

Principle and Development Trend of Wireless Charging Technology for Electric Vehicles

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Abstract: With the introduction of peak carbon, carbon neutrality, new development concept and the concept of community of human destiny, as well as the increasing prominence of energy and environmental protection issues, people gradually focus on solving the related problems. The article focuses on the principle and wireless charging technology on the development trend of new energy vehicles, sorting out the working mode, working principle, research results and trends on wireless charging technology ; introducing the advantages and disadvantages of electromagnetic induction, magnetic coupling resonance and radio wave wireless charging technology as well as wireless charging technology is located within an electric field and related workings. The advantages and disadvantages of wireless charging technology in electric field coupling and the related principles are summarised, and describes future trends regarding wireless charging technology.

Keywords: Wireless Charging Technology On Electric Vehicles; Magnetic Coupling Resonant; New Energy Vehicle; Electric Field Coupling

1. Introduction

With the advancement of time, people's quality of life is getting better and better, the development and progress of science and technology, as well as environmental protection and energy security issues are increasingly prominent, people for energy and environmental protection and other related issues to give more attention and attention. The emergence of electric vehicles has greatly alleviated and improved the relevant issues, in recent years, the demand for electric motor vehicles new energy vehicles and new energy industrial vehicles has increased greatly, and the government and the state in the relevant aspects of strong support. At present, wired charging technology is the main

charging method for electric vehicles, but wired charging technology has many problems in actual use, such as charging piles charging speed is slow and the number of less, but the number of new energy vehicles is more and lead to oversupply of problems, and charging port adaptability, wear and tear, and aging, etc. are also still wired charging technology drawbacks. Wireless charging technology has a higher level of safety compared to wired charging technology, displacement flexibility and stability and has a better development prospect. And in the last several years, the occupancy of new energy vehicles in China has increased greatly. Therefore, the current wireless charging technology on new energy vehicles is very research significance.

2. Current Status of Domestic and International Research

2.1 Status of Domestic Research

Electric vehicle wireless charging technology in the domestic research is mainly led by Tongji University, Chongqing Polytechnic University, Hong Kong Polytechnic University, Tsinghua University, Shenzhen University, Tianjin Polytechnic University and Shanghai Jiaotong University and other major universities, the research direction is mainly to optimise wireless charging technology on magnetically coupled resonant, the optimization of the transmission efficiency as well as electromagnetic shielding and compatibility and other fields. At present, wireless charging technology for new energy vehicles has begun to be researched by many domestic enterprises, such as BYD applied for a patent for a non-contact charger in 2005; the world's first pure electric vehicle MARVEL X that can be charged wirelessly was released by Rongwei on 23rd April 2018; subsequently, ZhiJi Automobile also announced that it had developed an electric vehicle that supports wireless charging; meanwhile, ZTE New Energy Vehicle, Beijing Qualcomm Technology Co.

Beijing Qualcomm Technology Company, Xiamen New Page Technology Co., Ltd. and other companies are also researching wireless charging technology on new energy vehicles.

2.2 Current Status of Foreign Research

China's wireless charging technology for new energy vehicles started late compared to foreign countries, so its research results are at the leading level compared with that in China. Foreign electric vehicle wireless charging technology is mainly researched by the Massachusetts Institute of Technology (MIT) in the U.S., Stanford University in the U.S., the University of Auckland in New Zealand, and the University of Tokyo in Japan. In 1987, the American inventor John George Burger began to try to wirelessly charge an electric vehicle; in 2001, a wirelessly charged electric vehicle was put on trial in a park in Seoul, South Korea; in 2007, BMW announced that it will use commercial wireless charging technology in new energy vehicles; and in 2019, Honda demonstrated an EV wireless charging technology at the International Consumer Electronics Show that can charge vehicles as long as the charger and receiver have an 80% overlap area.

3. Wireless Charging Technology on Electric Cars

3.1 Radio Wave Wireless Charging Technology

Radio wave wireless charging technology is a relatively reliable wireless charging technology. Radio wave wireless charging technology for the transmission of electrical energy is transmitted by radio waves, also known as electromagnetic waves, the antenna is an important part of the radio wave wireless charging technology, radio waves will be converted from electrical energy after passing through the transmitting device., the receiving device receives the radio waves, after the radio waves are converted into electrical energy. The advantage of radio wave wireless charging technology lies in the transmission distance, but its transmission efficiency is low, the disadvantage of low transmission power is very obvious, and radio waves in the process of transmission to the nearby human beings is a certain degree of influence. Therefore, In terms of wireless charging technology for new energy vehicles,

radio wave-based wireless charging technology has not been studied more deeply.

3.2 Electromagnetic Induction Wireless Charging Technology

Faraday's law of electromagnetic induction is wireless charging technology on the main principles of electromagnetic induction type, This charging method is the most common wireless charging method. The working principle of the transformer is similar to that of wireless charging technology on electromagnetic induction. The main working principle of electromagnetic induction wireless charging technology is that when the power input terminal is connected to the coil after the start of the input power, in the rectifier filtering will be transformed into DC alternating current, and then high-frequency inverter to reach the transmitting coil will be transmitted current from transmitter to receiver after electrical energy is output from rectifier inverter, wireless transmission of electrical energy is realised by this method. Electromagnetic induction wireless charging technology has the advantage of high transmission efficiency and simple circuit structure, is currently the most widely used, the most mature wireless charging technology, but in the process of using the coil needs to be aligned, and if there is a metal foreign body between the transmitter and receiver in the process of work, the metal foreign body will draw energy from the magnetic field to heat the metal foreign body and lead to danger, and since the gap exists between the transmitter and receiver, so it can only achieve centimetre-level wireless charging. Moreover, due to the existence of air gap between the transmitter and receiver, only centimetre-level power transmission can be achieved, and the transmission distance is short, which is only suitable for short-distance charging, and the efficiency of power transmission decreases with the increase of the distance. However, due to its low power loss in transmission and high adaptability, it is still an important part of wireless charging technology on the future of new energy vehicles.

3.3 Magnetic Coupling Resonant Wireless Charging Technology

Wireless charging technology on magnetically coupled resonant both at home and abroad its research time is relatively short, but its content

as well as technological innovation is relatively rich. Magnetic coupling resonant wireless charging technology charging mode is through the high-frequency electromagnetic field to carry out energy transfer, its working principle is mainly the power supply output power after rectification and filtering in the high-frequency inverter circuit after arriving at the transmitting coil, when the transmitter and receiver coils electromagnetic frequency and the intrinsic frequency is the same, after the resonator resonance, this time the receiving coil will be able to receive the electrical energy after rectification and filtering. After rectification and filtering, the receiving coil can start charging the battery. The advantages of wireless charging technology regarding the magnetically coupled resonant type are as follows: low loss in the energy transmission process, high transmission efficiency, can achieve long distance transmission and in the use of the process for the car and charging device relative position of the lower requirements, and can be more than one device at the same time for charging. However, magnetic coupling resonant wireless charging technology still has some problems, charging facilities, high cost, charging equipment is not compatible and charging standards are not uniform and other issues, in addition to high-frequency radiation hazards for the human body and high-frequency and high requirements of electronic components. However, due to wireless charging technology on magnetically coupled resonant of high energy conversion efficiency and stability, provide effective and robust support for the developments in wireless charging technology, so has high research value.

3.4 Electric Field Coupled Wireless Charging Technology

Electric field coupled wireless charging technology is also called capacitive wireless charging technology, its main working principle is through the metal pole plate coupling capacitor to transmit electricity. The main workflow about the electric field coupling type wireless charging technology type first power supply and the input terminal connection, and then through the high-frequency inverter circuit will be transformed into alternating current DC power, and then through the transmitter side of the compensation circuit to get the high voltage, high frequency alternating current (HFAC), under the action of the voltage transmitter and

receiver pole plate and the formation of the electric field formed between the currents will be transmitted from the transmitter to the receiver, after rectifier filtering circuit for the battery charging, thus realising the wireless transmission of electric energy. Thus, the wireless transmission of electric energy is achieved. In the past, wireless charging technology on electric field coupled is mainly concentrated in the short distance, low power application scenarios, which is mainly due to the limitation of electronic components. At present, wireless charging technology regarding the electric field coupling type can be applied to the long distance, high power transmission of electricity, such as wireless charging technology on new energy vehicles. The electric field coupling wireless charging technology has the advantages of high displacement flexibility and lightweight equipment, low investment and construction costs of equipment and power transmission efficiency is relatively high, and wireless charging technology on electric field coupled can overcome the problem of metal sensitivity. But the electric field coupling charging technology also has some disadvantages, such as the current technology maturity is low. However, due to its high stability, safety and high energy transmission efficiency, electric field coupled wireless charging technology still has high research value and promotion space in Wireless charging technology on new energy vehicles.

3.5 Comparison of Advantages as Well as Disadvantages of Wireless Charging Technology

The advantage of wireless charging technology with respect to radio waves is the relatively long transmission distance, which can reach kilometers, but higher energy loss during transmission and lower transmission efficiency. Wireless charging technology has the advantage of relatively high transmission efficiency regarding electromagnetic induction, but due to its short transmission distance, it can only be used for short distance charging, up to the centimetre level, which severely limits the real-life application of this wireless charging technology.

The advantages of magnetic coupling resonant wireless charging technology are high energy conversion efficiency during charging, high stability during transmission and long

transmission distance, but the wireless charging technology has higher requirements for the equipment, which requires the transmitting and receiving coils to be strictly aligned during the transmission process.

The advantages of electric field coupling wireless charging technology are high displacement flexibility, charging equipment is lightweight and simple structure, and relatively efficient transmission of electrical energy with good safety and stability, but the maturity of the current technology is relatively low.

4. Standardisation and Compatibility of Wireless Charging Technologies

With the development and popularisation of wireless charging technology, standardisation and compatibility will be a major obstacle to its development. Vehicle manufacturers, international organisations and countries should work together to compile standards on the size, type and power of wireless charging devices to ensure that different car models can use the same charging device and that it is safe and efficient.

5. Trends in Wireless Charging Technology for Electric Vehicles

Wireless charging technology on new energy vehicles is developing rapidly, with the development of the times scientific and technological progress, wireless charging technology about new energy vehicles will be used in the Internet of things, unmanned driving and more expansion of the application field. The combination of Internet of things and wireless charging technology can not only make use of the flexibility of wireless charging technology to make Internet of things devices get rid of the constraints brought about by wired charging and provide a more continuous and stable power supply for the devices, but also realise the interconnection and interoperability between wireless charging devices, and further improve the utilisation efficiency of charging piles and charging line rate and the combination of wireless charging technology and driverless technology can dramatically improve the user experience and convenience, increase the charging efficiency of the car, and realise truly unlimited range, thus enabling a higher degree of autonomous driving technology. And, with the increase in purchases about new energy vehicles, people for the new energy vehicle charging demand continues to grow, electric vehicle

wireless charging technology market will continue to expand, should ensure its charging efficiency, so that multiple new energy vehicles can be charged at the same time, but also in the future can be researched and developed in the new energy vehicle dynamic wireless charging technology. But there are still many technical challenges regarding wireless charging technology. Firstly, as the transmission distance increases, the transmission line rate of electrical energy with respect to wireless charging technology will be greatly reduced, resulting in the realisation of long-distance wireless charging with greater technical challenges. Second, wireless charging generates a large amount of heat during operation, which may lead to a fire risk. Thirdly, the popularisation and commercialisation of wireless charging technology is costly, and reducing the cost of wireless charging devices is also a major technical challenge. With the continuous development of science and technology and the gradual deepening of related research, the application fields of wireless charging technology on new energy vehicles will be more diversified, and the application will be more popular.

6. Reach a Verdict

This paper describes the development status, working principle and development trend of wireless charging technology for electric vehicles. In the field of new energy vehicle charging, wireless charging technology for new energy vehicles has higher safety than wired charging, stability and displacement flexibility than wired charging technology. This paper compares four wireless charging methods (wireless charging technology on radio waves, wireless charging technology on electromagnetic induction, wireless charging technology on magnetic coupling resonance, electric field coupling wireless charging technology), and it is concluded that wireless charging technology on magnetic coupling resonance type and wireless charging technology on electric field coupling type have higher research value in the future for wireless charging technology in the field of new energy vehicles. Currently, wireless charging technology about new energy vehicles has been applied in more fields, but in the field of wireless charging on electric vehicles needs more comprehensive and in-depth research. The main development direction of the future of new

energy vehicles is electric vehicles, and electric vehicles to achieve long range is an important guarantee of wireless charging technology about electric vehicles, to solve the problems of slow charging of electric vehicles, low efficiency, displacement flexibility provides an effective solution. In the future, the development and research in the transmission distance of electric vehicle wireless charging technology and the commercialisation of charging equipment should be strengthened. In the manufacture of transmission equipment, manufacturers and research institutes should intensify their research on the materials used in transmission equipment in order to find materials that have less impact on power loss when transmitting power. They should also create models of equipment with superior transmission efficiency and distance, and put them into production and use as soon as they are proven to be feasible.

In the future, as the market share of electric vehicles continues to increase, the demand for wireless charging technology will also increase significantly, which not only saves capital cost and time cost but also improves the efficiency and safety of charging. It is confident that in the near future, wireless charging technology will gradually develop more mature, and applied to wireless charging about electric vehicles in the actual scene, under the efforts of relevant researchers to promote the rapid development of wireless charging technology and related technologies and have a positive impact on the development of society.

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