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Innovation of new energy equipment in the context of smart grid

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Abstract. Charging pile technology is of great significance for the popularization of electric vehicles and the construction of smart grids. By analyzing the development status and trend of charging pile technology against the background of the smart grid, this paper discusses the future development direction of charging pile technology. The research results show that the development prospect of charging pile technology under the background of smart grids is very broad, and it is necessary for the government and enterprises to make joint efforts to solve the problems of high construction costs and unreasonable layout of charging piles through technological innovation and policy support, promote the rapid development of charging pile technology, and provide better support for the development of the electric vehicle market. Charging pile technology is an important device connecting electric vehicles and power grids, which is of great significance for the popularization of electric vehicles and the construction of smart grids. This essay designs a kind of high-power intelligent charging pile which can meet the security protection level, carry out real-time monitoring, real-time data acquisition and interconnection.

Keywords: smart grid, new energy, charging pile, equipment innovation.

1. Introduction

In the process of vigorously promoting the construction of charging facilities in the country, charging piles have been rapidly developed, but at the same time, many problems and shortcomings have been highlighted, and the current charging piles still cannot meet the market demand to a large extent. How to improve charging facilities, establish unified charging pile construction and charging standards, and pay attention to the operation of charging piles will become particularly important, so it should be driven by the smart grid. The innovation of new energy equipment against the background of the smart grid is a research field that attracts much attention. Prior to this, some scholars had conducted in-depth research on this topic from different angles. An intelligent study on new energy equipment shows that through the Internet of Things technology, new energy equipment and smart grids can achieve seamless connection, real-time monitoring of power production, storage, and consumption, and other aspects of the state, so as to achieve intelligent control and efficient scheduling of new energy equipment [1]. On the other hand, a study on the efficient use of new energy equipment found that with the support of the smart grid, new energy equipment effectively solved the bottleneck problem of energy conversion and transmission, and realized efficient energy utilization [2]. Different from previous scholars, this study discusses the sustainable development path of new energy equipment innovation under the background

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of the smart grid from the perspective of sustainable development of new energy equipment. This study analyzes three aspects: policy, technology and market, and puts forward policy suggestions, technological innovation direction and market promotion strategy for sustainable development of new energy equipment. The significance of this study is that it provides a new idea and method for the sustainable development of new energy equipment. The first chapter determines the research background, research significance and domestic and foreign development, and introduces the research objectives. The second chapter is to understand the charging mode of charging piles and the market demand for intelligent charging piles, formulate design parameters and carry out the overall design of intelligent charging piles for electric vehicles, and then discuss the key technologies of intelligent charging stations. The third chapter studies the development mode of intelligent charging pile, and looks forward to the prospect of intelligent charging station. Chapter four summarizes the research content of this topic and looks forward to the future development of intelligent charging pile.

2. Development of charging pile facilities at home and abroad

2.1. Domestic development status

In the early stage of development, there is a big gap between charging piles and foreign countries. Since 2011, the scale of electric vehicles in China has been increasing, and corporate ownership of public charging facilities has also been increasing. Starting from the construction and development of charging facilities led by large state-owned enterprises such as the State Grid and Southern Power Grid, to the injection of private capital, and then to the state's beginning to unify the construction standards of charging piles, it can be said that the construction and layout of charging piles are moving step by step toward standardization. From 2011 to 2016, charging piles were in a slow development stage, with eight large charging pile operators accounting for more than 90% of the total number of charging piles in the country, and the remaining 10% being occupied by other operators. Among them, the top three operators are "special call", "Star charging" and "National grid". The number of charging piles accounts for 70% of the total, but there is no unified, interrelated charging system and charging standard between them. Such a situation not only limits the development of charging piles, but also reduces the equipment utilization rate of other charging pile operators [3]. For the above situation, the State Quality Inspection Administration, the Ministry of Science and Technology, the Ministry of Industry and Information Technology and other departments in issued 2015 the newly revised electric vehicle charging interface and communication protocol 5 national standards, and began to implement in January 2016. This revision has greatly improved the safety and compatibility of charging piles. In 2017-2019, the charging pile construction has already had a basic scale, but the interconnection progress is slow, each operating company has assets, and they all want to get a share of the charging pile industry, so they will not choose to integrate resources, and precisely the charging pile is a heavy asset with a large initial investment and a long investment return [4]. Therefore, in 2020, the country once again attaches importance to the development of charging infrastructure, and solves the problem of scattered charging pile layout, insufficient ratio of car to pile, charging interconnection and charging safety.

2.2. Development status at abroad

Due to its strong economic strength and strong scientific and technological strength, the number of electric vehicles in the United States is also ranked first in the world, and the construction of electric vehicle technology and charging piles is far ahead in the world. To vigorously develop and promote the construction of electric vehicles and charging facilities, the United States government has adopted many policies. At the national level, the U.S. government first lays out smart grid technology and then lays out charging pile facilities on the basis of the smart grid. Moreover, a series of charging pile construction standards have been specially formulated to encourage and guide enterprises to correctly construct charging piles and comprehensively promote the diversified development of electric vehicles. The Japanese government is also pushing for electric vehicles and charging points. In 2010, Japan put forward the development strategy of electric vehicles and charging piles to promote the development

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and construction of charging piles and electric vehicles, and occupy a place in the development of new energy in the world. The Japanese government has proposed a "green growth strategy" for a decarbonized society by 2050, vigorously promoting the transition from fuel vehicles to electric vehicles. Moreover, Japan has focused its economy on related industries such as batteries and charging piles as strategic development goals [5].

3. Discussion on the design and key technology of electric vehicle intelligent charging pile

3.1. Charging mode of charging pile

Under the current charging pile construction, charging piles are divided into DC charging piles, AC charging piles and AC-DC integrated charging piles, which respectively correspond to DC charging mode and AC charging mode. According to the different charging principles of the two, the AC charging pile can be designed to be very small and convenient, and nothing extra is needed, because the AC charging pile cannot be directly connected to the battery of the electric vehicle, so it cannot set high current charging, which cannot meet the charging speed of the current electric vehicle battery. The DC charging pile needs a lot of built-in equipment, so it can only be designed to be large, plus the DC charging pile can directly add direct current to both ends of the battery, as long as the battery can withstand enough current, you can set the charging current to be very large, so the charging time will become very short. It is easier to meet the current requirements of electric vehicles [6].

3.2. Intelligent charging pile design requirements

Market requirement. According to the China Association of Automobile, the number of new energy vehicles in China reached 3.82 million at the end of 2019, accounting for about 1.4% of the total number of vehicles in China, an increase of 47% compared with the previous year. Among them, the number of electric vehicles is 3.1 million, showing a rapid growth trend [7]. From the point of view of the state's inclusion of charging piles in the "new infrastructure" key areas of future development and the cooperation of local governments, the demand for electric vehicle intelligent charging piles will rise sharply in the next few years. However, as far as the current ratio of car to pile in China is 3:1, the imbalance between the construction of charging infrastructure for electric vehicles and electric vehicles is still very large. The construction of intelligent charging piles ensures the long-term operation of electric vehicles and plays a very important role in the development of the electric vehicle market [8]. It can be expected that in the future, with the gradual completion of the transformation of the old community by the state, the fixed parking space in the community will increase, and the demand for charging piles and power grid load will also increase significantly.

Performance requirement. To ensure the reliability and market application of intelligent charging piles, the following performance requirements should be met.

Security. When charging electric vehicles, it is necessary to ensure the safety of charging personnel, charging facilities and the charging process. At the same time, the user's convenience should also be considered. For example, the charging pile must adapt to various natural environmental conditions. In a humid environment, the charging pile should have the ability to be waterproof and moisture-proof; otherwise, there will be water vapor inside the charging pile, resulting in the failure of the display screen and causing problems such as leakage. When the user opens or closes the charging pile, the power grid enters and exits the charging pile. If there is no power control system, the charging pile may be burned out when the power is unstable.

Rapid charging. Speed up the time when charging piles are full of electric vehicle battery power, focus on the development of DC charging piles and AC-DC integrated charging piles, and vigorously develop high-power charging interfaces that match the charging interface of electric vehicles to shorten the charging time of electric vehicles.

Universality. The charging pile industry has been developing for many years. Before 2016, there was no standardized standard for charging, and the data of charging piles was not interconnected. Most charging piles could only charge cars of their own enterprises, and some had to download the APP

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belonging to their enterprises before using the charging pile. So a universal charging facility becomes particularly important [9].

Monitoring and scalability. Electric vehicles may have high-power charging, overcharging and other problems when charging, thus causing damage to the battery, Therefore, smart charging posts should have the ability to monitor and provide timely feedback on the charging process and charging safety in real time. In the process of later application of intelligent charging pile, it will certainly add a lot of new business needs, which requires that the intelligent charging pile system should have the ability to expand, in order to prepare for the needs of future functional expansion.

Function analysis and basic parameter index of intelligent charging pile. The intelligent charging pile mainly realizes the following functions: security function, intelligent time-sharing billing and payment function, real-time monitoring function, coping with harsh environment function, cloud storage function, communication function, human-computer interaction function, charging interface compatibility function [10].

Intelligent monitoring function: real-time monitoring of charging status information, current and voltage steady state of the charging pile, and transfer this information to the superior charging facility monitoring platform, and then the superior platform for fault judgment and intelligent current management, so as to protect the battery safety, and ultimately achieve non-destructive charging; It can also monitor whether a car has been fully charged or the fuel car private station charging station does not charge; if not charged or fully charged, do not move the car for 20 minutes. It will charge a 0.5 yuan/minute timeout occupation fee so that the charging pile is more efficient and cracks the problem of occupied parking spaces.

Intelligent time-segment billing and payment function: The time-segment billing function is used to reduce the cost of grid use during the trough and increase the cost of grid consumption during the peak. Form a "grid off-peak period charging, peak period discharge" electric vehicle operation mode.

Intelligent human-computer interaction function: The simple human-computer interaction system simplifies the complex charging steps, and implements a state of "plug and charge, non-inductive payment". Users only need to brush the smart charging pile in advance to apply for the IC card or scan the code with the mobile phone APP, users can activate and use the smart charging pile, and then insert the charging gun, switch charging and settlement payment, the whole voice-assisted process, the user only needs to follow the prompts to complete the operation, greatly reducing the customer's operation time.

The smart charging pile display should display the following information:

①Electric vehicle battery capacity, battery type, maximum and minimum battery charging current and voltage, time required to charge to 80% and 100%, real-time billing price; ②Charging pile fault warning and alarm records; ③Display and hide user identity information (password required); ④ Information pane that can be entered manually; ⑤Charging fee details and printing;

This paper mainly designs a DC intelligent pile (three-phase-wire); its basic technical parameters are as follows:

(1) Power requirement:

Rated input voltage: AC 380V±10%; Rated input frequency: 50Hz±1Hz;

Rated output voltage: DC 350V~750V continuously adjustable;

Rated output current: 0~150Acontinuously adjustable; Precision of steady current:1%;

Voltage regulation accuracy: 1%; Maximum power output: 90kw;

Full load efficiency: >90%; Full load power factor: >0.9;

Switching frequency: 10KHz; Total harmonic factor: THD<5%; Noise: ≤65dB;

(2) Working environment requirement;

Operating ambient temperature: -50℃~+60℃; Relative humidity: 5%~95%; Altitude: ≤2000m;

(3) Safety protection requirements:

①Environmental requirements: charging pile shell protection level reaches IP54, waterproof level reaches IP67; Outdoor installation should be able to withstand the maximum wind speed requirements

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in different areas stipulated in GB/T 4797.5-1992; Meet the three protection requirements(moisture-proof, mildew proof, and salt spray), anti-theft protection and anti-oxidation protection, including salt spray corrosion ability which should meet the requirements of GB/T 4797.6-1996.

②Temperature requirements: at 45℃ ambient temperature, ensure that the metal part outside the charging pile can be touched by hand; At a temperature of 50°C, non-metallic parts can be touched, especially the display and charging plug parts; At 60°C, you can touch the rest of the area with your hands. The internal components of the smart charging pile should have a certain temperature rise range when it is running [11].

③Power requirements: with leakage, short circuit, over voltage, under voltage, over current, over temperature and other protection functions; The charged part does not leak out, and the charging pile is connected with the earth.

④ Communication requirements: The intelligent charging pile communicates with the battery management system to monitor the battery status in real time. When the battery management system monitors the battery fault, the charging pile automatically stops charging and prompts the fault signal [12].

⑤Electromagnetic compatibility requirements: The intelligent charging pile should be able to withstand the RF electromagnetic field radiation immunity test with test level 3 specified in Chapter V of GB/T 17626.3-2006, and the radiation immunity limit in line with this is shown in Table 1:

Table 1. Radiation immunity limits.

Frequency domain MHz	Quasi-peak dB
30~230	40
230~1000	47

3.3. Overall scheme design of intelligent charging pile

3.3.1. Overall design scheme. In this paper, the design of modules, to the state grid as the standard, using RFID radio frequency technology, CAN bus technology and electrical and electronic technology, Design the control module, communication module, monitoring module, billing module, printing module, FRID identification module, card reader module and touch display module in the electric vehicle intelligent charging pile system to meet the performance requirements of the intelligent charging pile. The design diagram of the intelligent charging pile is shown in Figure 1.

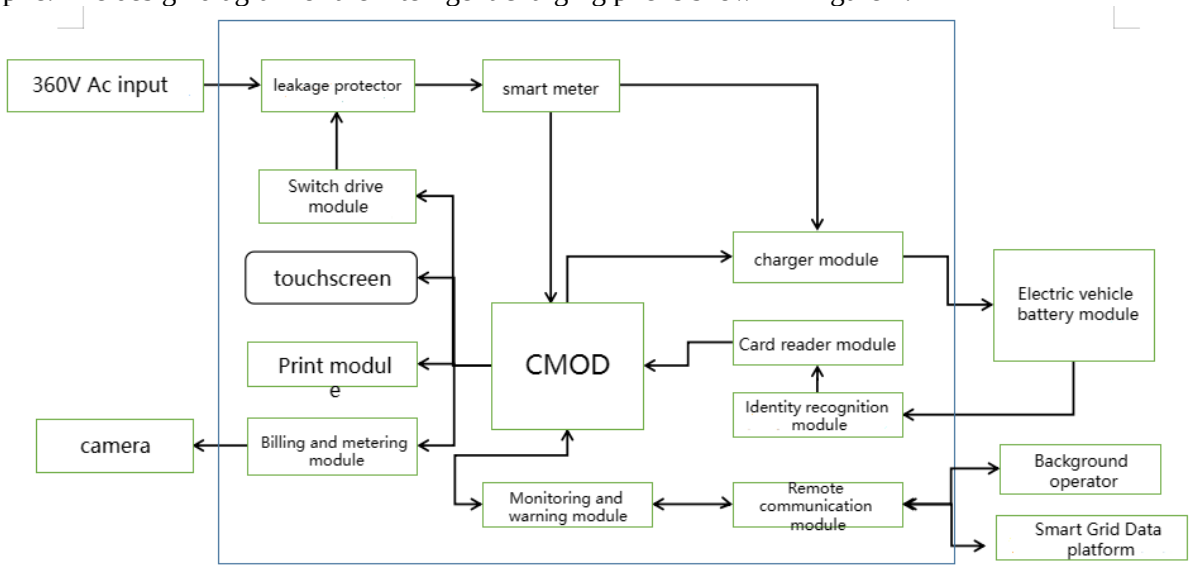

Figure 1. Schematic design diagram of the intelligent charging pile.

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The charging pile uses 380V three-phase four-wire alternating current. When the user uses the RFID identification module, the 380V current starts to be input into the charging pile, which is connected to the leakage protector after input. The control module of the intelligent charging pile controls the leakage protector through the switch driver module, and then the user sets the charging mode by touching the display screen, and the current is connected and communicated with the control module through the smart meter. Finally, the charging module rectifies the AC current to charge the battery pack of the electric vehicle and communicates with the battery management system. The control module controls the charging current, voltage, temperature, etc., and the monitoring and early warning module monitors the running status and power load of the intelligent charging pile in real time during charging, and communicates and exchanges data with the background operator and the smart grid data platform through the remote communication module. In the peak period, the smart grid data platform will feed back the voltage load information to the intelligent charging pile control module through the remote communication module, and the control module will adjust the output voltage and current according to the information to alleviate the electricity pressure and ensure the effective conversion rate of charging. At the end of charging, the charging module calculates the charging time, electricity consumption, cost, etc. Users can pay by purchasing membership cards, scanning codes with mobile phones or using cameras to brush their faces [13]. The printing module can print information such as charging time, the cost of this charging, and it can also print invoices for reimbursement.

To facilitate the future maintenance of the intelligent charging pile, each functional unit is partitioned. The Composition diagram of the intelligent charging pile system is shown in Figure 2.

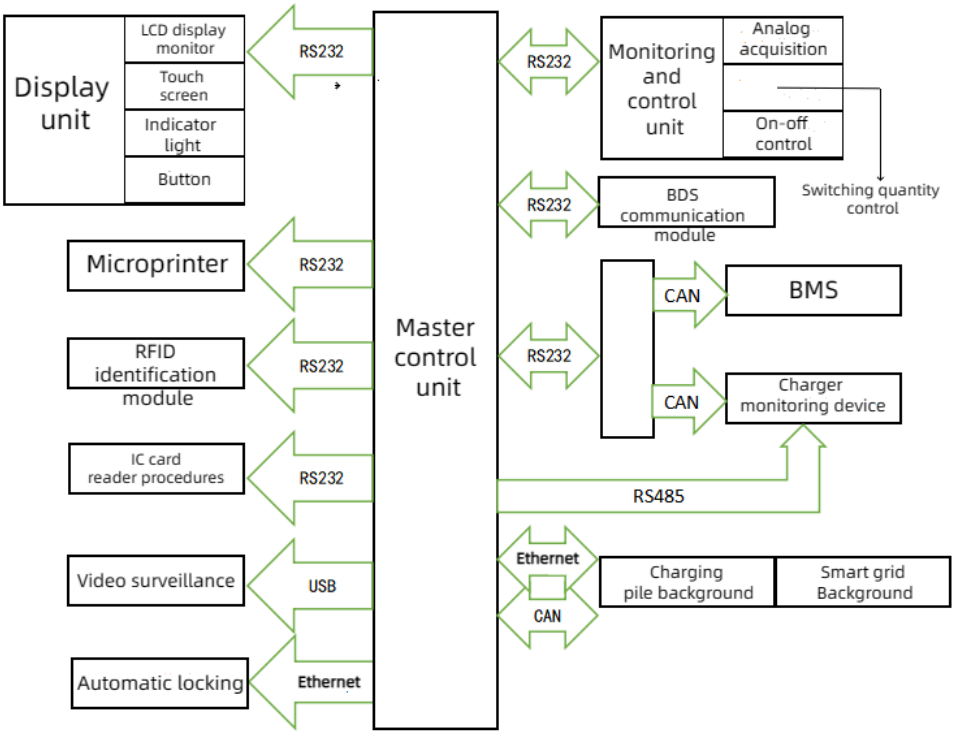

Figure 2. Composition diagram of the intelligent charging pile system.

The master control unit is the core system of the intelligent charging pile, mainly to control the start, operation and shutdown of charging facilities, and to control the communication between the whole system and real-time monitoring of charging status, and data transmission and communication through Ethernet and background. The master control unit uses the combination of RS232 and CAN to control the BMS battery management system and the charger monitoring device, so as to detect the voltage input, voltage output and current output of the charging pile. It also connects with the charger monitoring device through RS485 to ensure real-time monitoring of the on-board battery and the safety of the charging pile [14]. USB is used to connect the master control unit with the video monitoring, Ethernet

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and CAN are used to communicate with the charging pile background and the smart grid background, and RS232 is used to connect the other hardware with the master control unit.

The display unit and the monitoring unit ensure real-time monitoring of the charging pile by users and staff. The main control unit is connected to the LCD display screen, touch screen, indicator light and key. The user uses the touch screen and keyboard to operate and select the service content according to the content displayed by the LCD display. At the same time, users can also understand the charging demand according to the collection of analog and switching quantities by the monitoring unit, and make charging selection. When the charging pile is charging the battery pack, the indicator light will display red, and when fully charged, the indicator light will change from red to green. Finally, the user can query the charging time, charging power and balance, and use the functions of two-dimensional code scanning code payment, card or face payment to pay for the consumption amount. If paper data is required, paper printing is performed using a micro printer. When the charging failure occurs, the master control unit will immediately cut off the power supply and start the safety guarantee function. When the charging is complete, if no one can move the car within half an hour, the video monitoring system, BDS communication module and automatic locking unit will cooperate with the master control unit to lock and charge the electric car. The owner can only drive the electric car away after paying, which can effectively solve the problem of disorderly charging parking space and ensure that other users continue to use it.

3.3.2. Hardware design and software design. At present, the laboratory situation cannot meet the design requirements for intelligent charging pile hardware. Because this paper designs a high-power intelligent charging pile with an output power of 90KW, the software design of the intelligent charging pile is in the form of modularization, which can improve the reliability and scalability of the software. According to the module, the intelligent charging pile system can be divided into IC card reading and writing module, metering and billing module, printing module, human-computer interaction module, communication module, security module and charging module. The Functional block diagram of the software system is shown in Figure 3.

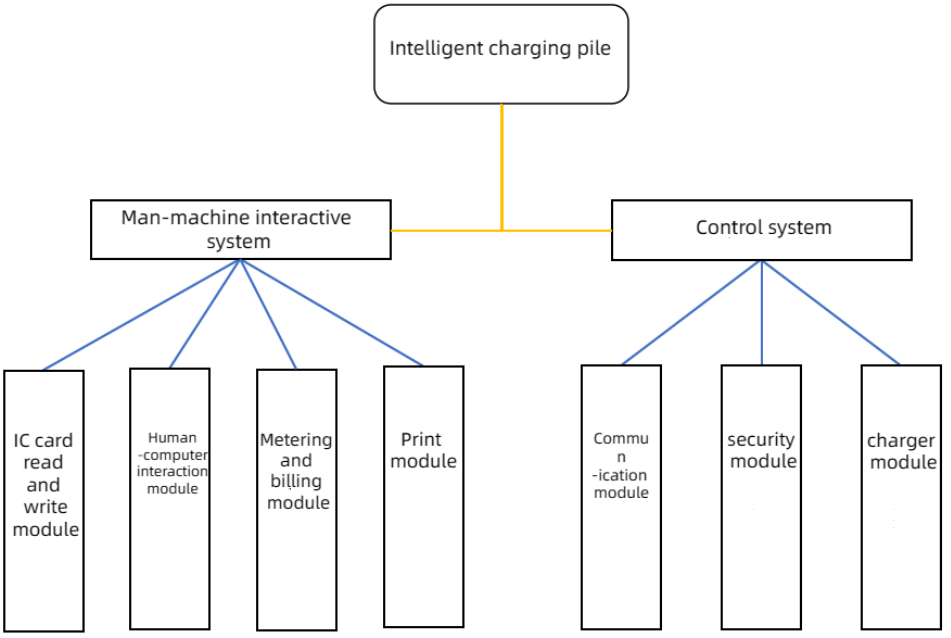

Figure 3. Functional block diagram of the software system.

The human-computer interaction system includes an IC card reading and writing module, a metering module, a printing module, and a human-computer interaction module. These modules are to make the intelligent charging pile more simple so that users can use it more conveniently. The user enters the human-computer interaction module after the information authentication, and the user inputs and selects

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in the display interface to charge the battery of the electric vehicle. After the charging is completed, the metering and billing module statistics the electricity consumption information, summarizes the cost, and displays the payment interface to the user. Finally, the printing module provides the consumption details for the paper printing function. The control system includes a communication module, a security module, and a charging module. The communication module ensures communication between the control system and each module and data exchange between the background management platform. The safety module monitors the state of input and output voltage and current at any time and controls the unstable voltage and current to ensure the safety of charging and the efficiency of current transmission. The charging module can not only ensure communication between the intelligent charging pile and the electric vehicle battery pack but also buck the large voltage and provide stable direct current for the electric vehicle battery pack.

3.3.3. Environmental and electromagnetic compatibility design. As far as the intelligent charging pile body is concerned, the surface of the charging pile is treated by the process of galvanized steel plate and metal parts baking paint to ensure that the charging pile body is not corroded in wet and rainy weather. Industrial grade components are selected to avoid electromagnetic interference and the problem that components cannot work normally under high temperature conditions. Lightning protection device is installed, piezoresistor and transient suppression diode are used to prevent static electricity, and magnetic ring and magnetic column are used to ensure the normal operation of the charging pile under electromagnetic interference.

4. Research on the development mode and prospect of intelligent charging pile

4.1. Development mode of intelligent charging pile

Combined with the latest technology of Internet of vehicles and smart grid, this paper studies the development mode of smart charging pile in business.

The mode of “Internet intelligent charging pile + service market” takes the intelligent charging pile as the center, and according to the situation that the power load of the business district is large and the smart grid coordinates the charging pile to reduce the charging speed, give priority to the development of electric vehicle market in large and medium-sized cities and establish a supporting commercial ecosystem of catering, fitness, beauty, convenience stores, commodity retail and leisure and entertainment.

The mode of “Internet intelligent charging pile + platform” collects data through the “e Charging” APP and provides users with big data and cloud computing services based on the management platform. On the one hand, under the application of big data, users can use the “E-charging” APP to quickly find charging piles and carry out charging pile location navigation. The APP can provide users with functions such as electric vehicle charging reservation, charging time required, charging completion reminder, remote monitoring of charging current and voltage status, and feedback of user usage evaluation to charging pile operators and manufacturers. On the other hand, it provides battery life cycle, vehicle condition information, charging information and user behavior and demand data analysis of charging pile usage for vehicle enterprises [15]. In addition, it can also build a service platform with cloud computing, and provide charging pile operators with a variety of charging power options and electricity peak time reminders through cloud management, so as to effectively reduce the operating costs of charging piles.

The model of “Internet intelligent charging pile + vehicle industry” integrates vehicle manufacturers, equipment manufacturers, charging pile operators, financial institutions, state grid, users and other commercial ecosystems together. Based on intelligent charging pile, a one-stop comprehensive service platform from electric vehicle production, sales, charging, repair, maintenance and power support is established.

The cooperation mode of “Internet intelligent charging pile + enterprise”, first of all, can choose to cooperate with new energy taxi companies, Didi and other online car-hailing platforms; these cars are

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mainly in the form of public charging pile. The cooperation between charging pile operators, taxi companies and online car-hailing platforms is conducive to integrating the resources of both sides and promoting win-win cooperation. Online ride-hailing platforms, buses and taxi companies can take advantage of the number of electric vehicles, improve the number of intelligent charging piles, improve the operation efficiency of intelligent charging piles by using technical and operational means, and provide flow for intelligent charging piles. Charging pile operators provide public charging pile equipment and comprehensive services for ride-hailing platforms and taxi companies to help ride-hailing platforms and taxi companies establish a sound intelligent charging service system, so as to share economic benefits and achieve mutual benefit and win-win results [16].

4.2. Prospect of intelligent charging pile

At present, the power battery is mainly based on lithium iron phosphate battery and ternary lithium battery. Although the efficiency and energy density of the battery are still growing, the speed of their rise has been greatly limited. Solid state batteries are a kind of currently recognized high-performance, good-safety battery technology. Their electrolyte is solid, so their volume can be small, and because of their density and structure, they can bring more ions together and conduct greater current, improving the capacity of the battery and reducing the weight of electric vehicles. So China put the solid state battery as the layout goal of the next generation battery. The advancement of electric vehicle battery technology will also guide the development of charging pile technology. At present, Tesla's third-generation supercharging station has been put into operation, indicating that the charging power of foreign smart charging pile can reach 350KW at most. Domestic star charging also developed a power of 500KW, voltage 1000V, current 500A high-power intelligent charging pile for buses and 4C rate battery. The charging power of the high-power intelligent charging pile of Special Call has reached 450KW, and the charging docking test has been carried out with electric vehicle manufacturers. The new intelligent high-power charging pile still takes into account the 2015 interface standard [17]. Through the development of charging piles in the market, high-power charging piles will be the main development trend in the future.

5. Conclusion

It analyzes the current market demand for the development of charging piles and proposes that the current charging pile needs to meet performance requirements such as safety, monitoring and fast charging. According to the standards of the State grid, the overall design of the smart charging pile is carried out. The innovative proposal is to exchange data between the smart grid platform and the smart charging pile through the communication module, and reasonably analyze how to adjust the voltage output according to the smart grid information during the peak period of power consumption and stabilize the output efficiency. It is also proposed that in the metering and billing module, when users pay, they can choose to scan the code to pay or brush their face to pay, to ensure the diversification of use functions. The innovative development mode of "Internet intelligent charging pile + real estate industry + State Grid" not only improves the repeated construction of intelligent charging piles in the community, unreasonable distribution, property management and other issues, but also ensures the construction of the distribution network of the state grid in the community, which provides logistical support for the power supply of intelligent charging piles. This paper discusses the future development direction of charging pile technology by analyzing the development status and trend of charging pile technology under the background of the smart grid. Fast charging technology is one of the important development directions of current charging pile technology. Fast charging technology can greatly shorten the charging time and improve the user experience. Intelligent charging technology is one of the important development directions of charging pile technology. Intelligent charging technology can realize the remote control and management of charging piles, and improve the intelligence of charging piles.

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