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# Hydrogen Fuel Cell used in Vehicles

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**ABSTRACT: Hydrogen Fuel Cell Cars (FCVs) are similar to electric vehicles (EVs) in that they power their wheels with an electric motor rather than an internal combustion engine. FCVs, on the other hand, create their own power rather than relying on batteries that must be recharged. Exploiting the global potential of renewable energy is now being examined as a means of generating energy utilizing technologies that are both efficient and low-polluting. One of the alternate alternatives for future clean energy systems is hydrogen fuel cell technology. The paper gives a comprehensive, up-to-date examination of fuel cell powered cars, including their working principle, essential components, how they vary from traditional electric vehicles, and their benefits. The study also goes into how hydrogen is refueled and what makes up a hydrogen filling station. In the future new energy generating methods are required in this environment to achieve minimal carbon emissions while also exploiting the potential of renewable energy sources.**

**KEYWORDS: Electric Vehicles, Fuel cell. Hydrogen Fuel Cell, hydrogen refueling, *renewable energy*.**

## 1. INTRODUCTION

The release of greenhouse gases such as carbon dioxide, methane, or nitrous oxide, as well as aerosols into the atmosphere, is the primary cause of climate change that our planet Earth is currently experiencing. Transportation vehicles released 14% of the total carbon dioxide released into the atmosphere. The market for electric cars has been growing and appears to be a good solution to combat climate change, as cars account

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for 72 percent of CO2 emissions in this sector. Vehicles powered by hydrogen fuel cells are also a viable alternative to vehicles powered by internal combustion engines. When compared to gasoline-powered counterparts, fuel cell cars and trucks can reduce emissions by over 30%(Foorginezhad et al., 2021; Haseli, 2018; Manoharan et al., 2019; Zhao et al., 2020).

### *1.1. Fuel Cell:*

A fuel cell is a device that generates electricity through an electrochemical reaction rather than combustion. The electrochemical reaction between hydrogen and oxygen produces electricity, heat, and water in a fuel cell. Fuel cells are currently used in a variety of applications, including providing power to homes and businesses, maintaining critical facilities such as hospitals, grocery stores, and data centers, and moving a variety of vehicles, including cars and buses(Ferraren-De Cagalitan & Abundo, 2021; Khan et al., 2021; Mao et al., 2021; Wong et al., 2021).

### *1.2. Generation of electricity through fuel cell:*

Platinum is used as an anode, which is a valuable metal catalyst that speeds up the process in a fuel cell. The positive terminal, or anode, receives hydrogen gas from the tank (the hydrogen storage tank should be exceedingly sturdy since hydrogen is volatile and explosive), while the negative terminal, or cathode, receives oxygen from the air. A catalyst breaks hydrogen molecules into electrons and protons at the anode (hydrogen ions). Positively charged protons are drawn to the negative terminal and pass through the electrolyte to reach it(Anand, 2019; Mangla et al., 2021; Mergel, 2012; Singh, 2019).

Only protons may travel through the electrolyte, which is a thin membrane formed of a specific polymer (plastic) film. The electrons are pushed across a circuit, creating an electric current and a lot of heat in the process. The power the electric motor (orange and black) that powers the car's wheels as they do so. Protons, electrons, and oxygen mix at the cathode to form water molecules. The water is released as water vapor or steam from the exhaust pipe. The Proton Exchange Membrane fuel cell is the name for

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this kind of fuel cell(Ambrose et al., 2017; Chang et al., 2019; Dodds et al., 2015; Madsen et al., 2020).

### *1.3. Vehicles powered by hydrogen fuel cells:*

There are two methods to power a contemporary car:

1) Use an internal-combustion engine that burns petroleum-based fuel to create heat. The resulting heat drives the gearbox and wheels by pushing pistons up and down.
2) Electric automobiles use batteries to provide electricity to electric motors that move the wheels directly. Internal-combustion engines and electric motors coexist in hybrid vehicles, which switch between the two depending on the driving circumstances.

A hydrogen fuel cell automobile contains a hydrogen tank that supplies high-pressured hydrogen gas to a fuel cell, which then reacts with oxygen. This initiates an electrochemical reaction, which generates energy, which is used to power the electric motor. As a result, hydrogen vehicles have features of both electric and traditional gasoline automobiles.

Fuel cells combine the power of an internal combustion engine with that of a battery. They generate power by utilizing fuel from a tank, much like an internal-combustion engine. A fuel cell, unlike an engine, does not consume hydrogen. Instead, it chemically reacted with oxygen in the air to form water. Electricity is released in the process, which is similar to what occurs in a battery, and this is utilized to power an electric motor that can propel a vehicle. Water is the sole waste product. Because the conversion of hydrogen gas to electricity generates only water and heat as a byproduct, fuel cell cars do not emit pollutants from their tailpipes while they are driven. Even when using one of the dirtiest sources of hydrogen, natural gas, fuel cell automobiles and trucks may reduce emissions by over 30% when compared to gasoline-powered competitors.

### *1.4. Hydrogen Fuel Cell Key Components:*

- Auxiliary battery

In an electric vehicle, the auxiliary battery provides power to start the vehicle before the traction battery is engaged, as well as to power vehicle accessories. The battery pack stores energy produced by regenerative braking and provides additional power to the electric traction motor.

- Converter

The DC/DC converter converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power required to operate vehicle accessories and replenish the auxiliary battery.

- Electric traction motor (FCEV):

This motor moves the vehicle's wheels using energy from the fuel cell and the traction battery pack. Motor generators are used in certain vehicles to provide both propulsion and regeneration. A fuel cell stack is a collection of separate membrane electrodes that create power from hydrogen and oxygen. A gasoline filler hooks a nozzle from a fuel dispenser to the vehicle's receptacle to fill the tank(Ambrose et al., 2017; Gomez & Smith, 2019; Liu et al., 2020).

- Hydrogen fuel tank:

Stores hydrogen gas aboard the car until the fuel cell need it. The power electronics controller (FCEV) regulates the flow of electrical energy between the fuel cell and the traction battery, as well as the speed and torque produced by the electric traction motor.

- Thermal system

The fuel cell, electric motor, power electronics, and other components are all kept within a safe operating temperature range by this system. Electric transmission: The gearbox is responsible for transferring mechanical power from the traction motor to the wheels.

*1.5. Differences between fuel cell and other automobiles*

- Driving range:

A hydrogen-powered automobile has a range of around 330 miles (550 kilometers), which is similar to that of electric cars. However, since hydrogen vehicles' energy storage is closely packed, they can often go greater distances. While most fully electric cars have a range of 100 to 200 miles on a single charge, hydrogen vehicles have a range of 300 miles.

- Refueling time:

The time it takes to pump hydrogen into the tank is much more intriguing than that of electric vehicles (5 to 10 minutes, exactly like any other petrol automobile). The battery of an electric automobile takes anything from half an hour to five hours to charge. This is a clear victory for the hydrogen automobile, owing to the fact that 1kg of hydrogen stores 236 times more energy than 1kg of gasoline lithium-ion batteries weighing a kilogram.

The size of the electric motor(s) that get electric power from the correctly sized fuel cell and battery combination determines the vehicle's power. Although most FCEVs have plug-in charging capability, most FCEVs utilize the battery to reclaim braking energy, provide additional power during brief acceleration events, and smooth out the power produced by the fuel cell, with the option to idle or switch off the fuel cell during low power demands. The size of the hydrogen fuel tank determines the quantity of energy stored onboard. With contrast, in an all-electric vehicle, the amount of power and energy available is proportional to the size of the battery.

The fuel cell is the maestro of all the operations that take place within the automobile in order for it to move. Fuel cells convert hydrogen gas into electricity (by combining it with oxygen). This energy is then utilized to power an electric motor, which propels

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the car without emitting any harmful pollutants at the exhaust. Water and heat are the sole by-products of the whole process, as a consequence of hydrogen and oxygen atoms joining to create H20 molecules.

Electric vehicles (EVs), on the other hand, are propelled by electric motors that draw power from a rechargeable battery or other portable power sources. Once they're moving, no chemical reaction occurs; instead, an electric reaction occurs as a result of the energy stored in the batteries.

### *1.6. Station for hydrogen refueling:*

A hydrogen fueling station's compression unit is a critical component. It compresses H2 that has been kept at low pressure to a pressure of up to 100 MPa. The appropriate compression method is determined by a number of parameters, including the hydrogen's starting condition (gaseous or liquid), station throughput, and the kind of vehicle to be fuelled.

- The ionic compressor is a device that compresses ions

The ionic compressor compresses gaseous hydrogen to 100 MPa in five phases. The eponymous ionic liquid, which does not bond with the gas, is one of the highlights. It serves as a lubricant and a coolant, reducing wear and tear greatly. In addition, compared to a traditional piston compressor, the ionic compressor has fewer moving components. Due to greater cooling and fewer dead spots during the compression process, the liquid also improves the compressor's energy efficiency. The ionic compressor protects the hydrogen against contamination by removing the need for lubricants. This guarantees excellent purity levels, making the compressor appropriate for purity-critical fuel-cell applications.

- The cryopump

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At -253° C, the cryo pump uses liquid hydrogen (LH2). However, at this temperature, hydrogen cannot be suctioned in. As a result, the pump employs a two-chamber design that is totally submerged in cryogenic liquid. LH2 from the storage tank is compressed to 0.6 MPa in the first chamber. In the second chamber, the pressure is compressed to 100 MPa. The temperature of the cryogenic gas is then raised until it reaches the fuelling temperature of 40° C. The high purity level of hydrogen is maintained throughout all of these manufacturing phases. The cryo pump reduces the amount of energy needed by the filling station, in addition to its compact size and high capacity. It uses just 10–20% of the energy that a traditional compressor does. Cryogenic LH2's cooling power also removes the requirement for an external supply line cooling system. Furthermore, the low-maintenance design lowers running expenses. Highlights of the ionic compressor and cryo pump:

1) Low usage of energy
2) Minimal footprint
3) Compression that saves energy
4) Minimal maintenance required
5) Long life expectancy
6) High level of dependability
7) Low noise levels

- The True Issue: Obtaining Hydrogen

Despite being the most abundant element in the universe, hydrogen does not exist in its pure form on the Blue Planet. This means that if we want to use it as a car fuel, we'll have to make it from other substances like water, natural gas, or other fossil fuels, or biomass. And in order to do so, energy is required, as well as environmental and economic costs. On the one hand, we can produce hydrogen in a clean manner by reversing the water electrolysis process. The difficulty is that splitting H20 molecules to get hydrogen consumes a significant amount of energy, making it a highly costly operation. However, if this energy can be obtained from renewable sources such as the sun or wind, the net energy cycle may be reduced to a very low carbon level, making the process more ecologically benign. Another issue is the process' efficiency, which is just 75% efficient and allows for 25% power losses. As a result, the majority of hydrogen fuel is now created by the natural gas reforming technique, which is less costly than electrolysis. The disadvantage is that the process produces damaging by-products like as carbon dioxide and carbon monoxide, and very occasionally methane, which contribute to global warming.

## 2. DISCUSSION

### *2.1. Water as a source of hydrogen:*

A solution is poured in a container and two terminals are dipped into it in an electrolyzer. Pass energy through the solution by connecting the terminals to a battery or other power source. Chemical reactions occur, and the solution disintegrates into its constituent atoms. If the solution is pure water (H2O), it will quickly split into hydrogen gas (at the negative electrode) and oxygen gas (at the positive electrode) (at the positive electrode). Collecting and storing these gases for future use is relatively simple.The operation of an electrolyzer to produce hydrogen gas from water is as follows:

- An electrolyte connects the positive or anode terminal to the negative or cathode terminal in a battery. Pure water could be used as the electrolyte in a simple laboratory experiment. The use of a solid polymer membrane as the electrolyte in a real electrolyzer improves performance significantly by allowing ions to pass through it.
- When the power is turned on, water (H2O) splits into positively charged hydrogen ions (hydrogen atoms missing electrons, shown in red) and negatively charged oxygen ions (oxygen atoms with extra electrons, shown in green).

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- The positive hydrogen ions are drawn to the negative terminal and pair up to form hydrogen gas (H2).
- Similarly, negative oxygen ions are attracted to the positive terminal, where they recombine in pairs to form oxygen gas.

*2.2. Fuel cell advantages*

- Low-to-zero emissions:

Fuel cells that utilize pure hydrogen as a fuel are carbon-free, with power, heat, and water as their sole byproducts.

- High Efficiency

Fuel cells may reach substantially greater efficiency than conventional energy generation systems such as steam turbines and internal combustion engines because they create electricity via chemistry rather than combustion.

- Reliability:

It will remain operating as long as hydrogen and oxygen are available. The only limiting element is the amount of hydrogen in the tank, since there is always sufficient of oxygen in the air.

- Fuel Flexibility

Hydrocarbon fuels such as natural gas, biogas, methanol, and others may be used in certain fuel cell systems.

- Energy Security

A fuel cell may be used in conjunction with a combined heat and power system, which utilises the waste heat from the cell for heating or cooling.

- Longevity:

Unlike batteries, fuel cells do not need to be recharged on a regular basis; instead, they continue to generate energy as long as a fuel source is available.

- Scalability

This refers to the capacity to connect individual fuel cells to construct stacks. These stacks may then be merged to form bigger systems. Fuel cell systems range in size and capacity from small-scale, multi-megawatt installations that provide electricity directly to the utility grid to large-scale, multi-megawatt installations that provide energy directly to the utility grid.

- Quiet Operation

Because fuel cells have no moving components, they are completely quiet.

## 3. CONCLUSION

Vehicles that run on hydrogen fuel gas are a good option. As much as possible, avoid pollution and reduce greenhouse gas emissions. Water and heat are the only byproducts. Because hydrogen has a higher energy storage capacity, it takes less time to recharge the car and has a longer driving range. The only issue is obtaining hydrogen. The current technologies for obtaining hydrogen have a significant energy loss, poor efficiency, and pollute the environment. However, other techniques of creating hydrogen are being developed, such as the proton exchange membrane, which experts claim may achieve an efficiency of 86 percent. Using the additional energy source for hydrogen generation and developing a hybrid hydrogen-lithium-ion vehicle might also be a good idea.

## REFERENCES:

Ambrose, A. F., Al-Amin, A. Q., Rasiah, R., Saidur, R., & Amin, N. (2017). Prospects for introducing hydrogen fuel cell vehicles in Malaysia. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2016.05.122

Anand, V. (2019). Photovoltaic actuated induction motor for driving electric vehicle. *International Journal of Engineering and Advanced Technology*, *8*(6 Special Issue 3), 1612–1614. https://doi.org/10.35940/ijeat.F1298.0986S319

Chang, X., Ma, T., & Wu, R. (2019). Impact of urban development on residents' public transportation travel energy consumption in China: An analysis of hydrogen fuel cell vehicles alternatives. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2018.09.099

Dodds, P. E., Staffell, I., Hawkes, A. D., Li, F., Grünewald, P., McDowall, W., & Ekins, P. (2015). Hydrogen and fuel cell technologies for heating: A review. In *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2014.11.059

Ferraren-De Cagalitan, D. D. T., & Abundo, M. L. S. (2021). A review of biohydrogen production technology for application towards hydrogen fuel cells. In *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2021.111413

Foorginezhad, S., Mohseni-Dargah, M., Falahati, Z., Abbassi, R., Razmjou, A., & Asadnia, M. (2021). Sensing advancement towards safety assessment of hydrogen fuel cell vehicles. In *Journal of Power Sources*. https://doi.org/10.1016/j.jpowsour.2021.229450

Gomez, A., & Smith, H. (2019). Liquid hydrogen fuel tanks for commercial aviation: Structural sizing and stress analysis. *Aerospace Science and Technology*. https://doi.org/10.1016/j.ast.2019.105438

Haseli, Y. (2018). Maximum conversion efficiency of hydrogen fuel cells. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2018.03.076

Khan, U., Yamamoto, T., & Sato, H. (2021). An insight into potential early adopters of hydrogen fuel-cell vehicles in Japan. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2020.12.173

Liu, X., Reddi, K., Elgowainy, A., Lohse-Busch, H., Wang, M., & Rustagi, N. (2020). Comparison of well-to-wheels energy use and emissions of a hydrogen fuel cell electric vehicle relative to a conventional gasoline-powered internal combustion engine vehicle. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2019.10.192

Madsen, R. T., Klebanoff, L. E., Caughlan, S. A. M., Pratt, J. W., Leach, T. S., Appelgate, T. B., Kelety, S. Z., Wintervoll, H. C., Haugom, G. P., Teo, A. T. Y., & Ghosh, S. (2020). Feasibility of the Zero-V: A zero-emissions hydrogen fuel-cell coastal research vessel. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2020.06.019

Mangla, S. K., Bhattacharya, A., Yadav, A. K., Sharma, Y. K., Ishizaka, A., Luthra, S., & Chakraborty, R. (2021). A framework to assess the challenges to food safety initiatives in an emerging economy. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.124709

Manoharan, Y., Hosseini, S. E., Butler, B., Alzhahrani, H., Senior, B. T. F., Ashuri, T., & Krohn, J. (2019). Hydrogen fuel cell vehicles; Current status and future prospect. In *Applied Sciences (Switzerland)*. https://doi.org/10.3390/app9112296

Mao, X., Ying, R., Yuan, Y., Li, F., & Shen, B. (2021). Simulation and analysis of hydrogen leakage and explosion behaviors in various compartments on a hydrogen fuel cell ship. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2020.11.158

Mergel, I. (2012). OpenCollaboration in Public Sector: The case of social codign on Github. *Government Information Quarterly*.

Singh, D. (2019). Robust controlling of thermal mixing procedure by means of sliding type controlling. *International Journal of Engineering and Advanced Technology*. https://doi.org/10.35940/ijeat.F1303.0986S319

ISSN PRINT 2319 1775 Online 2320 7876
*Research paper*  UGC CARE Listed ( Group -I) Journal Volume 11, Iss 2, Feb 2022

Wong, E. Y. C., Ho, D. C. K., So, S., Tsang, C. W., & Chan, E. M. H. (2021). Life cycle assessment of electric vehicles and hydrogen fuel cell vehicles using the greet model—a comparative study. *Sustainability (Switzerland)*. https://doi.org/10.3390/su13094872

Zhao, F., Mu, Z., Hao, H., Liu, Z., He, X., Victor Przesmitzki, S., & Ahmad Amer, A. (2020). Hydrogen Fuel Cell Vehicle Development in China: An Industry Chain Perspective. In *Energy Technology*. https://doi.org/10.1002/ente.202000179