



HYDROGEN GENERATOR DESIGN FOR ECO-FRIENDLY ENERGY CREATION

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ABSTRACT

This study explores the design and development of a hydrogen generator aimed at producing eco-friendly energy. The project addresses key challenges in hydrogen production, including efficiency, scalability, and sustainability. The prototype system demonstrates the feasibility of achieving efficient hydrogen production through water electrolysis, providing a pathway toward renewable energy solutions. Testing confirms the system's capability to produce 18 grams of hydrogen in 30 minutes, aligning closely with theoretical predictions. Recommendations for future improvements include material upgrades and integrating renewable energy sources for power supply.

Keywords: Hydrogen Production, Water Electrolysis, Eco-Friendly Energy, Renewable Energy

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1. INTRODUCTION

The global transition to sustainable energy has necessitated the development of innovative energy solutions to replace fossil fuels. Among these, oxyhydrogen (HHO) gas has gained attention as a promising energy carrier due to its high energy efficiency, versatility, and environmentally friendly combustion properties. With increasing global focus on achieving net-zero emissions and sustainable energy solutions, HHO gas systems represent a pivotal innovation in renewable energy technologies. The development of efficient and scalable HHO systems can contribute significantly to meeting future energy demands. [1,2]

Despite its advantages, the production of HHO gas through water electrolysis is accompanied by several critical challenges that need to be addressed for widespread adoption, **Energy Efficiency**; The electrolysis process requires substantial electrical energy input. Enhancing system efficiency is essential to minimize energy consumption and improve economic viability.

Material Durability; Electrodes and sealing components are exposed to high currents, water, and corrosive environments. Identifying and utilizing durable materials is necessary to extend system longevity. **Safety Concerns;** The storage and handling of HHO gas involves inherent risks due to its flammable nature. Effective safety mechanisms must be integrated to prevent leaks and mitigate operational hazards [3].

HHO gas, also referred to as Brown's Gas, is a mixture of hydrogen and oxygen gases produced through the electrolysis of water. This gas mixture is generated in a stoichiometric ratio of 2:1, corresponding to the molecular composition of water. The unique characteristics of HHO gas make it an efficient and clean-burning fuel for a variety of applications. The electrolysis process is governed by the following reaction; The hydrogen and oxygen gases are then combined immediately to form HHO gas. This process is typically facilitated by a direct current (DC) power supply and an electrolyte, such as potassium hydroxide (KOH) or sodium hydroxide (NaOH), to enhance water conductivity [4,5,6].

The overarching objective of this research is to design and develop a reliable, efficient, and safe HHO gas generator that addresses the challenges. Specifically, the project aims to Develop a robust and efficient electrolyze configuration to maximize gas production while minimizing energy losses [1,7].

2. EXPERIMENTAL PROCEDURE

The conceptual design phase involves developing an initial blueprint of the hydrogen generation system. This phase identifies the fundamental system requirements, constraints, and high-level design choices to ensure feasibility. The concept aims to deliver a system that can efficiently produce HHO while being economically and environmentally viable [6,8].

Electrolysis is the most mature and widely used water-splitting technique. It involves passing an electric current through water, causing it to break into hydrogen and oxygen gases. There are three primary types of electrolyzes: Proton Exchange Membrane (PEM), Alkaline electrolyzes, and Solid Oxide Electrolyzes. [1,9]

In the design of the HHO production system, careful consideration must be given to the selection of components, specifically focusing on power sources and electrolyzes. This section outlines the used standards, including materials, product forms, size selections, manufacturing processes, and testing procedures for each component. For the power supply options, standards relevant to solar panels (IEC 61215, IEC 61730), wind turbines (IEC 61400), and rechargeable batteries (IEC 62133) will be referenced. Additionally, electrolyzing will adhere to standards like ISO 14687 for hydrogen purity and IEC 62282 for fuel cell technologies. Where specific standards are not available, industry catalogs from manufacturers like SKF for bearings or various belt manufacturers will be utilized. The tables detailing the component selections and corresponding standards will be provided in the appendices following the references [10,11].

The hydrogen generator system consists of three primary components: the container, cover, and electrodes. These components are designed to work cohesively to ensure efficient hydrogen production through water electrolysis. Below are the detailed specifications



Figure 1: (A) container, (B) Cover, (C) Stalin-steel Electrodes.

The container is designed to hold up to 250 mL of water. It features an inner radius of 3 cm and an outer radius of 3.5 cm, with a height of 8 cm. The wall thickness of 5 mm ensures sufficient durability while maintaining a compact form factor. The material used is glass, chosen for its high thermal resistance and not conductive. The cover is a critical component for sealing the container and housing the inlet and outlet ports. It has a height of 1.5 cm and matches the container's radius dimensions. The cover includes three holes: two side holes with diameters of 12 mm, and a central hole with a diameter of 6 mm. These openings facilitate gas exchange while maintaining the integrity of the system. The electrodes are made of stainless steel with a height of 6 cm and the same diameter as the holes in the cover to fit inside perfectly. It has washers and nuts to increase the surface area of the electrodes and increase the process.

Glass: Used for its ability to resist high-temperature and not conductive to electricity. **Wood;** used for its ability to not be a conductor of heat and electricity. **Stainless Steel Electrodes;** sourced to serve as anodes and cathodes, ensuring resistance to corrosion and consistent electrical conductivity. **PVC Tubing;** used for the gas outlet to provide flexibility and durability under operating conditions.

Install stainless steel rods in designated positions within the container. Attach the PVC outlet tube to the specified outlet hole in the cover. Inspect and seal all connections and openings to prevent gas leakage.

The electrolyte plays a critical role in the electrolysis process by enabling the flow of ions between the anode and cathode, which is essential for the electrochemical reaction. In hydrogen production through water electrolysis, potassium hydroxide (KOH) is a commonly used electrolyte due to its high conductivity, stability, and compatibility with the electrodes. When dissolved in water, KOH dissociates into potassium (K^+) and hydroxide (OH^-) ions, facilitating the efficient transfer of electrical energy and enhancing the overall efficiency of hydrogen generation. Additionally, the alkaline nature of KOH reduces electrode degradation, contributing to the durability of the system.

3. RESULTS AND DISCUSSION

The final HHO generator design incorporates essential features to ensure efficient hydrogen production through water electrolysis. The components of the system are stainless steel electrodes, and PVC outlet tubing glass container and wood cover. Each component has been carefully engineered to balance cost-effectiveness, reliability, and functionality. The compact and modular design of the system allows for easy assembly, operation, and potential scalability for future applications.

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The system underwent rigorous testing to evaluate its performance under real-world conditions. Testing focused on three primary areas: HHO production efficiency, structural integrity, and operational safety.

$$V = \text{Voltage} = 12 \text{ V}$$

$$I = \text{Current} = 74 \text{ Ah}$$

$$HHV = \text{Higher Heating Value} = 142 \text{ MJ/kg}$$

$$E = V \times I \quad \text{Equation (1)}$$

$$E = 12 \times 74 = 888 \text{ Wh}$$

$$E = 888 \times 0.0036 = 3.19 \approx 3.2 \text{ MJ} \quad \text{Equation (2)}$$

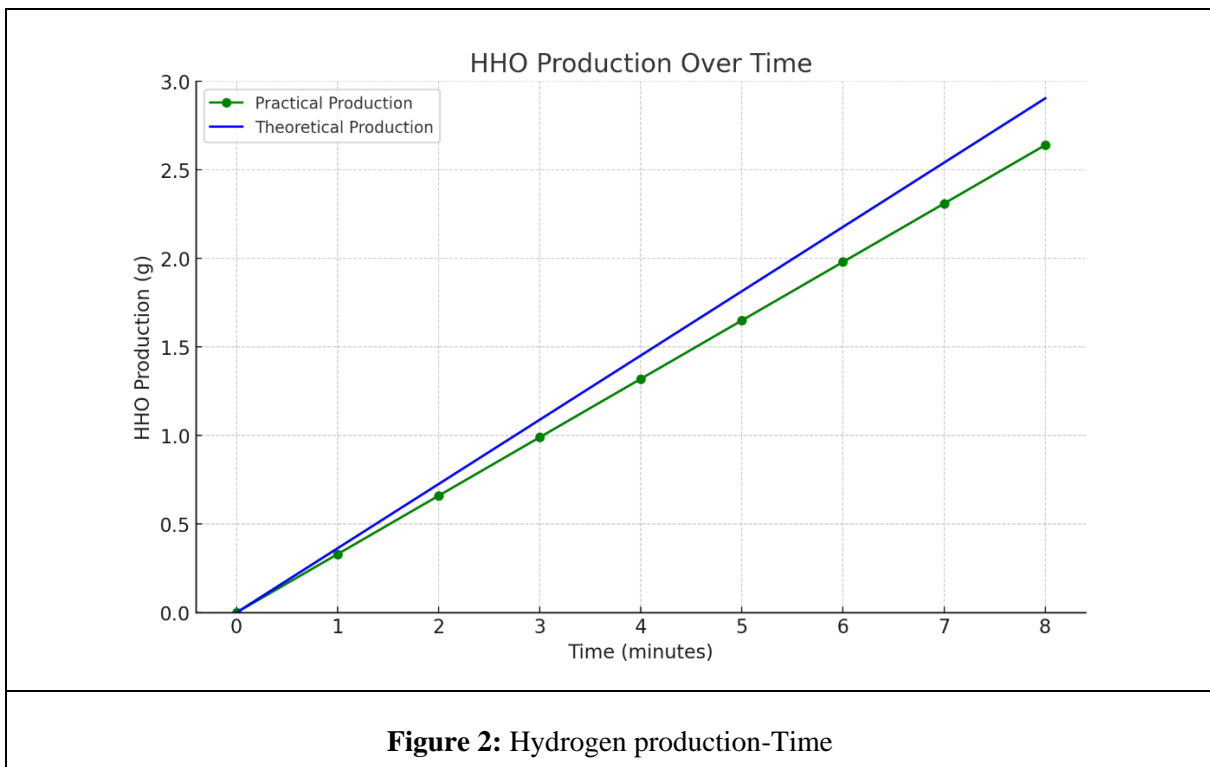
Mass of Hydrogen:

$$E = m \times HHV$$

$$m = \frac{E}{HHV} \quad \text{Equation (3)}$$

$$m = \frac{3.2}{142} \times 1000$$

$$m = 22.54 \text{ g}$$



The generator was filled with deionized water and connected to a 12V, 74Ah power supply to initiate the electrolysis process. Gas output measurements were recorded over a specified time interval to analyze production efficiency. The system successfully produced 22.54 grams of HHO gas during a 30-minute test period, closely aligning with the theoretical energy input of 3.2 MJ, confirming efficient energy utilization.

4. CONCLUSION

The system demonstrated strong performance during testing, achieving the primary objective of efficient HHO gas production. Key findings include:

- **Production Efficiency:** The measured HHO gas output closely aligned with theoretical predictions, confirming effective energy utilization and system efficiency.
- **Component Reliability:** Glass components, stainless steel electrodes, and PVC tubing performed exceptionally well under the tested conditions, demonstrating their suitability for the design and durability during operation.
- **Safety Assurance:** The absence of leaks and the stable operation of all components under pressurized conditions validated the system's robust safety features.

The HHO generator successfully demonstrated its ability to produce HHO gas efficiently through water electrolysis. While the design met its functional objectives, there are opportunities for improvement to align it further with eco-friendly goals. The use of a battery as the power source provided consistent operation, but integrating renewable energy sources such as solar panels or wind turbines would enhance the system's sustainability. Additionally, the material selection and component design proved reliable, with no significant issues observed during testing. Overall, the project achieved its primary goals, but future improvements should focus on enhancing environmental sustainability, optimizing energy efficiency, and scaling the system for larger industrial applications.

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