INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY ISSN(O): 2456-6683
Monthly Peer-Reviewed, Refereed, Indexed Journal [Impact Factor: 6.834]
Volume - 7, Issue - 4, April - 2023 Publication Date: 08/04/2023

DOIs:10.2017/IJRCS/202304003 --:-- Research Paper / Article / Review

A study on the Essential Components of an Electric Two-Wheeler

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Abstract: *Internal combustion engines work by burning fossil fuels like petrol, diesel, natural gas etc. and produce by-products like carbon dioxide, nitrogen oxides etc. These gases cause pollution to the environment. In order to reduce the pollution electric vehicles can be used which are great alternative to ICE vehicles. Electric vehicles do not produce any wastes and also requires very less maintenance and devoid of sound and vibration. Sales of electric vehicles are increasing rapidly every year which makes EV research and development very relevant. Asian countries like India, China, Philippines, Vietnam etc are big market for two wheelers and these markets are rapidly electrifying. So most of the research, development and production of electric two wheelers are highly concentrated in these countries*

Key Words: *Electric Vehicle, electric two wheeler, components, battery, sensors, controllers.*

1. INTRODUCTION:

Usage of electric vehicles is relevant in this era as the fuel prices are rising and to reduce the air pollution caused by internal combustion engines. So many automotive companies and institutions are rapidly developing electric vehicles for the world. New technologies for electric motors, batteries are also being developed in order to improve efficiency and performance of the electric vehicles. Compared to ICE vehicles, EVs have fewer mechanical components. Engine is replaced by an electric motor, which is a permanent magnet synchronous motor and battery supplies electric current for propelling the vehicle. Numerous sensors are used in EVs and all are linked with ECU. In case of electric two wheelers, hub wheel motor is a good alternative for traditional motors which drive the wheel via belt or chain. Hub wheel motors are small in size and eliminates transmission losses which occur in chain or belt drive. These motors can also act as a generator and thereby regenerative braking takes place. Battery is another important component which supplies electric current for the motor. Different battery technologies are used in the industry and lithium-ion battery is the most popular one. Placement of battery is very important as batteries are usually heavy and proper weight distribution is needed for good stability. Current crisis regarding the EVs is the disposal of used batteries as this leads to massive increase in e-waste. Also, batteries need to be replaced after certain years as its efficiency will be reduced after a number of charging cycles. These issues need to be rectified on further development. Suspension is also an important component as the longitudinal movement of the suspension can be used to produce electrical energy and range extension of electric vehicles is possible. DC converters are another important component as it helps in converting low voltage dc current to high voltage dc current and vice versa. Some vehicles may use AC motor and in such cases ac converters can be used. Different types of sensors are also used in EVs and some of them are wheel speed sensors, throttle position sensors and battery temperature sensors. Wheel speed and throttle position sensors determine the speed and required for the motor to propel the vehicle. In case of battery temperature sensor, it monitors battery temperature and sends signal for cooling if required. Battery temperature needs to be maintained as overheating may result in fire hazards. Also, optimum temperature needs to be maintained for best performance. Controllers are the ones which are in between battery and the motor. It helps in converting DC to AC in case of AC motors, controls energy flow and also regenerative braking. Just like ECU, controller controls every function in an electric vehicle.

2. LITERATURE REVIEW:

In the mid-19th century, the first electric vehicles appeared. Generally electric vehicles are very popular in recent days. These are made to travel very short distance. These vehicles are travelling range is 25 to 45 km range only. In India most of the people use two-wheeler vehicles and those two-wheeler vehicles are petrol vehicles they emit lot of emissions. To control these emissions electric vehicles are best choice [1]. By using these electric vehicles, we save fossil fuels for the future generations and control pollution.

Most of the old vehicles are very strong and those body can survive more years but those vehicles emit lots of pollution and facing some repairs or problems [2]. Instead of keeping them useless we can modify them into electric vehicles. These are very less in the weight. These are rechargeable, by using these vehicles we can travel short distance quickly. By using this type of vehicles, we can improve the quality of air around us. These vehicles do not make any noise

3. COMPONENTS:

3.1. Wheel Hub Motor

As the core component of an electric vehicle [3], the quality of driving motor has a great influence on the power, economic efficiency and safety of the electric vehicle. However, different from other industrial motors, the motor drive system of vehicle drive motor is not only affected by the size of vehicle structure, but shall also meet the operating conditions under complex conditions. Therefore, in addition to the requirements of high efficiency, low mass, high power density, small size, good reliability and low cost of the drive motor, it shall also adapt to the frequent start, stop, climbing, acceleration and deceleration conditions of vehicles, which require a wide range of speed and high overload factor of automotive drive motor in order to meet the performance requirements of high torque under low speed or climbing or low torque under high speed

The wheel hub motor drive completely eliminates the power train components such as clutch, transmission, differential and axle shafts, making the chassis structure simple, improving the transmission efficiency, reducing the vehicle mass, achieving more reasonable layout, and facilitating the realization of intelligent chassis and electrification control.

The external rotor of the motor is mechanically connected with the wheel hub and has no deceleration structure, which is a direct drive mode. Motor speed is generally 1500r/min or so, due to the lack of retarding mechanism, driving structure is compact with high transmission efficiency. But large current is required at the start, climbing or under large loads, which could easily damage the battery and permanent magnets. In order to ensure a large start torque and good dynamic property, the requirements of the motor are high, and low-speed external rotor permanent magnet synchronous motor is generally adopted.

Deceleration drive is a fixed speed ratio reducer installed between the motor and the wheel, playing the role of deceleration and torque-up. The deceleration device is generally a high reduction ratio planetary gear mechanism. The working speed of the motor is about 10000r/min, usually using high-speed inner rotor permanent magnet synchronous motor, the drive wheel hub drives the vehicle after deceleration and torque-up of motor output power. The motor is small, light and with high specific power of high-speed running. After deceleration and torque-up, the vehicle has good climbing ability, and it can guarantee the vehicle has a large steady torque when running at low speed. However, the structure is relatively complex, and the increase of unsprung mass affects the ride comfort and handling stability.

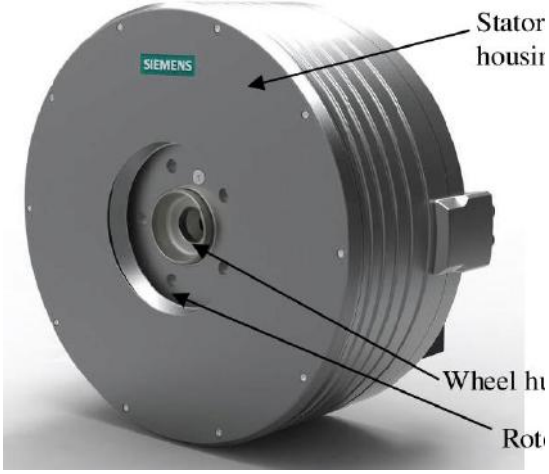

Fig 1. Wheel Hub motor

3.2. Battery

Battery is the crucial part of an EV [4], it determines the range of the vehicle, cost, safety and overall performance of the vehicle to a great extent. Different vehicles use different types of batteries considering various factors. Commonly used batteries in EVs are

3.2.1 Lead acid battery:

Lead acid batteries originally invented in the 19th century went through different changes and advancement to the product that it is of today. Lead acid battery, being the very commercialized battery in older generation as it was introduced in 1859. The major advantages of these batteries are low cost, high electrical activity, high reliability, fast response, strong surge capacity and efficiency ranging from 60 to 80%. The electrodes, separator and electrolyte constitute the internal structure of the battery. The anode is made of lead plates and cathode made of lead oxide plate is immersed in electrolyte solution of sulphuric acid. The electrodes turn into lead sulphate and electrolyte becomes water during the discharge process. Low cost, abuse withstanding features, reliable, robust, low internal impedance are some key features. Indefinite shelf life if stored without electrolyte, can be left on float charge for a long period. Wide range of sizes and capacities available and is the world's most recycled product. While the demerits include Coulombic charge efficiency being only 70% in general, and also have the danger of overheating during charging, which is not suitable for fast charging (compared to other batteries). Applications include automotive and traction applications, emergency power for electrical installations, used in submarines, UPS and other commercial uses.

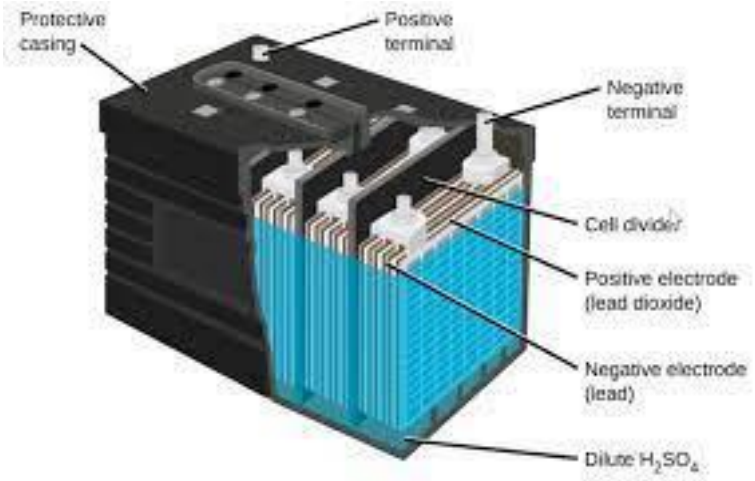

Fig 2. Lead Acid Battery

3.2.2 Nickel Metal Hydride battery:

Nickel-metal hydride battery is a rechargeable alkaline type which is one among the leading battery technologies in the hybrid electric vehicle industry. NiMH batteries are characterized by high energy density, extended service life, safety, high power, environment friendly and recyclability. It can be produced in sizes varying from a few milli ampere hours to hundreds of ampere hours. NiMH battery is called an alkaline storage battery since it uses Potassium Hydroxide as its electrolyte. KOH has a high conductivity factor and the ability to remain inert during the cell reaction which resulted in high conductivity throughout its battery life. KOH plays a vital role in keeping the overcharge and over discharge performance better in NiMH batteries as KOH concentration remains constant in the entire process of charging and discharging. NiMH battery has Nickel Hydroxide as its positive electrode. It is nonstoichiometric and has better gravimetric and volumetric energy densities. Battery life and abuse tolerance are enhanced by nickel electrodes because of its insolubility property in KOH electrolyte.

NiMH batteries also have many disadvantages. Its main drawbacks are self-discharging and negative electrode corrosion which depends on the temperature. Therefore, it needs a system that can manage temperature to have better charging efficiency and long life. It also works improper at low and high temperatures. NiMH are used in a variety of applications which includes mainly hybrid electric vehicles and stationary power applications like energy storage for telecom, UPS and distributed generation applications. NiMH battery technology is used for vehicles like Toyota Prius. Toyota Prius, a hybrid electric vehicle used NiMH for the first time

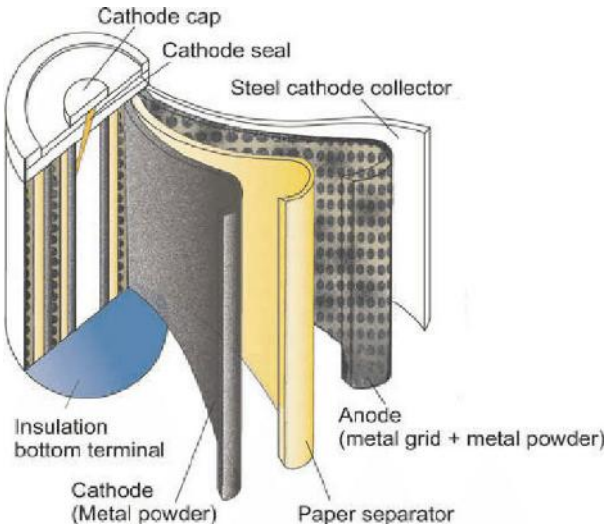

Fig 3. Nickel-metal hydride battery

3.2.3 Lithium-Ion battery:

Lithium-ion batteries are used in a broad spectrum of applications from portable devices like mobile phones to satellites due to a variety of reasons discussed in this section. Li ion batteries have many chemistries which are used for EV applications. Each one of them differ in terms of energy density, life cycles, durability, safety issues under overcharge and over discharge conditions. Both the electrodes of Li-ion cells work on the Intercalation process. In this process Lithium does not react with electrodes but they are either absorbed from the electrolyte and inserted to electrode or removed from electrode to electrolyte through deintercalation. The cell has a positive electrode, negative electrode, electrolyte, separator and current collector. Electrons are gained by the positive electrode from the external circuit during the discharge process. Electrons are given up by the positive electrode to the external circuit during the charging process. The electrolyte, media that conducts ions between electrodes, used in Li-ion cells contains salt, acid or base dissolved in solvent. The negative electrodes (anode) used are generally graphitic carbon. Silicon electrode is also used as anode, offers higher energy density but has a short life cycle. Current collector material is selected such that it can withstand the harsh environment inside the cell and normal environment outside the cell. The positive current collector generally used is Aluminium foil and the negative current collector used is Copper foil.

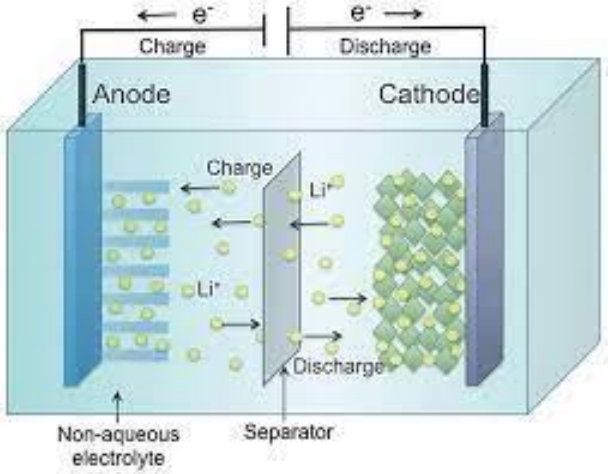

Fig 4. Lithium-ion batteries

2.3. Suspension

When vehicles drive on rough roads or change speeds, the shock absorbers installed in their suspension systems are compressed and stretched. Consequently, vibration energy will be dissipated in the form of heat. In terms of ease of installation, energy density and recovery efficiency, vibration energy recovery is one of the most efficient energy recovery methods and is widely utilised in commercial applications to recover energy to power batteries [5]. The first category is linear electromagnetic regenerative shock absorbers utilising coils of magnetic wire to generate electricity directly. The efficiency of this method is typically very high, but its damping coefficient is small relatively. The second category is bidirectional rotatory regenerative shock absorbers, which are designed to increase damping coefficients. By utilising mechanical structures, such as a rack and pinion, ball screws, or novel structures, irregularly reciprocating

linear oscillations are transformed into two-way high-speed rotation. The third category is unidirectional rotary regenerative shock absorbers, which transform irregularly reciprocating linear vibrations into unidirectional rotation. Therefore, this type of generator always rotates in one direction, which increases the efficiency of the energy-harvesting system and decreases the backlash between transmission structures compared to the second category.

Although existing regenerative shock absorbers are able to recover a high ratio of vibration energy, there are several drawbacks to completely replace conventional shock absorbers. Various factors in regenerative shock absorbers still challenge researchers. Regenerative shock absorbers can be perfected by aiming at the following two main problems. First, regenerative shock absorbers typically have low efficiency and do not perform as well as conventional shock absorbers. Second, applications of recovered energy must be thoroughly addressed. In previous research, a regenerative shock absorber utilising a pair of gear rack structures was proposed in order to achieve a high-efficiency and apply to range-extended EVs. While that system still exists the relatively large impact force caused by oscillatory motion and could not achieve a suitable damping ratio between upward and downward progress to provide passenger with a comfortable ride experience.

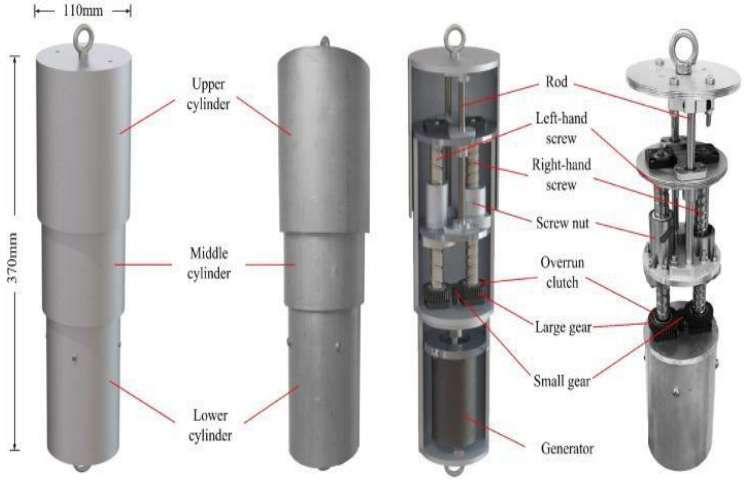

Fig 5. Suspension components

3.4. DC Converters

Bi-directional dc-dc converters are widely researched and developed for various applications such as battery charger and dischargers, electric vehicles and UPS system [6]. In case of the battery fed electric vehicles (BFEVs), electric energy flows between motor and battery side. For achieving zero emission, the vehicle can be powered only by batteries or other electrical energy sources. Batteries have widely been adopted in ground vehicles due to their characteristics in terms of high energy density, compact size, and reliability. This can be applied in Hybrid Electric Vehicle (HEVs) with a battery as an energy storage element to provide desired management of the power flows. In hybrid electric vehicle energy storage devices act as catalysts to provide energy boost. However, the high initial cost of BFEVs as well as its short driving range has limited its use. Bidirectional dc-dc converters are the key components of the traction systems in Hybrid Electric Vehicles. The use of a Bi-directional dc-dc converter fed dc motor drive devoted to electric vehicles (EVs) application allows a suitable control of both motoring and regenerative braking operations, and it can contribute to a significant increase the drive system overall efficiency.

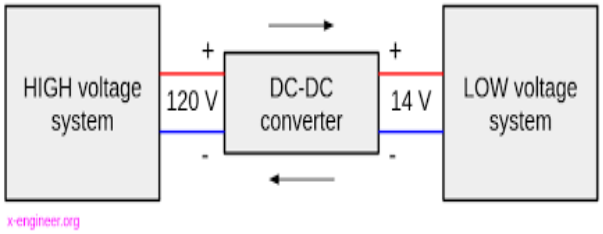

Fig 5. DC Converter

3.5. Sensors

Sensors are very important for any vehicles. Especially for electric vehicles, sensors play an important role. It helps in analysing vehicle speed, throttle input, battery charge management etc. Sensors need to reliable and must work efficiently. So good quality sensors must be used for electric vehicles as they solely depend on sensors for proper functioning. Different types of sensors are:

3.5.1 Wheel speed sensor:

It is used to determine the speed of the vehicle. Also used for odometers ad Anti-lock Braking system. Usually magnetic or optical sensors are used. Magnetic sensors are usually hall effect sensors. Hall effect sensor uses a hall sensing element, signal amplifier and signal processing which all takes place in one single chip. So, the space consumed is very less and can be effectively place in suitable positions, especially near to the wheels.

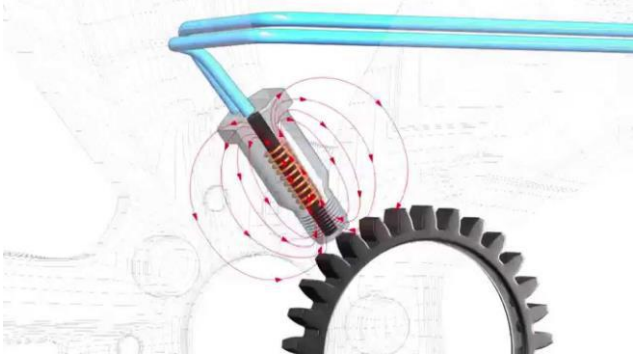

Fig 6. Wheel speed sensor

3.5.2 Throttle position sensor:

It is an important sensor in case of electric vehicles. It helps to know the throttle input. It sends signals to draw specific amount of current from the battery and sends signals to the motor. Throttle position sensors are basically potentiometers. In IC engine cars, these are mechanically connected and in most of the EVs it is by drive by wire technology. There are also EVs which uses mechanical linkages for accelerator pedal but they require analogue to digital converters as potentiometer produces analogue signal. Drive by wire system is most popularly used in EVs as incorporating throttle position sensor will be much easier.

Fig 7. Throttle position sensor

3.5.3 Battery Temperature sensor:

Battery is an important component in electric vehicles. Different types of batteries are used in electric vehicles depending on the requirements, manufacturer and the model. Most commonly used battery for electric and hybrid vehicles are lithium-ion battery, nickel metal hydride battery and solid-state batteries. Even though different battery technologies are used, battery cooling is an important factor. Proper cooling is required for efficient working, increased battery life as well as to avoid fire hazards caused by high temperature. Temperature of battery increases during charging and discharging. So, battery temperature sensors are required for maintaining the optimum temperature. Temperature sensors monitor the battery temperature constantly and if it detects high temperature, it helps in initiating the cooling process for the batteries. Most of the electric vehicles use liquid cooling technology for battery. When temperature rises, sensors detect and start the flow of cooling fluid into the battery casing. Thus, optimum temperature of the battery is maintained.

Fig 8. Battery Temperature sensor

3.6. Controller

The electric vehicle controller is the electronics package that operates between the batteries and the motor to control the electric vehicle speed and acceleration [7]. The controller transforms the battery's direct current into alternating current (for AC motors only) and regulates the energy flow from the battery. The controller will also reverse the motor rotation so that the vehicle can go in reverse and convert the motor to a generator so that the kinetic energy of motion can be used to recharge the battery when the brake is applied. The controllers on most vehicles also have a system for regenerative braking. Regenerative braking is a process by which the motor is used as a generator to recharge the batteries when the vehicle is slowing down. During regenerative braking, some of the kinetic energy normally absorbed by the brakes and turned into heat is converted to electricity by the motor/controller and is used to re-charge the batteries. Regenerative braking not only increases the range of an electric vehicle by 5 - 10%, it also decreases brake wear and reduces maintenance cost.

4. CONCLUSION:

The different possible components which can be used in electric vehicles are discussed. All these are important components for the development of electric vehicles. By developing all these components, performance and usability of the electric two wheelers can be improved to a great extent. As the fuel prices are increasing, electric vehicles are a better alternative and sales are increasing every year. So, charging infrastructure needs to be improved and also new battery technologies must be adopted for better range and improved battery life.

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