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WORD COUNT	4167	TIME SUBMITTED	28-JUL-2022 10:52AM
		PAPER ID	88904945

Water fuel cell for motorcycle

Abstract

The primary emphasis of the research is on how to use hydrogen as an energy source for motorcycle fuel. This is an intriguing hypothesis to explore since, at the moment, fossil energy is used to meet fuel demands, although fossil energy supplies are running limited. As a result, hydrogen energy is an option that may be employed as a fuel substitute utilizing commercial water raw materials and the electrolysis method. The research goal is to demonstrate that electrolysis of water to hydrogen gas may occur while the vehicle is in use, to compute the amount of hydrogen gas generated, and to determine the time the vehicle can be utilized using the gas fuel created. The long-term goal of this study is to create a vehicle powered entirely by hydrogen gas produced by water electrolysis, particularly for motorcycles. The experimental approach was employed in this investigation, with three phases of testing on a carburetor-type motorbike utilizing 1, 2, and 3 liters of Pertamax gasoline. The results demonstrated that the process of electrolysis of water into hydrogen gas on motorcycles is possible; however, the amount of gas generated is still quite little. The hydrogen gas generated by this electrolysis method is only 0.06 bar when 1 liter of fuel is used, 0.42 bar when 2 liters of fuel are used, and 0.98 bar when 3 liters of fuel are used.

Keywords: alternative fuel; water electrolysis; brown gas.

I. Introduction

Motorized vehicles are a major producer of air pollution, especially in big cities. The exhaust gases released by vehicles driven by gasoline and diesel fuel motors contain toxic gases, which can have a very detrimental effect on this environment, containing nitrogen oxides, carbon dioxide, methane, benzene, and also particles. The losses incurred are causing disease in humans, damaging the environment, killing plants and living things, making the earth even hotter, etc. In recent decades, several countries in the world have emphasized the environmental impact of the transportation sector and reduced dependence on petroleum. The depletion of conventional non-renewable fuels is one of the main issues in the modern energy scenario, which makes the state of the energy industry unsustainable, and also causes environmental problems such as the greenhouse effect [1][2]. To reduce toxic gas levels, there have been many developments in motor fuel by producing more complete combustion, one of which is the use of hydrogen derived from water (H_2O) [3]. Many studies have been developed to evaluate the challenges of transition of using the hydrogen fuel [4]. The steps which involved the implementation of a hydrogen economy have been investigated. The rationale of the hydrogen energy systems and technology has been studied including the present energy systems and their environmental impact [5].

The same thing was also expressed by [6] who stated that hydrogen fuel is known as an alternative energy source and is an effort to overcome the depletion of fossil fuels along with its higher use. Also, fossil fuels hurt the environment because the products of combustion gases in the form of carbon oxides, nitrogen, sulfur, etc. are one of the main causes of global warming. Therefore, hydrogen fuel is considered an alternative fuel and energy source and can be produced from environmentally friendly sources. To supply the energy demands of the more rapidly increasing global population, it is essential to upgrade to an alternative, sustainable energy source that does not negatively affect the environment [7][8]. The use of alternative fuels in internal combustion engines [9][10][11] can reduce dependence on petroleum-based fuels, where which is a step forward to maintain the security and availability of energy sources [12]. Vehicles fuelled by hydrogen dramatically reduce dependence on fossil fuel resources and significantly mitigate tailpipe emissions [13].

Hydrogen fuel produced from renewable energy resources through water electrolysis is one way to separate hydrogen and oxygen atoms from water or the resulting gas from this electrolysis process is better known as HHO or Brown gas [14]. Hydrogen gas can be used as alternative energy, apart from being a fuel, hydrogen does not cause pollution, and is colorless and odorless [15]. Hydrogen production from renewables is always environmentally friendly, whereas the hydrogen produced from non-renewables emits greenhouse gases (GHG) [16][17]. Figure 1 shows the water electrolysis circuit. Figure 1 is a water electrolysis circuit. The main circuit in the electrolysis of water consists of an anode (positive), a cathode (negative), and an electrolyte. These two poles are included in the electrolyte (water) and the current source according to their respective poles. From this process, brown gas will be formed.

Hydrogen has greater potential for use as a fuel in the future. It is estimated that, by the year 2030, the cost of fuel cells will be competitive with ICEs based on the technological improvements being made and the increased availability. Until now, many studies have stated that the amount of hydrogen produced from renewable energy sources through water electrolysis is too small and the highest amount is still produced from fossil fuels. Because of the advantages and flexibility of hydrogen fuel, in the long run, hydrogen will be an alternative to hydrocarbon fuels. Hydrogen fuel is also considered the highest energy-efficient and clean because it only produces water from its combustion. Most countries in the world have accepted to use of hydrogen fuel as an independent clean energy source that has a high energy content compared to fossil fuels.

Even though hydrogen fuel is a clean and sustainable energy source, it has so far only been used in motorized vehicles such as automobiles, buses, and others. The hydrogen gas required as the fuel is produced by huge gas generators and requires the same refilling stations as other fossil fuels. The novel aspect of this research is the use of hydrogen gas fuel in a low-cost vehicle, such as a two-wheeled vehicle. Until now, there have not been many studies that try to reveal the amount of hydrogen gas that can be produced through the electrolysis of water in vehicles. If this can be realized, it will create discoveries that can be applied to society.

Departing from this problem, an effort is needed to create a vehicle that uses hydrogen gas, because hydrogen fuel has become an alternative energy source that can be produced from environmentally friendly sources, and what is no less important is that it will only produce water from its combustion. Therefore, this research aims to try to prove that the electrolysis process of water into hydrogen gas can occur when the vehicle is used, determine the amount of hydrogen gas produced when the vehicle uses fossil fuels 1, 2, and 3 liters, and determine how long the vehicle can be turned on and used by using the resulting gas fuel.

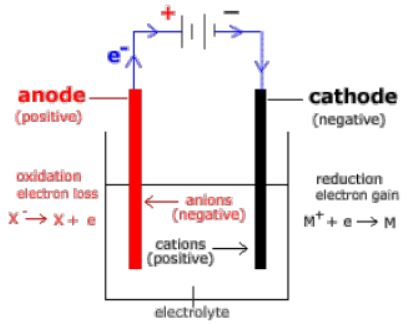

Figure 1. Water electrolysis circuit [18]

II. Materials and Methods

A. Materials

The material used in this study can be seen in Table 1 below. Table 1 shows the main materials used. To produce water electrolysis process. The anode and cathode materials in this study used 316 stainless steel plates (the best quality stainless steel), and the reactor tube used acrylic material with thicknesses 5 and 6. To function properly, several supporting components such as pressure gauge, water filter regulator, hoses, cables, and more.

B. Methods

In this research, the method used is the experimental method. According to Sugiyono, experimental research is a research method used to find the effect of certain treatments on others under controlled conditions. Meanwhile, [19] stated that experimental research is a research situation in which at least one variable called the experimental variable is manipulated or controlled, or varied by the researcher. From the two definitions above, it can be concluded that experimental research is research that aims to find a causal relationship between the independent variable and the dependent variable, where the independent variable is controlled and controlled to determine the effect on the dependent variable.

Table 1.
Materials used

No.	Material	Amount	Specification
1.	Stainless steel plate 316 2x9x7 mm	18 shetts	Stainless stell 316
2.	Acrylic box 18x11x10 mm	1 unit	Thickness 5
3.	Acrylic tube ϕ70x250	2 units	Thickness 6
4.	Pressure gauge 1 bar	1 unit	Skon 2,5″
5.	Air filter regulator	1 unit/set	Tekiro 0,25″
6.	1.5mm cable	3 meters	
7.	Cable skund	4 pieces	
8.	1/4″ hose	3 meters	
9.	1/4″ tap stop	3 units	Hato ¼″
10	Bolt	2 pieces	M12x1,5
11.	Acrylic glue	1 box	Crystal high
12.	Brass pipe ϕ1/4″	1 meter	
13.	Bolt ϕ5	1 meter	
14.	Nut	50 pieces	

The stages of the experimental method in this study can be seen from the research flow chart in Figure 2. Briefly, the diagram of this research begins with the process of cutting and assembling a 316 stainless steel plate into a reactor. After the reactor is complete, the next step is to add fluid in the form of water into the reactor tube as well as flow the electric current from the alternator/ motorcycle prok battery to the reactor anode and cathode. With the flow of electricity from the prok battery to the reactor, the electrolysis process occurs in the reactor tube which can produce hydrogen gas. The resulting gas is then channeled to the cooling tube and storage tube for further use as fuel for motorbikes through the carburetor.

To get the research results following the flow above, the researchers conducted initial tests on motorbikes using 1 liter, 2 liters, and 3 liters Pertamax fuel. This parameter is used because the average motorcycle fuel tank capacity is only 4-5 liters. The conditions when the fuel tank is full, will very rarely occur in the field. Therefore, the researcher took the value of 1 - 3 liters as the sample of this study. As long as the motorcycle is on, it will automatically produce hydrogen gas through the electrolysis process that occurs in the water in the presence of an electric current generated by the engine through the alternator/ prok battery. The volume and pressure of hydrogen gas produced are calculated according to the amount of fuel used up. Then the Pertamax supply on the motorbike is turned off so that it is replaced with the hydrogen gas produced earlier.

To do this, a reactor is needed. The reactor is a device designed to produce gas, which requires a DC electric current to decompose water into gas. Inside the reactor, several stainless plate plates function as decomposing water into gas. The electrolysis reactor will separate the water element into the gas element so that it can be used for the combustion process on a motorcycle.

Plate plates have many types and shapes, including their quality. The quality of the plates is very influential in the electrolysis process, the better the plates used, the perfect gas will be produced. In this tool, the researchers used a 316 stainless plate (the best quality), and as an insulator, a rubber material with a thickness of 5 mm was used. This rubber is resistant to heat generated by the plate plates. The following is a picture of the water electrolysis system used in this study.

Figure 3 shows a schematic of the electrolysis process that will be used in this study. In the reactor, electrolysis will occur if it is given a DC electric voltage so that gas pressure can occur. The gas produced will be input through a hose to the gas filter which functions as a separator for wet gas and dry gas. Next, the dry gas is fed back into the Bubbler tube to produce hydrogen and oxygen gas. Then the gas is put into the bubbler (cooling) tube, then it is expelled through the valve (gas valve) and immediately flowed to the motorcycle carburetor as a substitute for the fossil fuel.

For the first step, an experiment will be carried out on a motorcycle by making a dual fuel system consisting of fossil fuels and hydrogen gas as a result of the water electrolysis process when using these fossil fuels. Using this dual-fuel system provides more economic value than the technology used today. In the future, this research is expected to produce 100 % hydrogen gas-fueled vehicles, especially motorbikes.

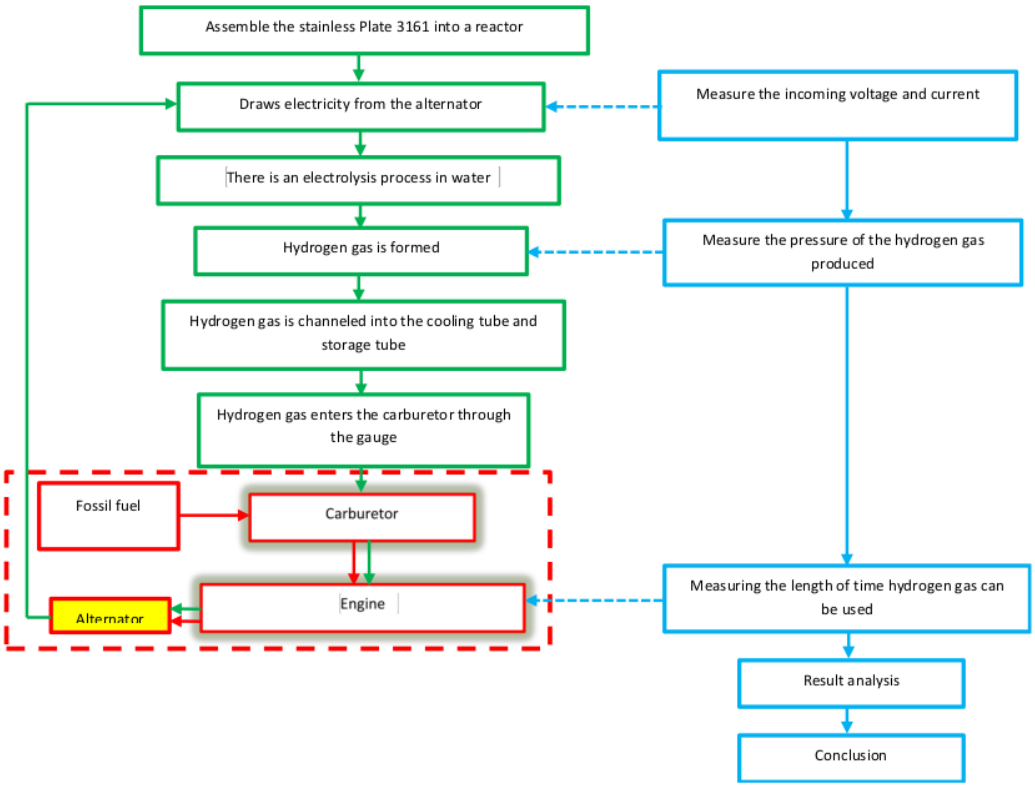

Figure 2. Research diagram

Figure 5. Installation of the reactor to the motorcycle

Figure 3. Electrolysis process schematic

C. Tool assembly and installation process

In testing the design of a gas-fired motorcycle, a single tube is used which functions as a reactor in the electrolysis process of water to hydrogen gas. The reactor tube is made using acrylic material with a thickness of 5 mm and dimensions of 18x11x10 mm. In this reactor tube, 4 holes are made, of which two 5 mm holes are used as the reactor installation (anode and cathode). One hole measuring 6 mm is used as an outlet for electrolyzed gas, and another hole with a size of M12x1.5 which functions as a channel for the intake of water to be used for the electrolysis process.

Besides, 2 tubes were also made, each of which functions as a gas cooling tube and a gas storage tube. The cooling tube and gas storage tube are made using acrylic material with dimensions of diameter 70 mm, height 250 mm, and thickness of 6 mm. In the gas cooling tube, 3 holes are made. One hole serves as the gas inlet from the reactor with a diameter of 10 mm. The second hole with a diameter of 6 mm is used for the conduit from the cooling tube to the gas storage tube. The third hole with a size of M12x1,5 is used as the gas cooling water inlet. Figure 4 shows a picture of the reactor tube.

To produce an electrolysis process in the reactor tube, a series of electrodes is made by combining 9 sheets of stainless steel with a size of 2x9x7 mm which functions as an anode (positive pole), and 9 other sheets of the stainless plate as a cathode (negative pole) in the reactor. To join this stainless plate, M6 bolts and nuts are used, and rubber with a thickness of 5mm is used as an insulator. After the electrode assembly is complete, the next step is to attach the anode and cathode to the reactor tube. The electrodes are paired alternately with each other and locked into the reactor tube.

Figure 5 is an electrolysis reactor tube that has been assembled and placed in the trunk of a motorbike that is used. The size of the reactor tube is adjusted to the size of the motorcycle trunk. The next process is to install the reactor, cooling tube, and storage tube on the motorcycle. The electrolysis reactor is placed in the trunk of the motorcycle, as well as the cooling tube and storage tube on the left and right of the motorcycle wing. The next process is to install the connecting hose between the reactor tube, cooling tube, and gas storage tube to the carburetor. Between the cooling tube and the storage tube, a gas filter is attached so that the water vapor that enters the storage tube can be filtered first.

Figure 6 is a gas cooling tube and a gas reservoir resulting from electrolysis. Each tube is placed on the left and right sides of the motorcycle. The cooling tube serves to cool the electrolyzed gas for further distribution to the storage tube and motorcycle carburetor. The next step is filling the electrolyte solution (water) into the reactor tube and gas cooling tube, as well as installing an electric current source. The current source for the electrolysis process is taken directly from the alternator/motorcycle prok battery. The purpose of taking direct current sources is that the resulting current is higher according to the rpm and speed of the motorbike. Here's a picture of the installation series.

Figure 4. Reactor tubes

Figure 7 is the arrangement of the electrical current source cable installation used for the electrolysis process. The current source is taken directly from the motorcycle battery output. In addition, there is also a gas hose installation from the gas storage tube to the carburetor through several taps.

III. Results and Discussions

To test the design of a hydrogen-fueled motorcycle, one motorcycle is needed. The motorbike used is the Honda Blade 110 cc with a voltage specification of 12 volts and a strong current of 5 amps. This motorcycle was chosen because it still uses a carburetor, a large trunk as an electrolysis reactor, and a wide motor wing as a place to place the cooling tube and gas storage tube.

A. Test result data

The first step is testing the results of the electrolysis of water into hydrogen gas by carrying a road motorcycle using Pertamax fuel in stages. The results of this test can be seen from the gas pressure resulting from the electrolysis process. In this study, researchers tested three times. The researcher aimed to test three times so that real data was produced so that further conclusions could be obtained.

For each test, the researcher uses the same amount of fuel, but the time required to spend the fuel is different according to the road conditions that the author is going through during the road trial. The first test was carried out using one liter of Pertamax fuel. The second test uses two liters of Pertamax and the third test uses 3 liters of Pertamax. Each of the above tests was carried out three times. The following is a table of the results of the tests carried out.

Table 2 illustrates that from the three tests the results of electrolysis still produce relatively small gas and have not been able to start the motorcycle. The increase in the amount of gas produced was relatively stable between each experiment.

Figure 6. Cooling cylinders and gas reservoirs

Figure 7. Installation series

B. Analysis results

Before the experiment was carried out, a motorcycle exhaust emission test was conducted first. An emission test is conducted to see the difference in exhaust gas emissions between motorbikes using Pertamax fuel and motorbikes using hydrogen gas fuel. From the results of emission testing with the use of Pertamax fuel, it is obtained that the emission value is still under the Euro 2 Standard.

After the emission test is carried out, the next step is to test the electrolysis of water into hydrogen gas on a motorcycle. From the test, it was found that the electrolysis of water into hydrogen gas on motorbikes can occur, it's just that the gas produced is still very little. In the first test, it is shown that no gas pressure is generated at all from this electrolysis process. After analyzing and observing it, it was found that there was a leak in the water filter regulator that the researchers used, where the exhaust valve was in an inverted position, causing the hydrogen gas to be produced to be immediately wasted and not enter the gas storage tube at all. After the researcher found and resolved this problem, the researcher continued to retest for the second and third times.

Based on the second test that has been carried out, the researchers found that the gas pressure value is still relatively small. The hydrogen gas yield from the results of this second test is only 0.05 bar with the use of one liter of fuel. When the volume of fuel used is increased, the hydrogen gas is greater, namely 0.40 bar. The higher yield of hydrogen gas from the electrolysis process is obtained from the use of 3 liters of fuel, which is 0.96 bar. The following is a graph of the results of the tests carried out.

Furthermore, the researchers conducted testing III. Based on this test, the hydrogen gas pressure was not too different from the previous test, which was only 0.06 bar with the use of one liter of fuel. When the volume of fuel used is increased, the hydrogen gas is greater, namely 0.42 bar. The higher yield of hydrogen gas from the electrolysis process is obtained from the use of 3 liters of fuel, which is 0.98 bar (Figure 8).

Based on the tests that have been carried out, the researcher found that there was only a very slight difference in the value of each test. The main cause of the amount of gas produced in the current generated from the alternator/prok battery of a motorcycle is still very low. The above matter is following the results of the tests carried out,

Table 2.
Test result table

Testing	Fuel (L)	Time required (minutes)	Gas generated (Bar)	Motorcycles can be started (minutes)
	1	58	-	-
I	2	124	-	-
	3	180	-	-
	1	54	0.05	-
II	2	118	0.40	-
	3	176	0.96	-
	1	56	0.06	-
III	2	121	0.42	-
	3	183	0.98	-

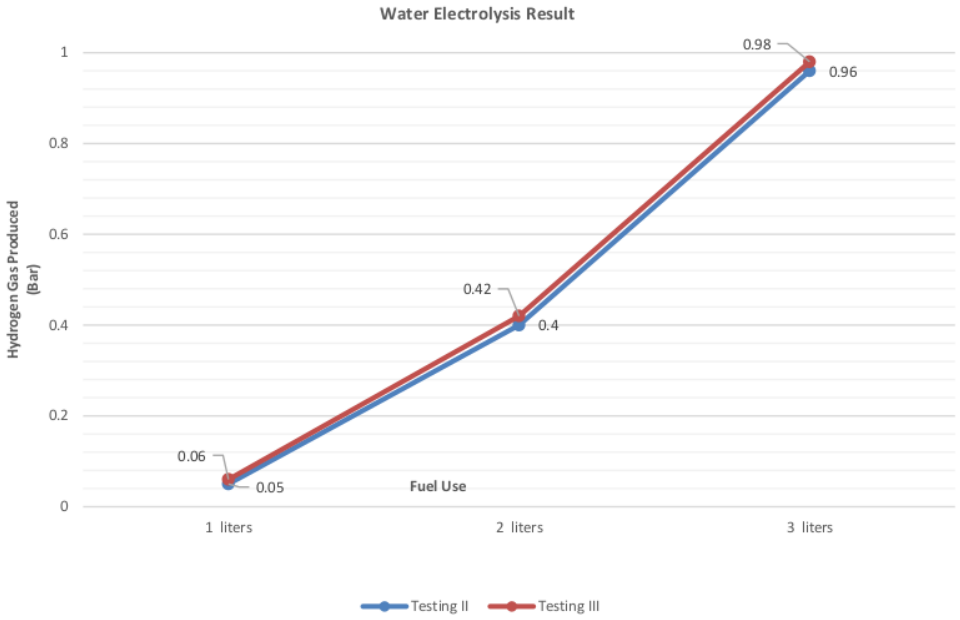

Figure 8. Water electrolysis result

where the gas bubbles produced in this electrolysis process are classified as small and very few.

Another cause that the researchers found was the inappropriate use of the arrangement, circuit, and the number of reactor cells. This is due to the adjustment of the shape and arrangement of the reactor cell with the luggage compartment on the motorcycle used. It is hoped that further research will use the best reactor cell arrangement and use a motorcycle with a higher current strength specification.

IV. Conclusion

Several conclusions may be taken from the tests that have been conducted, namely the process of electrolyzing water into hydrogen gas may take place on motorcycles; however, the amount of gas generated by this electrolysis process is still quite modest. This is owing to the motorbike's extremely low voltage and high current. The hydrogen gas produced by this electrolysis method has a pressure of just 0.06 bar when using one liter of fuel, 0.42 bar when using two liters of fuel, and 0.98 bar when using three liters of fuel. The motorcycle cannot be started in this test since the amount of hydrogen gas generated is still relatively low, at 0.06 bar. So basically, the use of a water fuel cell cannot stand alone and must be combined with other energy sources such as fuel on a motorcycle. The water fuel cell can be an alternative to reduce motorcycle fuel usage. Further research and development from this research are needed until the hydrogen gas obtained from the electrolysis of water can be maximized and can be used as motorcycle fuel.

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