Residential Electrolyzer Optimized with Pulse Width Modulation and Magnetism

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I. Introduction

Brown's gas has the potential to be a viable energy solution. This project will construct an electrolyzer that will measure the efficiency of the electrolysis process. The constraints of this project are largely defined by specification, ethics, standards, and potentially broader impacts. The conceptual design of this project will focus on defining all possible constraints of the project as well as the breakdown of the project into smaller sections so that the team can conceptualize it.

A. A Fully Formulated Problem

The system is expected to be a fully functioning electrolyzer that is able to measure the energy efficiency of the electrolysis process. The constraints that define the system are listed below.

A System shall accurately measure the electrical efficiency of the electrolyzer.

A.1 System shall accurately read electricity usage and gas output.

- Use sensors to determine how much electricity is used to create an amount of Brown's gas.

A.2 System shall quickly take in sensor readings and compute efficiency rating.

- An external device should be able to take the sensor readings as inputs and compute a specified output.

B System shall abide by all safety standards outlined by OSHA, NFPA, and those that the team feels are necessary.

B.1 System shall not use cast iron fittings for any piping, fitting, or tubing.

-This comes from OSHA standard 1910.103, which states that cast iron is susceptible to corrosion from hydrogen

B.2 System shall have an emergency stop button.

-This comes from NFPA 79 which states that when an emergency stop button is pressed, all dangerous actions will stop without creating new hazards.

B.3 System shall shut off if the pressure and temperature of the cell come close to ignition conditions of Browns Gas.

-This is a team-decided standard, created to avoid any sort of internal fire or explosion.

B.4 Safety controls shall be programmed on their own controller.

-This is a team-decided standard that aims to avoid any confusion with the programming of the system as a whole.

B.5 All safety sensors shall have two sensors.

-The two sensors will be a redundancy so that there will always be a back up in case one goes out. Readings from both sensors will be averaged together to make sure the system has an accurate reading from the systems.

C This system shall ensure the electrodes are fully submerged at all times.

-Keeping the electrodes fully submerged ensures the highest levels of efficiency can be attained. This constraint is derived because if the electrodes are not fully submerged, the system will suffer from poor efficiency.

D This system shall automatically control the water level of the electrolytic cell.

-This constraint is to keep the user from having to determine what an appropriate water level is. This constraint is derived from the need to ensure that the user does not have to overcome a learning curve with the device.

E This system shall ensure that the maximum volume of liquid inside the electrolytic cell does not exceed 85% of the cell's storage capacity.

- This constraint ensures that the system does not overflow and cause damage to other components in the device. This constraint is derived from the need to ensure all components can remain undamaged.

F System shall conform to all NEC and NFPA standards regarding power consumption and wire ampacity.

- This constraint originates from the need to follow guidelines provided by the appropriate regulatory agencies. Both the NFPA and NEC guidelines have many regulations in place that will ensure the system is able to be operated in a safe and orderly manner.

G This system shall pull a maximum of 30 amps at 240 volts.

- Exceeding the stated amperage can cause a fuse to be tripped in houses with 30 amp breakers attached to the system. The constraint is derived, as it is uncommon but not impossible to have fuses connected to the device above this range.

H This system shall not have unstable fluctuations in voltage of more than 10 percent greater or less than the rated voltage of the device.

- High voltage fluctuations from the system can cause inaccurate or poor efficiency calculations. The constraint is derived.

- This constraint is also derived from a desire to ensure safety at all times while the device is being operated.

I The material of the electrolytic cell housing shall not be reactive with lye. - Lye will be used in the electrolysis and will be in contact with the cell housing. This makes it imperative that the housing and lye not be reactive.

J The material of the electrolytic cell should be transparent or translucent. - This is to allow us to see what's happening inside of the cell, to visually observe functionality.

K The pulse generator's output should be rectified. - The pulse generator's output needs to be rectified to set up future use wherein the gases can be separated. Otherwise, each electrode would be producing hydrogen and oxygen due to the unrectified waveform. **L** System shall be setup in a well ventilated area

- The area needs to be well ventilated in the off chance of a leak or a pre

B. Background

C. Ethical

Engineers have a duty to make sure that the safety of the device is at a minimum. The system has inherent dangers due to the nature of the project. The team's responsibility is to keep the system as safe as possible.

Another ethical consideration is the effects that the system could have on the environment as any leak on the cell tank could lead to dangerous chemicals being released.

D. Standards

The system generates hydrogen and oxygen gas and each gas when handling will need to use its standards laid out by OSHA 1910.103 and 1910.104. These standards constrain us to how the corresponding subsystem should be set up.

E. Broader Impacts

The project is subject to broader impacts that are both positive and negative impacts that must be considered. Ideally, this system is efficient enough to be placed in homes giving them access to hydrogen gas. It could be used in third world countries to give them access to resources that they do not normally have.

Another Impact the system could make is on the military. It is usually looked at for the generation of hydrogen, but the system would be making oxygen gas. The need for oxygen on a submarine is something that needs to efficient as possible. Some inherent danger comes from the handling of the hydrogen gas as it is sufficient and needs to be expelled from the submarine.

A negative impact on oil companies as there could be less demand for fossil fuel products such as oil, natural gas, and gasoline. This would have the potential to reduce the workforce in the industry as the demand for natural gas to heat homes and kitchen appliances would decrease.

II. Block Diagram

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A. *Efficiency Calculations*

This subsystem will encompass all of the measurements and efficiency calculations required by the constraints of the project. This block will consist of a microcontroller to perform the computations, a sensor to read power into the electrolyzer, and the volume of gas produced by the electrolyzer.

1) *Microcontroller Unit:*
   Input: Power Consumption, Brown's Gas Content
   Output: Efficiency Calculations
2) *Watt Meter:*
   Input: 120/240V, 60Hz Power
   Output: Wattage Usage or Power consumption
3) *Hydrogen Sensor:*
   Input: Gas output of the electrolyzer
   Output: Digital signal to represent the amount of hydrogen generated
4) *Display Output:*
   Input: Microcontroller readings and computations
   Output: Text output of efficiency rating, power consumption, hydrogen content

B. *Safety System*

1) *Safety Controller:*
   Input: Pressure reading, Temperature reading, Emergency stop signal
   Output: Stop signal to the pulse inverter
2) *Pressure Sensor*
   Input: Power Consumption, Brown's Gas Content
   Output: Efficiency Calculations
3) *Temperature Sensor*
   Input:
   Output:
4) *Flame Detector*
   Input:
   Output:
5) *Manual Emergency Shutoff Switch*
   Input:
   Output:

C. *Electrolytic Cell System*

1) *Pulse Generator*
   Input:DC Current
   Output: Positive Pulse wave
   a) *Pulse Invertor*
      Input: DC Current
      Output: Pulse wave
   b) *Rectifier*
      Input: Pulse wave
      Output: Positive Pulse wave
2) *Electrolyzer*
   The rate of gas production through electrolysis must be matched to the combustion rate to prevent gas accumulation. This typically involves adjusting the current and

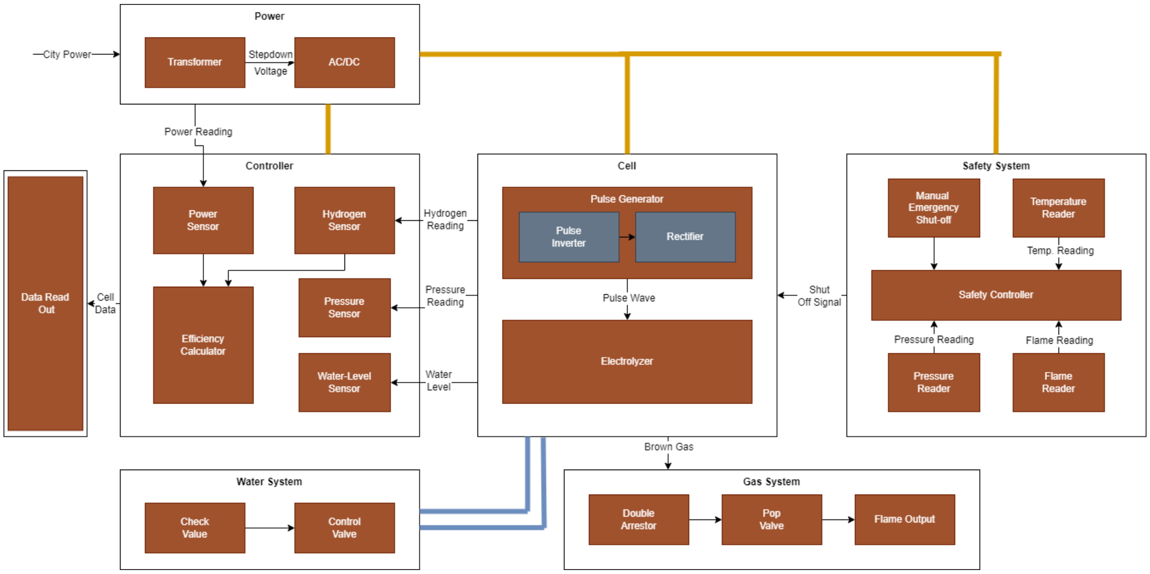

Fig. 1. Block Diagram

voltage appropriately to produce gases at a controlled rate.
Input: Water,Positive Pulse wave
Output: Brown's Gas

a) *Electrolytic Cell Housing*
Input: Water
Output: Brown's Gas

b) *Electrode*
Typically, inert materials like platinum or graphite are used as electrodes to prevent unwanted side reactions and corrosion.Faraday's First Law states that the amount of substance produced at an electrode is directly proportional to the quantity of electricity passed through the electrolyte. Electrode materials play a significant role in the gas production process.
Input: Positive Pulse wave
Output: Hydrogen Gas, Oxygen Gas

An emergency shutdown system should be in place to quickly halt the electrolysis process and isolate gas supplies in the event of a safety breach or hazard.It's crucial to emphasize that working with hydrogen and oxygen gases, especially when using electrolysis for their production, can be inherently hazardous due to their flammability and explosiveness.Depending on the application, the purity of the gases produced may be critical.

1) *Double Gas Flashback Arrestor*
The flame arrestor must be designed to safely prevent flashback into the gas supply system.
Input:
Output:

2) *Pop Valve*
Input: Brown's Gas
Output: Brown's Gas

3) *Flame Output*
Input: Brown's Gas
Output: Flame

D. *Water System*

The water subsystem will be the system controlling all water flow to the electrolytic cell. While the main purpose of the water subsystem is to allow water to be present to perform electrolysis, the water level must be kept within certain limitations for optimal efficiency. The first limitation is ensuring that the rods remain submerged at all times, as shown in constraint **C**. The second limitation is having the water level be automatically regulated, without any input needed from the user, as shown in constraint **D**. This will prevent the cell from being activated with no water present to perform electrolysis. The water subsystem will ensure that these conditions are always satisfied, while not overfilling the cell, as shown in constraint **E**. The subsystem will consist of two main components: the water level sensor and the control valve. The water level sensor will be some device that will read in the water level, and send that information to a micro-controller that will decide whether more water needs to be added to the system or not. The micro-controller will then tell the control valve whether it should allow water in or not.

1) *Water Control Valves*
Input: on/off
Output: Water

2) *Water level Sensor*
Input: Water Level
Output: Value of Water Level

E. *Power System*

The power subsystem will be designed in such a way that most devices will pull from a common supply, with commercially available power adapters being used for the main conversion from AC to DC, with buck converters being used as necessary on a per system basis. The electrolytic cell itself will be powered slightly differently. The cell will not have a transformed voltage, instead it will be converted directly to DC, with no transformation taking place. All aspects of power will follow the constraints as described by **F**, **G**, and **H**.

1) *Transformer*
   Input: 120/240 V, 60 Hz Power
   Output: Transformed 60 Hz Power (On a per system basis)
2) *AC to DC Converter*
   Input: Transformed 60 Hz Power
   Output: DC

III. Conclusion

The conceptual design of an Electrolysis Brown's gas generator is comprised of 6 main subsystems. These systems include a power system, an electrolysis cell, an efficiency calculation system, a safety system, a water intake system, and a gas output system. This conceptual design acts as an outline for the system as a whole, without deciding on the exact components that will be used to create the system.

References