

An Empirical Study for Achieving Economies of Scale by Utilization of (HHO) Hydrogen Hydroxy Gas as Additional Fuel

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Abstract

The scarcity of fossil fuel and Compressed Natural Gas (CNG) has made every 2nd fuel user to think on some alternative resources, or at least devise some sort of technique to overcome the shortage of fuel during CNG holidays. Thus this study covers an overview of HHO gas production, principles behind the reactions and statistical examples, observations of many engineers and observers who determined to make a use of HHO as additional fuel source. Up to now studies reveals that it is possible to produce burnable vapors of HHO gas in result of hydrolysis of distilled water with combination of some electrolyte sodium or potassium hydroxides. That Mixture is generally called Hydrogen-Hydroxide mixture (H-OH) can give 25%-28% efficiency to fuel combustion if used with fossil fuel. With thermodynamics advantages, by hydrolysis of steam and using different materials as electrode, using 1.3volt to 1.7volt at 0.4 A/cm² the total efficiency can be increased to 40-50% to enhance its utilization for industry use. But need to refine the misconceptions HHO gas is a standalone replacement of fossil fuel for a practical use in cars, scooters and other means of transport. This study suggest policy makers and entrepreneurs to take some supportive actions to promote HHO gas generators/ kits production because this is a low cost solution to cover the shortage of fossil fuel.

Keywords: HHO, Hydrogen, Hydroxy, Brown gas, Fuel efficiency.

1 INTRODUCTION

As it is generally believe that current energy resources are insufficient to satisfy the needs of consumer, therefore researchers are looking for various alternatives that could help them satisfy the consumer needs, here they have found that the a transition to hydrogen energy system could be very beneficial for economy in various ways for instance, it will enable them to achieve economies of scale, create job opportunities and decrease no of accidents (Perham, 2010)

Firstly it is believe that HHO can enable countries to achieve economies of scale and thus reducing the price as suspected reducing the cost per unit by 3000 euro, further importing crude oil cost countries millions of dollars were as if they could use hydrogen instead this will reduce the cost and further decreasing the trade deficit. In addition the cost associated with activities such as mining, drilling, exploring etc. could also be reduced enabling organizations to increase their profits thus causing the production methods of Hydrogen to be cost competitive as compared to methods of producing other energy resources (Perham, 2010).

Secondly if the organization moves to hydrogen energy system this will create job opportunities for employees working at all level of organization whether middle, lower or top. Thus reducing poverty by giving job to unemployed people further enabling countries to progress and improve their economy (Perham, 2010).

Lastly, human life which cost more than any expenses could be safe. As hydrogen is lighter than air thus it disperse in the air more quickly reducing the severness of accidents (Perham, 2010).

What is the HHO? And how this can be useful for a common man in Pakistan? Those were the basic questions which caused to go through this study. HHO is generally known as a mixture of Hydrogen- Hydrogen Oxide, which is produced by various means but here we will discuss mainly its production through Water electrolysis (HHO Research, 2012). Two gases Hydrogen and Oxygen form the Water, while the metal plates which are charged electrically, dipped in any electrolyte solution, both gases Hydrogen and oxygen generated together. Most chemists insist that it's a mixture of Oxygen and Hydrogen. This mixture is then inserted in the air intake of Petrol/ Diesel engine, which result increased efficiency of engine. It is known since times that Hydrogen may increase the engine efficiency, but not only Hydrogen some other gases also water vapors can do the same. But it was surprising when calculated per gram additional energy for mixture of hydrogen as HHO is comparatively hundreds time more then and energy yield by pure compressed hydrogen. These tests were taken

through professional environment with controlled operational engines of Trucks. Because Truck is well known for high consumption of fuel, also their engine couplings are easy to fit different system such like Dynamometers. Engines run tested at controlled speed and load differences under calculated and controlled condition (FoxValley Technical College Dynamometer Test Analysis, 2008)

A white paper of test results and analysis details attached at appendix –a., the resultant Engine Energy Table from that paper are given below (Cassidy, 1977).

Hydrogen Addition	Equivalence Ratio	Apparent Flame Speed		Input Energy		Energy Lost to Cooling System		Energy Lost to Exhaust		Indicated Horse Power		Break Horse Power		Exhaust Manifold Temperature	
		m/sec	ft./sec	Kw	hp	Kw	hp	Kw	hp	Kw	hp	Kw	hp	K	F
No	0.69	22	71	31	175	39	52	51	38	35	47	27	36	989	1322
Yes	0.69	35	114	118	158	42	56	32	43	37	50	27	36	896	1153
No	0.8	31	100	118	158	41	55	37	49	34	46	27	36	969	1286
Yes	0.8	40	132	122	163	45	60	33	44	37	50	27	36	943	1238
Yes	0.98	45	146	126	169	49	65	35	47	37	49	27	36	986	1315
No	0.96	34	113	122	164	46	62	34	46	37	49	27	36	981	1306

Table1: Energy Yield Values and other rationales to understand improving performance of HHO Gas

Peoples have some idea of HHO, some people thinks it as some miracle product to save every penny on fuel as to “run their cars and other vehicles on Water” or some people think it other way round as a fear of “carrying an explosive bomb in their Cars” which can explode any time; but the later study will help to understand both concepts are somehow more rigid then actual phenomenon. This study reveals and addresses the key factors keeping the point of view of a common man to have a broad view to help accept the realities, limitations and advantages of HHO gas, as well as it provide food for thoughts to derive simple ways and ideas to make a HHO generator with minimum effort and more safety. Saving time, with support of observation made for the pervious works done by hundreds of scientist, engineers, technicians and hobbyist.

1.1 Purpose

Purpose of this study is to clarify that how the HHO gas generating system works, and what is their behavior with different type of engine. Also to elaborate the precautions required in construction and use of a HHO cell to avoid negative affect on performance. This study may promote engineers and hobbyist to come forward and devise more useful system with better construction of HHO cells to be utilized as additional resource for fuel in Pakistan.

2 LITERATURE REVIEW

There are many examples of previous studies done to experiment the Hydrogen Hydro Oxy (HHO) Gas, different type of Hydrogen generating systems were introduced, with claims to be “best then ever built”. Here we review some of them to understand the construction and their salient features, quality of product with respect to the efforts consumed in making them.

2.1 HHO Generator Gas Conversion Kit Reviews

While ten years ago (Tylor, 2010) a certified mechanic step forward to test and trail different type of gadgets for achieving economic benefits in consumption of fuel. He got some 50miles to 80 miles per gallon (80km to 129km), though this achievement was anticipated with addition of hydrogen cell system inclusion. Now days more advance and compact fuel systems are being offered in European, US and Australian market. But in Pakistan yet peoples have not come up to this new technology. May be because this technology is not yet fame for the total replacement of fossil fuel, but this is to be worth to have as an additive tool for increased efficiency of engine, safer emission, yet help to make clean environment, and the utilization of car’s own electric thus no big consumable input, else to put distill water to the kits after hundreds of kilometers.

By a typical calculation this is revealed that the conversion of lunit of Water makes1850 times unit of HHO gas in volume (Ravi, 2008). Thus by empirical calculation this can be obtained if 1 liter of water is consumed, it may produce somewhat less or more, 1850 liters of burnable gas.. good enough to think for a seriously made effective and safe system for installation. So far the HHO gas kits may seem to give all best and efficient output. But there are some limitations and points to be noticed, as given below.

This is to clarify that there is NO 100% replacement of fossil fuel by adding HHO cell. (at least yet available systems in Pakistan). HHO gas is also known as Brown Gas, but this is to clarify that HHO gas is not brown in color, but it is named on Yule Brown, an Australian doctor. Who experimented and devised many type of HHO generator and booster systems.

HHO gas is highly inflammable with fuel, as it contains Oxygen, which is an oxidizing agent and can start burning with a small flame or heat as if exposed to heat in presence of any burnable substance, or gas.

The hydrogen part of HHO do not directly start burning, but as the production of H-H the hydrogen gas takes part in combustion, it makes other fuel to burn fast; but the Oxygen part of the HHO also instigate the burning on spark plug fire or combustion in diesel engine.

The amount of air intake taken to engine, not necessary to have a proper amount of oxygen, say there is less oxygen in the air, in hilly areas; or may be some industrial area having more other gases but lack of fresh air, and Oxygen. Thus installed HHO system helps provide a significant amount of Oxygen to the process, which result in good burning or combustion.

Self-experimenting or Installation of incomplete or rough construction of HHO cell replica are not recommended. Unless you have adequate knowledge of Gaseous Chemistry and handling of engine installation, wirings and precautions to work inside the engine compartment.

DANGER!! Less knowledge is always danger. Please use experience team/ vendors to install experimental system installations, if offered by some vendor as a Do It Yourself kit. (DIY)

However the efficiency of HHO systems have been claimed as of 30% to 50% by most of vendors, but it is also claimed by some users that they are running their cars 100% on HHO cell system. But those type of claim given by some extra ordinary experts and they did some typical modifications in plug system or in electronic system of cars. Novices are not recommended to trail modifications, to avoid serious losses and damages to their cars engine and Electronic Control Unit Or to prevent void the warranty on Car engine. (Tylor, 2010)

2.2 Production of HHO Gas by a Water Fuel Cell

This project involves creating a mixture of Hydrogen and Oxygen which is a highly EXPLOSIVE GAS if allow to burn in open air. When contained in a confined space, detonation of the gas would be highly dangerous and could cause serious injury.

2.2.1 How it works

Water is a compound made from the two elements of Hydrogen and Oxygen. It has the chemical symbol H₂O which indicates that each molecule is a combination of one Oxygen atom and two Hydrogen atoms.

All atoms can form 'ions'. These are just the same atom except with a little extra charge. Atoms can become ionized when in the presence an electric field. Hydrogen forms positive ions, and oxygen forms negative ions. We use this to our advantage by using an electric field to pull the water molecules apart.

By placing two electrodes (metal plates) into water we can create an electric field between them by connecting them to the terminals of a battery or power supply. The positive electrode is known as the anode, while the negative one is the cathode. Pure water actually does not conduct electricity so it is not suitable to be used without adding something to the water. Tap water already contains many dissolved compounds which allow the water to conduct. The ions formed in the water will be attracted to the electrode of opposite polarity, i.e. the positive hydrogen ions will move towards the cathode, while the negative oxygen ions move to the anode. Once the ions reach the surface of the electrodes the charges will be neutralized by adding or removing electrons. The gas is then free to bubble up out of the remaining water to be collected.

2.3 HHO Generators That Works. (Known as Dry Cell).

The new generation of HHO generators produced an amazing 52 mpg on a 2007 4cyl SUV are a complete departure from the previous HHO generator design from year 2007-2009. In the early model it was difficult to fit them in the small engine compartment. The main generator body was approx. 2.5 inches in width and about 12 inches long. But now the new rig is different. Because required hydrogen is 1 liter per minute, it allows them to make it compact. Looking at it in Fig1, it only 4 by 4 square inches! Anyone can almost fit this rig anywhere at the bottom of the engine by the frame.



Fig 1: HHO Dry Cell made of Steel plates (Grade 319L), housed in thick plastic plates



Fig 2: Construction and finished shape of latest type HHO cells. (Dry cell)

2.4 Study of some gadgets use to claim as Fuel saver

Mike Allan shared his experience conducted tests at the Universal Technical Institute, a large training facility for automotive technicians, in Houston. He tested following devices by using 4 trucks, with dyno pulls to determine horsepower and torque. Accelerated to a corrected 70 mph, set the cruise control to keep the speeds consistent and ran the trucks dry again, to study a base line of each truck's unmodified power and fuel consumption.

As several gadget studied showed no more than 1-2% difference in efficiency of engine, thus bring to idea that most of bubble reputed items are present in market but they are not effective such as they are claimed to be. Hence any device that claims quantum-level increases needs to be examined with considerable skepticism.(Allen, 2009)

2.5 The Project

This is a simple project that is used to create Hydrogen and Oxygen gas by electrolysis of water. The aim was to get good gas production rates without using extra chemicals or eroding the electrodes.

The first electrodes tried were ones left over from a different project. They were made from Copper coated Carbon rods which are not ideal due to copper being able to react with the water. The idea was that the copper would eventually all react away and there would be just Carbon left which would not pollute the water.

The copper seemed to take too long to react away and it was decided that this would not be useful at all. Below you can see the result of using copper electrode for electrolysis. The blue sludge floating on the surface of the water is some reactant of the copper and tap water.

Many people use electrodes made from stainless steel kitchen ware or switch plates because the stainless steel does not react as easily. The problem is that the grade of the steel often found in such items is not great and you will be left with a brown sludge after a few minutes of operation. They are also quite thin, usually less than 1mm, which means that they do not last a very long time before being totally eroded away. The erosion of the electrodes happens much more quickly when high currents or solutes (often called catalysts) are used. The volume of gas produced is proportional to the charge passing through the water (current) and therefore high current means more gas. To do this the spacing of the electrodes must be as close as possible while still having enough room for the gas to bubble out freely.

The metal chosen for the plates was special high grade stainless steel to reduce corrosion. Such metal is not as conductive as others like copper for instance, so these plates were made from thick sheets of 2mm to counter this potential limiting factor. Very high quality metal was used which meant it was too hard to cut with common DIY tools so these plates were cut using a high pressure water jet.

2.5.1 Information

Even the highest grade stainless steel will have some reaction with water and can produce toxic chemicals. Avoid touching the water after use.

The plates are layered on top of each other with nylon washers between used as spacing. They are placed in alternating positions so that the plates would be +-+-. Stainless steel fixings were then used to fit it all together. It is important that it is put together well otherwise sparks could occur in the gas production area resulting in an explosion.

A total of 16 plates were used in with 1mm spacing between each of them. The large combined surface area and thickness of the plates and bolts meant that this could carry very large currents without significant resistive heating in the metal. The total capacitance of the electrodes was 1nF when measured in air which indicates a large close surface area for gas production. This set of electrodes would draw about 25A from ordinary tap water. To collect the gas, the electrodes need to be placed in some sort of container. The container used was just something from a supermarket and was originally intended for storing something like tea!

This study shows the result of applying 12V to the electrodes when submerged in ordinary tap water. No 'catalysts' have been added to the water at all, this is just tap water!

It is drawing about 25A. Power to the cell is controlled using a pulse width modulation circuit.

The container was made from metal so it was important to place the electrodes on a plastic base to prevent any short circuits. This image shows how two banana sockets were installed either side of some copper and brass fittings used to extract the gas. The power and pipe fittings were screwed tightly and sealed with silicon sealant so that the closed container would be air tight.

The gas produced is a highly explosive mixture of Hydrogen and Oxygen and should be treated with extreme caution. A large volume of gas exists inside the container which if ignited would explode and destroy the container. To avoid detonating the gas, the pipe from the container is fed into the base of another container which is half filled with water. This allows the gas to bubble through the water to then be collected via another pipe which is used as the gas output. Now if any ignition occurs at the output, the flames can't get back past the bubbler device and into the large gas volume in the electrolysis cell. This is an absolutely essential safety device and should not be skipped.

Now it is just deciding what to do with the gas! A good way to see the how explosive the gas mixture is to bubble the gas through another container of water such as a mug and ignite the bubbles as they reach the surface. Each bubble will explode very loudly and probably blow out the lighter (R M Cybernetics, 2008).

2.6 Increased thermal efficiency

Thermal efficiency is different from combustion efficiency. Thermal efficiency refers to the amount of energy released by the combustion that gets converted to mechanical energy. It is almost always less than 50% for any type of heat engine, although it is comparatively high for diesel engines. Is it possible that the kinetics of the combustion could change in some way that increases thermal efficiency? This can be done by various means to some extent. It can be studied by monitoring instantaneous pressure in the cylinder as a function of crankshaft angle. This is a technique commonly used by automotive engineers. At some point, we hope to use this method to evaluate effects of HHO on combustion kinetics and thermodynamics. It has been used to study effect of hydrogen gas injection from compressed tanks in spark ignition engines; however the yields were only 15 kilojoules per gram of hydrogen, far below yields typically observed for HHO.

2.7 Clarification of Concepts regarding HHO

As per (Allen, 2009) addition of Hydrogen and Oxygen (known as Hydro Oxy) in the Fuel system of any combustion type engine, give increase combustion to the fuel (Petrol or Diesel). An action like as if used hi-octan or some high grade fuel introduce in engine. While as the HHO Cell use the current through voltages produced by existing alternator for battery charging and use in car electrical items. The electrical energy is ultimately produced by help of fossil fuel but its utilization with in production of HHO gas gives a instant return in energy gain by combustion of HHO gas mixture. Engine horse power is increased, also mileage by combustion of mixture of gas comparatively better then of Fossil fuel. This combination of two different chemical compositions do nto violate any law of physics, the advantage is gained due to better combustion which help to burn more of the fuel then it does with air only.

(Hodes, 1967) devised a combination of cells, instead of making a bigger size cell, he added 6 cells in in tubular design, and he kept all the cells to be separate, and typically isolated from other, such as water do not flow in between one cell to other, neither the gas produced from one cylinder pass through other one. But all of gas bubbles produced are collected at the top of container and then fed to one bubbler to eliminate water part from it. In such a way that water particles mix with water contained in bubbler and gas particles are taken to the engine air take for mixing with the fuel.

These types of cells are made at the early age of Hydrogen experimentation, but not popular now a days due to many risk factors. Such as fragility of container; because it contains liquid in which tubular electrodes are immersed. The overall temperature of container get rise while the current is passed through tubes and electrolytic solution. A re constructed model is shown below, with addition of Pulse width modulation circuit to control the current passing through tube electrodes. Right side of figure shows the production of HHO gas bubbles from all tubes separately and combining in the upper part of container.

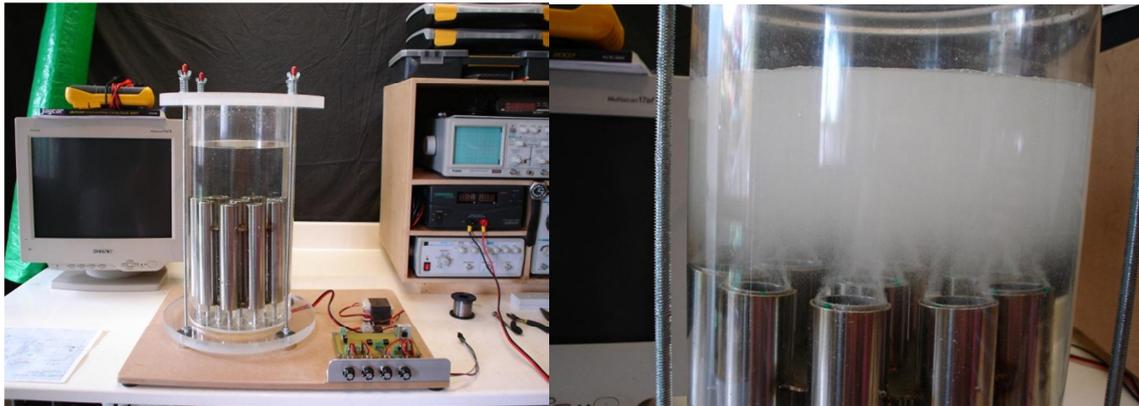


Fig 4: The typical construction of Tubular HHO wet cell. An orientation of HHO gas production (Ravi, 2008)

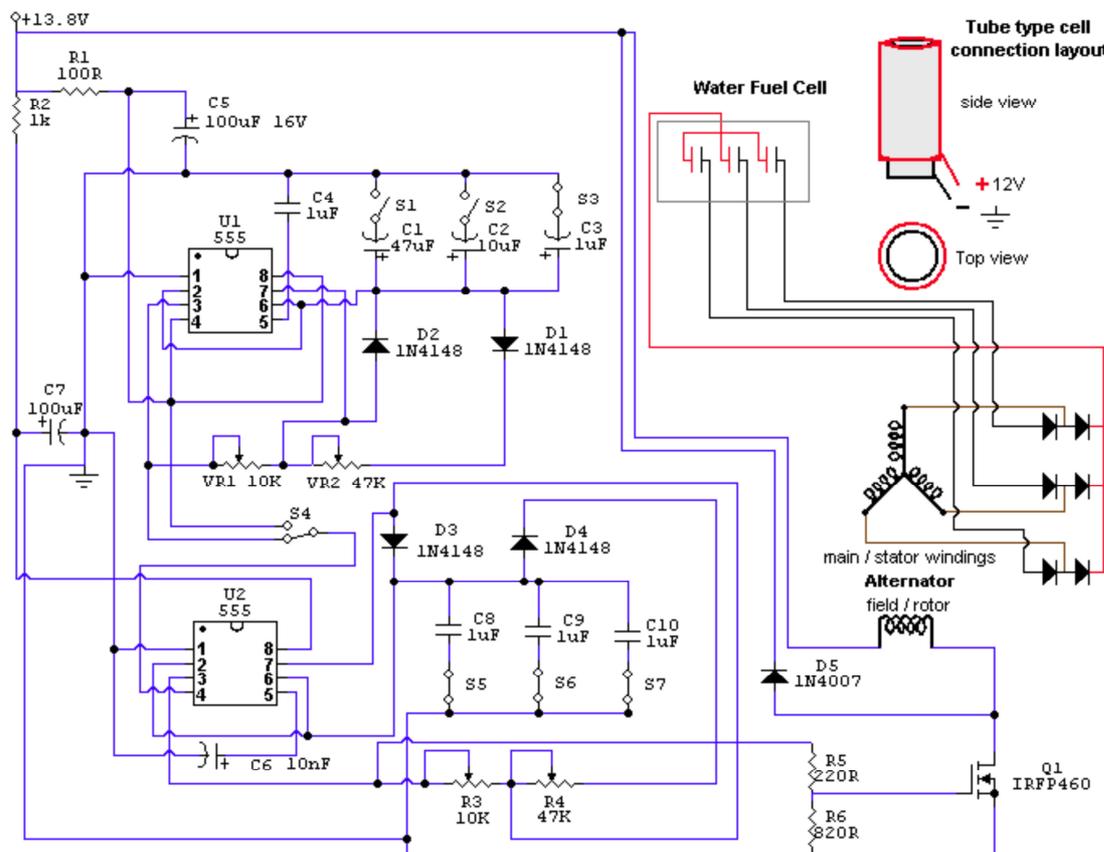


Fig 3: complete circuit diagram for HHO tube type cell, with DC pulse width modulation circuit. (Ravi, 2008)

Above given circuit for minimizing the heat, by controlling the frequency of positive going pulses which effects on ampere passing through tubes, but this also effect on brute force used for separating hydrogen and oxygen from water to produce HHO gas, but as the ampere drops the production of HHO gas also drops.

If someone measure the gas produced over 85 degree C, that would have more water than the burnable gas, hence it is learnt through practice that any system may not get over heat. Otherwise even if the bubbles are produced at very high level but no reasonable advantage will be gained in engine efficiency. Engine need at least 1 liter per min requirement for a normal run, and 2 liter per minute is well enough for a good speed.

HHO cell may need a cool place, where the fresh air may contact it directly to cool the body of the cell. It can be placed somewhere near to front grill, or near to fan. This will give help to have a fairly cool HHO system through air current. The output of water trap is connected to the air input, such as it enters into intake pipe before the breather. So that the gases introduced may filtered through air filter, this not only prevent back flash but works to give first line filtering of any more water vapors present that can be removed at this stage.

If the vehicle has fitted with electronic system, it is recommended to have Electronic Fuel Injection Emulator EFIE, with the HHO cell.

For a clean and longer last HHO cell working it is best to use best type of steel and pure distilled water.

The sweet point of every engine comes where the efficiency of engine gives great output out of HHO, but it has be learn via many hit and trails if any experimental system is installed. But for the professional made system, there are given approximate efficiency tables, as per different type of vehicles, but even then it is not always comply 100% because of change in vehicle engine condition, and different styles of driving.

The quantity mix of electrolyte is recommended at 5% for NaOH, or upto 10 % solution for KOH, such as the 50gram of NaOH mixed with 950 gram of water, or 100 gram of KOH mixed with 900 gram of water.

Below example of a practically tested pulse width modulator, which is based on well known timer IC LM555, this IC produce square waves of variable frequency, which can be kept adjusted as per practice requirement of some specific cell. The output of frequency modulated output from IC, is fed to FET transistors, which handles the current load to control the quantity of current passing through cell cylinders or plates. This circuit can handle 15- 25 amperes for continuous use of this PWM, it is recommended to use a small fan on the transistors, and heat sink to be fitted with care not to touch any plastic part or wires in the car control panel.

PULSE WIDTH AND FREQUENCY CONTROL FOR ELECTROLYSIS OF WATER.

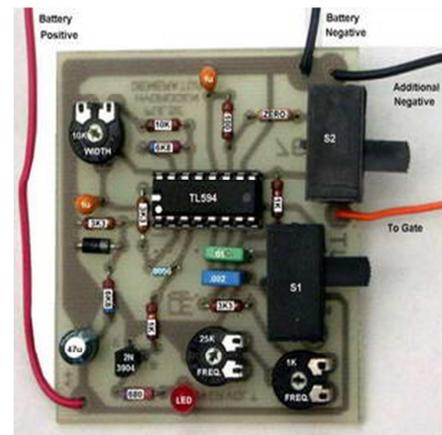
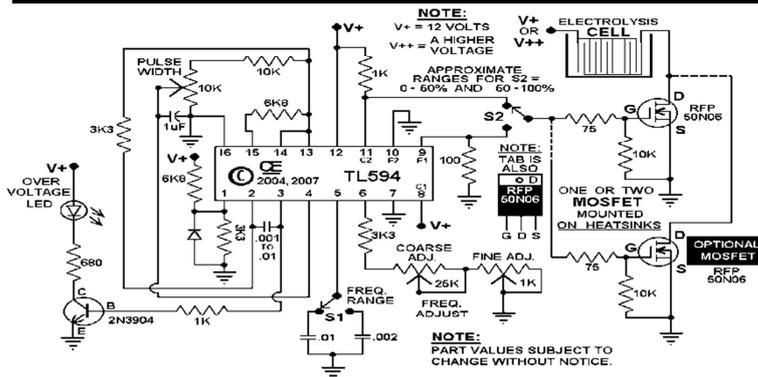


Fig 4: Schematic Diagram of Pulse width Modulator, with picture of a constructed circuit

As per Bob Boyce to get high resonance, efficient system, it needs to use high voltages. Because on lower voltages energy gain is not much higher than 1.1–1.2: 1 range. Bob Boyce concluded this result on 13.8v, he specifically recommends high voltage system, but with lower current dissipation, but the cost of high power system is concerned (Kelly, 2008)

2.8 A review of laws governing the HHO system

As per the studies of Faraday laws, it tells that 1.24v is the minimum required voltages to start efficient electrolysis. The pressure produced by 1.24v on electrodes two plates that make water to de-compose into its components i.e. Hydrogen and Oxygen. If the voltages are increased then it will increase the amount of heat produced. Experimenter Yule Brown did use 1.48v while Bob Boyce experimented with 2.0v to 3.0v. By hit and trail method it is learnt that Faraday’s defined 1.24v or later experimented 1.48v by Yule Brown, are somewhat not fulfill the purpose of HHO cell requirement. But by increasing the voltage this is observed that relatively high heat energy produced (actually loss of energy). But 1.24v seems to be very less pressure for the significant amount of HHO gas production. If require a 24hours, 7days a week service of HHO cell, it may need to use lower voltages for the electrolysis. This is also reveals through experiments that electrolyte substance, also affects the min. required voltages, and there are different minimum required voltages for different electrolytes to be used for hydrolysis production of HHO gas.

Faraday used the sulfuric acid as electrolyte, while he devised the 1.24v minimum required for hydrolysis. But by practice it is learnt that NaOH Sodium hydro oxide needs 1.69 v, and KOH potassium Hydro oxide need minimum voltage 1.67v.

Hence this helps to learn the fact that if a 12v DC battery is used with cells having 8p, 9p, 10p or more plates, that won’t work as it supposed to conceived, more plates more gas, by empirical formula of voltage and current, amperre this can be calculated as taking every cell as a load resistance to battery.

$$\text{Resultant voltage} = \text{Voltage of Cell 1} + \text{Voltage of Cell 2} + \text{Voltage of Cell 3} + \dots$$

For a system of 8 cells combined in series, the voltages requirement will be approx 14-15 volts, hence the practical output cannot be achieved by using a 12v battery. So far like this requirement of 11 cell will be approx 19-20volts. This gives a clear idea that why some experimental models do not give a practical output.

Hence if the 12.5 volt source is connected to 10 water compartment cells, it will give approx 1.25 volts drop against each cell. And the cell configuration will be +P OOOOO –N. As per Faraday’s law if a cell containing 11pltes in series, will produce 10.44 ML for every ampere. To maintain the heat produced by the cell

plates, current flowing through the cell is controlled. That's why there are several ways applied. One way is to use the Pulse Width Modulator, as a current limiter. The quantity of electrolyte solution to be used in proper percentage. Container of cell to be placed in such place where the air can contact it and make it air-cooled. The amount of current passing through the plates has a great affect on the production of HHO. Each side of plate passes .54 ampere of current through each square inch. More current passing through plates produce more amount of gas. But at the same time it makes more heat. Hence the produced bubbles are not always are the HHO gas, but it contains a large quantity of water vapors as well, thus it does not mean if the production of bubbles is more, it is the production of HHO gas.

Specific software is developed for the help of designers to determine approximate useable size of plates and current.

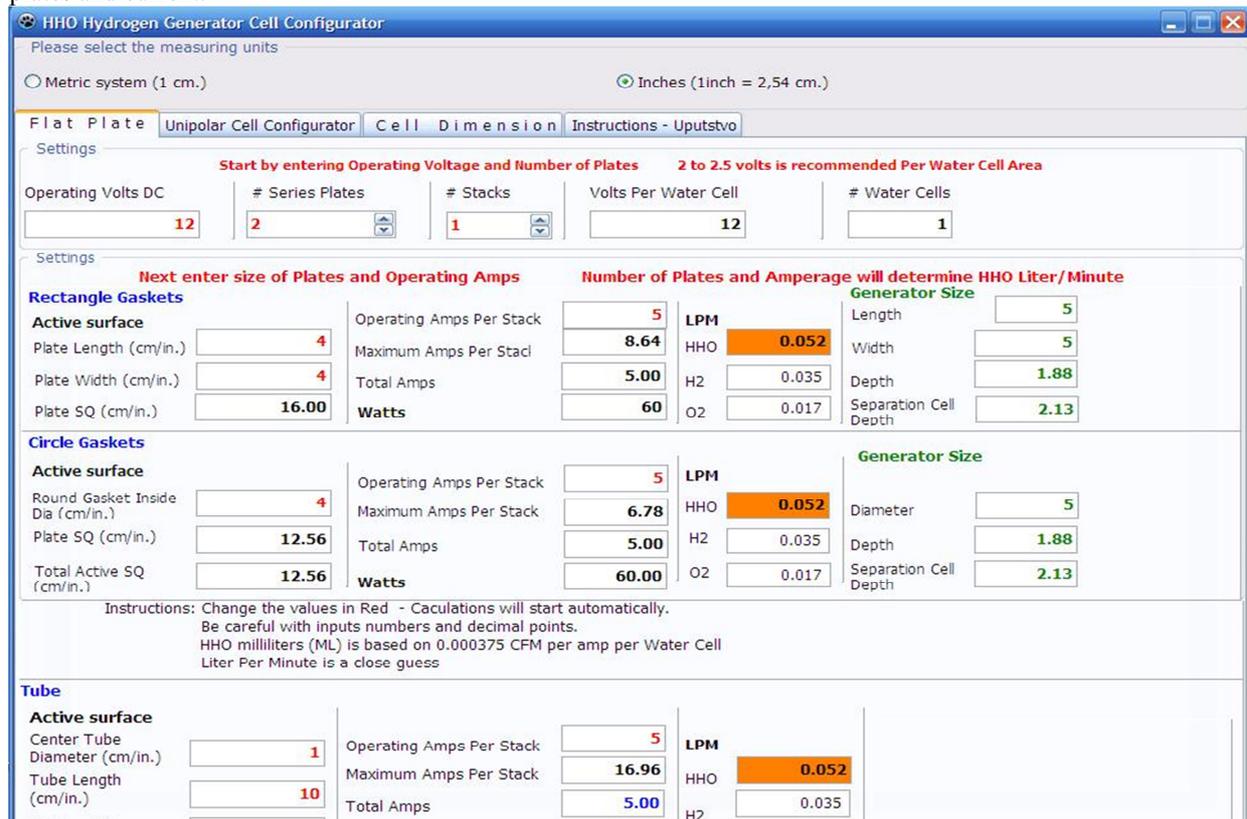


Fig 5: A typical view of Cell configurator software

3 METHODOLOGY

In this study I used exploratory and qualitative approach, most of the information gathered through secondary data via Case studies, Research papers, observation recorded by engineers and hobbyist.

Some part of primary data also included as I have interviewed Engineers test trail HHO systems, and some of them are related to market study, promotion of HHO kits. Respondents were selected on purposive basis. Also a sort of study is done by Experimental approach, for study of Dry and Wet Cell design, and pulse width modulator function.

4 RESULT&DISCUSSION

The outcome of literature review, and watching videos of several experiments of engineers and hobbyist, and production companies, it is concluded that HHO Kits are more likely a solution to decrease the load of Gas bills per month. But this product is yet not got matured market place or in some countries not yet legal to sale and authorized by national safety law agencies, therefore it is not recommended by car makers, to add/ alter their designed hardware otherwise the warranty will be void. But as in Pakistan most of the car users are running Cars already out of manufacturer's warranty, hence they have no fear of warranty violation, but this is again danger to alter the engine and its surroundings with a minimum knowledge, this is to be adhered strictly for the safety of one's self and surroundings.

4.1 Advantages of HHO

1. Savings a significant amount on gasoline for both long run highway movers, and within town driving.

2. Performance of vehicle is increased by adding HHO kit, engine wreckage can be delayed.
3. Carbon dioxide emissions reduced resulting safe environment.
4. Engine Temperature is reduced. Engine life span improved.
5. Cleans Carbon. It helps to remove carbon, and prevent carbon deposit in future.
6. Engine sound much quieter than before.

4.2 How the HHO system benefit?

The HHO cell, works to break the water through electrolysis into vapors (these vapors are burnable), process occurs in presence of some electrolyte. For this process of electrolysis, metal plates are electrically charged by the battery charging system of engine.

But it does require feed these vapors to engine via the inlet manifold lower the predetermined petrol or diesel delivery. If the hydrogen would reach the combustion chamber ready to combust with the normal petrol/ diesel fuel it wouldn't save any petrol/ diesel quantity because the engine doesn't know that there is hydrogen in the system and would not automatically lower fuel trim to suit the addition.

Piston moves inside the engine, in up-down position as per the speed of engine. The pistons up ward and down ward motion creates power which is converted to circular motion with the help of gears, and Car moves forward. (Or in reverse if reverse geared). When a Piston is down, it makes a vacuum, the valves takes air and fuel from different intake points, and while Piston moves UP, it compress the air, with Fuel and at this time a fire takes place through spark plug and the fuel ignite. A blast occur and repulsion force push the piston to lower position, and burnt fuel fumes emitted through exhaust valves by which a cycle of piston motion completes, its linear energy is converted to circular motion through crank, and the cycle is repeated accordingly. But if the fire of spark plug is bit early full amount of fuel is not burnt, and un burned fuel thrown out which not only increase pollution but increase consumption of fuel as well.

While HHO cell output (Hydrogen mixture vapors) combines with air and come into contact with fuel at combustion chamber of engine, piston gives more compression to fuel as the amount of molecules are increased, and later on ignition the hydrogen part given more fast burning to fuel, which reduce wastage of fuel, as un-burn emission. This also increases a power to engine and increase the efficiency kilometers per liter as evident by (Cassidy, 1977)

5 CONCLUSION

As there is a great shortage of fossil fuel in Pakistan, and consumers are suffering with loss of business or paying heavy cost for fossil and fuel; and now a day's CNG has become an "un approachable" product, even if someone may like to buy he cannot suffer for hours long queue. Even after paying high cost, some cities of Pakistan there is no availability of CNG over 3 to 5 week days. Consumers are suffering because of no alternate or any way to extend support in their existing fuel requirement. HHO fuel cells, runs on car's electric alternator and utilize water as consumable and it can be used as a low cost additional source of fuel to increase the per filling mileage of vehicle and can give a relief to the small scale – medium scale user after installation of HHO conversion. But HHO generators cells (electrolysis kits) need to be used with extra care. This is a mean to shelter the load but still there would be some requirement if fossil fuel. May be future models can eliminate the necessity of addition to fossil fuel.

Above study reveals that HHO cell provide more environmental safe emission and improve engine efficiency output 20%- 40% depends on the nature of engine and driving style.

5.1 Limitation of study

After the studies it is relinquish that more studies should be required to elaborate safety measures and additional methods to improve the current losses in electrolysis of water. More ever the considerable caution and practice with deep knowledge of gas handling is required to develop a "Self Made" HHO kit.

This study is not intended to market some specific product or to promote the manufacture, but to help in understanding the generation Hydrogen generators kits, and to answer some basic question regarding use of Hydrogen as alternate fuel.(Raju, 2008)

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