International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 07 | July - 2021 ISSN: 2582-3930

Solar Powered Hydrogen Stove

A.Janagiraaman [1], B.Shri Karthick[2], V.S.Sivachandran[3], M. Sadam Hussain[4]
[1] *Assistant professor, Department of EEE, Sri Manakula Vinayagar Engineering College, Puducherry, India.*
[2,3,4] *UG Scholor, Department of EEE ,Sri Manakula Vinayagar Engineering College, Puducherry, India.*

Abstract - This paper present about the use of Hydrogen as a cooking fuel over LPG gas. The Hydrogen gas separated from the water molecules by the process called electrolysis. In present days, LPG is used as a cooking fuel which gives out gases. LPG gas produced form fossil fuels which is a non renewable resources. It is also known that the availability of resources for the LPG fuel is low and we need to move for another fuel. Alternate fuel like Hydrogen will be a remarkable fuel in the tomorrow's world, which will answer today's non-renewable fuels shortage. The aim of this proposed project is to implement Hydrogen as cooking fuel by the process known as ELECTROLYSIS. The Hydrogen gas is driven out through the pipe connection from the tank here we have pressure sensor and a temperature sensor connected to it. These two sensors check the pressure and temperature if there is any change in the values this will generate the signal and sends to controller and this send a signal to relay to cut off the supply cut off the supply for electrolyzer. If the values from sensors are under the safe limit then the Hydrogen fuel gas moves to stove through the pipe. The gas came out is used as like a normal fuel for the stove and used to cook food. In this project, gasoline with Hydrogen gas which is an alternative energy. This can be used as fuel for cooking purpose .Our propose is to provide safe purpose of using Hydrogen gas as a cooking fuel and to work the stove under power cut situation by using solar system.

***Key Words*:** Water, Electrolysis, Hydrogen Gas, Cooking Gas.

1.INTRODUCTION

Non-renewable energy plays an important source of energy in the world. to Renewable energy is a growing field in the present world. In future, Renewable energy plays an important role as a source in various fields. Also, the non-renewable sources like coal and other sources are depleting in the earth's crust. This paves the way for bloom of various alternative fuels like renewable energy resources. In future, Hydrogen will be growing alternative Our conventional stove uses LPG gas as a cooking fuel. LPG gas is made up of Propane which is produced from Non-Renewable energy resources such as fossil fuels which is less abundant in nature. LPG gas is toxic, highly dangerous and it leaks, turning of near by devices may cause explode. The re-filling of gas cylinders is very difficult once cylinders is empty and membership is needed. Although the heating in induction stove is fast but on an average rated power is from 1500 to 3000 per hour watts. In order to use renewable energy resources and also with less power ratings we use Hydrogen as a cooking fuel. Under power cut situation the use of induction stove is difficult so we are using two sources for the stove. In order to overcome this type of difficulties, we use solar system with solar charge controller to provide supply for the electrolysis. By charging circuit we can use the stove both in normal and power cut situations.

2.PROPERTIES OF HYDROGEN

Hydrogen gas is flammable and odourless can be used as a good alternative fuel for non renewable source which can be produced from water.

Burning Concentration	4% in air
Pressure	0.5 to 12 atm
Temperature	100 degree (ambient temperature)

3.COMPARISON OF HYDROGEN AND PROPANE GAS

LPG gas is made up of mixture of Propane. Here we comparing the auto ignition rate of Hydrogen and Propane.

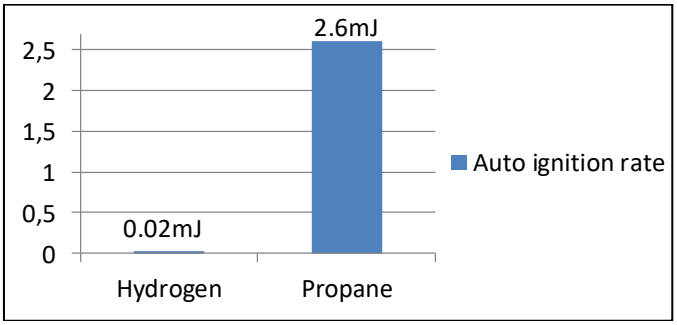


Fig -1: Comparison of auto ignition rate Hydrogen and Propane.

From the Fig 1, Hydrogen gas needs only 0.02mJ for ignition whereas Propane (LPG gas) need about 0.26mJ for ignition. Therefore, the auto rate of ignition is fast in Hydrogen than Propane.

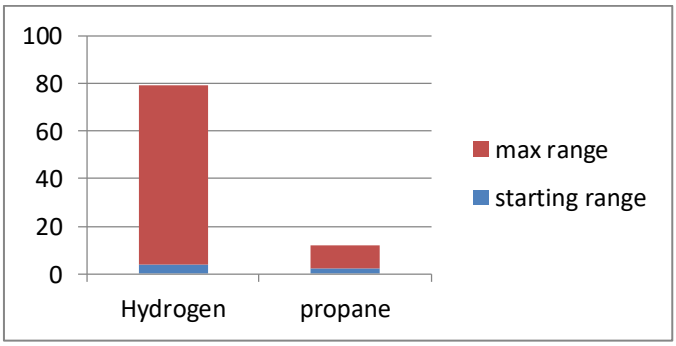


Fig -2: Comparison of flammability range of Hydrogen and Propane gas

From the Fig 2, it can be understood that the flammability range of Hydrogen is greater than Propane. So we suggest that

the Hydrogen gas is more efficient than LPG by using as a cooking fuel.

4.BLOCK DIAGRAM OF PROPOSED MODEL

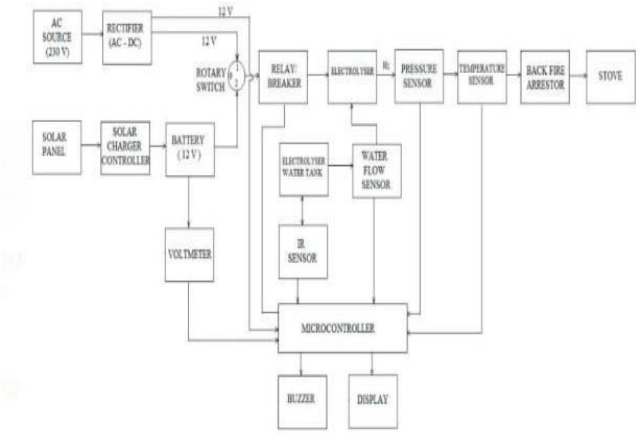


Fig -3:Block diagram of proposed model.

The Fig 3 describes the block diagram of the proposed model. The working of the proposed model can be understood from the block diagram.

The Hydrogen gas is produced from the electrolyzer tank when the electrolyzer gets supply from battery. If the battery does not have enough voltage, it is indicated in the display. And supply is switched over to Alternating current using rotary switch. The relay will be switched ON. The electrolyzer produces gas by electrolysis process using demineralized water from the tank.

The produced gas is send to the pipe and monitored. The temperature and pressure of the gas is checked and the signal is send to the microcontroller. These sensors will be present in the gas pipe. If the limit exceeds, the microcontroller send signal to the relay to OFF position. The electrolysis process stops. When the condition becomes normal, the relay switches to ON position and conducts supply to electrolyzer. Again the electrolyzer does electrolysis process and produces Hydrogen gas.

The produced Hydrogen gas is send to the pipe. And then send to back fire arrestor to avoid back fire. The final Hydrogen gas is send to the stove through the gas pipe. This Hydrogen gas is used as cooking gas.

5.DESIGN OF SOLAR POWERED HYDROGEN STOVE

5.1 Hydrogen production by electrolysis

Electrolysis is the process is used to ionize or break the water into Hydrogen and oxygen. Water(H_2O) molecule is divided into Hydrogen and oxygen by supplying 12v Dc voltage to the electrodes such as Cathode and Anode. The Hydrogen gas produced at Cathode and oxygen gas produced at Anode. From Cathode, Hydrogen gas produced is collected and used as the cooking fuel.

$$water(H2O) + DC\ supply \rightarrow 2H2(gas) + O2$$

At Cathode: $2H2O + 2electrons \rightarrow H2(gas) + 2OH$

At Anode : $2H2O \rightarrow O2(gas) + 4H + 4electrons$

To increase the Hydrogen production either we increase the input voltage or by adding the catalysts. Usually NaOH is used as the catalysts, Chlorine will accumulates in Cathode so it leads to corrosion. When KOH is used as a catalysts, it produces Hydrogen well as brown gas, it is less effective. So we suggest that $Ca(OH)_2$ as a catalysts, it speeds up the reaction and increases the productivity of Hydrogen. Oxygen will promotes the Hydrogen gas for combustion.

$$Ca(OH)2 + water \rightarrow Ca2(aq) + 2OH -$$

We are using two sources for the production of the Hydrogen both in normal and power cut situations.

5.2 **Sources for production**

AC Source

230V,50hz Ac supply is given to the step down transformer which step downs the 230V to 24V.Then step down Ac voltage is rectified to 12V dc supply. This power is used for the operation of electrolysis in the electrolyzer tank.

Solar Panel

The main source of DC supply comes from the solar energy. The 12 volt, 100 watt solar panel is used for this purpose. The energy from the panel is stored in the 12 volt battery using charger control circuit. The voltage of the battery is found by a voltmeter placed across the battery terminal. Which is checked by the controller, if the voltage in the battery is low then controller insists the user to switch the supply from Solar panel source to AC supply source.

6.DESIGN FOR BATTERY SELECTION

Step 1: Load estimation

Table -1: Load estimation table for battery

Load	Watts	Hr/day	Number	Watts-hr
Electrolysis tank	108	1	1	108

The table 1 describes about the load estimation of battery needed for solar powered hydrogen stove .

Step 2: Battery capacity

Energy needs to be supplied by battery is 108Wh, system voltage is 12V

$$\text{charge capacity} = \frac{\text{energy required}}{\text{Req vol}}$$

Battery Ah=9 Ah

Let us consider 12 V,9 Ah battery

So 108W battery needs about 3hours for charging from 40W solar Pannel

Therefore ,out of 9Ah battery capacity, only 9*0.7=6.3 Ah is usable

Usable watts from battery=(6.3)*(12)=75.6

Back time = 40 minutes

6.1 Relay and Rotary Switch

A rotary switch is used to switch the supply mode either from Solar or to AC Supply

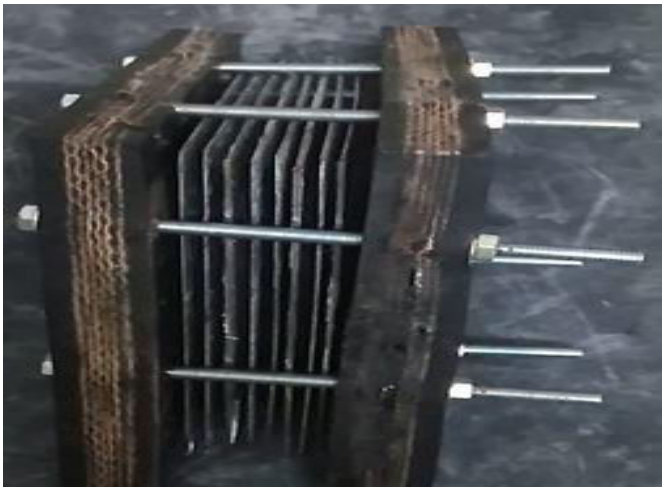
A relay switch is used for the ON & OFF control of the electrolyzer. Under normal condition, relay will be in ON position, therefore there will be a continuous supply to the electrolyzer. If Hydrogen produced at abnormal pressure and temperature, the relay switched to OFF position and stops the supply to the electrolyzer. And so the electrolysis process is stopped and also the production of Hydrogen gas is stopped. Then insist the user to wait for few seconds to obtain the normal condition as given by the latest alarm and lcd display system.

6.2 Electrolyzer

Electrolyzer is a tank, where electrolysis process takes place. Electrolysis is the chemical process of stimulating endergonic reactions by using electric current. DC supply is given to the electrolysis tank. On passing DC supply, Hydrogen gas is evolved from Cathode and oxygen is evolved from Anode. Demineralized water with catalysts is fed to the electrolyzer tank simultaneously.

It conist of electrodes made up of-stainless steel,11plates.

- Rating :12Volts,3Amps.
- Electrolyte-water+Calcium Hydroxide(catalyst)
- Thickness-2mm
- Length and Height-9cm
- Separator-Rubber Sheet
- Outer casing-1.2cm thickness of Hardplastic



6.3 Catalysts

$Ca(OH)_2$ (calcium Hydroxide) is used as the catalysts to increases the production of the Hydrogen gas.

$$Ca(OH)2 + water \rightarrow Ca2(aq) + 2OH -$$

Thus the addition of catalysts will increases the efficiency of the Hydrogen production. So 1:2 ratio of catalysts and water is added in the container with regular intervals.

6.4 Pressure Sensor

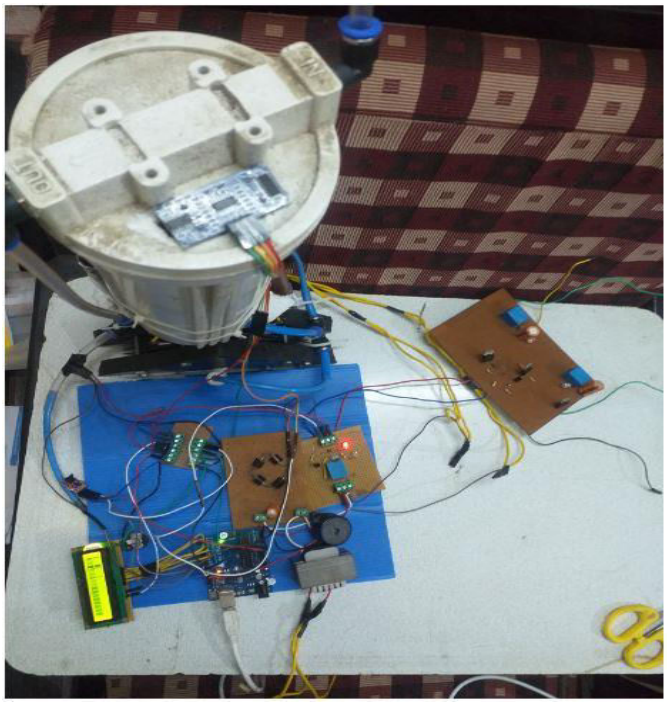
The pressure of the Hydrogen is also checked to avoid unconditional situation. If the pressure increases, there is a chance of explosion. Hence, a pressure sensor is used to monitor the pressure of the gas. The sensor gives the signal to microcontroller. If the pressure increases above 12 atm, the microcontroller sends a signal to switch off the relay and stops the process of production. This helps in reducing over production of gas, and so pressure also reduces.

6.5 Temperature sensor

LM35 Temperature sensor is used to sense the temperature of the outlet gas from the electrolyzer tank. It detects the temperature and sends the signal to a microcontroller.

6.6 Ultrasonic sensor

HCSR04 Ultrasonic sensor is fixed on the top of the container to check the level of water. It gives information about the whether the water level is full or not and insist the user to fill the container if it is empty.



The figure shows the hardware model of our project

7.CIRCUIT DIAGRAM

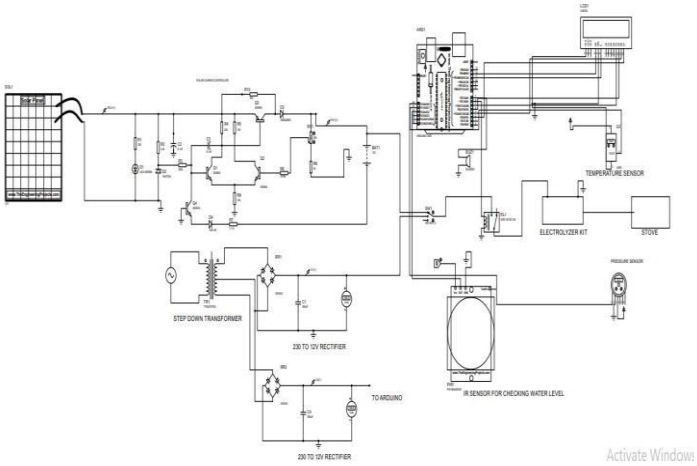


Fig -4: Circuit diagram of proposed model.

The fig 4 describes the circuit diagram of the proposed model.

This circuit diagram of our proposed model describes that two sources are given to the electrolyzer one is Ac source and another one is solar source. Solar source is controlled by the solar charge controller for charging the battery upto the rated voltage. Another source is Ac source (230v) is rectified into 12v by using rectifier and given to the electrolyzer. The sources given to the electorlyer is controlled by using relay system and either one of the source is selected or switched by the user. The MCU is used to control the circuit by manipulating the datas form pressure and temperature sensors. Our proposed model is to provide secure and safe production of Hydrogen which is used as the cooking fuel. The ultrasonic sensor is used to check the water level in container to maintain the sufficient level of water for Hydrogen production. Lcd display is used for insisting the users about the temperature and pressure results to switch off the circuit under abnormal conditions.

8.RESULTS

50 ml of water is consumed when 12v supply is given to the electrolyzer kit, it consumes 1.5Amps and produces about 2 bar pressure in 10 mins.

Power consumed for 10 mins = (12V)(1.5 amps) =18Watts

Power consumed for 1 hour = (18watts)(6)=108 Watts hour

Power consumed for 3 hours = (108)(3) = 324 Watts hour

Thus power consumed by Hydrogen stove is less than the power consumed by induction stove (1500 to 3000 watts per hour).

Thus the power consumed by proposed model is less than the induction stove.

This proposed model has more advantage than the Liquefied Petroleum Gas. First, the proposed model uses demineralized water which is more available than Liquefied Petroleum Gas Which is produced from. Hydrogen gas does not pollute the environment when burns. Filling up LPG gas is more complicated. There is no transportation cost for filling up the tank. The electrolyzer tank can be filled manually and easier to fill. Much of cost is reduced in this model.

Table -2: Hydrogen produced in bar with respect to time in minutes

Time(minutes)	Pressure(Bar)
5	1.75.
10	2
15	2.35
20	2.75
25	3

Table 2 describes about Hydrogen produced in bar with respect to time in minutes

Table -3: Electrolyzer to produce Hydrogen in moles

Current(Amps)	Moles(mJ)	Pressure(Bar)
0.5	0.01	0.5
0.75	0.02	1.5
1.25	0.4	1.75
1.5	2	2
2	2.5	2.8

Table 3 describes about the how much required for electrolyzer to produce Hydrogen in moles

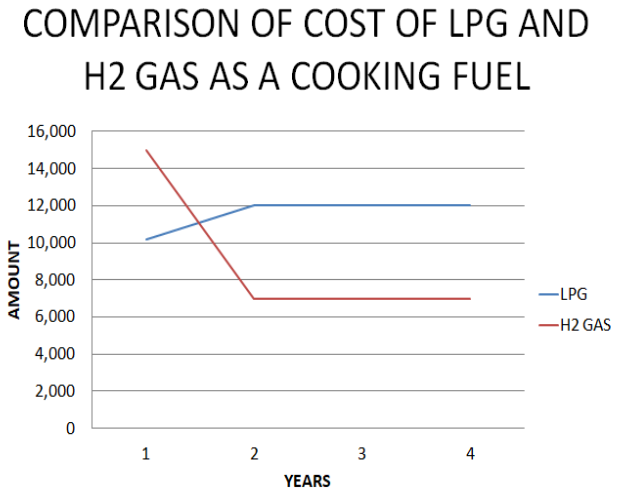


Fig -5:Comparison of cost of LPG and Hydrogen gas as cooking fuel

From the Figure 5, it can be seen that the initial cost of Hydrogen gas is high but in the preceding years, the cost reduces. In case of LPG gas stove, the initial cost is low, but the proceding years have a constant cost greater than the Hydrogen gas.

9.CONCLUSION

This proposed model gives wonderful opportunity for the use of Hydrogen gas as cooking gas. This can be used for cooking purpose. The primary source is demineralized water which is available in house. The process is simple and easy. It is much efficient. This proposed model is safe. This fuel saves LPG gas and reduces its consumption. This proposed model consumes less money and does not need much maintenance. As Hydrogen is ecofriendly, it does not pollute environment.

10.FUTURE SCOPE

In the proposed project the most inexhaustible element Hydrogen is produced at low cost. As there is a need to scale-up the existing low-carbon technologies at a much faster rate, this hydrogen fuel serves as promising fuel. Among various hydrogen gas production methods, electrolysis of water is the best method as there is no toxic by-products produced.

Hydrogen gas is extricated by the process of electrolysis, by passing electric current into the water. During this process separate hydrogen and oxygen gases are obtained. The electrolysis process is combined with renewable energy source that is solar energy, thus completely clean and renewable source of energy is obtained as output. . Thus electrolysis is coupled with photo voltaic power. The photovoltaic process that transforms sunlight into electricity does not require any fuel and has no operating cost. By this we are saving and generating energy using renewable source of energy which is abundant and eco-friendly.

Electrolysis with solar energy technology is the cost effective hydrogen production method. The produced hydrogen gas can be used for cooking purpose. The primary source is demineralized water which is available in house. The process is simple and easy. It is much efficient. This proposed model is safe. This fuel saves LPG gas and reduces its consumption. This proposed model consumes less money and does not need much maintenance. As hydrogen is ecofriendly, it does not pollute environment. The evolution of hydrogen gas will rule the world soon.

REFERENCES

1. Ann Cornell. Hydrogen production by electrolysis. International Journal of Hydrogen Energy 42(2017) 7269-27283.
2. Md Mamoon Rashid, Mohammed K. Al Mesfer, Hamid Naseem, Mohd Danish. Hydrogen Production by Water Electrolysis: A Review of Alkaline Water Electrolysis, PEM Water Electrolysis and High Temperature Water Electrolysis. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-4 Issue-3, February 2015.
3. Jun Ch, Hongmei Yu. Water electrolysis based on renewable energy for Hydrogen production. Chinese Journal of Catalysis 39(2018)390–394.
4. Kwasi-Effah C. C., Obanor A. I., A Review on Electrolytic Method of Hydrogen Production from Water, American Journal of Renewable and Sustainable Energy, Vol. 1, No. 2, 2015, pp. 51-57
5. Kazuo Onda, Takahiro Kyakuno, Kikuo Hattori and Kohei Ito, 'Prediction of Production Power for High-Pressure Hydrogen by High-Pressure Water Electrolysis', Journal of Power Sources 2004; 132: 64 -70.
6. Harrison K. and Levine J.I. 'Electrolysis of water', Chapter 3 in Solar Hydrogen Generation: Toward a Renewable Energy Future , Edited by Rajeshwar, R. McConnell, S. Licht K., Springer Science, New York, NY 2008.
7. Joshi A.S., Dincer I. and Reddy B.V. Exergetic assessment of solar Hydrogen production methods', International Journal of Hydrogen Energy, 2010; 35: 4901–4908.
8. Padin J., Veziroglu T.N. and Shahin A. 'Hybrid solar high temperature Hydrogen production system', International Journal of Hydrogen Energy 2000; 25: 295–317.
9. Liu M, Yu B, Xu J, Chen J. Thermodynamic analysis of the efficiency of high-temperature steam electrolysis system for Hydrogen production. J Power Sources 2008; 177: 493 - 99.
10. Akanksha , P B L Chaurasia,' Home Gas by Hydrogen Fuel Cell ',International Journal of Science and Research : 2319-7064 .
11. Dr. Z. M, Shapiro T. R. Moffette,' Hydrogen Flamability Data And Application ',WAPD-SC-5ii5
12. S.M. Bashi, N. F. Mailah, M.Y.Yusof ,' Production of Hydrogen using Photovoltaic Electrolysis ',Student Conference on Research and Development (SCOReD) 2003 Proceedings, Putnjaya, Malaysia
13. Molnarne, M.; Schroeder, V. Hazardous properties of Hydrogen and Hydrogen containing fuel gases. Process Saf. Environ. 2019, 130.