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Design of Electric Vehicle Along With Brief Description of Different Types of Batteries and Motors

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***Abstract*- In today's era the electric vehicle is need of the current scenario, because the conventional fuels are one the way of depletion and the most economic way to get rid of this is electric vehicle. As compared electric vehicles are more economic than traditional ones. Also these types of vehicles are more efficient than old ones. Amount of pollution caused is almost negligible as compared to others. The noise pollution caused is totally down because of zero noise emission. The government also provide some subsides for ebikes as the also want to promote the production of ebike.**

INTRODUCTION

There are various types of electric vehicles according to research in Indian market, moped scooters, electric bikes, electric auto rickshaw, electric carriers, electric cars, etc. an ideal electric vehicle contains of following parts:

- DC Motor
- BLDC Motor
- Battery
- Battery management system
- Charging system
- Tranissimion system
- Display system
- Rectification unit
- Braking system
- Acceleration system

1) DC MOTOR:
Principle:
A machine that converts dc power into mechanical power is called as a dc motor. its operation is based on a principle that when a current carrying conductor is placed in a magnetic field a current carrying conductor experiences a force. The direction of force is given by Flemings right had ruled and magnitude is given by:

$$F = B1J\ newtons$$

Basically there is no difference between dc motor and dc generator. The same dc machine can be run as dc generator and dc motor.

Working:
Consider a part of a multipole DC motor as shown in the figure 01 below. When the terminals of the motor are connected to an external source of DC supply:

- The field magnets is excited developing alternate North and South poles
- The armature conductors carry current.

Part of a Multi-polar DC Motor
All conductors under North-pole carry current in one direction while all the conductors under South-pole carry current in the opposite direction.

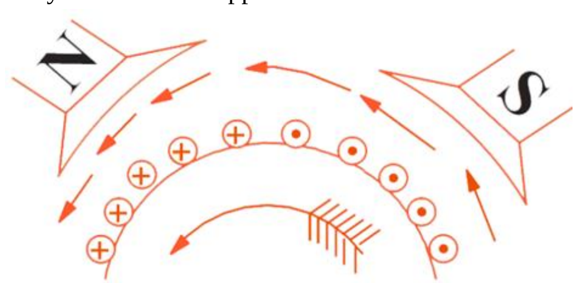


Fig no .01

The armature conductors under N-pole carry current into the plane of the paper (denoted as ⊗ in the figure). And the conductors under S-pole carry currents out of the plane of the paper (denoted as ⊙ in the figure).
Since each armature conductor is carrying current and is placed in the magnetic field, a mechanical force acts on it.

On applying Fleming's left-hand rule, it is clear that force on each conductor is tending to rotate the armature in the anticlockwise direction. All these forces add together to produce a driving torque which sets the armature rotates.
When the conductor moves from one side of a brush to the other, the current in that conductor is reversed. At the same time, it comes under the influence of the next pole which is of opposite polarity. Consequently, the direction of the force on the conductor remains the same.
It should be noted that the function of a commutator in the motor is the same as in a generator. By reversing current in each conductor as it passes from one pole to another, it helps to develop a continuous and unidirectional torque.

Back EMF:
When the armature of a DC motor rotates under the influence of the driving torque, the armature conductors move through the magnetic field and h hence is induced in them as in a generator.
The induced emf acts in opposite direction to the applied voltage V (Lenz's law) and is known as Back EMF or Counter EMF (Eb).
The equation to find out back emf in a DC motor is given below,

$$E_b = \frac{P\emptyset ZN}{60A}$$

The back emf Eb (= PΦZN/60 A) is always less than the applied voltage V, although this difference is small when the motor is running under normal conditions.

The significance of Back EMF
Back emf is very significant in the working of a dc motor.
The presence of back emf makes the d.c. motor a self-regulating machine i.e., it makes the motor to draw as much armature current as is just sufficient to develop the torque required by the load.
Armature current (Ia),

$$I_a = \frac{V - E_b}{R_a}$$

When the motor is running on no load, small torque is required to overcome the friction and windage losses. Therefore, the armature current Ia is small and the back emf is nearly equal to the applied voltage.
If the motor is suddenly loaded, the first effect is to cause the armature to slow down. Therefore, the speed at which the armature conductors move through the field is reduced and hence the back emf Eb falls.
The decreased back emf allows a larger current to flow through the armature and larger current means increased driving torque.
Thus, the driving torque increases as the motor slows down. The motor will stop slowing down when the armature current is just sufficient to produce the increased torque required by the load.
If the load on the motor is decreased, the driving torque is momentarily in excess of the requirement so that armature is accelerated.
As the armature speed increases, the back emf Eb also increases and causes the armature current Ia to decrease. The motor will stop accelerating when the armature current is just sufficient to produce the reduced torque required by the load.
Therefore, the back emf in a DC motor regulates the flow of armature current i.e., it automatically changes the armature current to meet the load requirement.

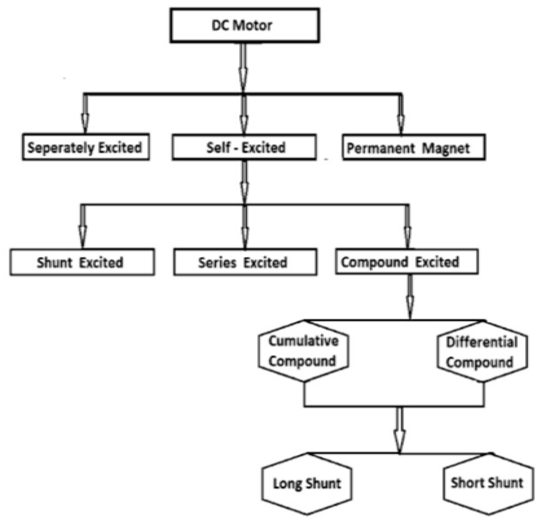
Voltage equation:
Let in a Dc motor,
$V = applied\ voltage$
$E_b = back\ emf$
$R_a = armature\ resistance$
$I_a = armature\ current$
Since back emf E_b acts in a opposition to the applied voltage V the net votage across the armature circuit is V-E_b . The armatyre current I_a is given by:

$$Ia = \frac{(V - Eb)}{Ra}$$

$$V = Eb + IaRa$$

This is known as voltage equation of a dc motor

Types of DC motor:
- Permant magnet dc motor (PMDC motor)
- Separately excited dc motor
- Self excited dc motor
- Shunt wound dc motor
- Series wound dc motor
- Compound wound dc motor
- Short shunt dc motor
- Long shunt dc motor0
- Differential compound dc motor



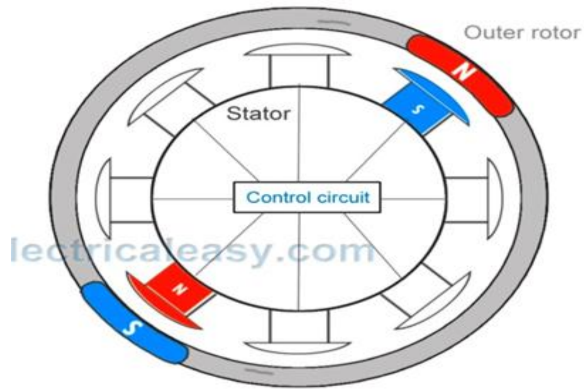
Among these motor brushless dc motor is used in recent electric vehicles

2) BLDC motor:
A bldc motor is also known as electronically commutated dc motor and also synchronous dc motor a bldc motor is supplied by a direct current through inverter which produces electricity in alternating current to drive each phase of motor via a closed loop controller. The speed of a bldc motor is controlled by providing a pulse to motor winding.

Construction:
The construction of bldc motor is similar to permanent magnet synchronous motor. Just like another dc motor bldc motor has two main parts stator and rotor. Permanent magnets are mounted on the rotor of bldc motor and stator has several numbers of poles. This is basic difference between bldc motor and traditional ones.
There can be two types of bldc motor depending upon construction

- inner rotor design
- outer rotor design

Working principle
Stator winding of a bldc motor is connected to a control circuit. The control circuit energizes proper winding at proper time intervals in a pattern which rotates around stator. The rotor magnet tries to align with the energized electromagnet of the stator, as soon as iṭ aligns the next electromagnet is energized. Thus the motor keeps running.



Advantages of BLDC over traditional dc:

- High torque to weight ratio
- More torque per watts
- Higher speed
- More efficiency
- Produces less noise
- No power losses

Application of bldc motor:

- Electric vehicles
- Preventing blood clots in hospitals
- Adjusting solar arrays in space vehicles
- Providing mobile breathing assistance

3) Battery:
These electric vehicle batteries are used to power electric motors of electric vehicles. These batteries are usually a rechargeable battery. These are usually lithium ion batteries, traction batteries specially designed for high ampere hour capacity which are used in forklifts, electric golf carts, ridding floor scrubber, electric motor cycles, electric cars, trucks, cars and their vehicles.
Electric vehicles contains batteries which provides supply for headlights, horns, indicators, and others parts so the battery should be much capable for supplying all this stuffs. Batteries of electric vehicles should last long. Kilometer range of battery should be as maximum as possible.
Batteries for electric vehicles can be characterized by their relatively high power to weight ratio, specific energy, energy density. Smaller and lighter batteries reduce the weight of bike also the performance
Rechargeable batteries used in electric vehicle contains:

- Lead acid

- Nickel cadmium
- Nickel metal hydride
- Lithium ion
- Lithium ion polymer
- Zinc air
- Sodium nickel chloride

The most common battery in electric cars and bikes used are lithium ion and lithium ion polymer because this battery have less weight and has more energy as compared to other in their weight and density

Lithium ion battery:

Lithium is the lightest of all metals among others. Lithium has the greatest electrochemical potential and has the less weight as compared to others. Attempts to develop rechargeable lithium batteries were failed due to safety problems as it burst when it overcharges or heats. Because of the inherent instability of lithium metal, especially during charging, research shifted to a non-metallic lithium battery using lithium ions.

The energy density of lithium-ion is twice that of the standard nickel-cadmium battery. The load characteristics are comparably good and behave similarly to nickel-cadmium at time of discharge. The high cell voltage of 3.6 volts per cell allows battery pack designs with only one cell. Most of today's mobile phones run on a single cell. A nickel-based pack would require three 1.2-volts cells connected in series.

Lithium-ion battery is a low maintenance battery. In addition, the self-discharge density is less than half compared to nickel-cadmium. Lithium-ion cells cause little harm when disposed as compared to traditional ones.

Despite its overall advantages, lithium-ion battery has its drawbacks. It is fragile and requires a protection circuit to maintain safe operation or else it may burst. Aging is a main problem with most lithium-ion batteries and many manufacturers remain silent about this problem. Some fault in batteries is noticeable after one year, whether the battery is in use or not. The battery certainly fails after two or three years.

Manufacturers are constantly improving lithium-ion batteries. New and enhanced chemical combinations are introduced in this new era

Storage in a cool place slows the aging process of lithium-ion battery and don’t let its temperature to be increase. Manufacturers recommend storage temperatures of 15°C (59°F) to 18. In addition, the battery should be partially charged during storage process means it should not be kept idle. The manufacturer recommends a 40% to 80% charge.

The most economical lithium-ion battery in terms of cost-to-energy ratio is the cylindrical 18650 (size is 18mm x 65.2mm). This cell is used for mobile computing and other applications .If a slim pack is required, the prismatic lithium-ion cell is the best choice. These cells come at a higher cost in terms of stored energy.

Advantages

- High energy density potential for higher capacities.
- Relatively low self-discharge
- Low Maintenance
- Specialty cells can provide very high current to applications

Limitations

- Requires protection circuit to maintain voltage and current within safe limits to avoid damage of batteries.
- Storage in a cool place at 40% charge reduces the aging effect.
- Shipment of larger quantities may be subject to regulatory control. This restriction does not apply to personal carry-on batteries.
- Expensive to manufacture, about 40 percent higher in cost than nickel-cadmium.
- Metals and chemicals are changing on a continuing basis.

Lithium Polymer:

The lithium-polymer differentiates itself from conventional battery systems in the type of electrolyte used in it . The original design contains a dry solid polymer electrolyte. The polymer electrolyte is replaced by the traditional porous separator, which is soaked with electrolyte.

The dry polymer design is made just simple with respect to fabrication, ruggedness, safety and thin body. the dry lithium-polymer suffers from poor conductivity. The internal resistance is too high and cannot deliver the current bursts needed to power modern communication devices and spin up the hard drives of mobile computing equipment.

Heating the cell to 60°C (140°F) and higher increases the conductivity, a requirement that is unsuitable for portable applications. To compromise, some gelled electrolyte has been added. The commercial cells use a separator/ electrolyte membrane prepared from the same traditional porous polyethylene or polypropylene separator filled with a polymer, which gels upon filling with the liquid electrolyte. Thus the commercial lithium-ion polymer cells are very similar in chemistry and materials to their liquid electrolyte counter parts.

Advantages

- Batteries resembling the profile of a credit card are feasible.
- Flexible form factor - manufacturers are not bound by standard cell formats. With high volume, any reasonable size can be produced economically.
- Lightweight
- Improved safety
- Less chance for electrolyte leakage.

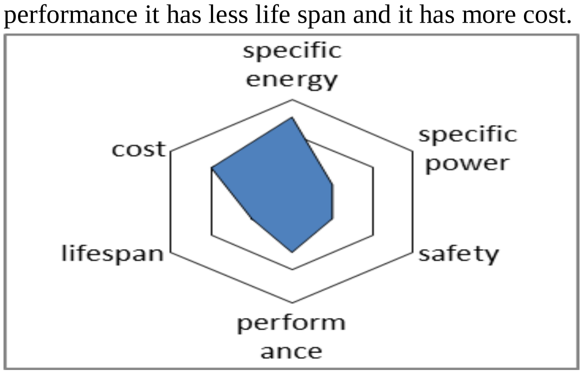
Limitations

- Lower energy density and decreased cycle count compared to lithium-ion.
- Expensive to manufacture.
- No standard sizes. Most cells are produced for high volume consumer markets.
- Higher cost-to-energy ratio than lithium-ion
- Restrictions on lithium content for air travel

Characteristics of different types of batteries (including specific energy, cost, specific power, safety, performance, life span)

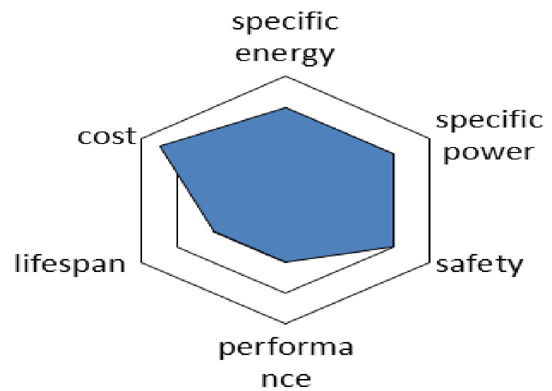
Li-cobalt Battery (LCO):

It has maximum specific energy and moderate specific power also it has moderate safety and good performance it has less life span and it has more cost.



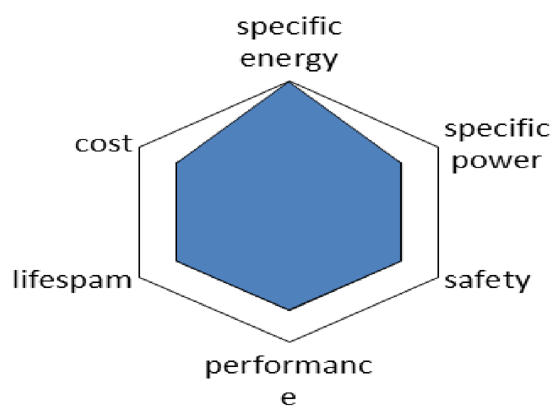
Lithium Manganese Oxide (LMO):

Its has moderate specific energy. Moderate specific power. It has moderate safety. Less performance and les life span and high cost.



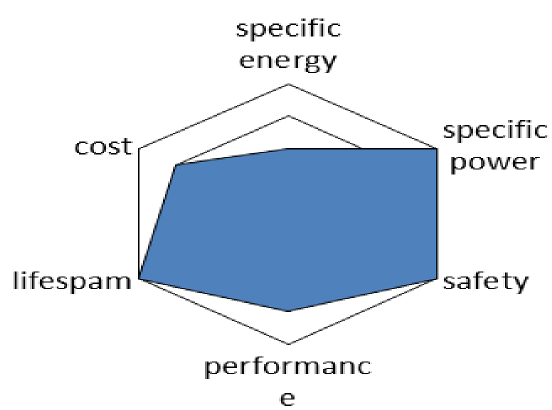
Lithium nickel Manganese cobalt oxide (NMC):

It has excellent specific energy more specific power, moderate safety, moderate lifespan, moderate cost.



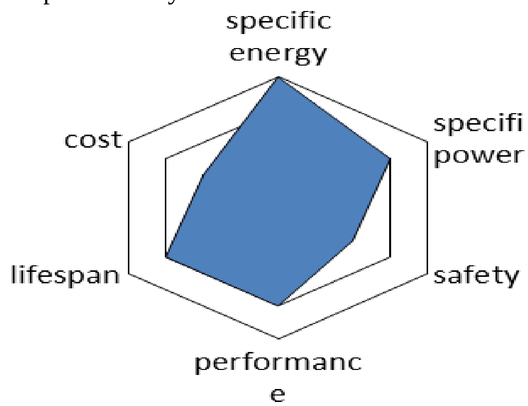
Lithium iron phosphate (LFP)

Its has very low specific energy, but maximum specific power, safety, performance and lifespam and moderate cost.

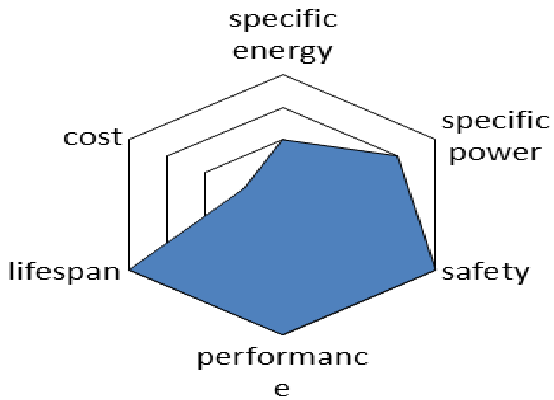


Lithium nickel cobalt aluminum oxide(NCA)

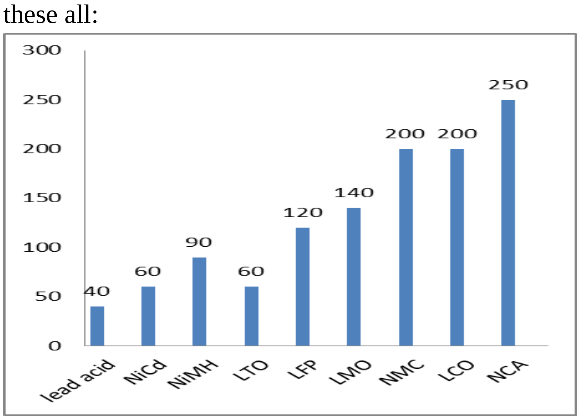
It has maximum specific energy moderate specific power, less safety, less performance .also it has more life span and very much less cost.



Lithium titanate(LTO)
It has maximum performance, maximum safey, and maximum lifespan .also it has moderate specific power. But it has less specifc energy and it is very much cheaper.



The following graph shows the best battery among these all:



4) Battery management system:
There are lots of factors that are to be considering while designing a bms the complete consideration depend on exact end application in which the bms will be used. Apart from evs bms is used in many places such as solar panel array, windmills, power walls, etc. following factors should be consider while designing a bms:

Discharging control
The main function of bms is to maintain lithium cell within the safe operating region. For example a typical lithium 18650 cell will have an under voltage rating of 3 volts. Hence it is responsibility of the bms to make sure that none of the cell gets discharge than 3 volts.

Charging control
Apart from discharging the charging process should also be monitored by bms. Most of the batteries gets destroy of get reduced lifespan because of inappriopate charging
For the lithium battery charger a 2 stage charger is used. The first stage is called as constant current (CC) during which the charger gives output for constant current to charge the battery. when the battery gets nearly full the constant voltage (CV)stage is used during which the constant voltage is suppy to battery at very low current . the bms should take care tthat the both current and voltage should not excced the permissible limit so as not to over change or over charge battery. The maximum voltage and maximum current would be found on the battery datasheet.

State-of-Charge (SOC) Determination
We can think SOC as the fuel indicator of the EV. It actually tells us the battery capacity of the pack in percentage. Just like in our phone. The voltage and the current charge/discharge should be monitored always to predict the capacity of tank.onces the voltage is measured there are lots of algorithm that are to be calculate the SOC of battery pack. The most common method for measuring is the coulomb counting method. Measuring the values and calculating the SOC is also the responsibility for BMS.

State of Health (SOH) Determination
The capacity of battery does not depend on voltage and current but also on its age and operating temperature. The SOH tells us the age and expected

life cycle of the battery based on usage history. This way we can find out the mileage of the EV reduces as the batter ages and also we can know the time to replace battery. The SH should be calculated and kept track by BMS.

Cell Balancing

This is another main function of BMS to maintain balancing of cell. For example I a cell pack of 4 cells connected in series the voltage of all four cells should always have equal .if one cll is less or high voltage than the other it will affect the entire pack. , say if the one cell is of 3.4 volts while the other cell is at 4 volts. During charging one cell will reach 4.2 volts while other one would just reach 3.7 volts similarly this cell will be first to discharge to 3volts before other three one.

Hence, all the cells should be of same current and voltage rating. in series or parallel combination according to design.

Thermal control

The life and efficiency of a lithium battery depend in thermal operating temperature. The battery tends to discharge fast in hot climate as compared to that in room temperature. Consumption of high current would increase temperature. this work of thermal system is to maintain low temperature during hot climate and cold climate within permissible imit.

The BMS is responsible for measuring the individual cell temperature and control the thermal system and maintain accordingly overall temperature of the battery pack.

5) Charging system:

Just like you plug in your cell phone to charge the battery at home, plugging in your electric vehicle to charge works in most the same way. In fact, rechargeable electronic devices and electric vehicles both use similar kinds of batteries, usually either lithium ion batteries or nickel-metal hydride batteries. These batteries have high energy storage density and are rechargeable, making them ideal for electric vehicles. However, to charge these batteries requires special chargers to boost the battery charge level while balancing safety and efficiency.

ESVE Charger

For electric vehicle owners plugging their car in at home, an ESVE charger is what is required. An ESVE charger is any device that brings AC electricity from your mains source to be converted to DC electricity in your electric vehicle battery. There are a number of different types of EVSE chargers, and it's important to choose the right one for your needs. A certified electrician can help advice you which EVSE charger will charge your car most efficiently while being safe and effective for your home.

Level one charging - esveLevel 1 charging

Level 1 charging is the technical name for simply plugging your electric vehicle charger into an outlet in your home. This means level 1 charging uses your 120-volt power supply to charge your electric vehicle. Level 1 charging is the slowest and cheapest form of charging for electric vehicles. It's easy to get 40 miles of charge from a level 1 charger overnight, which is generally enough for most commutes and daily use. Of course, specific charging rates and vehicle range depend on your vehicle model and ESVE charger type.

For most vehicles, level 1 charging equals about 4.5 miles of charge per hour. It sounds unimpressive, but level 1 charging is the most basic level of charging you can choose. Talk to your local electrician about installing a level 1 EVSE charger, or to discuss whether upgrading to a higher efficiency charger would be better for you.

DC Fast Charging

DC fast charging is the standard for public electric car charging stations. Pumping 40 miles worth of charge into an electric vehicle every 10 minutes, DC fast charging is the most efficient and rapid form of charging. However, these stations are very expensive with a price tag of around $100,000, and use more power than your house, so chances are you'll never have one at home. This charging technology is used in commercial charging stations and is a great way to top up the charge on your electric vehicle while on the go.

Level 2 Charging

Level 2 charging is the middle ground between Level 1 charging and DC fast charging. This form of charging uses higher power 240-volt electricity to

charge your electric vehicle more quickly. The electricity passes through the charging box and a cord to improve safety, and a level 2 EVSE charger can offer a range of charging powers.
esve charging station The maximum charging rate of most EVSE level 2 chargers is around 19.2 kilowatts (kW), or about 70 miles of range per hour. Because these specialty level 2 EVSE chargers use more electricity, they require expert installation by a licensed electrician. In some cases, new wiring and electrical infrastructure may also need to be installed by your electrician. Level 2 EVSE charging stations are the preferable electric car charging option for those who want to fully charge their electric vehicle at home. Some grants are available for new EVSE charger installation, so talk to your licensed electrician about your options to secure the right electric car charging station for the right investment.

CONCLUSION

In this paper i have concluded the various batteries that can be used for e vehicle.

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