"HYDROGEN: FUE OF FUTURE"

Naval Kishore Jain, Ajay Singh Bhati, Daivik Sharma, Daksh Sharma, Devanshu Sharma
Poornima Group of Institutions, Jaipur
2016pgimeajay005@poornima.org,
2016pgimedaivik020@poornima.org,
2016pgimedaksh079@poornima.org,
2016pgimedevanshu021@poornima.org

ABSTRACT

21st century is the most prominent century in terms of technological advancements & discoveries. These technological advancements ranging from the detection of gravitational waves to building supercars that runs on an electric engine. All these discoveries & technological advancements are necessary to sustain the fast paced world with an alarming increase in population with augury of crossing 8bn by 2030. This increase in population is responsible for many things like the increase in demand of energy & fuel. Since most of the fuel is derived from crude oil, which already is a scarce resource & by our rate of consumption will be obsolete in the near future. The rise in population is also responsible for the alarming rise in pollution level especially in densely populated areas where the smog levels are creating havoc for people causing substantial health problems. To overcome this pollution problem many alternative fuels are being developed which are cleaner, recyclable & better for environment in many ways. This paper gives an overview of hydrogen fuelled IC Engines which the big industry names like BMW, Audi, Hyundai, Toyota, Volkswagen, etc. are using or going to use in future for their vehicles and a comparison of hydrogen with other available fuels.

Keyword- *Diesel engine, Hydrogen, Wide flammability limit, High burning rate, Engine-out emissions, Dual Fuel, Efficiency and Performance.*

1. INTRODUCTION.

The world's population is set to cross 8bn by 2030, with this staggering rise in population there is also an alarming rise in use of crude oil as energy source. Albeit crude oil is the main resource of harnessing fuel, it is an exhaustible resource, which is vanishing at a pace that is not cope able, hence the decrease in crude oil is troublesome for future generation.

To preserve whatever remaining crude oil is there, alternative energy sources are being developed. These alternate energy resources consist of electrical, thermal, LPG, CNG etc.

In this context, hydrogen (H2), a non-carboniferous and non-toxic gaseous fuel, has attracted great interest of industry and has huge potential. H2 is only one of many possible alternative fuels that can be derived from various natural resources.
Albeit H2 can't be used directly in IC Engine because of it's higher self- ignition temperature, but it can be used in the dual fuel mode. This paper focuses on the use of H2 in internal combustion engines (ICE)
When talking about hydrogen as a fuel for traffic applications, most people make the link to fuel cells. The fuel cell is like a battery and needs hydrogen and oxygen to work.
When hydrogen is used as an alternate fuel in ICE, it is more efficient and cleaner than the lot. But the consideration of fuel cell when talking about hydrogen as a fuel is common because of the image formed by the fuel. Hydrogen as a fuel is more expensive and difficult to produce. 1.2bn vehicles are currently on road with augury of reaching more than 2bn by the year 2035. To replace them in a relatively short time by fuel cells is impossible.
Currently the hydrogen production is the cheapest through the steam reforming of methane, but CO emissions cannot be avoided.

2. PROPERTIES OF HYDROGEN

Henry Cavendish discovered hydrogen in 1766*, but it was named by Antoine Lavoisier in 1783.
Hydrogen has an atomic number 1, with an atomic weight of
1.00795, ergo it is the lightest element in periodic table. Molecular formula of Hydrogen is H2.

2.1 PHYSICAL PROPERTIES

Melting temperature is -259.2°C
Boiling temperature is -252.76°C
It is a colorless gas without any taste or smell.
It is a non-toxic, nonmetallic & highly combustible gas.
It is 14.5 times lighter than air.

2.2 COMBUSTIVE PROPERTIES OF HYDROGEN

The properties contribute to use hydrogen as a combustible fuel is:
Wide range of flammability limits (4 −75%)
Low ignition energy (0.02 mJ)
Small quenching distance (0.064 cm)
High auto ignition temperature (5850 C)
High flame speed (2.91 m/s)
High diffusivity (0.63 cm2/s)

Low density (0.0899 kg/m3)

A. Wide Range of Flammability

It can be seen that the flammability limits (= possible mixture compositions for ignition and flame propagation) are very wide for hydrogen (between 4 – 75 percentage hydrogen in the mixture) as compared to that of gasoline which lie in (between 1 - 7.6 percentage). This means that the load of the engine can be controlled by the air to fuel ratio, as for diesel engines. Nearly all the time the engine can be run with a wide-open throttle, resulting in a higher efficiency.

B. Low Ignition Energy

Since hydrogen has low ignition energy about one third than that of the other conventional fuels and other alternative fuels, this low energy enables the engine to ignite lean mixtures and ensures prompt ignition.

However this low ignition energy of hydrogen also gives rise to some of the more dangerous problems that could prove fatal for the engine. One of the major problem faced is that the hot gases and hot spots on the cylinder serves as a source of ignition, which causes premature ignition and flashback.C. Small Quenching Gap

Hydrogen has a small quenching distance, smaller than other hydrocarbon fuels, consequently, hydrogen flames travel closer to the cylinder wall than other fuels before they extinguish. The smaller quenching distance can also increase the tendency for the backfire since the flame from a hydrogen-air mixture passes more rapidly towards closed intake valve, than a hydrocarbon-air flame.

D. High Auto Ignition Temperature

Hydrogen has a relatively high auto ignition temperature. This is important implication, when a hydrogen-air mixture is compressed. In fact, the auto ignition temperature is an important factor in determining, what compression ratio an engine can use, since, the temperature rise during compression is related to the compression ratio. The temperature may not exceed hydrogen' s auto ignition temperature without causing premature ignition. The higher auto ignition temperature of the hydrogen allows larger compression ratios can be used in a hydrogen engine than in a hydrocarbon engine.

E. High Flame Speed

The flame speed is comparatively higher than that of other fuels; because of this high flame speed of hydrogen the combustion in the engine is substantially close to that of a thermodynamically ideal engine cycle. At leaner mixture however, the flame velocity decreases significantly.

F. High Diffusivity

Hydrogen has high diffusivity. This ability to disperse is greater than that of gasoline and other alternate fuels which proves advantageous for two main reasons: firstly, it facilitates the formation of a uniform mixture of fuel and air and secondly, if a hydrogen leak develops, the hydrogen disperses quickly.

G. Low Density

Hydrogen's low density is a problem for it's storage as a large volume system will be required for this purpose.

3. EXPERIMENTAL SET-UP

A single cylinder, four-stroke diesel engine is used in this experimental. The engine was made to run at a constant speed of
1500rpm on dual-fuel mode, using diesel as the pilot fuel and hydrogen as the main fuel. A solenoid-operated hydrogen gas injector was set on to the engine cylinder head. The hydrogen injector was placed just above the intake valve at some distance from the intake valve seating position [20, 21]. The hydrogen was stored in a cylinder at a high pressure of 140 bar at 32 0C was reduced to a pressure of 1.2 bar by a CONCOA pressure regulator. For regulating the volume flow rate of hydrogen, a flow regulator has been placed in the hydrogen circuit. A flame arrestor was provided to suppress any possible fire hazard in the system, which acts as a non-return valve. Additionally a bubbler tank is incorporated in the circuit to dampen out any pressure fluctuations in the hydrogen supply line.

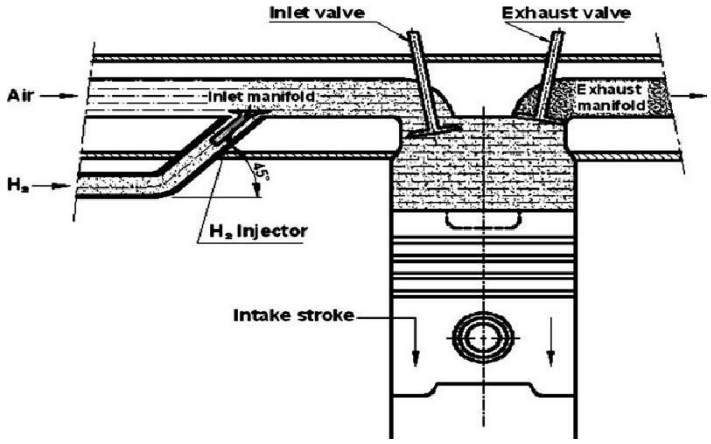


Fig 1: Schematic layout of the manifold injector

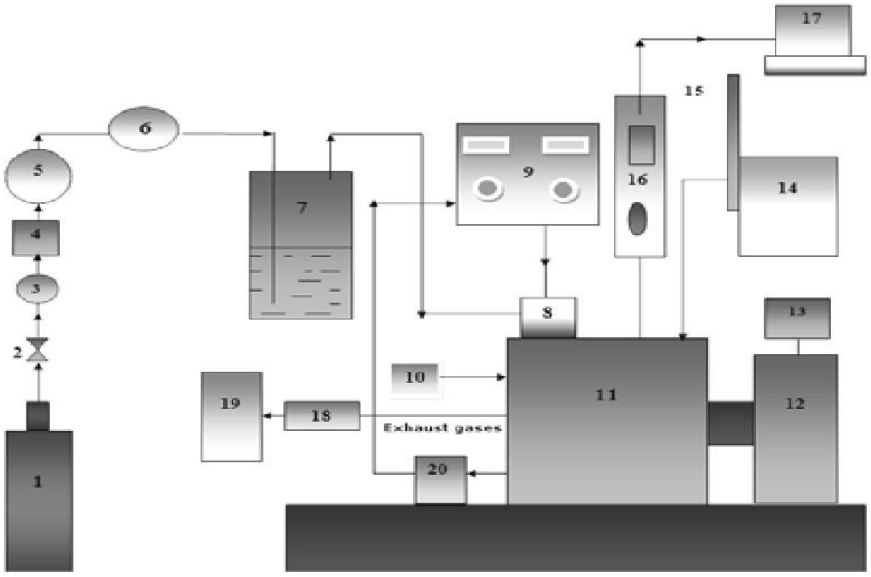


Fig 2: Schematic layout of the experimental setup

1. Hydrogen cylinder
2. Pressure regulator
3. Pressure gauge
4. Flame arrester
5. Pressure reducer
6. Gas flower
7. Water bubbling tank
8. Gas injector
9. DAQ station with injector driver & DAQ card and PC
10. Air filter.
11. VCR engine
12. Electrical dynamometer
13. Loading device
14. Fuel tank
15. Burette
16. Engine control panel with sensors 17. Computer panel
18. Exhaust Gas Calorimeter.
19. Gas Analyzer.
20. Crank Angle Encoder.

4. COMPARISION OF HYDROGEN WITH OTHER ALTERNATIVE FUELS

4.1 COMPARISION OF CALORIFIC VALUES

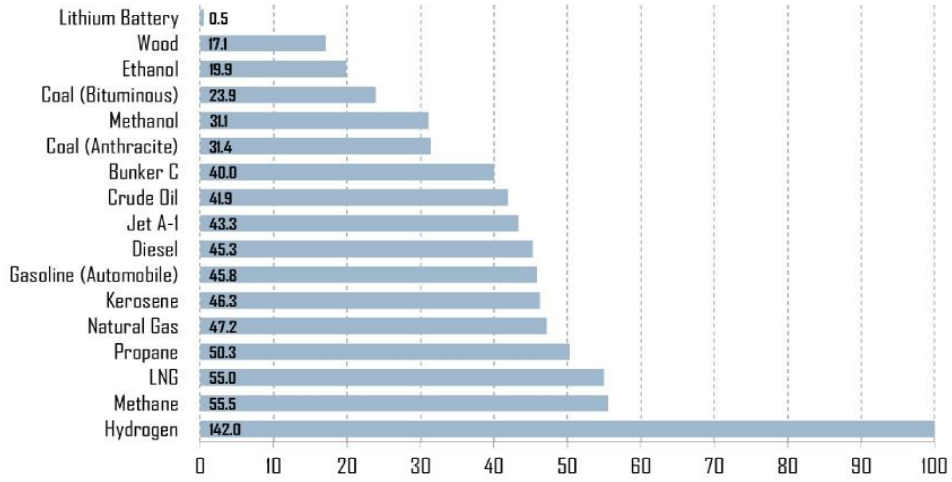
FUEL	CALORIFIC VALUE(KJ/Kg)

PETROL	45000
KEROSENE	45000
DIESEL	45000
METHANE	50000
CNG	50000
LPG	55000
HYDROGEN	150000

4.2 ENERGY CONTENT & CO_2 COMPARISION

FUEL	H/C RATIO	ENERGY CONTENT (KJ/g)	CO_2 RELEASED (mol/10^3KJ)
HYDROGEN	N/A	120	N/A
GAS	4/1	51.6	1.2
PETROLEUM	2/1	43.6	1.6
COAL	1/1	39.3	2.0
ETHANOL	3/1	27.3	1.6

4.3Energy Content Graph



5. CONCLUSION

After all this research we reach to the conclusion that hydrogen when supplied directly as a fuel to SI Engine has a plethora of advantages over the conventional and alternative fuels used currently. There is a very good possibility that hydrogen might be used as a fuel in the coming years.

However, amid all these advantages there are certain limitations of hydrogen as a fuel in IC Engines, these limitations are due to the certain technological restrictions in our current scenario, albeit these limitations are the very reason that hydrogen cannot be supplied directly as a fuel in IC Engines cost efficiently but these restrictions will be obliterated in the near future as the technology advances.

After all the comparisons made between hydrogen and other conventional and alternative fuels in the aspects of energy, cost, storage, pollution, calorific value, CO_2 emissions and other various properties it can be said that the use of hydrogen in future as a fuel in IC Engines is prominent.

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