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A Review on Hydrogen as a Future Fuel for Hydrogen Fuel Cell Vehicles

[1]Sagar M. Bechara, [2]Mihir D. Gajjar, [3]Paresh M. Sangadiya, [4]Milan M. Pankhaniya, [5]Mayur R. Chotaliya

[1,2,3,4,5] Lecturer,
[1,2,3] Department of Automobile Engineering, [4,5] Department of Mechanical Engineering
[1]Atmiya University, Rajkot, India

Abstract: The Paris Agreement's sustainable development goals concept of zero carbon emission is the foundation of decarbonisation implemented in the majority of developed countries worldwide. Hydrogen fuel cell technology is one of the efforts being made to decarbonize the environment. Though there are numerous renewable energy sources, hydrogen is ideal for use as a vehicle energy source. Onboard hydrogen storage in vehicles is an important consideration when designing fuel cell vehicles. The advancement of hydrogen fuel cell engines is examined in order to assess the viability of using hydrogen as a major fuel in transportation systems. There are several challenges regarding safety concern, hydrogen fuel cells will play an important role in the transportation industry in the near future.

Keywords **– Hydrogen Fuel Vehicle, Sustainable goals, Renewable energy, Safety, Challenges**

1 INTRODUCTION

The availability of energy affects a nation's economy, infrastructure, transportation, and quality of life. The discrepancy between global energy availability and use is an issue. All countries currently rely on non-sustainable sources of energy, namely fossil fuels, to provide their energy. It is crucial to switch to an alternative, sustainable energy source that does not have a detrimental impact on the environment in order to meet the energy needs of the world's population, which is expanding at an increasingly rapid rate [1,2,3].
One of the primary concerns with the current energy situation is the depletion of non-renewable conventional fuels, which not only makes the status of the energy industry unsustainable but also contributes to environmental issues like the greenhouse effect [4,5]. The usage of fossil fuels is still a significant percentage of energy production today, and it is predicted that this proportion will reach about 75% in 2050 [6].
Now a days, cars are more fuel-efficient, and hybrid electric cars are more and more popular. Electricity is one of the alternative fuels that is used in cars most frequently. Battery electric vehicles (BEVs) are incredibly good at converting grid energy into tractive force, and they can recover energy while driving by using regenerative braking. Due to the size and expense of the batteries required for the vehicle's power and energy requirements, BEVs typically have a restricted range, which is one of its main disadvantages. In comparison to a normal car, the "refueling" of the battery systems can take several hours. The simplest form of a molecule is hydrogen, which has the highest energy content of any fuel by weight but the lowest energy content by volume. Both as a gas and a liquid, it can be found in the atmosphere and in water. The heating value of hydrogen is three times more than that of petroleum and it emits no hazardous pollutants. There is a lot of research being done to develop a sustainable and efficient method of producing hydrogen and to use it in transportation [3].
A vehicle that runs on hydrogen fuel is known as a hydrogen vehicle. The chemical energy of hydrogen is converted to mechanical energy, either by the reaction of hydrogen with oxygen in a fuel cell to power electric motors or, less frequently, through the burning of hydrogen in internal combustion engines. [7] Correlation between adopting Hydrogen fuel cell vehicles (HFCVs) and their direct and indirect impact on SDGs (7, 9, 11, 12, 13, 14 and 15) [8].

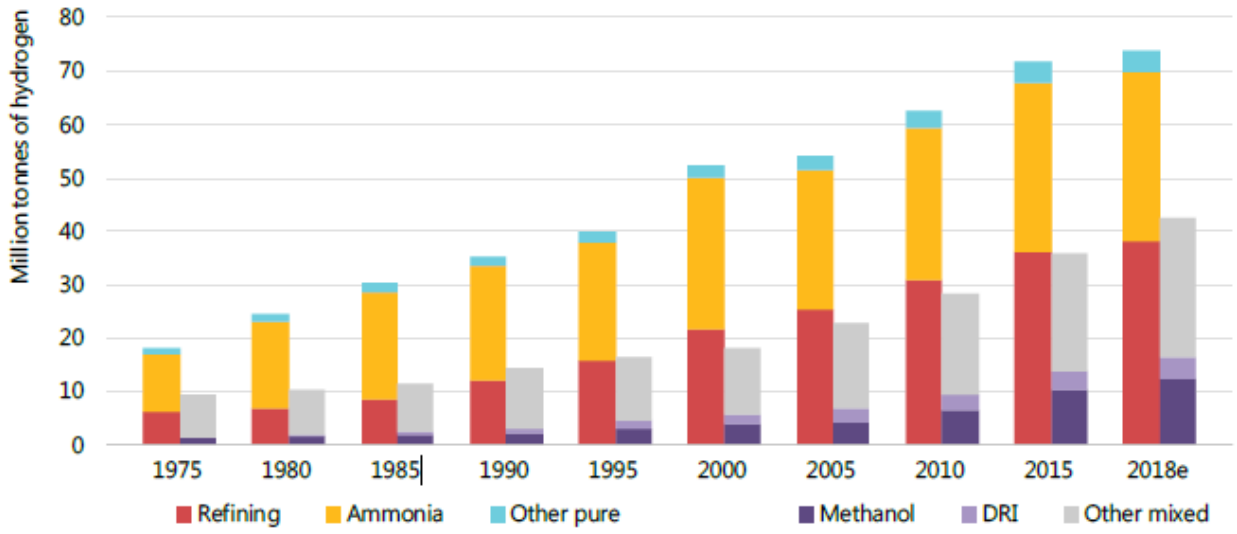
2 TRANSPORTATION FUEL: HYDROGEN

A lot of work is being done to develop applications for hydrogen in motor vehicles as well as an effective and sustainable method of producing hydrogen. Fuel cell vehicles (FCVs) that run on hydrogen have begun to be produced by automakers like Honda, Toyota, and Hyundai. The majority of early adopters have purchased these FCVs, which are currently offered in North America, Asia, and Europe. The current consumers, or early adopters, are mainly highly educated people, high-income families, those who have larger households, those who are willing to modify their lifestyles, and those who have other characteristics that are similar [9].

The Chevrolet Electrovan, produced by General Motors in 1966, was the first car on the road to be propelled by a hydrogen fuel cell. The Toyota Mirai (2014), the world's first mass-produced dedicated fuel cell electric vehicle (FCEV), and the Hyundai Nexo (2018) are the only two hydrogen automobile models that will be publically available in a few markets by 2021[10]. Between 2016 and 2021, the Honda Clarity was manufactured.

3 HYDROGEN: AS A FUTURE FUEL

Sustainable energy future can benefit from hydrogen in two ways:
1. Hydrogen produced utilising alternative, cleaner production techniques and from a wider variety of energy sources can be used in existing applications.
2. Hydrogen can be employed as a supplement to the increased usage of electricity in various applications, as an alternative to the current fuels and inputs, or both.
Hydrogen can be used in these situations, such as in transportation, heating, steel production, and electricity, or it can be transformed into hydrogen-based fuels such synthetic methane, synthetic liquid fuels, ammonia, and methanol [11]



Notes: DRI = direct reduced iron steel production. Refining, ammonia and "other pure" represent demand for specific applications that require hydrogen with only small levels of additives or contaminants tolerated. Methanol, DRI and "other mixed" represent demand for applications that use hydrogen as part of a mixture of gases, such as synthesis gas, for fuel or feedstock.

Fig. 1 Global annual demand for hydrogen since 1975 [11]

4 HYDROGEN VEHICLE: COMPONENTS

I. Battery (auxiliary): The low-voltage auxiliary battery of an electric drive vehicle powers accessories as well as starting the vehicle before the traction battery kicks in.
II. Battery pack: This high-voltage battery stores energy generated from regenerative braking and provides supplementary power to the electric traction motor.
III. This device, known as a DC/DC converter, transforms higher-voltage DC power from the traction battery pack into the lower-voltage DC power required to operate the vehicle's accessories and recharge the auxiliary battery.
IV. Electric traction motor (FCEV): This motor propels the wheels of the car using energy from the fuel cell and the traction battery pack. Several automobiles employ motor generators that serve as both drives and regenerators.
V. An arrangement of individual membrane electrodes used in fuel cells, which use hydrogen and oxygen to generate electricity.
VI. Fuel filler: To fill the tank, a nozzle from a fuel dispenser is attached to the tank's receptacle on the car.
VII. Fuel tank (hydrogen): Holds hydrogen gas within the car until the fuel cell needs it.
VIII. Fuel cell and traction battery electrical energy flow is managed by the power electronics controller (FCEV), which also regulates the torque and speed of the electric traction motor.
IX. Thermal system (cooling) - (FCEV): This system keeps the fuel cell, electric motor, power electronics, and other components within a safe operating temperature range.
X. Electric transmission: The electric traction motor drives the wheels by transferring mechanical energy through the transmission.

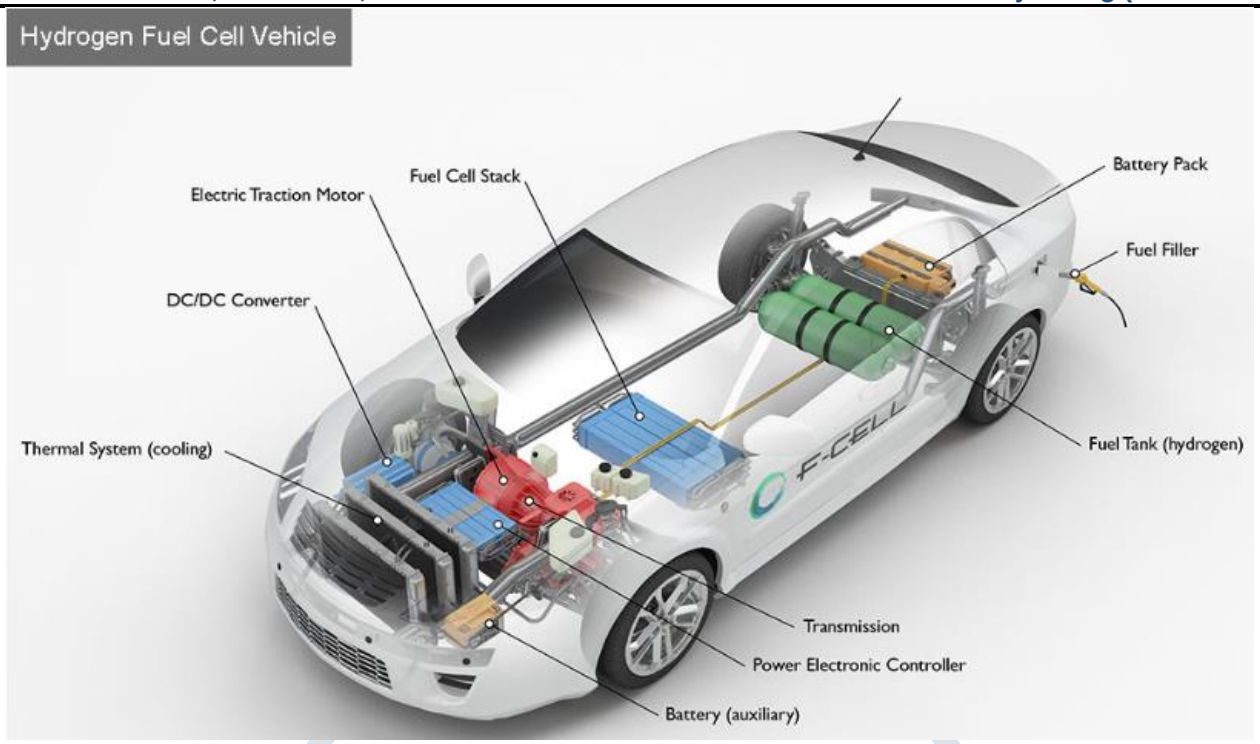


Fig. 2 Fuel cell vehicle with on-board storage [12]

5 HEALTH & SAFETY

When utilised extensively, hydrogen poses specific health and safety issues. If the risks are poorly understood and managed, safety issues and mishaps may delay or even prohibit the adoption of a new energy technology. To handle hydrogen, certain tools and practises are needed. Due to its small size, hydrogen has the potential to infiltrate into various materials, especially some varieties of iron and steel pipes, increasing the likelihood of failure. In comparison to bigger molecules like natural gas, it also escapes through sealing and connectors with more ease. Although not being hazardous, hydrogen is a very flammable gas due to its fast flame velocity, wide ignition range, and low ignition energy. It has a flame that is not visible to the human eye and it is colourless and odourless, making it harder for people to discover fires and leaks. Standards are required for vehicle refueling nozzles, hydrogen supply pressures, refueling station permits, and safety procedures for high-pressure hydrogen and liquid hydrogen delivery by trucks [11].

6 SUSTAINABLE & RENEWABLE ENERGY

Nowadays, hydrogen is frequently mentioned for its advantages in terms of energy access, local air pollution, energy security, and economic growth. Hydrogen has several uses. Hydrogen is able to produce, store, move, and utilise energy in a variety of ways thanks to current technologies. Hydrogen can be produced by a wide range of fuels, including nuclear, natural gas, coal, and oil as well as renewable energy sources. Similar to liquefied natural gas (LNG), it can be carried by ships in liquid form or as a gas through pipes. The SDS is completely in line with the Paris Agreement's objective of keeping the rise in the world's average temperature to well below 2°C above pre-industrial levels and pursuing efforts to keep it to 1.5°C, as well as with the accomplishment of the UN Sustainable Development Goals on achieving universal access to energy and reducing the serious health effects of air pollution [11].

7 BENEFITS & CHALLENGES

I. Fewer emissions of greenhouse gases

Vehicles fuelled by gasoline or diesel release greenhouse gases (GHGs), primarily carbon dioxide (CO2), which are a factor in climate change. Pure hydrogen-powered fuel cell vehicles (FCVs) only emit heat and water from the tailpipe, not greenhouse gases. Depending on the technology used to produce the hydrogen for FCVs, GHGs may be produced. Even yet, it produces far fewer GHGs than regular gasoline and diesel automobiles.

II. Decreased reliance on oil

As hydrogen can be produced domestically, FCVs may help us become less reliant on foreign oil. Together with renewable resources like water, biogas, and agricultural waste, these sources also include natural gas and coal. That would lessen the reliance of our economy on other nations and our susceptibility to shocks caused by the rising volatility of the oil market.

III. Reduced Air Pollution

In contrast to FCVs driven by pure hydrogen, which release no harmful air pollutants, highway vehicles are a major source of the air pollutants that lead to smog and damaging particles. Pollutants are produced during the production of hydrogen from fossil fuels, however they are far fewer than those produced by conventional cars.

IV. Vehicle Cost

Currently, FCVs are more expensive than regular cars and hybrids. Nonetheless, costs have drastically dropped and are getting closer to DOE's 2020 goal (see graph). For FCVs to be competitive with conventional vehicles, car manufacturers must continue to reduce prices, particularly for the fuel cell stack and hydrogen storage.

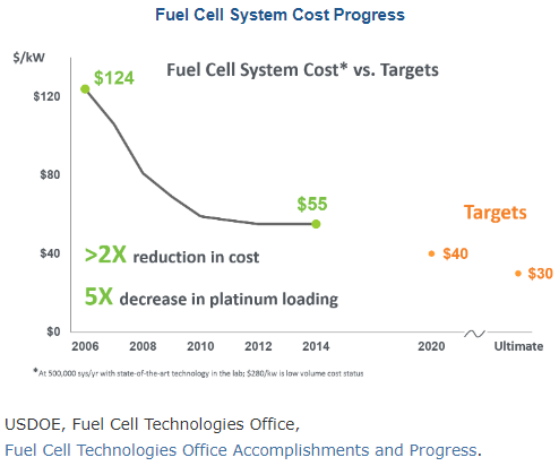


Fig. 3 Fuel Cell System Cost Progress [13]

V. Durability and dependability of fuel cells

In various temperature and humidity ranges, fuel cell devices are not yet as resilient as internal combustion engines. Currently, the durability of on-road fuel cell stacks is only about half of what is required for commercialization. Although durability has significantly improved in recent years from 29,000 miles to 75,000 miles, experts think FCVs still need to reach a 150,000-mile projected lifetime in order to compete with gasoline vehicles [13].

VI. Safety Concerns

Currently, installing hydrogen fuel cells in automobiles is the primary plan for integrating them into daily life. The science is flawless, and the technology has been created with this in mind. The question of safety is the only genuine issue. More so than conventional fuel, hydrogen is highly combustible and more difficult to confine [14].

Conclusion: In this paper, study clarified that Hydrogen can be used as a clean fuel in a transport sector as compared to conventional gasoline and diesel engines. For that various medication can be necessary to apply on large scale production o vehicles. Hydrogen fuel can meet a sustainable development goal as a renewable energy. Despite of several benefits of clean fuels, there are several challenges regarding large scale vehicle market.

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