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Fabricating and Testing an Inline Twin-Cylinder Engine: Experimental Study

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Abstract

The usage of lightweight and cost-efficient engine is trending in our market now. Here this project introduces a hand-built SI twin cylinder engine. It is the smallest and compact twin cylinder under 200cc displacement. 270-degree crankshaft configuration is used in this engine for optimum power delivery and reduced vibration. This engine uses dual fuel for power (DUAL FUEL). It is an alternative to market available high-performance engines that use petrol as the only fuel. The current form of twin cylinder engines is highly expensive and heavy. Fossil fuel depletion will be a major challenge in the upcoming times due to that hydrogen is used as secondary fuel. At present fuel price being very high it is very difficult for common people to afford multi-cylinder engines. The main alternative to this is to make a cost-effective engine with high fuel economy.

Keywords: Inline twin cylinder engine, dual fuel power, hydrogen is secondary fuel, hand-built engine, 200cc displacement engine, fuel economy

INTRODUCTION

Internal combustion engines are the most common type of power plant used in motor vehicles, and they rely on a fuel source to power their operation. There are a variety of different fuels that can be used in internal combustion engines, including gasoline, diesel, and alternative fuels such as hydrogen. One of the main advantages of alternative fuels is that they can help to reduce the dependence on fossil fuels, which are a limited resource and a significant contributor to air pollution and climate change. Alternative fuels can also help to reduce emissions from vehicles, which can have a number of benefits for the environment and human health. One alternative fuel concept that has been proposed is the use of a combination of hydrogen and gasoline as energy sources for vehicles. This approach combines the advantages of both fuels in order to optimize the performance and efficiency of the vehicle. Hydrogen is a clean-burning fuel that produces few emissions when burned, and it has a relatively high energy density, which means that it contains a large amount of potential energy per unit of volume. Gasoline is also a high-energy density fuel, and it is widely available and easy to store and transport. By using a combination of hydrogen and gasoline, it is possible to take advantage of the strengths of both fuels. Hydrogen can be used for part load conditions, while gasoline can be used for full-load operating conditions. This can help to minimize the consumption of fossil fuels and reduce emissions, while still providing the necessary power and performance for the vehicle.

LITERATURE REVIEW

To perform this project, literature review has been made from various sources like journal, books,

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article, and others. This article includes all important studies which have been done previously by other research work.

Md. Fahel Bin Noor [1] The present study examined the performance of two types of cylinders made from different materials: aluminium alloy and grey cast iron. The results showed that the aluminium alloy cylinder had a higher level of surface temperature and total heat flux compared to the grey cast iron cylinder. This indicates that the aluminium alloy cylinder was more effective in terms of surface temperature and total heat flux than the grey cast iron cylinder. The surface temperature of a cylinder is an important factor to consider, as it can affect the overall performance and efficiency of the device. Similarly, the total heat flux, or the rate at which heat is transferred through a material, is also a crucial characteristic that can impact the effectiveness of a cylinder. The results of this analysis suggest that the aluminium alloy cylinder may be a more suitable material for these specific characteristics. Overall, the findings of this study highlight the importance of considering the material of a cylinder when evaluating its performance and effectiveness. The use of aluminium alloy in cylinders may provide improved surface temperature and total heat flux, leading to better overall performance.

Zeyaullah Ansari [2] The purpose of this study was to analyse the deformation, stress, and strain experienced by a camshaft under different conditions. The results of the study provide valuable information about the behaviour of camshafts and can be used to inform future research and development in this area. The findings of the study offer a comprehensive understanding of camshafts and will be useful in guiding the design of more effective and efficient camshafts in the future. Overall, this study is an important contribution to the field of camshaft research and will be helpful in shaping the direction of future work in this area.

Aniruddha Joshi [3] The focus of this study is on how modifying the timing of a valve lift event in an engine can affect its efficiency, performance, and maximum power output. The purpose of the research is to identify opportunities for improving the efficiency, performance, and power of the engine by adjusting the timing of the valve lift event. This is a significant area of inquiry because changing the timing of the valve lift event can significantly impact the performance of the engine. By identifying the optimal timing for the valve lift event, it may be possible to enhance the efficiency, performance, and power of the engine. The results of this study will be valuable for engineers and designers looking to optimize the performance of engines through the timing of valve lift events.

Tao Huang, Jisheng Zhang [4] Imbalances in crankshafts can have a number of negative impacts on the overall performance and operation of an engine. These imbalances can lead to increased vibration, noise, and wear on the various components of the engine, which can ultimately result in reduced efficiency and lifespan. In order to address these imbalances, it is important to have an effective and efficient method for correcting them. One such method that has been proposed is the use of dynamic balance modelling and synthesis techniques to identify and address imbalances in the crankshaft. This approach involves using computer modelling and simulation to identify areas of the crankshaft that are contributing to imbalances, and then using this information to guide the drilling out of specific areas at a specific angle. This can help to improve the overall balance of the crankshaft, reducing vibration and wear on the engine components. One of the key benefits of this method is that it is relatively fast and accurate. By using computer modelling and simulation, it is possible to quickly and accurately identify the specific areas that are causing imbalances and to develop a plan for addressing them. This can help to minimize the time and resources required to correct imbalances, making it an effective and efficient solution. Additionally, because this method involves drilling out specific areas of the crankshaft rather than replacing it entirely, it can also be more cost-effective than other approaches. Overall, the use of dynamic balance modelling and synthesis techniques to address imbalances in crankshafts offers a fast, accurate, and cost-effective solution that can help to improve the performance and lifespan of engines.

Mayank Kumar [5] The selection of appropriate materials and their properties is an important factor to consider in many different fields. Materials science is the study of the properties and behaviour of different materials, and it is a key discipline that helps to inform the selection of materials for various applications. There are many different factors that need to be taken into account when selecting materials, including their physical properties (such as strength, density, and conductivity), chemical properties (such as corrosion resistance and reactivity), and mechanical properties (such as toughness and elasticity). The specific requirements of the application will determine which properties are most important and will help to guide the selection of materials. In addition to considering the properties of the materials themselves, it is also important to consider how the materials will be processed and manufactured into the final product. This can have a significant impact on the overall performance and reliability of the product, and it is important to choose materials that can be processed and manufactured in a way that meets the necessary requirements. Overall, the selection of appropriate materials and their properties is a critical aspect of many different fields, and it requires careful consideration and analysis in order to ensure that the right materials are chosen for the specific application.

Internal combustion engines, which are found in many types of vehicles, rely on a fuel source to power their operation. There are a variety of different fuels that can be used in internal combustion engines, including gasoline, diesel, and Liquified Petroleum Gas (LPG) [6]. Each type of fuel has its own unique properties and characteristics and may be more or less suitable for different types of engines and applications. In this investigation, LPG was used as a fuel for an internal combustion engine with a capacity of 97 cubic centimetres. This engine was tested under different operating conditions to evaluate the performance and efficiency of LPG as a fuel. It was found that LPG is a suitable fuel for use in lower speed vehicles, but gasoline is more appropriate for higher speed operations. This may be due to the fact that LPG has a lower energy density than gasoline, which means that it contains less potential energy per unit of volume. As a result, LPG may not be able to provide the same level of power and performance as gasoline at higher speeds. However, LPG does have some advantages over gasoline as a fuel. It is generally less expensive than gasoline, and it produces fewer emissions when burned, making it a potentially more environmentally friendly option. LPG is also easy to store and transport, and it is widely available in many parts of the world. Overall, the choice of fuel for an internal combustion engine will depend on a variety of factors, including the performance requirements of the engine, the intended use of the vehicle, and the availability and cost of different fuel options. LPG may be a suitable choice for certain types of vehicles and applications, but it may not be the best fuel for all situations.

Liquified Petroleum Gas (LPG) is a type of fuel that is composed of a mixture of hydrocarbons, primarily propane and butane. It is a versatile fuel that can be used in a variety of different applications, including heating, cooking, and as a fuel for internal combustion engines. LPG has a number of properties that make it an attractive fuel option in certain situations. It has a relatively high energy density, which means that it contains a relatively large amount of potential energy per unit of volume [7]. This can make it a good choice for applications that require a high level of power and performance. LPG is also relatively clean-burning and produces fewer emissions than other fossil fuels, making it a potentially more environmentally friendly option. In order to use LPG as a fuel, it is necessary to make certain modifications to the components of the engine. This may include installing a dedicated LPG fuel system, which includes a fuel tank, fuel lines, and a fuel injector system. It may also be necessary to modify the ignition system and other engine components in order to optimize the engine for LPG operation. Overall, the selection and modification of components for LPG fuel requires careful consideration in order to ensure that the engine is properly configured for LPG operation. By choosing the right components and making the necessary modifications, it is possible to use LPG as an efficient and effective fuel for internal combustion engines.

Prof. Bhushan Mahajan [8] The Morse test, also known as the Morse Indicator Diagram method, is a method for measuring the indicated power and mechanical efficiency of multi-cylinder engines. It involves using a Morse Indicator, which is a device that measures the pressure within the cylinders of an engine as it operates. By analysing the pressure data collected by the Morse Indicator, it is possible to determine the indicated power and mechanical efficiency of the engine. The Morse test is generally considered to be a reliable and accurate method for evaluating the performance of multi-cylinder engines. It is often used in the development and testing of new engine designs, as well as in the evaluation of existing engines. One of the key advantages of the Morse test is that it provides detailed information about the performance of individual cylinders within the engine, which can help to identify problems or areas for improvement. It is also relatively easy to use, making it a practical and convenient method for evaluating the performance of multi-cylinder engines. Overall, the Morse test is a useful tool for measuring the indicated power and mechanical efficiency of multi-cylinder engines, and it is widely used in a variety of different applications.

Mayank Sharma [9] The proper timing of the valves in an internal combustion engine is critical to its performance and efficiency. The valves play a key role in controlling the flow of air and fuel into the engine's cylinders, and the timing of their opening and closing can have a significant impact on the engine's power output and fuel efficiency. In order to optimize the timing of the valves, it is often necessary to use some form of valve timing mechanism. These mechanisms can take a variety of different forms, ranging from simple mechanical linkages to complex electronic control systems. One approach that has been proposed in this study is the use of a valve timing mechanism that is controlled by a solenoid valve. A solenoid valve is an electrically controlled valve that uses a solenoid (a type of electromagnet) to actuate a valve stem or other moving part. By using a solenoid valve to control the timing of the engine's valves, it is possible to achieve precise and automated control of the valve timing. The use of an electrically controlled valve timing mechanism has a number of potential benefits. It allows for precise and fine-tuned control of the valve timing, which can help to optimize the engine's performance and efficiency. It also allows for automation of the valve timing process, which can reduce the need for manual intervention and improve the consistency and reliability of the engine's performance. Overall, the use of a solenoid-controlled valve timing mechanism has the potential to improve the power and efficiency of internal combustion engines through the precise and automated control of valve timing. By carefully controlling the timing of fuel injection and combustion, it is possible to optimize the performance of the engine and improve its overall efficiency.

Automobile pollution refers to the harmful substances that are released into the air as a result of the operation of motor vehicles. One of the main sources of automobile pollution is the internal combustion engine (ICE), which powers the majority of the world's cars and trucks. Internal combustion engines release a range of pollutants into the air, including carbon monoxide, nitrogen oxides (NOx), and particulate matter. These pollutants can have a variety of negative impacts on the environment and human health, including air pollution and climate change. Nitrogen oxides (NOx) are a group of highly reactive gases that are produced as a result of the high temperatures and pressures that occur during the combustion process in internal combustion engines. NOx emissions are a major contributor to air pollution, and they have been linked to a range of health problems, including respiratory issues and heart disease. Reducing NOx emissions from internal combustion engines is an important goal in efforts to improve air quality and reduce the negative impacts of automobile pollution. There are a number of strategies that can be used to reduce NOx emissions from internal combustion engines, including the use of emission control technologies such as catalytic converters and the adoption of alternative fuels and advanced engine designs [10].

METHODOLOGY

System Overview

Hydrogen fuel internal combustion engines (HICEs) are a type of engine that uses hydrogen as a fuel source. These engines have the potential to be more efficient and produce fewer emissions than traditional internal combustion engines that use fossil fuels such as gasoline and diesel.

There are several steps that can be followed to design and implement a HICE:

1. Determine the desired performance and efficiency goals for the HICE. This may include factors such as power output, fuel efficiency, and emissions levels.
2. Select an appropriate engine design and architecture. There are a variety of different engine architectures that can be used for HICEs, and the choice of architecture will depend on the specific performance and efficiency goals of the engine.
3. Develop a fuel delivery and management system for the HICE. This may include the design and construction of a fuel tank, fuel lines, and a fuel injector system.
4. Configure the ignition system for hydrogen fuel. Hydrogen has different ignition characteristics than fossil fuels, and the ignition system will need to be tailored to these characteristics in order to ensure reliable and consistent ignition.
5. Test and tune the H2ICE to optimize its performance and efficiency. This may involve using computer simulations and physical testing to fine-tune the engine's operating parameters.

The schematic diagram of the proposed methodology is shown in the Figure 1. Initially the study is carried out. To fabricate the Hydrogen powered internal combustion engine, the material selection is carried out. The materials are mainly classified into two, Electric materials and the raw materials. The electric materials mainly include battery, Hydrogen control module, Hydrogen generator and micro controller. The raw materials include the Aluminium blocks, Crankshaft, Steel plates, Carburettor, and additional engine components. The raw material and the electric materials, when assembled properly to Hydrogen generator. The testing is carried out to check the performance.

HARDWARE USED

The major hardware incorporated in the IC engine includes the battery, Hydrogen control module, Hydrogen generator, flashback arrestor, Hybrid fuel system etc. The details of the components are as follows:

12V, 12 Ah Battery

A rechargeable battery that powers a motor vehicle is known as an automotive battery. Its primary function is to supply starter fluid, which powers the engine. The alternator charges as demand rises or falls while the engine is running, supplying power to the vehicle's electrical systems. Six cells make up a wet cell battery, like the one found in a car.

A lead storage battery has alternate plates made of a lead alloy grid that are either coated in lead peroxide or filled with sponge lead (cathode plates) for each cell. The electrolyte, a solution of sulfuric acid, is present in every cell.

At first, each cell had a filler cap through which water could be added and the level of electrolyte could be seen. A small vent hole in the filler cap let the hydrogen gas produced during charging escape from the cell. From one cell's positive plates to the negative plates of the cell next to it, short, heavy straps connect the cells. At the top, or sometimes on the side, of the battery, a pair of bulky terminals coated in lead to prevent corrosion are installed. Plastic cases and woven sheets are used in modern units to prevent cell plates from touching and short-circuiting.

Batteries are typically made of six galvanic cells in series circuit. Each cell provides 2.1 volts for a total of 12.6 volts of full charge. During discharge, a chemical reaction releases electrons, allowing them to flow through conductors to produce electricity. As the battery discharges, the acid of the electrolyte reacts with the materials of the plate, changing their surface to lead sulphate.

When the battery is recharged, the chemical reaction is reversed: the lead sulphate reforms into lead dioxide or lead peroxide. With the plate restored to the original condition, the process may be repeated. The charging and discharging in a lead acid battery is shown in the Figures 2.

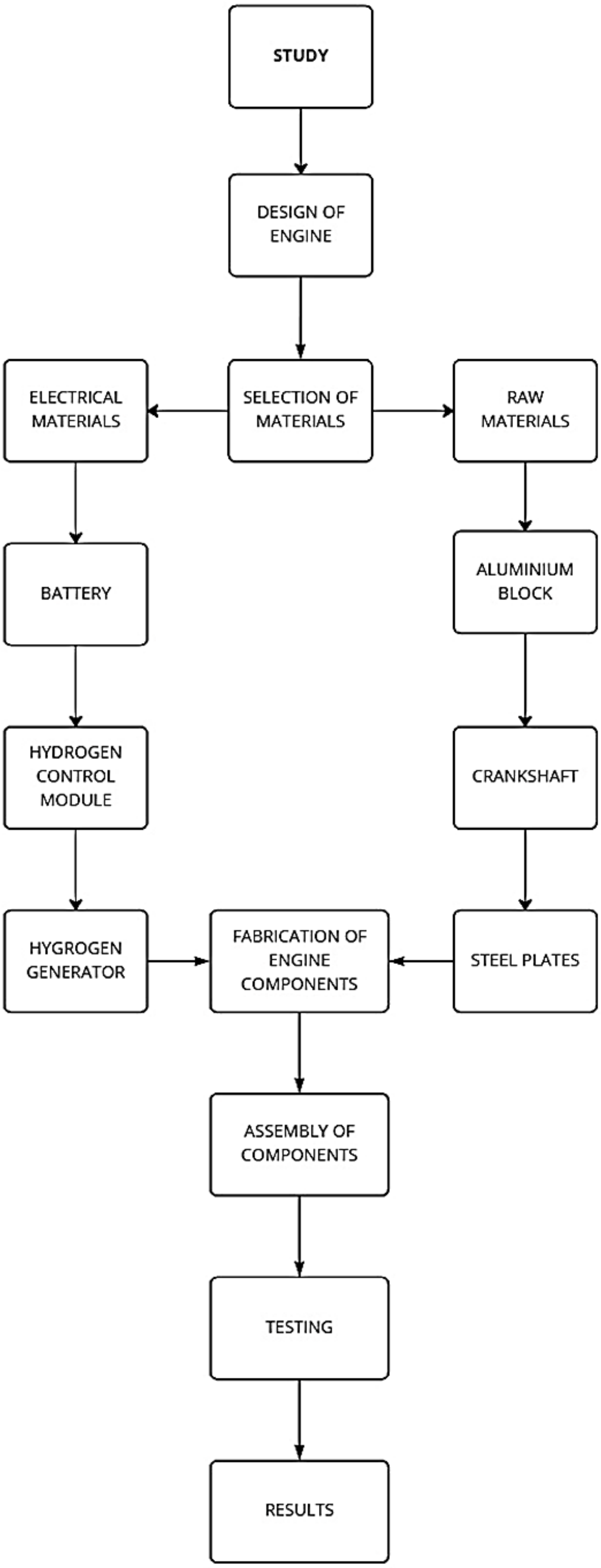

Figure 1. Schematic diagram of the methodology.

Figure 2. 12 V, 12 Ah battery.

As, **PbO_2** - Lead peroxide
Pb-Lead
H_2SO_4-Sulphuric Acid
$PbSO_4$-Lead Sulphate
H_2O-Water

The chemical reaction in a battery while charging is given as follows:

$$PbO_2 + Pb + 2H_2SO_4 \longleftarrow 2PbSO_4 + 2H_2O$$

The charging of the lead acid battery is shown in the Figure 3. During the charging, the lead sulphate on the anode converted to the lead peroxide and that of the cathode converted to sponge lead. The acid leaves from the anode and cathode to form the dilute sulphuric acid solution. The charging starts, when a charger is connected between the anode and the cathode. The electrons flow from the anode to cathode.

The chemical reaction during the discharging of lead acid battery is given below:

$$PbO_2 + Pb + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$$

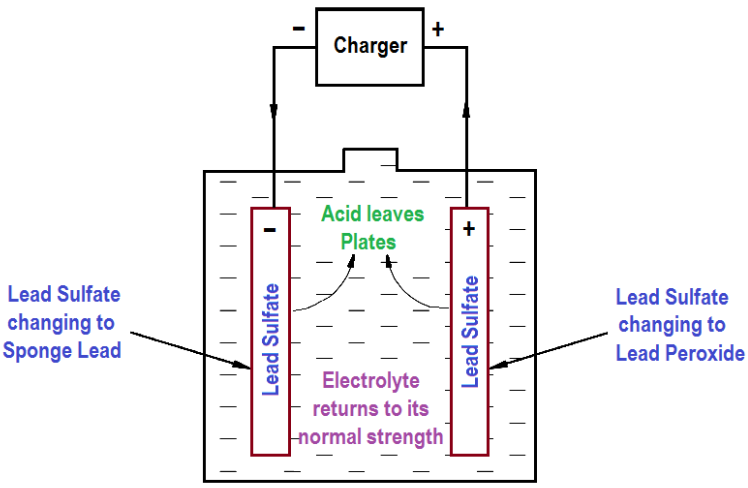

Figure 3. Charging of lead acid battery.

The Figure 4 shows the discharging of the battery.Here the cathode,which is sponge lead converted into the lead phosphate and the anode,which is the lead peroxide too converted into the lead phosphate.The sulphuric acid is converted into water ,when the acid goes into plates to from the lead phosphate.The dicharging starts takesplace when the battery load is connected between the anode and the cathode.The electron flow occurs from cathode to anode.

The specification of the lead acid battery is given in the Table 1. Four lead acid batteries rated 12V,12 Ah battery are connected in series. The input and the output frequency of the current is 50 Hertz. Each of the battery weighs half kg.

Dry Cell Hydrogen Generator

A dry cell HHO generator is a device that uses electricity from a dry cell battery to produce hydrogen and oxygen gas through the process of electrolysis. The hydrogen and oxygen gases are then mixed and burned to generate heat or used to power a fuel cell to generate electricity.

Dry cell HHO generators have a few potential applications, including use as a supplemental fuel source for vehicles, portable power generation, and emergency backup power. They are generally considered to be more efficient and environmentally friendly than traditional fossil fuel-based power sources, as they produce fewer emissions and do not rely on non-renewable resources (Figure 5).

One potential disadvantage of dry cell HHO generators is that they can be expensive to operate, as they require a constant supply of electricity to function. They also require careful maintenance to ensure that the hydrogen and oxygen gases are produced and burned safely (Figure 6).

Electrolysis of water is the best method of producing high purity hydrogen gas on demand. The most important element of the generator is the electrolyser cell where the electrolysis reaction takes place. The cell consists of two electrodes (an anode and a cathode), which are separated by the ion exchange membrane. To produce the highest purity of hydrogen up to up to 99.9995% purity, a platinum catalyst is used at the electrodes.

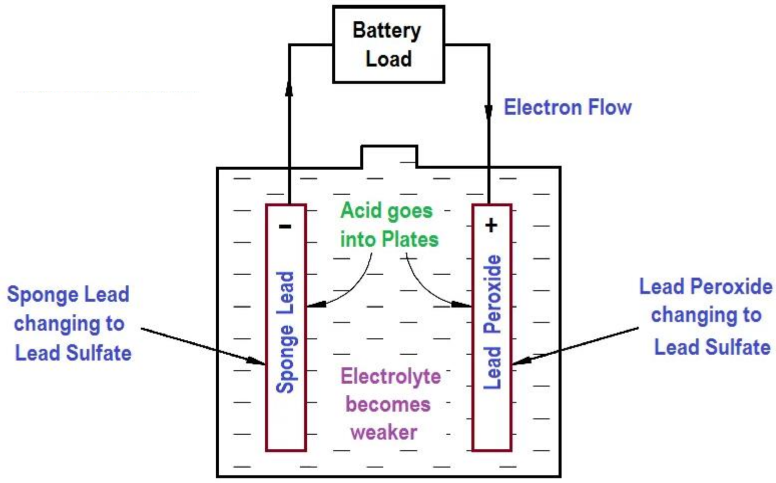

Figure 4. Discharging of the battery.

Table 1. Lead-acid battery specification.

Voltage	12 V
Electric Charge	12 Ah
Quantity	1
Frequency	50 Hz
Weight	0.5 kg

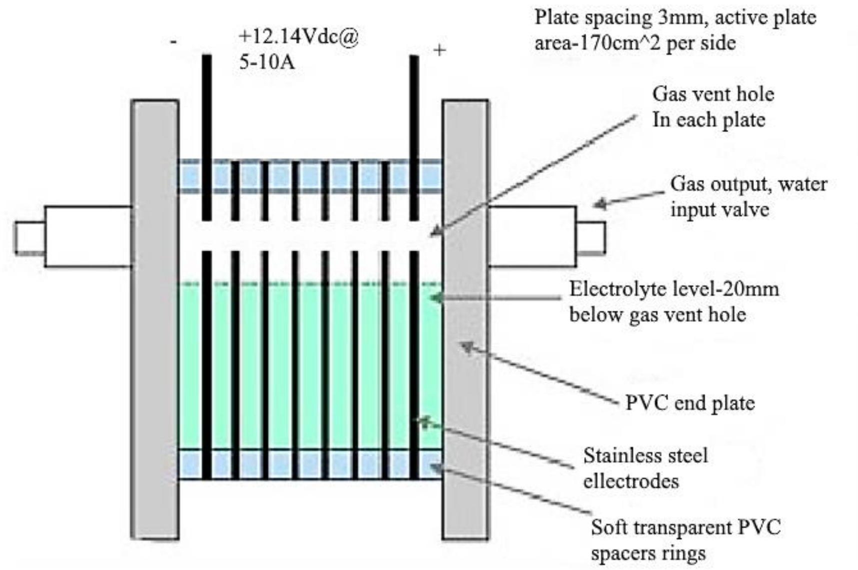

Figure 5. Hydrogen dry cell configuration.

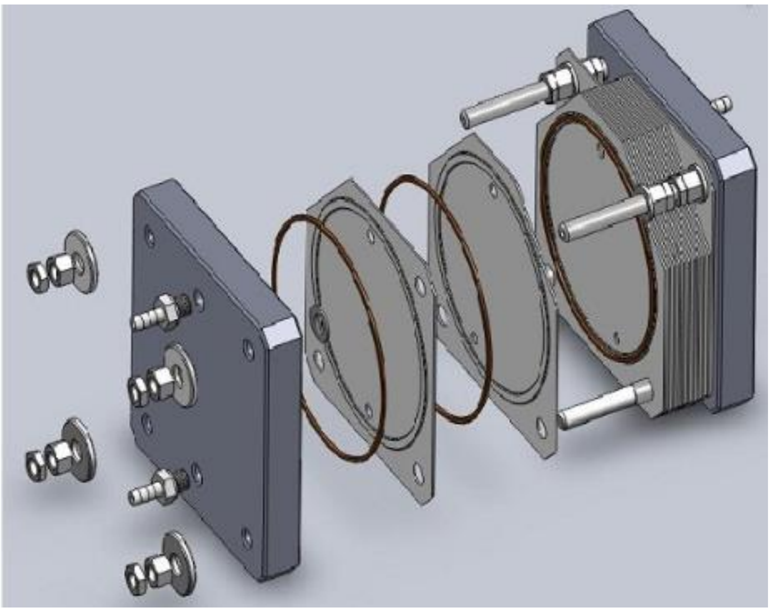

Figure 6. CAD Model of HHO Generator.

When a continuous voltage is applied to the electrodes on the electrolyser cell, the following reactions take place:

At the anode (the positively charged electrode), the water molecules lose two electrons, forming an oxygen molecule and four hydrogen ions.

Anode $2H_2O - 4e = O_2 + 4H^+$

The oxygen that is produced in this half of the reaction is safely vented to atmosphere from the back of the generator. The four hydrogen ions that have been produced then pass through the ion exchange membrane (attracted by the negatively charged cathode) and collect four electrons reducing them to two hydrogen molecules.

Cathode $4H^+ + 4e = 2H_2$

The hydrogen gas produced is separated from the oxygen by the ion exchange membrane, which is impervious to molecular oxygen (Figure 7).

NaOH is electrolysed.

$NaOH \rightarrow Na^+ + HO^-$

$H_2O \rightarrow H^+ + HO^-$

At cathode: $2H^+ + 2e^- \rightarrow H_2$

At anode: $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$

CONSTRUCTION

Engine

For the modification, we selected Bajaj Kawasaki 120 cc engine. This engine must be modified to work on both Hydrogen and Gasoline. The engine block and its parts need alternations (Figure 8).

DISASSEMBLY OF ENGINE

To start the work, we need to disassemble both the engine using spanners, screwdriver, mallet etc. After disassembly of the engine there were a lot of oil inside the engine and to work with it, we need to clean the part properly using some diesel, which help clean and remove the oil from the part easier.

After using diesel to clean the engine parts we kept this aside so that the diesel gets vaporized from the surface of the parts. And we kept all the parts in one place by arranging them in proper way so that we can take the parts easier (Figure 9).

SHAPING OF ENGINE BLOCKS

After disassembly crankcase need to be cut in required dimension to fit properly with each other and with correct clearance to fit the crankcase into the block.

The left side engine block needs to be altered for the installation of 270^0 crankshaft. The block is cut to precise same using a vertical milling machine (Figures 10 and 11).

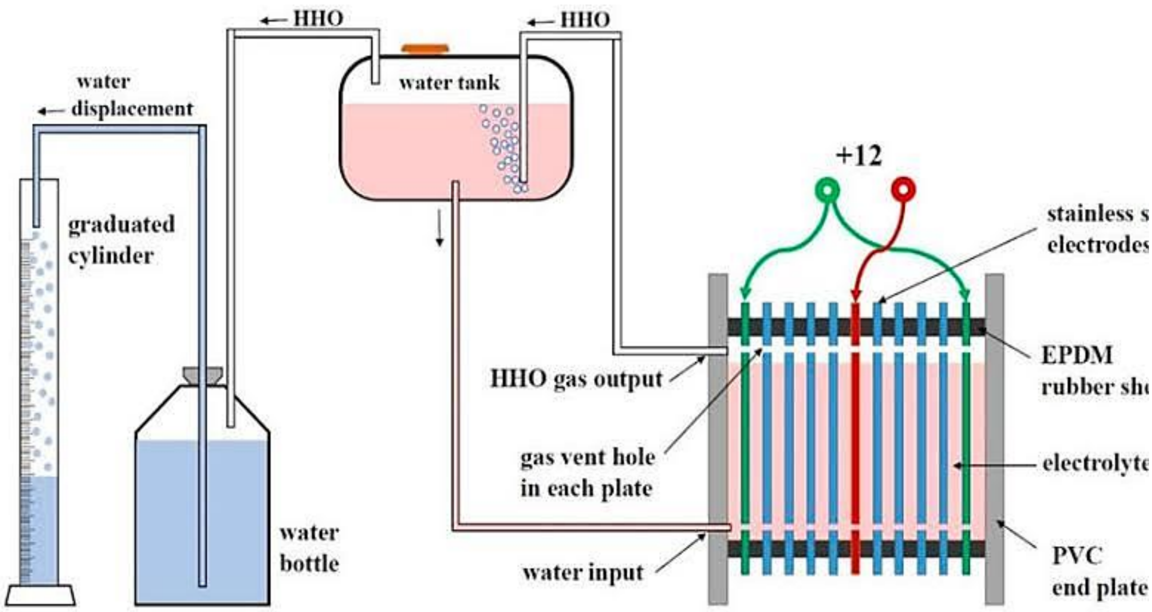

Figure 7. Electrolysis of hydrogen using dry cell configuration.

Figure 8. Bajaj Kawasaki 120 cc engine.

Figure 9. Arranging parts of engine.

Figure 10. Cutting left block using milling machine.

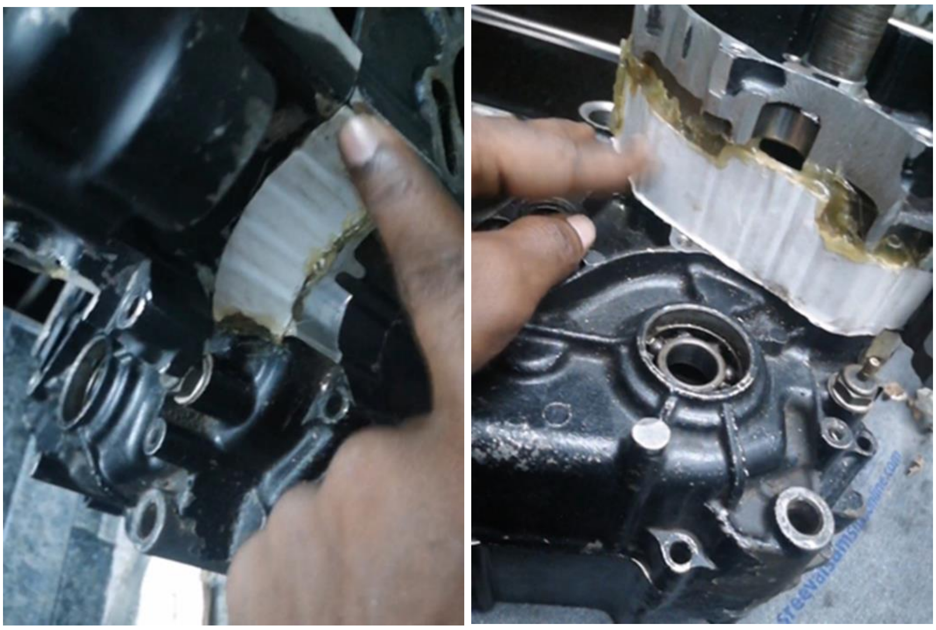

Figure 11. Cut-out portion from engine block (covered with white board).

CONCLUSION

The Pulsar 220 engine has a higher fuel consumption than our twin cylinder engine as we use hydrogen as our secondary fuel, as the petrol fuel required to run the engine is much lower than the 220cc motorcycle. The air fuel ratio to run a convention motorcycle is about 14:1, But when we introduce our engine to Hydrogen, we can increase our air fuel ratio that reduces the fuel consumption of our engine.

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