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The perspective of hydrogen and e-fuels for vehicles propulsion

Marieta Šoltésová [1], Matúš Lavčák [2], Michal Puškár [3]

[1] *Technical University of Košice, Faculty of mining, ecology, process control and geotechnologies, Institute of Earth resources, Department of geo and mining tourism, email: marieta.soltesova@tuke.sk*

[2] *Technical University of Košice; Faculty of Mechanical Engineering, Department of Design, Automotive and Transport Engineering, matus.lavcak@tuke.sk*

[3] *Technical University of Košice; Faculty of Mechanical Engineering, Department of Design, Automotive and Transport Engineering, michal.puskar@tuke.sk*

* *Corresponding author: Michal Puškár, michal.puskar@tuke.sk*

Abstract: Hydrogen is a promising alternative fuel for vehicle engines due to several advantages. These include its high energy content and sustainable availability. The use of hydrogen as a standalone fuel for combustion engines is currently under development. In the short term, e-fuels show greater potential. Another alternative at present is the combination of hydrogen with diesel or biofuels. One of the main challenges of using hydrogen in vehicles is storage space. Due to its low density, it requires more storage capacity, especially for long-distance trips. Hydrogen has a broader flammability range than any other fuel, allowing the engine to operate with various equivalence ratios. Additionally, hydrogen requires significantly less energy to ignite compared to other types of fuels. Synthetic e-fuels have the advantage of being usable in existing vehicle engines without the need for major modifications to power units. It can be concluded that both hydrogen and climate-neutral e-fuels will likely play an important role not only in vehicle engines but also in sectors where the use of battery-electric drives is inefficient.

Keywords: hydrogen, perspective, vehicles, propulsion

Perspektywy zastosowania wodoru i e-paliw do napędu pojazdów

Marieta Šoltésová [1], Matúš Lavčák [2], Michal Puškár [3]

[1] *Technical University of Košice, Faculty of mining, ecology, process control and geotechnologies, Institute of Earth resources, Department of geo and mining tourism, email: marieta.soltesova@tuke.sk*

[2] *Technical University of Košice; Faculty of Mechanical Engineering, Department of Design, Automotive and Transport Engineering, matus.lavcak@tuke.sk*

[3] *Technical University of Košice; Faculty of Mechanical Engineering, Department of Design, Automotive and Transport Engineering, michal.puskar@tuke.sk*

* *Corresponding author: Michal Puškár, michal.puskar@tuke.sk*

Streszczenie: Wodór jest prawdopodobnym alternatywnym paliwem dla silników pojazdów ze względu na swoje pewne zalety. Należą do nich wysoka zawartość energii i trwała dostępność. Wykorzystanie wodoru jako samodzielnego paliwa do silników spalinowych jest w fazie rozwoju. W krótkiej perspektywie większy potencjał mają paliwa syntetyczne (e-paliwa). Obecnie alternatywą jest również połączenie wodoru z olejem napędowym lub biopaliwami. Jednym z głównych problemów związanych z wykorzystaniem wodoru w pojazdach jest miejsce na jego magazynowanie. Ze względu na niską gęstość, wymaga on większej przestrzeni magazynowej, zwłaszcza przy długich trasach. Wodór ma szerszy zakres palności niż jakiekolwiek inne paliwo, co pozwala silnikowi pracować z różnymi proporcjami równoważności. Wodór potrzebuje również znacznie mniej energii do zapłonu w porównaniu z innymi paliwami. Syntetyczne e-paliwa mają tę przewagę, że mogą być wykorzystywane w obecnych silnikach

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pojazdów bez konieczności istotnych modyfikacji jednostek napędowych. Można stwierdzić, że wodór i neutralne dla klimatu e-paliwa prawdopodobnie odegrają ważną rolę nie tylko w silnikach pojazdów, ale także w sektorach, w których wykorzystanie napędów elektrycznych zasilanych bateriami jest nieefektywne.

Słowa kluczowe: wodór, perspektywa, pojazdy, napęd

1. Introduction

Internal combustion engines have become very popular because of their wide use, but the emissions produced by these engines are no longer at such a satisfactory level. In order to reduce emission levels, researchers are looking for new combustion methods and associated new fuels, including hydrogen and synthetic fuels called eFuels. Hydrogen technology and eFuels (electric fuels) are two innovative areas in the energy sector that focus on reducing greenhouse gas emissions and finding sustainable alternatives to fossil fuels.
Since hydrogen is the most abundant element on Earth and can be synthesised by the decomposition of seawater, the use of these types of hydrogen-based fuels has enormous potential in industry or transport, where it may compete directly with fossil fuels in the future.

2. Materials and Methods

eFuels stands for ecological fuels, which are synthetic liquids or gases produced mainly from renewable energy sources. Research into eFuels focuses on the development of new technologies and processes for the production of these fuels in order to reduce greenhouse gas emissions while meeting the energy demand of transport, which is one of the main areas of energy consumption. Currently, eFuels are mainly made from hydrogen and carbon dioxide, which are converted into synthetic diesel, diesel fuel or gasoline. These fuels are produced from renewable energy sources such as solar or wind power and are therefore considered as potentially sustainable energy sources.
Research in the eFuels field is focused on addressing a number of technical challenges, including improving the efficiency of production processes, reducing production costs and improving fuel properties such as cetane number. At the same time, researchers are trying to find new ways to use eFuels in practical applications such as aviation and maritime transport. Research in the eFuels field is focused on addressing a number of technical challenges, including improving the efficiency of production processes, reducing production costs and improving fuel properties such as cetane number. At the same time, researchers are trying to find new ways to use eFuels in practical applications such as aviation and maritime transport. Research in the eFuels field is focused on addressing a number of technical challenges, including improving the efficiency of production processes, reducing production costs and improving fuel properties such as cetane number. At the same time, researchers are trying to find new ways to use eFuels in practical applications such as aviation and maritime transport.

eFuels are synthetic fuels that are produced from renewable energy sources such as solar, wind or biomass, and are used as an alternative to conventional fossil fuels such as petrol or diesel. The usability of eFuels depends on many factors, including price, production technology, environmental sustainability and efficiency.
Currently, eFuels are not widely used because they are relatively expensive to produce compared to fossil fuels. However, their usability may be increased in the future if production technologies are improved and their price drops to a more competitive level.
In addition, eFuels can be used as an alternative to fossil fuels in situations where it is difficult or impossible to replace them with other alternatives, such as in aviation or in some industrial processes. In these cases, eFuels could help reduce greenhouse gas emissions and improve the environmental sustainability of these sectors
Overall, the applicability of eFuels is dependent on many factors and so far they are only used on a limited basis, but they may have potential in the future as an alternative to fossil fuels in certain situations. [1,4]

3. Results

3.1. eFuels production

eFuels, also called synthetic fuels, are artificial liquid fuels produced using electricity and CO_2 from the air or industrial sources. The production of eFuels typically consists of three steps: CO_2 capture, hydrogen production and fuel synthesis.

- CO_2 capture is the first step in the production of eFuels. CO_2 can be captured from the atmosphere using various technologies such as adsorption processes, absorption processes and electrochemical processes. CO_2 can also be captured directly from sources such as industrial emissions or natural gas.
- The second step is the production of hydrogen. Hydrogen is produced by water electrolysis, which splits water into hydrogen and oxygen using electricity. The electricity is usually obtained from renewable sources such as solar, wind or hydroelectric power.
- The third step is fuel synthesis. Hydrogen is mixed with CO2 to synthesize a fuel that can be used as an alternative to conventional fossil fuels. The resulting fuel usually consists of hydrocarbons that are chemically similar to gasoline or diesel fuel. [2,4]

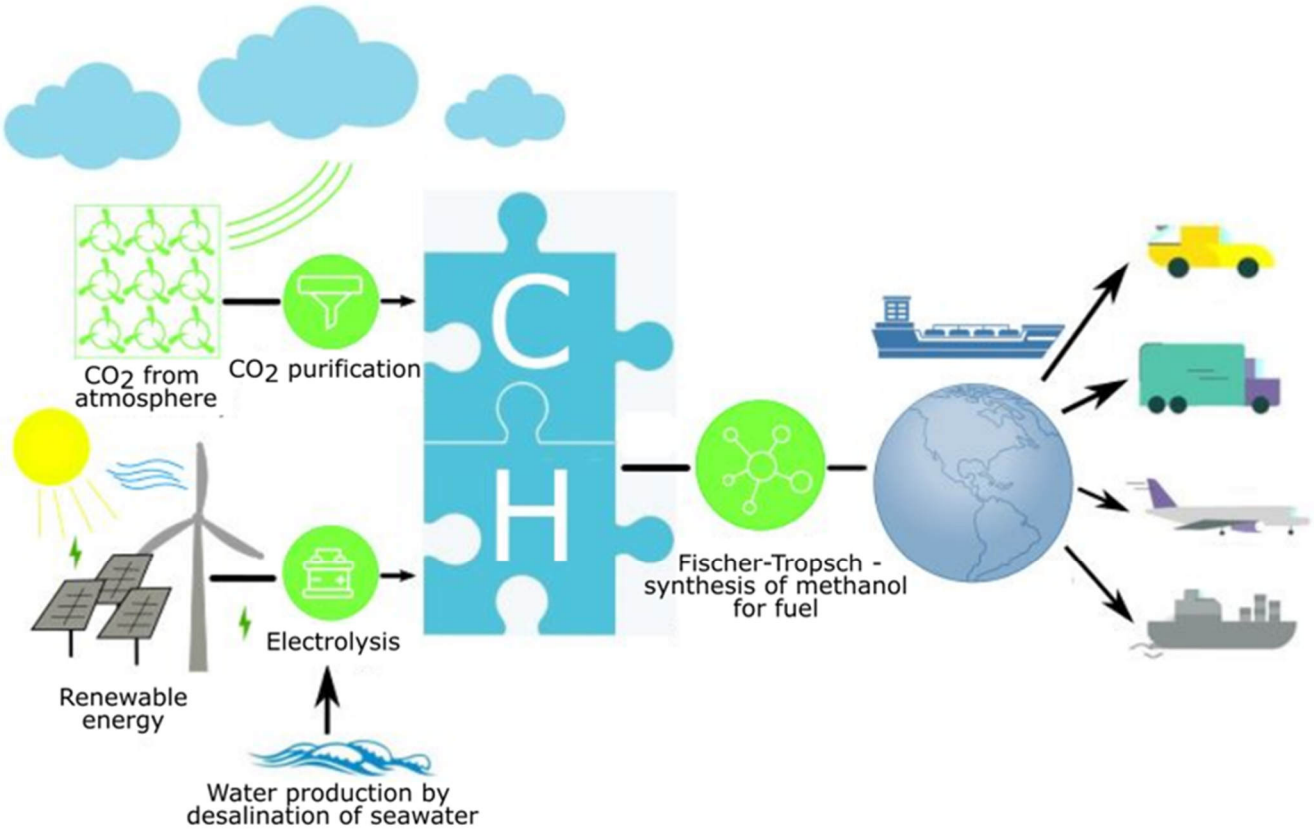

Figure 1. eFuels production

Advantages of eFuels

eFuels are synthetic fuels made from electricity, water and CO2, which means they are produced from renewable energy sources. Below are the main characteristics of eFuels:

- Renewability
  eFuels are renewable fuels, which means they are produced from renewable energy sources such as wind, solar or hydro power. This means they are less harmful to the environment and help reduce dependence on fossil fuels.
- High energy densitye
  eFuels have a high energy density, which means they can store and release large amounts of energy. This means they can be used to replace traditional fuels such as petrol and diesel without losing power.

- Compatibility with existing vehicles
  eFuels are designed to be compatible with existing internal combustion engines in cars, ships and aircraft. This means that costly vehicle modifications may not be necessary.
- Lower emissions
  eFuels produce fewer emissions than traditional fuels. When burned in the engine, only water and carbon dioxide are produced, reducing the overall carbon footprint.
- Production
  The production of eFuels is quite expensive and requires large amounts of electricity. Nevertheless, eFuels can be advantageous in areas where renewable energy sources are available and fossil fuels are unavailable.
- Storage
  eFuels are easy to store and have a longer shelf life than traditional fuels, which means they can be stored without worrying about fuel quality deterioration. [1,2,3]

Disadvantages of eFuels

eFuels are fuels made from electricity using processes such as water electrolysis and Fischer-Tropsch synthesis, a chemical process that combines hydrogen and carbon dioxide at high temperatures and pressures to create liquid fuels that are similar to conventional petroleum fuels. However, there are also some drawbacks associated with the use of eFuels:

- Production costs
  Producing eFuels is expensive and costs more than traditional petroleum-based fuels. The process of producing eFuels requires large amounts of electricity and other raw materials, which increases production costs.
- Energy
  The production of electronic fuels consumes large amounts of electricity, which must be supplied from the electricity grid. If this electricity is produced from fossil fuels, the environmental benefits of eFuels are reduced.
- Efficiency
  The energy put into the production of eFuels is greater than the energy these fuels provide when burned. This means that the production of eFuels can be less efficient than the production of traditional fuels.
- Storage
  eFuels are liquid fuels and must be stored in tanks. These tanks are expensive and can be dangerous if stored incorrectly.
- Volume
  eFuels have a lower energy density than traditional petroleum-based fuels. This means that more fuel has to be transported the same distance, which increases transport costs.
- Competitive ability
  eFuels are a new technology and are still less competitive than traditional fuels. Because eFuels are more expensive and less efficient, they may be impractical for many people and businesses today. [2,4]

These, rather serious drawbacks, may hinder a faster uptake into real world use.

Types of eFuels

eFuels are synthetic fuels that are produced by electrolytic synthesis from water and carbon dioxide (CO_2). There are different types of eFuels depending on the raw material used to produce them. The most common types of eFuels include:

- Methanol eFuels
  It is produced from carbon sources such as biomass, wood waste and even water, using electrolytic synthesis.
- Ethanol eFuels
  Similar to methanol, ethanol eFuel is produced by electrolytic synthesis, but its feedstocks are typically sugarcane, corn and other plant sources.
- Diesel eFuels
  They are made from vegetable oils, fats and fatty acids.
- Kerosene eFuels

They are made from lignocellulosic sources such as wood residues. [3,4,5]

3.2 Hydrogen technology

Combustion of hydrogen in the automotive industry is one of the possible uses of hydrogen as a fuel for powering vehicles. Hydrogen fuel is used in engines with a combustion process similar to that of petrol or diesel.
When hydrogen is burned in vehicles, the hydrogen combines with oxygen from the air to form water (H_2O) as the only by-product. Hydrogen internal combustion engines have the potential to provide a cleaner, low-emission solution for transport as they emit no greenhouse gases or harmful emissions into the air.

Hydrogen combustion

Toyota has pioneered the development of hydrogen fuel cell vehicles (FCVs), such as the Toyota Mirai, which use the combustion of hydrogen to generate electricity and power the vehicle. It is important to note that the actual combustion process takes place in the fuel cell.

In Toyota's FCVs, hydrogen gas (H_2) is stored in high-pressure tanks on board the vehicle. The hydrogen is then fed into the fuel cell tank, which consists of several fuel cells. In each fuel cell, the hydrogen gas is split into protons (H+) and electrons (e-) by a process called electrolysis. The protons pass through a membrane called a proton exchange membrane (PEM) while the electrons are conducted through an external circuit, creating an electric current. The flow of electrons through this circuit can be used to power the vehicle's electric motor, which provides propulsion. On the other side of the PEM, oxygen from the air enters the fuel cell stack. It combines with the protons and electrons that have passed through the outer circuit and forms water vapour (H_2O) as a by-product. This process is known as an electrochemical reaction.

The overall chemical equation for the electrochemical reaction in a fuel cell is:

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(g).$$

As a result, Toyota FCVs use the combustion of hydrogen in the fuel cell stack to generate electricity that powers the vehicle's electric motor. The only by-product of this process is water vapour, making it a clean and environmentally friendly form of propulsion. Toyota is actively working to develop the technology and infrastructure for hydrogen fuel cell vehicles to support the deployment of sustainable transport solutions. The company believes that hydrogen-powered vehicles can play an important role in reducing greenhouse gas emissions and promoting a low-carbon future. [5]

4. Conclusions

Hydrogen technologies and syntheticnic fuels (eFuels) represent a promising path to sustainable and low-carbon energy. The use of hydrogen and e-fuels in transport offers the potential to reduce greenhouse gas emissions, improve air quality and reduce dependence on fossil fuels. However, it is important to stress that the use of hydrogen technology and eFuels is not entirely without its problems. Investments in infrastructure for the production, storage and distribution of hydrogen and eFuels are needed. The costs of these technologies are also still high. However, with continued research and innovation, hydrogen technologies and eFuels have the potential to become important elements of the transition to sustainable and low-carbon energy. Their use in transport can contribute to achieving environmental goals and reducing dependence on fossil fuels, thus promoting a cleaner and more sustainable future.

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