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OPTIMIZATION OF FUEL CONSUMPTION USING HHO IN HDL TECHNIQUE VERIFIED IN FPGA.

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ABSTRACT

Fuel optimization plays a vital role all over the world. In this work, there are three major faces: The first face is designing HHO generator assembly which is related to mechanical designs and second face is designing a circuit board for Pressure sensor, Temperature sensor, and Oxygen sensor and its overall electrification, plumping works with gas tight protection, and also designing electronics circuits for different sensors to interface with FPGA the third face is designing electrolytic process control using a System on Chip as a Core in VHDL and implementing in FPGA. This Core monitors the HHO generator with sensors and its accessories continuously measuring the vehicle engine performance . From this design the fuel utility is reduced from 15% to 30% which minimizes the carbon deposition in the cylinder thereby increasing the changing period of engine oil, it also improves the efficiency of the engine and the life span. Engine torque also increased and pollution gets reduced to maintaining the green house effect. Overall the cost of the product is very low.

Key words: *HHO*, CPU, VHDL, FPGA, sensors.

1. INTRODUCTION

Alternate fuel is important and it should be fossil one. Actually we spend one third of our income for our vehicle fuelling and the vehicle gives harmful decomposed materials like *CO, NOx, HC, WCBSFC*, etc...in the form of smoke. These materials are all affects the engine performance, and pollutes the environment. Compare to other kinds of fuel around the world, water is one of the free recourses and by applying the technique, it can be converted into hydrogen with oxygen, its chemical term is *HHO* and in general "*Free Energy*". It is cheaper, safer, tremendous explosive and never pollutes the atmosphere. While crossing a gas or diesel operated car we can feel the smell of the respective fuels, it shows that the fuel is not completely burnt. It is explicit that we waste fuel and pollute the atmosphere. To avoid these drawbacks, some level of *HHO* is mixed with filtered air, which is after the air filter system and before the engine in taken system of the car. This mixed *HHO* ignites releasing the extra electrons into the igniting fuel and thus the added extra energy from the *HHO* leads *cent percent* of complete burning of the fuel. The *HHO* has *Polymorphism* that is it acts differently - *before burning, while burning, and after burning.*

Before burning of *Hydrogen*, which is a lightest gas with one proton and one electron and more efficient fuel three times of the explosive power when camper to fuel gas and five times than petrol. Actually, the *Hydrogen* requires little bit of energy of ignition to produce wide level of tremendous flammable temperature in the speed of lighting and there is no chance to compare with other fuel in this world. As a result of fact it increases the engine performance, torque, and millage and minimums fuel consumption.

During burning the *HHO* into the engine with a tremendous explosion on that area and gives off high power of energy and automatically reverts to water vapour at once. Due to this action the engine not only getting higher torque but also gets easily cooled from 10 to 20 times faster than other fuels. For example after combustion of fuel in the engine the level of temperature is approximately 250^{o} F, but on the other hand mixing of *HHO* with same fuel means the engine temperature reduces approximately from 150^{o}F to 200^{o}F only because of vapour formations after combustion. Thus the engine life period gets wider, and reduces lubricating oil degradation beyond the limit of *Km.* Then oil changing period also gets

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lengthened. It leads in decrease of the maintenance cost and increase of interval of maintenance.

After burning the *HHO*, the engine gives steam and some percentage of oxygen on the exhaust side and the stream is automatically converted into water form in the atmosphere. Thus the exhausts emission also controls from 10% to 50%. The pollution also reduces and remaining *Oxygen* comes out from the exhausts.

1.A. CHEMICAL EQUATION

HHO is popular and common gas produced from electrolysis .It is really a combination of two gases hydrogen *H2* and *Oxygen O2*.The simple chemical equation for conversion of water *(liquid)* to *HHO (gas)* can be written as

$$H_2O_{(l)} \rightarrow HHO_{(g)}$$

Connected with a help of Direct current to Electrolytic cells is to dissociate water into hydrogen and oxygen.

$$2H_2O + ENERGY \rightarrow 2H_2 + O_2$$

The chemical process could be easily speed up by using catalyst and during the process the selected compound does not change its property. The main purpose of the catalyst is to reduce the amount of energy required for conversion. The following chemical equation describes the function of catalyst.

$$2H_2O + CATALYST + ENERGY \rightarrow 2H_2 + O_2 + CATALYST$$

As a result, *Hydrogen* (H_2) as well as *oxygen* (O_2) will be produced while splitting up of water. Chemically the following process is going on

Electrolysis: $2\,H_2O \rightarrow 2\,H_2 + O_2$

1.B. ENGINE CC DETAILS

Cubic Centimeters (CC): All automobile engines are categorized into its *CC*. For example an engine has four cylinder and each one is 100*CC* means then total *CC* is 4*100= 400 *CC*. 1000 *CC* is equal to one litre. The *HHO* requirements also depend upon the level of engine *CC* and other devices belted with engine like *AC,AirCompressor, Oilcompressor,etc*... Approximately 1000 *CC* engine without *AC* requires half a litre of *HHO* per minute. The car *AC* device capacity is 0.94 *Pounds* and approximately 100 *CC*. Hence the same 1000 *CC* engine with *AC* requires three fourth litre of *HHO* per minute.

2. DESIGN OF *HHO* GENERATOR

2.A. BASIC DETAILS FOR *HHO* GENERATOR

As said before, the *HHO* generator involves in the production of hydrogen and oxygen with a help of process of electrolysis. In this process, Direct Current is passed through electrodes to water, due to chemical reaction, the *positive plates* generate Oxygen and *negative plates* generate Hydrogen.
Pure water does not conduct electricity. Adding a base to the water creates an electrolytic solution and increases conductivity, allowing electrolysis to occur. Distilled water and *KOH* is the preferred electrolyte.
An electrolysis device is called an electrolyze cell, the process of using *DC* supply to the arranged electrodes which are immersed into the electrolysis split water into hydrogen and oxygen. The positive plate emits oxygen and negative plate emits hydrogen. When both are bubbled up and collected together – so called highly burnable fuel is produced. Storing this gas creates explosive effect so directly hosed into the air intake of the engine. Within the engine before firing this *HHO* gas is automatically mixed with filtered air and then combines with the fuel. By nature *HHO* supports with gas as well as diesel, another property.

While designing the *HHO* generator the following important points should be taken care: selection of electrodes, distance between two electrodes, connectivity between electrodes, selection of catalyst, its level, merits and demerits, selection of container, electrical connectivity and plumping with gas tight arrangement ,backfire protection .

2.B. MATERIAL SELECTION TO DESIGN ELECTRODES

There are different materials could be used as an electrode. But each one has its own merits and demerits .From the overall search the selection of material for electrodes should be *stainless steel*

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thicker in size. The electrodes shape is either in plate or tube form. The numbers of electrode depends on our gas requirements. The distance between each plate should be minimum and should have equal space all over the arrangement of electrodes. There are two methods of arrangements of *electrodes - without-neutral* and *with-neutral*. The *without-neutral* electrodes construction consists of number of positives P and negatives N plates which are all arranged alternatively, example if there are three set of positive and negative electrodes then *P-N-P-N-P-N* is the arrangement. Next *with-neutral* electrodes construction consists of number of *positives P ,neutral Nu ,and negatives N* plates which are all arranged in the following manner *P-Nu-Nu-N-Nu-Nu-P-Nu-Nu-N,or , P-Nu-Nu-Nu-N-Nu-Nu-Nu-P-Nu-Nu-Nu-N,* etc… The purpose of neutral plate is to prove better cooling effect while electro processing. Here the neutral plates are also of the same material and same size .But in this work the former one has been selected and designed as *P-N-P-N-P-N*. For the connectivity among positive electrodes and negative electrodes, they are arranged not to make any shot circuit at any condition and mechanically should be strong to withstand the electrolyte corrosions.

2.C. MATERIAL SELECTION TO DESIGN A CONTAINER

The container should have the following properties as follows: should withstand chemical corrosion, mechanical stress and strain, tremendous vibration and temperature. If it is transparent, it is easy to check the electrolyte level and its color and it should be a gas tight container, because *HHO* is a light weight gas compared to air. On the top of the container there are five holes as shown in figure two holes in opposites are for positive and negative terminal, one hole for gas outlet through gas hose, remaining two holes are provided for pressure sensor and temperature sensors .These arrangements are as shown in *figure 1.* With in the container up to top of the electrode either rain water or distilled water with a very little amount catalysts are added, because pure water will not conduct electricity. In this model of *HHO* tank one liter of distilled water with a pinch of *Baking Soda (NaHCO3)* and half a gram of *Sodium Hydroxide (NaOH)* are added as a catalysts.

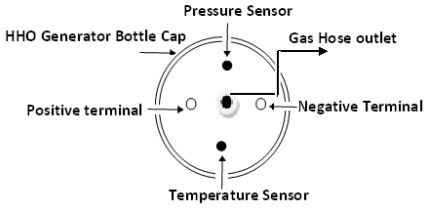

Figure1. HHO generator container bottle Cap with all sensors, Terminals and gas hose outlet details.

2.D. SELECTION OF CATALYSTS

The catalysts may be pinch of salt or *White Vinegar (H3C-COOH)* or *Baking Soda (NaHCO3)* or *Sodium Hydroxide (NaOH)* or *Potassium Hydroxide (KOH)* or *Potassium Carbonate (K2CO3).* Each catalyst has its own merits and demerits. As per the requirement the requirement the catalyst is chosen; otherwise it gives more heat with more gas but consumes more *DC* current from the vehicle battery. Density of electrolyte is directly proportional to current consumption.

2.E. DESIGNING OF BUBBLE BOTTLE

Bubbler is otherwise called safety bubbler or collector, which has a simple arrangement. The container should be flexible and withstand the vibration and little bit pressure, transparent and should have feet of height. These all conditions are satisfied by a simple water bottle made of plastic. With the incoming and outgoing plumbing works are as shown in *figure 2*,then it is called Bubbler.

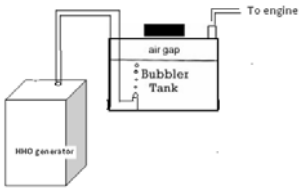

Figure 2: Single Bubbler arrangement.

The three fourth of the bubbler should filled with water. The gas incoming tube from the *HHO* generator should be dipped into bottom of the water level always. For that purpose the side of the tube is pasted up to bottom level of the bottle with little gap to let gas bubbles from the tube to the top of the water level. The outgoing tube should be at the top of the bottle top. These arrangements should be a gas tight one. This bubbler solves two important problems as the

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generated *HHO* bubbles are washed and avoid the chemicals from electrolyze to flow into engine and another important function is protection of flashback effect. Instead of single bubbler we may use more bubbler for our safety and cleaning the *HHO* brown gas as shown in *figure 3*.

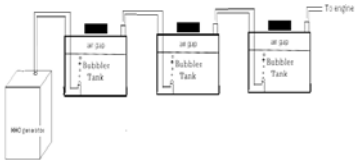

Figure 3: A *HHO* generator with three bubbler tank

For each and every incoming bubbler one back flow check valve has to be placed to avoid the back flow of the water into the *HHO* generator side. An important caution about the backfire is that we must ensure the water level in the bubbler at all times or otherwise it will lead to back fire explosion because *HHO* is ignited easily. To avoid this level of sever explosion we should use flashback arrester valve which are all available in market in different size and variety and if it is not available means we may use our own design with a help bronze wool as a backfire protection and do not try to store the *HHO* even if in small quantity level it may lead to larger explosion.

2.F. MINIMIZATION OF THERMAL RUNAWAY EFFECT IN ELECTROLYZE

Due to ageing of electrolyze or higher density the electrolysis process generates more temperature, due to this raises in the temperature the current flow through the electrolyzed also gets increased. Again due to current increases the temperature again and again gets increased and finally the electrolyze come to dry-out condition this effect is called thermal runaway. To avoid this *thermal runaway effect, a Pulse Width Modulator PWM* is used. A *PWM* generates a square wave with variable on to off ratio pulses, variation of the on to off period is from 0 to 100%. Through this variable on to off period of power supply which is applied to the *HHO* generator cell electrode as a result of fact the *PWM* avoid the thermal runway effect on the electrolyze. In this work, instead using a separate *PWM*, a *SoC Core* is designed and utilized .

2.G. PURPOSE OF EFIE

EFIE-Electronic Fuel Injection Enhancer is used to make it to avoid extra fuel consumption during extra oxygen in the engine. This device is readily available in automobile stores. Instead of *EFIE*, a *SoC Core* is designed and performance of *HHO* is continuously monitored with a help of oxygen at the exhaust side. A pressure sensor also placed in the *HHO* generator continuously monitor the *HHO* container pressure level and a temperature sensor is also used to avoid the *thermal runaway effect*. These three sensors *Oxygen, pressure,* and *temperature* outputs are connected as inputs to the *SoC core*. That core continuously watching these processes and vary the *DC* input pulse depends upon the thresholds value as what we set. This *SoC Core* is designed in *VHDL* with a help of *ModelSim SE6.1a* tool and the Counter Cell view details using *Mentor Graphics – Leonardo spectrum RTL schematic* also verified.

3. DESIGN OF *SoC Core*

The *SoC Core* has three inputs and single output. The *input voltage* is called as *Vin* and for the *PWM* purpose a clock is designed to generate continuous clock pulse to connect the electrode and depending upon duty cycle it could be varied its on and off period. As a input to the core *Vin 12 V DC*, and *Clock Clk* set to 100ns, that is *On* period is 50ns and *Off* period also 50ns. There are there *threshold values* are chosen for Pressure and oxygen sensor as “00” indicates low level of sensor output , hence during that time 15 pulses will be applied to electrode and 11 as high during that time only one pulse will be applied to electrode and 01 or 10 considered to be medium during that time 6 pulses will be applied to electrode. There are three sensors as listed; there are four cases as listed below.

3.A. CASE-1

When the Pressure and Oxygen sensors level are high means both will send “11” signal to the core and that core will reduce the Pulse to the electrode from previous condition of clock pulse to one clock pulse and continuously maintain until next threshold signal . Due to this lower pulse rating to the electrode, the generating gas level also reduced to certain required level, which is as shown in *Graph I*.

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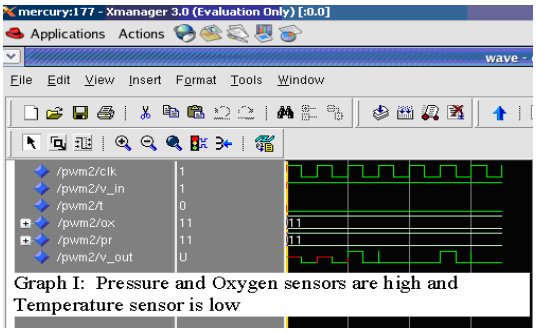
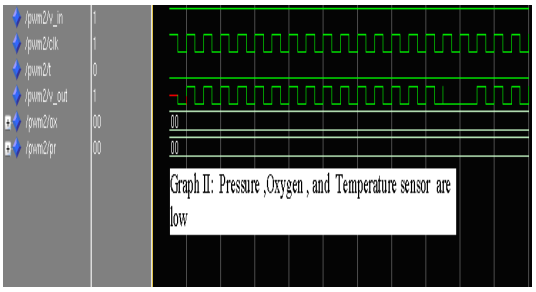


Graph I: Pressure and Oxygen sensors are high and Temperature sensor is low.

3.B. CASE II

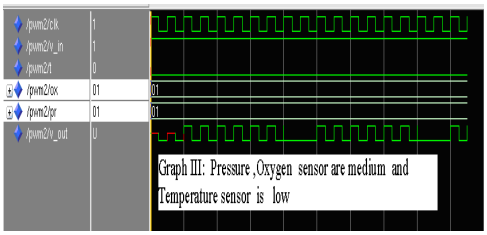
When the Pressure and Oxygen sensors level are low means both will send "00" signal to the core and that core will improve the Pulse to the electrode from one clock pulse to 15 clock pulses and continuously maintain until next threshold signal . Due to this higher pulse rating to the electrode, the generating gas level also improved to certain required level, which is as shown in *Graph II.*



Graph II: Pressure, Oxygen, and Temperature sensor are low.

3.C. CASE III

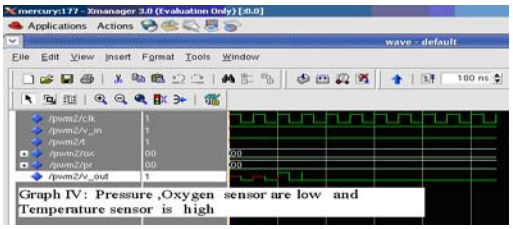
When the Pressure and Oxygen sensors level are Medium means both will send either "01" or "10" signal send it to the core due to this now the electrode gets 6 pulses instead of 15 clock pulses and continuously maintain until next threshold signal . Under this condition the generating gas level is maintained continuously to keep the pressure at a medium level, which is as shown in *Graph III*.



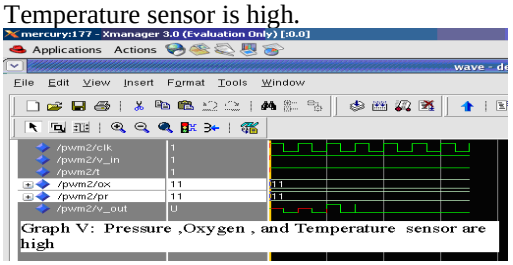
Graph III: Pressure, Oxygen sensors are medium and Temperature is low.

3.D. CASE IV

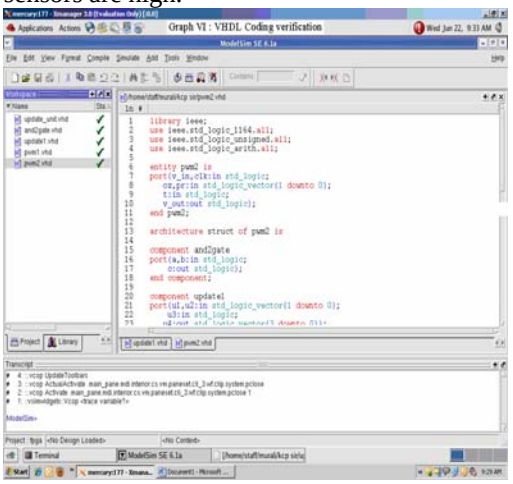
Among these three sensors the very important effort is given to the thermal run-away is continuously monitored by thermal sensor. Under any condition of Oxygen and Pressure sensor, whenever the temperature sensor gives logical '1' value means the temperature level is high in the generator, during that time the core automatically set the pulse to the minimum level, that is one pulse and continuously maintain until next threshold signal from the temperature sensor, which is as shown in *Graph IV*. Due to this lower pulse rating to the electrode, the generating temperature in the electrolyte also reduced to certain required level. If the temperature sensor gives logic '0' value, then the core will follow the first three cases, which is as shown in *Graph V*. The *Graph VI* shows the *SoC* simulation model.



Graph IV: Pressure, Oxygen sensors are low and Temperature sensor is high.



Graph V: Pressure, Oxygen and Temperature sensors are high.



Graph VI: VHDL Code verification using ModelSim SE6.1a.

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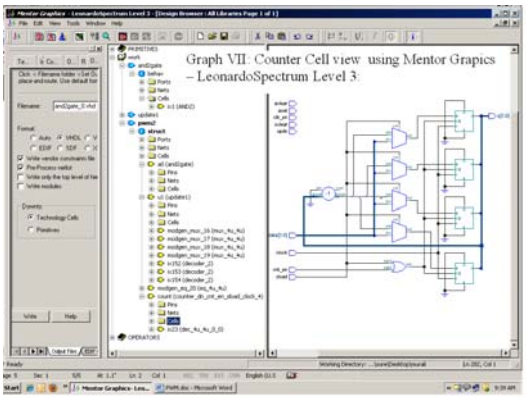

Graph VII: Counter Cell view details using Mentor Graphics – Leonardo spectrum RTL schematic.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS

In the testing point of view, there are three methods as first one without *HHO* generator, the second condition with *HHO* generator but without *SoC Core* and the final condition as with *HHO* generator and *SoC Core* .All the test are done on the *870CC* petrol start gas run car engine. All the condition like its performance of mileage, *HHO* generator heat, car engine heat, current consumption by *HHO* generator, engine running performance all are noted under road test condition with average speed of from 60Km to 120Km. Exhauster water wafer is monitored under standstill condition all are shown in *Table 1*. Compare these three conditions the last condition the *HHO* with *SoC Core* gives more performance. During this condition car mileage gets increased to 20% and engine runs very smoothly. more engine torque with less paddling of accelerator, under loaded condition on the steep climbing road even if the accelerator pedal is gradually reduced the engine gives constant torque without vibration. From starting of the engine to till the end, more sprinkle of water vapour is found when compared to previous two conditions. Engine temperature is noted with a help of car dashboard temperature monitor and it is found that position of the needle is found in lower position when compared to previous two conditions.

Condition	Mileage Mileage per liter In KM	HHO Generator electrolyte temperature in centigrade	HHO Generator Current consumption In Amps	Engine functionality and exhaust wafer level	Engine Temperature monitored from dash board indicator and thermo meter.
Without HHO generator	14	----	---	Good running and normal water drops from the exhaust	Meter needle at middle (≈200°F)
With HHO without Core	16	30o o 50o	3.5	Smooth running Light water wafer continuously from exhaust.	Somewhat less than the previous position (≈180°F).
HHO with Core	18.5	15o to 25o	1.25	Very smooth and continuous sprinkle of water wafer continuously from exhaust.	Meter needle at one third position. That is less than the previous condition (≈160°F).

Table 1: Engine performance details with and without *HHO* generator and SoC Core.

5. SAFETY PRECAUTIONS

1. Creates serious damage for vehicle as well as human being if it is not properly installed.
2. While installing the *HHO* kit the installer should use goggles and gloves.
3. The *HHO* kit should be installed while the engine in cool condition.
4. Should not store the *HHO* gas in any form.
5. During the electrolytic preparation use pure water with minimum level of catalyst.
6. Continuously watch water level.
7. Gas tight proof for container and all other accessories should be provided.
8. Pack electrical connection with fuse.
9. Use fire buster to avoid back fire effects.
10. No metallic dust particles should be found inside the *HHO* generator container.
11. Car battery terminals should be tight and corrosion free.
12. Vehicle should have fire fighting equipments.

6. TIPS AND TRICKS

While driving at High Way, reduce your throttle step by step as a result of fact it gives more fuel economy and it can be noted that more power is produced from vehicle, with the help of Fuel from *HHO* generator. This is because *HHO* helps to burn cent percent of fuel and let only 70% less emissions on the exhaust side.

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7. CONCLUSION

From this design the fuel efficiency and vehicle performance are increased. This is the safest method to give green house effect to the next generation people by installing this *HHO* model in all two and four wheelers vehicles.

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