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Electric Motors Used in Electric Vehicle Applications: A Review

Saneep K[1], Dr. Vasanthi V[2], Abeena A[3]

PG Student [Power Electronics], Dept. of EEE, NSS College of Engineering, Palakkad, Kerala, India[1]

Associate Professor, Dept. of EEE, NSS College of Engineering, Palakkad, Kerala, India[2]

Assistant Professor, Dept. of EEE, NSS College of Engineering, Palakkad, Kerala, India[3]

ABSTRACT: The environment should be clean and pure then only the lives becomes possible for the next decade. For this, the vehicles handle a major role. The use of Combustion engine makes more hazardous gases and environmental issues. It overcome by the development of electric vehicles. We need to conclude the most efficient and cost effective design for the same. Here conducting a review on the basis of electric motors Incorporated with the electric vehicle. The basic element of a drive Is the electric motor. This Is handled by the different types of motors AC,DC Reluctance motors…etc. The review carried out on dofferent motors on the basis of different parameters like Design aspects, cost, ruggedness and efficiency. Finally, we prove Brushless DC motor is most suitable and efficient drive for an electric vehicle.

KEYWORDS: Electric Vehicle, EVs, Electric Drive, Renewable Energy

I.INTRODUCTION

The energy is essential for large applications like industrial application, transportation, domestic applications, and agricultural application. Energy may be in different forms like light energy, heat energy, electrical energy, chemical energy, and nuclear energy. From these forms the electrical energy becomes more popular and convenient form of energy. This is one of the most diverse forms of energy, that shaping the vision of transmission, distribution and control.

The usage of energy plays a very important role in one's life. The adequate and acceptability of energy makes more popularity in the development. Moreover, it increase the level of individuals. There is an important bond between the social development and use of energy. The a study about the relation between the development and energy gives a conclusion that, those countries having high capita annual energy consumption have high literacy rates. Similarly, countries with low capita energy consumption have lower literacy rate. For an example, the US has more than 12,000kWh per year capita annual energy consumption rate while it is just over 600kWh per year in India.

Now the energy has an important role in our life. So that the use of energy become secure and sustainable. At the same time, it must be economical, environment friendly and socially acceptable. Nowadays the energy consumption is not secure and sustainable. The increasing consumption of fossil fuels causes the increase in greenhouse gas emissions It threaten our safe supply of energy and effects the environment. Inflation could lead to worldwide recession and environmental impact could lead to irreversible change in global climate. The lack of adequate energy supply will hinder the growth of billions of people living in developing countries. So that for a developing country it must give priority for clean, safe and sustainable energy sources.

Electric motors are classified into three categories, namely DC motor, AC motor and special purpose motors. From this, the DC motor again classify into different types, they are Series wound, Shunt wound, Compound wound and Permanent Magnet DC Motor. Similarly, AC Motor are categorized into, synchronous motor and asynchronous induction motor. Moreover, there are some motors where we use commonly for a special purpose. They are named as special purpose motors and some of them are stepper motor, servomotor, linear induction motor etc.

The motor consists of two main part, namely field winding and armature winding. The field winding used to generate magnetic field and the armature winding gives the spot for conductors. Due to the interaction of magnetic field and armature conductors, the rotor experiences a force that cause to generation of required torque to rotate the motor.

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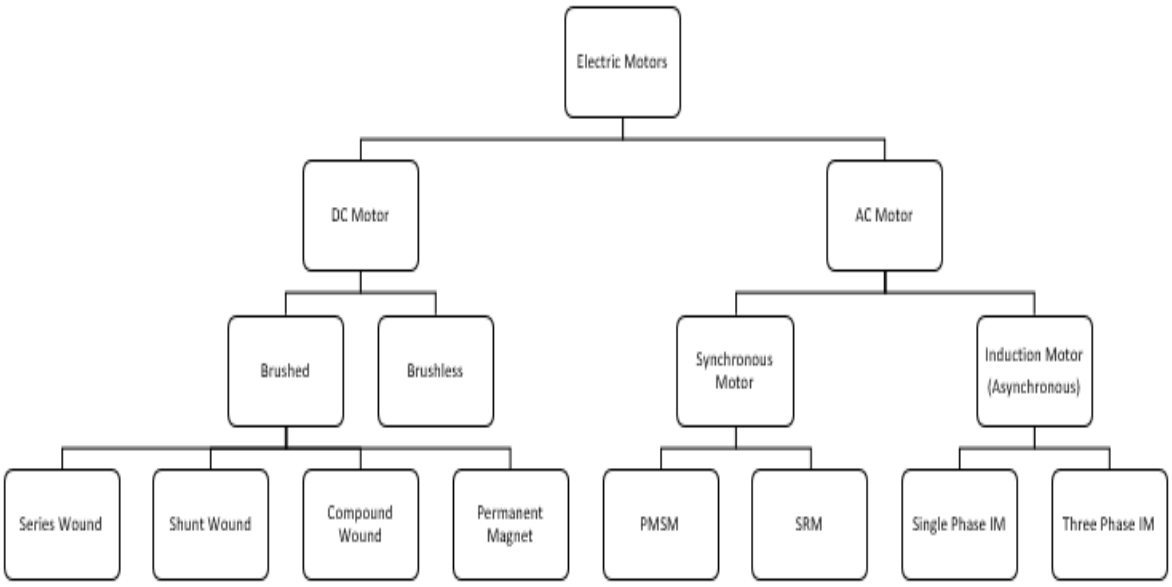

Fig. 1 Classification of Motors

II. ALTERNATING CURRENT MOTORS

A. Synchronous Motor

These type of motors operated using three phase AC supply. The stator part develops Field current,and this current rotates with a constant speed, which is depending on the frequency. The rotor part of this machine follows the same speed of stator current. For an ideal motor, there is no gap between them. The reason behind name "Synchronous Motor" is the behavior of rotating in the same speed or synchronously with the stator current. These type of motors are used in robotics, automation systems etc.

Basically,it is single phase motor, and it is similar to cage type induction motor when considering constructional features. The rotor construction is similar to squirrel cage and the stator has two part, main winding and auxiliary winding. The auxiliary winding help to smooth starting of the machine.

i. Permanent Magnet Synchronous Motor

In [10] authors addressed a PV based PMSM drive for water pumping system. Depending upon the head and flow rate, the power delivered from PMSM to motor. A DC_DC boost converter is used to obtain a constant DC voltage while inverter along with SPWM is used to obtain AC voltage for PMSM drive. The major advantage offered by the proposed system is that it can be modified to any power level as per requirement by connecting more PV panels in series.

Analyses the performance PV array and battery fed four wheeler EV under various load and driving mode conditions. Inspired by various features like small size, light weight, high power density and small moment of inertia Permanent Magnet Synchronous Motor (PMSM) is readily invoked for the design of electric vehicle. Simulation results shows that the proposed work shows far better performance as the use of PV module reduces battery power consumption and PMSM motor drive effectively tracks the speed trajectory. Additionally the whole system can met the speed and torque requirements during dynamical switching between two sources, thus can be used as the drive train for EV [19].

ii. Switched Reluctance Motor

In [2] Dhumal et al considers a solar PV array fed water pumping system using Switched Reluctance Motor (SRM) drive. The visible benefits of using the proposed motor drive includes low cost , improved efficiency and high reliability which mainly comes from its simple construction. The usage of DC-DC boost converter under Continuous Conductance Mode (CCM) reduces stress on the converter while providing balanced voltage to Asymmetrical Power Converter(APC). Oscillation occurring at MPPT is avoided by incorporating Incremental Conductance (INC) MPPT techniques. The MATLAB simulation results shows that the efficiency of the introduced water pumping system is far better compared to other systems based on either DC or induction motors.

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A low cost SPV array fed Switched Reluctance Motor (SRM) drive for water pumping system is devised in [11]. Incremental Conductance (INC) algorithm with MPPT technique is adopted to enhance the efficiency of pumping system. Voltage pulses for phase wind excitation are provided with the help of a mid-point converter having two split capacitors. Furthermore, PI based controller is used as the control system for four phase SRM drive for minimal torque ripples and speed control. A DC-DC cuk converter is made to operate in CCM mode to reduce stress level on converter elements by lowering the ringing effect and thus improves the efficiency of overall pumping system.
Switched Reluctance Motor (SRM) as candidate for EV is demonstrated in [12]. SRM is chosen as strong candidate for powering EV as it possesses advantages like ruggedness and manufacturability because of the absence of concentrated rings and magnets. High efficiency, extended power region and low foreseen manufacturing cost also prove applicability of SRM motor drives as the drive train for EV applications.
A water pumping system using SRM drive is discussed in [23]. A DC-DC boost converter operating in Continuous Conduction Mode (CCM) is used to manipulate dc-bus voltage which in turn controls the velocity of SRM motor. Advantages of operating the converter in CCM mode are reduction the ringing impact, decrease in losses on switching elements and minimum switching pressure on converter. Incremental Conductance (InC) MPPT helps in smooth starting of motor by providing non-stop input/output current to motor. In addition the model shows superior performance over various insolation stages.

B. Asynchronous (Induction Motors)

This type of motors are very familiar and uses for many applications in our daily life. In this type of AC motor the speed of rotor is less than that of synchronous speed, and the speed also depend on the load connected to it. That is the connected load in the motor is greater, then the speed of rotor will be low. The Asynchronous or Induction Motor is classified two types based on the construction of rotors, they are Slip ring and Squirrel cage type. These types of motors are used in large applications like water pumps, mixer grinders, small table fans and fruit juicers etc. These motors are operated with 230V AC supply. Moreover, there is another classification of the motor is three phase Induction Motor, this uses 415V AC supply for operation. They are used for heavy application like air compressor, blowers and big size cooling fans etc.
[1] Proposes a architecture for single phase induction motor electric vehicle combined with buck/boost converter. The architecture is an integration of MPPT SEPIC converter, bidirectional buck/boost converter and an induction motor. SEPIC converter used for power extraction from solar PV also ensures a safe battery recharge. It is noteworthy that for high power processing the single phase induction motor can be replaced by three phase motor without changing other driver setup. The analytical results show that the system has enhanced efficiency through regenerative breaking and is highly eco-friendly.

III.DIRECT CURRENT MOTORS

A. Brushed DC Motors.

The Brushed DC motors are commonly used in the past. The main advantage of this type of motor is that it becomes cost effective. So that the motors required for a cost effective application these type of motors are selected. The control topology for this motor quite simple. These motors have large applications like industrial and consumer etc. They classified into DC series, shunt, compound and Permanent magnet DC motors.
In [3] formulates a cost effective method of utilizing solar power for driving and speed control of BLDC motor, which are commonly used in solar powered electric vehicle. The speed control is carried out by feeding the DC bus rated voltage the motor windings. Furthermore a boost converter is used to boost the input voltage to a high voltage that is required by the motor. A PI controller is integrated in the system to regulate the motor speed. The simulation results validates that the proposed system has high accuracy and robust operation from zero to high speed levels.
Solar PV fed DC motor speed control system is devised in [9]. The prototype make use of IC MPPT algorithm to extract maximum available solar power in such a way that the duty cycle of boost converter is adjusted within the algorithm itself without going for a separate control loop. The system is the integration of PV array, battery, boost converter and additionally a speed sensor and MOSFET to control the speed of PMDC motor. Better performance and fast tracking without any oscillations are the key advantages offered by the prototype.

B. Brushless Motors

Brushless motor is an advancement of Brushed motor. So that these types of motors can eliminate the problems involved in Brushed Motors. They have long life span and simple design as compared to DC motors. One of the important part of this motor controller is the Hall Effect sensors. They are used to locate the rotor position. By using this information from hall effect sensor the motor controller controls the speed accurately by controlling the current through the rotor coils. The advantages of this technology are the longevity, short maintenance and high efficiency

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(85% - 90%), while the drawback is high initial cost and more sophisticated controllers. Such motors are commonly used for speed and positional control with applications such as fans, pumps, and compressors that require reliability and ruggedness.

Electric vehicle using BLDC motor drive is devised in [5] as it possess many advantages like high efficiency, high torque, reduced noise, longer life time and easy speed control. Lead-acid batteries are used to energize the BLDC motor. The aforementioned system can be further be improved by using renewable energy sources like solar power to energize the battery which can make the system more efficient and eco-friendly. Although BLDC motors are of high power rating, it has the potential drawbacks as that it is highly expensive, it requires matching controller and coupling of the motor is time consuming and complex.

Gives attention to a solar powered BLDC Motor driven EV which make use of the renewable solar energy. The system is the integration of PV module, controllers, batteries, boost converter and BLDC motor. Designed prototype is subjected to various real time test conditions and the simulated results verified its satisfactory working under heavy load conditions. In addition the rate of battery discharge is directly affected by the load [14].

Have explored an eco-friendly solar PV powered electric vehicle which can effectively overcome the key issues of fuel , noisy operation and pollution. The battery is charged from solar PV modules and thus it completely builds a green environment. MPPT controller is used to transverse the maximum power point in the solar panel. In addition Buck-Boost converters are used to boost up the DC voltage coming from battery whose output is then directly applied to an inverter .Inverter convert DC power to AC power which can track the BLDC motor in an electric vehicle application. The key benefit of the projected system includes higher efficiency, power density and various speed levels [4].

IV.RESULT AND ANALYSIS

From the detailed study, we conclude it into a Table. It gives the clear idea about the Electric Drive system and Motor to be used. When we design Electric Vehicle only based on efficiency we select BLDC Drive. PMSM Drives are more cost effective and Reluctance Drives are less cost as compared to the given motors. By comparing these motors on the parameters like Efficiency, cost and weight the efficient and suitable electric drives can be selected.

Table no 1: Comparison Between of Different Types of Motors

Motors	Brushed Motor	Brushless Motor	Reluctance Motor	Induction Motor	PMSM	Synchronous Motor
Efficiency	1.5	5	3.5	3.5	4.5	3
Weight	2	4.5	4.5	4	4	4
Cost	5	4	4.5	4	2	3
Total	**8.5**	**13.5**	**12.5**	**11.5**	**10.5**	**10**

V.CONCLUSION

In this work, a review is carried out based on different types of motors used as Drive in the Electric Vehicle Application. Here presented a discussion based on a detailed study of the Operation, Working principles, other features and drawbacks of different motors available. Finally, because of study carried out it can be concluded, as the brushless DC motor becomes the most efficient and suitable for Electric Vehicle Application. This motor offers high efficiency, high power density and easily available. Due to these characteristics, this motor is popularly used as Drive for Electric Vehicle.

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