An overview of Performance evaluation of battery and motor of an electric vehicle

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Abstract

The performance and evaluation of an Electric vehicles involves the various parameters like the overall performance of vehicle,safety of person , environmental friendliness etc. A growing issue in today'sworld are related with environmental protection and energy conservation.The automotive manufactures are developing various alternatives for the existing fossil fuels driven vehicles. There are many inventions going for Electric vehicles and Hybrid Electric vehicles about price fluctuations , improving range of the vehicles and global warming also. The main contribution of this work lies in comparative study of different types of the motors and batteries. This study will help us for making a superior electric vehicles with more advantages. The performance and evaluation of Electric vehicles will also help us for making an efficient vehicles and providing safety of vehicles.

Key-words: *Motor,Battery,Performance,Hybrid*

Introduction:

In recent years, many existing automobile manufacturers and new dedicated companies have put a remarkable effort in transforming the conventional vehicle into an Electric Vehicle that provides green and reliable solution. In terms of market share, EV demand is raising. It starts replacing conventional vehicle In USA, Europe and Asia. EVs are clean due to their zero local emissions and low global emissions. They are also green due to their environmental friendliness, since electricity can be generated by renewable sources. Despite these obvious benefits, EVs have not been widely used around the world; the key reasons are due to their high price, short driving range or lack of charging facilities. Air pollution is also another important concern. EVs provide low emission urban transportation, even taking into account the emissions from power plants needed to fuel the vehicles, the use of EVs can reduce carbon dioxide (CO2) emissions significantly. From the energy aspect, EVs are efficient and environmentally friendly. Thus, EVs are promising green vehicles that can reduce both energy consumptions and CO2 emissions.

Battery selection parameter

A. <u>Energy and Power</u>

The battery does not discharge at the theoretical voltage due to internal losses and cannot completely deliver the theoretical ampere-hours. The specific energy can be expressed in volumetric terms *(Wh/L)*, where "Z" is the volume.

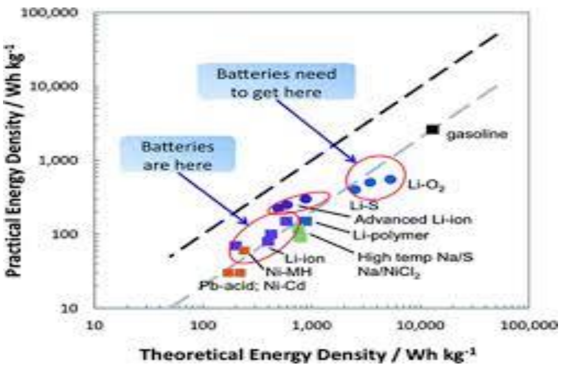


Fig.1: Practical Vs theoretical energy density.

• <u>Specific power</u>*:* This is the maximum power per unit weight that the cell (or battery) can produce in a short time period and is expressed in *W/kg.* It mainly depends on the internal resistance of the cell.

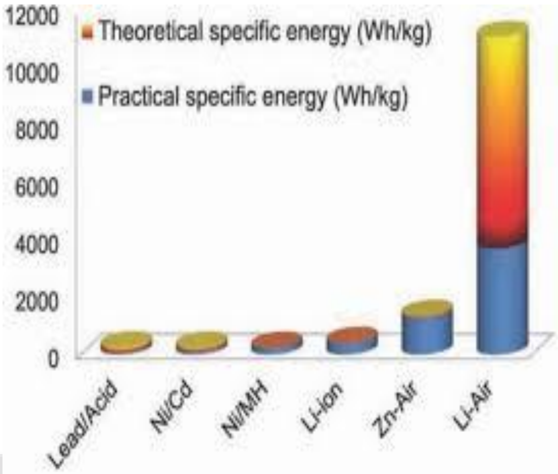


Fig.2: Theoretical Vs practical specific energy.

B. <u>Energy Efficiency</u> :

The energy and power losses during battery discharge appear in the form of voltage loss. The efficiency at a given operating point during discharge is therefore defined as the ratio of the cell operating voltage to the theoretical thermodynamic voltage.

C. <u>Life of the battery</u>

• <u>Cycle life</u>*:* This is defined as the number of complete charge/discharge cycles a battery can perform before its capacity falls below 80% of its initial rated capacity.

• <u>Calendar life</u> : This is the elapsed time before a battery becomes entirely unusable.In addition to these criteria, the battery selection is also dependent on the range of ambient temperature over which it is expected to perform satisfactorily.

<u>Battery performance factors :</u>

The parameters listed above are used to adjudicate the performance of the battery and select the most appropriate combination in accordance with a specific application. These parameters are influenced by many factors, thus varying the battery performance. The major performance affecting factors are listed below:

• <u>Current drain of discharge</u>: The battery performance is related to the rate of discharge current. With the increase in the current, the ohmic losses and polarization effect increase, thus reducing the discharge voltage and service life of the battery.

• <u>Mode of discharge</u>: The battery can be subjected to three modes of discharge namely the constant current, the constant load and the constant load mode. These variations in discharge have significant effect on the battery performance. Thus, the mode of discharge is applied after performing appropriate tests for a specific application.

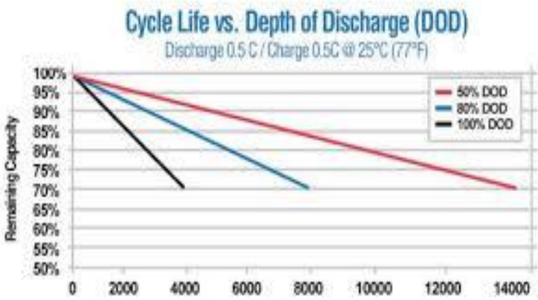


Fig 3: Cycle life Vs Depth of Discharge.

• Battery temperature: The battery temperature during discharge has pronounced effect on its capacity and voltage characteristics. At lower temperatures, the battery capacity decreases, the internal resistance increases, resulting in more losses and less efficiency. At higher temperatures, the resistance decreases, resulting in higher discharge voltage. But, after the optimum operating temperature of the battery, the chemical activity increases to an extent where it is rapid enough to cause a net loss in capacity.

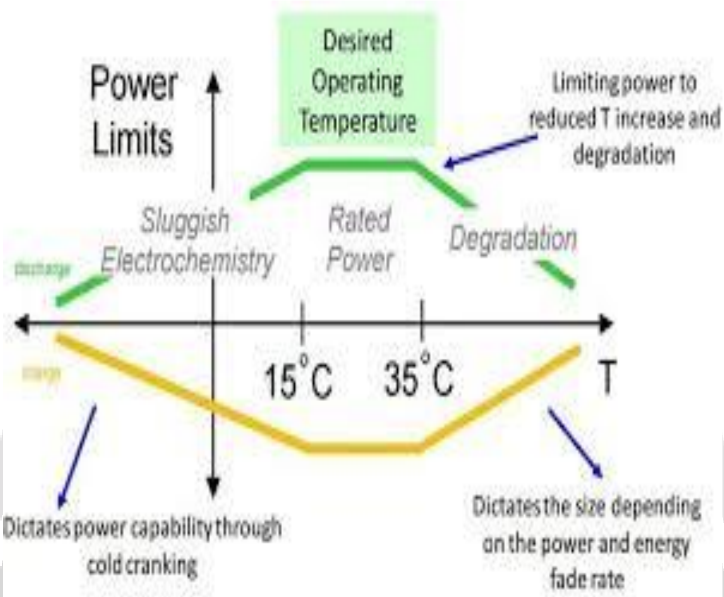


Fig.4: Power limits Vs temperature

• Type of discharge: The battery can be subjected to continuous or intermittent type of discharge. The types of discharge result in certain physical and chemical changes in the battery that are reflected in its performance. When a battery stands idle, after undergoing a deep discharge, the voltage will rise after a rest period, giving a saw tooth shaped discharge and enhancing the service life.

• Duty cycles: The variation in discharge current during a single duty cycle results In a significant variation in battery performance. Moreover, with the number of duty cycles, there results in permanent change in the chemical and physical property of the battery. These changes also affect the battery performance.

Charging mode: Similar to the discharging procedure, the different charging modes such as constant current, constant current constant voltage, constant voltages affect the battery performance.

Table No 1:Comparison of Different Batteries

Parameters	**Lead acid-battery**	**Ni-mh Battery**	**Li-ion battery**
Voltage(V)	2.1	1.2	3.2
Energy density(Wh/kg)	35	80	150-200
Power density(W/kg)	110	230	500
Discharge Life	400	700	1000
Charge Rate	Medium	High	Medium
Cycle Life	50-100	500	2000
Cost	low	Medium	medium

Different types of motors :

1.Direct Current Motors :

DC brushed motors can accomplish high torque at low velocities, shaping them to be appropriate for traction framework. However, poor power density is a downside of brushed DC motor for accounting in electric vehicles. DC brushless motors in the contrary provide better efficiency and have less maintenance.

2. Induction Motors :

Three phase induction motors are generally utilized in electric vehicles in view of immense proficiency, great speed control and no commutator. 3-phase AC supply is associated with stator winding, thereby building up the rotating magnetic field. A.C Induction Motor Drive is ideally utilized in E.V.

3. Permanent Magnet Synchronous (PMS) Motors :

In synchronous motor, rotor pivots at synchronous speed. The rotor is energized from a DC supply, although the stator is associated with a 3-phase AC supply. PMS motors are also known as brushless AC motors. Regarding the vitality productivity, the most effective motor is the Permanent Magnet (PM) Brushless Motor Drive, pursued by Induction Motor having relatively comparable effectiveness. As a matter of fact, numerous vehicle makers, (for example, Nissan, Honda and Toyota) have effectively utilized these motors.

4. Permanent Magnet Brushless DC and AC Motors :

One more sort of motors in options to utilize is the permanent magnet brushless dc motor. These are accessed by for all intents and purposes transforming the stator and rotor of the permanent magnet dc motor. Despite the fact that their setup is relative to the PMS motors, the BLDC motors are fed by an AC supply that is rectangular in nature as opposed to a sinusoidal supply. Another benefit of PM BLDC motors is their capacity to deliver a greater torque when contrasted with other motors at similar apex amount of current and voltage.

BLDC motor in electrical vehicles :

BLDC (*Brushless Direct Current*) motor is an electric engine that converts electrical energy into mechanical energy. Today the use of BLDC motors has been widely applied to various fields, such as electric vehicles, industry, and housing. The use of BLDC motor is due to their characteristics that are easily controlled, high speed, little *noise*, and high durability. To support the performance of the BLDC motor, several observations are needed on the motor parameters including magnetic field density, voltage, EMF back voltage, current, rotor speed, torque, and efficiency of the motor. BLDC motor parameters can be affected by factors originating from the environment and surrounding conditions, thus affecting the characteristics of the motor.

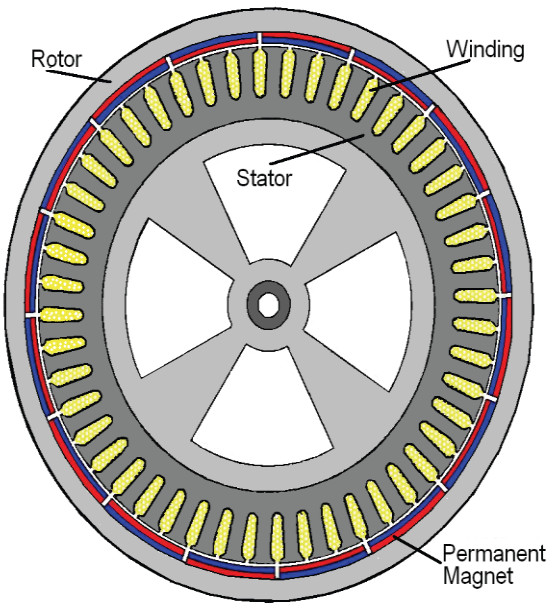


Fig. 5. Cross section of the BLDC Motor

Theoretical Analysis :

An attempt has been made to analyze five diverse electric motors for electric vehicle application on various paradigms. Relative assessments shall demonstrate the accompanying highlights.

1. DC motors are difficult to control, provide large torque at curtailed speeds yet possess major support cost, expansive structure, and deficient efficacy.

2. BLDC motors have advanced power density, high productivity and small size, yet up keeping costs and controller expenses are huge.

3. 3-phase IM give productivity over 91%. They have extreme fidelity, low power density and substantial area, ease furthermore, and average acceleration. BLDC motors and 3-phase IM are the two most preferred engines by EV makers.

4. Synchronous machines have greater proficiency at lesser accelerations and enhance battery usage and propulsive extent. Synchronous motor is favoured wherever steady torque is needed.

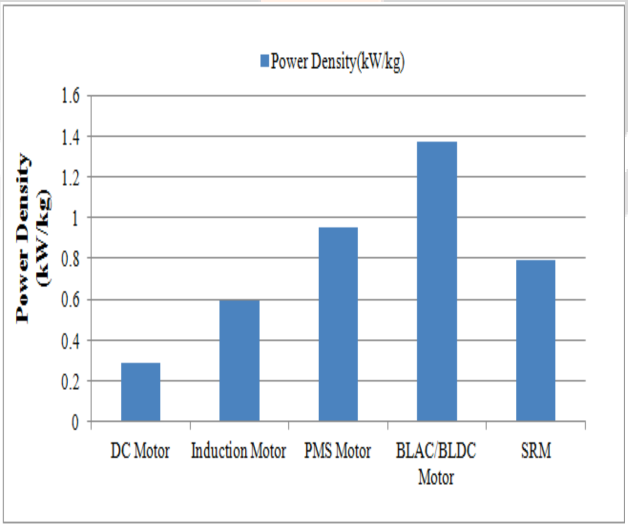
5. SRMs give an extraordinary option with motor/controller cost being very less, reliability, good efficiency, and adaptation to internal failure capacity

Comparative Study of the Electric Motors :

The motive of this paper is to establish a correlation among the different electric motors used in electric cars by manufacturers and the factors that are considered to choose any of the motor to be best suited to them. The observation has been made on the specific parameters.

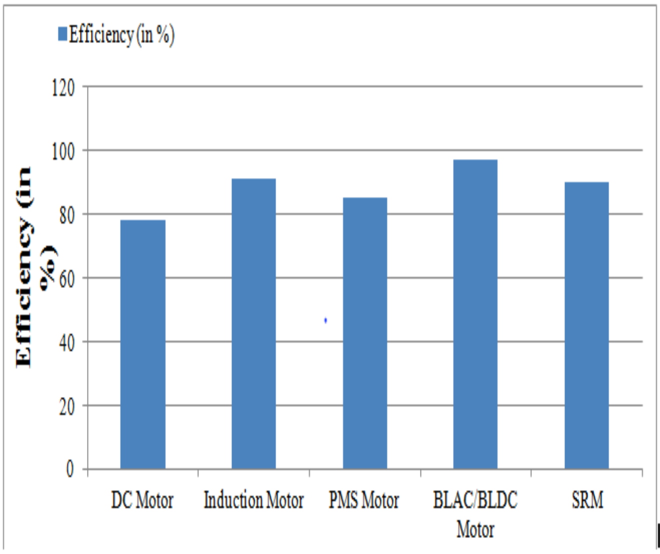
1.Power Density :

Power Density is capacity-to-weight proportion of any electric motor and is normally computed utilizing the motor apex power. Power density for any motor is acquired by subdividing the apex power yield (in kW) by mass (in kg) Measurement unit of power density is kW/kg.



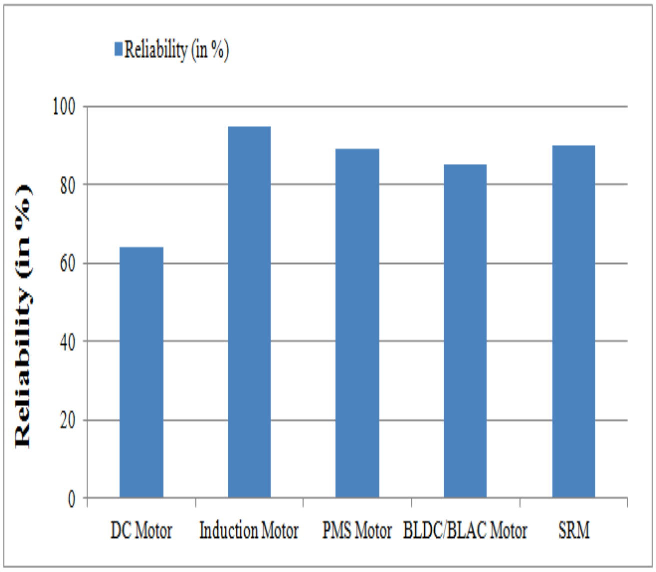
2. Energy Efficiency :

Electric motor efficiency provides us connection among electrical and mechanical yield. Every single electric motor is generally intended to work at maximal efficiency at measured output. It is observed that BLDC motor gives the best energy efficiency (greater than 95%) followed by Induction Motors (greater than 90 %) Indicate references by Ahmed A. AbdElhafez, 2017.



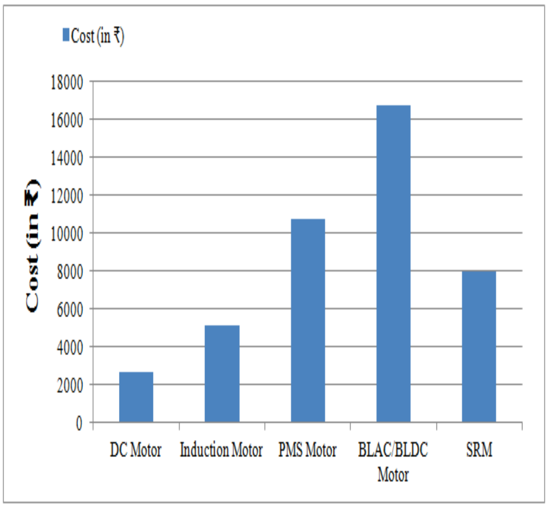
3. Reliability :

Presently comparing based on fidelity of the Electric Motor that is breakdowns and support ought to be least, utmost reliable ones are IM and SRM as indicated by Gagandeep Luthra, Gaurav Nanda and Narayan C. Kar, 2017. dependable is the DC Motor. DC motor brushes It is pursued by PM motors. Slightest and switches enter current in the armature, along these lines and hence are less decisive and ill-equipped for maintenance free task.



4. Cost Factor :

One of the vital difficulties in front of electric car producers is providing customer an EV belonging to same class as fuel vehicle yet inside a moderate cost. The ultimate to be utilized here are the IM pursued by the DC and SRM Motors. The induction engines are accepted by most manufacturers for the EV applications since they are economical. For large capacity motor, the price of DC motor is much higher than that of AC motor of same capacity. If two motors are with the same power capacity are compared, a higher speed, lower torque motor will cost less than a lower speed, higher torque motor.



Conclusion

- By comparing Performance of all above motors and Batteries it is observed that in batteries, li-ion battery gives low discharge rate and charging time as well which is our primary need of an electrical vehicle as well as these batteries also have high energy density, so we can conclude that Li-ion battery is more suitable for any kind of electric vehicle than all other batteries .
- By studying all above motors we found performance of brushless direct current (BLDC) motor is more efficient and suitable for an electric vehicle.

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