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PRACTICAL APPLICATIONS OF HYDROGEN FUEL AND ITS TECHNOLOGICAL PROSPECTS

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Annotatsiya (o'zbek tilida):

Maqolada quyosh energiyasi yordamida vodorod yoqilg'isini olish texnologiyalari tahlil qilingan. Yuqori temperaturali quyosh qurilmalari yordamida suv molekulalarini termokimyoviy parchalash jarayonining samaradorligi, issiqlik yo'qotish omillari va energiya tejovchi yechimlar o'rganilgan. Tadqiqot natijalari shuni ko'rsatadiki, 1000–1500°C harorat diapazonida ishlovchi konsentratsion quyosh tizimlari orqali vodorod ishlab chiqarish iqtisodiy jihatdan maqsadga muvofiq va ekologik xavfsiz yo'l hisoblanadi.

Kalit so'zlar: vodorod yoqilg'isi, quyosh energiyasi, yuqori haroratli tizimlar, termokimyoviy jarayon, energiya samaradorligi.

Аннотация (на русском языке):

В статье рассматриваются современные технологии получения водородного топлива с использованием солнечной энергии. Проведен анализ термохимического разложения воды при высоких температурах с применением концентрирующих солнечных установок. Установлено, что при температуре 1000–1500°C скорость выделения водорода значительно повышается, а потери энергии уменьшаются за счет оптимизации конструкции зеркальных концентраторов.

Ключевые слова: водородное топливо, солнечная энергия, высокотемпературные системы, термохимический процесс, энергетическая эффективность.

Abstract (in English):

This paper investigates hydrogen fuel production technologies using solar energy. The study analyzes thermochemical water decomposition under high temperatures achieved by concentrating solar power systems. Results indicate that at temperatures between 1000°C and 1500°C, hydrogen yield increases while energy losses decrease due to the optimization of concentrator geometry and heat recovery mechanisms.

Keywords: hydrogen fuel, solar energy, high-temperature systems, thermochemical process, energy efficiency.

Introduction:

In recent years, the integration of renewable energy sources into energy systems has become a pressing issue. The limited availability of hydrocarbon resources and the problem of global warming necessitate a transition to alternative, environmentally friendly energy sources. From this perspective, hydrogen production technology based on solar energy is recognized as a promising direction.

Hydrogen fuel has a high energy density, produces only water during combustion, and does not emit harmful gases into the atmosphere. There are various methods to obtain it, among which the use of high-temperature solar devices is one of the most efficient ways.

Main Part

1. Structure of High-Temperature Solar Devices

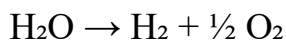
High temperatures are generated using optical systems that concentrate sunlight, such as paraboloid reflectors, Fresnel lenses, or heliostat arrays. This heat source is used to split water in a thermochemical process.

The system consists of the following main components:

- an automatic tracking mechanism that follows the sun;
- a heat-collecting reflector;
- a heat exchange chamber that directs steam to the reaction zone;
- a gas separation module.

2. The Essence of the Thermochemical Process

Water molecules decompose at temperatures up to 2000°C according to the reaction:



In practice, this process occurs in several stages at lower temperatures (1000–1500°C). Metal oxides or ceramic catalysts accelerate the reaction and reduce energy consumption.

3. Energy Efficiency and Results

Experimental calculations show that up to 65–70% of the thermal energy obtained from solar concentrators is converted into useful work. The rate of hydrogen formation is directly proportional to the heat flux per 1 m² of optical surface. In high-temperature systems, heating water vapor requires about 200–230 MJ of energy to produce 1 kg of hydrogen, which is 20–25% less than with electrical electrolysis.

4. Environmental and Economic Advantages

Using solar energy:

- reduces carbon emissions close to zero;
- consumes 30% less water compared to thermal power plants;
- has a system lifespan of 15–20 years.

Hydrogen energy can also be widely applied in transport, industrial processes, and electricity generation. Global economic growth, population increase, and technological development lead to higher energy demand. Currently, most of this energy is supplied by fossil fuels, which emit significant amounts of greenhouse gases contributing to climate change.

The next mandatory agreement of the European Union focuses on reducing carbon emissions through hydrogen. This study examines various technologies for producing hydrogen using both renewable and non-renewable resources. Furthermore, a comparative analysis of renewable-based technologies is conducted to evaluate which options are more promising economically and energetically.

Results show that biomass-based technologies can achieve comparable hydrogen yields to water-based methods, while offering higher energy efficiency and lower operational costs. Specifically, gasification of biomass and steam reforming achieve an optimal balance, where gasification increases hydrogen yield, and steam reforming is more energy-efficient.

Nevertheless, using hydrogen as a future energy vector also requires sustainable energy sources and renewable raw materials. This combination has the potential to produce green hydrogen, reduce carbon dioxide emissions, limit global climate change, and establish what is known as the hydrogen economy.

Hydrogen is one of the most promising energy carriers for the future. Among all existing production methods, water electrolysis is considered the most environmentally friendly, as it does not emit greenhouse gases. However, this technology requires expensive catalysts such as platinum. Therefore, developing highly efficient and low-cost catalysts is an urgent task.

To prevent irreversible global temperature rise, the Paris Agreement was adopted by consensus on December 12, 2015, under the UN Framework Convention on Climate Change. It aims to reduce atmospheric carbon dioxide, keep the global average temperature rise “well below” 2°C, and strive to limit it to 1.5°C. Maintaining global temperature can be achieved by expanding the use of renewable energy sources and transitioning to energy-saving and energy-efficient technologies. In recent years, the use of hydrogen fuel, especially “green hydrogen” as an energy storage medium, has started to develop rapidly.

Conclusion

The technology for producing hydrogen fuel using high-temperature solar devices can become an important component of global energy security in the future. This technology stands out not only for its environmental cleanliness but also for its economic efficiency. In the context of Uzbekistan, where high solar radiation is available, the prospects for implementing such systems are extremely promising.

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