

HYDROGEN FUEL: A WHOLE CYCLE – MINING, APPLICATION AND POTENTIAL RISKS

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Annotation. The paper highlights the issue of promoting the use of gaseous fuel. The most well-known methods of extraction are listed. A special attention is given to the comparison with other sources of energy, such as fossil fuels and electricity. Finally, possible ideas of advancing hydrogen fuel are described.

Key words: hydrogen fuel, gas fuel, extraction

Introduction. Due to the development of modern technology humanity has faced the problem of finding ecologically safe fuel. It is clear, that oil's reserves will be exhausted in the near future at the current rate of its consumption. The use of gas (hydrogen) fuel may let avoid disasters. The efficiency of using hydrogen is almost the same as the oil's one, but at the same time it is absolutely harmless to the environment.

The aim of the article is to attract the consumers' attention and persuade them of actuality of using hydrogen fuel (HF). In that article the most well-known methods of extraction (EX) of hydrogen are demonstrated. Foremost pros and cons of the gas fuel (GF) are described. And similarly ideas of promoting the GF are suggested.

Main part. Hydrogen – the most spread element in the Universe, about 75% of all substances contain it. It makes its reserves inexhaustible for the humanity. Hydrogen is a colorless gas without any smell or taste. It is extremely volatile and energy-intensive. During the combustion it releases about 120 MJ – three times more, then during the combustion of petrol, and the only product of the reaction is water.

Table 1 –The most popular methods of mining a gas fuel

Method	Chemical reaction
Steam conversion of methane	$\text{CH}_4 + 2\text{H}_2\text{O} = 4\text{H}_2 + \text{CO}_2 - 165 \text{ kJ}$
Electrolysis of water	$2\text{H}_2\text{O} = 2\text{H}_2 + \text{O}_2 - 571 \text{ kJ}$

This method of EX is the most spread due to its efficiency and minimum costs of production. During the reaction CH_4 heats up to 700–1 000 C in the presence of a catalyst and water vapor, forming hydrogen and carbon dioxide (CO_2). The main its disadvantage – carbon dioxide emissions, that increase the pollution of the atmosphere.

It is based on the decomposition of water into hydrogen and oxygen with a use of electrical current. Electrolysis lets gain high purity hydrogen, up to 99.99%, and it is not accompanied by emissions of CO_2 , if renewable energy sources are used. [1] Electrolysis is environmentally friendly: it doesn't produce harmful emissions. The only disadvantage is high costs, because it requires immerse a huge amount of energy. Despite that, technologies are developing rapidly, and this way is expected to be one of the most perspective directions.

Comparison with other types of fuel. To become widely spread, fuel should be:

- cheap,
- reliable,
- efficient
- and safe.

The idea of HF usage was very appealing to the science fiction writer Jules Verne, that he described in his novel "The Mysterious Island" (1875). Characters were discussing diverse energy sources, when the main hero Cyrus Harding made a guess: in future people will learn to gain energy from the water. It was stated: "Water is the coal of the future." Although water itself is not an energy

source, hydrogen can serve as an efficient energy carrier. Notably, one kilogram of hydrogen provides 2.7 times more energy than a kilogram of gasoline. [2]

The eventual end of the oil era is inevitable, as its reserves are finite. Furthermore, its combustion releases hydrocarbons, contributing to the greenhouse effect, and it offers lower overall efficiency compared to alternatives.

Another widely adopted fuel is electricity. As a renewable energy source, its demand is visibly increasing. Electric vehicles represent a monumental breakthrough in the automotive industry. However, the main challenge lies in developing batteries that are safe for disposal and recycling. From this perspective, hydrogen vehicles appear superior: they offer a greater driving range and require fewer raw materials for production. This raises the question: why hasn't hydrogen transportation gained similar popularity?

The reasons are numerous.

Firstly, there is the cost of production. Economically viable and safe technologies for producing affordable hydrogen are not yet widespread.

Secondly, storage poses a significant challenge. As a gas stored under immense pressure, it requires extremely robust and heavy cylinders, leading to high material costs.

Thirdly, hydrogen-air mixtures are highly flammable, with a wide range of concentrations that can lead to ignition or explosion, raising serious safety concerns. [3]

Finally, public awareness is low. Many people are simply unaware of hydrogen as a fuel option. Acquiring a hydrogen cylinder is far more complicated than charging a battery or filling a tank with gasoline.

After reviewing all the advantages and disadvantages, it's clear that HF is not currently a front-runner in the consumer automotive market. However, it plays a critical role in the space industry due to its unique properties. This lightweight and powerful gas is used as rocket fuel to launch spacecraft and satellites into Earth's orbit and beyond. [4]

Despite current limitations, it is only a matter of time before hydrogen transport becomes a priority. The following ideas could help popularize the use of this gaseous fuel.

1 State-Level Initiatives:

- introducing tax breaks and trade-in subsidies for replacing old vehicles with new hydrogen-powered models;
- organizing the use of hydrogen-powered vehicles in low-emission «green zones»;
- funding the construction of a network of hydrogen refueling stations along federal highways, placing them every 100–150 kilometers.

2 Consumer-Level Solutions:

Combining solar panel systems with home electrolyzers to produce hydrogen. This would enable individuals to use hydrogen not only for home heating but also for refueling their personal vehicles.

Conclusion. All in all, hydrogen technology is a promising field for future development. Although it currently lacks the widespread popularity of fossil fuels or electricity, its distinct advantages are undeniable. Despite the present low consumer market demand, GF has already secured a vital role as a specialized fuel for satellites and rockets.

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