Analysis on Coupling Structure of Dynamic Wireless Charging in Electric Vehicle

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Abstract. The existing electric vehicles use charging piles for charging, which is inefficient and inconvenient, so wireless charging technology has become the research focus. Compared with the traditional charging mode, electric vehicle wireless charging does not need wiring, more convenient, safe and efficient. This paper presents a three-coil compensation optimization scheme. Based on the research of square-square coupling coil, while determining the optimal winding mode of the coil, the magnetic cores of transmitting and receiving coils were selected to analyze the coupling situation according to the magnetic field distribution cloud map, and use the Simpleror Maxwell and ANSYS software simulation, analysis, contrast system coupling way, the purpose is to meet the needs of dynamic charging, solve the problem of the current electric vehicle charging limited.

1. Introduction
With the development of new energy automobile industry, vehicle battery has become the main reason to limit its development.

Existing batteries cannot fully meet the range capacity and service life of electric vehicles[1-2]. Charging piles not only limit the use places of electric vehicles, but also occupy land resources. Therefore, the development of wireless charging technology has become an important issue.

The key technology of power wireless transmission by chongqing university radio can transmit technology research and development team introduced[3]. The purpose of wireless charging system is to improve the power and efficiency of energy transmission, and the key to solve this problem is the design of magnetic coupling coil[4].

At present, there are two measures to improve the coupling ability of coils, the first is to design the winding mode of coils, and the other is the design of coil core structure. This paper uses Simpleror and ANSYS Maxwell software simulation to select the best collocation scheme.

2. Selection of Coil Structure for Coupling Structure of Wireless Charging Device
Inductive WPT technology[5] is widely used in academic circles, and it is a technology that can safely and efficiently transmit electric energy through non-contact magnetic coupling.

It can be divided into three types: electromagnetic induction type, electromagnetic radiation type and magnetic coupling resonance type. Simultaneously interpreting three kinds of resonant modes for different transmission power and transmission distance, it is found that the magnetic coupling resonance is more suitable for[6]. By analyzing the transmitting and receiving devices of wireless charging, it is determined that the system can have the maximum output power and transmission...
efficiency at a fixed angular frequency by compensating the dynamic impedance. Figure 1 is a schematic diagram of the application of dynamic impedance compensation.

Figure 1 Dynamic charging three-coil compensation device

The coupling mechanism of electric vehicle WPT device is usually affected by the parameters, shape and position of transmitting coil and receiving coil. The general transmitting coil is fixed inside the base and the receiving coil is installed inside the car. At the same time, the change of the relative position of the transmitter and receiver leads to the change of the coupling parameters of the system, and finally leads to the unstable change of the power. Two kinds of WPT systems, circle square coupling coil and square square coupling coil, are analyzed, and the coupling mechanism model is established[7]. It is concluded that the circular-square coupling coil structure is more sensitive and the square-square coupling coil structure is more stable when the offset changes. Stability is the first condition of wireless charging. Therefore, this paper is based on the structure of square square coupling coil.

3. Design and analysis of coil winding mode

Dynamic wireless charging uses long rail buried underground cable, but due to the different winding way of coil, the magnetic field is also different, so the structure of narrow side and wide side transmitting coil is analyzed.

3.1. Narrow side transmitting coil

Wires are wound tightly with no gap between them, called narrow-sided coils.

Figure 2 and Figure 3 show that the receiving coil of the intensity distribution of the transient magnetic field is located at the end and the middle.

Figure 2 Magnetic field at the end

Figure 3 Magnetic field in the middle

Figure 4 shows the variation of the coupling coefficient of the receiving coil when it moves along the track length direction.
In the actual charging process, the receiving coil will move along the direction of the transmitting coil. From this direction, the coupling coefficient changes as shown in Figure 4, and the coupling coefficient remains unchanged in a certain range.

3.2. Wide side transmitting coil

Wire-to-wire is sparsely wound, with a gap in the middle called a wide-side coil.

In Figure 5 and Figure 6, the distribution of transient magnetic field intensity shows that the receiving coil is located at the end and the middle.

It can be seen from the figure that when the receiving coil moves along the transmitting coil, the coupling coefficient at both ends of the trajectory is large, while the coupling coefficient at the middle part is small and does not change within a certain range.
Compared with figure 4 and 7, it can be found that the coupling coefficient of narrow edge transmitting coil is larger than that of wide edge transmitting coil. In summary, the narrow edge coil of the transmitter is used in this paper.

4. Selection of core shape
When the magnetic field of lack of core, spatial spillover is large, energy cannot be efficient transmission, so want to through the core guiding magnetic field, reduce invalid diffusion, and select the manganese zinc ferrite as core material.

4.1. Simulation analysis of magnetic core structure at transmitter

4.1.1. Plate core structure
The magnetic conductivity material of guiding space magnetic field is plate core under the long guide rail of emission coil, which can reduce the loss of magnetic field. The plate core requires that the length of the core is equal to the length of the coil.

By observing the magnetic field distribution of the transmitting coil plus the plate-type magnetic core in Figure 8 and Figure 5 and 6, it can be seen that the addition of the plate-type magnetic core can shield the magnetic field below the transmitting coil and increase the magnetic field density above the coil to a certain extent.

4.1.2. Slot core structure
The slot magnetic core structure is that the magnetic core is arranged at the inner, outer and lower sides of the coil. The inner core is hollow, the width is the sum of the thickness of the coil and the outer core, the height is twice of the coil, and the cross section is U-shaped.

It can be seen from the magnetic field distribution of the transmitting coil and the slot core in figure 9 that some of the magnetic field of the slot structure is under the coil, but the proportion is low. In general, because a large number of cores can be saved in the middle part, the economy is strong.

4.2. Simulation analysis of magnetic core structure at receiving end
In summary, the following analysis of the transmission coil using slot magnetic core, and for the compensation coil to add Sichuan type magnetic core, the shape of the receiving coil analysis and comparison.

4.2.1. Plate core structure
A plate structure with a magnetic core laid above the receiving coil is the magnetic core of the receiving coil. The length of the plate core should be equal to the length of the coil.
By can be seen in figure 11, plate type magnetic core between receiving and transmitting coil magnetic field is stronger, and vacuum magnetic field exists in the receiving coil above, can be in the upper part formed block, reduce the harmful magnetic radiation.

Figure 11 Magnetic field distribution of plate core transmitting coil

Figure 12 Magnetic field distribution of receiving coil with cover core

4.2.2. Cover core structure

Laid a layer above the receiving coil and coil around the equal length and increase core enclosure structure called cover type magnetic core, its shape like square lid.

From the comparison of figures 11 and 12, it can be seen that the magnetic field distribution of the cover type and the plate type is roughly the same, but the structure has a magnetic core wrapped around the coil, which significantly reduces the distribution of the coil in the X direction. At the same time, the structure can also shield the position directly above it, and the shielding range is larger, so the cover type core structure is better than the plate type core structure.

In summary, the coupling structure of three coils with magnetic core discussed in this paper is composed of transmitting coil matching slot core, compensating coil adding Sichuan type core and receiving coil matching cover core.

5. Conclusions

Based on the premise of dynamic charging process and the purpose of selecting the coil and magnetic core structure which are reasonable in economy and technology, a three coil coupling structure is formed.

First of all, on the basis of three coil structure in the output when its maximum power transfer efficiency is also the biggest, again to a basic party-square transceiver coil structure analysis device coil, core two parts, the conclusion is narrow and rectangular coil as the transmitter coil, the core structure of the magnetic core, matching groove compensating coil in Chuan fonts core at the same time, the receiving coil to join cover type structure which has the best coupling effect of magnetic core.

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