Research on Fuel Cell Technology of Electric Vehicle

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ABSTRACT
With the growing shortage of energy and environmental pollution problems, the community on the car's efficient, clean, economic and security put forward higher requirements. This paper introduces the history of fuel cell vehicles, the classification of electric vehicles, the fuel cell electric vehicle technology, the classification of fuel cells, the problems existing in fuel cell technology and the urgent need to be solved, and the development prospects of fuel electric vehicles, analyzes the fuel cell electric the key technology of automobile in development and application needs to be solved. Pointed out that the fuel cell as a new energy, with its high efficiency and zero pollution and other advantages of increasing attention, fuel cell electric vehicles and its technology has also been more widely applied and developed.

KEYWORDS: electric vehicle; fuel cell; economy; efficiency

1. Introduction

In recent years, due to the continuous improvement of the world economy, people's living standards are getting higher and higher, so people's purchasing power is also greatly improved, so the car into the tens of thousands of households.

So the question is coming. First: the vast majority of the world's cars are driven by internal combustion engines, fuel is gasoline or diesel, and the world's oil resources are increasingly less and more expensive so the cost of fuel vehicles will be higher and higher.

Second, the internal combustion engine is the environmental pollution problems, because the internal combustion engine fuel is gasoline or diesel, so the emissions of exhaust gas contains a lot of harmful substances, is the environment we live on a great degree of pollution, to us the health caused a great threat. As a result of these two reasons to make the new energy vehicle research has been widely attention.

In the last few decades, due to the extensive use of internal combustion engine vehicles have led to more and more serious environmental pollution, more and more depleted resources, especially oil resources, so that a new energy vehicle can replace the internal combustion engine car is its current car there is an urgent need to address a problem. How to find alternative alternatives to internal combustion engines, there are two aspects to consider: 1: highly efficient energy consumption. 2 low emissions and low pollution. Electric cars to meet these two requirements, and the biggest advantage of electric cars is the noise is small, low pollution, vibration, and high energy efficiency.

As early as the fifties and sixties of last century, before the advent of oil-fueled cars, electric vehicles had already begun to be applied, according to data show that in the early nineteenth century, electric vehicles in the market occupies a large proportion, internal combustion engine technology innovation and continuous improvement and electric vehicle battery technology is not perfect, electric vehicles and thus gradually out of the market until the nineteen nineties, the united states has launched an electric car, although only in the united states the mainland to sell, but it will undoubtedly become an important milestone in the development of electric vehicles.

The fuel cell electric vehicle as the leading technology of electric vehicles, fuel cell is the use of electrochemical power generation of a power generation device, in the case of constant temperature in accordance with the chemical way, without the heat of the case of electricity directly from the chemical energy conversion from the carnot cycle limit so the energy utilization rate is very high and pollution is very small, which makes it an ideal energy, will be more
and more accepted by people, and with the fuel cell technology more and more mature, fuel cell technology, fuel cell vehicles will certainly be a great development, fuel cell vehicles will account for more and more market share.

Now, the development trend of new energy vehicles is zero emissions of pure electric vehicles and ultra-low emissions of hybrid electric vehicles. In recent years, although China's rapid economic development, but at the same time the environment has been a serious damage, greatly reduce the air quality, and the destruction of the air environment is a large part of the reason is because the traditional fuel vehicle emissions, of the exhaust gas contains a large number of harmful substances, these substances greatly endanger our health. Therefore, the new energy vehicles have been widespread concern, at present, nissan, toyota, BYD and many other well-known brands have their production of electric vehicles on the market.

1.1. Fuel cell car history

Dating back to the 1830s, william grove found that the generation of points could be produced by hydrolysis in constant experiments. Later, in 1889, two scientists, Charles Long Court and Zhu Xinhua monde, both created the term 'fuel cell' through research. The fuel of the first fuel cell was gas and air. Reaction material, when the first time into the twentieth century scientists need to further research and production of fuel cell vehicles, the arrival and maturity of internal combustion engine technology is to develop the fuel cell vehicle technology has been curbed.

In 1932, Francis Bacon developed the world's first fuel cell equipment, which is now widely used hydrogen fuel cell from the alkaline electrolyte and the composition of the later monde and long court used by the cheap the catalyst for the role of the catalyst, because some of the technical and economic common factors, in 1959 Bacon and his team to develop a cheap catalyst for the role of the alternative is 5kw fuel cell system. In the same year, Harry has also developed a cheap catalyst for the role of the catalyst. This is the fuel cell technology has been a qualitative leap.

In the 1950s, NASA conducted research on fuel cells after scientists, and NASA provided funding for hundreds of fuel cell technology issues support. These developed fuel cell technology projects successfully participated in several US space missions, in the US space program, fuel cell technology has played an irreplaceable role.

Over the past decade, the vast majority of the world's largest car manufacturers have been involved in the research and manufacture of new fuel cell technology, which has made a new source of power for electric vehicles, but for the time being popular there are still some difficulties, so there are many electric vehicle fuel cell research and development that you need to overcome the popularity of electric vehicles for a long time.

2. Classification of electric vehicles

Electric vehicles can be divided into battery electric vehicles (EV), fuel cell electric vehicles (FCEV), hybrid electric vehicles (HEV), the following simple to introduce these three types of electric vehicles:

2.1. Battery electric vehicle (EV)

EV is one of the best zero pollution or ultra-low pollution vehicles, it is no noise and vibration, good operating performance, far ahead of the fuel vehicle, is the current development and development of alternative fuel vehicles preferred car models, EV power The source uses a battery-motor system.

1.1 Battery electric vehicle components

1 Car power section
2 Battery management system part
3 Drive motor and drive system section
4 Control technology section
5 Body and chassis part
6 Security protection system section

2.2. Fuel cell electric vehicle

Fuel cell electric vehicle (FCEV) is a fuel cell as a power source of electric vehicles. Fuel cell electric car is the heart of the fuel cell drive system, its fuel variety, can be hydrogen, it can be methanol, due to the different fuel so the corresponding power generation system is also different.

A hydrogen - powered power generation system
2.3. **Hybrid electric car**

Hybrid electric car (HEV) is the latest car models, it has the most market potential. Hybrid electric vehicles will be the combination of existing internal combustion engine and storage equipment, this combination not only played the advantages of internal combustion engines and battery cars and solve the two car disadvantages: mixed electric vehicles greatly reduce emissions and reduce emissions the energy consumption, so that hybrid electric vehicles have a great future market.

3. **Fuel cell electric vehicle technology**

3.1. **How the fuel cell works**

The working principle of a fuel cell can be explained by the above equation: his working principle is to reverse the process of water, hydrogen and oxygen to lose electrons or get the chemical reaction of electrons and finally get water to produce electricity. Its working principle as shown below:

Anodic: hydrogen near the anode produces a proton and an electron by the action of the catalyst. After the hydrogen atoms lose their electrons, they become positively charged protons through the electrolyte membrane to the cathode, and the electrons that lose their electrons become negatively charged protons through the external circuit to reach the cathode, through the process of electronic movement due to the current, resulting in electrical energy.

Cathode: the oxygen near the cathode reacts with the electrons and protons through the catalyst to generate water.

3.2. **Fuel cell classification**

There are many kinds of fuel cell varieties, there are many ways to classify, which can be based on the different working temperature, depending on the type of dielectric, can also be classified according to the different types of combustion.

3.2.1 Operating temperature is different

As the working temperature is different, the fuel cell can be divided into low temperature fuel cell, medium temperature fuel cell and high temperature fuel cell three types.

1. When the fuel cell operating temperature at room temperature to 100 degrees celsius, this fuel cell known as low-temperature fuel cell, solid polymer electrolyte fuel cell is a low-temperature fuel cell.

2. When the fuel cell operating temperature is greater than 100 degrees celsius less than 300 degrees celsius, this fuel cell known as the temperature fuel cell, phosphoric acid type of fuel cell is one of them.

3. When the fuel cell operating temperature is greater than 500 degrees celsius, this fuel cell called high temperature fuel cell, molten carbonate fuel cell and solid oxide fuel cell is belonging to high temperature battery.

3.2.2 Sources of fuel are different

Fuel cells due to different sources of fuel can be divided into three categories:

1. Direct fuel cell: when the fuel cell fuel directly using hydrogen, rather than through other fuel conversion from the fuel cell is called a direct fuel cell.

2. Indirect fuel cell: when the fuel cell fuel is through a certain technical means to other fuels such as alkanes (methane or other hydrocarbon compounds), alcohols (methanol) into hydrogen or oxygen-rich mixture gas is supplied to the fuel cell rather than supplying the hydrogen directly to the fuel cell as a direct fuel cell.

3. Renewable fuel cell: this type of fuel cell is the reaction of the fuel cell before the reaction of water, through a certain technical means decomposition into hydrogen and oxygen, water decomposition into hydrogen and oxygen after the hydrogen and oxygen again to the fuel cell to re-power.

3.2.3 Different types of electrolytes

According to the fuel cell type of electrolyte classification has been gradually adopted by domestic and foreign fuel cell researchers. Currently being developed commercial fuel cells, according to the type of electrolyte can be divided into five categories:

1. Alkaline fuel cell (AFC);
2. Phosphoric acid fuel cell (PAFC);
3. Proton exchange membrane fuel cell (PEMFC);
4. Molten carbonate fuel cell (CFC);
5. Solid oxide fuel cell (SOFC).

4. **Fuel cell vehicle fuel**

According to the current world of oil and the current world industrial development situation: the current global demand for oil is getting higher and higher, and an annual growth rate of 30 percent increase, according to this law, according to the current the amount of oil in the world over three decades or so oil resources will be run out by us. And we use the oil at the same time, the deterioration of the environment, the atmosphere of pollution, is our ecological environment further deterioration, leading to the culprit is now the internal combustion engine exhaust emissions. According to a world environment organization data show that the world's most polluted cities, most of them from china. And the data also show that exhaust emissions account for 70 percent of all air pollution. So that research and development can replace the internal combustion engine of the new fuel vehicles without delay, this will make the environmental pollution, air pollution and greenhouse effect is effectively alleviated. And developed with the new fuel, can make the lack of oil resources to be effectively alleviated.

4.1. **Fuel-to-fuel fuel cell electric vehicles**

4.1.1 Advantages of hydrogen as fuel for fuel cell fuel

When the fuel cell fuel is hydrogen, according to the chemical equation of hydrogen and oxygen and the reaction mechanism, hydrogen and oxygen reaction will only produce water after, and not talk about oxygen compounds, so that the use of hydrogen fuel vehicles to achieve the pollution zero emissions. As fuel cells with hydrogen as fuel do not use reforming equipment, hydrogen fuel cell is the system weight of the fuel cell, the volume is reduced, the manufacturing cost is reduced, and the structure is simple. In the long run, fuel cell when the future fuel cell best fuel choice, but at this stage it seems hydrogen generally as fuel for fuel cells, there are still some difficulties, because the instability of hydrogen and the explosive nature of this technology difficult to promote at this stage. Hydrogen has a higher specific energy than any fuel, as shown in the following table:

<table>
<thead>
<tr>
<th>Fuel specification (Wh/kg) Energy density (Wh/L)</th>
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<tbody>
<tr>
<td>Compressed hydrogen a 33600 600</td>
</tr>
<tr>
<td>Liquid hydrogen b 33600 2400</td>
</tr>
<tr>
<td>Hydrogen storage magnesium 2400 2100</td>
</tr>
<tr>
<td>Storage of vanadium</td>
</tr>
<tr>
<td>Methanol 5700 4500</td>
</tr>
<tr>
<td>Gasoline 12400 9100</td>
</tr>
</tbody>
</table>

4.1.2 Disadvantages of hydrogen as fuel for fuel cell fuel

1. Hydrogen storage and transportation problems

Usually at room temperature, a standard atmospheric pressure due to the different density, the same quality of gasoline in the space occupied by only a few thousandths of hydrogen space, so that the same mass of hydrogen in the volume is much larger than gasoline, so that the storage and transportation of hydrogen will be very difficult. So the hydrogen gas must be pressurized to reduce the volume of hydrogen, when the storage pressure of 200 atmospheric pressure, so the storage volume is greatly reduced, but the volume that the same quality gasoline thirty or four times. It is necessary to pressurize the hydrogen, the hydrogen pressure of the gas to make it into a liquid, so that the transport of hydrogen will become possible, but this pressure is huge, the liquid hydrogen transport also made a great request, and under the existing technology, the container of the liquid-hydrogen transport vehicle has been able to withstand three hundred forty-five atmospheres.

2. Liquid hydrogen storage, consumption and evaporation problems
Liquid hydrogen storage has a great problem: the first technical problem is the hydrogen to the liquid hydrogen conversion process to consume a lot of energy, in this process, the hydrogen liquefaction of liquid hydrogen consumption of energy accounted for total hydrogen thirty percent. The second technical problem is: liquefied hydrogen storage will heat, because the liquid hydrogen storage tank and the outside temperature is huge, so the liquid hydrogen will have a very serious evaporation state, if the liquid hydrogen long-term preservation and not use, then the liquid hydrogen there will be a large part of the loss due to evaporation.

3. Storage safety and efficiency

As the liquid hydrogen storage pressure is huge, it will bring a lot of security problems, and hydrogen to liquid hydrogen liquefaction of this process will consume some energy, thus reducing the efficiency of the system the and liquefied hydrogen in the storage tank, because the tank and the tank outside the temperature difference is large, the tank of hydrogen absorption of hydrogen absorption, will lose part of the energy, after evaporation of hydrogen into hydrogen, so that the liquid hydrogen storage tank Increased pressure, causing danger. In order to avoid the high pressure caused by the danger, it must be in a certain period of time to liquid hydrogen storage tank gas discharge, at the same time, due to the discharge of hydrogen insight into the system efficiency.

4. Equipment for the supply of hydrogen fuel

The existing technical situation, the hydrogen fuel cell electric vehicles need a lot of hydrogen fuel, but for the time being the supply of hydrogen fuel equipment is still very scarce, cannot meet the There is a demand for hydrogen fuel for cars.

4.2. The advantages of methanol as fuel for fuel cell fuel

Methanol is very rich in resources, a lot of ways to make methanol can be from natural gas, biogas and other carbon substances in the system out.

In the fuel of existing fuel cell electric vehicles, the reforming temperature of methanol is low at around 280 degrees celsius.

Methanol-fueled fuel cell electric vehicles are easier to promote, because the methanol supply station is easier to build, the safety performance requirements than the hydrogen fuel supply station is much lower.

The energy density of methanol is high. After filling a box of methanol, methanol-fueled fuel cell electric vehicles can run a long mileage.

4.3. Disadvantages of using methanol as fuel for fuel cells

Although the use of methanol as a fuel has many advantages, in addition to toxicity, corrosion and other physical properties of their own, due to the existence of the reorganization process, brought the following negative effects:

1. Increase the complexity of the structure and the weight of the system, the cost of methanol reforming fuel cells and hydrogen fuel cells compared to the addition of the reformer, increasing the system weight, cost and structural complexity, while compared with the traditional models reduce the available space of the vehicle.

2. Energy loss according to the methanol reforming mechanism, in the process of reforming, the first methanol vaporization, methanol vaporization consumes the energy of the system.

3. Environmental pollution according to the mechanism of methanol reforming, methanol reforming process produced CO, CO2 and other carbon oxides and nitrogen oxides, resulting in environmental pollution. In addition to methanol reforming fuel cells, countries are also developing direct methanol fuel cell. Direct methanol fuel cell and methanol reforming fuel cell reaction mechanism is very different, methanol without reorganization, can be directly in the fuel cell stack electrochemical reaction. Since the methanol reforming and removal of CO is not required, the cost and weight of the methanol fuel cell system can be reduced and the system structure can be simplified. Direct methanol fuel cell and methanol reforming fuel cell compared to the technology is not yet mature.

4.4. Fuel-fueled electric vehicles for fuel-based fuels

4.4.1 Gasoline fuel internal structural reaction between the reorganization process

Hydrogen is the main component of gasoline components, C6H14 as an example to analyze the composition of gasoline, his structure is simple from 12 oxygen atoms and 6 carbon atoms from the combination of re-production, the
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fuel cell reaction required hydrogen that is, a large number of hydrogen atoms in the gasoline molecules through the reform and transformation. The reorganization process is as follows:

1. Gasoline vaporization.
2. The gasoline vapor, which is cleaned by sulfur removal, reacts with the air under the action of the catalyst to cause a vigorous reaction of the mixture to produce the desired fuel composition CO and hydrogen.
3. Pass the generated water vapor and allow it to react with CO to produce exhaust gas CO2 and fuel hydrogen.
4. Ignite the remaining unresponsive CO to make it fully combusted to produce CO2.
5. The hydrogen is subjected to an electrochemical reaction by combustion to produce clean water and a small amount of low-pollution emissions, while at the same time outputting the required electrical energy.

4.4.2 Advantages of gasoline fuel cell

CO2 is produced during the process of gasoline reforming. In the case of the same volume of gasoline being burned through a series of reactions, more CO2 is produced during the gasoline reforming process than to increase the amount of carbon dioxide produced by direct combustion of gasoline, but the resulting hydrogen is subjected to an electrochemical reaction the energy created will be much higher than the direct combustion of gasoline produced by the energy of 2 to 3 in the case of comparison, in the production of the same power when the fuel reforming fuel cell economy, better emissions. According to the observation of methanol reforming fuel cell is my efficiency is higher than the efficiency of gasoline refueling fuel cell electric vehicles but it is higher than the efficiency of electric vehicles and internal combustion engine cars, indicating that the oil, gasoline, methanol energy conversion process, the gasoline through reorganization efficiency is relatively high. Although it is not as high as the conversion energy of formaldehyde, it can be seen that the calorific value of methanol is lower than the calorific value of gasoline and the volume energy density is lower than the volumetric energy density of gasoline reforming.

<table>
<thead>
<tr>
<th>Fuel density (kg/L)</th>
<th>High calorific value (MJ/kg)</th>
<th>Volume energy density (MJ/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen 200atm0.02</td>
<td>140</td>
<td>2.8</td>
</tr>
<tr>
<td>Methanol 0.79</td>
<td>22.7</td>
<td>17.9</td>
</tr>
<tr>
<td>Gasoline 0.70</td>
<td>45.9</td>
<td>32.1</td>
</tr>
</tbody>
</table>

Has a considerable advantage also makes a large degree of gasoline to fuel for the fuel cell fuel, so you can use the current perfect matching conditions can also make full use of the existing fuel supply facilities. But still in the initial stage of the gasoline reforming technology to bring us a fairly complex technical problem, the development is still not yet mature, and the reaction of gasoline molecules need the temperature of the internal structure is difficult to grasp, the most important is the gasoline weight The whole process involved in the conversion problem is a very critical issue.

5. 5 Fuel cell technology issues and prospects

5.1. Fuel cell technology issues

At present, the development of fuel cell vehicles is because of its superior economy in the economy, power and emissions, it is precisely because of these compared to the advantages of traditional internal combustion engine vehicles, so we vigorously develop new energy vehicles, but in this new roads cannot help but we need to explore the innovative technical problems.

1. Reduce production costs

In the initial stage of innovation and production we invest in large scientific research and operating funds, which for the initial exploration of a new road business is legitimate and must face the difficult period, but when we really reach the technical of the mass production period, we need to continue to reduce costs to meet the economic needs of the majority of people. Which is the most difficult to solve the current promotion is the most difficult to block the use of fuel cell capacity. We need to increase the storage capacity of the fuel cell in terms of the structure of the car and the convenience of the people, but the large capacity not only increases the cost but also cannot meet the body design structure. But the small structure cannot make good use of the advantages of fuel cells. Comprehensive above the contradiction, our most important thing is to maintain the economy at the same time maximize the fuel cell life.

2. The characteristics of hydrogen energy make it necessary to control the storage and use costs: fuel cells are currently possible to use three kinds of fuel is mainly hydrogen, methanol and gasoline, in which the problem of hydrogen storage is a big cost. We can hydrogen from the state of hydrogen storage can be divided into three forms, the first is the direct use of gas hydrogen, in order to be able to long-term power and endurance capacity requires a large
6. Flammable gas high pressure vessel and the need to compressed to reduce the body area. The second is stored in liquid form by liquefaction and pressurization, so that a series of complex refrigeration equipment and better safety safer compression are installed in the front or inside of the container. The third is the use of hydrogen and other chemical reaction of the reaction, usually the gold magnesium and vanadium and hydrogen role in the formation of hydrogen storage, but there is unavoidable high hydrogen separation temperature (and also accompanied by more energy than Low unavoidable shortcomings. There are very few attempts to use methanol as fuel to provide energy, and its working principle is also by mixing with water, evaporating a series of reactions, and through the vehicle reformer changes the final formation of hydrogen and carbon dioxide gas. Methanol compared to hydrogen although the storage safety, but when the requirements of its conversion of high technical and there are some external conditions, the most important is its own a certain degree of toxicity, conversion or improper storage will cause great human harmed.

3. Gasoline cracking difficulty: we can extract the hydrogen fuel needed for the fuel cell through the petrol cracking reaction, but this is a very difficult thing, and his difficulty is far more than the difficulty of cracking the methanol. Only to meet the high temperature of 850-1000 gasoline cracking reaction can be carried out smoothly, such a high temperature even if the fuel cracking at the end, but the high temperature cooling is also very difficult. In contact with the outside world at the same time the reaction results will produce conducive to the formation of greenhouse effect of the gas. Sometimes due to some changes in the conditions of its reaction may also occur unexpectedly the role of the accidental.

4. Equipment expenditure problem: now that not only the cost of the fuel cell itself is high but also the technology of high production equipment is required, the problem of equipment expenditure in the case of strict guarantee of fuel cell quality is the very important equipment technology funds that need to be faced first problem. Fuel cell vehicle production equipment and some of the relevant links of the funds to be further reduced. 5., icing is related to the normal operation of the fuel cell fatal weakness. Through a series of reaction with the fuel cell, in the course of its work will inevitably produce some reaction residue. The main remnant of which is the most of the water produced, how to ensure that the water can be used in a low temperature to avoid the occurrence of icing, because the water will break the ice will destroy some of the vulnerable polymer membrane. The most important low temperature state of the fuel cell does not react so as to stop the conversion of energy response, so we must meet the low temperature in the reactor can also be very good and normal work.

5.2. Prospects for fuel cell technology

In recent years, because of the serious shortage of resources, so that the price of oil and other resources is getting higher and higher, most of the world's automobile production and manufacturers of new energy automotive market have a very strong interest in these manufacturers of new the goal is to enter the new energy or energy-efficient car market, and they are in the development of fuel cell electric vehicle new technology to dominate the future of the new energy automotive market.

There are many kinds of electric vehicles, and fuel cell electric vehicles is the most promising type of electric vehicles, it is the next few decades the most competitive a car technology, this new technology is the fuel cell electric vehicle fuel hydrogen and oxygen to produce electricity to produce a reaction device, and the reaction product is water, this technology truly zero pollution, and save less and less oil resources.

Under the current stage, the fuel cell in the world of automotive researchers’ efforts, the fuel cell electric vehicle fuel cell technology has made rapid progress, and now the fuel cell electric car is difficult to promote the reason is difficult to mass production is not fuel battery electric car itself is a technical problem. So the world's major automobile manufacturers are increasing efforts to promote the promotion of fuel cell electric vehicles to do their best efforts. Various countries have promulgated relevant policies with strong support for car manufacturers to give financial support. Thus to the promotion of fuel cell electric vehicles played a huge role in promoting.

6. Conclusions

As the traditional internal combustion engine car to the current resources and our existing environment has brought a series of problems, so the new energy vehicles are increasingly accepted by people, and china and the world are vigorously research and development of new energy vehicles, and fuel battery electric vehicle technology is the most promising new energy vehicles and prospects for the development of automotive technology.

In this paper, the history of electric vehicle fuel cell vehicles, electric vehicle classification, fuel cell classification, features are a comprehensive introduction, and a detailed analysis of the fuel cell electric vehicles at this stage of the existing problems, as well as fuel cell electric vehicles prospects. Although fuel cell electric vehicles have a very good prospect, but because of a lot of technical reasons is the fuel cell electric vehicles cannot be widely used, but with the
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continuous development of technology and progress, these problems will be solved, I believe that in the near future fuel cell electric the car will enter the tens of thousands of households, as people indispensable means of transport.

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