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DEVELOPMENT OF A FUEL ELEMENT TECHNOLOGY TO REDUCE THE TECHNOGENIC LOAD OF THE ENVIRONMENT

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The stated material assumes a theoretical justification for the improved technology of the fuel element, the use of which reduces the technogenic load on the environment.

Formulation of the problem. Special attention to many scientists in the world to explore new sources of energy that do not affect the environment and do not pollute it due to the development of the modern world economy. Fuel Element, as a new type of power source, has been very popular in the field. However, fuel element is very costly and difficult to be controlled well. And the hydrogen which acts as the fuel also takes a lot of manpower and money for its storing and transporting. Therefore, in order to reduce the developing cost of fuel element application equipment, as well as to increase the developing benefit, it is significant and valuable to study, design and manufacture a fuel element output performance simulated system. When the fuel element is active, inside the stack there are both chemistry reaction processes and physics processes, such as gas-liquid two phase current, ions and electrons transportation processes and so on. Parameters of these processes are highly coupling with each other. This phenomenon makes it very difficult to find out an accurate mathematics model to describe the fuel element output performance exactly. With fuel element working principle, performance, large amount of experiment data and experience formulation, a simplified fuel element model was reasoned out and was made as similar as the fuel element performance.

Analysis of recent research and publications. The fuel theory applies the method of electrolysis. Two main electrochemical reactions occur in a fuel element. One is at the anode and the other is at the cathode. The voltage output simulated by the model is coherent with the output of fuel element at low current and the dynamic response of the system is the same with the ohmic overvoltage effect part of the fuel element. But the drawbacks of the system, such as error, voltage drop at high current and inability of simulating dynamic response of polarized overvoltage and concentration overvoltage, need to be solved by improving the structure of main circuit and rebuilding a more accurate model.

But the drawbacks of the system, such as error, voltage drop at high current and inability of simulating dynamic response of polarized overvoltage and concentration overvoltage, need to be solved by improving the structure of main circuit and rebuilding a more accurate model. The major benefit is that not only can the entire development process be accelerated, but design altematives can easily and rapidly be investigated-in days rather than months-to come up with significantly improved designs. Once a validated model has been constructed it can be used to optimize virtually any aspect of component and system design and operation at a relatively small incremental cost.

The purpose of the article. A mathematical model of obtaining new energy resources is proposed. The most up-to-date topics in the field of conservation of energy resurfaces are raised. The article is original and useful for the future.

Basic research materials. Energy can be divided into different types according to different forms of division. Energy can be divided into primary energy and secondary energy. Primary energy is natural energy, which refers to energy that exists in nature, such as coal, oil, natural gas, and hydropower. Secondary energy refers to energy products converted from primary energy processing, including gas, steam, electric energy and various petroleum products. Primary energy can be divided into renewable energy and non-renewable energy. Renewable energy includes water, wind and biomass. Non-renewable energy includes coal, oil and natural gas. Coal, oil and natural gas are the core of primary energy. The foundation of global energy is mainly composed of them. At present, energy has become the top priority of all countries' development. Energy issues often cause disputes among countries. Therefore, energy security has become an important guarantee for the country's economic and political development. Fossil energy has been over-exploited in the last 200 years. According to experts' estimates, according to the current energy consumption rate, oil resources will be exhausted in the next forty or fifty years [1].

Petroleum, the world's most prolific fuel, is becoming scat-cer and its burning produces emissions which shoulder much of the responsibility for air pollution. Contributions also come from deforestation, carbon dioxide from the burning of coal, and methane release. In order to reverse the trend of destroying the environment, a change to a more ecologically mundane resource or method ofproducing energy such as hydrodynamic, wind, geothermal, solar and tidal is desirable. These methods are presently employed in a somewhat small scale, but require specific environments in order to work effectively. Fuel elements [2] need no particular environment to work well (other than a heat sink) and are highly efficient both electrically and physically(without sound and with far fewer harmful air pollutants).

A fuel element is an electrochemical device which brings together hydrogen and oxygen, or air in the midst of a catalyst to produce electricity, heat and water. The single element fixture consists with a single electrolyte sandwiched between electrodes. This inner sandwich is then placed in-between current collectors which usually serve as the poles of the element . A fuel element generates current by transforming(usually by using the catalyst in the electrodes) hydrogen gas into a mixture of hydrogen ions and electrons on the anode side of the element . Because of the insulating nature of the electrolyte, the anions transfer through the electrolyte to the cathode side of the element while the electrons are conducted to the current collectors and through a load to do work. The electrons then travel to the cathode side current collector where they disperse onto the electrodes to combine with incoming hydrogen anions, oxygen, orair in the presence of a catalyst to form water completing the circuit [3].

The fuel element was first invented in 1839 by Sir William Grove, a professor of experimental philosophy at the Royal Institution in London. He tested what turned out to be the precursor to the phosphoric acid fuel element by enclosing platinum in tubes of hydrogen and oxygen gas while submerging the tubes in sulfuric acid [4].

Unfortunately, he was hampered by the inconsistency of element performance (a common feature of elements today), but realized the importance of the three phase contact (gas , electrolyte and platinum) to energy generation. He spent most of his time searching for an electrolyte that would produce a more constant current . He found several electrolytes [5] which produced current , but still struggled with consistent results . He also noted the potential of the energy production method commercially if hydrogen could replace coal and wood as energy sources.

Since that time , researchers world wide have attempted to increase element performance electrically, chemically as well as physically.

Their experiments ranged from an improved three phase contact to smart materials and the adoption of off gases from other power sources.

After over 150 years of research, fuel elements can be divided into five major categories named after the electrolyte used in each, alkaline , solid polymer, phosphoric acid, molten carbonate and solid oxide. The five types resulted from the knowledge that heat accelerates chemical reaction rates and thus the electrical current.

The materials used for electrolytes have their best conductance only within certain temperature ranges and thus other materials must be used in order to take advantage ofthe temperature increase.

Several processes are involved in the operation of a fuel element. The processes can be summarized as : gas transfer to the reaction sites, the electrochemical reaction at those sites, the transfer of ions and electrons and their combination at the cathode. Gases must diffuse through the electrode leaving behind any impurities which may disrupt the reaction while liquid produced at the surface of the electrolyte, or added through humidification must be either added to the electrolyte for hydration, or drawn away from the reaction sites so as not to block reaction sites.

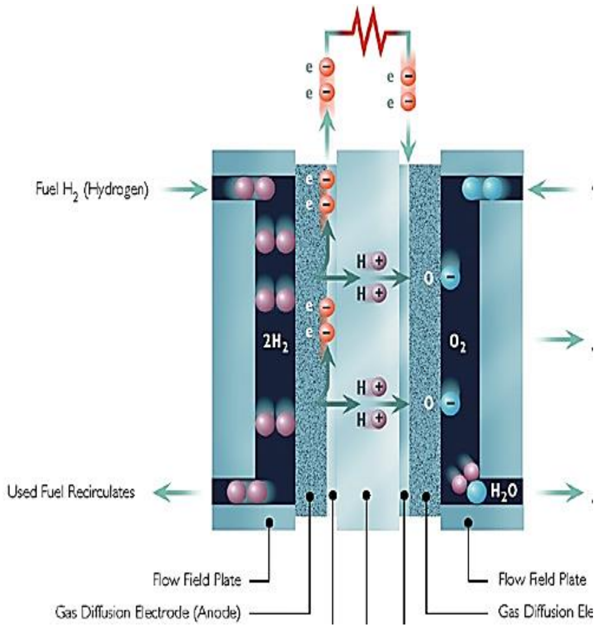

Figure 1 - The fuel element

Gases move towards the reaction sites based on the concentration gradient between the gas channel(high concentration)and the reaction sites(low concentration). Platinum, which is used as an electro catalyst(in AFC, SPFC and PAFC) serves as the acmal electrode, but since it must be physically supported to allow minimum concentrations(and thus less cost), the support and the platinum become the electrode. The concentration gradient refers to the difference between the concentration of free flowing gas in the channels and the concentration at the platinum reaction sites. This gradient varies depending on pressure and temperature of the gases and the diffusion coefficient of the electrode material. When the gas comes nears the reaction sites, the flow is dominated by a capillary action based on the reaction rates at the sites.

Two main electrochemical reactions occur in a fuel element. One is at the anode and the other is at the cathode.

At the andoe:

$$H_2 \rightarrow 2H^+ + 2e^- \quad (1)$$

And at the cathode:

$$2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O \quad (2)$$

Which together give the result:

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \quad (3)$$

At the anode, the reaction releases hydrogen ions and electrons whose transport is crucial to energy production. The ions build up on the anode creating a positive potential which pushes the outer ions away from the anode. The ions transfer through the electrolyte either by remaining connected through an attraction to a water molecule which travels through the electrolyte, or by transferring between water molecules. The hydrogen side of the water molecule contains a slight negative charge which attracts the ions and may become attached to it, but the attraction is weak so any forces made are easily broken. The actual method of transfer varies, but is based on the thickness of the membrane, the amount of water in the membrane and the number of ions transported.

Thus, the anode contains a net positive charge while the cmhode, towards which the ions drift, contains a negative potential. A key benefit of modeling is that less successful designs or inappropriate materials can be screened out before proceeding to physical testing. This provides an immediate saving in time and money. One major developer of residential fuel elements claims a saving of US $ 250,000-US $ 500,000 every time the need to build and operate a test rig is eliminated.

Modeling also provides a valuable framework in which experimental data can be analyzed using model-based data analysis techniques, as well as the wealth of information already within the model, to make sense of data in such a way that it can immediately be used to generate value. If performed in the correct way,such analyses are capable of providing a reliable quantitative measure of the risk involved in any design decision.

However the major benefit is that not only can the entire development process be accelerated, but design altematives can easily and rapidly be investigated-in days rather than months-to come up with significantly improved designs.Once a validated model has been constructed it can be used to optimize virtually any aspect of component and system design and operation at a relatively small incremental cost. The most significant benefits are achieved by embarking on modeling early 0n in the development process. A reliable membrane model can be used for quantification of element stack effects;a reliable element-stack model can be used for control design and analysis of system dynamics, and SO on.

Not only is the time invested in model development repaid many times over,but a consistent basis is used for all stages of design.

A fuel element modeling usually contains a element voltage model, an anode and cathode flow model and a membrane hydration model.

The assumptions on which the model is based are:

●The cathode and anode of the fuel element are a volume with a constant pressure and temperature.

●All gases behave like ideal gases.

●The inlet mass flows enter the anode and cathode volume without a pressure drop and the outlet mass flows leave the volumes via a nozzle.

●If the relative humidity of the water exceeds 100 %, liquid water will condense in the anode or cathode volume. Contrary to the basic model, it is possible that the outlet gas flows can transport a limited amount of liquid water, e.g. in the form of droplets.

●The gas diffusion in the gas diffusion layers (GDL) and at the electrode surfaces is neglected.

Conclusion. From the above material we can see that in recent years fuel element, especially PEM fuel element, has drawn more and more attention all over the world. Price and control problem of fuel elements are still the mainly obstacle to its development, so lower price and easier operation product is needed to substitute the fuel element for research and studying. And this is the main objective the thesis focusing on. The conclusion Can be drawn that the voltage output simulated by the model is coherent with the output of fuel element at low current and the dynamic response of the system is the same with the ohmic overvoltage effect part of the fuel element. But the drawbacks of the system, such as error,voltage drop at high current and inability of simulating dynamic response of polarized overvoltage and concentration overvoltage, need to be solved by improving the structure of main circuit and rebuilding a more accurate model.

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Анотация

РОЗРОБКА ТЕХНОЛОГІЇ ПАЛИВНОГО ЕЛЕМЕНТА ДЛЯ ЗНИЖЕННЯ ТЕХНОГЕННОЇ НАВАНТАЖЕННЯ НА ДОВКІЛЛЯ

Барсукова Г.В.

Заявлений матеріал передбачає теоретичне обгрунтування удосконаленої технології паливного елемента, використання якої знижує техногенне навантаження на навколишнє середовище.

Аннотация

РАЗРАБОТКА ТЕХНОЛОГИИ ТОПЛИВНОГО ЭЛЕМЕНТА ДЛЯ СНИЖЕНИЯ ТЕХНОГЕННОЙ НАГРУЗКИ НА ОКРУЖАЮЩУЮ СРЕДУ

Барсукова А.В.

Изложенный материал предполагает теоретическое обоснование усовершенствованной технологии топливного элемента, использование которой снижает техногенную нагрузку на окружающую среду.