DESIGN AND FABRICATION OF MOTOR AND TRANSMISSION SYSTEM FOR AN ELECTRIC VEHICLE

A PROJECT REPORT

Submitted by

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In partial fulfilment for the award of the degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

SAVEETHA ENGINEERING COLLEGE

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ACKNOWLEDGEMENT

We wish to express our sincere thanks and heartfelt gratitude to our honourable and beloved Founder President **Dr. N. M . Veeraiyan**, our director **Dr. S. Rajesh** and **Dr. Saveetha Rajesh**, Managing Trustees for their support through the institution.

We express our gratitude and sincere thanks to Prof. **Dr. N. Durai Pandiyan**, Principal, Saveetha Engineering College, for providing us the necessary facilities and opportunity to carry out this project.

We take immense pleasure to thank **Dr. N. Balaji Ph.D.** Head of the Department of Mechanical Engineering for his valuable guidance, encouragement, suggestions, and advise towards nourishment of our career

We express our sincere thanks to our project coordinator **Dr. A. Thamaraiselvan M.E.,Ph.D.** Associate Professor, for his unstinted guidance at every stage. His constant encouragement and advice provide provided us with a drive to see that endeavour reaches the level of excellence required in this field.

We are extremely indebted to all the staff members of Department of Mechanical Engineering, for their continuous guidance. Our special thanks to our parents who motivated and helped us to make this project a successful one.

We take this opportunity to express our gratitude to all, whose Contribution in the project work can never be forgotten.

ABSTRACT

This project involves the conversion of a conventional internal combustion engine car into an electric vehicle (EV), employing a 2 kW BLDC motor and adapting the existing 5-speed gearbox from a Maruti Suzuki 800. The initiative seeks to seamlessly integrate electric propulsion into the established automotive framework, emphasizing the recycling and repurposing of components for a sustainable approach. The chosen BLDC motor is incorporated into the vehicle's engine compartment, interfacing with the gearbox to facilitate a five-speed transmission.The conversion also entails designing a battery system, power electronics, and a cooling system to optimize the electric drivetrain's efficiency and ensure thermal stability. Safety measures, regulatory compliance, and performance testing are integral aspects of the project to guarantee the converted EV's reliability and adherence to standards. Beyond the technical intricacies, environmental considerations guide the project, emphasizing responsible disposal of internal combustion engine components and the use of eco-friendly materials. Ultimately, this endeavor represents a comprehensive approach to EV conversion, harmonizing traditional automotive design with contemporary electric propulsion technologies for a cost-effective, sustainable, and performance-oriented urban transportation solution.

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NOMENCLATURE

LIST OF ABBREVIATIONS

S.NO	UNITS	FULL FORM
1	kg	Mass
2	W	Watts
3	kW	Kilowatts
4	m/s	Velocity
5	m/s^2	Acceleration
6	Kg/m^3	Density of air medium (roh)
7	θ	Angle of inclination (Theta)
8	N	Force
9	m^2	Frontal area
10	BLDC Motor	Brushless direct current motor
11	SRM Motor	Switched reluctance motor
12	PMSM	Permanent magnet synchronous motor

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION OF EV

Electric vehicles (EVs) are gaining popularity as a green alternative to internal combustion engines (ICEs), which have been the primary mode of transportation for over a century. EVs are powered by a battery-driven electric motor. An electric motor, which is an electrical machine, that transforms electrical energy into mechanical energy. The operation of the electrical motors is due to the interaction between the motors electric field and current windings which generate force in the rotation form. Using direct current sources (DC) such as from batteries, motor vehicles, and by alternating current sources (AC) as an influence grid, inverters these electric motors are often powered. An electrical generator is mechanically similar to that of an electric motor, but it operates in a reverse direction which accepts mechanical energy and converts that accepted mechanical energy to electrical energy.

General-purpose motors with standard size and features are used to offer easy mechanical power for industrial applications. The biggest electric motors, with ratings approaching 100 megawatts, are utilized for pumped-storage applications, pipeline compression, and ship propulsion. The term "electric vehicle" refers to a vehicle that uses one or more electric motors for propulsion.

An electric car can be fuelled by off-vehicle sources through a collector system by electricity, or it can be self-contained with a solar panel and a battery to convert fuel to electricity. In the market, there are a variety of electric vehicles. Different motors are used for different functions in these vehicles. We will be discussing electric automobiles in this article, and the electric motor functions will be used to drive the electric car's powertrain.

Many factors must be considered, including power density, energy efficiency, cost factor, reliability. Depending on the vehicle's intended usage, several types of electric motors are used. The choice of a motor for an electric vehicle must be made carefully, as motor attributes have an impact on the vehicle's total performance.

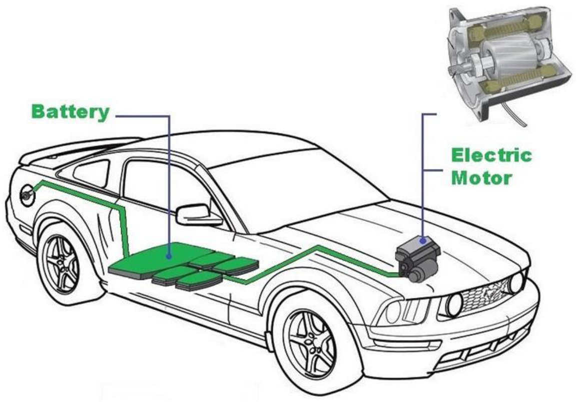

Fig 1.1 Motor and battery placement in EV's

1.2 SCOPE AND IMPORTANCE OF EV

Electric vehicles (EVs) represent a forefront of technological innovation, with ongoing advancements in propulsion systems, battery technology, and materials contributing to their continual evolution. Research and development efforts focus on improving energy density, reducing charging times, and extending battery life. Simultaneously, enhancements in electric motor efficiency play a pivotal role in shaping the trajectory of EV technology.

A fundamental aspect of the electric vehicle landscape is the development of a robust charging infrastructure. This involves establishing an extensive network of charging stations, including conventional outlets, fast-charging stations, and wireless technologies. This expansion is crucial for alleviating range anxiety and promoting widespread EV adoption, making electric vehicles a practical and convenient choice for consumers.

Electric vehicles also play a crucial role in integrating renewable energy sources. Systems are being developed to allow EVs to be charged using electricity generated from solar, wind, or other renewable sources. This integration aligns with global efforts to create a more sustainable and greener energy ecosystem, fostering a circular economy where energy consumption and production are intertwined.

The scope of electric vehicles extends beyond personal cars to encompass diverse transportation modes, including buses, trucks, bicycles, and scooters. This expansion is vital for addressing emissions across various sectors and reducing the overall carbon footprint of urban mobility.

Moving to the importance of electric vehicles, their positive environmental impact is paramount. Unlike traditional internal combustion engine vehicles, EVs produce zero tailpipe emissions, contributing significantly to mitigating the adverse effects of vehicular pollution on air quality and climate change.

Another crucial aspect of EV importance lies in their inherent energy efficiency. The electric drivetrain's efficiency in converting electrical energy stored in batteries to mechanical energy for propulsion results in reduced energy consumption per mile traveled, contributing to energy conservation and aligning with sustainability goals.

The economic implications of electric vehicles are substantial. The growth of the electric vehicle industry stimulates economic activity, creating jobs in manufacturing, research and development, and the maintenance of charging infrastructure. Governments and businesses worldwide recognize the economic potential of the electric vehicle sector, fostering investment and innovation that contributes to economic growth.

Furthermore, electric vehicles reduce dependence on fossil fuels, offering an alternative mode of transportation powered by a diverse range of energy sources, including renewable energy. This diversification enhances energy security and resilience in the face of geopolitical and supply chain challenges.

Investments in electric vehicles drive technological innovation and enhance the competitiveness of nations and industries. Countries and companies at the forefront of electric vehicle development are positioned as leaders in the global transition to sustainable transportation. The importance of fostering innovation in battery technology, materials science, and vehicle design cannot be overstated in a rapidly evolving automotive landscape.

Moreover, electric vehicles contribute to improved urban air quality by eliminating tailpipe emissions. The importance of this impact is evident in densely populated urban areas where vehicular emissions contribute significantly to air pollution. Cleaner air has direct positive implications for public health, reducing respiratory ailments and improving overall well-being, especially in urban environments.

The significance of electric vehicles in mitigating climate change cannot be overstated. By reducing greenhouse gas emissions associated with transportation, EVs contribute to global efforts to limit temperature rise and combat climate change. The electrification of transportation aligns with international agreements and commitments to reduce carbon emissions, making electric vehicles a key player in the global fight against climate change

1.3 ALTERNATIVE OF COMBUSTION ENGINE

The pursuit of sustainable transportation has led to intensive research and development into alternatives for internal combustion engines (ICEs). As the environmental impact of traditional fossil fuel-powered vehicles becomes increasingly apparent, the need for cleaner, more efficient propulsion systems has driven innovation across various technologies, considering their environmental benefits, technological advancements, and potential to revolutionize the future of mobility.

Electric vehicles (EVs) have emerged as a frontrunner among alternatives to traditional internal combustion engines. Powered by electricity stored in high-capacity batteries, EVs produce zero tailpipe emissions, mitigating air pollution and reducing greenhouse gas emissions. Ongoing advancements in battery technology, particularly lithium-ion batteries, have significantly increased the range and efficiency of electric vehicles, making them increasingly viable for everyday use. Beyond personal electric cars, electrification extends to buses, trucks, bicycles, and scooters, transforming urban transportation fleets. The proliferation of charging infrastructure, from conventional outlets to high-speed charging stations, addresses range anxiety concerns and fosters the adoption of electric vehicles on a global scale. Additionally, the integration of renewable energy sources, such as solar and wind, into the electric vehicle charging ecosystem enhances the sustainability of electric mobility.

Hydrogen fuel cells represent another promising alternative for powering vehicles. These cells generate electricity through a chemical reaction between hydrogen and oxygen, producing water vapor as the only emission. Hydrogen fuel cell vehicles offer a quick refueling experience and a longer range compared to traditional battery electric vehicles. However, challenges related to hydrogen production, storage, and distribution infrastructure need to be addressed to realize their full potential.

Biofuels derived from organic materials, such as crops or waste, provide a renewable alternative to traditional gasoline and diesel. Ethanol and biodiesel are two prominent examples of biofuels that can be used in existing internal combustion engines with minimal modifications. Biofuels offer a carbon-neutral or even carbon-negative lifecycle, as the plants used for their production absorb carbon dioxide during growth. However, concerns about land use, food production competition, and the overall sustainability of certain biofuel sources underscore the need for careful consideration and regulation.

Natural gas, particularly compressed natural gas (CNG) and liquefied natural gas (LNG), serves as a transitional alternative to conventional fuels. Natural gas engines emit fewer pollutants than traditional gasoline or diesel engines, contributing to improved air quality. The existing infrastructure for natural gas distribution, especially in some public transportation fleets and commercial vehicles, makes it a practical option in the short to medium term. However, its potential is limited by the finite nature of fossil fuel reserves and the associated carbon emissions.

Hybrid vehicles, combining an internal combustion engine with an electric motor and battery, offer a transitional solution that leverages the strengths of both technologies. Hybrid systems optimize fuel efficiency by utilizing electric power during low-speed, stop-and-go driving and the internal combustion engine for higher speeds. This technology mitigates range anxiety, improves fuel economy, and reduces emissions, serving as a bridge towards full electrification.

CHAPTER 2

LITERATURE SURVEY

In conducting the literature survey for selecting a motor and drivetrain system for an electric vehicle, it is crucial to explore various sources, including journals, books, articles, and other relevant publications. This chapter aims to compile essential studies conducted in the field of electric vehicle propulsion systems.

The literature review encompasses an investigation into different types of motors and drivetrain configurations used in electric vehicles. It emphasizes the importance of understanding the diverse technologies available to make informed decisions during the project. This phase serves as a foundation for implementation, ensuring that the chosen motor and drivetrain system align with the projects requirements.

Categorically, the search is focused on electric motors, drivetrain layouts, and associated technologies. Specific areas of interest include motor efficiency, power delivery, regenerative braking, and overall system integration. By reviewing existing research, this project aims to gain insights into the advancements, challenges, and best practices in the realm of electric vehicle propulsion systems. The scarcity of comprehensive studies in certain aspects of this field may underscore the need for further exploration and experimentation.

Ultimately, the literature survey sets the stage for the development of a robust motor and drivetrain system for the electric vehicle, ensuring a well-informed and technically sound approach to the project.

N. PRABHU1 , R. THIRUMALAIVASAN 1 , (Senior Member, IEEE), AND BRAGADESHWARAN ASHOK2 (Oct,2023) has specified in that "Critical Review on Torque Ripple Sources and Mitigation Control Strategies of BLDC Motors in Electric Vehicle Applications" about Brushless DC (BLDC) motors, while offering advantages in terms of efficiency and longevity, come with notable disadvantages. One significant drawback is the complexity associated with their control. BLDC motors require advanced control algorithms for smooth operation, adding intricacy to the overall system design. Cost is another concern, as BLDC motors tend to be more expensive than traditional brushed motors, impacting the economic feasibility of certain applications. Electromagnetic Interference (EMI) is also a challenge, with electronic commutation in BLDC motors contributing to potential interference issues that necessitate additional measures for mitigation. Some BLDC systems depend on position sensors for commutation, introducing both cost and complexity. Additionally, BLDC motors may exhibit limitations in the high-torque range, experiencing reduced torque at high speeds. Effective heat dissipation is crucial due to the heat generated during operation, requiring additional components like heat sinks or cooling systems. Maintenance challenges persist as well, despite being brushless, especially in harsh environments or with prolonged use. Finally, integration into existing systems may pose difficulties due to differences in control requirements compared to traditional motors, underscoring the need for careful consideration when implementing BLDC technoloy.

ZHIKUN WANG, TZE WOOD CHING, (Senior Member, IEEE), SHAOJIA HUANG3, HONGTAO WANG , (Member, IEEE), AND TAO XU (Dec,2020) has specified in that "Challenges Faced by Electric Vehicle Motors and Their Solutions" about Electric vehicle motors face several challenges. First, battery limitations impact the overall range and efficiency, as advancements in battery technology are crucial. Second, heat dissipation becomes a concern, affecting motor performance and lifespan. Third, the high initial cost of electric vehicle motors poses an obstacle to widespread adoption. Additionally, charging infrastructure and the time required for charging remain significant challenges. Fifth, the environmental impact of manufacturing batteries raises sustainability questions. Moreover, the weight of electric vehicle motors impacts overall vehicle efficiency. Furthermore, addressing the rare-earth material dependency in motor components is vital for resource sustainability. Finally, educating consumers about electric vehicle technology and dispelling misconceptions is essential for broad acceptance.

Utkal Ranjan Muduli , Member, IEEE, Abdul R. Beig , Senior Member, IEEE, Ranjan Kumar Behera , Senior Member, IEEE, Khaled Al Jaafari , Senior Member, IEEE, and Jamal Y. Alsawalhi , Member, IEEE (Jun,2022) has specified in that "Predictive Control With Battery Power Sharing Scheme for Dual Open-End-Winding Induction Motor Based Four-Wheel Drive Electric Vehicle" about The predictive control with battery power sharing scheme for dual open-end-winding induction motor-based four-wheel drive electric vehicles comes with several disadvantages. First, the complexity of implementing predictive control algorithms increases, demanding sophisticated computational resources. Second, the real-time nature of predictive control may introduce latency issues, affecting the system's responsiveness. Third, calibration and tuning parameters for optimal performance can be intricate, requiring specialized expertise. Fourth, the scheme's dependency on accurate predictive models implies susceptibility to uncertainties and variations in vehicle dynamics. Additionally, the increased cost associated with dual open-end-winding induction motors raises concerns about economic viability. Furthermore, the potential for increased energy consumption during predictive control optimization may offset efficiency gains. Lastly, the compatibility and interoperability challenges with existing automotive systems pose hurdles to seamless integration.

Stefano De Pinto, Pablo Camocardi, Aldo Sorniotti, Member, IEEE, Patrick Gruber, Pietro Perlo, and Fabio Viotto (Feb,2017) has specified in that “Torque-Fill Control and Energy Management for a Four-Wheel-Drive Electric Vehicle Layout With Two-Speed Transmissions” about The torque-fill control and energy management system for a four-wheel-drive electric vehicle layout with two-speed transmissions may present several drawbacks. Firstly, the complexity of integrating torque-fill control and managing energy across multiple drivetrain components can increase the system's overall complexity, potentially leading to higher maintenance costs and increased chances of malfunctions. Secondly, the implementation of a two-speed transmission in an electric vehicle may introduce additional mechanical complexities, reducing overall system efficiency and reliability. Moreover, the increased weight and space requirements associated with a two-speed transmission can impact the vehicle's overall performance and agility. Additionally, the integration of torque-fill control may introduce challenges in achieving seamless transitions between different torque levels, leading to potential drivability issues. The need for precise synchronization between the electric motor and transmission components may also result in increased manufacturing and calibration complexities. Furthermore, the inclusion of additional components can contribute to higher production costs, potentially limiting the affordability and market competitiveness of such vehicles. Lastly, the limited availability of charging infrastructure for electric vehicles may hinder the widespread adoption of complex drivetrain configurations, such as those involving torque-fill control and two-speed transmissions.

FABRICIO A. MACHADO (Student Member, IEEE), PHILLIP J. KOLLMEYER (Member, IEEE), DANIEL G. BARROSO, AND ALI EMADI (Fellow, IEEE) (Oct,2021) has specified in that “Multi-Speed Gearboxes for Battery Electric Vehicles: Current Status and Future Trends” about the various gearbox topologies for battery electric vehicles (EVs). Manual Transmission (MT) is reliable and cost-effective but seldom used in production EVs due to concerns about ride quality and system efficiency. Automated Manual Transmission (AMT) addresses these issues by employing electrohydraulic or electromechanical actuators, providing precise control of motor speed and torque. Inverse-Automated Manual Transmission (I-AMT) further improves torque interruption during shifting, enhancing suitability for electrified traction systems. Dual-Clutch Transmission (DCT) combines MT and AT advantages without torque interruption, with efficiency influenced by the type of clutch used. Continuously Variable Transmission (CVT) allows a continuously variable gear ratio but suffers from power loss. Infinitely Variable Transmission (IVT) offers the ability to operate an internal combustion engine at idle without a clutch. Magnetic Gear Transmission (MGT) uses a magnetic field for force transmission, but its efficiency and cost make it unappealing for EVs. Overall, the discussion provides insights into the trade-offs and considerations in selecting gearbox types for electric vehicles

BOGDAN ANTON AND ADRIANA FLORESCU, (Senior Member, IEEE) (Dec,2020) has specified in that “Design and Development of Series-Hybrid Automotive Powertrains” that addresses the primary drawbacks of internal combustion engine (ICE)-powered vehicles, specifically fuel consumption, noise, and air pollution, which are most pronounced in city driving scenarios. In contrast to previous proposals advocating parallel-hybrid configurations, this study introduces a plug-in series-hybrid powertrain architecture designed to mitigate these issues. Figure 1 illustrates a comparison between a conventional powertrain and the proposed series-hybrid architecture. In this novel approach, a smaller 1.2-liter 3-cylinder Diesel ICE drives a permanent magnet brushless Electric Generator (EG), supplying energy to the High Voltage Battery (HVB) or the permanent magnet synchronous Traction Electric Motor (TEM) and the HVB concurrently. The TEM, EG, and power inverters (INVs) replace the Alternator (A) and Electric Starter (ES). The series-hybrid configuration eliminates the need for a clutch, and the conventional gearbox is replaced by a simpler, more efficient aggregate. Additionally, the AC-DC converter facilitates plug-in charging from the grid, while the DC-DC converter charges the 12V lead-acid battery and powers the conventional electrical system. The design process incorporates mathematical calculations, computer-aided simulations, and real-world measurements to accurately determine power and energy requirements at different driving speeds. MATLAB Simulink simulations enhance the validity of results, ensuring the robustness of the proposed series-hybrid powertrain.

PROBLEM IDENTIFICATION

From the above literature survey Electric vehicles face several challenges. One primary issue is the inefficient utilization of power, leading to reduced overall efficiency and compromised performance. Without dynamic control over power delivery, these vehicles may struggle to adapt to diverse driving conditions, such as acceleration, slopes, or maintaining optimal speeds. This limitation not only impacts versatility but also contributes to range anxiety and concerns about battery life. Additionally, the absence of a gearbox makes the integration of electric components more complex, potentially increasing conversion costs and implementation times. Cost-effectiveness and accessibility are further hindered, limiting the broader adoption of electric vehicles, especially in regions where affordability is crucial. Moreover, the environmental impact is compromised as optimizing power efficiency becomes challenging, and the disposal of outdated components may not follow sustainable practices.

SOLUTION

In response to the challenges faced by electric vehicles, By implementing a solution that involves the integration of a 5-speed transmission system and a BLDC (Brushless DC) motor. This strategic combination aims to address issues related to power utilization and dynamic control. The inclusion of a multi-speed transmission system is intended to optimize power delivery across diverse driving conditions, such as acceleration, slopes, and maintaining optimal speeds. Simultaneously, the use of a BLDC motor enhances overall efficiency and performance. This solution not only tackles concerns like range anxiety and compromised versatility but also offers potential improvements in energy consumption. By incorporating these components, aims to mitigate complexities, enhance adaptability, and contribute to the broader adoption of electric vehicles, particularly in regions where cost-effectiveness and accessibility are crucial considerations.

CHAPTER 3

TYPES OF MOTORS USED IN EV

DC motors are used in the majority of electric vehicles (4 kW and less power). The induction motor is a well-known type of AC motor which is used in a large number of high-power electric vehicles (above 5kW). In most cases, a vector drive is used to control torque and acceleration. Directly, BLDC motor applications can be found in low-power electric vehicles. In an electric vehicle, the battery is the principal energy storage device. Lately, tremendous works have been accounted for ion-battery enhancement such as Li-particle, which is now being used by a new generation of electric vehicles. Different types of motors have different characteristics, thus it's important to compare motors using certain basic criteria before choosing one for an electric vehicle. Electric motors used in electric vehicles should have important characteristics such as a simple design, high energy output, minimal maintenance costs, and excellent control. There are various types of motors used for EVs. This article looks into the mechanics of electric vehicles and provides an overview of the most prevalent motor types.

1. DC motors
2. Permanent Magnet Brushless DC motors (PM BLDCs)
3. Induction Motors
4. Permanent Magnet Motors
5. Switched Reluctance Motors (SRM)

3.1 DC MOTOR

One of the motor types used in EV applications is the DC motor which is also known as Direct Circuit motor. They were extensively employed in variable speed applications before the advancements in power electronics. They are preferred in EVs because of their ease of use and durability. Brushed and brushless DC motors are the two types of DC motors available. Brushless DC motors are preferred for low-power vehicles. The brushed motors are said to be universal motors, it works by the direct current and it is lightweight. The larger

DC motor is applicable for electric vehicles, drives, mills, and elevators. The multiple turns are provided inthe windings, in case the large motors carry the parallel current paths.

Shunt motors are more controllable than series motors. Due to their decoupled torque and flux control properties, separately excited DC motors are intrinsically suited for field weakening operation.

Separate field weakening, on the other hand, allows for a wider spectrum of constant power activities. The commutator is connected through the ends of the wire to energize the coils and the brushes are provided to connect the coils with the external power supply.

They do, however, have certain disadvantages, including a huge construction, low efficiency, limited reliability, and high maintenance costs due to the brush and collector construction.Furthermore, the maximum motor speed is limited by friction between the brush and the collector.

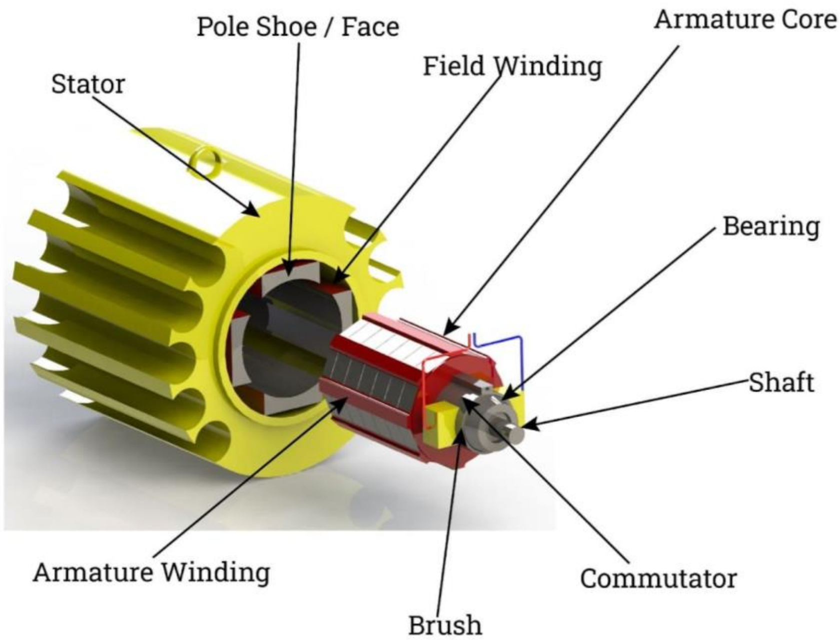

Fig 3.1 DC Motor diagram

3.2 INDUCTION MOTOR

Three-phase AC Induction motors are commonly used in EV applications because of their simple structure, reliability, robustness, low maintenance requirements, low cost, and ability to operate in poor environmental conditions. The elimination of brush friction allows the motors to increase their maximum speed limit, and the greater speed rating allows these motors to provide high power. The frequency of voltage is changed to change the speed of induction motors. The electric current in the rotor required to produce torque is obtained through electromagnetic induction from the magnetic field of the stator coil.

An induction motor can be built without any electrical connections to the rotor. In an induction motor, the rotor can be either squirrel-cage or wound. Its magnetic field is established via induced current. Unidirectional torque is produced by the interaction of a rotating magnetic field with a field due to induced currents. Vector control methods can be used to segregate torque and field control. Flux weakening in the constant power zone can widen the speed range.

When compared to permanent magnet motors, IM has disadvantages such as low efficiency, increased losses at high speeds, and a low power factor. Dual inverters are utilized to provide constant power and rotor losses are decreased at the design stage to overcome these issues

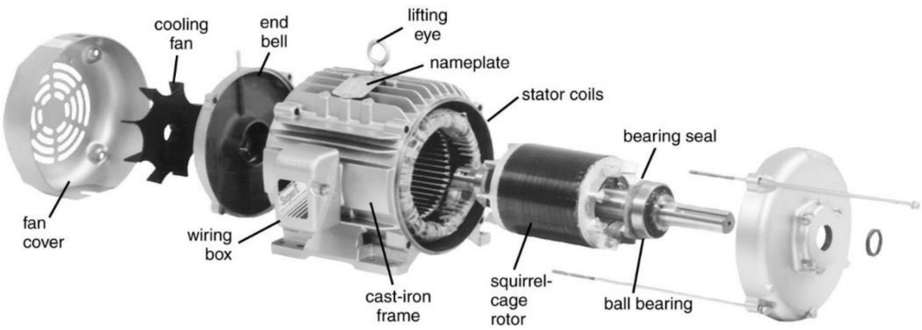

Fig 3.2 Induction motor

3.3 PERMANENT MAGNET SYNCHRONOUS MOTOR (PMSM)

The rotor pivots at synchronous speed in a synchronous motor. The rotor is powered by a DC source, while the stator is powered by a three-phase AC source. Brushless AC motors are another name for PMS motors. They are suited for use as traction motors because of their simple construction, high efficiency, and high power density (common in hybrid vehicles, EVs, and buses). In comparison to IM motors, PMSM motors are more efficient. Several automobile manufacturers (including Nissan, Honda, and Toyota) have successfully utilized these engines.

Highly conductive materials with high permeability, such as Samarium-Cobalt and Neodymium-Iron-Boron, are used in permanent magnets. This is a particularly suitable material because of its cost-effectiveness and availability. On the rotor core, those magnets can be observed. The constant power zone of these motors is naturally narrow. The conduction angle of the power converter can be changed at speeds greater than the base speed to extend the speed range and efficiency of PMS motors. It is possible to increase the speed range to three or four times the base speed.

These motors have the disadvantage of being susceptible to demagnetization due to heat or armature reaction. The disadvantages of this type are high costs, eddy current loss in PMs at high speeds, and a reliability risk due to the possibility of breaking of magnets.

There are two types of PMSM motors which are surface-mounted permanent magnet (SPM) and interior permanent magnet (IPM) synchronous motor drives. IPM motors are more efficient than SPM motors, although they have a more complicated design.

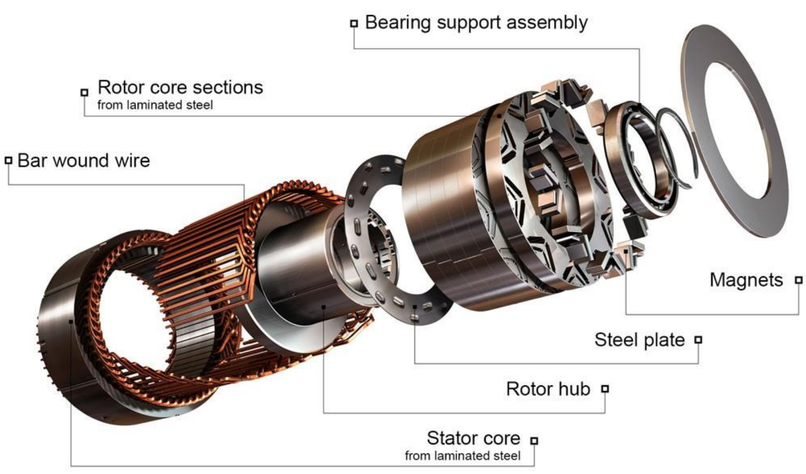

Fig 3.3 Permanent Magnet Synchronous Motor

3.4 PERMANENT MAGNET BRUSHLESS DC MOTOR (PM BLDC)

Another motor type to consider is the Permanent Magnet Brushless DC motor (PM BLDC). When compared to brush DC motors, BLDC motors are more efficient and require less maintenance. A revolving self-synchronous machine with a permanent magnet rotor and known rotor shaft positions for electronic commutation is referred to as a BLDC motor. In addition, heat is efficiently vented to the environment. If a conduction-angle control is utilized on a PM BLDC motor, the speed range can be expanded three to four times beyond the basic speed.

When compared to other motors with identical apex current and voltage, another advantage of PM BLDC motors is their ability to provide more torque. Permanent magnet brushless dc motors have a good chance of being used in the EV propulsion system since they provide a strong power thickness and a lot more productivity. BLDC motors have a capacity of 85 to 90 percent, whereas brushed DC motors have a capacity of 75 to 80 percent. The brushless DC motor will solve the problem that a typical DC motor has. The Lorentz force law, in particular, states that any current-carrying wire placed in a magnetic field will expose a power.

There are some drawbacks, such as mechanical forces and magnet costs. The increase in centrifugal forces at higher speeds poses a risk in terms of driving safety due to the chance of magnets breaking, Magnets are also susceptible to high temperatures. Because of the high working temperature, the residue flux density decreases, lowering the machine's torque capacity. Although PM BLDC motors do not have a brush to limit speed, there are still concerns about the magnet's fixing intensity, which limits the maximum speed if the motors are of the inner-rotor type. Furthermore, the field weakening capability of this motor is relatively limited. The presence of the PM field, which can only be diminished by producing a stator field component that opposes the rotor magnetic field, is the reason for this. Nonetheless, by extending the commutation angle, extended constant power operation is achievable.

BLDC motors further have two types:

a. In-runner type BLDC Motor
b. Out-runner type BLDC Motor

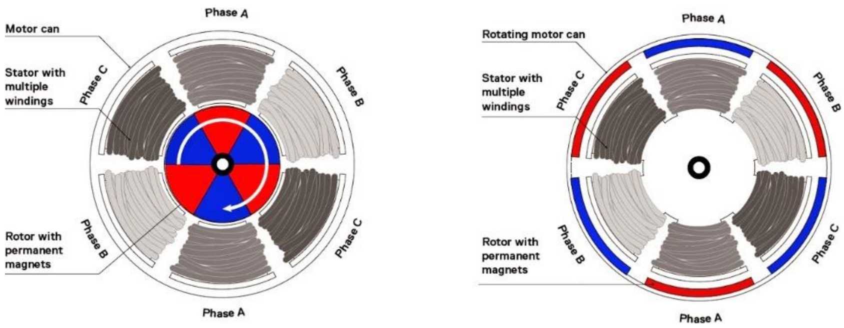

Fig 3.4 (a) In-runner type BLDC Motor (b) Out-runner type BLDC Motor

3.5 SWITCHED RELUCTANCE MOTOR (SRM)

A switching reluctance motor (SRM) is a form of stepper motor that is operated under torque. SRM drives are gaining popularity and are being recognized as having potential for electric vehicle applications. The high torque component of SRMs allows them to be used in a variety of applications, including wind energy, generator starter systems in gas turbine engines, and high-performance aerospace applications. Their durability, simplicity of control, high efficiency, large constant power operation area, fault tolerance, and effective torque-speed characteristics are all advantages in EVs. The efficiency of SRM is about 95% when compared to IM. SRM is an ideal motor type for EV applications because of these characteristics.

Without any windings, magnets, commutators, or brushes, the rotor structure is incredibly simple. Because of the absence of magnets, mechanical forces are not a problem, allowing the motor to run at a high speed. There are no copper losses in the rotor because the motor's windings are not employed, ensuring that the rotor temperature is lower than other motor types. SRM motors can continue to run even if one of the phases is disconnected since the phases are not connected. The motor's fault tolerance is likewise quite high. SRM has exceptionally rapid acceleration and extremely high-speed operation because of its simple structure and minimal rotor inertia. SRM is particularly well suited for gearless operation in EV propulsion because of its large speed range.

When contrasted to other DC motors, the hazardous power is sent to the stator, which is larger than the rotor. The motor's mechanical design does not require power to move parts because the electrical design is complex, switching devices are required to give power. A good motor design allows for a large constant power operation range, which allows for high speeds. SRM is also relatively easy to cool and insensitive to high temperatures due to the lack of magnetic sources (i.e., windings or permanent magnets) on the rotor. The latter is particularly useful in automotive applications that require functioning in severe environments. Using a suitable Control, an expanded range of 2-3 times the base speed is usually attainable. This motor has many drawbacks, including high noise, high torque ripple, a unique converter topology, and electromagnetic interference. SRMs feature a torque/power speed characteristic that is suited for EV applications.

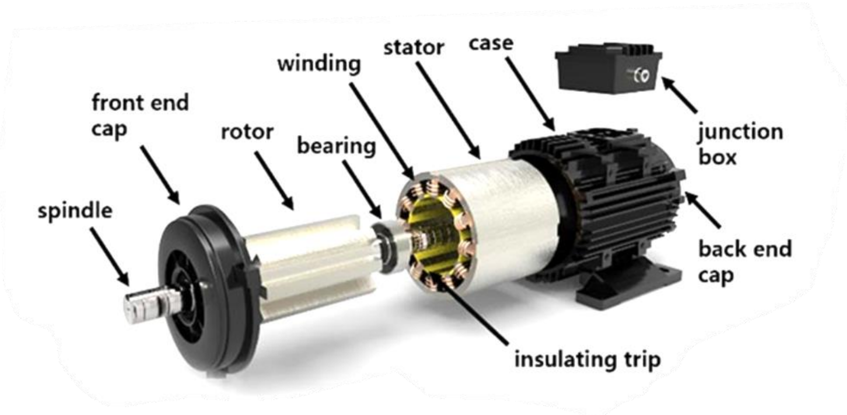

Fig3.5 Switched Reluctance Motor

CHAPTER 4

DRIVETRAIN SYSTEMS OF EV's

The output characteristics of electric motors in EVs differ from those of internal combustion engines. The electric motor, in most cases, eliminates the need for a motor to stay idle while stopped, allows large torque to be produced at low speeds, and provides a wide range of speed fluctuations. Using the features of electric motors, it may be able to design lighter, more compact, and more efficient systems. The choices of drivetrain systems in an EV include mainly:

- Propulsion mode, such as front-wheel drive, rear-wheel drive, or four-wheel drive;
- Number of electric motors in a vehicle;
- Drive method, such as indirect or direct drive; and
- A number of transmission gear levels.

As a result, EV drivetrain systems can be configured in the following six ways.

4.1CONVENTIONAL TYPE

In EVs, the traditional ICE is replaced with an electric motor for the conventional drivetrain system. This design does not alter the conventional structure of an ICEVs drivetrain system, making it simple to build.

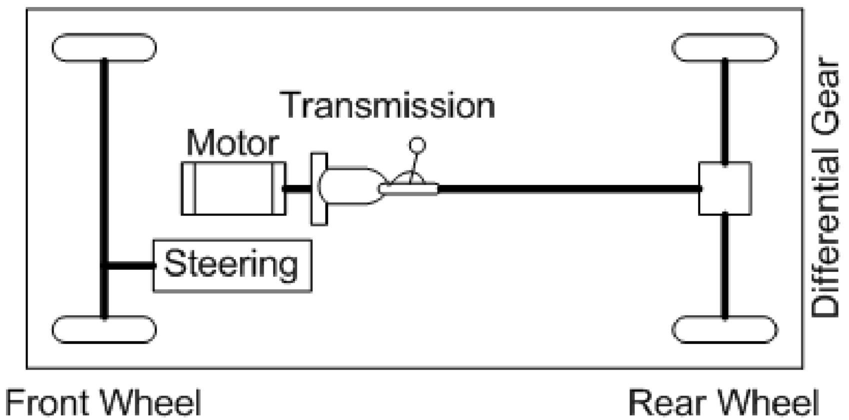

Fig 4.1 Conventional type of drivetrain system

4.2TRANSMISSION-LESS TYPE

The transmission-less drivetrain system in EVs simplifies the conventional drivetrain system by removing the transmission

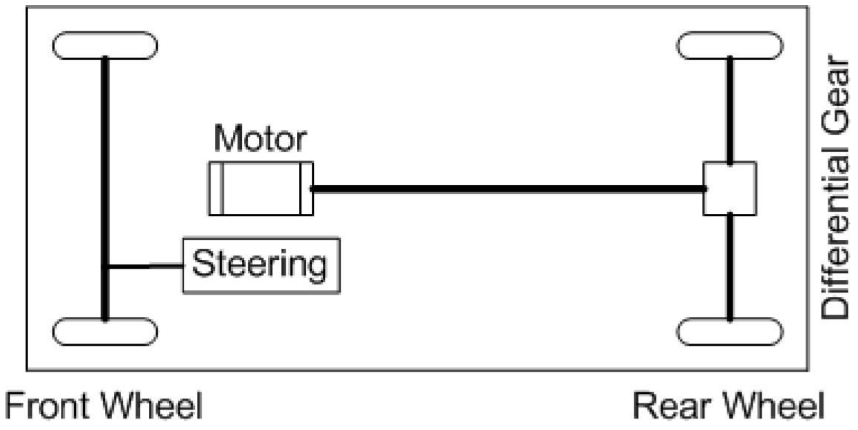

Fig 4.2 Transmission-less type

4.3 CASCADE TYPE

If the differential gear is eliminated from the transmission-less type, it can be simplified to a differential-less type. Two motors are fitted on the body side, with joints to send power to the wheels, resulting in a function equal to the differential. The direct-drive type is another name for this type.

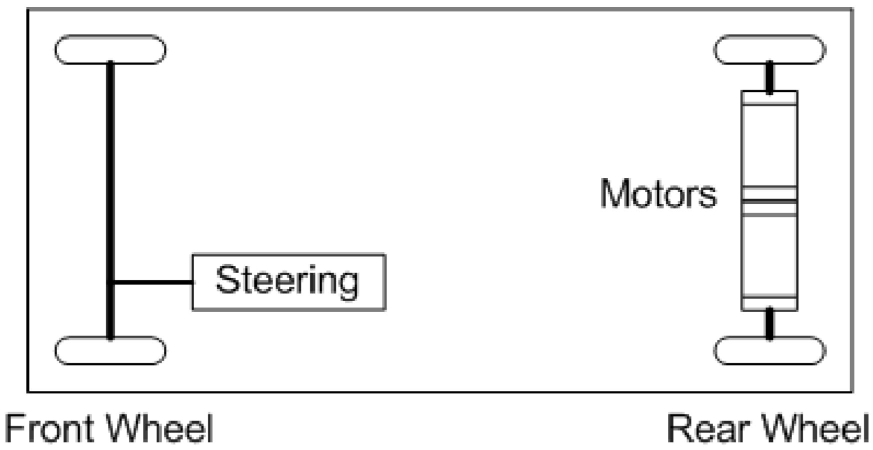

Fig 4.3 Cascade motors drivetrain system

4.4 IN-WHEEL TYPE USING REDUCTION GEARS

This type is derived from the simplification of the transmission-less type using Reduction Gears.To drive the wheels, two motors are fixed to the wheel side with reduction gears.

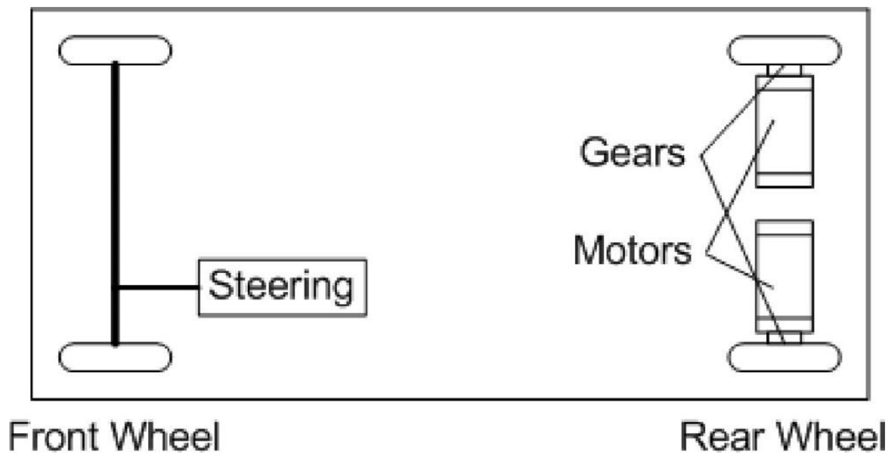

Fig 4.4 In-wheel type using In-wheel type using reduction gears gears

4.5 IN-WHEEL DIRECT-DRIVE TYPE

Because the rear wheels and motors are integrated, rotations can be caused directly without theuse of gears. This is a sort of in-wheel drivetrain system that uses direct drive.

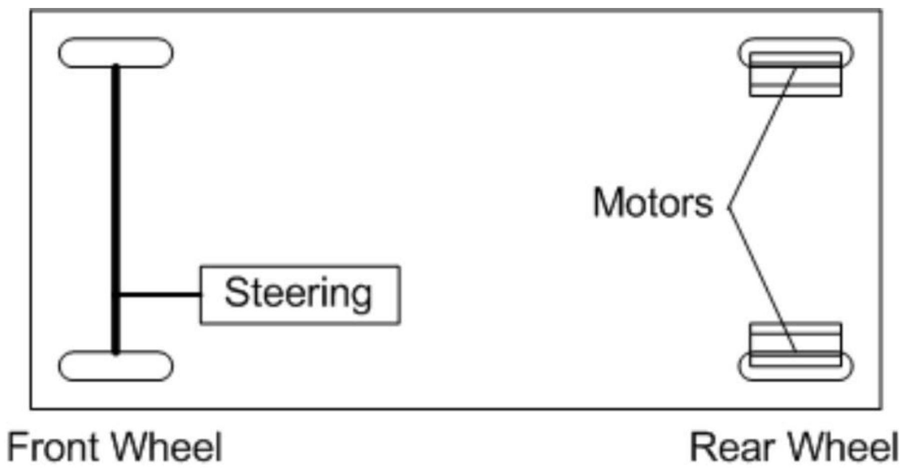

Fig 4.5 In-wheel direct-drive drivetrain system

4.6 FOUR-WHEEL DIRECT-DRIVE TYPE

The four wheels are driven directly by four in-wheel motors. It's feasible that the EV's direction will be controlled by electric steering**.**

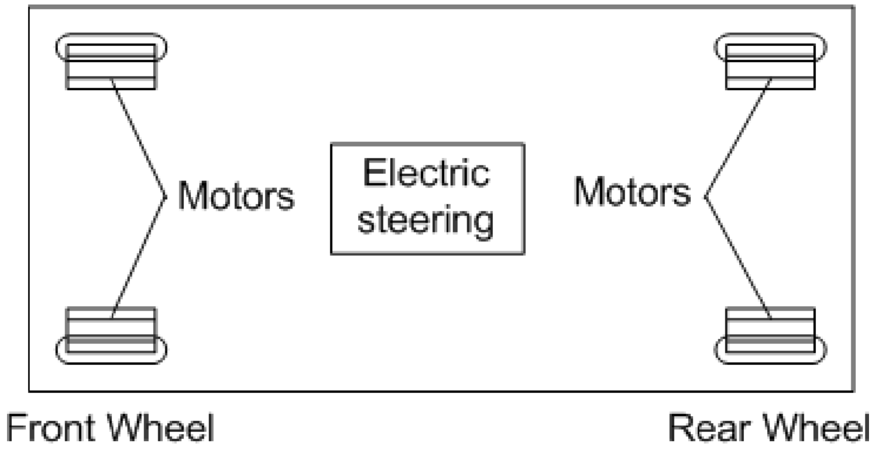

Fig 4.6 Four-wheel direct-drive type

As research progresses, the drivetrain system shrinks in size and minimizes power transmission losses. At the same time, the size and weight of the motor and reduction gear must be lowered. The direct-drive drivetrain technology necessitates a motor that is light and produces a lot of torque. The drivetrain scheme with the single-level reduction gear is an excellent choice for taking full advantage of the wide range of output characteristics and small motor size resulting from high maximum speed for electric motor drives.

CHAPTER 5

DESIRED OUTPUT CHARACTERISTICS OF MOTOR DRIVES IN EV

Torque-speed or power-speed parameters are used to evaluate EV performance. The torque-speed curve is defined by two major design factors: maximum slope and maximum speed. For proper grade ability and beginning acceleration, the vehicles must run at constant power. The motor drive should have high torque at low speeds for acceleration and cruising, as well as high power at high speeds for cruising and a wide speed range under constant power. Beyond base speed and up to maximum speed, the motor is run in a constant power region.

The motor type affects the constant power operation. Before achieving maximum speed, some motor drives switch to constant power and complete the natural operation. The maximum torque falls proportionally to the square of speed in natural operation. This may also result in a lower total power requirement.

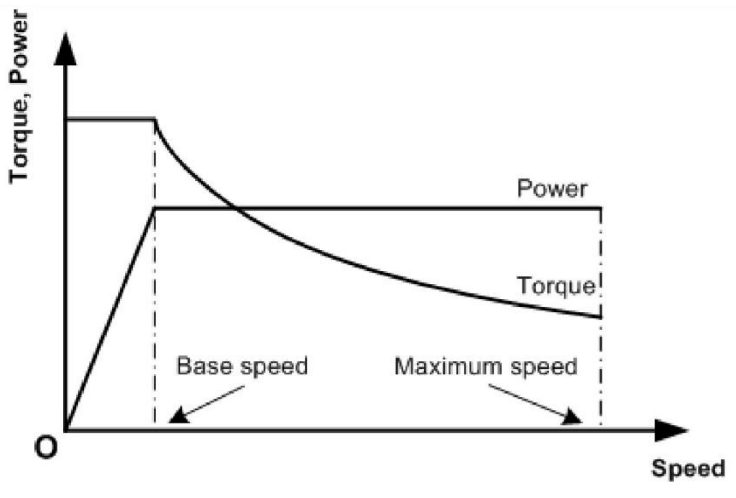

Fig 5.1 Desired outputs of electric motor drives in EVs

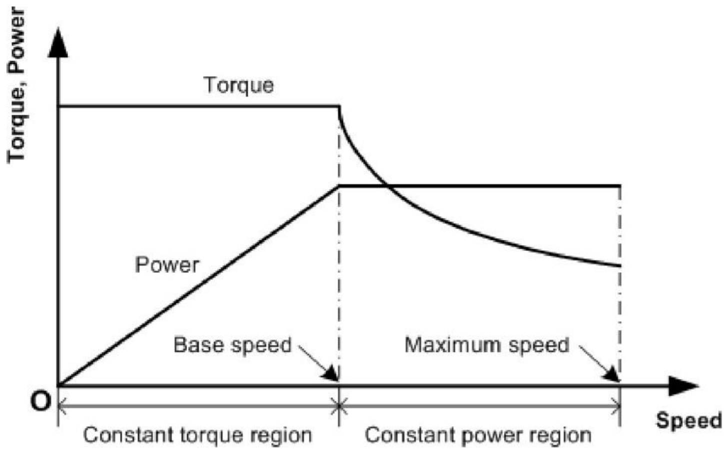

Fig 5.2 Typical performances of electric motor drive in industrial applications

CHAPTER 6

COMPARATIVE STUDY OF ELECTRIC MOTORS

For selecting the appropriate electric vehicle motors basically, we need to determine the most demanding requirements of the performance, the operating conditions, and the cost associated with the vehicle. The observation has been made on the specific parameters.

6.1.POWER DENSITY

The capability to weigh the proportion of any electric motor is known as power density, and it is usually calculated using the motor's apex power. Subdividing the apex power yield (in kW) by mass yields power density for every motor (in kg). The power density measurement unit is kW/kg. Because of the close proximity of high power density permanent magnets, PM motors have the highest power density. The PMS machine has the maximum power thickness, allowing for a powerful machine with minimal substance in a car's motor cell's constrained installation field. PM Brushless motors are then sought most aggressively by both IM and SRM. DC motors, once again, have the lowest power density. As this machine has the highest power density, PM is approved to pick up the distinct characteristics for EV application.

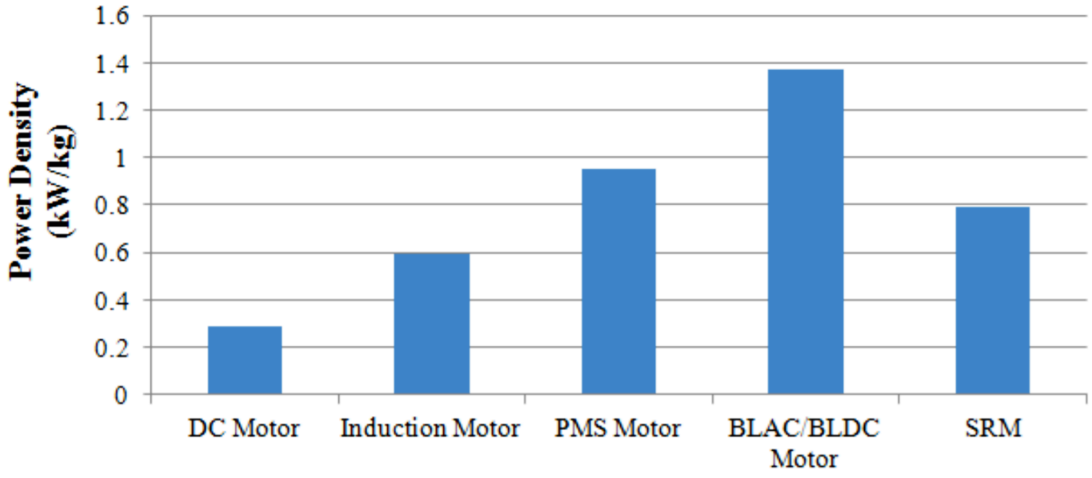

Fig 6.1 Power density comparison with different types of motors

6.2.ENERGY EFFICIENCY

The relationship between electrical and mechanical yield is provided by electric motor efficiency. Every electric motor is designed to operate at maximum efficiency at the specified output. The best energy efficiency (more than 95%) is found in BLDC motors, which are followed by Induction Motors (greater than 90 percent). Due to the absence of rotor losses, BLDC Motors has the highest efficiency. In a specified velocity run, BLDC strives for the highest proficiency. The PMBLDC motors are the most productive motors in terms of efficiency. The induction comes next, and the SRMs are essentially indistinguishable in terms of efficacy. DC motors are the least effective of all the motors used in the EVD design.

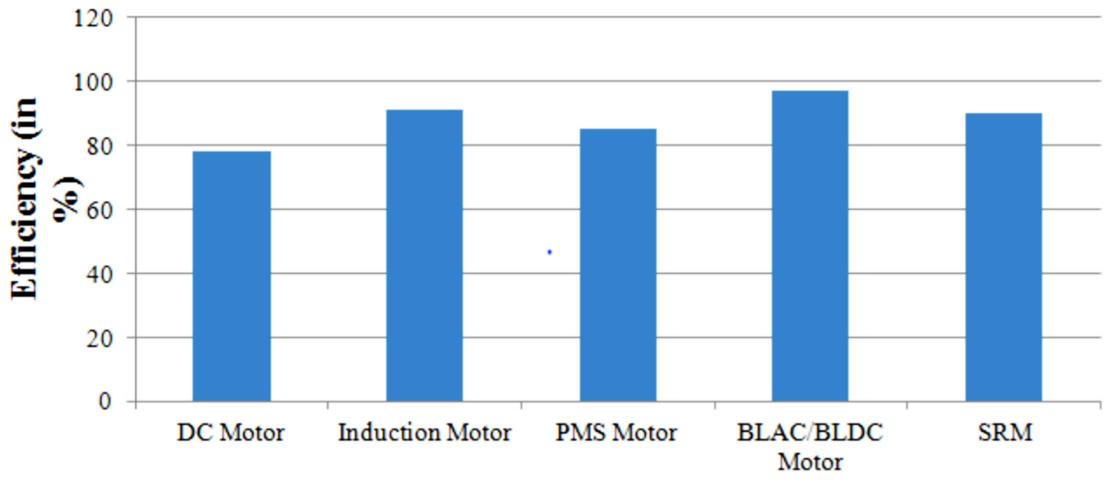

Fig 6.2 Energy efficiency between different types of motor

6.3.RELIABILITY

Presently comparing based on the fidelity of the Electric Motor that is breakdowns and support ought to be least, utmost reliable ones are IM and SRM. PM motors are pursuing it. The DC Motor is the least trustworthy. Along these lines, DC motor brushes and switches enter current inthe armature, making them less decisive and ill-equipped for maintenance-free work. Due totheir dependability, induction motors are the most important competitor

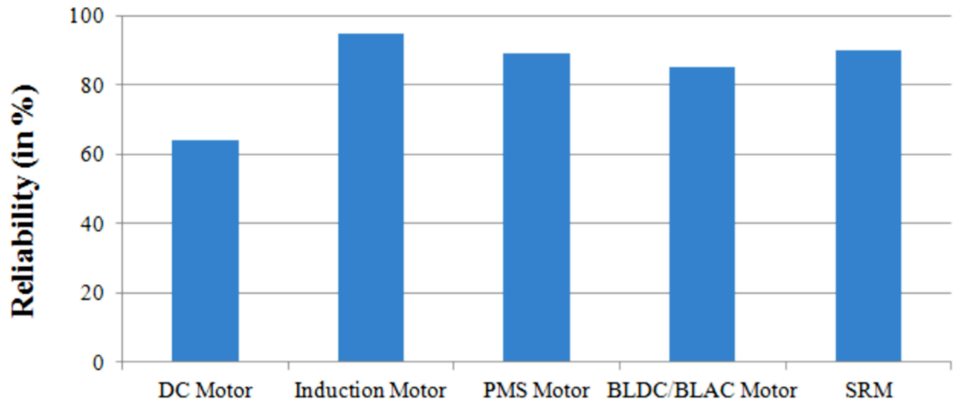

Fig 6.3 Reliability of different types of motors

6.4.COST FACTOR

One of the most difficult challenges electric car manufacturers face is offering customers an EV that is in the same class as a fuel vehicle but at a reasonable price. The IM, which is pursued by the DC and SRM Motors, is the ultimate to be used here. Most manufacturers accept induction engines for EV applications because they are cost-effective. DC motors are substantially more expensive than AC motors of the same capacity as large-capacity motors. A faster speed, lower torque motor will cost less than a lower speed, greater torque motor when two motors with the same power capacity are compared. A motor with a greater operating voltage but lower current needs will be less expensive than one with a lower operating voltage but greater current need.

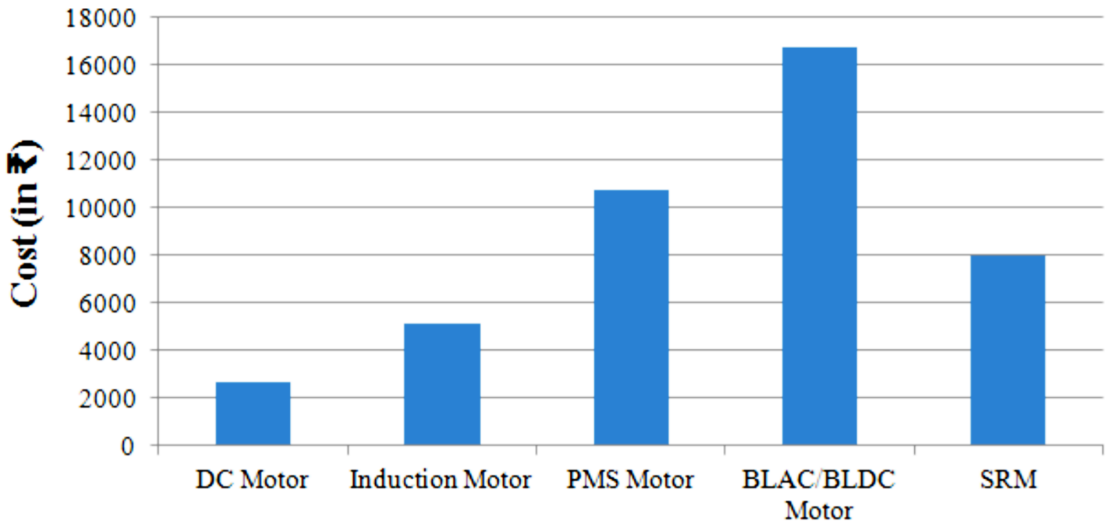

Fig 6.4 Price range of motors

CHAPTER 7

DESIGN CALCULATIONS

To select an motor for the electric car of 1 Ton that can reach a maximum of 35 km/hr

$$F_{total} = F_{Rolling} + F_{Gravity} + F_{Aerodynamic\ drag}$$

1. Rolling resistance:

$$F_{Rolling} = C_r \cdot m \cdot a$$

Where,

C_r - Coefficient of rolling resistance
m - Mass of vehicle in kg - 1500kg
a - Acceleration due to gravity (m/s^2) - 9.8 m/s^2

Coefficient of rolling resistance (C_r) for normal Indian roads = 0.01

$F_{Rolling}$ = (0.01) (1500) (9.81)

= 147.15 N

Power required to overc
this rolling resistance } = $F_{Rolling}$ x (Velocity of car in m/s)

= 147.15 x 35 (1000/3600)

= 1430.298 Watts

2. Gradient resistance:

$$F_{Gradient} = m \cdot a \cdot \sin\theta$$

For our requirement $\theta = 0^{\circ}$, when the vehicle travels at flat surface.

$$F_{Gradient} = 0\ N$$

3. Aerodynamic drag:

$$F_A = 0.5ev^2C_AA_F$$

Where,

ρ	-	Density of air medium
	-	1.23 kg/m^3 (for air at sea level)
V	-	Velocity of vehicle in m/s = 9.72 m/s
C_A	-	Co efficient of air resistance
A_F	-	Frontal area of vehicle (in m^2)

According to the manufacturer catalogue of Maruti Suzuki 800, Frontal area is 1.8 m^2

And coefficient of air resistance C_A is 0.25.

$$F_{Aerodynamic\ drag} = 0.5 \times (1.23) \times (9.72)^2 \times 0.25 \times 1.8$$

$$= 26.14 \text{ N}$$

Power required to overcome this air resistance

$$= F_{Aerodynamic\ drag} \times \text{ velocity of car m/s}$$

$$= 26.14 \times 9.72$$

$$= 254.147 \text{ Watts}$$

So, total power required to overcome these resistant forces will be equal to total power required to move the vehicle.

Power needed for motor = 1430.298 + 0 + 254.147

$$= 1684.445 \text{ Watts}$$

$$\approx 1.7 \text{ Watts}$$

Therefore, the power required for the motor of the Maruti 800 electric vehicle, considering gravity, aerodynamic drag, and rolling resistance, is approximately 1684.445 Watts or 1.7 kW

Based on the calculations, a 2-kW BLDC motor appears to be sufficient for the project. The calculated power requirement for overcoming the combined effects of aerodynamic drag, gravity on an incline, and rolling resistance is approximately 1684.445 Watts or 1.7 kW.

Choosing a 2 kW BLDC motor provides some headroom, allowing for additional factors like drivetrain losses, variations in road conditions, and efficiency considerations. It's always a good practice to include some margin in motor power ratings to ensure that the system can handle unexpected or variable conditions.

CHAPTER 8

RESULT AND DISCUSSION

In our ground-breaking project, we successfully converted a conventional internal combustion engine (I.C) car into an electric vehicle (EV) by seamlessly integrating a robust 2kW Brushless Direct Current (BLDC) motor. This transformative conversion, coupled with the incorporation of a 5-speed gearbox, brings forth a host of advantages that redefine the driving experience and contribute to the evolution of sustainable transportation.

The 2kW BLDC motor serves as the beating heart of this electric conversion, offering a myriad of benefits that extend beyond the environmental advantages inherent in electric propulsion. One notable benefit lies in the motor's efficiency, translating electrical energy into mechanical power with minimal energy loss. This efficiency not only enhances the overall performance of the vehicle but also plays a crucial role in maximizing the driving range per charge.

Furthermore, the BLDC motor's design, characterized by its brushless operation, contributes to reduced maintenance requirements. The absence of brushes minimizes wear and tear, resulting in a more durable and long-lasting motor. This durability, combined with the inherently lower maintenance needs of electric powertrains, contributes to a significant reduction in operational costs over the lifespan of the vehicle.

The integration of a 2kW BLDC motor also enables precise control of the vehicle's power delivery, enhancing responsiveness and acceleration. This dynamic control is particularly pronounced when paired with the 5-speed gearbox, allowing for optimal adaptation to varying driving conditions. The result is a driving experience that not only meets but often surpasses the expectations set by traditional internal combustion vehicles.

Moreover, the BLDC motor's compact design and lightweight construction contribute to the overall efficiency and performance of the converted electric vehicle. These characteristics play a pivotal role in achieving a favorable power-to-weight ratio, further enhancing the acceleration and handling capabilities of the electric vehicle.

In conclusion, our project signifies a milestone in the realm of electric vehicle conversions, where the integration of a 2kW BLDC motor alongside a 5-speed gearbox represents a harmonious convergence of innovation and practicality. The benefits derived from the efficient, low-maintenance BLDC motor, combined with the dynamic capabilities introduced by the 5-speed gearbox, underscore the potential of electric vehicles to redefine modern transportation. This conversion not only aligns with the global shift towards sustainability but also exemplifies the adaptability and performance achievable in the exciting landscape of electric mobility.

Fig 8.1 Maruti Suzuki 800 front view(bonnet opened)

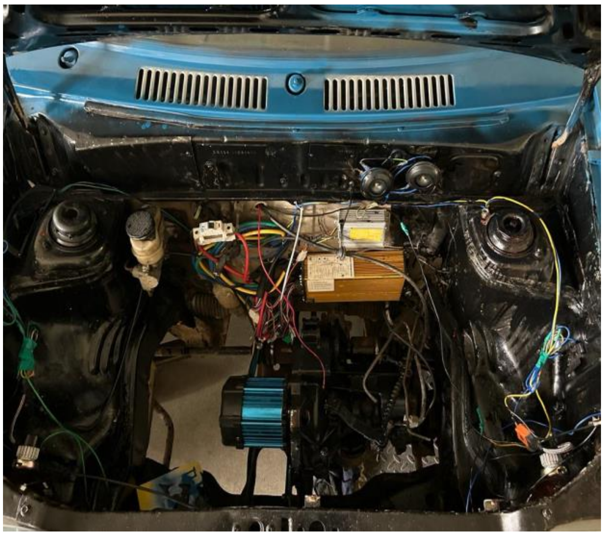

Fig 8.2 Transmission system

Fig 8.3 2kW BLDC Motor

CHAPTER 9

COST ESTIMATION

The Cost estimation of the Transmission system is given in a tabular column Below. The entire cost for the design and fabrication of motor and transmission system is ₹ 99,380

Table 9.1 cost estimation for transmission system

S.NO	COMPONENTS	PRICE
1	2 kW BLDC MOTOR	₹ 40,000
2	BLDC CONTROLLER	₹ 16,500
3	DC TO DC CONVERTER	₹ 980
4	TOOLS KIT	₹ 15,000
5	GEAR AND CLUCTH PLATE	₹ 1,900
6	TOTAL	₹ 74,380

CHAPTER 10

CONCLUSION

In conclusion, this project represents a ground-breaking endeavour in redefining electric vehicle (EV) design through the integration of a 2 kW Brushless DC (BLDC) motor with the existing 5-speed gearbox of the Maruti 800, with a specific focus on the peak RPM of 4200. The meticulous selection of a 2 kW BLDC motor underscores a commitment to achieving a harmonious balance between power and efficiency, effectively addressing challenges related to control algorithm complexity and contributing to an economical electric drivetrain. The utilization of the 5-speed gearbox not only resolves issues highlighted in the literature but also ensures a versatile transmission system capable of optimizing power delivery.

The incorporation of a peak RPM of 4200 is strategically chosen to enhance the project's performance in urban transportation scenarios. This RPM value aligns with the demands of city commuting, enabling the project to achieve a maximum speed of 50 km/h and ensuring that the drivetrain operates at its optimal efficiency. The peak RPM serves as a crucial parameter in maximizing the motor's capabilities during acceleration and maintaining an efficient power band for urban driving conditions.

As the project unfolds, success will be gauged by the seamless integration of the 2 kW BLDC motor with the Maruti 800's 5-speed gearbox, coupled with reliable and efficient power transmission to the rear wheels through the axle. The specific focus on the 4200 RPM peak aligns with the project's overarching goals, adding a performance-oriented dimension that enhances the EV's ability to meet speed targets and overall drivetrain efficiency. This project not only addresses current challenges in electric mobility but also positions itself as a forward-looking solution, contributing to the realization of urban transport systems that prioritize efficiency, reliability, and environmental sustainability. Continuous monitoring, refinement, and adaptation will be imperative to ensure that the selected motor and transmission configuration effectively meets its objectives and sets a precedent for the future of electric transportation.

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