Universe Scientific Publishing

DOI: 10.18686/ahe.v6i15.5173

Optimization Scheme of Bipolar Plate for Hydrogen Fuel Cell

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Abstract: Fuel cell is one of the main powers of new energy vehicles. In the fuel cell, bipolar plate is an important component for its normal operation, which plays a variety of roles, such as distributing reaction gas, collecting current, draining water, conducting heat and supporting machinery. Its flow field structure determines the proportion of reaction area, the uniformity of reaction gas distribution, etc., and significantly affects many important parameters such as fuel cell power, current density distribution in the range of electrode plates, voltage consistency between electrode plates, etc., thus determining the working performance index and service life of fuel cell, which is an important content of fuel cell structure design. at present, the hydrogen fuel cell technology is in the initial stage, and there are some problems, such as uneven distribution of reaction gas in the whole system, low conversion rate of hydrogen and electricity, and high production cost, especially the low reaction effect of bipolar plate flow field and the utilization rate of membrane electrode, which seriously affect the popularization of fuel cells.

Keywords: Fuel cell; Bipolar plate; Structure design

Fund Project: Shandong Industrial Vocational College Horizontal Project Funding Project: Design and Development of Metal Bipolar Plates for Hydrogen Fuel Cell Stacks for Vehicles (Jinan Ying Hydrogen Power Technology Co., Ltd., Project No. 2021HX002)

1. Analysis of working principle of hydrogen fuel cell

The fuel cell contains two electrodes, a cathode and an anode, which are filled with electrolyte respectively, and a permeable membrane is formed between the two electrodes. Hydrogen enters the fuel cell from the anode, while oxygen enters the fuel cell from the cathode. Under the action of the catalyst, the hydrogen molecule of the anode is decomposed into two protons and two electrons, in which the protons are "attracted" to the other side of the film by oxygen, while the electrons form a current through an external circuit and then reach the cathode. Under the action of cathode catalyst, protons, oxygen and electrons react to form water molecules.[1]

The "hydrogen" fuel used in the fuel cell can come from hydrogen gas and any hydrocarbon produced by the electrolysis of water. As the fuel cell generates current and water through the chemical reaction of hydrogen and oxygen, it is not only completely pollution-free, but also avoids the time-consuming problem of traditional battery charging. It is the most promising new energy method at present. If it can be popularized and applied to vehicles and other high-pollution power generation tools, it will significantly reduce air pollution and greenhouse effect.[2]

2. Main research contents

Under the background of new and old kinetic energy conversion and peak carbon dioxide emissions's carbon neutral strategy, based on the typical bipolar plate structure of fuel cells for new energy vehicles, the author optimized the structure of hydrogen and oxygen channels in metal bipolar plates, designed a one-step metal bipolar plate model with more compact structure, higher energy density, more uniform gas and temperature distribution, lower cost and more suitable for mass production, solved the problem of uneven distribution of reaction gas in the whole system, and improved the reaction effect of bipolar plate flow field and the utilization ratio of membrane electrodes.

2.1 Determine the layout of bipolar plate flow channel

Since the emergence of fuel cell technology, people have done a lot of research on the flow field. At present, conventional flow fields are straight channel, serpentine, spiral, interdigital and grid, etc. At the same time, relevant researchers are constantly developing new flow fields, such as bionic flow field and 3D flow field.

The DC channel is simple in structure and easy to process. The straight channel flow field has many parallel flow field channels, short process distance and small inlet and outlet pressure loss, which can realize the uniform distribution of current density and battery temperature. However, due to the short retention time of reaction gas in the straight channel, low gas utilization rate and relatively low flow rate, the produced water cannot be discharged in time, which is easy to cause water plugging.

The S-shaped channel structure will form a crossing part in the waterway, and the crossing part can make the water flow of adjacent cooling water channels mix and convect, so that the cooling water can be fully mixed, and its heat transfer performance is better than that of the straight channel with the same cross section. However, many key technologies of S-shaped channel have been protected by intellectual property rights and blocked by foreign automobile manufacturers, which makes it difficult to research and develop.

The serpentine flow field can be divided into single channel and multi-channel. There is a single serpentine flow channel, and all gases flow in one channel. The gas flow rate is very high and the flow channel is long, resulting in excessive pressure loss. Although it is beneficial to the removal of reaction water, it is not conducive to the uniformity of current density and the utilization of catalyst.

Therefore, after comprehensively considering the advantages and disadvantages of all kinds of metal bipolar plate runner layout

types, the author finally selected the serpentine runner as the layout type of metal bipolar plate runner to be innovated.

2.2 Optimize bipolar plate material

Bipolar plate materials can be roughly divided into three categories: carbon materials, metal materials and composite materials of metal and carbon.

Traditional bipolar plates are made of dense graphite, which is machined into gas channels. Graphite bipolar plate has stable chemical properties and low contact resistance with ethanolamine in fuel cell, but its mechanical properties and electrical conductivity are poor.

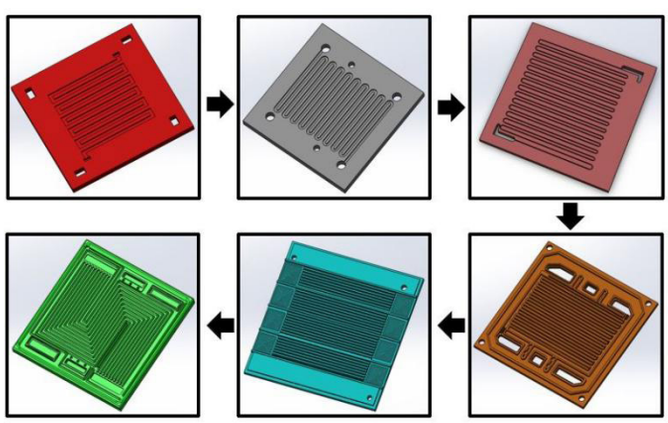
Metal materials such as aluminum, nickel and titanium can be used to make bipolar plates. The metal bipolar plate is easy to process, can be manufactured in batches, has low cost and thin thickness, and the volume specific power and specific energy of the battery are high.

Among all kinds of commonly used bipolar plate materials, graphite has the smallest contact resistance, and non-conductive oxide films are formed on the surfaces of stainless steel and titanium to increase the contact resistance. Composite materials can solve the shortcomings of metal materials and carbon materials, but the cost is high, so it is not suitable for the popularization of fuel cells.

Therefore, in order to control the cost of enterprises and improve the hydrogen-electricity conversion capacity of fuel cells, the author decided to choose metal materials as the bipolar plates of new fuel cells.

3. Implementation process

The metal bipolar plate of conventional fuel cell has the problem of uneven gas distribution in the reaction process, which leads to uneven heat dissipation of the metal bipolar plate, resulting in unsatisfactory reaction effect of the bipolar plate. According to the innovative idea of “preliminary design-sample making-sample test-result feedback optimization”, the author continuously laid out the internal structure of bipolar plate and made finite element analysis in 3D modeling Solid works software. Finally, a new type of metal bipolar plate was designed and optimized and applied to the whole vehicle, which solved the problem of uneven distribution of reaction gas in the whole system, and improved the reaction effect of bipolar plate flow field and the utilization ratio of membrane electrode. After the implementation, the fuel cell is more compact in the whole vehicle, which is beneficial to improve the space layout of the vehicle. The new metal bipolar plate runner is formed in one step, making it easier to produce in batches, and further reducing the manufacturing cost. The implementation process is as follows:



4. Conclusion

Generally speaking, the optimized compact bipolar plate structure improves the spatial layout of vehicles, and the once-formed bipolar plate runner is more suitable for mass production, with high energy density, thus improving the endurance of vehicles, more uniform gas and temperature distribution, and more stable hydrogen-electricity conversion, which has been affirmed by service enterprises. At the same time, it has certain guiding significance for the design and production of fuel cell and new energy vehicle enterprises.

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