Future Vehicle Trend: A Comparative Study of the Fuel Vehicle, Electrical Vehicle, and Hybrid Vehicles

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Abstract. As the second largest carbon emission industry in the world, the automobile industry faces serious energy consumption and environmental pollution problems. The development of a low-carbon economy requires cars to achieve low energy consumption, lower emissions require the development of more advanced and environmentally friendly technologies. Three dominant kinds of vehicles, fuel vehicles, electrical vehicles, and hybrid vehicles will be explored in this paper. Section one introduces the types of fuel vehicles, the factors that affect them, and their negative impact on the environment. Section two focuses on the advantages of hybrid vehicles over gasoline and pure electric vehicles in terms of their operation and driving costs. Section two discusses the advantages of hybrid vehicles compared to gasoline and electric vehicles in terms of their operation and driving costs. In section three, the characteristics of various types of electric vehicles are comprehensively evaluated, and the prospects of the exhibition of electric vehicles are discussed. Finally, the future development trend of electric vehicles is forecasted.

Keywords: Fuel vehicle; Hybrid vehicle; Electrical vehicle.

1. Introduction

Nowadays, due to the aggravation of the global energy crisis, environmental pollution, and greenhouse effect, the market offers consumers a choice of not only traditional gasoline and diesel vehicles, but also new hybrids and pure electric vehicles. It is an inevitable trend for fuel cars to be replaced by other energy cars. In the future, cars will become more resource-efficient and produce fewer emissions. But emerging technologies can also have some negative effects at this stage of development. By comparing the differences between conventional vehicles, hybrid vehicles, and pure electric vehicles, this paper draws conclusions accordingly.

2. Gasoline Vehicles

As the most common resource of cars, gasoline is still playing an important role in our life. In this section, the shortcomings of fuel vehicles in environmental protection and energy efficiency will be discussed.

2.1. The type of fuel vehicle

Fuel vehicles are divided into gasoline vehicles and diesel vehicles. The diesel engine does not require an ignition system, but by using the direct injection of diesel oil after compressed air to produce combustion, which made the diesel engine simple in structure, long service life, and has high thermal conversion efficiency compared to gasoline engines. At the same time, in the case of the same displacement, the fuel consumption of diesel vehicles is lower than that of gasoline vehicles. However, due to the high freezing point of diesel oil, it is very inconvenient for people to use diesel vehicles in winter [1]. In addition, diesel vehicles cause too much noise because of the way they ignite compressed air. Also, because the diesel quality in some areas is too low, the local diesel engine is easy to be blocked by impurities in the injector. These reasons have led to the penetration rate of diesel vehicles being now far inferior to that of gasoline vehicles [2].

2.2. Factors affecting fuel vehicles

The most important factors affecting the carbon emissions of a fuel car include the internal factors of the car itself and the external factors of the car's driving. Internal factors include the performance and quality of the engine. External conditions include the car's driving conditions and speed, as well as the fuel itself. The higher the quality of the car itself, the higher the carbon emissions when the car is manufactured, and the pressure on the engine will be greater and the fuel consumption will increase. The stronger the engine's performance, the higher the power, and the faster the energy consumption, the greater the carbon emissions. The driving conditions of the car determine the speed and the working condition of the engine, and the resistance of the car affects the efficiency of the engine.

2.3. The disadvantages of fuel vehicles on the environment

The disadvantages of fuel vehicles include the following 2 points: the engine cannot always run at the ideal speed; the efficiency of the car cannot be higher and higher. For fuel engines, the faster they run, the more thermally efficient they are. But the reality is that cars need to brake, stand by, and start repeatedly at intersections and traffic lights in the city. This results in a much higher actual fuel consumption of the fuel vehicle than would in ideal driving conditions. Secondly, at present, the thermal efficiency of pure fuel vehicles has approached the limit, and the combustion efficiency of gasoline has approached its physical limit.

3. Hybrid electric vehicles

With the rapid development in technology, saving energy is becoming a heated topic considered by the public. Related to vehicles, this phenomenon explains new energies used to fuel cars. In this section, several aspects of hybrid electric vehicles, the transitional part between gasoline ones and pure electric ones, are explored in detail.

3.1. Types of hybrid cars

First of all, it is important to get the effective categories of hybrid cars. There are two main categories of hybrid cars: hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs). In these two general parts, further classification can base on the powertrain, including parallel, series, and power-split and such classification applies to both.

3.1.1. Hybrid electric vehicle (HEV)

HEVs are a hybrid between conventional cars and pure electric vehicles, combining the most outstanding advantages of both. Under the operation mode of HEV, there is both internal combustion engine and electric motor (including the battery and inverter link) so that HEV has the advantage of high energy efficiency of conventional vehicles and the benefit of low emission of pure electric vehicles. Both purposes of energy saving and emission reduction and driving efficiency are achieved at the same time. Although pure electric vehicles have lower emissions, HEVs are undoubtedly the best compromise solution because of the high cost of making batteries at the beginning of their production and the fact that the battery energy density is much less than that of gasoline. In the hybrid vehicle powertrain, the fuel engine only accounts for a small portion. Within reason, the smaller the better the conventional engine is, the more it will only do part of the work. The remaining considerable part is taken up by the electric motor system. As mentioned earlier, this hybrid system combines the advantages of both engines.In this way, the hybrid vehicle can work efficiently and for a long time with less pollution and less noise. According to literature research, this power unit can increase the thermal efficiency of the car by more than 10% and the exhaust emissions can be increased by more than 30% [3].

3.1.2. Plug-in hybrid electric vehicle (PHEV)

Plug-in hybrid electric vehicles (PHEVs) are a type of hybrid electric vehicle, similar to HEVs, and the difference between PHEVs and HEVs is that they are charged in different ways. PHEVs can rely not only on the generator but also on external power sources. Like HEVs, PHEVs generally do not have a large battery capacity and can only support short trips. Often, some PHEVs run almost entirely on the electricity stored in the battery. Gasoline is simply the fuel that provides additional power during the drive. Other segments of PHEVs are powered by both in all cases. The power unit of this PHEV organically combines parts of the structure of a conventional car and a pure electric vehicle. And it has a charging port and a high-capacity battery.

3.2. Th Fuel saving and carbon emission

More than 90% of the transportation covered by fuels comes from oil. However, due to the price of oil, problems with the supplies, and emission of air pollutants and other greenhouse gas(GHG), such consumption of these fuels cause debates in the public [4].

Compared to cars fueled by internal combustion engines (ICE) only, hybrid vehicles have lower fuel consumption. Therefore, hybrid ones produce lower emissions. This has to do with the way hybrids operate. This type of vehicle focuses on three main areas to minimize the use of fuel within a reasonable range [5]. First, within their operating range, they simply run in the most efficient section with a smaller engine. Through the electric drive system, hybrid vehicles can adjust the overall load on the engine, reducing fuel consumption. In addition, in the case of low drive power, some models of HEV can even use an all-electric mode drive, preventing the engine from being wasted and running inefficiently. Typical examples are low driving speeds or vehicle stops. Finally, because of the unique structure of the gasoline-electric hybrid, this type of car, unlike traditional gasoline vehicles, reduces a part of the kinetic energy lost during braking: the battery in the HEV stores part of the kinetic energy, and when needed, this part of the energy can be released to assist the operation of the gasoline engine.

Using relatively less fuel to drive, HEVs also produce fewer emissions while driving compared to conventional gasoline and diesel vehicles. In this way, it seems that the more electricity used to drive travel, is more efficient and environmentally friendly, and cheaper, but this is not the case. Compared with pure electric vehicles, HEVs also have significant advantages. Considering the most important part of the production of pure trams: the battery, this part is very expensive. Considering the fuel consumption of the two under the same mileage, even if the battery production cost of pure electric vehicles can be reduced by 90%, HEVs are still more competitive in the market. Especially for long-distance travel, especially for taxi drivers, although the cost of buying an HEV is higher, the performance and performance of emerging hybrid vehicles are better at the same price point. Considering the tax subsidies introduced by the government to promote environmental protection work on such models, hybrid vehicles may be a good choice. For households, some national governments, especially the Dutch government, have introduced special subsidy concessions, and even in the case of only driving 20,000 kilometers, the driving cost of hybrid vehicles is lower than other models [6].

3.3. Market analysis of hybrid vehicles

Using the Chinese vehicle market as an example, in 2022, one automaker, Wuling, launched a hybrid under 100,000 to explore the market potential. As the Chinese market stands now, the pricing of a mainstream model under 100,000 yuan, whether it is a pure electric or a plug-in hybrid, will be out of control with the current battery costs. At the same time, Wuling's consumption structure, mainly in low- and middle-tier cities, also determines that any model with range anxiety and inconvenient use is unlikely to be the only car in the family. Therefore, the hybrid car that can save fuel and is not expensive, is favored by consumers. Consumers are willing to buy hybrids, but they won't go for high-priced, unrealistic hybrids. Wuling's first hybrid model under 100,000 yuan is an exploration of the entire Chinese market. This makes not only Wuling's own market acceptance of more hybrid cars under 100,000 yuan rising but also makes this part of the consumer awareness of

HEVs increase. Taking advantage of this, Wuling's future market upward space for the launch of PHEV models will be greater. This trend can also better promote the development of hybrid vehicles in the Chinese market [7].

4. Electric Vehicles

4.1. Classification and characteristics of electric vehicles

Electric vehicles are vehicles that run on an onboard power source and use motors to drive the wheels. Types of electric vehicles: hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), and battery electric vehicle(BEV). Since HEVs and PHEVs have been explored in detail above, this section, mainly discuss battery electric vehicle.

4.1.1. Battery electric vehicle (BEV)

Battery electric vehicle usually refers to pure electric vehicle.Pure electric vehicles, with energy source of battery and drive system of electric motor, are characterized by completely zero emission and no dependence on oil, which is more relevant at the time of increasing conflict between international energy supply and demand. However, the main problem is the specific energy and price of the battery, so the most important thing we should do is to develop a kind of batteries which cost relatively less prince and become more high-efficiency.

4.1.2. Fuel cell electric vehicle

Fuel cell electric vehicles, with fuel cells as the energy source and electric motors as the drive system, are characterized by long driving distances, high energy efficiency, and no Long driving range, high energy efficiency, no dependence on oil, no exhaust emissions or ultra-low emissions, but the technology has not yet made a breakthrough, and the cost is high.

4.2. Key technologies for electric vehicles

4.2.1. Battery

For decades, the automotive industry has been slowly consolidating while technology and brand differentiation have diminished. The powertrain, the system that converts energy into motion, is arguably the most valuable intellectual property of automakers and has undergone more than a century of refinement and improvement. In this context, the emergence of new vehicle manufacturers is remarkable because it means that powertrain technology is being challenged.

A typical internal combustion engine (ICE) vehicle has a 15-gallon fuel tank, which equates to nearly 500 kilowatt hours of electricity. 15 gallons of gasoline translates into a 375-mile range for an ICE vehicle; 500 kilowatt hours of electricity translates into a 1,450-mile range for an electric vehicle. This tremendous energy efficiency advantage is what ultimately made the electric car a winner, but the biggest problem facing today's generation of electric cars is that their battery capacity does not match the range of internal combustion engine cars. The battery pack of an electric car consists of hundreds of cells working in series, producing voltages of 400 V to 800 V [8]. Overcharging and overdischarging can damage the battery or prematurely age it, thereby reducing capacity or life and eventually leading to battery failure. The primary function of a battery management system is to determine and control the state of charge and health of each of the cells that make up the battery newspaper. Any lithium-ion battery charged to a 100% charge state or discharged to a 0% charge state will reduce its capacity [9]. Determining the state of charge requires measuring cell voltage and temperature, and the accuracy of these measurements directly determines how well the state of charge is managed. In summary, the electronics of the battery management system are key to maximizing the operating range, life, reliability and safety of the EV battery system.

4.2.2. Motor

At present, electric motors for electric vehicles mainly include asynchronous motors, permanent magnet motors and switched reluctance motors. The drive motor of electric vehicle is part of special motor, that is the pivotal component of electric vehicle. To let the electric vehicle performs much better, we should widen speed range of motor to make it reach higher speed, enlarge its starting torque, minish volume.Moreover make the EV have light mass, high efficiency and excellent ability of dynamic braking and energy feedback advantages. At present, among the electric motors used in electric vehicles, DC motors have basically been replaced by asynchronous motors, permanent magnet synchronous motors or switched reluctance motors [10]. Due to the advantages of compact structure, high efficiency and power density, permanent magnet synchronous motors have been widely utilized in electric vehicle adhibition in recent years. To further meet the special needs of vehicle applications, new special motors such as hybrid excitation motors and disk motors are also used in the automotive field. The motors used in electric vehicles are developing towards high power, high speed, high efficiency and miniaturization.

4.2.3. Controller system

At present, motor speed control is generally done by chopper speed control device using power transistor module.By changing the three-phase current conduction sequence of the magnetic field, the commutation of AC asynchronous motors, permanent magnet synchronous motors and brushless DC motors can be completed, which make the control circuit more simple to a great extent and improves the system's reliability , and the control of the motor mostly includes frequency control, vector control and direct torque control to achieve best performance of the motor .On this basis, fuzzy control, neural network, white adaptation control,genetic algorithm and sliding mode variable structure and other intelligent control methods are used to improve the system robustness and dynamic response, suppress torque pulsation, and enhance the comprehensive performance of the system . Inverter speed control has simple structure, low cost, small speed control range, unsatisfactory torque characteristics, low control accuracy and poor dynamic performance. Vector control has low loss, high efficiency, good reliability, wide speed control range, good dynamic performance, complex structure and high cost. Direct torque control structure is simple, rapid dynamic response, direct self-control, excellent control performance, but low-speed torque pulsation; neural network vector control good dynamic response performance, the impact of changes in motor parameters on the control system is reduced, but the network structure is complex, sample acquisition training is difficult. Adaptive control can rely on continuous collection of control process information to determine the current operating state of the controlled object, optimize the performance criteria, generate adaptive control laws, so as to adjust the structure or parameters of the controller in real time, so that the system always works automatically in the optimal or sub-optimal state, but the structure and control algorithm is complex. Sliding mode variable compound control has good speed, good stability, small speed fluctuation and strong anti-interference ability, but the structure and control algorithm are complex. Fuzzy control white rectification PID control without overshoot, fast response, small speed fluctuation, strong robustness, but fuzzy rules and subordinate degree function need a lot of experience.

5. Conclusion

This paper mainly compares the advantages and limitations of three kinds of electric vehicles, introduces several key technologies used in electric vehicles, and discusses the development prospect and future development direction of electric vehicles.

The characteristics of gasoline and diesel cars cause them to never be as environmentally friendly as hybrids and electric cars. Hybrid vehicles are more acceptable to consumers in the low and mid-range markets because of their price advantage in cost and lower emissions brought about by their mode of operation. HEVs play both the advantages of the engine's long working time and good power and the benefits of non-polluting and low-noise electric motors, complementing each other's strengths

and weaknesses. Not only is it less harmful to the environment and has a larger application market. PHEVs are both the engine, transmission, drivetrain, oil circuit, and fuel tank of the traditional car, and the battery, motor, and control circuit of the pure electric car. And the battery capacity is relatively large, with a charging interface. These advantages make it more competitive. But the advantage is not very obvious in the long road driving process. For purely electric vehicles, due to the disadvantages of various types of batteries, such as high price, short life, large size and weight, and long charging time, BEVs are limited to certain specific applications, and the market is relatively small.

The three key technologies of electric vehicles have a certain development space. For the future expansion of the market of electric vehicles, battery endurance and battery density need to be further optimized. Motor technology and Controller technology are relatively mature but can be improved in accuracy. In general, electric vehicles still have a very good development prospect, and the government and people from all walks of life have strong support for the field of electric vehicles.

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