# ANALYSIS OF HYDROGEN FUEL USAGE IN IC ENGINES

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## Abstract.

The paper investigates the study and analysis of hydrogen as a fuel to create a new phase in the current technological era for the future by improving the economy, health and environment at its best. The focus of research article is to solve the problems associated with power generation thereby increasing the efficiency of hydrogen fuel based IC engines. The outcome of study reveals to save the environment and use alternative eco-friendly sources as much as possible. The review since last 10 years shows that the technology is already into existence and being used in certain areas of the world. The statistical data reveals how countries like India can move ahead in the era of development of hydrogen as a fuel and make it as a dependable source of energy for future generations.

**Keywords**. Hydrogen Fuel, IC Engine, Efficiency, Zero emission

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## 1. INTRODUCTION

Many people are worried about the future of low-carbon and energy-efficient strategies. Today entire world is suffering from the effects of global warming and environmental pollution; Therefore, alternative fuel is considered as an alternative system to protect the environment. And this technology also applies to transportation systems. Primary function of fuels is to store and generate energy, thus it's important that it's readily available in a stable form. Generally, the fossil fuels we are using are quite polluting. And today that fuel is also depleting due to its long term and ubiquitous use. This is why various alternative fuels are being developed to overcome this problem, hydrogen fuel being one of them. This technology is significant as well as in the field of transportation systems. If we consider the internal combustion engine, first it releases harmful gases, secondly fuel combustion of the internal combustion engine is also an issue along with that the efficiency of the engine, after the depletion of fossil fuel, the engine would stop working and fuel consumption is also less. These are some of the problems that are associated with internal combustion engines. [1] Hydrogen is able to store and carry energy through chemical processes. Consequently, hydrogen is a sustainable and low-emission fuel source. In other hand, the main byproduct of burning this fuel in an internal-combustion engine is water., and there is zero production of carbon dioxide.[2] Hydrogen is a high flammable and minimum ignition energy, wide range of flammability limits and high calorific value, these all properties makes hydrogen suitable internal combustion engine.[3]

## 2. LITERATUREREVIEW

Hot spots in the combustion chamber: deposits and particulates - Bardon and Haycock (2002), MacCarley (1981); the spark plug – Das (2002), Lucas and Morris (1980); residual gas - Das (1996), Lucas and Morris (1980), Berckmülleret al. (2003); exhaust valves - Berckmüller et al. (2003) , Stockhausen et al. (2002), Swain et al. (1988), TÜV Rheinland (1990).[4]Combustion in the piston top land persisting up to inlet valve opening time and igniting the fresh charge - Lucas and Morris (1980), Swain et al. (1996), Koyanagi et al. (1994), Lee et al.(2000)[4] Maro JELIĆ and Neven NINIĆ have discussed the analysis of Internal Combustion Engine Thermodynamic Using the Second Law of thermodynamic. And they found that a powerful tool for optimizing compress and spark ignition engines for lower fuel consumption and fewer emissions was obtained by combining numerical simulations of the system of internal combustion engine which is based on thermodynamics $2^{nd}$ law.[5] The fundamentals of the combustion sector its whole system has been the subject of Arka Ghosh's research. New designs for combustion chambers are a major focus of their investigation. [5]

### *2.1. Internal Combustion Engine*

More than 2000 years ago, people discovered the method of moving an object with heat, and this concept was first implemented on Aeolipile. After another 2000 years. first steam engine was invented. After this invention people wanted to have more effective engine. In 1679 D. Papin invented the boiler with steam power that hold the steam inside a cylinder. In 1791, John Barber developed the gas turbine. The purpose of this turbine was to make a carriage which can move without any animal power. And for rotating the turbine hot gas generation was necessary, so they used the mixture (fuel and air) in the cylinder and burn those components for produce hot gas. The first internal combustion engine was patented by Robert Street in 1794. But the actual development was happened in $18^{th}$ century. This development makes a huge revolution in the whole world. In 1876 Nikolaus Otto carried this revolution forward by inventing first four stroke internal combustion engine which was much more effective than other previous engines.

### *2.2. Hydrogen fuel*

A very commonly known element in this planet is Hydrogen. In 1766 British scientist Henry Cavendish proved $CO_2$ as a fixed type air and another is $H_2$which is flammable type. Hydrogen is combined with oxygen to produce hydrogen fuel, in this procedure there is no chance to produce carbon. Hydrogen has some special properties; it is the most resourceful alternative to fossil water of the present era. This element is also used in a number of important fields like in industry, automobile sector, power generating sector etc. Due to its many positive aspects, it has been suggested to use it as a fuel of the future. Itis an environmentally benign, quickly depleting type of renewable energy. [6]A minor power of only 0.02 mJ is required for ignition of hydrogen air mixture. Since $H_2$ has a density of 0.0838 kg/m3, which is lighter than air and may easily diffuse into the atmosphere.[7] The higher compression ratios possible in hydrogen internal combustion engines are due to hydrogen's higher self-ignition temperature of 858 K compared to diesel's 453 K. [8]

## *2.3. Specifications of useable fuels in IC Engines*

| | HYDROGEN | GASOLINE | DIESEL |
|---|---|---|---|
| Density (Kg/m3) | 42 | 700-800 | 830 |
| Energy Content (MJ/Kg) | 120 | 44.0 | 35.86 |
| Auto Ignition (K) | 858 | 550 | 483 |
| Cost (Rs/kg) | 320-330 | 96.72 | 100 |
| Emission of carbon (Kg) | 0 | 2.3 | 2.7 |
| Efficiency | 60% | 50% | 55%-60% |
| Flame speed (m/s) | 1.85 | 0.37 - 0.43 | 1.28 |

Table 1 -Most usable fuels in IC Engines [9]

# 3. METHODOLOGY

To control the carbon emission from the vehicles and producing energy from its source. To reduce carbon emissions the energy used in transportation needs to be change.[10] The structure of a $H_2$ powered engine is nearly similar of a general conventional engine (IC engine). The highest potential power output depends on its ratio of fuel and air in $H_2$, and fuel injection mechanism. $H_2$ has a fixed fuel-air ratio of 1:34. $H_2$ occupies 30% of the combustion chamber with this air fuel ratio, leaving more than 70% for air. Gasoline fuel reduces this mixture's energy content. The output level of gasoline engines is around 85% due to fuel-air mixing and direct injection systems' pre-combustor fuel-air mixing. The highest engine power for direct fuel injection system, that combine the mixture of air and fuel inside the closed intake valve (combustor has full of air), may be 15% greater than for gasoline engines.

## *3.1. Purpose*

The project has some aim for better transportation system for the modern society.

1) To solve the combustion engine’s problems and reducing the carbon emission from it.

2) To reducing the cost from the ongoing electric and other types of vehicles.

3) To improve the fuel consumption than the hybrid and combustion engines.

## 4. RESULT &ANALYSIS

| SN. | AUTHOR/ YEAR | STUDY | RESULT |
|---|---|---|---|
| **1.** | Das, et al. | Result comes from after using renewable resources in SI engines. [11] | ● The present study involves testing clean-burning fuels, such as hydrogen, in engines with modest spark ignition.<br>● This research contrasts hydrogen fueling with compressed natural gas operation since CNG is currently utilized as an auxiliary fuel source for internal combustion engines. |
| **2.** | Verhelst & Sierens. | Behavior of hydrogen engine. [12] | ● The promise for sustainable growth, notably in the transportation industry, is offered by hydrogen as an energy carrier.<br>● The possibilities for a hydrogen-fueled engine emissions from internal combustion engines are far cleaner.<br>● The rapid propagation speed and wide flammability limitations can improve efficiency.<br>● By using multipoint injection method the benefits and drawbacks of power regulation via altering the air – fuel ratio and throttle are assessed. |
| **3.** | Natkin, et al. | Application of hydrogen IC engine in Ford car.[10] | ● When produced from renewable resources, hydrogen is sustainable and clean, making it ideal for use as a transportation fuel.<br>● To advance the plan for moving away from the petrol economy and toward the hydrogen economy, it is simple to take advantage of the advancement and application of hydrogen Internal combustion engine H2ICE technology. |
| **4.** | Manikant,et al | Current position of the hydrogen energy for application. [14] | ● The state of hydrogen generation, storage, and application are outlined in current research and active initiatives.<br>● Analyzed as potential barriers to the commercialization of hydrogen-powered cars in the Indian market are issues with infrastructure development, distribution, regulation, pricing and public acceptance. |

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|---|---|---|---|
| **5.** | Ciniviz & Kose | Use of hydrogen in IC. [7] | ● The rapid depletion of non - renewable has accelerated the need for research into practical alternative fuels capable of meeting ecological energy requirements with minimal environmental impact. |
| **6.** | Bhaskar, et al. | Performance of $H_2$fueled in IC engine. [4] | ● For IC engines to reach zero output of carbon dioxide we should apply such a fuel which is not produce $CO_2$ in transportation applications and the fuel will be hydrogen.<br>● The manufacturing, storing, and establishment of the necessary infrastructure are the real downsides of using hydrogen in IC engine. |
| **7.** | Faizal, et al | An analysis of behavior of $H_2$in IC engines. [15] | ● The need for alternate fuel sources has increased in order to avoid an energy catastrophe. hydrogen is a modern transport energy source,this fuel is an excellent small-scale energy source for fueling batteries and fuel cells.<br>● The need for hydrogen has led to the development of a number of production, storage, and transportation techniques that make hydrogen as accessible as petroleum while posing less environmental risks. |
| **8.** | Verhelst. | The progress of hydrogen fuel for IC engines. [16] | ● This study examines the developments in modelling, direct hydrogen injection, in-cylinder heat transfer, and combustion techniques both at the engine and vehicle levels.<br>● Impressive efficiency levels have been achieved as a result of these efforts, both at Peak and half load operating with emissions much below the legal limit establishing reasonable specified power output limitations. |
| **9.** | Shadidi, et al. | Hydrogen as a Fuel in IC Engines. [17] | ● Hydrogen-powered vehicle research and development wants to increase the efficiency of the new fuel energy(H2) and make a continuity in the transportation sector.<br>● The result comes from adding hydrogen in different types of ignition engines on their gas emissions and performance. |
| **10.** | Kanna, et al. | Efficiency enhancer of IC engine using hydrogen. [18] | ● The decision to attempt using hydrogen as a kind of alternative power for the automobile due to the escalating expenses of gasoline and diesel fuel.<br>● The aim behind a hydrogen generator is to use hydrogen instead of a portion of the gasoline. |

## 5. CONCLUSION

When using hydrogen as a fuel, the engine cycle does not need to be changed. [24] The energy we use in the future should be safer and more efficient. Hydrogen is the best alternative fuel for lowering or eliminating harmful vehicle emissions and protect the environment from damage. Because hydrogen is just one of several atmospheric components, It's one of the best substitutes for fossil fuels, and it's widely available. Hydrogen can be used to improve the performance of IC engines while also reducing harmful exhaust emissions. Hydrogen is an attractive energy option due to its low negative impact on the environment and long lifespan. [11] The study shows that HCNG is a viable fuel option for IC engines. In CNG, added $H_2$ as a fuel in spark ignition engines has a noticeable and beneficial effect on efficiency, especially towards the lean limit. Since HCNG allows the engine to be run smoothly, and it also produces less carbon dioxide, hydrocarbon etc. [1]

## 6. REFERENCE


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