ORES

Научно-практический электронный журнал
Оригинальные исследования (ОРИС), *ISSN 2222-0402*
www.ores.su
original-research.ru

УДК 620.92

ЦЕЛЕСООБРАЗНОСТЬ ПЕРЕХОДА С УГЛЕВОДОРОДОВ НА ВОДОРОДНОЕ ТОПЛИВО

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Аннотация

В данной статье рассмотрена стратегия перехода на водородное топливо. В ходе работы определены основные причины, по которым переход на водородное топливо является целесообразным. Также проанализированы возможности и перспективы использования водородного топлива в будущем.

Ключевые слова: водород, водородное топливо, топливные элементы, электроэнергия.

FEASIBILITY OF THE SWITCHING FROM HYDROCARBONS TO HYDROGEN FUEL

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ABSTRACT

The strategy for switching to hydrogen fuel is considered in this article. In the course of the work, the main reasons were identified for which the switching to hydrogen fuel is feasible. The possibilities and prospects of using hydrogen fuel in the future are also analyzed.

Keywords: hydrogen, hydrogen fuel, fuel cells, electricity.

Introduction.

Global warming is making its own adjustments to the lives of people. And the main culprit for the increase in the temperature of the planet is CO2 (carbon dioxide). Carbon dioxide itself is not harmful to the environment. On the contrary, it is one of the main elements of the life process of plants. They absorb CO2, recycle it and release oxygen into the atmosphere. But if carbon dioxide becomes too much, it begins to act as thermal insulation for the planet. Radiation from the Sun freely passes through the atmosphere, but back into space, the less thermal energy goes, the more greenhouse gases in the Earth's gas envelope. The surface of the planet begins to heat up. Ice melts, climate and species composition of flora and fauna change [1].

Humanity is one of the suppliers of large amounts of CO2 into the atmosphere. So, in 2018, the total volume of carbon dioxide emissions in the world amounted to 33.9 billion tons, in 2019 mankind emitted 37 billion tons of carbon dioxide into the atmosphere [2]. In 2020, the coronavirus pandemic and the ensuing economic crisis affected almost every aspect of energy production, supply and consumption worldwide, resulting in a 2 billion tons reduction in carbon dioxide emissions. This is the largest annual percentage decline since World War II. This is stated in the report of the International Energy Agency (IEA). The IEA stressed that significant reductions were in fossil fuels, especially oil and coal. The decline in fuel demand was strongly influenced by the reduction in the use of road and air transport. But as soon as economic activity recovered, emissions began to increase and by December, the pace overtook 2019 by 2% [3]. The pandemic has clearly shown that the transport sector plays a decisive role in the amount of carbon dioxide emissions of mankind. The transfer of vehicles from internal combustion engines running on hydrocarbons to engines that do not emit CO2 into the atmosphere should be a priority in the fight against global warming.

Hydrogen was identified as the most promising fuel for replacing hydrocarbon fuels. It is promising for several reasons:

1. Hydrogen is the most abundant element and makes up 90% of the universe, and the third most abundant on Earth.

2. Hydrogen is the most energy-intensive and lightest substance of all fuels.

3. The combustion of hydrogen in the engine produces water.

Hydrogen fuel requires an engine to run on it, and its development has gone in two directions. The first direction of development is a conventional internal combustion engine, where hydrogen is used instead of hydrocarbons. This concept has not been disseminated. Hydrogen, which is of high purity, comes into contact with oil in the combustion chamber. Therefore, the exhaust gases, although in much smaller quantities, contain toxic components. In addition, the operation of such vehicles is unsafe and requires significant costs [4]. The second direction of development is with the use of hydrogen fuel cells (FC). Hydrogen fuel cells are electrochemical

devices that use hydrogen and oxygen in the air to generate electricity and heat. The process of generating electricity in fuel cells is significantly more efficient than in heat machines. In addition, there are no moving parts in the fuel cell and the role of fuel combustion is minimized, which makes the process noiseless and environmentally friendly [5]. When using fuel cells, a vehicle powered by a hydrogen engine is fundamentally the same electric vehicle. The difference is that on pure electric traction, the battery is charged from external sources, while in a hydrogen car, electricity is continuously drawn from fuel cells.

H2 filling stations were developed for replenishment with hydrogen fuel (Fig. 1).

Figure1. Hydrogen filling station in Germany.
[Electronic resource]. https://zap-online.ru/info/avtonovosti/vodorodnie-zapravki

At these special stations, the fuel tank is filled with compressed hydrogen. It enters the fuel cell, where there is a membrane that separates the chambers with the anode and cathode (Fig. 2). The first receives hydrogen, and the second – oxygen from the air intake. Each of the membrane electrodes is covered with a catalyst layer (most often with platinum), as a result of which hydrogen begins to lose electrons – negatively charged particles. At this time, protons – positively charged particles – pass through the membrane to the cathode. They combine with electrons and form water vapor and electricity at the exit [6].

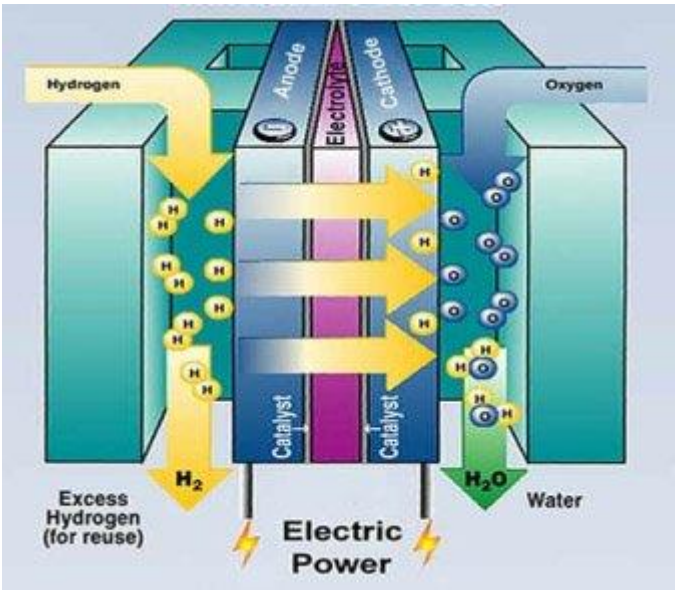

Figure 2. The principle of operation of a fuel cell on hydrogen. [Electronic resource]. https://best-energy.com.ua/support/battery/bu-210

The principle of obtaining energy, embedded in a fuel cell, is twice as efficient as burning carbon fuel. The efficiency of a fuel cell engine reaches 60%, depending on the type of cell, while the efficiency of a hydrocarbon-based ICE reaches 25-30%.

But there are also disadvantages. And these disadvantages still slow down the spread of transport on hydrogen fuel cells.

Although hydrogen is very common, it is not as easy to obtain as compared to hydrocarbons because hydrogen is found in compounds. Hydrogen is present in the same hydrocarbons, water and other compounds. To extract hydrogen from compounds requires the expenditure of energy and investment in production. The energy consumption for the evolution of hydrogen partially neutralizes the value of the final energy that will be obtained from it in the future. Investing additional funds in the hydrogen evolution cycle increases its cost. The necessary utilization of by-products, which, in turn, pollute the environment, also leads to an increase in the cost of hydrogen. It would seem that this is a vicious circle. Instead of greenhouse gas emissions at the time of fuel combustion, as with hydrocarbons, emissions at the stage of fuel production are obtained in the case of hydrogen. But various methods have been developed to release hydrogen, including completely eliminating greenhouse gas emissions. Each method is assigned a different color depending on the amount of carbon oxides emitted. The less hydrocarbon oxides are released during the production of hydrogen, the more environmentally friendly its production is.

Green hydrogen

This hydrogen is the most environmentally friendly, since it is obtained using electrolysis. If electricity comes from renewable energy sources (RES) such as wind, solar or hydropower, there are no CO2 emissions.

Yellow (orange) hydrogen

Like green hydrogen, it is produced by electrolysis. However, the source of energy is nuclear power plants (NPP). There are no CO2 emissions, but the method is not completely environmentally friendly.

Turquoise hydrogen

This hydrogen is produced by the decomposition of methane into hydrogen and solid carbon by pyrolysis. The production of turquoise hydrogen produces relatively low carbon emissions that can either be buried or used in industry such as steel production or production of batteries. Thus, it does not enter the atmosphere.

Gray hydrogen

Gray hydrogen is produced by steam reforming of methane. The feedstock for this reaction is natural gas. This process is easily feasible from a practical point of view, however, in the course of a chemical reaction, carbon dioxide is released, and in the same volumes as in the combustion of natural gas (energy is also consumed for conversion).

Blue hydrogen

Blue hydrogen is hydrogen, which is also obtained by steam reforming of methane, like gray hydrogen, but the carbon released during the process is not released into the atmosphere, but is captured and stored. This method reduces carbon emissions by about half. This type of hydrogen production is very expensive and energy consuming.

Brown hydrogen

To obtain brown hydrogen, brown coal is used as a feedstock. Further, with the help of gasification of brown coal, synthesis gas (syngas) is formed: a mixture of carbon dioxide (CO2),

carbon monoxide (CO), hydrogen, methane and ethylene, as well as a small amount of other gases. The first two of these gases are useless in power generation. This makes the process very environmentally friendly compared to other methods [7].

In a global perspective, all produced hydrogen should be green and obtained with the help of renewable energy sources (RES). To date, several countries have announced the implementation of a hydrogen program. But the German government has gone farthest, having already adopted and now is implementing an ambitious "National Hydrogen Strategy", which is based on green hydrogen obtained by electrolysis (Fig. 3).

Figure 3. Oxygen and hydrogen at the electrolysis plant in Prenzlau [Electronic resource]. https://www.dw.com/ru/a-53764630

Furthermore, the program of the German government is aimed at ensuring that all produced green hydrogen is obtained using "green" renewable energy sources (RES) [8]. First of all, it is about the wind (Fig. 4).

Figure 4. One of the wind farms of Germany. [Electronic resource]. https://www.cleanenergo.ru/2016/ves-germanii-v-2015-g-uvelichili-vyrabotku-elektroenergii-na-50/

To partially supply Germany with green hydrogen, it is planned to commission equipment for its production with a total capacity of up to 5 GW by 2030, "including the necessary power generating installations in the sea and on land," the national strategy says. For the period up to 2035, "at the latest" until 2040, another 5 GW is to be added to them. Taking into account this strategy, by

2050 Germany plans to radically reduce greenhouse gas emissions – by the middle of the century, annual CO2 emissions should be reduced by 80-95% from the 1990 level [9].

For maximum efficiency, the switching to hydrogen fuel must take place simultaneously and preferably also intensively around the world. Of course, only the switching to hydrogen fuel will not solve the problem of global warming, but it can slow down the rate of warming, as well as, along the way, improve the local ecology in megalopolises.

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