Research on the Development of pure electric vehicle power battery Technology based on patent analysis

Xinyue Yuan*, Jie Wu*

School of Economics and Management, Jiangsu University of Science and Technology, Zheng Jiang, 212003, China

*0511wujie@just.edu.cn

* Corresponding author’s e-mail: yuanxy1229@163.com

Abstract. Power battery is the key to the widespread use of pure electric vehicles. In this paper, patent mining and data analysis technology are adopted to summarize the development trend and main patentee of battery electric vehicle power battery patent technology. Combined with the patent text, the key technologies in the field of battery electric vehicle power battery in recent years are analyzed in depth. The research results show that China has entered a period of rapid technological development in the field of battery electric vehicle power battery, and its innovation subjects are mainly enterprises. The key technologies mainly focus on three aspects: battery heating, battery cooling and charging methods.

1. Introduction

With the rapid development of economy and society, environmental pollution and energy shortage have attracted more and more attention. As a new energy vehicle that only relies on rechargeable batteries to provide power, pure electric vehicles have the advantages of high energy efficiency, fossil energy saving, clean and pollution-free, etc., and have gradually attracted global attention[1]. However, technical problems such as short cruising range, long charging time, and short battery life of pure electric vehicles have hindered their development. The fundamental reason is that the capacity of pure electric vehicle batteries has not yet met people's needs. Therefore, it is necessary to analyze the battery technology of pure electric vehicles.

In recent years, with the in-depth development of the globalization of the knowledge economy and the increasing importance of various countries on intellectual property rights, patents have gradually become the focus of technological competition. Through in-depth excavation of technical information in patent documents, it can form valuable information, which has an extremely important role in promoting the development of the technical field [2]. Up to now, scholars have used patent analysis methods to explore and research the technology in the field of pure electric vehicles. Qiu Hui et al. [3] based on global pure electric vehicle patent data before 2014, conducted a comparative analysis of major global patent applicants and major Chinese patent applicants in the pure electric vehicle industry; Tian Sujie et al. [4] based on global data before 2016 China’s pure electric vehicle patent data focuses on the analysis of the gap between China’s technology level and the international level; Zhang Liying[5] based on China’s pure electric vehicle patent data before 2017, explored China’s pure electric vehicle patent development strategy; Peng Yao et al. [6] Based on China's data before 2019, the development of pure electric vehicles in key regions of China's patent applications was compared.
Literature research shows that there are already many studies based on patent intelligence analysis in the field of pure electric vehicles. However, research focusing on the core technology of power batteries has not yet appeared. In addition, scholars in the past focused on patent data information, but ignored the importance of patent text information analysis for technological development research. According to WIPO statistics, 90-95% of the world's annual invention and creation achievements can be retrieved in patent documents, of which 85% of the technical content has not been published in other non-patent documents [7]. Thus, in terms of technological advancement and creativity, patent documents have obvious advantages in promoting technological development compared with other non-patent documents. Therefore, this article combines patent data analysis with patent text analysis to explore the technical development of the battery field of pure electric vehicles, and provide a reference for the technical development of the battery field of pure electric vehicles in the future.

2. Patent analysis

2.1. Patent application trend analysis
The data in this article comes from the Patsnap database. As of August 2020, a total of 19,424 related patents have been obtained through search and data noise reduction processing.

The status of patent applications can generally reflect the development trends of the target technology field [8]. Figure 1 compares the trends in the number of patent applications and authorizations in the field of pure electric vehicle power battery technology between China and the world. It can be seen from Figure 1 that foreign pure electric vehicle power battery technology has entered a development period as early as the 1990s. From 1990 to 2005, during this period, foreign pure electric vehicle power battery technology did not exceed 200 patents per year. The number of patent applications in the field of power battery technology for pure electric vehicles has been rising rapidly after 2006, and the number of patent applications in 2018 exceeded 1,600, marking a global pure Electric vehicle power battery technology has entered a stage of rapid development.

China's development in the field of pure electric vehicle power battery technology is obviously later than that of foreign countries, but in recent years, the number of patent applications and authorizations in China has been roughly the same as the world. From 1990 to 2005, during this period, there were no more than 50 patents in the field of power battery technology for pure electric vehicles in China, which is still in the embryonic stage of technology; from 2006 to 2015, the number of patents in the field of power battery technology for pure electric vehicles in China began to show a growth trend. However, the growth rate is relatively slow; after 2015, the number of patent applications in China has increased rapidly, with more than 500 patent applications per year, which means the rise of China in the field of pure electric vehicle power battery technology.

It can also be seen from Figure 1 that the trends in the number of patent grants in China and the world are consistent, and the number of patent grants in the field of pure electric vehicle power battery technology is relatively high, which shows that the quality and quantity of patents in China are developing simultaneously. As a strategic material that determines the range of pure electric vehicles, the development momentum will continue to be maintained.
2.2. Patent owner analysis

Analysis of the patentee can reveal the source of the patented technology [9]. In the field of pure electric vehicle power battery technology, the world's top ten patentees and their patent applications are shown in Figure 2.

Figure 2 shows that all the top ten patentees are enterprises. It can be seen that enterprises are the main subjects of technological innovation in the field of pure electric vehicle power battery. Chinese
companies account for half of the world's top 10 patent applicants, with STATE GRID (No. 4), BYD (No. 5), BAIC BJEV (No. 6), ZHEJIANG GEELY (No. 9) and CHERY (No. 10). FORD of the United States topped the list with 272 patents, well ahead of Germany's BOSCH, which ranked second. South Korea's HYUNDAI came in third with 113 patents; TOYOTA came in eighth with 72 patents. To sum up, it can be concluded that the key technologies in the power battery field of pure electric vehicles are mainly in the hands of China, the United States, Germany, Japan and South Korea.

3. Key patent technology analysis

Through the overall analysis of patents, it is found that patent applications in the field of pure electric vehicle power batteries are mainly concentrated on three technical levels of battery cooling, battery heating, and charging methods. The following is a technical analysis of the technical problems existing in each technical level, combined with patents, in order to provide references for related enterprises and R&D institutions.

3.1. Battery cooling

Pure electric vehicles rely on the electric energy provided by the battery to drive the motor and rotate the wheels through the power transmission device. Multiple batteries are connected in series or parallel to form the voltage required by the motor. Such a battery will generate heat during charging and discharging, thereby increasing the temperature of the battery, and the increase in the temperature of the battery will reduce the electrical performance and durability of the battery. Therefore, there is a need for a battery cooling device that can maintain the constant use temperature of the battery within an optimal temperature range to improve battery life and durability.

At present, battery cooling in the industry includes air cooling and refrigerant cooling. The operating principle of air cooling is: when the battery temperature is higher than the set value and the temperature of the passenger compartment is lower than the internal temperature of the battery, the centrifuge sucks air from the passenger compartment into the air duct of the battery pack, thereby dissipating heat from the battery. However, this method has disadvantages such as low cooling efficiency and reduced power performance of the entire vehicle. The operating principle of refrigerant cooling is: the refrigerant is divided to the passenger compartment refrigeration and battery cooling circuits through two refrigerant solenoid valves. This cooling method not only affects the cooling effect of the passenger compartment, but also requires a coolant channel and a refrigerant channel on the battery pack.

In response to the above problems, Chery Automobile proposed a new type of pure electric vehicle cooling system in its patent, which divides the traditional radiator into two separate layers, which are the electric drive cooling circuit and the battery cooling circuit cooling. The electric drive cooling circuit adds water cooling to the charger, and the battery cooling circuit and the battery low temperature heating circuit switch the working mode through a three-way valve. Such a battery cooling system is not only simple in structure and low in cost, but also has high cooling efficiency and strong reliability.

3.2. Battery heating

The most suitable working temperature for power lithium batteries used in pure electric vehicles is 35-45°C. When used at temperatures below 0°C in winter, the battery's discharge performance and charge acceptance will be greatly reduced by the effect of low temperature. The power battery is generally arranged under the floor of the vehicle compartment. Even if it is completely sealed, it is difficult to avoid being affected by the external low temperature. As a result, the heat generated by the battery discharge during the driving of the vehicle is less than the heat dissipation of the battery to the outside, so that the battery cannot be properly Work within the temperature range. These problems will affect the power and driving range of electric vehicles in severe cold areas, and even affect the service life of power batteries, severely limiting the scope of their use and promotion.
In order to solve the above problems, the traditional method is to install a temperature control device inside the battery pack, and at the same time install a power resistance unit or electric heating film material inside the battery pack. When the battery management system detects that the battery environment temperature is lower than the set temperature, the temperature control device starts to work, and uses the battery power of the battery pack itself to heat the battery. When the temperature is higher than the set temperature, the heating is automatically turned off. However, if the heating system in this method is frequently used, it will greatly consume the electric energy of the battery itself, which will affect the power and driving range of the entire vehicle.

Beijing New Energy Automobile Co., Ltd. proposes a power battery heating control system for pure electric vehicles in its patent. The heat source device is provided to provide heat energy, and the heat energy is absorbed by the condensate in the circulating pipeline and input to the power battery. The heating of the battery ensures the working temperature of the power battery, prolongs the life of the power battery, and improves the driving range during low temperature operation.

3.3 Charging method

The charging methods of pure electric vehicle batteries generally include wired charging and wireless charging [10]. Since the function of the charger for charging the power battery is relatively single, the charging process is relatively long, and more external control intervention is required during the charging process. Even with human intervention, there are still more control components serving the charger. Therefore, DC/DC or low-voltage batteries have to be used to power the control components during the charging process, so that the DC/DC works in the low efficiency range or wastes low voltage. Battery energy. This inevitably affects the efficiency of use, the convenience of use and the rationality of the charging process, thereby affecting the life of the power battery to a certain extent, and then hindering the popularization and application of electric vehicles.

In its patent, Chongqing Changan Automobile Co., Ltd. proposed an intelligent charging method and device for pure electric vehicles based on a high-performance control chip. By adopting a fast and intelligent charging control strategy that combines multi-stage constant current charging and limited voltage charging, the battery information detection circuit is added to realize the improvement of charging efficiency, and at the same time, it is beneficial to extend the life of the battery, reduce manual intervention or achieve zero intervention in the charging process.

4. Conclusion

From the perspective of patent application trends, China has developed late and patent applications in the field of pure electric vehicle power battery technology. However, after 2015, the number of patent applications in China has increased rapidly, which means that China is in the field of pure electric vehicle power battery technology. The demand for research and development of electric vehicles has increased, and pure electric vehicle power battery technology has entered a rapid development period. From the perspective of the patentee's analysis, the innovation subjects in the field of pure electric vehicle power battery technology are mainly enterprises. China, the United States, Germany, Japan and South Korea are the main competitors in this field. Among them, the number of technological innovation entities in China ranks first, indicating that my country has aroused the enthusiasm of many innovative entities under the active guidance of favorable policies.

From the perspective of patented technology, the patents in the field of pure electric vehicle power battery technology are mainly concentrated on three technical levels of battery cooling, battery heating and battery charging methods. In terms of battery cooling, the key is that the cooling device can maintain the cooling efficiency while not affecting the performance of the vehicle and not increasing the cost; in terms of battery heating, battery heating technology using external heat sources is the focus of R&D personnel; in terms of battery charging, the intelligent charging system that takes a short time and does not require manual intervention is the future development trend.
Acknowledgments
Thanks for the support from the national Social Science Fund for the project of "Research on the Subject Knowledge Transfer Game and Innovation Performance of industry-University-Research Alliance" (19FGLB029) and the Project of Jiangsu Province Graduate Practice Innovation Plan "Research on Enterprise Technology Status Identification and Technology Innovation Countermeasures Based on Patent Analysis" (SJCX20_1442)

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