Analysis on Wireless Charging Technology of Electric Vehicle

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Abstract. With the progress of science and technology and the development of the times, people's living standards are gradually improving, and the use of travel tools is becoming more and more frequent. However, due to the lack of fuel resources in China and the great environmental pollution caused by the use of fuel resources, the country is vigorously promoting the development of new energy to alleviate the domestic oil crisis, among which electric energy is the most widely used energy. Enterprises can use power resources to realize wireless charging technology of electric vehicles. As far as the wireless charging technology currently studied in China is concerned, many technologies are not perfect, which can not meet the needs of people and enterprises for the performance of the wireless charging automobile industry. Therefore, according to the problems existing in the development of the current wireless charging technology, this paper makes relevant analysis.

1. Introduction
Nowadays, China has popularized big data network in an all-round way, which makes domestic development highly informationized, and wireless charging technology, as an important one, is being vigorously researched and developed. With the gradual improvement of people's quality of life, the use of transportation tools is increasing. At the same time, the current domestic automobile energy is relatively scarce, which makes the country face an energy crisis at any time. Therefore, the country studies the new energy-wireless charging technology by using information technology, so as to meet people's demand for automobiles and alleviate the energy crisis. The charging technology of electric vehicles has been continuously improved and perfected, and its charging method has developed from traditional wired charging to wireless charging which is being perfected at present. Compared with the traditional charging method, the traditional charging method is complex, which needs to be combined with socket and charging line at the same time to complete charging, while wireless charging is to achieve wireless power transmission through the specific working principle of electric vehicles, and it is convenient and quick to operate. Therefore, at present, efforts are being made to improve wireless charging technology in China, so as to expand the development path of electric vehicles.
2. Main development fields of wireless charging technology

2.1. Development mode of wireless charging technology in foreign countries
The research on wireless charging technology abroad is earlier, which can be traced back to the 19th century, and at that time, Nikolai Tesla defined the working principle of wireless transmission technology as wireless power transmission[1]. In the 19th century, Nikolai Tesla constantly studied and tested the way to realize the wireless power transmission. Finally, one day in 1889, Nikolai Tesla used the working principle of electromagnetic induction to light a light bulb from a distance. This is the first time since the research that wireless power transmission in the true sense has been realized, which has milestone commemorative significance. After that, based on the working principle of electromagnetic induction, the researchers made an in-depth study on electromagnetic waves, and proved that electromagnetic waves can realize wireless energy transmission in theory. In the following years, through unremitting efforts, Japanese scientists and their team invented a new type of wireless power transmission carrier-microwave transmission wire, which mainly converts electric energy into microwave, so that it can spread quickly in the air. With the passage of time and the increase of scientific and technological talents, in the early 1960s, the United States officially turned the theoretical microwave wireless transmission into reality for the first time. The U.S. national defense company began to study the wireless power transmission mode in 1960, improved the research mode through continuous experimental tests, and after a period of research, invented an antenna composed of semiconductor diodes, which can convert microwaves into direct current, thus realizing the charging function. The concept that the invention enables electric energy to be wirelessly transmitted through the air has been confirmed.

2.2. Development mode of wireless charging technology in China
Compared with foreign developed countries, the domestic research on wireless charging technology started later, starting from this century[2]. The research and development of wireless charging technology in China mainly depends on the talents of universities and research institutes. Although the research on wireless power transmission technology in China is late, it has only been more than ten years since the beginning of the research, but the research results are quite good. Chongqing University is the most representative university among many universities studying wireless charging technology in China. Chongqing University began to study wireless power transmission technology in 2002. Its main research is the transmission technology in theory and its application in practical industries. At the same time, Southeast University is also studying wireless power transmission technology, which mainly studies the background system of wireless transmission technology, and finds that the inner and outer coils can generate resonance with the same current frequency when charging electric vehicles. At the same time, when studying the working principle of this resonance type, it is confirmed through repeated experiments that there is a mutual influence between antenna specifications and transmission efficiency. Then, in October 2011, the relevant talents of domestic universities and research institutes held the first special discussion conference on wireless charging technology. The main purpose of the conference was to analyze the key points of wireless transmission technology and the development trend of its application in the market, and issued a statement. In the future development of wireless charging technology, special discussion conferences related to it will continue to be held, so as to protect the development of domestic wireless charging technology [3].

3. Working principle of wireless charging technology for electric vehicles

3.1. Working principle of electromagnetic induction wireless charging for electric vehicles
Among the three concepts of wireless power transmission for electric vehicles, the working principle of electromagnetic induction is the earliest one, and it is also the working principle which has been
widely used in the field of wireless charging for electric vehicles so far. Its circuit structure in automobiles is shown in Figure 1.

![Figure 1. Internal structure of electromagnetic induction system in automobile](image)

There are secondary side of electromagnetic induction coil, rectifier circuit, control circuit and battery inside the car, and electric energy is transmitted in this order. There are circuit structures from power grid to primary side of electromagnetic induction coil outside the car and on the ground under the car, including power grid, power input, rectifier circuit, high frequency inverter circuit and primary side of coil, in which the primary side of underground induction coil and secondary side of induction coil inside the car need to be aligned when charging, and the distance between them should be kept at 0.1, so as to ensure that electromagnetic induction can realize wireless charging of automobiles. The process of electromagnetic induction is that the power input end receives the power from the power grid, passes through the rectifier circuit, reaches the high-frequency inverter circuit, and finally outputs to the primary side of the induction coil, which completes the flow process of electric energy outside the automobile. Subsequently, the secondary side of the induction coil inside the automobile is affected by the primary side of the coil, which will generate corresponding induced current, then filter it through the rectifier circuit, adjust the power, and finally input the current to the battery end to complete the charging process[4].

3.2. Resonance working principle of inner and outer coils with current frequency

Since Southeast University discovered the resonant working principle, although it has only been a short period of more than ten years, it has not affected the development speed of the wireless charging principle. In this short period of time, after many researchers' efforts and innovative research, the resonant working principle has become the core of wireless charging technology for electric vehicles, and successfully promoted the development of wireless charging technology. Its circuit structure in automobiles is shown in Figure 2.
Figure 2. Internal structure of resonant system in automobile

The working principle of resonance type is that the primary side and secondary side of induction coil will resonate when the current frequency is the same, so as to realize the process of electric energy transmission from outside to inside of automobile. The process of resonance in automobile and the flow of electric energy transmission are as follows: the power input converts the electric energy (alternating current) output by power grid into direct current through rectifier circuit, then converts the direct current into high-frequency alternating current through high-frequency inverter circuit, and then outputs the high-frequency alternating current to the primary side of induction coil. At this time, under the action of LC compensation circuit outside and inside automobile, the secondary side of coil will generate current with the same frequency as the primary side of coil, thus generating resonance reaction, enabling the electric energy to flow between the primary side and the secondary side of coil, and finally, electric energy. Because the current frequency between the primary side of the coil and the secondary side of the coil is hardly affected by the external magnetic field, this resonant working principle is widely used in the current wireless charging of automobiles[5].

3.3. Microwave operating principle through energy conversion process

The working principle of microwave mainly refers to the process of converting electric current into microwave, so that it can spread rapidly in the air and then be converted into electric energy after reaching the destination. Its circuit structure in automobile is shown in Figure 3.

Figure 3. Internal structure diagram of microwave working system in automobile

The process of wireless charging by microwave is that the electric energy flows into the rectifier circuit from the power grid, then converts AC into DC signal by rectification, then converts DC into microwave signal by converter, and then transmits it to the air in the form of electric radiation for propagation. At this time, the receiving antenna inside the automobile will echo its microwave and
receive it, and finally it will be converted into DC by the rectifier control circuit inside the automobile, and then input to the battery for charging the automobile [6]. When using microwave working principle to charge automobiles, it will not only produce certain radiation and cause certain damage to people's health, but also spread a large range of microwave in the air, which will easily cause some energy loss. Therefore, microwave working principle is rarely used in automobile industry.

4. Research progress of electric vehicle wireless power transmission at home and abroad
By comprehensive comparison, the research progress of wireless charging technology for electric vehicles in foreign developed countries is undoubtedly the biggest in the United States and South Korea. As early as 1990s, the United States began to study the practical application of wireless power transmission, and designed a charging platform, and the charging process can achieve 95% work efficiency. Some researchers in the United States have made a more in-depth and detailed study on the resonant wireless charging of electric vehicles, especially focusing on the primary coil and the secondary coil. Through a large number of experiments, it is concluded that placing the coil on a plane and carrying out spiral winding can greatly improve the transmission efficiency of electric energy between the automobile and the external environment. Similarly, based on the electromagnetic induction principle, South Korea developed the first electric vehicle in 2010, and built a road for wireless charging of electric vehicles in the following three years. The road is 24km long and the charging efficiency is as high as 85%. This product has achieved a strong support for its theory. As far as the development of wireless charging technology in China is concerned, its progress speed is not as fast as that of developed countries abroad, but its research results are comparable to those of foreign countries [7]. Domestic wireless power transmission technology mainly depends on the scientific and technological talents of universities and research institutes. After more than ten years of hard research, Chongqing University finally developed a wireless charging system and device in 2015, which can detect the electric quantity of automobile batteries and make corresponding charging response. At present, many domestic and foreign enterprises are vigorously promoting the development and application of wireless charging technology, and further improving the efficiency of wireless power transmission and reducing energy loss by cooperating with other enterprises.

5. Problems and development direction of wireless charging technology for electric vehicles
Although the wireless charging technology of electric vehicles has achieved good research results, there are still many shortcomings, such as: the wireless power transmission frequency will be affected by the distance between the vehicle and the charging device and the location of the vehicle, and some electric energy will produce harmful radiation during the wireless transmission process, and the wireless charging technology needs to invest a lot of money in the early stage of development. Therefore, in the future development of wireless charging technology, researchers can make improvement measures for the following problems [8]. First, the position between the primary side and the secondary side of the induction coil. The position and distance between coils directly affect the transmission efficiency of electric energy. Researchers can find out the best position and arrangement distance between them through experiments to solve this problem. Second, the microwave transmission of electric energy produces the problem of radiation. Strengthen the research on the transmission modes of electric energy, compare and learn from each other's advantages and disadvantages, so as to minimize the harm of radiation to human body.

6. Conclusion
To sum up, the study of wireless charging technology is conducive to promoting the development and popularization of electric vehicles, so as to alleviate the current domestic energy crisis. At the same time, there is a lot of room for improvement of this technology, and domestic researchers need to make continuous efforts to strengthen improvement, so as to promote the better development of electric vehicles.
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