A Portable Hydrogen Generator for the Homemaker

Princeton University Chapter of International Association for Hydrogen Energy (IAHE-PU)

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Introduction

Hydrogen does not exist in its pure form on earth. The viability of a sustainable hydrogen economy greatly depends on the development of an efficient, cost-effective method of hydrogen production. One potential model for addressing this challenge is to deploy portable hydrogen generators on the home scale. IAHE-PU has designed and created one such generator, which produces hydrogen through the electrolysis of water. The final design was created to optimize cost-effectiveness and portability while maximizing hydrogen output.

Our design Objectives are:

✓ Cost effectiveness
✓ Safe operation
✓ Portability
✓ Maximum hydrogen output

Method

We selected PV-electrolysis as a means of hydrogen generation, because all of the components are readily available, the system is easy to assemble and deployable on a large scale, and the parts are cost-effective, fulfilling all of our objectives for the project.

The chemical equations for the basic electrolysis reaction are:

Net Reaction: 2 H_2O (l) → 2 H_2(g) + O_2(g)

Cathode (reduction): 2 H_2O (l) + 2e^- → H_2(g) + 2OH^- (aq.)

Anode (oxidation): 2 H_2O (l) → O_2(g) + 4 H^+(aq.) + 4e^-

As a proof-of-concept of home scale do-it-yourself portable H2 generator, our system utilizes simple household items such as Glasslock® food containers, nickel strips and home-use KOH. A Sharp ND130UF 130W solar module panel powers our system. The total material cost is effectively limited to $600 for a six cell unit.

Results and Discussion

Overall Generation of Hydrogen

Our data, taken on a sunny spring day in Princeton, New Jersey, gave us an average rate of 0.399 ml of hydrogen per second per electrolysis cell (Table 1). Assuming a constant rate of gas generation, our simple setup, which consists of 6 equivalent cells, will give a total hydrogen production of 8.61 liters over an hour’s operation.

Table 1: Solar, electrical and chemical energy conversion efficiency analysis.

<table>
<thead>
<tr>
<th>V (V)</th>
<th>I (A)</th>
<th>Electrical Power (W)</th>
<th>Rate of H2 (ml/s)</th>
<th>Chemical Energy (W)</th>
<th>EC Efficiency (%)</th>
<th>Total Solar Efficiency (%)</th>
<th>Overall Total Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.54</td>
<td>3.43</td>
<td>12.2</td>
<td>0.399</td>
<td>3.94</td>
<td>32.6</td>
<td>10.4</td>
<td>3.38</td>
</tr>
<tr>
<td>±0.20</td>
<td>±0.13</td>
<td>±1.1</td>
<td>±0.004</td>
<td>±0.04</td>
<td>±3.3</td>
<td>±1.5</td>
<td>±0.48</td>
</tr>
</tbody>
</table>

Production Economics Analysis

We assumed: 1) the solar panel has a 25-year lifetime; 2) no replacement KOH or electrode is needed; 3) the price of water is $1.50 per 1000 gallons; 4) the system runs for 12 hours per day throughout the year. Given these assumptions, the total amount of hydrogen produced at STP is about 75,542 kg over 25 years. The cost per kg of hydrogen production is $8.58.

The average industrial production cost of hydrogen is about $6.92 per kg. Our system appears to produce hydrogen more expensively by $1.50 per kg. However, it is difficult to compare small-scale production against industrial manufacturing.

Conclusion

Our portable hydrogen generator can be easily replicated using readily-available household materials. The design is straightforward enough for almost anyone to construct, making it an appealing choice for general public use.

Despite the simplicity of our design, our hydrogen generator approached industrial standards for cost and efficiency. Our system was tested on a late March afternoon in New Jersey; in one hour, we produced 8.38 L of hydrogen gas at an estimated cost of $8.58 per kilogram of hydrogen gas. These preliminary results suggest that a hydrogen generator such as ours is indeed an option that is worthy of more attention and research.

In the future, we hope to further improve our hydrogen production rate by testing different electrodes, electrolyte concentrations, cell configurations, and other variables that may be adjusted to optimize our system.

References:


Acknowledgments:

Many thanks to Don Schoorman, PRISM and Ted Borer, Energy Plant Manager of Princeton University for their generous assistance.