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## Design of HHO cell as energy source for electric vehicles

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**Abstract.** Hydrogen has proven itself to be a great source of energy due to its physical characteristics and its high availability. One way to use the energy inside hydrogen is the fuel cell. But inside a moving car, hydrogen storage tank existence requires high precautions and present many increasing risks; so our idea takes the theory of HHO (hydrogen generator) to separate hydrogen and then utilize a fuel cell to produce clean source of energy. This produced electrical energy will be used in operating an electrically powered car, and in charging the HHO cell. Electrically powered cars as an aim draws us to this work, the first part for producing hydrogen gas from water, the design parameters of the electrochemical cell, and the reached findings will be presented. It was found that stainless steel 304 was more convenient for the electrode materials compared with other metals. The amount of hydrogen evolved was confirmed by pop-sound test. The fuel cells was settled to be the most effective way to handle this source of power as its efficiency is relatively high. The fuel cells are used to convert the power in the hydrogen atoms to electricity by combining them with oxygen atom forming water molecules.

**Keywords:** Fuel cell Electric Vehicle, HHO (hydrogen generator), Electrical cars.

### 1. INTRODUCTION

As a result of fluctuation oil prices, consumption of fossil fuel resources, global warming and pollution, political tension and the enormous growth in energy demand, alternative renewable energies and effective use of fossil fuel have become the main concern for every nation. Energy demand and environmental crises and conflicts are combining to motivate national and international trend towards shifting from fossil fuel to a new, reliable, clean, and efficient source of energy.



Hydrogen has proven itself to be a great source of energy due to its physical characteristics and its high availability. One way to use the energy inside hydrogen is the fuel cell [1]. A simple hydrogen generator (HHO) is added to system, which uses electricity to obtain hydrogen from distilled water containing an electrolyte by electrolysis of water.

## 2. Previous Work

A new global concern, toward decreasing fuel consumption and emissions of internal combustion engines, is pushing research work to search alternative solutions that would not require a dramatic modification in engines design or using low cost electric vehicles. Among such solutions is using H<sub>2</sub> as an alternative fuel to enhance engine efficiency and produce solution to global warming [2]. This is not feasible from a commercial point view; building a system that generates H<sub>2</sub> and integrating it with the engine system yield an expensive manufacturing cost [3] and impact the vehicle market price.

Other recommended option is blending H<sub>2</sub> with Natural Gas [4– 13]. Ma et al. showed that the H<sub>2</sub>/NG mixture achieved shorter flame development and propagation periods, and so, the combustion efficiency is enhanced and emission levels were lower[3]. Musmar and Al-Rousan have designed, integrated and tested a compact HHO generating device on a gasoline engine. Their results showed that nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), and fuel consumption were reduced by 50%, 20%, and 30%, respectively, with an addition of HHO gas [14,15].



Fig. 1 Customized system by HHO[16]

The effect of HHO addition on CI engines was studied by Yilmaz et al.; their results reported an increase in engine torque by an average of 19.1%, a reduction in CO and Hydrocarbons (HC) emissions, and Specific Fuel Consumption (SFC) by averages of 13.5%, 5%, and 14%, respectively [17]. Ji et al. [18] have studied the effect of H<sub>2</sub> enrichment on a SI methanol-fueled engine, and reported an increase in Brake Mean Effective Pressure (Bmep) and both the thermal and volumetric efficiencies, with 3% of H<sub>2</sub> by volume of the intake air. The customized system shown in fig.1 represents our team aim from HHO application in the production of electricity by means of fuel cell, which will pave the road on the application of hydrogen fuel produced from HHO generator by means of water, air and fuel cell.

### 3. Methodology of research

Fig. 2, indicates the methodology of the research which passes through stages:

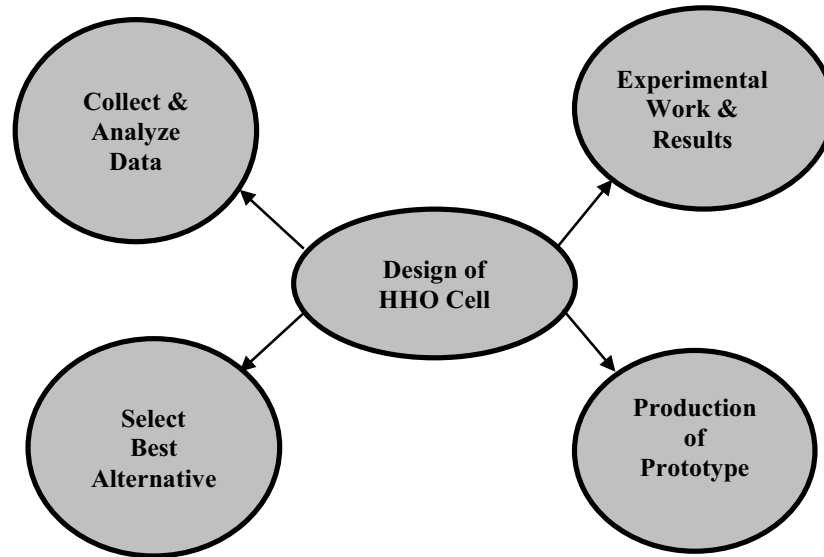


Fig. 2 Methodology of research

- Collect and analyze data
- Select best alternative
- Production of prototype
- Experimental work and results

### 4. Materials and methods

In the beginning, different types of materials were considered to be used, the difference between them and the advantages and disadvantages of each were scanned. For example, the hydrogen generator cell cover was previously found to be Artelon or Acrylic.

The Acrylic material was selected due to its characteristics, as it is transparent so it facilitates experiment observation. For the metal plates, it was optional to use iron, stainless steel and other materials, and the best option was stainless steel. Because of its ability to resist corrosion and its electrical conductivity, STST was selected. Then there were two choices: stainless steel (316, 304)

This work was chosen stainless steel 304 for several reasons such as: cheaper than (316) and easier measurement which was designed and then was chosen a suitable size for the insulator between the layers stainless steel which is compressible. After that, the raw materials were bought from local suppliers then have been formed based on measurements that have been designed in advance.

## 5. Design of HHO Cell

In the beginning the design of the shape of the hydrogen cell was executed based on the view of some different designs of the hydrogen cell and how to build it and then the appropriate design was chosen for the system in terms of design of cell slices and cell cover and length and type of screws as shown in Fig. 3-5, and then the full assembly of HHO cell is shown in Fig 6.

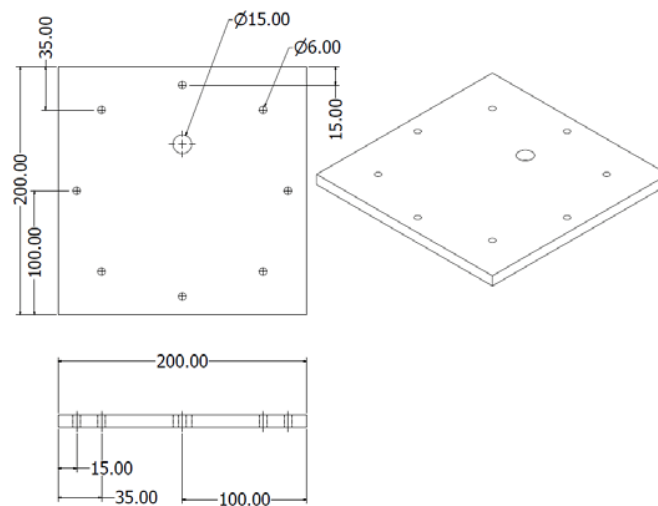


Fig. 3 Acrylic case design

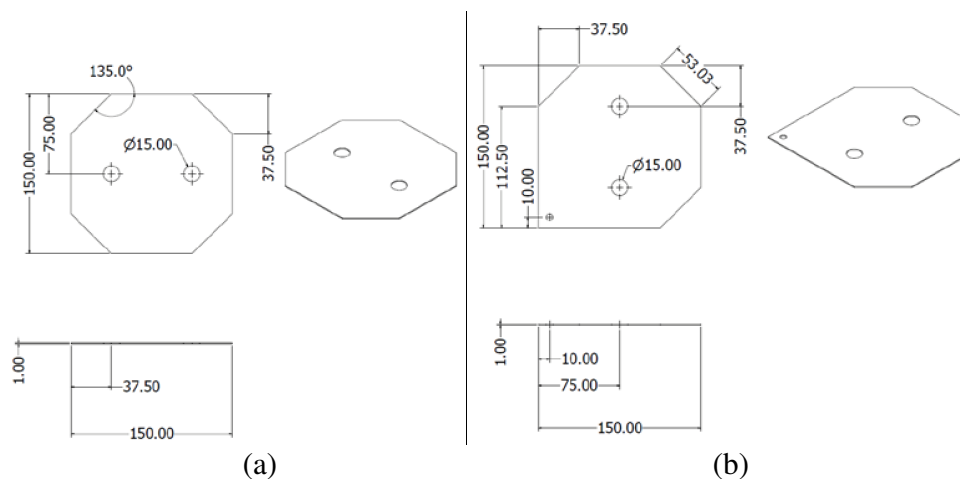


Fig. 4 (a) shows polarities plate design, (b)Neutral plate design

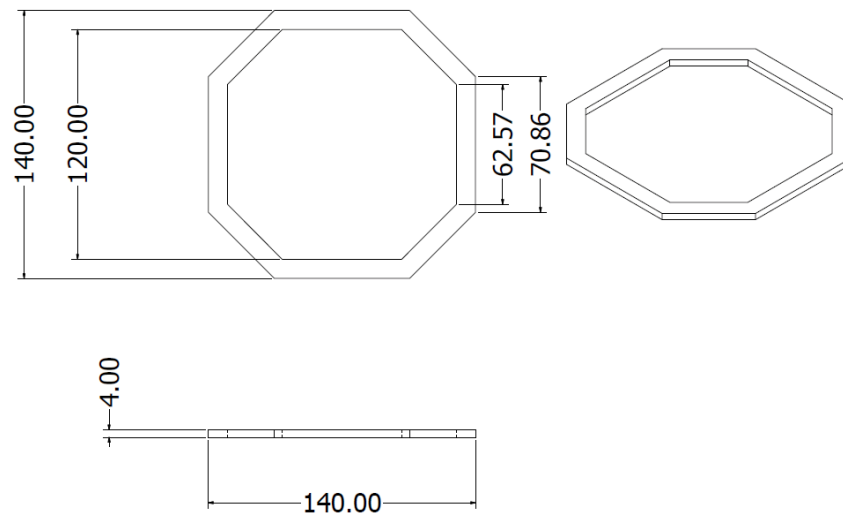


Fig. 5 Sealing design

## 6. Assembly of HHO cell

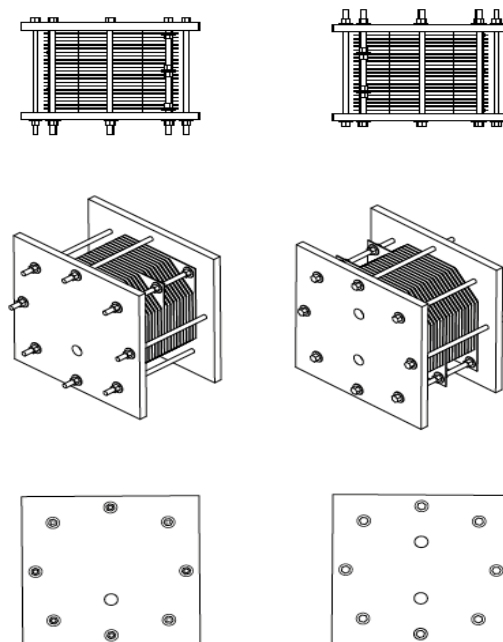


Fig. 6 Whole assembly of HHO cell

## 7. Experimental work and result

The assembly was determined to be 5 slabs would carry charges, between each two charged slabs 4 neutral plates as shown in fig. (6). Also, between each two stainless steel plate an insulation strips are to be added to prevent water from leakage.

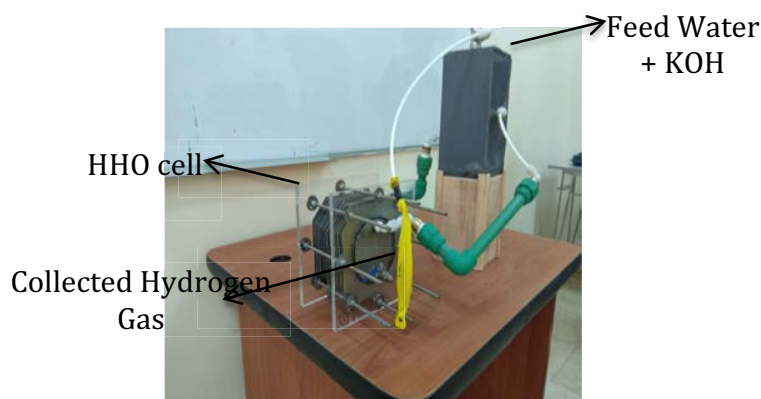


Fig. 7 Real HHO system generator

Then repeat this arrangement according to the size of the cell to be manufactured, in our case. Then two acrylic plates were used at both ends of the cell parallel to the plate. To bring this assembly together, a group of screws, nuts and washers were used. Then connect the water tank to the cell through two hoses and tight closed reservoir to prevent the leakage.

The real system implemented by our team is shown in fig.7 where hydrogen gas is produced by using 12.5 g/litre KOH as catalyst with distilled water which forms 0.15 litre  $H_2$ /min and assumed to increase with the increase in KOH concentration, and/or the number of plates.

## 8. Conclusion and Future work

As hydrogen was proven to be a great source of power due to its huge presence on earth's surface, a convenient way has to be found to control and use this source of power.

HHO generator will present a source to maximize the flow rate of hydrogen gas liberated from water when combined with fuel cells producing electricity and water. The power in the hydrogen atoms will be converted to electricity by combining them with oxygen atom forming water molecules and so get rid of risk of hydrogen storage with the absence of hydrogen re-fueling stations.

As a result for this project a hydrogen generator was built according to water electrolysis principle, which will be used to take in water and decompose it into oxygen and hydrogen gas. The output of this hydrogen generator is suitable for the use of the fuel cell to generate electrical power.

It is recommended for the future work to study the effect of both catalyst ratio and volume of water used advance on introducing HHO generator. The effect of replacement of hydrogen tank risks in moving cars will be also highlighted. The efficiency of fuel cell



used in producing electricity from hydrogen and oxygen. The control sensors used for flow and concentration of hydrogen produced will be recorded. An economic evaluation will be presented based on quantification of amount of electricity produced and both cells efficiency.

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