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Design Modularity in Electric Vehicles

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Abstract - *This paper provide an idea about the modular design concept of the recent electric vehicles in India. The paper describes the development of vehicles in the phase of transition from diesel to electric. This consist of building the vehicles without major aggregate modifications and packaging the existing components. The paper finally shows how regular vehicles are converted to electric vehicles.*

Key Words: Electric vehicle, Motor, Inverter, Battery, chassis,

1. INTRODUCTION

Electric vehicles are driven by pure electric system. Internal combustion engine are not used to drive these vehicles. All the power generated is through the electric energy source. Apart from this the basic vehicle systems and architecture remains as it is. India is on the verge of electric vehicle phase. In this phase it is not possible for any manufacturer to design and develop a complete electric vehicle as there is no complete market available for these vehicle. Considering this paper provide concept of modular vehicle design for electric vehicle. There are three main components

1.1 Power Supply

The electric Vehicle or Battery Vehicle uses high capacity batteries and electric motor for propulsion. It drives all the power from its battery packs. It has no internal combustion engine neither fuel. The only power is battery power which is generated through electrical charging of batteries.

These batteries are a rechargeable and Deep-cycle batteries. A deep-cycle battery is a battery designed to be regularly discharged deeply up to its complete capacity. To meet this deep cycle requirement typically lithium-ion batteries are used. The batteries have a high energy density, no memory effect and low self-discharge.

These batteries, specifically designed with a high ampere-hour capacity. These Electric vehicle batteries differ from regular starting, lighting, and ignition batteries as they are designed to give power over sustained periods of time.

As these are high capacity batteries these are bigger in size than regular batteries and heavy too.

1.2 High Torque Motor

In EVs, battery is the original energy source and provides electric power to electric motor drives.

The typical control system of EVs includes mainly five electric control units (ECUs), which are the main ECU, Battery ECU, Motor ECU, Electric equipment ECU and Brake ECU.

The main ECU controls the drive torque of EV by computing the motor torque based on information such as accelerator opening and vehicle speed. The torque request value is sent to the motor ECU. On the basis of the drive requirement output value is requested by the main ECU, the motor ECU controls the output current to the motor drive to develop the desired torque. The motor drive is used to achieve desired torque.

There are verities of electric motors available for industrial applications. These all are used to drive different types of industrial devices. These same motors can be used to drive all electric vehicles. However, there are some performance criteria of electric vehicle needs to be considered while selecting the motor for electric vehicles. Some of the requirements can be stated as motor efficiency, cost, weight and dynamic performance characteristics.

Battery ECU, Brake ECU, and Electric Equipment ECU

1.3 Inverter

The inverter is a bi-directional electric voltage converter that accepts the high voltage from the traction battery and converts it typically in the three phase AC voltage suitable for the traction E-motor. It controls the input supply voltage to the motor during vehicle propelling. During the deceleration (regenerative breaking period) the motor absorbs the torque and provide the AC voltage to the inverter. The inverter controls the amount of the energy generated by the motor and consequently the intensity of the braking. The harvested energy is applied back to the HV battery as a charge.

The regenerative breaking improves significantly the vehicle efficiency and in turn the distance the vehicle can travel on a given battery charge. A large capacitor in the size of 0.5 to several mF (milliard) is an essential part of the inverter. Its role is to decouple the bus voltage, limit the switching ripple and most importantly limit the voltage overshoot.

2. Vehicle Architecture

In vehicle architecture we define part layout of vehicle. The vehicle part layout consists of different aggregates and their installation location on vehicle. To understand the modularity concept first we need to understand basic architecture difference between traditional vehicle architecture and electric vehicle architecture. So let's get brief information about traditional vehicle architecture and electric vehicle architecture.

2.2 Gasoline Vehicle Architecture

The existing gasoline engine vehicles are having an chassis as a main frame over which an engine is installed. Drive train is followed by engine and through a propelling shaft it gives power to the rear axle or front axle depending on the vehicle type.

Remaining all systems like fuel tank, light volt batteries, Exhaust system and other systems are packaged on the chassis at suitable locations.

Over this a separate engine cooling system is required for these vehicles which maintain the engine temperature. Fig 1 shows detail architecture as described.

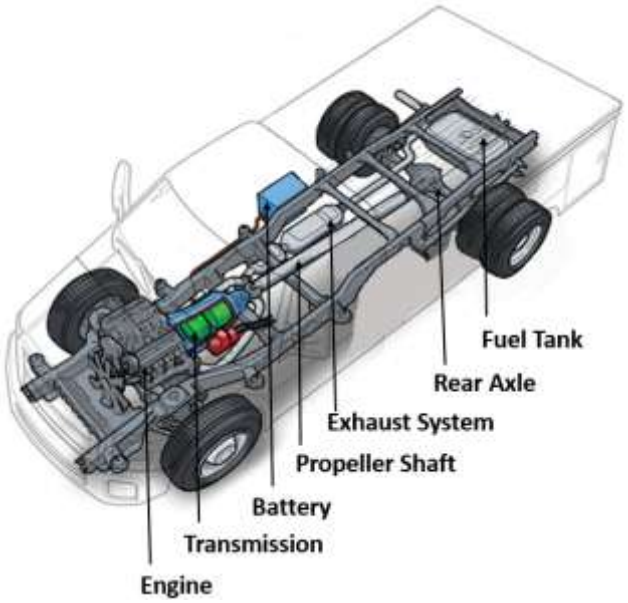

Fig -1: Gasoline Vehicle Layout

2.2 Electric Vehicle Architecture

The electric vehicle architecture is different than the traditional gasoline engine. It has a motor as a driving unit. Motor takes power from battery and provides driving power to the vehicle.

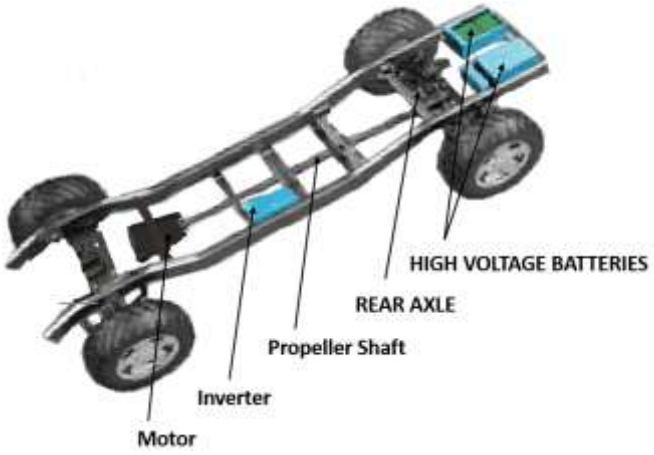

Fig -2: Gasoline Vehicle Layout

Inverter is a bi-directional converter installed between the battery and motor. It controls the current to motor in assistance of the ECU.

All the other aggregate systems remains same as traditional gasoline vehicle. All these systems are installed on the chassis system same as gasoline vehicle.

3. Vehicle Design Modularity

Vehicle design modularity in this section can be defined as measure of the degree to which the architecture of gasoline vehicle and electric vehicle resembles with each other.

Looking at the gasoline vehicle architecture driving system i.e. engine and transmission are mounted on the chassis and through propeller shaft it provides power to rear axle.

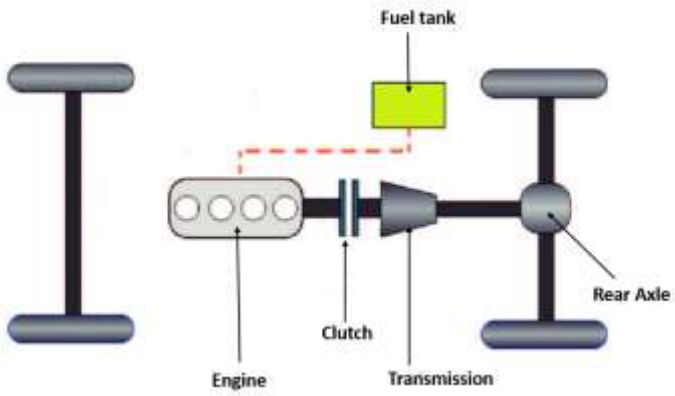

Fig -3: Schematic Gasoline Engine vehicle Layout

Now in consideration of modularity no vehicle architecture can be change. As this change in architecture

can cause addition in cost and also development of major new components.

To overcome this situation Indian vehicle manufacturing organizations has come up with a modular vehicle design. This is achieved by keeping all the basic vehicle architecture same as gasoline vehicle.

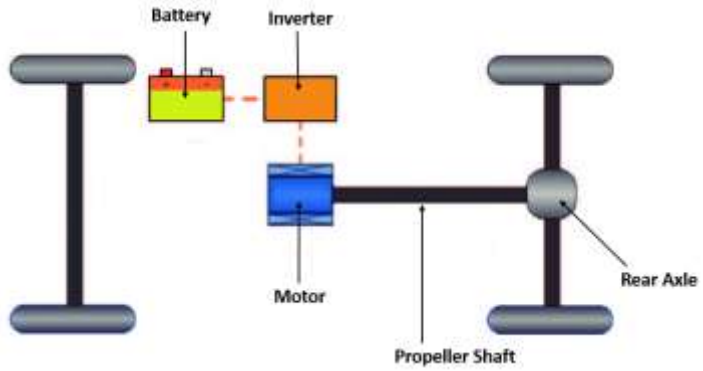

Fig -4: Schematic Electric Vehicle Layout

The only change is in the replacement of existing aggregate systems of gasoline engine with electric vehicle aggregates.

In detail engine and transmission is replaced with motor keeping propeller shaft and rear axle as it is. The suitable small modifications are done in the system to accommodate battery as a power source.

This modularity in design reduces variety of major aggregates. It also provide ease in manufacturing and serviceability. As many of the systems are derived from existing vehicles the component validation cost reduces drastically.

3. CONCLUSION

The paper presents an overview of vehicle architecture of both gasoline and electric vehicle. It also explains the concept of design modularity over gasoline vehicle design. In particular the vehicle configuration, power train and critical accessories requirements are defined thoroughly.

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