# Analysis of the Principle and Facilities of Generators and Motor

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**Abstract.** As a matter of fact, for motors, the new energy vehicle industry that is forced to develop due to the environment is an industry that rarely develops again in modern society. This paper introduces the application of different kinds of motor and generator in modern society and its development trend. Although the motors currently used have not been able to make new energy vehicles have the same power and durability as traditional fuel vehicles, if the algorithm and internal assembly method proposed recently can be implemented, this will be of great help to new energy vehicles to reduce energy consumption. On the generator side, people's consumption of electricity is in a growing trend, but in China's view, the total amount of power generation is in decline. The reason is also the concept of reducing greenhouse gas emissions in modern society, and the market for thermal power generation is gradually shrinking, while the market for pollution-free hydropower and wind power is gradually increasing.

**Keywords:** Motor; generator; new energy vehicle.

## 1. Introduction

The motor, that is, the motor in our daily life, can be traced back to the 18th century. The emergence of motors is largely due to the discovery of the law of electromagnetic induction and the law of electromagnetic force, and motors, generators, transformers, and control motors are machines that work on the basis of the principle of electromagnetic induction. As a kind of electromagnetic equipment that converts or transmits electric energy, the key is to generate driving torque. As a key equipment for energy conversion in electromechanical engineering, the motor is the basic component of electric transmission.

In 1820, the physicist Oster discovered the magnetic effect of electric current after research, which determined the close relationship between electric current and this and relied on this effect to lay the foundation of electromagnetism. In 1821, Faraday designed the world's first electric motor model through his theorem and paid attention to it., and in 1822 Faraday proved that electricity could work and move, and mankind entered the electric age. The second Industrial Revolution began with the successful invention of the first practical electric generator. Faraday discovered the phenomenon of electromagnetic induction in 1831.In 1870, the Belgian Gram invented the DC generator. In design, DC generators are very similar to electric motors. Later, Gram showed that the rotor of a DC engine would spin like a motor if current was fed to it. As a result, this Gram type motor is manufactured in large quantities, and the efficiency is significantly improved. In 1888, the American inventor Tesla invented the AC motor. This kind of motor is simple in structure, the use of AC, no rectification, no spark, is widely used in industrial household appliances, AC motors are usually powered by three-phase AC [1, 2].

Since the British physicist Faraday made the first prototype electric motor in 1821, humans have for the first time a device that can convert electrical energy into mechanical energy. Until 1831, Faraday made the first generator composed of a cylindrical coil and a magnetic rod, which represents that human civilization officially entered the electrical age. In the decades since, electric motors and generators have undergone several improvements and advances, developing different versions that can be used in different environments to achieve the same purpose.

In the development of the motor is the first to be developed is the DC motor, the first half of the development of DC motor can be divided into a permanent magnet as a magnetic field stage, to the

electromagnet as a magnetic pole stage and change the excitation mode stage. Because the use of the motor must be provided by the DC generator current, so in these three stages of development excitation technology is a key technology for the development of DC motor, he provides technical and theoretical support for the generator, the development of the motor with the development of the generator and progress, it makes the motor into a new application stage.

Helt, Denmark, 1854. The Werner brothers patented a self-excited generator. Since then, scientists have invented series self-excited motors and self-shunt generators, which have greatly changed the performance of DC generators, making the development of DC motors enter a new stage. In 1889, the engineer Dulev from Russia - Dupolovolsky invented the squirrel cage three-phase motor, which is the first three-phase AC motor that can be used, and the motor has developed to the stage of industrial application [3-5].

In modern society, diesel generator sets are widely used in industry, commerce, schools and other small and medium-sized enterprises for lasting (temporary) electricity; Small generators can also be used in homes. The motor is frequently used in various fields because of its wide range of uses, but also because the use of the motor conditions is very flexible, can work in a low energy environment, while changing its structure for high energy conversion work. Depending on the internal structure of the motor, it can complete the energy conversion work of AC or DC current. Due to the pollution caused by traditional cars to the environment, various countries have also begun to promote the development of new energy vehicles, and the motor, as the core component of the car, has ushered in a new round of changes to adapt to the new environment, and its internal structure and component materials will also change due to the different use of the environment [6, 7]. Similarly, manufacturers will also assemble different types of motors on different models according to their practical performance. Therefore, under different assembly structures and different component materials, the efficiency and performance of the motor will change.

With the continuous development of modern science and the gradual improvement of various theories, the performance of motors and generators is also gradually improving. In the 21st century, the application level of generators and motors has reached the peak, and in the following article, the application and development of generators and motors in modern society will be introduced.

## 2. Basic Description of Motor and Generator

### 2.1. Motor

Motors can be roughly divided into DC motors, AC motors and switched reluctance motors according to the type of current used. The key to the operation of the DC motor is the brush and the commutator, which are two devices to ensure that the current cycle in the motor is consistent, so that the motor can run sustainably. It is generally used in the field of home appliances, such as electric toothbrushes or some small electric equipment. Because these devices can only work at low voltage, DC motors that can use a fixed power supply are the best choice, and AC motors are generally divided into induction motors and synchronous motors.

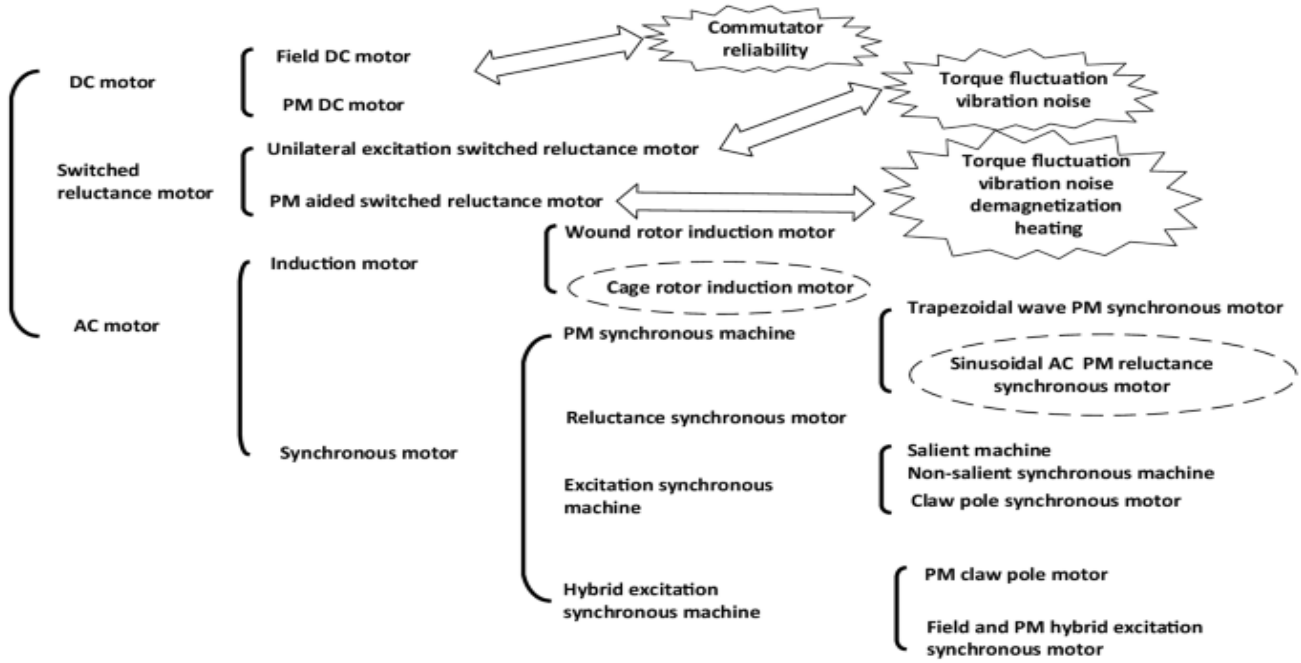


**Fig. 1** Types of motor.

In the industrial field, the most common is the three-phase asynchronous AC motor, three groups of windings spacing 120° when the power generated magnetic field and the conductor in the stator cut each other to generate induction current, and the magnetic field generated by the rotor is mutually repelling and rotating. Since its current will short circuit in the stator, no other magnetic field will be derived to interfere. Similarly its rotor speed will never exceed the stator. The synchronous motor is that the rotor and the stator maintain the same speed, and the stator's magnetic field is pulled by the rotor's magnetic field to rotate. Also because the conversion efficiency of synchronous motors is very high, it is generally used for power generation. The operation of the switched reluctance motor mainly relies on the principle of minimum reluctance, that is, without third-party magnetic field interference, the magnetic force of the two magnetic fields will naturally reach balance [8]. The switched reluctance motor is also often used in industry and its mining industry because of its large output power [9]. Types of motors are shown in Fig. 1.

### 2.2. Generator

Generators are divided into DC generators and alternators, and alternators can also be divided into single-phase generators and three-phase generators. Generators are divided into many different types, there are synchronous ones, asynchronous ones, single-phase ones and three-phase ones. From the production mode, there are turbogenerator, hydrogenerator, diesel generator, gasoline generator and so on.For energy, there are thermal generators and hydraulic generators.

## 3. Generator

Due to the natural properties of wind energy such as volatility and intermittent, its speed regulation ability is limited, which also affects the dynamic stability of regional power grids with high infiltration rate of wind energy. In 2008, Professor Conroy proposed the control strategy of virtual synchronous fan system relying on energy storage. The interface characteristics of the virtual synchronous generator at the junction point after the combination of fan and energy storage equipment are realized [10].

The idea of virtual synchronous generator originates from the control of three-phase inverter, which has similar grid-connected interface characteristics with traditional synchronous machine and can respond to the dynamic changes of the system and adjust the voltage and frequency independently.

The mechanical power command is generated by the governor model, the excitation current command is generated by the exciter model, and the internal potential vector with synchronous speed is generated by the generator body model. The virtual synchronous generator body model is mainly composed of electromagnetic model and electromechanical model. By introducing virtual inductance, virtual resistance and virtual speed, its output frequency can be determined by model parameters, which provides the control model basis for frequency support independent of wind turbines. The virtual synchro demonstration project directly applied to inverters has been promoted and implemented under the drive of relevant enterprises such as the State Grid, and its analog inertia, damping characteristics and frequency support effects have been widely verified. In order to better integrate wind power into the current power system dominated by large synchronizer, scholars at home and abroad have proposed a variety of virtual synchronous fan technology schemes, the essence of which is to make the fan at the grid-connected interface can simulate the inertia, damping characteristics, frequency and voltage support capacity of the traditional synchronizer.

## 4. Motor

In the 20th century, the motor has been mature and gradually integrated into various fields, and in the 21st century, due to the destruction and impact of traditional cars on the environment, it gradually withdrew from modern society, and the launch and development of new energy vehicles, which makes the motor once again concerned and developed. Compared with traditional motors, the motors applied to new energy vehicles need to pursue greater efficiency, so the permanent magnet synchronous motor with higher conversion efficiency has become the first choice, and the asynchronous motor with low cost and high speed is also a common choice.

In general, the permanent magnet synchronous motor can be divided into surface mount type and internal embedded, and the internal embedded has a lower magnetic leakage coefficient than the surface mount type, which means that the utilization efficiency of the permanent magnet in the motor is higher than the surface mount type. [4] At the same time, the internally embedded permanent magnet synchronous motor generally adopts a closed design, which leads to very low wind wear and noise, and the permanent magnet synchronous motor itself has the characteristics of high reluctance torque. [1] This makes the internal embedded permanent magnet synchronous motor the first choice for new energy vehicles. However, the battery life of new energy vehicles is still very insufficient, so its motor needs to improve the utilization efficiency of resources. In 2022, a loss minimization algorithm based on the Hamiltonian system energy shape method principle was proposed, which can reduce the power loss of its permanent magnet synchronous motor by 4% to 7% compared with the previous stable operation. [5] Although it is still in its theoretical model, it is also a big step forward in reducing its energy consumption. Changes in the way important components are connected to and between new energy vehicles can also reduce losses and vehicle emissions. [1] The engine, motor and battery are connected in parallel, in series or in both ways, which can make its fuel economy and acceleration efficiency have been improved. But its internal work efficiency will also be reduced.

The switched reluctance motor also has a high conversion efficiency, and its simple, solid structure allows continuous operation under certain faults, but it cannot accurately control the torque and produces a lot of noise during operation. As a result, switched reluctance motors in the automotive industry cannot have too large a market. However, in 2018, researchers from the School of Automation of Nanjing University of Aeronautics and Astronautics proposed to restructure and optimize the sectors of the electrical space on the basis of the traditional direct torque control method and adjust the width of each sector and release the appropriate voltage vector, so that the torque ripple can be reduced by nearly 40%. [3] This makes the switched reluctance motor have a heavier ratio with other motors, but the accuracy of its torque needs to be strengthened and the noise problem is also extremely fatal.

## 5. Conclusion

China's rapid economic development, the industrial scale continues to expand, the quality of national life continues to improve, the whole society's electricity consumption continues to grow rapidly, laying a solid foundation for the development of the generator industry, but in recent years, the output of generators has declined. From 2012 to 2016, the output of China's generator sets fluctuated greatly, and it has shown a continuous decline since 2017. According to the data of the National Bureau of Statistics, in 2018, the output of China's generator set was 10600.49 million kilowatts, and the output in 2019 was 92.741 million kilowatts, down 12.5% year-on-year.

In China's generator industry, the number of enterprises with large scale, strong research and development ability and high technical level is relatively small, and more enterprises are weak. Under the promotion of national policies, the structure of China's power industry is being adjusted and optimized, thermal power market shares gradually reduced, hydropower, nuclear power, wind power and other market shares gradually increased, the power industry's demand structure for generators has changed, but also the performance requirements of products continue to improve, promoting China's generator industry into the product structure adjustment stage. In the short term, the output of China's generator industry has declined, but in the long term, it is conducive to the healthy development of the industry.

Generators are widely used in the power industry and other industries, and the market space is large. With the rapid growth of China's economy, China's social electricity consumption continues to rise, providing sufficient power for the development of the generator industry. In the context of energy structure adjustment, the output of China's generator industry has declined, but in the long run, in the case of increasing market competition pressure, enterprises with small scale, weak research and development capacity and low technical level will gradually withdraw, which is conducive to the continuous optimization of industry structure.

Because the motor has already matured in the 20th century, different types of motors have been developed according to the needs of their different fields. So, in the early years people showed enough concern for its development. However, since the signing of the Paris Agreement in 2015, new energy vehicles have gradually entered the public's vision, in order to meet their needs for resources and power. The engine was once again concerned and developed by the world. However, because the research and development of new energy vehicles is not perfect, its performance is difficult to compare with traditional fuel vehicles. Therefore, new energy vehicles have high requirements for their motor efficiency and function. Although many high-efficiency, high-durability and low-cost electric motors have been put into the new energy vehicle industry, they have always been unable to jointly meet these conditions, so they cannot now be compared with traditional fuel vehicles. Fortunately, several models and algorithms for the new motor have been proposed, if these models can be successfully implemented, and the new algorithm can be successfully applied to the motor. Then the efficiency and performance of the motor can be greatly improved.

## Author Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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