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Performance of hybrid compression ignition engine using hydroxy (HHO) from dry cell

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ABSTRACT

The high consumption rates of fossil fuel and unburned hydrocarbons pollution in exhaust gases are considered to be the main problems that face the world today. The use of Brown's gas (HHO gas i.e. mixture of hydrogen and oxygen) as a new source of energy, reducing the amount of injected fuel and ensuring complete combustion of the mixture are gaining an increasing interest worldwide. There are two different types of HHO cells; HHO wet cell and HHO dry cell. In this paper, the HHO dry cell was used because it has several advantages, such as its small size and ease to install in engines. The HHO dry cell uses the electrolysis process in order to produce the HHO gas from water, which is ionized by adding NaOH as the electrolyte. Three types of HHO dry cell were used, namely alpha, beta and omega cells. Many measured data were done to choose the best one of the HHO dry cells. Oxygen sensor, MAP sensor, and MAF sensor were used to control the fuel injection. From the recorded measured experimental data, the beta cell has shown a good performance for the engine. The amount of HHO gas needed to be supplied to a 1500 CC engine is 0.375 LPM. The results also showed that there is a 17% reduction in fuel consumption and a 17% reduction in CO, a 27% reduction in HC, a 15% increase in O_2 and a 1% increase in CO_2.

1. Introduction

In the present time, the growing concern of the world is the availability of fuel for both the current and the future generations. The use of fossil fuel has increased over the past few decades. This fuel causes a high level of pollutants in the atmosphere, which can cause mega world problems such as global warming [1]. So a new trend arose in the world in the past few decades to reduce the usage of fossil fuel gradually, by replacing it with a cleaner, renewable energy source. Many scientists have conducted many researches and experiments about biodiesel and hydrogen usage [2,3]. Hence began the evolution of the hybrid vehicles. A hybrid vehicle is defined as any vehicle that has combined more than one source of on-board power that can directly or indirectly provide propulsion power [4]. The hybrid vehicle attempts to significantly increase the mileage and reduce the emission levels of gasoline powered engines and diesel engines.

One imperative, generally spread hybrid engine is the hydrogen hybrids engines. These engines are utilized with the hydrogen fuel cell by converting the gasses to electrical power for movement. Hydrogen is widely acknowledged as a non-polluting, renewable and recyclable fuel. It has many advantages such as; a wide range of flammability, low ignition energy, small quenching distance, high auto ignition temperature, the high flame speed at stoichiometric ratios, high diffusivity and very low density [5]. Car producers around the globe are creating hydrogen-fueled technologies, for example, BMW, HONDA, and MAZDA by utilizing hydrogen-fueled internal combustion engines. These frameworks are unique in relation to the HHO generator. The hydrogen cell vehicles supplant the fuel with hydrogen, and they have a tank to store hydrogen, which is filled occasionally. Hydrogen is extremely dangerous and on account of a crash, the tank could detonate causing a disaster. On the other hand, the HHO generator controlled vehicles are significantly more secure than hydrogen engine. This kind of generator is can be implemented easily in any car with some minor modifications.

HHO gas is a blend of hydrogen and oxygen resulting from the electrolysis procedure of water. The water hybrid vehicle utilizes the

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HHO (Oxy-Hydrogen) generator to supply hydrogen on request by electrolysis. The electrolysis procedure occurs in the HHO dry cell when the current starts flowing through the stainless steel plates, water molecules separated as HHO gas between the two terminals of the plates. During the operation of the IC engine of a hybrid vehicle, the battery is continuously charged using the battery-utilizing alternator that run through the generator. The hybrid engines provide an affordable low emission fuel-efficient vehicle with high performance better than the conventional engines.

Ji and Wang [6] studied experimentally the effect of hydrogen addition on enhancing the engine performance. They used two hydrogen volume fractions of 3% and 6%. The results showed that using hydrogen improved the brake thermal efficiency by 26.37–31.56%, with a 6% hydrogen blending level. In addition, the emissions of HC and CO_2 are reduced, but the NO_x emissions are increased with increasing the hydrogen addition. Sopena et al. [7] compared the emissions characteristics of the hydrogen and gasoline engines. Their results showed that the thermal efficiency of the engine using hydrogen was higher than that of the gasoline engine. However, the torque output of hydrogen engine was lower than that of the gasoline engine due to the low volume energy density of hydrogen. Wang et al. [8] compared the effects of using hydrogen and hydroxy on the performance of a gasoline engine at 1400 rpm. An electronic control unit was used to control the hydroxy volume fractions. Their results showed that the fuel flow rate decreased after hydrogen addition, but it increased with hydroxy blending. The emissions of HC decreased, whereas NO_x increased with the increased hydrogen and hydroxy. The CO emissions increased after hydrogen but decreased with using hydroxy.

Wang et al. [9] investigated the effect of using hydroxygen on the performance of a gasoline engine. They used three hydroxygen volume fractions of 0%, 2%, and 4%. The emissions of HC and CO decreased, but the emissions of NO_x increased after the hydroxygen addition. The effect of increasing the hydrogen volume fraction in hydroxygen was studied by Wang et al. [10]. Their results confirmed the obtained results of [9]. Changwei et al. [11] investigated the performance of a methanol engine at part load and lean conditions by using hydrogen addition. They used two hydrogen volume fractions in the intake of 0% and 3%. Their results showed that using hydrogen enhanced the brake thermal efficiency of the engine, and the emissions of HC and CO emissions reduced. The emissions of NO_x dropped to a low level under high excess air ratios for the engine. Masjuki et al. [12] evaluated the biodiesel fuel economy and emission characteristic using HHO gas for IC engine.

Their results showed that the HHO generator improved the engine power by 2%, and 5% less fuel consumption. The CO and HC emissions reduced by 20% and 10% respectively. Baltacioglu et al. [13] compared the emission characteristics and the performance of a diesel engine using pure hydrogen, biodiesel and HHO gas. The results showed that the engine performance (brake power, brake torque, and brake specific fuel consumption) was increased with the use HHO more than pure hydrogen compared with the standard diesel fuel operating condition. Regarding the exhaust emission values (NO_x, CO_2, CO) pure hydrogen provided better results than HHO gas.

Ozcanli et al. [14] investigated the emissions characteristics and the performance of a diesel engine fueled with hydrogen or HHO-enriched Castor oil methyl ester (CME)-diesel blends. The results showed that, using HHO-enriched CME20 improved the performance by 4.3% compared with diesel fuel. On the other hand, using pure hydrogen enriched CME20 fuel only increased the performance by 2.6%. Uludamar et al. [15] evaluated the vibration level of a hydroxyl gas generator and diesel engine using different kinds of biodiesel fuels. They used different values of flow rates of sunflower, canola, and corn biodiesels. The results showed that, HHO addition improved the vibration with average decrement of 1.23%, 2.34%, and 3.54% for HHO-2, HHO-4 and HHO-6 addition, respectively.

From the previous reviews, it is very important to increase the engine performance and reduce the exhaust emission values of NO_x, CO_2 and CO. Therefore, the main objectives of this paper are to design, build and compare three dry cells, namely alpha, beta, and omega. Also to design and build a practical and economical HHO generator that can be used to increase engine efficiency by using the process of electrolysis, yielding a mixture of hydrogen and oxygen gas.

2. Experimental setup and procedure

2.1. Types of HHO cells

There are two different types of HHO cells, dry and wet cells. In the case of wet cells, the electrodes in the gas generator became immersed in the electrolyte liquid contained in a vessel of water. There are many advantages for wet cells such as more gas production, stability, easy maintenance, and easy manufacturing. The disadvantages of the wet cell are that it needs more current, more heat generated through the cells, and corrosion through the positive electrodes (anodes) [16]. The heat generated through the cells and the additional current generates more heat, which converts the water into steam. The steam is collected and replaces the hydrogen gas volume. Dry HHO cells are designed to overcome the disadvantages of the wet HHO cell type. The result of HHO gas is the same in both types, but the difference relies on the electrolyte reservoir and electrodes plate displacement. Dry HHO cell has many advantages, such as that it needs less current for each cell due to the volumetric size of the electrolyte within the closed chamber. It is compact in design to benefit the modern engines and for less frequent maintenance [16]. Less corrosion occurs on the anode plates due to the restricted volume of electrolyte solution per second.

2.2. General design of dry cell

The used dry cell for hydrogen generators has been sealed between each set of electrodes (plates) to prevent any water leakage from one compartment to another. The bottom edges of the plates are sealed in a manner that keeps the water from touching them. Dry cell designs are cheaper since they are usually smaller. This design can vary in shape or size and is very easy to install. The used material for the plates is stainless steel 316L, and regular rubber O-rings are used to separate them. These types of cells have water continuously running through them, so a water tank should be used. Fig. 1 shows a schematic illustration of the HHO system with safety component installed on the engine.

2.3. Parameters controlling the cell design

As mentioned before the dry cell design can vary in shape or size depending on the purpose of the cell and the amount of the output needed from the cell. Obviously, some parameters can control the cell performance and design. The dry cell can be constructed manually by assembling the main components, which are; plates, sealing agent, hoses and nails, valve, electrical wires, bubbler and water tank. According to the electrolysis process, the plates should be made of metal. It is necessary to select a fine material of metal that has the suitable properties, specifically good electrical conductivity, lightness, corrosion resistance, good thermal properties and good physical properties. After studying the different types of metals and their properties, it is found that the most suitable metal for the electrolysis process is stainless steel 316L. Its density is 7.96 g/cm^3, melting point 1370–1400 °C and thermal conductivity 16.3 W/m K. The sealing agent is required between each plate in order to separate the plates creating multi-cell systems.362902527113865 This sealing agent has an important function to prevent the direct contact of plates and prevent escaping of water and gas.

The gasket and O-rings are used to provide a tight seal over a range of pressures, temperatures, and tolerances. Acrylic plastic is used to cover the plates and the sealing agent. It contains the inlet and outlet