

# On the possibility of large-scale use of hydrogen fuel engines in real-life

Tianhao Zhang

## Abstract.

A potential new technology that can offer clean and effective power for various transportation applications is hydrogen fuel engines, particularly in big mechanical transport vehicles like ships. This research examines the pros and cons of employing hydrogen-fueled engines in real-world applications compared to contemporary internal combustion engines and electric motors. According to the paper, hydrogen engines surpass traditional technology in every way, including power output, integration ability, and reduction of emissions. The paper also highlights a few of the challenges that need to be overcome to produce and transport hydrogen fuel, such as the effects that different hydrogen production technologies have on the environment, the economy, and society; the logistical and technical difficulties that come with transporting hydrogen in all its forms; and the infrastructure and legal requirements that need to be met to guarantee the security, dependability, and sustainability of hydrogen fuels. The paper concludes that additional study and development are required to overcome these challenges and allow hydrogen fuel engines to be extensively deployed in real-world applications.

**Keywords:** transportation, hydrogen fuel engine

## 1. Introduction

In today's society, electric cars are gradually replacing internal combustion engines. After Tesla's success, many car companies discovered that the electric car market was huge, so they followed Tesla and began to develop electric cars. These car companies use Tesla's technology or their own developed technology to make electric vehicles gradually popular. The world is gradually entering an era of electric transportation. But in such an era of electrification, a very important problem has arisen. Although electric vehicles are cheaper and have lower maintenance costs than fuel vehicles, and the tram system is not prone to problems, many users charge their electric cars could be a big question. Because placing charging piles is inconvenient, not everyone has a place to charge. At the same time, because the charging speed is too slow, it is also troublesome to charge the tram using public charging piles. It may be three or four hours before the car in front is fully charged. It only takes less than five minutes to refuel a fuel vehicle. For this reason, finding new energy sources to drive electric vehicles is important. The use of hydrogen as an energy source to power cars has long been proposed.

A multitude of purposes, particularly in the transportation sector, might be powered by hydrogen, a potential energy source. The hydrogen-fueled engine is one of the technologies that can use hydrogen as fuel to produce mechanical power. By burning hydrogen and oxygen,

hydrogen-fueled engines may provide zero-emission energy, unlike traditional internal combustion engines (ICEs), which burn fossil fuels and emit greenhouse gases and other pollutants. This article will discuss the feasibility of hydrogen as an energy source for automobiles and the obstacles and challenges associated with using hydrogen to power automobiles. The study evaluates the benefits and drawbacks of employing hydrogen-fueled engines in real-world applications, particularly for big mechanical transport vehicles like ships. This study compares current internal combustion engines (ICE) and electric motors with hydrogen-fueled engines.

## 2. Comparison of Hydrogen Fuel Engines with ICEs and Electric Motors

Internal combustion engines (ICE) and hydrogen fuel engines (HFE) use the combustion principle to convert chemical energy into mechanical energy. But there are several crucial areas where they greatly diverge. First, hydrogen-fueled engines use hydrogen instead of internal combustion engines (ICE), which burn gasoline, diesel, or natural gas. Hydrogen can provide more energy from a given quantity of fuel because it has a greater energy density per unit mass than most fossil fuels. Because hydrogen has a lower energy density per unit volume than most fossil fuels, storing the same amount of energy takes up more storage space. Therefore, hydrogen fuel engines require larger, heavier storage tanks to store enough hydrogen for long-distance driving.

Second, hydrogen-fueled engines only produce heat and water during combustion, whereas internal combustion engines release harmful pollutants, including carbon dioxide, nitrogen oxides, and particulate matter. Thus, compared to internal combustion engines (ICE), hydrogen-fueled engines are less damaging to the environment and can lessen air pollution and climate change. But there are also certain emissions-related problems with hydrogen engines. For instance, due to the high temperature and combustion pressure, hydrogen-fueled engines can produce minute quantities of nitrous oxide (N<sub>2</sub>O), a potent greenhouse gas. Additionally, unburned hydrogen released by hydrogen-fueled engines has the potential to escape into the atmosphere and cause ozone loss as well as smoke creation.

Electric motors are a different type of technology that can use hydrogen as a energy source. Electric motors require magnetic and electric fields to transform electrical energy into mechanical energy. Electric motors can be driven by fuel cells or batteries. When required, the battery directly releases the electrical energy it has stored. Fuel cells use electrochemistry to mix hydrogen and oxygen to create energy. Batteries and fuel cells, which produce no emissions when in operation, can power electric motors.

However, as compared to engines powered by hydrogen, electric motors also have considerable drawbacks. First off, complicated and expensive parts like inverters, converters, controllers, and sensors are needed for electric motors to govern power output and performance. Second, since they have a lower power density and torque than engines powered by hydrogen, electric motors are less appropriate for heavy-duty applications that need tremendous power and acceleration.

Third, the efficiency of the electric motor is influenced by the hydrogen production method and the power supply's quantity and standard. The environmental effect of the electric motor will be reduced if the energy or hydrogen is generated from fossil fuels or other non-renewable resources.

### **3. Advantages of Hydrogen Fuel Engines for Large Mechanical Transportation Vehicles**

Compared to internal combustion engines (ICE) and electric motors, hydrogen-fueled engines provide several benefits, especially for big mechanical transport vehicles like ships. Ships are a major source of air pollution and greenhouse gas emissions in transportation. According to the International Maritime Organization (IMO), ships accounted for about 2.9% of global CO<sub>2</sub> emissions in 2018 <sup>1</sup>. Moreover, ships emit large amounts of nitrogen

oxides (NO<sub>x</sub>), sulfur oxides (SO<sub>x</sub>), particulate matter (PM), and black carbon (BC), which can harm human health and the environment <sup>2</sup>. As a result, employing cleaner fuels and technology is necessary to lower ship emissions.

Using hydrogen-fueled engines in the marine sector might help it become more environmentally friendly and cut carbon emissions. Hydrogen fuel engines can provide ships with massive power

Density and torque while producing no carbon dioxide or particulate matter. Hydrogen fuel engines can also reduce NO<sub>x</sub> emissions using lean-burn combustion or selective catalytic reduction (SCR) systems <sup>3</sup>. Furthermore, hydrogen may be produced from green or low-carbon sources, such as steam methane reforming with clean energy electrolysis or CCS. In this approach, ships with hydrogen-fueled engines may operate with emissions that are close to zero or even negative.

Another benefit of hydrogen fuel engines for ships is how easily they can be incorporated into existing ship designs and infrastructure. Hydrogen fuel engines are compatible with conventional propulsion systems such as propellers or water jets <sup>4</sup>. Hydrogen fuel engines can also use existing bunkering facilities with minor modifications <sup>5</sup>. Moreover, hydrogen fuel engines can be retrofitted into existing ships or installed in new ships with minimal changes to the hull and layout <sup>6</sup>. As a consequence, switching to more eco-friendly and efficient technology may be affordable and flexible for shipowners and operators using hydrogen engines.

### **4. Challenges of Hydrogen Fuel Production and Transportation**

Although engines that run on hydrogen fuel have several advantages, manufacturing and transporting hydrogen fuel has several drawbacks. Energy, water, and land are needed to produce hydrogen. Hydrogen fuel's effects on the environment, economy, and society may need to be balanced depending on its source and manufacturing technique. For instance, employing renewable energy for electrolysis can result in the production of clean hydrogen. Still, it may also increase the demand for power and water, making it more difficult to get and raise the price of other uses. Carbon dioxide may be expensive and dangerous to transport, store, and use in steam methane reforming via CCS, which can create low-carbon hydrogen. Biomass gasification can provide renewable hydrogen but may compete for land with food production and biodiversity preservation.

Transporting hydrogen fuel has a few logistical and technological challenges as well. Compared to other fuels,

hydrogen fuel has a lower volumetric energy density; hence, it requires more room to store and transport. Hydrogen fuel can be transported in three main forms: compressed gas, liquid, or metal hydride 7. Everyone has benefits and cons regarding safety, efficacy, pricing, etc. The easiest and most common way to transport hydrogen is by compressed gas. However, this approach calls for very huge, heavy, high-pressure tanks. Compressed gas is much harder to keep at a low temperature despite having a lower energy density than liquid hydrogen since it requires so much energy. Metal hydrides are solid materials that, at room temperature, can store hydrogen, although they have a low energy density and a sluggish release rate.

As a result, substantial planning and coordination between several stakeholders, including producers, distributors, regulators, and consumers, are needed to produce and deliver hydrogen fuel. Hydrogen fuel production and transportation also need the building and upkeep of infrastructure, such as pipes, tanks, terminals, stations, and vehicles. Hydrogen fuel production and transportation must adhere to all applicable rules and legislation to be secure, high-quality, and sustainable.

## 5. Conclusion

A potential new technology that can offer clean and effective power for various transportation applications is hydrogen fuel engines, particularly in big mechanical transport vehicles like ships. Compared to internal combustion engines and electric motors, hydrogen engines have several benefits regarding emissions reduction, power output, and integration opportunities. However, there are several challenges that hydrogen fuel engines must overcome in the production and distribution of hydrogen fuel. These challenges include the effects of various hydrogen production technologies on the environment, the economy, and society; the logistical and

technical difficulties of transporting hydrogen in various forms; and the infrastructure and legal requirements to guarantee hydrogen fuel's long-term viability, safety, and quality. Further research and development are required to overcome these challenges and make hydrogen fuel engines extensively used in daily life. At the same time, future research directions can also focus on vehicle energy choices between countries. For example, Japan once designed a plan for hydrogen energy vehicles, while China vigorously promotes transportation electrification. Which of the two is more successful? Comparing the current situation of the two energy modes can also be a research focus.

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