The speed of series motor can be dangerously high, so they are either geared or connected directly to the load.

SYNCHRONOUS MOTOR

It is an AC motor differentiated by a spinning rotor with coils passing magnets at the same rate as the alternating current which creates the magnetic field which rotates it. This motor has zero slip under normal working conditions unlike in induction motor which must slip to generate torque.the rotor get its supply with the help of slip rings and brushes. There is a hysteresis synchronous motor which is a two phase motor with phase shifting capacitor for one phase. The get start like an induction motor but when the rate of slip is sufficiently reduced the rotor becomes temporarily magnetized. Having distributed poles make this to act like a permanent magnet synchronous motor. The material of the rotor will stay magnetized but it can be demagnetized but with little difficulty. There is no drift in rotor poles when it starts rotating.

2.1.2 TYPES OF TYPES OF COOLING SYSTEMS

Electric vehicles are equipped with the cooling system to keep its battery at lower temperature.
Extreme temperature affects the performance hugely hence a functional cooling system is required for an Electrical Vehicle.

Air Cooling

Air cooling involves passage of air along the surface of the batteries in order to absorb the heat and carrying it away from the site, thereby cooling it.
It is comparatively crude in comparison to a more complicated liquid cooling, but at the same time it is much more simple, easy to apply and robust.
But there are various downsides. The system is not very efficient in carrying the heat away as air can absorb very little heat and is quite a poor conductor. Also the cooling performance severely depends upon the ambient temperature.

Liquid Cooling

This cooling solution requires a liquid as a coolant which takes the heat away from the site. This is much more expensive and much more complex as compared to an air cooling solution, but it is significantly more efficient than its other counterpart.

Liquid coolers possess better thermal capacity and are quite good at carrying the heat away. Their thermal capacities exceed that of air cooling systems. The downsides are, that they are prone to leakages, higher installation and maintenance costs.

2.2 BATTERY SELECTION

Battery selection is one of the critical tasksin designing of Electric Vehicle. It may affect the overall performance of model in every aspect.

Also to make battery package compact and light weight the selection of optimum battery is mandatory.

Here the various types of battery and its composition are listed along with its advantage and disadvantage.

2.2.1 TYPES OF BATTERIES

The battery of an electric vehicle defines the range, acceleration ability and the recharge time for the vehicle. As battery have the energy to run the EV and not every battery/cell can be used to power up any vehicle. There are other technologies like flywheel and ultra-capacitors which are heavily advanced areas in electric battery.

The cell/battery generally consists of positive and negative electrode/terminal popped out of a casing which contains electrolyte and separator. The positive terminal receives electrons from the external circuit when the cell is under discharge condition. The negative terminal electrode provides/donates electrons to the external circuit as cell discharges. The medium where the charge flows between both electrodes is the electrolyte and both electrodes are electrically isolated by the separator.

WORKING OF A CELL

A loop is created whenever a cell is put into a circuit which allows charge to flow uniformly around the circuit. The charge flow in the external circuit is electron resulting in electric current and inside the cell the charge flowing is in the form of ions which are transported from one electrode to another. That flow is created due to the reduction and oxidation reactions occurring at both the electrodes. Oxidation reaction causes the generation of a free electron at the negative electrode and reduction reaction at the positive electrode consumes that electron. The potential of 1.685V is generated due to the discharge reaction at the positive electrode in a lead acid battery which is given by:

$$PbO_2 + SO_4^{-2} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$$

And potential of 0.356V is generated at the negative electrode,givenby:

$$Pb + SO_4^{-2} \rightarrow + PbSO_4 + 2e^-$$

This states that the overall voltage of a lead acid cell is around 2.04 volts. This is called the SEP (standard electrode potential). Acid concentration is the another factor which can affect the terminal voltage of the cell. The final chemistry of the cell decides the capacity and power delivery. Single cell may have the range from fraction of ampere-hour to hundreds of ampere-hours. The number of electrons which can be obtained determines the capacity of the cell.

Application like electric vehicle needs tremendous amount of energy. So many cells are connected electrically to get the required power storage. so, cells can be put together in series or parallel configuration.

LEAD ACID BATTERY

A French physicist Gaston Planté invented the lead-acid cell, the first rechargeable battery in 1859. There are electrodes of lead and lead dioxide dipped in electrolyte of sulphuric acid. The reaction between the electrodes and the electrolyte is reversible, which gives advantage to these cells to store electrical energy.

Energy density is the thing which is the main consideration while making any kind of portable storage batteries, that is the total amount of electrical energy that can be stored in a given volume and mass. For a particular mass, lead-acid batteries have relatively low energy density.

NICKEL CADMIUM

A Swedish scientist WaldemarJungner invented the first Nickel-Cadmium battery in 1899. As compared to other alternative for batteries, Nickel-Cadmium has numerous advantages over them. As these cell discharges, they provide constant output voltage; for a longer duration they can be used, around 3000 charge cycles. These cells can hold the electrical charge for a longer time, and have the ability to provide surge current output. They can be kept for a longer time for storage in discharged state. Even though, there are few disadvantage too, it is the Cadmium which is extremely toxic which leads to create problems in disposal and recycling.

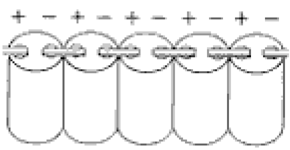
It will suffer subsequently voltage drop at a point where when the nickel-cadmium cell is repeatedly partially discharged to that same point and fully charged then. A discharge point will be developed as a memory at that point which will appear to be fully discharged while still holding a partial charge in there.

LITHIUM ION

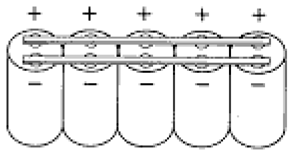
A lithium-ion battery or Li-ion battery is a rechargeable battery where lithium ions move from the negative electrode to the positive electrode during discharge and reverse when charging. An intercalated lithium compound as one electrode material is used in Li-ion batteries, as compared to

the metallic lithium used in a non-rechargeable lithium battery. The electrolyte allows ionic movement. The two electrodes are the constituent components of a lithium-ion battery cell.
The cost, chemistry, safety and performance characteristics vary across Li-ion battery types. In most of the electronic products LIBs are used which are based on lithium cobalt oxide ($LiCoO_2$), which provides high energy density, but can cause safety risks, especially when they get damaged. Lower energy density is in Lithium iron phosphate (LiFePO4), lithium ion manganese oxide battery (LiMn2O4, Li2MnO3, or LMO) and lithium nickel manganese cobalt oxide (LiNiMnCoO2 or NMC) but longer lives and inherent safety. So, these batteries are widely used for medical equipment, electric tools and other purposes. NMC in particular is a leading contender for automotive applications. For specialty designs aimed at particular niche roles, Lithium nickel cobalt aluminum oxide (LiNiCoAlO2 or NCA) and lithium titanate (Li4Ti5O12 or LTO) are preferred. The highest performance-to-weight ratio is delivered by the new lithium–sulfur batteries
Lithium-ion batteries can have unique safety hazards as they contain a flammable electrolyte and may be kept under pressure. An expert notes "If a battery cell is charged too quickly, it can cause a short circuit, leading to explosions and fires”. Because of these risks, testing standards are more stringent than those for acid-electrolyte batteries, requiring both a broader range of test conditions and additional battery-specific tests. (#wiki)

2.2.2Battery package composition
SERIES CONFIGURATION
In a series configuration, the negative terminal of one battery is connected to the positive terminal of the next and so on until the desired voltage and energy capacity of the battery are met. The total voltage of the battery package can be found by multiplying the number of cells in the circuit by the individual cell voltage.



PARALLEL CONFIGURATION
In a parallel configuration, the positive on one battery is connected to the positive on the next and the same goes for the negative terminal. In this we can store the required energy. But, in this parallel configuration the overall voltage of the battery formed is equal to the terminal voltage of the individual cell in the circuit. There’s much more than a battery in the battery system. There are other components which controls and monitors the other major working parameters of the battery.



2.2.3 BATTERY MOUNTING
Battery mounting and its location is the most important division in which current EV manufacturer have to work on. Most commonly a rigidly mounted battery package is equipped in Electric vehicle, as a result user has to recharge the mounted battery compulsory, and theycannotquickly replace the drained battery with the charged one. But a concept of quick replacing battery can be used in EV.
A Thailand based company GOGORO has developed a removable battery package which can be replaced by the other charged battery package as simple as fueling an ordinary combustion vehicle. It provides freedom to user from a limited range of the vehicle.

Battery Management System
There are many different types of charger and charging ways. So there must be something which can monitor the status of the batteries being discharged and charged. Battery Management System (BMS) have been developed which are controlled by microcontroller which allows charge algorithms to be programed into the system for all the different types of batteries virtually.Energy consumption by the vehicle while being driven, cell temperature, voltage of the battery package and voltage of the individual cell are monitored by the system. And while charging, the same process is being monitored in reverse which ensures safety net whenever there is a problem with a single cell within the battery pack.
Many of the existing electric vehicles and battery chargers usually take several hours to recharge n electric vehicle battery pack. Basically, the total time required to recharge the battery pack of the electric vehicle depends on the voltage and the current supplied from the source which is charging the battery pack and the ability of the battery package to accept the amount of current at the defined voltage to get recharge keeping the temperature of the battery package to a safe value.
The development in the charging technologies and the battery packaging has reduced the charging time effectively to 10- 15 minutes. Pulse battery charger is one the example which can charge the battery

pack under 20 minutes without any damage to it. And if these type of technology to charge electric vehicle will be deployed in future then the electric vehicles will be fueled with electricity similar to gas stations which will allow electric vehicle to operate and recharge quickly.

2.3 Chassis Structure

2.3.1 Monocoque

This is as opposed to using an internal frame or chassis that is then covered with cosmetic body panels.

It is common to see monocoque construction in modern cars where the structural members around the window and door frames are strengthened by folding the metal several times, or building up the layers of carbon fiber on more exotic models.

In these situations the main concerns are spreading the load evenly, having no holes for corrosion to start, and reducing the overall workload. Compared to older techniques, in which a body is bolted to a frame, Monocoque cars are less expensive and stronger.

Monocoque design is so sophisticated that the windscreen and rear window glass can play an important role in the structural integrity of automobiles built in this manner.

2.3.2 Space frame

The Space frame chassis uses numerous cut and shaped pieces of structural metal tubing (usually steel) joined together to form a strong framework. The principle of space frame design is to use triangulation of the tubes to create a rigid structure. Space frame chassis structure is less costly than Monocoquechassis also it provides flexible assembling options. However the selection of chassis structure depends on size of battery package and type of motor.

III. CONCLUSION

By analyzing the various aspects of packaging in electric vehicle it is clear that the selection of different components should be taken strictly with their requirement. A variety of options are available in each and every component of Electric vehicles hence by selecting an optimum component may help to reduce the size of vehicle greatly. As each and every component has its own advantages and disadvantages hence while designing electric vehicle the designer has to take care of the above mentioned

References

[1]. L. Ni, "Energy storage and management for a small series plug-in hybrid electric vehicle" 2010.
[2]. Bellis, M. *History of Electric Vehicles.* Retrieved January 31, 2010 from http://inventors.about.com/library/weekly/aacarselectrica.htm.
[3]. C. C. Chan, "Electric hybrid and fuel-cell vehicles: architectures and modeling", *IEEE Transactions on Vehicular Technology*, vol. 59, no. 2, pp. 589-598, February 2010.
[4]. J. C. King, "Model-based design of a plug-in hybrid electric vehicle control strategy", 2012.
[5]. ANSI/NFPA 496-1989, Purged and Pressurized Enclosures for Electrical Equipment.
[6]. P. Salminen, M. Niemela, and J. Pyrhonen, "Permanent magnet motor with embedded magnets and flux barriers," in ISEF2005, Vigo, September 2005, pp. 460-466.

International Journal of Engineering Research and Applications (IJERA) is UGC approved Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

Rahil Patel " Analysis of Packaging issues in current Electric vehicles.." International Journal of Engineering Research and Applications (IJERA) 7.8 (2017): 50-55.