CLEAN TECHNOLOGY USING ALKALINE BASED GREEN HYDROGEN ELECTROLYZER

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Introduction:

The growing demand for clean energy solutions has led to increased interest in the production of Green hydrogen production as a sustainable alternative to fossil fuels. In various methods for the production of hydrogen production, alkaline electrolysis must be integrated due to its high efficiency, cost-effectiveness and ability to integrate into renewable energy sources, such as solar performance. we present an experimental test for the integration of 12V solar panel and a prototype-alkaline Electrolyzer to assess the suitability of hydrogen production. it has been built by MS steel plates and gaskets. The prototype consists of 3 stacks, each with 13 plates. Contains potassium hydroxide (KOH) Input Parameters Voltage, Current, Power Supply Operating Parameters: Electrolyte Concentration, Stack Temperature, Current Density Various performance parameters were measured using the appropriate device, including: Electrolyte Concentration, Stack Temperature, Current Density. Hydrogen production parameters Hydrogen production rate, Faraday efficiency, purity level Energy consumption parameters Specific energy consumption, solar efficiency of hydrogen from the sun. This study also examines the effects of solar radiation of variability on system stability and efficiency. The results show that the 12V solar panel meets the operating requirements, but efficiency can be further improved with the optimal electrolyte concentration and power management strategy. this paper Optimization

Strategy Temperature Control, Electrical Density Control, Electrolyte Concentration Control Hydrogen Yield and Hydrogen Efficiency from the Sun. It's an practical approach to build an equivalent circuit model for commercial systems, which can adequately model realistic rectifier waveforms While photovoltaic panels can be directly coupled to alkaline water Electrolyzers, which is connected in parallel. By combining alkaline water electrolysis with hydrogen storage tanks and fuel cells, power grid stabilization can be performed.

Objectives:

1. Designing and modelling of alkaline Electrolyzer
   To Develop Model of 5 ml/Min Green Hydrogen Production Alkaline Electrolyzer, with Zero gap technology minimize energy losses and enhance electrode surface area.
2. Production of Pure Green Hydrogen
   Usage of inexpensive materials like Stainless steel as Electrodes and Nylon as end plate Enhance durability and affordability of alkaline Electrolyzers
3. Carbon Neutrality
   To Enhancing electrolyte concentration and temperature in alkaline Electrolyzers Usage Of Potassium Hydroxide (Koh) As An Electrolyte significantly reduces energy consumption.

Methodology:

BLOCK DIAGRAM

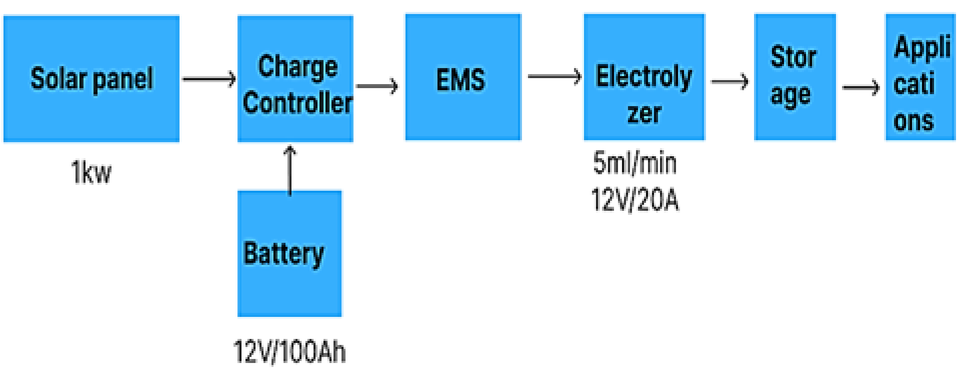

Fig 1. Block Diagram of Alkaline Based Hydrogen Production

Fig.1. shows Green hydrogen is a promising renewable energy source that is produced through water electrolysis powered by renewable energy sources such as solar or wind energy. The image above represents a solar-powered alkaline water electrolysis system for green hydrogen production. The process begins with a photovoltaic (PV) 1kw panel that converts sunlight into electrical energy. This energy is then used to drive the electrolysis process, splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2). An optional DC/DC converter is sometimes used to regulate the power supplied to the 5ml/min Electrolyzer, optimizing efficiency. Its an prototype alkaline Electrolyzer powered by 12V/20Ah. setup consists of three stacks with 13 plates, configured with 2 negative, 3 positive, and 8 neutral plates, and uses potassium hydroxide (KOH) as the electrolyte. and investigating how solar energy can efficiently power the Electrolyzer by using a 12V solar panel and measuring various performance parameters. project aims to contribute to pure green hydrogen production, ensuring environmental sustainability while optimizing efficiency and cost-effectiveness.

Result and Discussions:

Table 1.1 Intial inputs of Alkaline Electrolyzer

Parameter	Value
Applied Voltage	12V/20A
Number of Stacks	3
Total Plates per Stack	13
Negative Plates	2
Positive Plates	3
Neutral Plates	8
Electrolyte	KOH
Electrolyte Concentration	20–30 wt%
Stack Temperature	40–60 °C
Device Capacity	5ml/min

These input parameters were carefully monitored to understand their impact on hydrogen production rate, system efficiency, and energy consumption and form the basis for performance analysis and optimization.

Table 1.2 Intial Readings

Reading No.	Voltage (V)	Current (A)	Temperature (°C)	Power (W)
1	11.8	12.0	35	141.6
2	12.2	11.5	38	140.3
3	11.5	12.2	42	140.3
4	12.0	11.8	45	141.6
5	11.9	12.1	48	143.9

Waveforms have plotted as per above Readings

Test 1. Production of hydrogen and Voltage

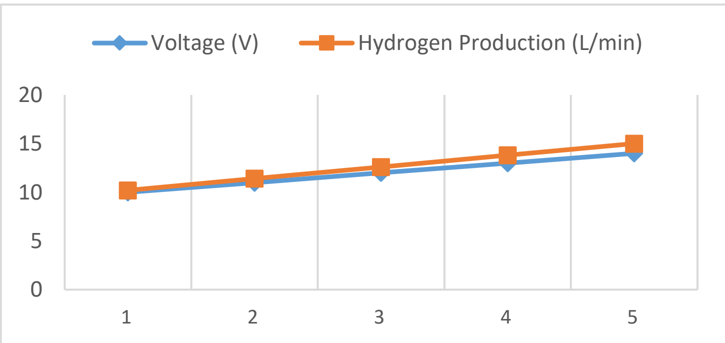

Figure.2. Voltage(Va) & Hydrogen(L/Min)

Figure 2 illustrates the relationship between voltage (V) and hydrogen production rate (L/min) in the alkaline electrolyzer prototype, showing a gradual increase in hydrogen output from 10 V to 14 V as the system stabilizes and electrodes become fully active. Optimal hydrogen production peaks at 14 V after 12 minutes of operation, beyond which efficiency slightly drops due to heat buildup and resistance.

Test 2. Current (A) and hydrogen production

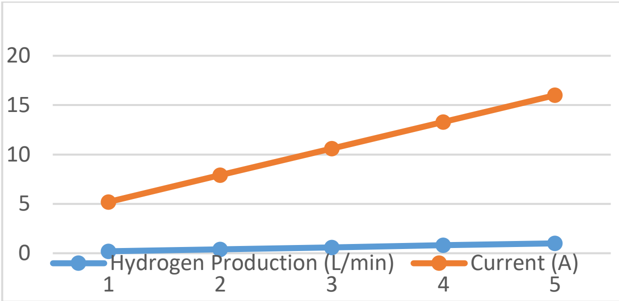

Figure.3.Current(Ia)&hydrogen(L/min)

Figure 3 illustrates that hydrogen production increases with current in a 12V alkaline electrolyzer, showing a direct relationship as per Faraday's laws. Initial low current limits output, but it rises over time, enhancing hydrogen yield with optimal KOH concentration. Solar intensity boosts current supply, though fluctuations may momentarily affect efficiency.

Test 3. Hydrogen Production vs. Temperature

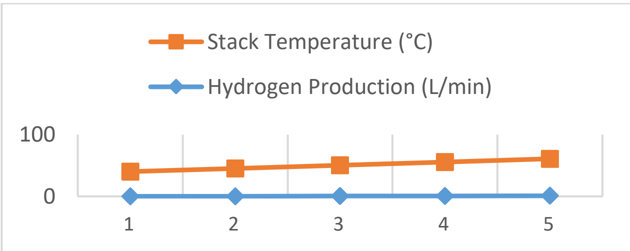

Fig.4.Hydrogen(L/Min) & Temperature(C)

Test 4. Hydrogen Production vs Energy Consumption

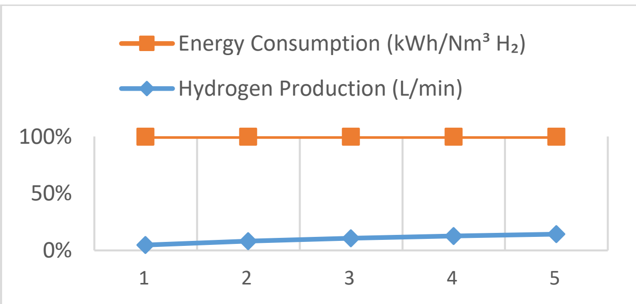

Fig.5 Hydrogen(L/Min)& Energy(Kwh)

Fig.4. and 5 shows the comparission of Hydrogen Production vs. Energy consumption Hydrogen production increases over time, but energy consumption is almost constant, indicating stable efficiency of electrolysis. And figure.10. Hydrogen Production Compared to Stacked Temperature As the stacking temperature increases the hydrogen production slightly.

Table 1.3 Electrolyzer Performance Parameters

Parameter	Values
Electrolyzer Voltage per Cell	1.8 – 2.2V
Current Drawn	5 – 15A
Electrolyzer Current Density	100 – 400mA/cm²
Faraday Efficiency	80 – 90%
Hydrogen Production Rate	0.2 – 1.0L/min
Oxygen Production Rate	0.1 – 0.5L/min
Specific Energy Consumption	4 – 6kWh/Nm³ H_2

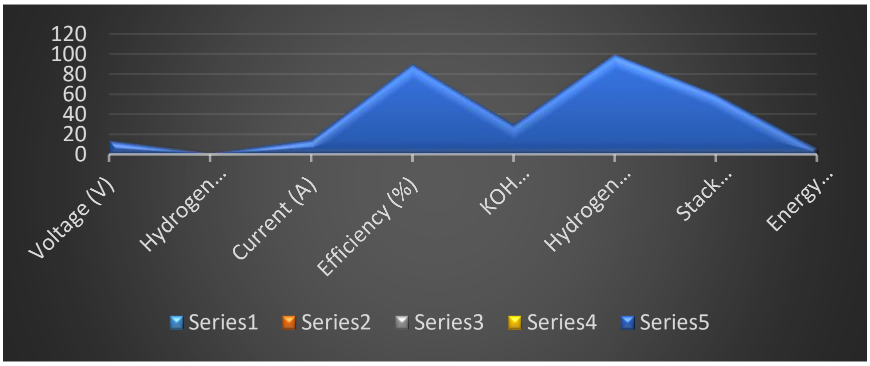

Fig.6. Voltage (V), Hydrogen Production Rate (L/Min), Current (A), Efficiency (%), KOH Concentration (%), Hydrogen Purity (%), Stack Temperature (°C).

Figure 6 illustrates that while the electrolyzer maintains stable energy consumption and high hydrogen purity, hydrogen production remains low, emphasizing the need to optimize KOH concentration and monitor stacking temperature for improved efficiency and output. Efficiency peaks are influenced by heat loss and electrode behavior, indicating that controlled operating conditions are essential for maximum performance.

Conclusion:

This study focused on integrating solar energy with an alkaline electrolyzer and successfully developed a working prototype. The system produced green hydrogen using a 12V input, with the potential for solar-powered operation. Key parameters like voltage, current, efficiency, hydrogen purity, KOH concentration, and energy consumption were analysed. A real-time measurement system ensured accurate monitoring and performance optimization. The setup included 13 plates in 3 stacks immersed in a KOH solution to enhance conductivity and hydrogen yield. Hydrogen and oxygen gases were generated through electrolysis. Fluctuations in voltage and current affected efficiency and output rate. Temperature was controlled to prevent heat loss and maintain performance. Data supported the impact of KOH concentration and purification on production. The project highlights a scalable and efficient green hydrogen solution with scope for future improvements.

Project Outcome & Industry Relevance:

- The possibility of producing green hydrogen using an alkaline electrolyzer powered by solar energy, creating zero carbon emissions during production.
- The fabrication process involved local industry collaboration for sheet metal cutting, plate design, insulation, and sealing systems.
- The system is applicable in off-grid locations, rural electrification, and emergency power setups.
- produced can be used in fuel cells, IC engines, making it versatile for multiple industry sectors.

Working Model

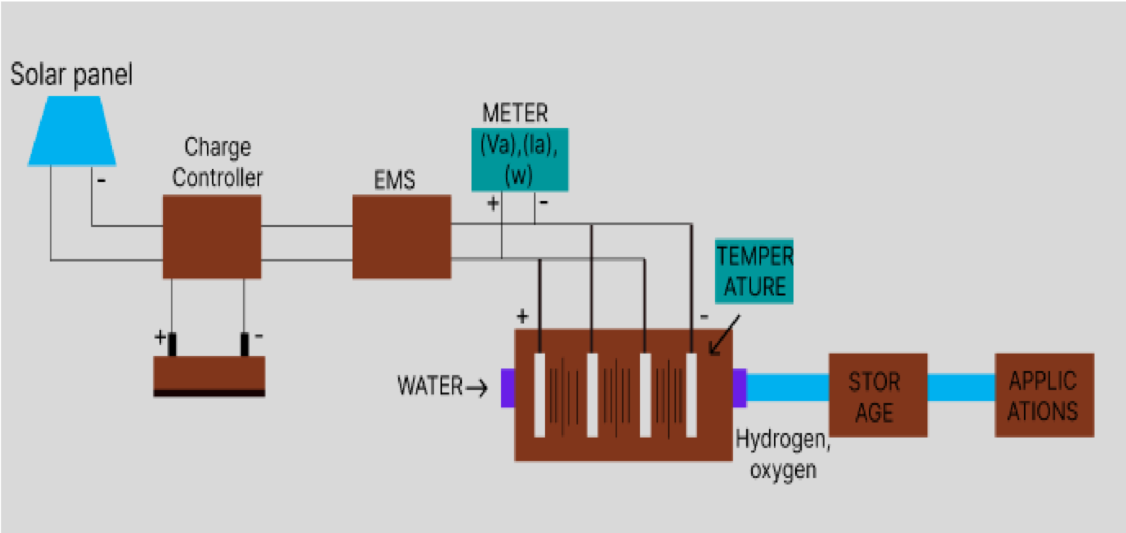

Fig:7 Schematic Diagram of Alkaline Electrolyzer

Fig:8 Model Of Alkaline Electrolyzer

Fig 7 & 8 shows the image shows a prototype Alkaline Electrolyzer designed for green hydrogen production. This operates on the principle of water electrolysis, where an electric current is used to split water (H_2O) into hydrogen (H_2) and oxygen (O_2) using an alkaline electrolyte. it is powered by a 12V energy source, which can be solar-based for sustainable operation. The solar-powered alkaline electrolyzer uses a 12V panel to split water into hydrogen and oxygen using Mild Steel (MS) electrodes. Nylon sheets and pneumatic connectors ensure structural strength and smooth gas/water flow. Fig.9 Shows the setup which includes 3 stacks (13 plates: 2 cathode, 3 anode, 8 neutral) to optimize electric field distribution and boost efficiency. It achieves a hydrogen production rate of 5mL/min, with overall efficiency around 60–70%, tested using multi meter, gas flow meter, and thermometer. This cost-effective and scalable system proves the potential of renewable energy for clean hydrogen generation. A meter is connected to monitor voltage, current, and power in real-time. Water mixed with potassium hydroxide (KOH) is introduced into the electrolyzer chamber. Neutral plates help maintain uniform electric field distribution, increasing the system's efficiency. The gases are collected through pneumatic connectors, and a temperature sensor tracks heat rise during operation. Finally, the produced hydrogen and oxygen are directed to a storage unit, where they can be utilized for various applications like internal combustion engines, fuel cells, or recycled into other green hydrogen systems.

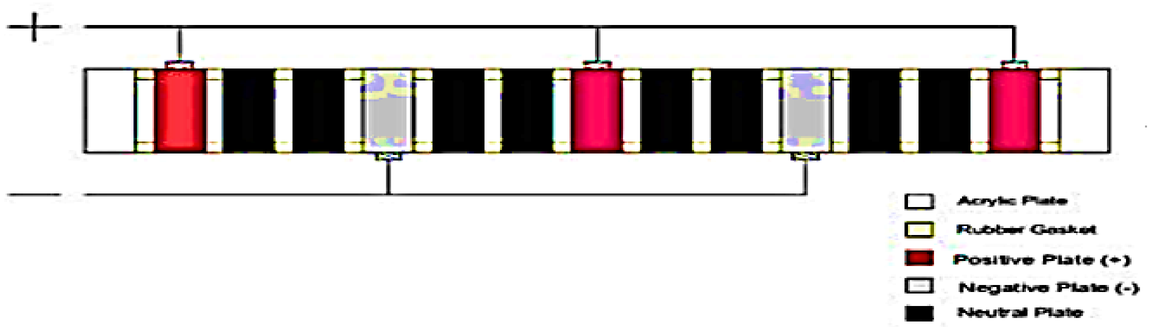

Fig 9.Stacking Pattern Of Alkaline Electrolyzer

Project Outcomes and Learnings:

- We can use 12V, 20A solar panel can effectively power a small-scale alkaline electrolyzer, enabling consistent hydrogen production using renewable energy with proper regulation and control.
- As KOH solution increases current also Increases, if we use more than 30%
- Designed and tested a working hydrogen production prototype using solar energy.
- Student-level innovation can impact global problems like pollution, energy security, and climate change.

Future Scope:

The future scope of this project includes:

1. Alkaline electrolysis offers a low-cost, scalable method for green hydrogen production.
2. Future advancements aim to improve electrode catalytic activity using non-precious metals.
3. Enhancing corrosion resistance will increase electrode lifespan and reduce maintenance.

4. High-performance materials can enable compact systems with higher current densities.
5. Optimizing electrolyte composition may lower energy losses and improve efficiency.

6. Recycling electrolytes can cut costs and support sustainable operations.

7. High-temperature electrolysis could boost efficiency by minimizing energy waste.

8. Systems capable of handling higher current densities can increase hydrogen output.

9. Integration with solar or wind energy will make the process fully renewable.

10. Smart control systems and modular designs will enhance performance and flexibility.