{H2}tech

clean fuel technology of the future today

H2 technology White paper – HHO gas for vehicles.

Abstract

This review covers specific aspects of the hydrogen enriched fuels technology and applications. In short, the overall science, methods of implementation, implications of voltage and key parameters affecting the output of the process. Electrolysis and combustion is shortly presented to produce a comprehensive report. Scientific review is the short version due to other requirements covered here.

Report Part A: Science explanation

The reason that all products are so alike is the science behind the application which dictates simple constructions and sets the electrolysis efficiency limits. When fuel [gasoline, diesel, etc] is combusted in a combustion chamber, due to ineffective [incomplete] pressurization by the working pistons, only a fraction of it is actually burned to provide energy. This fraction is usually between 20 and 40%, and reaches higher levels for specific fuels such as LPG; it also reaches lower limits, for example for bio diesel. Lower efficiency means lower octane number.

The HHO mixture optimizes combustion in two ways; firstly, due to its superb energetic content in comparison to the fuel mixture and its efficiency in burning, and secondly due to effects [structural/ chemical] on the basic fuel. Hydrogen properties are presented in Table 2. When HHO is added to the fuel, the energetic content rises greatly. Also, HHO is a gas, and no compression effects can reduce its energetic combustion efficiency. The second effect [structural/ chemical] is due to the nature of combustion. Fuel is normally sprayed in small droplets [liquid] that are combusted outside in based on their specific external area. When HHO gas hits the fuel, a division of droplets is observed that effectively generates multiple surface areas, thus leading to more effective combustion. This effect results in the need for less fuel consumption to produce the same energetic output.

Table 2: Hydrogen properties

Limits of flammability in air	4–75% vol.
Minimum energy for ignition	0.02 mJ
Auto-ignition temperature	858 K
Quenching gap in NTP air	0.064 cm
Burning velocity in NTP air	265–325 cm/s
Diffusion coefficient in NTP air	0.61 cm^2/s
Heat of combustion (LCV)	119.93 MJ/kg

The other scientific aspect is the electrolysis part. When electric current is passed through a liquid, it provokes dissociation of the liquid to the anode and cathode [electrodes]. When this liquid is just water, atomic hydrogen and oxygen are produced in their 2:1 ratio. Electrolysis kits are so simple that no limitations occur in this step; also, the amount of HHO required is so low that ultra low Amperes are required for production. One of the greatest advantages of this application is that HHO gas is produced 'on demand', meaning only when it is needed. This attribute makes it possible to bypass safety issues exhibited by hydrogen storage materials that can prove especially dangerous in the case of a car crash. Combination of electrolysis equipment with a combustion chamber with HHO inlet is the heart of the HHO generator kit.

Report Part B: Investigations of parameters

Basic parameters of the system include:

- Size of the engine [thus combustion chamber]
- Fuel used [different levels of HHO needed for optimization]
- Anode/ cathode set up
- HHO flow pipe/ tube
- Measuring / display device
- Water quality

The greater the size of the engine, the larger quantity of energy is required by the fuel combustion. For the same fuel, larger engine means larger HHO quantities thus larger electricity intensities and voltage are required. Flow diameters of larger sizes are also required to satisfy the 'HHO on demand' principle. One initial consideration was exactly this; what is the upper limit of A and V produced and used in a vehicle to reach the HHO content/ flow stoichiometrically required for optimization of combustion.

Different fuels exhibit different combustion efficiencies and thus require different HHO ratios to achieve their maximum combustion output. In general, the higher the quality of the fuel [LPG] the lower the expectation of the HHO use, and the lower the quality of the fuel, the greater the expectations of HHO use.

Electrolysis device functionality and life span mainly depends on the electrodes used and their maintenance. Purity of both electrodes is of the essence and this purity is the most important manufacturing parameter for the HHO kit. Specific instructions are provided by the manufacturers for the cleaning of these electrodes, quite commonly with distilled water. HHO flow pipe/ tube connects electrolysis device with combustion chamber. Diameter of pipe is directly connected to HHO content/ production to satisfy the 'on demand' principle.

Water quality does not actually affect the electrolysis/ combustion procedure. It does not affect the output or the inner procedures; the less impurities in water used lead to less often cleaning of the electrolysis device and especially of the electrodes.

Measuring/ display devices are used to control output and efficiency but could also be used to follow other parameters such as HHO flow rates, existence of any impurity, etc. The actual parameters of interest are of chemical nature, not electrical.

Report Part C: Scientific literature review [short version]

The potential use of HHO or Brown's gas for the efficiency optimization of fuel combustion has been the topic of numerous works [1-10]. A research work described the manufacture and testing of a HHO generator device in real small scale engine [11]. In this work, it was found that for the small engine [197cc] a reduction of 20-30% in fuel consumption was achieved, together with lower exhaust temperature. The most important factor influencing this device was the available electrolyte are which was required to be 20 times larger than the piston area. The system under investigation was gasoline based. Previous works had also suggested that lower concentrations of pollutants were observed when HHO was also used in fuel combustion [12, 13]. Figure 1 presents the suggested configuration. Figure 2 presents the electrolysis cell.

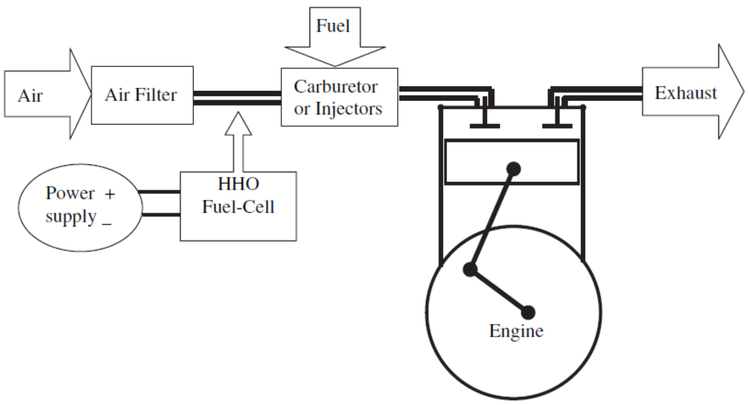

Figure 1: Schematic illustration of HHO device [1]

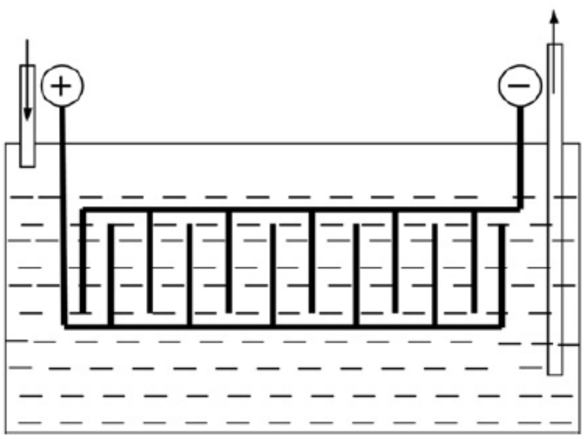

Figure 2: electrolysis cell: inlet air, outlet HHO, electrodes, steel plates

A diesel based apparatus was the topic of another investigation [14]. In this work the main goal was the pollution control in the exhaust fumes. It was reported that fuel consumption was decreased by more than 15%, and unburned hydrocarbon emission was reduced by more than 25%. Experimental set up is presented in Figure 3. Previous investigations on diesel engines had led to CO emission reduction of 30%, particulate matter decrease by 60% and NO_x increase of 19% in comparison to diesel combustion [15]. Similar results were obtained for HHO produced by electrolysis, with addition of 30l/min of H_2/O_2 mixture [16]. When flow rates corresponding to 3.38% hydrogen were used in other diesel related works, an efficiency increase of 3.8% was reported for the output power [17]. In another related work, HHO produced smaller fuel droplet sizes in the combustion chamber, efficiently increasing output power and consumption rate [18].

Another worked focused on the effects of two different HHO contents on a gasoline engine [19]. Two different contents were used, 4.5% and 9% HHO in the combustion chamber. Thermal efficiencies for the three different fuel concentrations are given in Figure 4. Unburned H/C emissions are also presented in Figure 5.

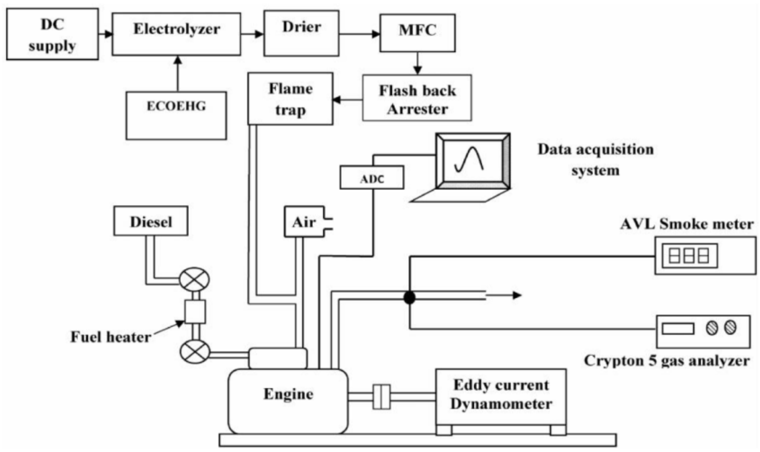

Figure 3: Experimental setup of the diesel based apparatus [14]

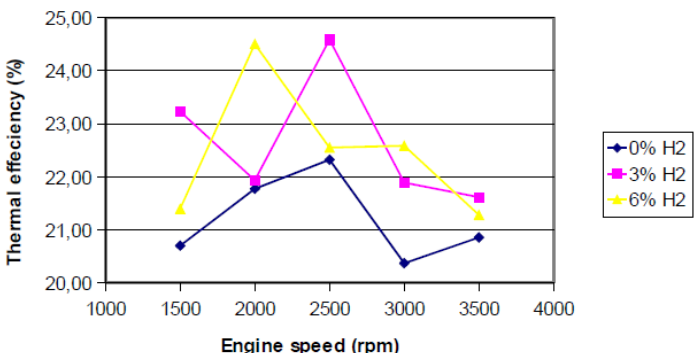

Figure 4: Thermal efficiency for three different compositions of HHO [0, 4.5, 9%] [19]

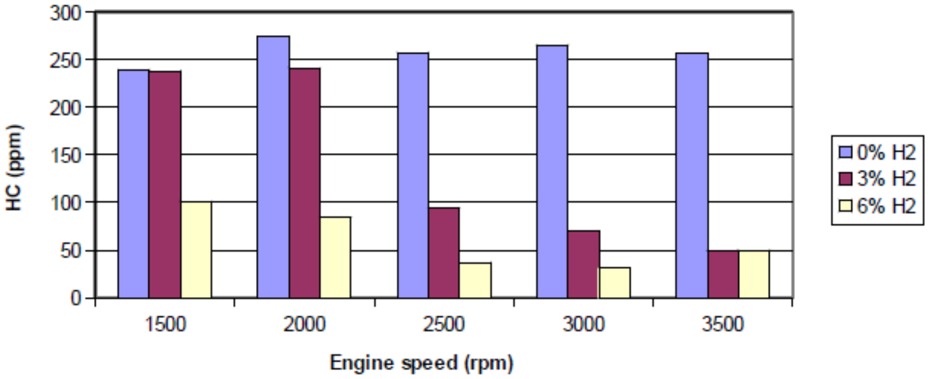

Figure 5: Variation of unburned hydrocarbons emissions for different HHO content [19]

Emissions of H/C were investigated in a research study that concluded in a strong relation between Hydrogen content and H/C reduction [20]. It was suggested that the effect of HHO was more evident at high loads and lean mixtures.

A different investigation used different electrolytes for the preparation of HHO gas [KOH, NaOH, NaCl] and different electrode designs [21]. NaOH was chosen as the most efficient HHO producer. Hydroxy gas was used as a supplementary fuel in a four cylinder, four stroke, compression ignition (CI) engine without any modification and without need for storage tanks. Experiments showed that constant HHO flow rate at low engine speeds (under the critical speed of 1750 rpm for this experimental study), turned advantages of HHO system into disadvantages for engine torque, carbon monoxide (CO), hydrocarbon (HC) emissions and specific fuel consumption (SFC). Investigations demonstrated that HHO flow rate had to be diminished in relation to engine speed below 1750 rpm due to the long opening time of intake manifolds at low speeds. This caused excessive volume occupation of hydroxy in cylinders which prevented correct air to be taken into the combustion chambers and consequently, decreased volumetric efficiency was inevitable. Decreased volumetric efficiency influenced combustion efficiency which had negative effects on engine torque and exhaust emissions. Therefore, a hydroxy electronic control unit (HECU) was designed and manufactured to decrease HHO flowrate by decreasing voltage and current automatically by programming the data logger to compensate disadvantages of HHO gas on SFC, engine torque and exhaust emissions under engine speed of 1750 rpm. Fuel consumption is presented in Figure 6.

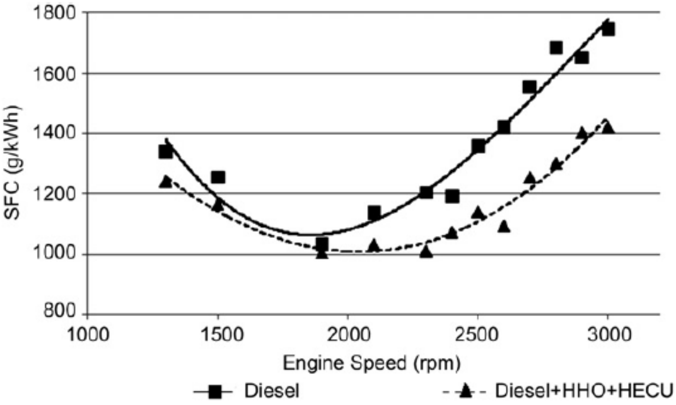

Figure 6: Fuel consumption vs engine speed [21]

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