International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Hydrogen as an Automobile Fuels

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ABSTRACT

In many nations, natural gas is a possible alternative fuel for meeting stringent engine pollution laws. (CNG) is a fuel that has been used for a long time. Users anticipate safe, convenient, and customer-friendly fueling as hydrogen fuel cell vehicles progress from concept to commercialization. Fuel cell stack performance and lifetime, as well as other parameters like valve operation, are influenced by hydrogen quality. Previous research on hydrogen as a possible main fuel of the future has been thoroughly examined in this publication. Hydrogen is an energy carrier that may be used as a fuel in internal combustion engines and as a fuel cell in cars to replace fossil fuels. Engine design should be examined when using hydrogen as a fuel in an internal combustion engine to avoid anomalous combustion. As a result, engine efficiency, power production, and NOx emissions can all be improved. The acceptance of hydrogen technology is contingent on understanding and awareness of the benefits of hydrogen to the environment and human existence. According to a recent survey, people still lack adequate hydrogen knowledge.A fuel cell is an electrochemical device that uses chemical gases and oxidants as reactants to generate energy. The fuel cell produces electricity by splitting the cation and anion in the reactant using anodes and electrolytes. Fuel cells use environmentally friendly reactants that produce water as a byproduct of the chemical reaction. The fuel cell can provide direct current (DC) power to power the electric automobile because hydrogen is one of the most efficient energy carriers. A sustainable hybrid car can be created by combining a hydrogen fuel cell with batteries and a control system with strategies.

Keywords: CNG Engine, Efficiency of Engine, Performance and brake power of Engine, Indicated power of Engine.

1. Introduction.

Excessive use of fossil fuels is directly linked to significant environmental and societal problems such as global warming and local pollution. Such issues drive research, development, and demonstrations of clean energy resources, energy carriers, and, in the case of transportation and power trains, transportation and power trains. According to a recent study, hydrogen is one of the energy carriers that potentially replace fossil fuels, but more research is needed to uncover the benefits and drawbacks of this alternative fuel before it can be commercialized. Hydrogen is the most environmentally friendly fuel, with a heating value three times that of petroleum. However, because hydrogen is a man-made fuel rather than a natural source of energy, it has a higher production cost, accounting for three times the price of petroleum products.

Although there are still issues with obtaining renewed hydrogen from water, the market availability and cost of hydrogen do not now represent a bottleneck for hydrogen vehicles, even though the hydrogen used today may not be regenerated. However, due to hydrogen's exceptional characteristics, researchers are exploring the availability of H2 in internal combustion (IC) engines and investigating the performance of hydrogen-fueled engines as one of the most important research directions. As a result, we will evaluate prior developments and studies on hydrogen as a possible primary fuel of the

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future, employed in internal combustion engines and as a fuel cell in automobiles, in this study. The goal of this research is to look at hydrogen as a fuel for internal combustion engines for vehicle propulsion, including its benefits, drawbacks, and fundamentals. In contrast, the study of car fuel cells focuses on performance, cost, infrastructure, kind of storage, and type of hydrogen generation.

1.1. New concept of Hydrogen as a fuel

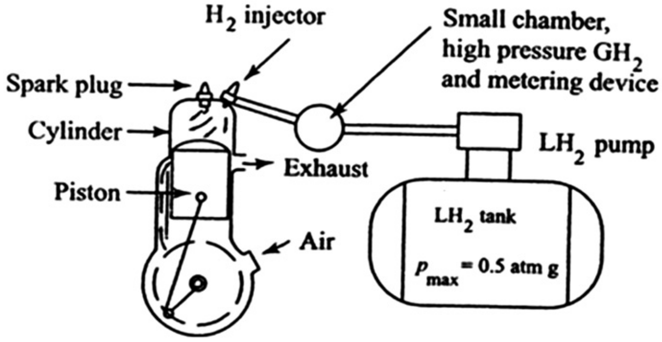

Fig 1 Concept of Hydrogen in New Engine[1]

Hydrogen can be used in SI engine by three methods :

(i) Through a process known as manifold induction
The manifold is filled with cold hydrogen via a valve-controlled channel .

(ii) By injecting hydrogen directly into the cylinder
In a cryogenic cylinder, hydrogen is held in liquid form. This liquid is pumped via a tiny heat exchanger and transformed to cold hydrogen gas. This unit is also used for hydrogen metering. Cold hydrogen minimizes NOx generation while also preventing pre-ignition. Figures 1 and 2 show the configuration of liquid hydrogen storage and the specifics of hydrogen induction into the SI engine cylinder, respectively [8,9].

(iii) By supplementing gasoline
In a SI engine, hydrogen can also be used as a supplement to gasoline. Hydrogen is injected with gasoline, compressed, and ignited by a spark in this mechanism.

The system dynamics technique has been used to analyze the reduction of energy use and CO2 emissions, as seen in this study. As a result, system dynamics modeling is a widely used technique for studying complex systems like urban transportation systems. However, none of these studies have looked at natural gas as an alternative fuel for urban transportation and its impact on CO2 emissions as a fuel for the transition from high-to-low-emission fuels. Natural gas fuel is not considered a separate subsystem in these research. Forrester introduced the fundamental concept of system dynamics. System dynamics is the study of system control policies and decision-making, as well as the structural properties of systems, using a technique with various distinctive aspects. First and foremost, system dynamics studies the dynamic behavior of systems, particularly changes in system behavior over time. Second, system dynamics looks for the origins of dynamic changes in the feedback structure.

In comparison to iso-octane and methane, which represent natural gas and gasoline, respectively [5,] certain properties of hydrogen are listed in [1]. In comparison to iso-octane–air and methane–air at stoichiometric mixture, the mixture properties of hydrogen–air when operated at lean and stoichiometric mixture [6]

1.2 Hydrogen Transportation of Fuel

Hydrogen is the most basic of all molecules; it has the least amount of energy by volume but the most amount of energy by weight of any fuel. It exists as a gas in the atmosphere and as a liquid in water. Hydrogen is used as a fuel in applications such as FCs and rockets because of its high energy content. Hydrogen emits no toxic pollutants, which is one of the most major disadvantages of fossil fuels, and it has a heating value three times that of petroleum. Because hydrogen is a man-made fuel, it has a high manufacturing cost, costing around three times more than petroleum refining [4]. Significant research is being done to develop an efficient and sustainable method of producing hydrogen, as well as applications for hydrogen in transportation engines. Automobile manufacturers such as Honda, Toyota, and Hyundai have begun to produce hydrogen-fueled fuel cell vehicles (FCVs). Early adopters have mostly purchased these FCVs, which are currently accessible in North America, Asia, and Europe. Early adopters are primarily highly educated individuals, high-income families, those with larger family units, those willing to modify their lifestyle, and others that have similar characteristics [7]. As of June 2018, over 6500 FCVs had been sold to consumers. Because California has the world's greatest network of hydrogen filling stations and automakers selling the vehicles there, it is the main market for FCVs, with roughly 3000 FCVs supplied out of 5233 vehicles sold globally. Several manufacturers are currently marketing FCVs to consumers, which are frequently compared to BEVs. BEVs and FCVs both have zero tailpipe emissions and use electric motors. They can also be powered using renewable and sustainable energy sources. The driving range and refueling style are the most noticeable distinctions between FCVs and BEVs. FCVs have a driving range of over 300 miles and can be refueled in less than 10 minutes at a hydrogen refueling station, making them more equivalent to regular ICE fossil fuel vehicles. Hydrogen has a bigger future potential for usage as a fuel. Based on technology advancements and improved availability, it is predicted that by 2030, the cost of fuel cells will be competitive with that of ICEs [4]. One of the most significant obstacles to widespread hydrogen utilization is more effective storage. Hydrogen cannot be stored as easily as traditional fossil fuels due to its low density. Compression, cooling, or a combination of the two are required for hydrogen. Because pressurised tanks are commonly available, physical containment is the most advantageous form of hydrogen storage. All composites (Type IV) are used largely, with metal lined composites (Type III) being employed on occasion. When the hydrogen is pre-cooled, the fill time of these tanks is comparable to that of fossil fuels.

Because the material and assembly costs are high, compressed hydrogen (CH2) tanks are widely used. Another potential stumbling block is public opposition to the use of such high-pressure (70 MPa) storage tanks in automobiles [6]. A tank with an internal skeleton, which is a complicated design of struts in tension within the tank to resist the stresses of compressed gas, is still being explored as an alternative to regular CH2 tanks. Liquid hydrogen (LH2) storage has vastly improved, with the best specific mass (15%) of any previous vehicular hydrogen storage technology. When liquid hydrogen is used, energy efficiency is reduced. Before LH2 systems to be broadly adopted, the boil-off process must be improved. A cryo-compressed tank, in which hydrogen is highly compressed at cryogenic temperatures, is a promising alternative design. More research on this method is needed to determine its long-term viability and public acceptance. To achieve the requirements for large-scale application, hydride storage systems require extensive research and development. The most well-studied hydride is NaAlH4, but it lacks the capacity required for practical use. According to the findings of a few previous studies, tanks without internal heat transmission devices could be built using the moderate heat of hydrogen absorption on surfaces. Despite the fact that hydrogen is abundant in the atmosphere, it is not in its purest form. Water, hydrocarbon fuel, hydrogen sulfide, and other chemical components can all be used to produce hydrogen. External energy, such as thermal, electrical, photonic, and biological energy, is required to create hydrogen from its associated elements. Ammonia is a chemical element with a high hydrogen content that has been proposed as a fuel for internal combustion engines because to onboard degradation into hydrogen and nitrogen. Hydrogen may be extracted from both renewable and non-renewable energy sources. While hydrogen produced from renewable sources is always environmentally favorable, hydrogen produced from non-renewable sources generates greenhouse gases (GHG). GHG-free hydrogen is produced from waste biomass utilizing electrochemical reactions, which do not require a lot of energy or have high manufacturing costs. Bread chaff, cypress sawdust, and rice chaff are all potential biomass feedstocks. Newspaper might be used in a similar way to make hydrogen through direct electrolysis. Newspaper is made up of 69.2% cellulose and 11.8% lignin, and it decomposes into monosaccharides, disaccharides, and aliphatic keto acids in the solvent H3PO4 under electrolysis-like conditions. The electrolysis of humidified methane can also produce hydrogen [6].

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1.3 Hydrogen Induction in Petrol Engine

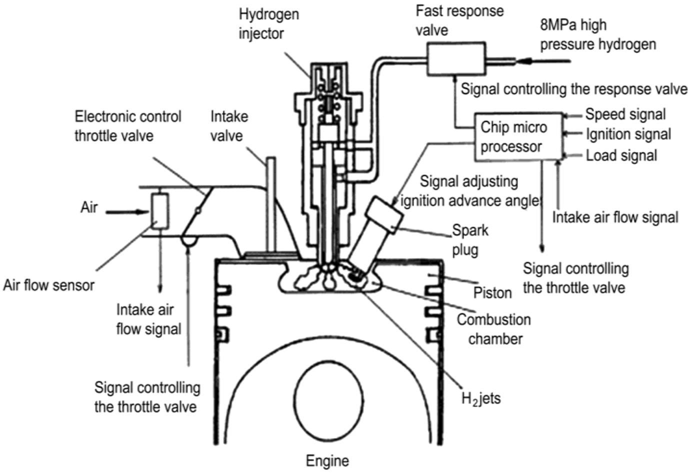

Figure 2. Hydrogen Injected in Petrol Engine

Property	Hydrogen	Methane	Iso-octane
Molecular weight (g/mol)	2.016	16.043	114.236
Density (kg/m3)	0.08	0.65	692
Mass diffusivity in air (cm2/s)	0.61	0.16	~ 0.07
Minimum ignition energy (mJ)	0.02	0.28	0.28
Minimum quenching distance (mm)	0.64	2.03	3.5
Flammability limits in air (vol%)	4.75	5-15	1.1–6
Flammability limits (l)	10–0.14	2–0.6	1.51–0.26
Flammability limits (c)	0.1–7.1	0.5–1.67	0.66–3.85
Lower heating value (MJ/kg)	120	50	44.3
Auto-ignition temperature in air (K)	858	723	550
Flame velocity (ms—1)	1.85	0.38	0.37–0.43
Higher heating value (MJ/kg)	142	55.5	47.8
Stoichiometric air-to-fuel ratio (kg/kg)	34.2	17.1	15
Stoichiometric air-to-fuel ratio	2.387	9.547	59.666

2. Limit of Maximum Temperature

The flammability limit indicates the proportion of combustible gases in a mixture; if the proportion of combustible gases in a mixture falls between these limits, the mixture is flammable. Table 1 shows that the flammability of hydrogen in air (mixture) ranges from 4–75 percent, giving hydrogen a wider range of flammability than other fuels [14]. It is obvious that 4% is significant.

The 4% figure refers to the configuration of a single experiment. As a result, in real-world settings, the limit might be as low as 4% or as high as 12% (depending on the situation). This restriction is crucial for safety reasons, but it is less important for engine combustion [5]. Extremely lean or rich hydrogen mixtures that combust with air are possible with a wide variety of hydrogen mixtures. This allows the hydrogen engine to run on a lean mixture, which results in improved fuel economy and a more complete combustion process [6]. As can be seen in [2,] the final combustion temperature will be lower as a result of the reduced laminar burning velocity.

When compared to a hydrogen engine that works on a stoichiometric mixture, the lean mixture is rapidly reduced, with speeds of 12 cm/s (at j14 0.25) and 290 cm/s (at j14 1). Pollutants such as NOx will undoubtedly be reduced as a result of this [3]. The minimal amount of energy necessary to ignite a flammable vapour or gas mixture is known as minimum ignition energy. The minimum ignition energy of a hydrogen–air mixture is an order of magnitude lower than that of iso-octane–air and methane–air mixes under atmospheric circumstances. Only 0.017 MJ is obtained at hydrogen concentrations of 22–26 percent. Capacitive spark discharge is typically employed to determine minimum ignition energy and is hence reliant on the spark gap [2]. The figures in [2] are based on a 0.5 mm gap. When utilizing a gap of 2 mm, the minimum ignition energy can increase by roughly 0.05 MJ and remain more or less constant for hydrogen concentrations between 10% and 50%. The advantages of a low ignition energy hydrogen engine for igniting a lean mixture and ensuring rapid ignition [4]. However, having a low ignition energy will enhance the likelihood that the hydrogen air combination in the combustion chamber will be ignited by a source other than the spark plug (hot spot) [3].

3. Fuel cell vehicle with on-board storage

Metal hydration can be used to hold hydrogen below 3 or 4 MPa at temperatures above room temperature; however, the metals add too much weight and are also expensive for most vehicles [3]. Lithium nitride has been discovered to be capable of reversibly storing enormous amounts of hydrogen. When kept at 255°C for 30 minutes, this material accumulates hydrogen fast in the temperature range of 170–210°C, with a 9.3% weight percent absorption. At temperatures below 200°C, nearly two-thirds of the hydrogen was released under high vacuum (10–9 MPa, 10–5 mbar). The remaining third of the hydrogen has to be released at temperatures over 320°C. Lithium amide (LiNH2) and lithium hydride were formed from the hydrogen (LiH). The authors proposed that analogous metal-N-H systems be investigated in order to determine more realistic pressures and temperatures for a hydrogen storage device [4].

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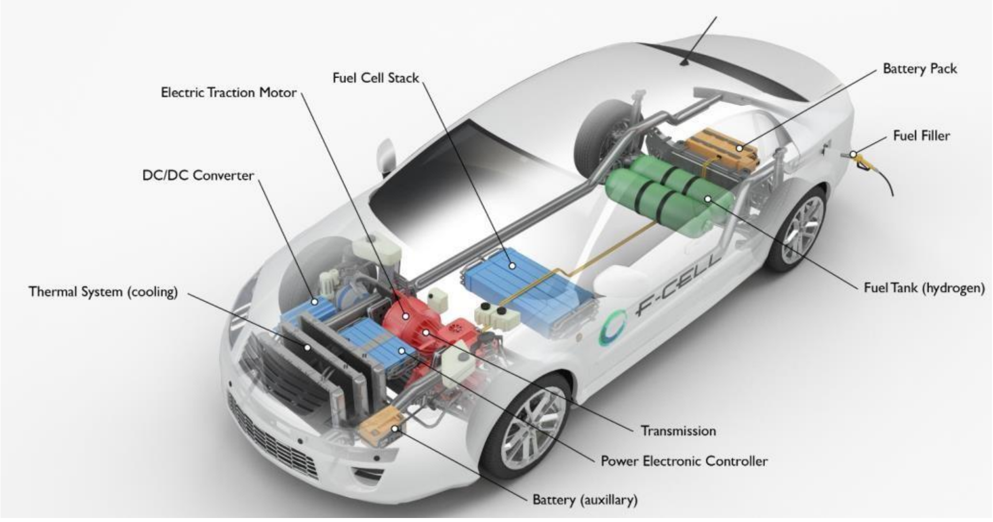

Figure 3 Outlook of Hydrogen Vehicle with all assembly fitted

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4. Principles of Fuel Cell

FC systems come in a variety of shapes and sizes. Their functions, however, are comparable in theory. An anode, a cathode, and an electrolyte are the three pillars of a fuel cell system. The type of electrolyte substance used in FCs is classified. Although an FC can be made up of hundreds of individual cells, they all have the same three basic components. Between the cathode and the anode is the electrolyte. A schematic of a polymer electrolyte FC (PEMFC) operation diagram is shown in Figure 2 [5]. A proton exchange membrane FC is another name for this type of FC. The PEMFC is the most prevalent type of mobile power converter seen in vehicles. While the type of electrolyte used varies depending on the type of FC, the main operation of the system is as follows: fuel (pure hydrogen) is fed into the anode compartment, while air or pure oxygen is pumped into the cathode compartment.

5.Conclusion

Hydrogen offers several advantages in terms of combustive qualities in internal combustion engines, but it requires careful engine design to avoid anomalous combustion, which is a key issue with hydrogen engines. As a result, engine efficiency, power production, and NOx emissions can all be improved.

The purity of hydrogen in fuel cell vehicles can have an impact on their performance. This contaminant is caused by sulphur poisoning during the manufacturing process. Fuel cell vehicles emit less pollution than traditional vehicles, but they require more room and weight to place the battery and storage tank, which raises the cost of production.

The cost and efficiency of a hydrogen plant are determined by the electricity price and the sources of hydrogen production. It will assist to reduce costs if the area is close to its natural resources, therefore location with its sources should be considered when developing a hydrogen plant.

Before hydrogen fuel and automobiles can be commercialized and compete with other types of fuels, research into manufacturing methods, vehicle performance, plant performance, infrastructure availability, emissions, and air pollution is required.

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Acknowledgements

We are thankful to of Team members and staff of our Institute for helping us in this article.

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