Kuwait Journal of Engineering Research
ISSN: 2984-8016
Vol 1 Issue 1 (2023)

The Role of Hydrogen as Green Energy in Reciprocating Engines

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Submitted: 18/01/2023 **Revised**: 20/02/2023 **Accepted**: 10/03/2023

Abstract: The need for fossil fuels is growing day by day with the rise in manufacturing and energy request in the world. Hydrogen is an alternative fuel with good efficiency. The hydrogen engine is capable of operating over a wide range of equivalence ratios: from ultra-lean mode to stoichiometric conditions. However, it has been observed that the engine gives maximum thermal efficiency and minimum NOx emissions and without any problems of backfire if operated within a definite range of lean operation. The fuel induction technique has been found to be very crucial to hydrogen engine development. The paper describes a path to the most characteristic features of hydrogen in reciprocating engines, and the Future sources of hydrogen production could use solar energy or Steam Methane Reforming…. etc. Finally, the paper concludes the properties of hydrogen with the main areas of research that require further efforts and the hydrogen combustion chamber.

Keywords: Internal combustion engine, Hydrogen, reciprocating engine, fuel, reenable energy.

1.INTRODUCTION

Thirty years ago, hydrogen was identified as "a critical and indispensable element of a decarbonised, sustainable energy system" to provide secure, cost-effective and non-polluting energy.1 Today, energy leaders see hydrogen as the lowest impact and least certain issue facing the global energy system.2 "Hydrogen, as a viable alternative fuel, continues to promise much and deliver precious little. Global warming and the associated efforts for decreasing CO2 emissions have rendered hydrogen one of the most important energy carriers of this century[1]. Since the world economy runs on energy ,Large projects and scientific research on hydrogen energy development has taken place[2]. Hydrogen is environmentally friendly fuel when it is produced renewable sources[3]. From water hydrogen generated thermally or electrolytically [4]. Hydrogen and gas mixtures containing hydrogen are an excellent fuel for the gas engine[5] . There have been numerous of research investigations of hydrogen as a reciprocating engine fuel, and a recent review of much of this literature is available, The present paper considers the use of hydrogen as a fuel in reciprocating engines, and focuses on engine performance and the principal ,prorates of hydrogen's and the production [6]. The use of pure hydrogen allows for an efficient lean combustion but, compared to liquid fuels[7].

Conventional internal combustion engines can be modified to run on pure hydrogen ('HICEs') and could see early deployment as they are substantially cheaper than fuel cells. However, hydrogen combustion is less efficient than a fuel cell and releases NOx, hence is not expected to play a significant long-term role in transport. Hydrogen can be blended with natural gas ('hythane') or diesel in dual-fuel vehicles; or it is possible to switch between both in bi-fuel powertrains. This allows the use of existing infrastructure, but these are not zero-emission and could eventually be displaced by lower-carbon options. Hydrogen can be used as a fuel in conventional spark-ignition engines such as the Otto and diesel engines used in motorcars and the gas turbines used in conventional power plants.

2.METHODS OF USING HYDROGEN IN INTERNAL COMBUSTION ENGINES

Hydrogen can be used in internal combustion engines as fuel, or in fuel cells to provide power to electric motors. Unlike the direct use of hydrogen in internal combustion engines, with the small changes on the combustion system, the combustion form of the fuel can be altered. In many researches about the use of hydrogen in internal combustion gasoline engines in the automotive sector, the way the hydrogen enters the combustion chamber of the engine has been realized by injection or carburetor systems from the premixed

manifold[8]. It is better to use hydrogen as a fuel in internal combustion engines, because can be used under high compression rate case and it has a high ignition temperature.

Use of hydrogen as a first fuel

use hydrogen as a first fuel, different car makers have designed some analysis prototypes. For example, BMW and Mercedes manufacturing their "sole hydrogen engine" that had been used in light duty cars. The material of this type of engines was chose carefully because of hydrogen's flammability limits and high temperature and pressure caused by combustion. In addition to there is spark plugs designed only for hydrogen systems.

Use of hydrogen as a secondary fuel

The use of hydrogen in internal combustion engines takes place in two methods. The first method is used as a single fuel and the second method is used as an additional fuel. Although there are some problems in the use of hydrogen as a single fuel, the research studies move on. In current conditions, the addition of hydrogen to the fuel can be considered as a more suitable method.

3. PRODUCTION METHODS OF HYDROGEN

The following are the various ways for producing hydrogen:

3.1. Steam Methane Reforming

90% of the world's hydrogen is produced using the steam methane reforming. Under a 3–25 bar pressure. Natural gas is source of methane that requires for steam methane reforming, the hydrogen generated is derived from natural gas at high-temperature steam the ranges of 700℃ to 1000℃ under 3 to 25 bar pressure (1 bar = 14.5 psi) (43.5_362.5 psi) with a catalyst present. The steam–methane reforming process for hydrogen production is like that of producing other fuels like ethanol, propane, or even gasoline.

Equation of reaction steam–methane reforming[9]:

$H2O$+ CH4+ $heat \rightarrow CO$ + $3H2$ (1)

Reaction between Gas-Water:

$CO + H2O \rightarrow CO2 + H2$ + Heat (little amount) (2)

3.2. Electrolysis

Electrolysis is a viable way for producing carbon-free hydrogen from renewable and nuclear energy. The process of separation water into hydrogen and oxygen using electricity is known as hydrogen production. An electrolyte splatted to the cathode and the anode in an ,different electrolyzes [9]. There are a few commonly used electrolytes along with them electrolyzes.

3.3. Coal Gasification

Coal contains two parts: carbon-based matter (is made of five primary components: carbon, hydrogen, oxygen, nitrogen, sulfur) and mineral stuff. The method of producing hydrogen from coal begins with partial oxidation, which involves adding some air to the coal that produces carbon dioxide through burning. carbon monoxide is formed when carbon dioxide interacts with the remainder of the carbon in coal. Carbon monoxide in the gas stream now reacts with steam to produce hydrogen and carbon dioxide therefore we are now producing hydrogen[8].

4.HYDROGEN PROPERTIES

Hydrogen is simple element, and is the most plentiful element in the universe making up 75% of the mass of all visible matter in stars and galaxies, the hydrogen atoms consist of a single proton, a rare form (or "isotope") of hydrogen contains both a proton and a neutron. This form of hydrogen is known deuterium or heavy hydrogen[10]. Several advantages for hydrogen as fuel, it has a good specific heat of combustion air compared to the other fuel and it is fairly easy to accumulate, store, and transport [11].

Table 1
chemical and physical data on hydrogen, methane, methanol, and gasoline[12]

Parameter	H2	CH4	CH3OH	Gasoline
1. Flammability limits in air (%)	**4–77**	**4–16**	**6–36**	**1–7.6**
2. Density at normal temperature and pressure (NTP) (kg m−3)	**0.084**	**0.67**	**791**	**~751**
3. Liquid density (kg m−3)	**77**	**425**	**786**	**~751**
4. LHV (MJ kg−1)	**119.9**	**50.0**	**19.9**	**44.0**
5. Minimum ignition energy in air (MJ)	**0.02**	**0.3**	**0.14**	**0.8**
6. Ignition temperature in air (◦C)	**585**	**540**	**385**	**230–480**
7. Molecular weight (kg kmol−1)	**2.016**	**16.04**	**32.04**	**107.0**

5.HYDROGEN COMBUSTION CHARACTERISTICS

there have been several previous research of hydrogen as a fuel for reciprocating engine, it has been found possible to take advantage of hydrogen's wide flammability limits to operate engines under highly efficient lean unthrottled conditions. Properties for hydrogen is given table 2 and reference values for isooctane [6].

TABLE 2 [6]
Thermodynamic and combustion properties of hydrogen and isooctane

Property	Hydrogen	Isooctane
Heat of combustion, KJ/Kg	1.20 x 105	4.44 X 104
Flammability limits, Vol. % in Air or (Q)		
Lean	4.0 (0.10) *	1.0(0.6)
Lean	9.0 (0.23) **	1.O (0.6)
Rich	75.0 (7.1)	6.0 (3.8)
Stoichiometric Mixture Properties		
Air-fuel ratio (mass)	34.6	15.2
Air-fuel ratio (volume)	2.38	59.7
Volumetric energy content at STP, J/cm3	3.18	3.73
Approximate Laminar Flame Speed at cp = 1, P = 0.1 MPa, Cm/sec	180	40
Minimum Ignition Energy		
at Q= 1, P = 0.1 MPa, MJ	0.02	1.O

- **Storage of Hydrogen:**
  1. **Carbon Nanofibers**
  2. **Reversible Metal Hydride**
  3. **Liquid**
  4. **Compressed Gas**[12]**.**

5.CONCLUSIONS

The need for fossil fuels is increasing because of globalization and rising energy demands. And this led to, many nations are exploring alternative energy sources, and hydrogen is an efficient and practical alternative fuel[8]. In order to know clearly the effect of hydrogen fuel on internal combustion engine carrying out, more detailed studies are required on different types of engines, lubricating oil is not produced for engines that use hydrogen as an additional fuel in current [13]. In the study paper hydrogen fuel is a clean and sustainable energy[14]. As research progresses, the technologies used to produce the hydrogen are expected to shift toward those that produce no net greenhouse gas emissions. Hydrogen is the most plenty element present on earth[15]. Hydrogen is a chance green alternative to fossil fuels that can also be make using renewable energy sources, although the transport and storage of hydrogen are fishy [16].Hydrogen is expected to be one of the most important fuels in the near future to meet the stringent emission norms. hydrogen is a long-term renewable and less-polluting fuel. hydrogen is clean burning characteristics and best performance drives more interest in hydrogen fuel. The use of the hydrogen as fuel in the internal combustion engine represents an alternative use to replace the hydrocarbons fuels, which produce polluting gases during combustion[17]. Hydrogen produces only water after combustion engine. It is a non-odorant gaseous matter, non-toxic in addition can be burn completely. There are several properties of hydrogen that immensely impact the technological development of a reciprocating engine that uses hydrogen as fuel[18]. Hydrogen-fueled reciprocating engine have been the topic of research for many years, and contemporary reviews have surveyed the relevant study [19].

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