Conversion of Petrol Engines to Oxy-Hydrogen Fuel Systems: A Comprehensive Study on Water Electrolysis and Engine Modifications

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Abstract- This paper explores the potential of using an Oxy-Hydrogen mixture as an alternative fuel extracted from the water, considering the impending depletion of petroleum fuel. The demand for fossil fuel is increasing, but estimates suggest it will be exhausted before the 2060s. If this occurs, all conventional fuel vehicles will become obsolete. Our research primarily focuses on converting existing petrol engines to run on an Oxy-Hydrogen mixture with slight modifications done to the engine. This study encompasses the production of the Oxy-Hydrogen mixture, lubrication of the fuel system, cooling of the electrolysis process, charging of the battery, and necessary modifications to the petrol engine for efficient combustion of the Oxy-Hydrogen mixture. The Oxy-Hydrogen mixture is produced using the water electrolysis process, which separates Oxygen and Hydrogen from water using electricity. The generated Oxygen and Hydrogen are then collected and introduced into the internal combustion engine to produce the required power. Hydrogen production is done as the requirement because storing the Oxy-Hydrogen mixture may cause some issues for safety. To regulate the amount of hydrogen generation this study has developed an ampere regulator and for the safety flashback arrestors are used. For future developments, this paper will utilize the use of lubrication in this fuel system is essential due to the corrosive nature of Oxygen and Hydrogen on the fuel line. To mitigate this, we utilized a solid-type lubricant that does not mix with the oxy-hydrogen mixture. Solar energy for the production of the Oxy-Hydrogen mixture. Lastly, this research outlines the modifications required for the internal combustion engine to operate on an Oxy-Hydrogen mixture, including the volume and fuel ratio of the prototype engine we constructed.

Index Terms- Hydrogen production control; Hydrogen fuel; Renewable energy; Oxy-hydrogen gas; Alternative fuel; Water as a fuel.

I. INTRODUCTION

The internal combustion engine (ICE) stands as a cornerstone of modern transportation, powering the majority of vehicles on our roads today. This technology relies on the controlled explosion of fuel within a combustion chamber to generate mechanical energy, which is then translated into the movement of the vehicle. While internal combustion engines have been instrumental in propelling the automotive industry forward, their reliance on fossil fuels has raised concerns about environmental sustainability and climate change. For decades, the automobile industry has been deeply intertwined with the extraction and consumption of fossil fuels, primarily gasoline and diesel. The combustion of these fuels releases carbon dioxide (CO2) and other pollutants into the atmosphere, contributing significantly to global warming and air pollution. As the world grapples with the consequences of climate change and strives to reduce its carbon footprint, there is a growing imperative to transition away from fossil fuels in favor of cleaner and more sustainable alternatives.

Governments and international bodies are increasingly pushing for stricter emission standards and promoting the development and adoption of alternative power sources, such as electric and hydrogen fuel cell technologies. The emergence of electric vehicles (EVs) represents a pivotal shift in the automotive landscape. These vehicles use electricity stored in batteries to power electric motors, eliminating the need for traditional internal combustion engines and the associated reliance on fossil fuels. The rise of EVs has not only prompted established automakers to invest heavily in electric technologies but has also spurred the development of new players in the industry, fostering innovation and competition. While the transition to cleaner technologies is underway, challenges persist. The infrastructure for electric vehicle charging needs to be expanded, and advancements in battery technology are crucial for enhancing range and reducing charging times. Additionally, the cost of electric vehicles remains a barrier to widespread adoption, although this is expected to decrease as technology matures and economies of scale are realized.

Hydrogen as a Sustainable Transportation Solution

In the pursuit of sustainable transportation solutions, hydrogen-powered internal combustion engines have emerged as a promising alternative to traditional fossil fuel vehicles. As the world grapples with the environmental consequences of carbon emissions and seeks cleaner energy sources, hydrogen stands out as a versatile and clean fuel option. The integration of hydrogen into internal combustion engines presents a unique pathway to address environmental concerns while leveraging existing infrastructure and automotive technologies.

Research Motivation

The increasing concerns over climate change and the finite nature of fossil fuel resources have propelled the automotive industry to explore alternative and sustainable energy sources. Among these alternatives, hydrogen has emerged as a promising candidate for transforming internal combustion engines, traditionally reliant on gasoline, into eco-friendly powerhouses. This thesis delves into the conversion of gasoline engines to hydrogen-powered engine, aiming to address the pressing need for cleaner and more sustainable transportation solutions.

Global Impact

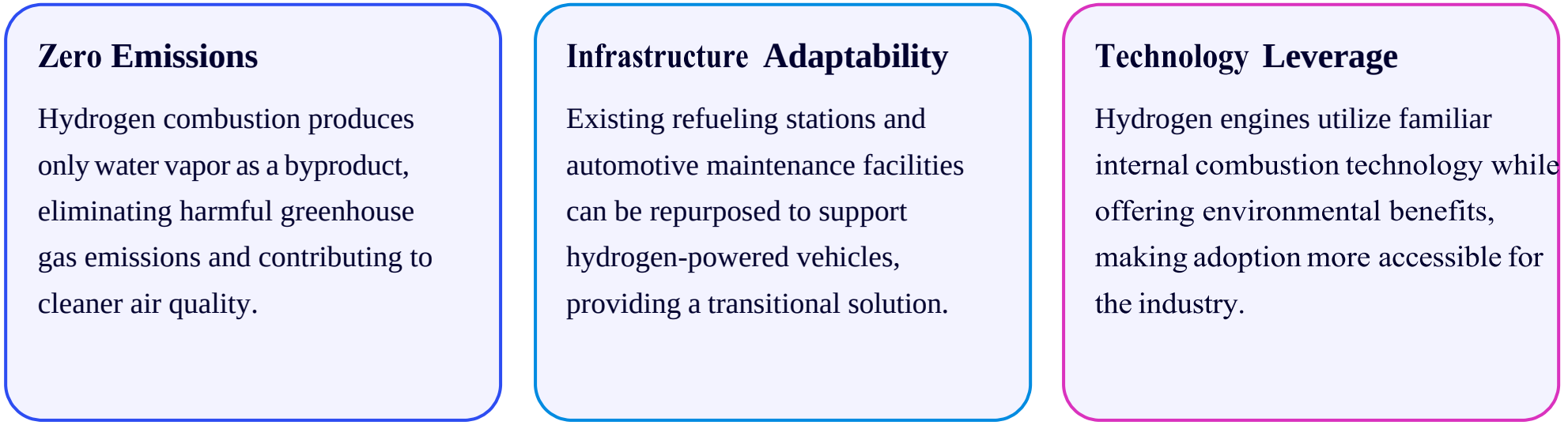
As the global community intensifies efforts to reduce carbon emissions and mitigate environmental impact, the automotive sector faces a pivotal moment in transitioning from conventional fuel sources to cleaner alternatives. Hydrogen, with its potential to serve as a clean and efficient energy carrier, presents a viable solution for the automotive industry seeking to align with stringent emission standards and sustainable development goals.

This research investigates the technical aspects, challenges, and advantages associated with converting gasoline engines to hydrogen-powered systems. By exploring the intricacies of this conversion process, we aim to contribute valuable insights to the growing body of knowledge surrounding sustainable transportation technologies. The thesis will also address key considerations such as infrastructure development, economic viability, and the overall impact of hydrogen-powered vehicles on the environment.

Through a comprehensive examination of the conversion process, this research seeks to provide a roadmap for engineers, policymakers, and stakeholders interested in adopting hydrogen as a mainstream fuel for internal combustion engines. By shedding light on the potential benefits and challenges of this transition, we aspire to contribute to the ongoing discourse on sustainable transportation and catalyze the adoption of hydrogen-powered vehicles as a viable and environmentally responsible alternative to conventional gasoline engines.

Hydrogen Combustion Technology and Infrastructure

Hydrogen, when used as a fuel, holds significant appeal due to its ability to produce energy through combustion without emitting harmful greenhouse gases. Hydrogen combustion generates only water vapor as a byproduct, making it a zero- emission alternative and a potential key player in the transition to a more sustainable transportation sector. The concept of hydrogen-powered internal combustion engines involves adapting traditional combustion technology to utilize hydrogen as the primary fuel. Unlike conventional internal combustion engines that rely on fossil fuels, hydrogen combustion engines offer the advantage of near-zero emissions, addressing air quality and climate change concerns.
This makes them a compelling choice for those seeking a balance between environmental responsibility and the familiarity of internal combustion engine technology.



Furthermore, the existing infrastructure for internal combustion engines, including refueling stations and automotive maintenance facilities, can be repurposed to support hydrogen-powered vehicles. This adaptability provides a transitional solution that leverages current infrastructure while paving the way for a broader shift towards cleaner energy sources. However, challenges exist, such as the development of cost-effective hydrogen production methods, the establishment of a robust hydrogen distribution network, and advancements in combustion technology to optimize efficiency. As research and development efforts intensify, collaborations between governments, industry players, and research institutions become pivotal in overcoming these challenges and realizing the full potential of hydrogen- powered internal combustion engines.

Hydrogen Engine Technology and Water Electrolysis

Hydrogen Engine

The world population increase and the most use of the fossil fuel have resulted in a significant increase in the global demand for energy production in the world. However, fossil fuel is a finite resource that is becoming increasingly rare and expensive because of their low availability. Another problem is fossil fuel exhaust gas emit SOx, NOx, CO2 and CO. These gases affected to the environmental pollution like as acid rain, global warming and human health. "A hydrogen fueled engine has the potential for substantially cleaner emissions than other internal combustion engines. Other benefits arise from the wide flammability limits and the high flame propagation speed, both allowing better efficiency." [3]

Hydrogen is a most suitable fuel for future energy demands. Hydrogen internal combustion engines have low Nox emissions, almost zero HC and CO2 emissions. Hydrogen is environmentally friendly when it is produced from renewable sources in a sustainable and efficient process. (In our case we are using water electrolysis process.). In comparison to hydrocarbon fuels such as natural gas, gasoline, and diesel, utilizing hydrogen as a fuel in internal combustion engines can improve thermal efficiency while decreasing carbon emissions. A key benefit of using hydrogen for transportation is that it increases our reliance on renewable sources while reducing our usage of non-renewable fossil fuels.

of different fuels [8–10].

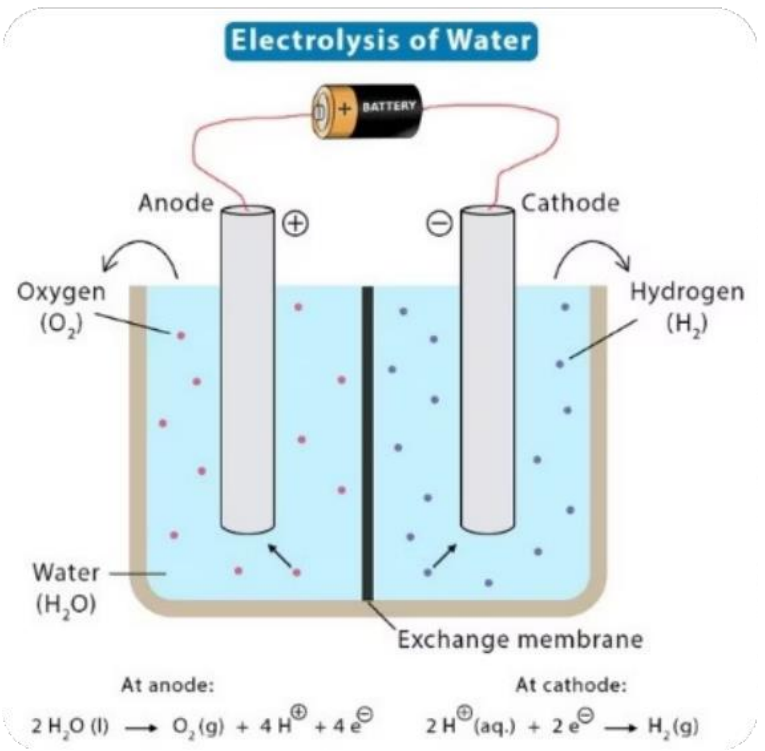
el	Gasoline	Hydroge
	37–43	265–325
	44.0	120.0
20	260–460	585

and diesel have different characteristics

perties	Hydı
ntent (mass percent)	0
cular mass	2.0
iometric ratio	34.
e of ignition (K)	85
adiabatic flame (K)	238
/s) flame speed	23
its (vol percent in air)	4.1-
g the gap (cm)	0.0
e per kilogram (MJ/kg)	12
under stoichiometric conditions	0.6

Water Electrolysis Process

Pure water does not conduct electricity and requires a lot of energy to overcome the power generation process. Therefore, electrolysis is done in the presence of acid to increase conductivity by increasing the concentration of hydrogen ions (H+). These electrolytes are sulfuric acid (H2SO4) and sodium nitrate (NaNO3). "As the water molecule has a very much stable structure in ambient temperature, the required energy to decompose it via electrolysis is relatively high. The most deficiency of the commercial and industrial grade electrolysis systems is their expensive gas production costs. Electricity power demand expense constitutes the largest fraction of hydrogen production costs by using electrolysis method." [5] Electrolysis takes place in an electrolytic cell, usually made of platinum, with a positively charged anode and a negatively charged cathode. The reaction of water electrolysis can be divided into two partial reactions that occur at the cathode and anode.



- A reduction occurs when hydrogen ions at the cathode gain electrons and transform into hydrogen gas. The reaction is in below,

$2H^{+}(aq.) + 2e^{2} \rightarrow H_2(g)$

- Oxidation occurs when water molecules donate electrons to the anode and release gas from the anode. The reaction is in below,

$2H_2O(l) \rightarrow O_2(g) + 4H^{+}(aq.) + 4e^{2}$

- The final chemical reaction is in below,

$2H_2O(l) + \text{electrical energy} \rightarrow 2H_2(g) + O_2(g)$

Thus, the water electrolysis reaction shows the separation of hydrogen and oxygen from water. For two moles of water, two moles of hydrogen and one mole of oxygen are released. Twice as many moles of hydrogen are produced due to oxygen. Also, charge is exchanged between the electrodes and the electrolyte. For each mole of hydrogen, 2 electrons are transferred from the cathode to the electrolyte. For each mole of oxygen, 4 electrons are transferred from the electrolyte to the anode

Methodology

Firstly, study the working principle of the internal combustion engine and fuel system for petrol engines and identify advantages, disadvantages, and other related information by referring to research papers, research gaps, journals, books, etc. As well as study different technologies related to alternative fuels as hydrogen fuel in different vehicles.

To run the internal combustion engine properly we need a fuel source and some kind of a helping agent for the combustion. The fuel source of Hydrogen needs to be collected for combustion. To manufacture the Hydrogen fuel here used the Electrolysis process. This process is done by splitting water (H2O) into hydrogen and oxygen, by using a stainless-steel electrode. Electrolysis generates no direct greenhouse gas emissions, and if the input electricity has no associated greenhouse gas emissions in its generation process. Here in this method of the electrolysis process, the output is not only hydrogen but also oxygen fuel. Because of the making of this oxygen, the amount of air needs to run the internal combustion engine can be minimized. This mixture of oxygen and hydrogen mixture is known as the Oxy- hydrogen mixture.

01
Research and Analysis

Study internal combustion engine principles, fuel systems, and alternative fuel technologies through research papers, journals, and technical documentation.

02
Hydrogen Production System

Implement water electrolysis process using stainless-steel electrodes to split H2O into hydrogen and oxygen, creating the Oxy-hydrogen mixture.

03
Power Management

Design battery and alternator system where the engine charges the battery through a generator, with alternator balancing power drainage.

04
Gas Purification

Install separate container with distilled water to remove unreacted water particles that could interfere with combustion process.

05
Engine Modification

Increase combustion chamber volume to accommodate hydrogen's higher air-fuel ratio and remove unnecessary components to reduce weight.

06
Testing and Validation

Compare fuel consumption, efficiency, cost-effectiveness, and reusability between petrol and hydrogen systems through comprehensive testing.

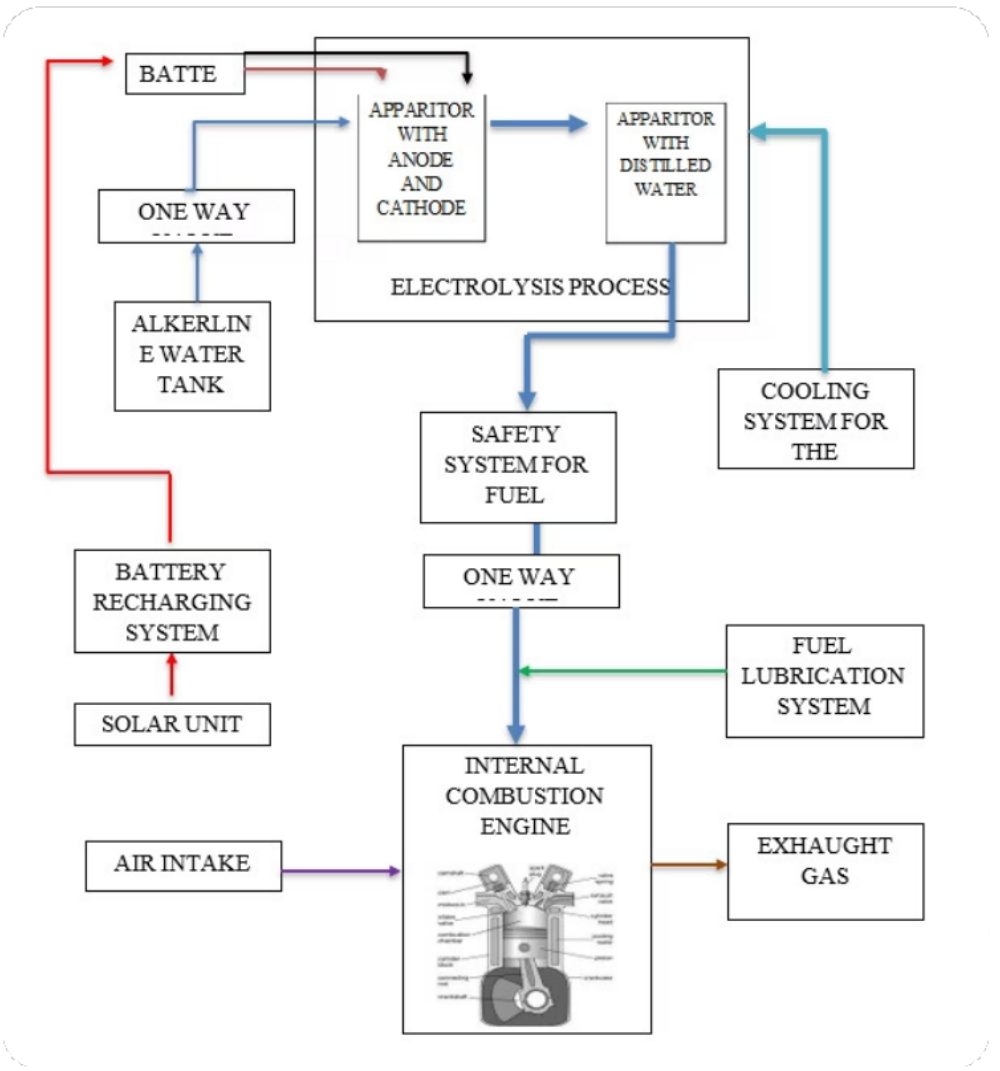
The process of making the Oxy-hydrogen mixture needs electricity. To fulfill this here use the battery The overall system is working as the engine is used to charge the battery through the generator. This battery is always providing power to ignition and self-starting system which are used to drive the vehicle. To balance out the power drainage here we added the alternator to generate electricity that can be stored in the battery.

Here, the designed system should be a low-budget project, increase the overall efficiency of the engine and overcome the disadvantages of petrol fuel. After the fuel of Oxy- Hydrogen mixture is created in the container, it needs to be extracted without water particles. Because the water particles will create a major problem for the combustion process. To reduce this drawback, here used a separate container with distilled water. This will remove any and every molecule that is not reacted.

After that oxy-Hydrogen mixture was extracted, it comes directly to the combustion chamber. Because hydrogen has a higher air: fuel ratio we have to increase the volume of the combustion chamber so it can help for the efficiency of the engine. Here the engine is used only to charge the battery, therefor it should remove some unwanted parts from the engine to reduce the weight of the engine and increase its performance as well.

After planning the system working procedure, identify what are the future risks and problems we have to face when developing, integrating, and other all the stages of the project and how to overcome them. next have to focus on utilizing space to integrate the new system, especially for motors, generators, and batteries by keeping the engine balance and smooth. After integrating the new components.

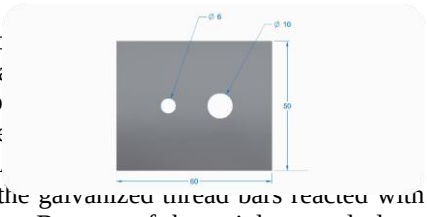
Next about the testing. To ensure the new system will enhance the efficiency of the engine and last a long period without having an issue and compare both results concerning fuel consumption of petrol and hydrogen. About the cost- effectiveness and the reusability of the fuel. finally, all the results may analysis and discuss the benefits and enhancement of the modified hydrogen combustion system for petrol engines.



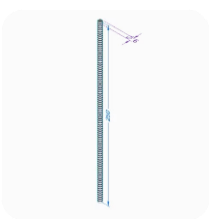
Electrolysis Process Components and Assembly

Stainless Steel Plates

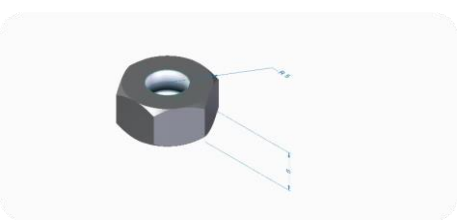
This is a stainless steel(304L) plate. This c



We use 22 plates in our generator for gener
plates were cut to the sizes to better fit the p
the complete anode, cathode and electrolyte
and attached to the galvanized thread bar.
the results were not satisfactory. Because the galvanized thread bars reacted with the process and contaminated the electrolyte. Because of the stainless-steel plates need to be polished and make some rough surface to increase the reaction. Those were given in the figure below. By roughing up the surface creates the microscopic groves that can increase the surface area of the electrode. The both holes are not same size because when it stacked together one by one layer produces anode and the cathode.



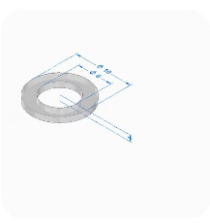
- This one also stainless-steel tread bar. This tread bar use anode and cathode in our electrolysis apparatus.



- Stainless steel nuts are employed to secure the stainless-steel plates and stainless-steel electrodes together in the construction of the electrolysis apparatus.

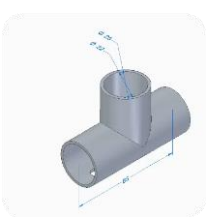
Why we use stainless steel for our HHO generator

- Stainless steel is known for its corrosion resistance, which is important when working with electrolytes and water. Using stainless steel helps ensure the longevity of our electrolysis apparatus. Stainless steel is a good conductor of electricity, which is essential for the efficient operation of an electrolysis cell. Stainless steel is a durable material that can withstand the physical demands of us



- electrolysis experiments. It is less likely to deform or deteriorate over time compared to some other materials.
- This is a silicon rubber washer. We use a rubber washer to insulate and separate the connection between the anode and cathode in the electrolysis apparatus. This phrasing conveys that the rubber washer is used to prevent electrical contact or connection between the anode and cathode, which is important for safety and proper functioning of the electrolysis setup.

- Assemble of electrolysis generator



This ½ inch PVC TEE pipe two ends use for attach the two electrode and other tee pipe end use for attach the electrolysis generator part to the container.

This is our container use for attach the electrolysis generator and get the output gas

This is a final assemble of HHO generator part in this electrolysis process. This one is fully sealed container and it have only input and output ports. Input port use for send the wire connection and output port use for output the oxy- hydrogen mixture.

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This one is full assemble of electrolysis generator. This black container produces the oxy-hydrogen mixture and blue container use for filter free electron in the oxy-hydrogen mixture. (Blue container fill with distilled water)

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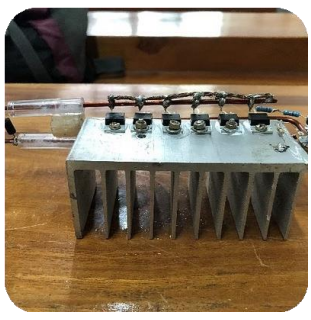
Safety Systems and Hydrogen Production Control

To regulate the amount of hydrogen production there were different types of various kinds techniques were used in the industry like connecting a valve to restrict the flow of the input, install a separate storage system to control. But in this research, we have chosen to regulate the amount of hydrogen production because of the Oxy-Hydrogen mixture is a highly explosive gas that can be exploded even in the slight change in pressure or littler spark. Because of this limiting the production of the hydrogen is a safer way to prevent any buildup of hydrogen gas.




The above shown Figure 6.11 was the current controlling system made from MOSFET IRFZ44N(49A),50K Potentiometer,20K Ohm Resistors,47 Ohm Resistors and 1N5404 Diode. This will regulate the amount of current given in to the electrode ultimately regulating the production of hydrogen production. MOSFETs, with their low ON-state resistance and high efficiency, enable precise control over current flow. Their fast-switching speed allows for quick transitions between the ON and OFF states, making them suitable for applications requiring rapid response times.

MOSFETs also exhibit low input capacitance, contributing to reduced switching losses in high-frequency applications. The compact design and compatibility with digital control make MOSFET-based current control systems suitable for diverse electronic applications. Additionally, advancements in silicon technology continually enhance MOSFET performance, ensuring temperature stability and reliability across a broad operating range. Overall, MOSFETs provide an efficient and versatile solution for achieving accurate and responsive current control in electronic circuits.

Current Regulation

MOSFET-based system controls hydrogen production by regulating current flow to electrodes, preventing dangerous gas buildup.

Flashback Protection

Flashback arrestors prevent retrograde flame propagation, protecting equipment and personnel from explosion hazards.

Safety Compliance

System meets industry safety standards for handling flammable gases in automotive applications.

For the increasing of the safety of this system we have taken another step to increase the functional safety from against the blowback effect and other types of effects we have install a flashback arrestor.

A flashback arrester is a crucial safety device employed in industries where flammable gases are utilized, such as welding and cutting processes. Its primary function is to prevent the retrograde flow of flames or explosions into the equipment or system from which they originated. The advantages of flashback arresters are multifaceted. Firstly, they enhance workplace safety by mitigating the risk of accidents and injuries associated with the backward propagation of flames. These devices also safeguard equipment from damage caused by flashback incidents, promoting longevity and reducing maintenance costs. Compliance with safety regulations is another significant advantage, as flashback arresters are often mandated in industries dealing with flammable gases. Their versatility allows for use with various fuel gases, making them adaptable to different applications. In essence, flashback arresters play a pivotal role in preserving both human safety and equipment integrity in environments where the handling of flammable gases is commonplace.

Engine and Attachment

- Initially, we fabricated an iron L-bar frame designed to securely accommodate the engine, water electrolysis containers, and various other engine attachments.


- The engine was firmly affixed to the iron frame, and the engine wiring was meticulously completed to ensure optimal functionality. We use 90cc four stroke Chinese engine for test the oxy-hydrogen mixture.


All the equipment pertinent to the engine, including the battery and self-start motor for engine initiation, were meticulously connected. Following this, a comprehensive inspection of all wiring connections was conducted. Gasoline was introduced, and the engine was successfully started and run without any complications. The engine and its associated attachments are now prepared for the evaluation of the oxy-hydrogen mixture

Results and References

Result

The tests we have done with the electrolysis process gave the advantages findings and useful data not only for the electrolysis but also about the water quality that have used and what are the effects that are causes those problems. When using stainless steel 304L as electrodes in an electrolysis process, impurities primarily arise from the degradation of the stainless steel itself. Stainless steel 304L contains iron, chromium, and nickel as its main constituents, but it may also contain trace amounts of impurities like carbon, sulfur, and silicon. During the electrolysis process, especially in acidic or corrosive environments, the stainless-steel electrodes can slowly corrode, releasing iron and chromium ions into the electrolyte. These ions can contaminate the solution, affecting the purity of the final products. Additionally, any impurities present in the stainless steel from the manufacturing process, such as surface contaminants or non-metallic inclusions, can also be released as the electrodes corrode. To minimize impurities in such cases, it is essential to choose high-quality stainless steel, maintain proper operating conditions, and periodically inspect and replace electrodes when they show signs of degradation.

The electrolysis process had some changes when the different types of waters were interduce as an electrolyte. One of these changes and issues are the;

Used Battery Time to fill the bottle in Seconds

Battery capacity	Time (s)	Given current (A)
35Ah	153	16.68
45Ah	80	23.25
65Ah	61	35.44
90Ah	58	38.22

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