Analysis of Typical Principles and Popularisation Measures of Wireless Charging for Electric Vehicles

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Abstract. Currently, the tram and tanker markets are competing fiercely, and whether wireless charging for electric vehicles can be successfully promoted in the future depends largely on whether the tram market can gain an advantage. Wireless charging has developed to the point where the overall system is not too perfect, so optimising the power system and developing more efficient and safer wireless charging methods is necessary. This paper introduces the basic principles of wireless energy transmission technology and some of the wireless charging methods. The two wireless charging methods of microwave electric power wireless charging and magnetic coupling resonant wireless charging are introduced in principle and the advantages and disadvantages are compared. The safety of wireless charging is maintained, and today's lifestyle is analysed to provide different charging methods for different people. The paper also gives the corresponding measures for the various kinds of dangerous situations that may occur. Finally, the paper gives an outlook and conclusion for the future of wireless charging.

Keywords: Wireless charging; magnetic coupled resonant wireless charging; microwave power wireless charging; optimisation of charging systems.

1. Introduction

Since the 21st century, the world is facing the crisis of environmental pollution and energy depletion, in order to ensure the health and safety of the human home, and provide a guarantee for the survival of future generations, countries around the world have begun to vigorously promote the use of clean energy. Such as the United States Musk as the first to launch the electric car industry has led the development of the electric car industry in various countries. China's Xiaomi Company 'Xiaomi SU7' has attracted widespread attention, but also shows that Chinese companies are also making efforts to make achievements for the world's environmental protection. Domestic charging piles are often not enough, European countries have not yet unified charging interface, and wireless charging is the best way to solve this problem to the electric car, so there is a need to vigorously develop wireless charging as a means of transmission of electrical energy.

The advantage of wireless charging is that it is based on inductive transmission of electricity, which does not take up too much space and can greatly enhance the utilisation of social resources to provide sufficient space for other related platforms.

Wireless charging technology for electric vehicles needs to meet certain requirements. For charging power, due to the need to promote comprehensive use, charging time reduction becomes a necessary element, so the power transmission needs more power under the premise of ensuring safety; For charging distance, wireless charging itself is to save space, its device must be controlled at the centimetre level, the vertical range of 15~45cm, the horizontal offset should be greater than 15cm, in order to achieve the purpose of saving space [1]. For charging efficiency, in general, the charging efficiency needs to be greater than 85% to have practical value, wireless charging in order to ensure the reduction of energy loss caused by the medium, should try to ensure that the environment is in a vacuum. For ensuring insulation, insulation performance is crucial in all kinds of extreme weather conditions, such as thunderstorms and rain. Because high power output will trigger high voltage, good insulation performance can ensure the stable and normal operation of the charging system [2]. After the basic hard requirements are met, the customer's own experience and practical needs need to be taken into account.

The goal of this research is to screen out more effective and feasible wireless charging methods. After screening, it will be improved according to the actual needs of customers, so as to achieve the goal of full popularization of wireless charging for electric vehicles.

2. Basic Overview of Wireless Charging for Electric Vehicles

2.1. Brief History of the Development of Wireless Charging

In 1891, Tesla, an American engineer magnate of electromagnetism, had researched the important technology of wireless charging, and he demonstrated for the first time the concept of wireless energy transmission, realising wireless power supply through resonant circuits. His experiments laid the foundation for later wireless charging technology [3]. Starting from small power wireless charging, charging is done by electromagnetic induction, for example, for mobile phone charging, we use Qi method, but for large cars wireless charging is done inductively [4]. For example, in 2005, China's BYD applied for a patent for a non-contact inductive charger, the technology used is electromagnetic induction [5]. Even today, technology is so advanced, wireless charging technology continues to progress, countries have just embarked on large-scale wireless charging technology, research on wireless charging of electric vehicles and its popularity is one of the categories. 2014, Vattenfall Electricity, located in Sweden, and Volvo Cars and do, successfully launched a wireless charging system based on the principle of magnetic resonance for power supply. 2021 , BMW developed a new wireless charging system for electric vehicles through the principle of electromagnetic induction. in December 2023, the high power fusion fast charging wireless charging standard group was established, in order to ensure that the mobile portal terminal fusion wireless charging standard with the times, China is ready to launch the fusion fast charging wireless charging standard in line with the relevant national industrial norms.

2.2. Microwave Electricity Wireless Charging vs. Magnetically Coupled Resonant Charging.

2.2.1. Microwave power wireless charging

Microwave power transmission: first, the electrical energy (DC or AC) is converted into microwaves through a microwave converter, and then the microwaves are sent to space through the microwave transmitting antenna of the transmitting station. The microwaves are transmitted in space to a ground receiving station. The received microwaves are converted by a converter to industrial frequency alternating current (AC) for use by the user. The principle can be viewed in figure 1. Therefore, the principle is similar to that of radio transmission, except for the difference in the energy level and direction of the transmission [6]. The main research and application areas of microwave power transmission are solar satellite power stations and aircraft receiving wireless power. In the United States, has demonstrated microwave power-driven helicopters; 600W microwave power transmission experimental system; send and receive the two ends of the distance of 1609km, the power of 30kW microwave power transmission system. Japan has manufactured a satellite power station, located in geostationary orbit, power generation capacity of 500kW, 36,000km from the ground [7].

Microwaves are electromagnetic waves with wavelengths between radio waves and infrared radiation. The advantage of microwave power wireless charging is therefore that microwaves can pass through the ionosphere without reflection compared to radio medium and short waves. Therefore the advantage of microwave power transmission technology is high efficiency and energy saving, its transmission energy is higher, the loss of energy is low, which can effectively solve the problem of large loss of electrical energy. Radiation pollution, microwave power transmission technology does not have any adverse effects on the surrounding things, compared with cable and optical cable transmission technology microwave power transmission technology is more distant, can be taken to achieve the purpose of optimising the design. Other aspects also have corresponding initiatives, this

technology has great potential, with the development of science, microwave power transmission will certainly be in the future to make a big difference.

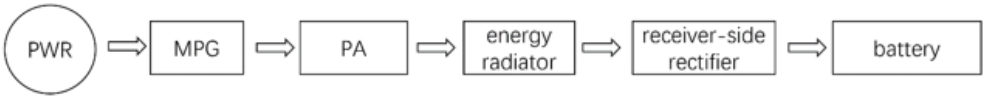

Fig 1. The principle of microwave electricity wireless charging.

2.2.2. Magnetically coupled resonant charging

There are two forms of magnetically coupled wireless power transfer, one is Magnetically-Coupled Inductive Wireless Power Transfer (MCI-WPT) and the other is Magnetically-Coupled Resonant Wireless Power Transfer (MCR-WPT). Resonant Wireless Power Transfer (MCR-WPT).

Magnetically Coupled Resonant Wireless Power Transfer (MCR-WPT) is mainly suitable for medium-distance transmission and has advantages over the common inductively coupled wireless power transfer technology. Its low radiation and low directionality significantly improve the transmission efficiency and increase the transmission distance.

Magnetic coupling resonant wireless energy transmission technology makes use of the resonance effect of the magnetic field to achieve the wireless transmission of the required power. Magnetically coupled resonant wireless energy transmission technology utilises the resonance effect of a magnetic field to achieve wireless transmission of the required electrical energy. It mainly relies on resonant coupling, where the impedance of the coil loop is minimised when the two coils are in self-resonance. At this time, most of the energy can be transferred from the transmitting end to the resonant receiving end to achieve the purpose of energy transmission [8].

Magnetic coupling resonant wireless energy transmission technology has been used in various fields because of its ability to achieve long-distance energy transmission and high transmission efficiency. For some implantable medical electronic devices, this technology can achieve the role of no battery replacement, thus reducing the physiological and psychological burden of patients. For underwater power equipment, it can provide power for large marine underwater navigation detectors. For the problem of coil clutter in daily life, this technology provides the convenience of providing electrical energy.

For wireless charging of electric vehicles, the lower and middle parts of the car, where the chassis is located, are inlaid with a receiver and self-resonance occurs between the transmitter and receiver of external charging equipment. When the loop impedance of the two coils is minimised, energy can be transmitted with high efficiency. The coupling between the coils may be affected by a number of factors, such as the distance between the coils, the orientation of the coils and the presence of other objects that can absorb or reflect the magnetic field [9]. More precise data analysis is required for specific cases. This charging principle can be viewed in Figure 2.

Two types of wireless energy transmission are described above, magnetically coupled resonant wireless energy transmission and microwave wireless energy transmission. Depending on the usage scenario and environment, the corresponding power transmission methods are different. For electric vehicle charging, faster and higher power charging is often required. In contrast, microwave radio transmission is too low power and can only be used to power low power devices. Therefore, magnetic coupled resonant radio transmission is highly feasible for wireless charging of electric vehicles.

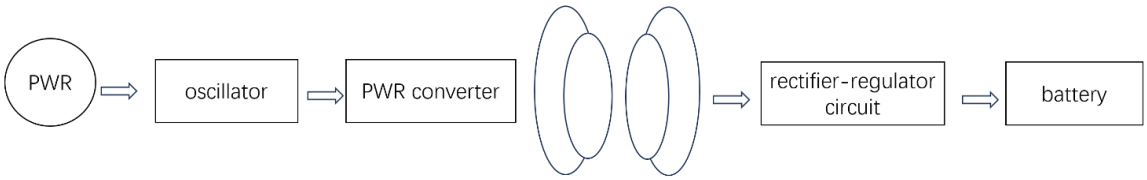

Fig 2. Magnetically-Coupled Resonant Wireless Power Transfer.

3. Initiatives Taken to Safeguard the Full Rollout of Electric Vehicles

3.1. Charging Safety Design that Optimises the Customer Experience

As an initiative to be fully promoted, wireless charging of electric vehicles should always put customer experience in the first place. Different customers have different charging times and different charging needs. For example, customers who often go on business trips abroad have high requirements for battery capacity and charging speed, so intelligent charging scheduling and intelligent charging algorithms can be used. According to the changes in electricity prices, the optimal charging time is selected to reduce charging costs, and the charging speed and method are adjusted according to the health status of the battery and usage habits, such as using trickle charging or fast charging mode. In the case of simultaneous charging of multiple devices, charging resources are allocated according to the needs and priorities of the devices to achieve charging priority management, a level that can better enhance the user experience Manufacturers can develop mobile phone apps to connect to the electric vehicle, and remotely start and stop or adjust the charging settings through the apps Provide advice on maintaining the battery according to the usage habits and charging data, to help the user prolong the life of the battery. In order to ensure the safe and reliable operation of the charging system, overcurrent, overvoltage, short circuit and other functional modules should also be added to the basic wiring design. In order to ensure that the long-term operation of the system does not occur overheating, electromagnetic interference and other issues. When designing the basic wiring, we also need to consider heat dissipation, electromagnetic compatibility and other issues. [10].

3.2. Intelligent Monitoring Equipment and Measures in Emergency Situations

Car wireless charging is a new industry, to protect people's safety. Because the wireless charging device needs to have a high-efficiency power transmission capacity, so after the sending end, through the rectifier device, power amplifier, and other equipment, and finally to the receiving end we should adopt intelligent management to prevent the over-voltage or over-current situation. Therefore, we can use different voltage sensors and temperature sensors to monitor the charging battery in real time. The charging power can be adjusted according to the results of the monitoring to ensure the safety and reliability of the charging process. The battery should be liquid-cooled to avoid fire hazards in the event of overheating during the charging process. For the dangerous situation of leakage of electricity, an automatic power-off protection device should be installed on the charging side, which can be activated immediately in case of over-current or over-voltage. Ensure that wireless charging devices comply with relevant international and national standards such as Qi standards, CE certification to improve product reliability and safety, so that customers feel at ease. Design waterproof and dustproof charging systems and devices to ensure safe use in different environments. When the wireless charging device or the electric car malfunction while driving, the customer initiative or the intelligent setting in the car automatically connects to the relevant departments. Child lock is set up to avoid accidental touching by children. The manufacturer's personnel for customers to timely remind or ask in case of fire, car accidents and other emergencies automatically dial 119 and roadside assistance. This can protect the lives and property of users. If the user does not get a response in the call, automatically transfer the relevant departments for help, and will be sent to the relevant departments to establish the location of the child lock, to avoid accidental contact

4. Conclusion

This paper mainly introduces the brief history of the development of wireless charging, and explains the principle and compares the advantages and disadvantages of magnetic coupled resonant wireless charging technology and microwave power wireless charging technology, which are worth focusing on to explore. For the shortage of charging resources in China before, wireless charging has an important role to play, which also prompts the rapid development of China's electric vehicle industry. In order to ensure the full popularity of wireless charging for electric vehicles, it is also

necessary to optimise the customer experience, such as designing charging solutions and installing intelligent monitoring equipment.

With such rapid technological innovation, wireless smart charging technology will become the main charging mode for electric vehicles, and the development of new technologies that are convenient and efficient will maximise the user experience. The development of wireless charging technology for electric vehicles heralds the trend of using clean energy in the world in the future, and also drives the development of the economy, healthcare and other aspects, giving the industry more opportunities. The main direction for the popularisation of wireless charging for electric vehicles in the future is to reduce costs and improve quality.

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