Experimental Hydrogen Booster Model

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Abstract: This work presents an investigation to the effect of Hydrogen Booster System on exhaust gases emissions of an internal combustion engine. The hydrogen booster produces hydrogen and oxygen using six water fuel cells and water droplets from the bubbler, these gases are then injected into intake system of the engine. The water fuel cells are provided with electrical power from the dynamo of the engine. The input power is 13.8 V DC, 6A. It is found that the fuel consumption decreases and the value of the octane number of gasoline also increases. In addition the pollution produced from the engine emissions is decreased into considerable values.

Key words: Hydrogen booster • Fuel consumption • Exhausts emissions • Fuel cells • Bubbler and internal combustion engines

INTRODUCTION

With the negative changes in the economy and rapid increase of gasoline prices the use of a supplemental hydrogen booster system in vehicles can greatly increase the fuel economy. Other benefits of using such a system include an increase in horsepower and a great reduction in harmful pollutants and emissions that damage our environment and shorten the life of engines. The hydrogen booster system separates each water particle (molecule) into a different arrangement: two “H” for Hydrogen, bonded together, plus one “O” for Oxygen. This combination, in its gaseous state, is called HHO. [1].

The Hydrogen booster give Hydrogen-On-Demand. This system offers the safest and most economical solution, rather than producing it in an expensive and polluting factory, then delivering it in huge trucks and storing it unsafely in high-pressure gas tanks. The world now knows that Hydrogen is powerful and everybody's talking about it. Unfortunately, Hydrogen-powered as well as hybrid cars have not matured yet. Their MPG performance is not as great as expected. And even worse, Hydrogen pressure tanks in cars and in fuel stations are a huge safety hazard.

Figure 1 (appendix 1) shows the schematic diagram of the proposed system. In the water at the negatively charged cathode, reduction reactions take place, with electrons (e⁻) from the cathode being given to hydrogen cations to form hydrogen gas (the half reaction balanced with acid):

Cathode (Reduction):

\[ 2H^+ (aq) + 2e^- \rightarrow H_2(g) \]

At the positively charged anode, an oxidation reaction occurs, generating oxygen gas and giving electrons to the cathode to complete the circuit:

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Anode (Oxidation):

\[ 2H_2O(l) - O_2(g) + 4H^+ \text{ (aq)} + 4e^- \]

The same half reactions can also be balanced with base as listed below. Not all half reactions must be balanced with acid or base. Many do like the oxidation or reduction of water listed here. To add half reactions they must both be balanced with either acid or base. [2, 3].

Cathode (Reduction):

\[ 2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^- \text{ (aq)} \]

Anode (Oxidation):

\[ 4OH^- \text{ (aq)} \rightarrow O_2(g) + 2H_2O(l) + 4e^- \]

Combining either half reaction pair yields the same overall decomposition of water into oxygen and hydrogen:

Overall Reaction:

\[ 2H_2O(l) \rightarrow 2H_2(g) + O_2(g) \]

The number of hydrogen molecules produced is thus twice the number of oxygen molecules. Assuming equal temperature and pressure for both gases, the produced hydrogen gas has therefore twice the volume of the produced oxygen gas. The number of electrons pushed through the water is twice the number of generated hydrogen molecules and four times the number of generated oxygen molecules, [3,4]. Values of voltages produced or needed are shown below in the following two chemical equations:

Anode (Oxidation):

\[ 2H_2O(l) \rightarrow O_2(g) + 4H^+ \text{ (aq)} + 4e^- E^{O}_{\text{an}} = -1.23V \]

Cathode (Reduction):

\[ 2H^+ \text{ (aq)} + 2e^- \rightarrow H_2(g) E^{O}_{\text{red}} = 0.00V \]

Thus, the standard potential of the water electrolysis cell is 1.23 V at 25°C. The positive voltage indicates the Gibbs Free Energy for electrolysis of water is greater than zero for these reactions. This can be found using some chemical equilibrium equations. The reaction cannot occur without adding necessary energy, usually supplied by an external electrical power source but also possible with thermal energy. An ‘electrolyser’ is a cell which breaks water down into hydrogen and oxygen gases by passing an electric current through the water. [2,3, 5] The resulting gas is called ‘hydroxy’ gas, as it is a mixture of hydrogen oxygen. Hydroxy gas is highly explosive, much more so than hydrogen on its own and very much more dangerous than petrol vapor, burning at least 1,000 times faster. The slightest spark will set it off exploding as little as a single cupful of hydroxyl gas produces a bang so loud that it can cause permanent hearing damage Consequently, the most important information about electrolyser concerns the safety devices techniques which must be used with them. The objectives are to keep the amount of hydroxy gas actually present in the system, to an absolute minimum and to prevent any spark reaching the gas. The output from an advanced electrolyser can replace fuel oil altogether, but such electrolyser is difficult to build and the exhaust system will rust and the piston rings may also rust. [3,6]. Many articles discussed using hydrogen as a fuel. David J. Bents. (2008), The closed-cycle hydrogen-oxygen proton exchange membrane (PEM) regenerative fuel cell (RFC) at the NASA Glenn Research Center has demonstrated multiple back-to-back contiguous cycles at rated power and round-trip efficiencies up to 52 percent. It is the first fully closed-cycle RFC ever demonstrated. (The entire system is sealed; nothing enters or escapes the system other than electrical power and heat.) During fiscal year (FY) 06 to FY07, the system’s numerous modifications and internal improvements focused on reducing parasitic power, heat loss and noise signature; increasing its functionality as an unattended automated energy storage device; and in-service reliability, [2]. Ulf Bossel, ( 2003). Stated that Hydrogen is a synthetic fuel. At least the heat (enthalpy) of formation (\( \Delta f H^0 = 286 \text{kJ mol}^{-1} \)) must be invested for its “fabrication” from water by electrolysis. This number corresponds to the Higher Heating Value HHV (= 142 MJ kg-1) of hydrogen. According to the energy conservation principle, this is the true energy carried by hydrogen gas at 25°C. Consequently, for any known process of recombination of hydrogen and oxygen to water, the energy efficiency must be related to the original energy input or the Higher Heating Value HHV of the synthetic fuel. The widespread use of the Lower Heating Value LHV may be a convenient
convention, but it is not supported by physics. In fact, the use of the Lower Heating Value for hydrogen produced by electrolysis (and other means) violates the energy conservation principle. Comparative studies of competing fuel options including hydrogen are meaningful and fair only if the analyses are based on the Higher Heating Values HHV of all energy carriers considered, [3]. Paolo Chiesa et al., This paper addresses the possibility to burn hydrogen in a large size, heavy-duty gas turbine designed to run on natural gas as a possible short-term measure to reduce greenhouse emissions of the power industry. The process used to produce hydrogen is not discussed here: we mainly focus on the behavior of the gas turbine by analyzing the main operational aspects related to switching from natural gas to hydrogen. We will consider the effects of variations of volume flow rate and of thermo-physical properties on the matching between turbine and compressor and on the blade cooling of the hot rows of the gas turbine. In the analysis we will take into account that those effects are largely emphasized by the abundant dilution of the fuel by inert gases (steam or nitrogen), necessary to control the NOx emissions. Three strategies will be considered to adapt the original machine, designed to run on natural gas, to operate properly with diluted hydrogen: variable guide vane (VGV) operations, increased pressure ratio, re-engineered machine. The performance analysis, carried out by a calculation method including a detailed model of the cooled gas turbine expansion, shows that moderate efficiency decays can be predicted with elevated dilution rates (nitrogen is preferable to steam under this point of view). The combined cycle power output substantially increases if not controlled by VGV operations. It represents an opportunity if some moderate re-design is accepted (turbine blade height modifications or high-pressure compressor stages addition), [6].

RESULTS AND DISCUSSION

After finishing installing Hydrogen Booster on the engine of car and analyzing the exhaust gases for the engine, the results of readings for exhaust gases (HC, CO, CO2, O2, NOx) in different speeds for the engine are represented in the following figures. Figure 2 shows the amount of HC gas which decreases by using Hydrogen Booster system. It reduces approximately 30%. As well as, this indicate that more complete combustion occurs in the engine. At low speed the reducing percent is more than at high speed.

![Fig 2: The Relation of Engine Speed (RPM) & HC (ppm)](image)

![Fig 3: The Relation of Engine Speed (RPM) & CO (%)](image)

![Fig 4: The Relation of Engine Speed (RPM) & CO2 (%)](image)

![Fig 5: The Relation of Engine Speed (RPM) & O2 (%)](image)
Fig. 6: The Relation of Engine Speed (RPM) & NOx (PPM)

Figure 3 shows the amount of CO gas, it can be noticed that the amount of CO is decreased by using Hydrogen Booster system and reduces approximately 22%.

As well as, this indicate that more complete combustion occurs in the engine.

From Figure 4 the amount of CO₂ gas is increased by using Hydrogen Booster system and increases approximately 8%.

As well as, this indicate that more complete combustion occurs in the engine. At high speed the increasing percent is more than at high speed.

Figure 5 above shows that the amount of O₂ gas is increased by using Hydrogen Booster system and it increases approximately 18%. As well as, this indicates that more complete combustion occurs in the engine. At high speed the increasing percent is more than at high speed.

As shown in Figure 6 above, the amount of NOx gas decrease by using Hydrogen Booster system and reduces approximately 29%, as well as, this indicate that the temperature of the combustion is decreased because the Hydrogen Booster system injects water droplet into intake system that increases volumetric efficiency. It also decreases temperature in combustion chamber. There is direct relation between a mount of NOx and temperature of combustion (as temperature decreases the amount of NOx decrease). At low speed the reducing percent is more than at high speed. It is also found that the fuel consumption of the car with Hydrogen Booster is decreased compared with the case of without it in the same way and speed, the car mileage was 46 km by 5 liter without Hydrogen Booster and with hydrogen booster the car mileage was 49 km by 5 liter also, this means that the fuel consumption reduces approximately by 6%. And the Hydrogen Booster is very safety, because the hydrogen that produced from the water fuel cell goes to the engine to be burned directly. This means that there is no need to store hydrogen at high pressure. Also the pressure inside the system is less than atmospheric pressure. As well as there is many safety device like Breaker, Relay, Bubbler and Check Valve (anti back fire valve) and the system wired with ignition switch of the car.

CONCLUSIONS

- The Hydrogen Booster system reduces fuel consumption for the engine, approximately 6%.
- The Hydrogen Booster system reduces these gases HC, CO and NOx (30%, 22% and 29% respectively) and increases these gases CO₂ and O₂ (8% and 18% respectively) for the exhaust gases from the engine.

REFERENCES