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Experimental study of the use of brown gas HHO (Hydro Hydrogen Oxy) produced by variation of the number of electrodes plates on the performance of a 4-step motor

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Abstract

The purpose of this study was to determine the production of HHO gas produced by the wet sheel type HHO generator which can be used as a premium mixture for alternative fuels on a 4-stroke motorbike. The electrodes used are 304 Stainless Steel plates with a size of 100 × 50 mm with a plate thickness of 1 mm. The distance between the electrode plates used is 3 mm and the electrolyte of sodium bicarbonate (NaHCO3) is 40 grams / 2 liters of pure water. Variations in the number of 6 electrode plates, 12 pieces and 18 pieces arranged vertically with a 12V 60 Ah power supply, while the motor used is a 4-stroke motor with a variation of flowrate brown gas 0 ml/s, 1 ml/s, 2 ml/s, 3 ml/s. The results showed that the best performance was obtained at the HHO generator with 18 electrode plates at an average production rate of 0.59 liters/minute and an efficiency of 61.50%. The highest power and torque were produced by the addition of Brown Gas at a flow rate of 3 ml/s of 8.59 HP (an increase in power by 10.84%) and 9.5 Nm (an increase in torque of 8.96%) when compared to a flowrate of 0 ml/s. In addition, with the addition of Brown gas at a flow rate of 3 ml/s, the use of specific fuel (SFC) became more efficient by 7.99 x 10-3 kg/kwh or a decrease of 19.37% compared to the 0 ml/s flowrate.

Keywords

Hydro hydrogen oxy, 4-step motor, Brown gas

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Introduction

With the depletion of fossil energy sources, it is necessary to develop alternative energy sources. Water is a renewable energy source that can be used as an alternative energy source through the electrolysis process. The water electrolysis process is one way to separate the H2 and O2 content from water, the result of this electrolysis gas is better known as HHO gas or brown gas [1].

Basically, water electrolysis is carried out by passing an electric current into the water through two electrodes (cathode and anode). In order for the electrolysis process to occur quickly, the water is mixed with electrolytes as a catalyst [7].

Oxidation reaction at anode (+) : $2 H_2O (l) \rightarrow O_2 (g) + 4 H^+ (aq) + 4 e^-$

Reduction reaction at cathode (-) : $2 H^+ (aq) + 2 e^- \rightarrow H_2 (g)$

Overall reaction : $2 H_2O (l) \rightarrow 2 H_2 (g) + O_2 (g)$

Electrolysis is a process that can increase efficiency in the use of premium fuel, because brown gas functions to increase the octane value of premium fuel, so that the combustion process becomes more efficient [2].

HHO gas (Hydro Hydrogen Oxy) is an alternative energy source as a substitute for fossil fuels. The HHO generator functions to convert water (H_2O) into gas through the electrolysis process with a wet cell type HHO generator. The product produced is HHO gas which can be used as a premium fuel mixture in a 4-stroke motorbike. The HHO gas produced by this electrolysis process is called Brown Gas. HHO gas is a technology to save fuel because it is in the form of electrolysis from H_2O to H_2 gas and O_2 gas. The dry cell type HHO gas generator application uses PWM (pulse width modulation) to engine performance by varying standard conditions, as well as adding HHO gas to the ignition timing setting, reversing the ignition time from the standard conditions 12°-18 ° to 12°-15° before MA, the test is carried out starting from the engine rotation 2000 rpm 5000 rpm interval 500 rpm, ignition timing is set to a minimum in the maximum best torque (MBT) method. the result is an increase in maximum performance when reversing the ignition angle of 6.55% torque, 7.65% power, 15.50% thermal efficiency and 22.06% BSFC [3].

In the experiment, the effect of distance between electrode cells on the performance of dry cell type HHO generators with 3, 4, and 5 mm electrode cell distance variations. Observations were made on the performance of the HHO generator such as power, efficiency and HHO gas production rate. The test results show that the smaller the distance between cells, the smaller the power required for the electrolysis process and the greater the efficiency and rate of HHO gas production. This is because the small cell spacing makes it easier for the electrons to jump on each cell so that the electrolysis process occurs quickly [4].

The results of research on the Characteristics of the Wet Cell Model HHO Generator with Perforated Plate Electrodes using aluminum plates as electrodes whose size is 60 × 60 × 0.5 mm^3 with variations: without holes, 4 holes, 6 holes and 9 holes. Each of the holes is 4 mm in diameter. Variation in input voltage 3.5; 6; 7.5; and 9 Volts. The largest HHO gas discharge is produced with 9-hole electrodes, namely 5.77 cc / minute with an input power of 4.59 Watts. The highest generator efficiency is also produced with 9-hole electrodes, namely 63.16% with an input power of 0.52 Watt [5, 6, 7].

Research conducted by [8] on HHO gas production using Stainless Steel 316 L2 with a percentage of Na HCO_3 (Sodium Bicarbonate) 2.5; 5; 7.5; 10; 12.5 and 15%. The results showed that the largest HHO gas production rate occurred at the use of 12.5% Na HCO3, namely 1183.33 ml / s with an electric power consumption of 280 Watt. The efficiency of HHO generators tends to increase by 18.95%.

Research using the HHO generator was also carried out by Suprastowo, with various configurations of the electrolyte solution of baking soda 5 g, 10 g, 15 g, and 20 g in every 1 liter of distilled water. The results showed that the configuration of baking soda electrolyte 10 g with the outer electrode as the cathode had the greatest HHO generator efficiency, namely 9.43% [9].

Research with the addition of HHO on the performance and ionization of gasoline motor combustion shows that the output power increases by an average of 19%, the Specific Fuel Consumption (SFC) decreases by 26%, the exhaust emissions are better (CO and HC levels decrease) respectively 40% and 38 %, The ionization of combustion is getting better (voltage increases by 12%, combustion time decreases by 22%) [10].

In this study, researchers will apply brown gas to a 4-step motor, namely the Experimental Study of the Use of Brown Gas HHO (Hydro Hydrogen Oxy) Produced by Variation in the Number of Electrode Plates on the Performance of a 4-Step Motor.

Methods

In this research, the research steps refer to the flow diagram, according to Figure 1.

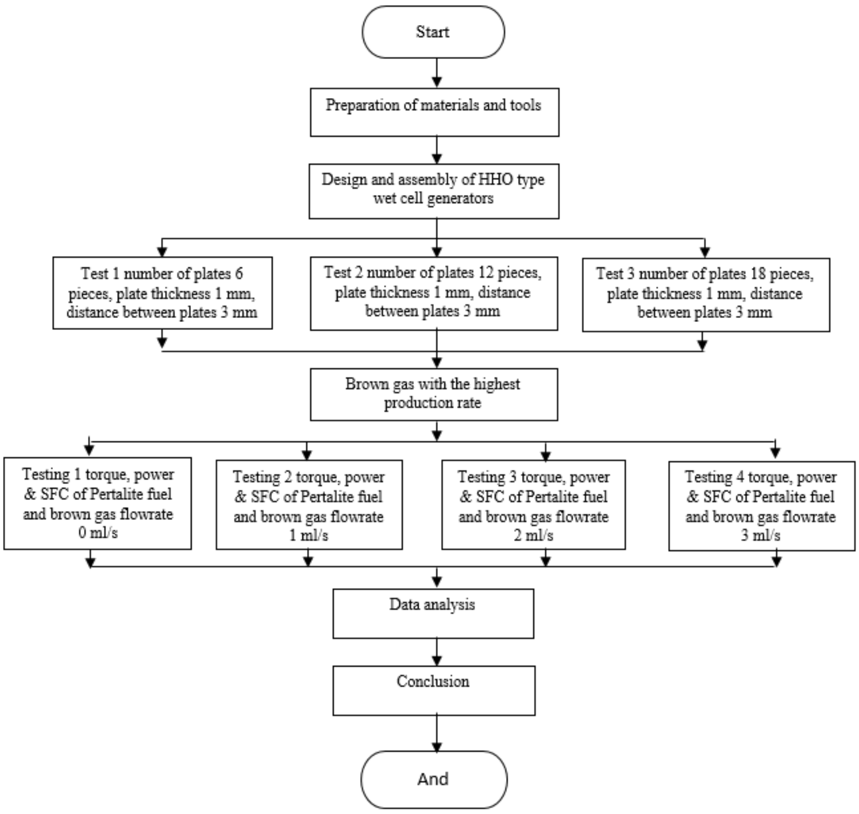

Figure 1. Research flowchart

The materials used in the study were: Sodium Bicarbonate (NaHCO3) catalyst or baking soda, pure water or distilled water, premium, and brown gas. While the tools used in this research are HHO Generators, Hydrogen Tubes, Acrylic Tubes, Acrylic Sheet, 304 Stainless Steel Plates, PVC Pipe Clamps, 12V 60Ah Battery, Battery Charger, PVC Pipe Caps, Hose, Battery Clamp, Shock Neppel, Cable, Nut M5 × 100, M8 × 15 Bolt Nut, Angle Iron, Hand Grinding, Drilling Machine, Wrench, screwdriver, pliers, Chainsaw, Measuring Cup, Digital Scales, Rotameter, Digital Multitester, Stopwatch, Ampermeter, Voltmeter, Burret, Supra X 125 cc motorcycle, where the research scheme is shown in Figure 2.

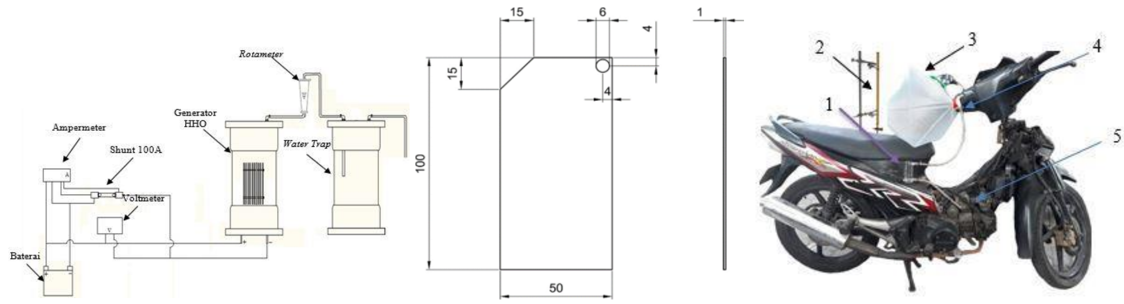

Figure 2. Schematic of research tools

Caption:

1. Rotameter
2. Burret
3. Brown Gas Container
4. Valve
5. Intake Manifold

Results

HHO gas test results

The results of HHO gas production using variations in the number of 6 stainless steel plates are in Table 1. Variations in the number of 12 plates are in Table 2 and variations in the number of 18 plates are in Table 3.

Table 1. Variation test results with number of plates 6

Time (minutes)	Voltage (V)	Arus (A)	Production rate (l / min)	Power (watt)	Energy (joule)	Efficiency (%)
1	9.0	44.7	0.70	402.30	402.30	49.74
2	8.0	44.0	0.60	352.00	704.00	48.72
3	8.0	42.0	0.50	336.00	1008.00	42.54
4	7.5	40.0	0.45	300.00	1200.00	42.88
5	7.0	40.0	0.40	280.00	1400.00	40.83
6	6.7	38.0	0.35	254.60	1527.60	39.28
7	6.5	35.0	0.30	227.50	1592.50	37.69
8	6.3	30.0	0.25	189.00	1512.00	37.81
9	5.5	28.0	0.20	154.00	1386.00	37.12
10	4.3	28.0	0.15	117.60	1176.00	36.46

Table 2. Variation test results with number of plates 12

Time (minutes)	Voltage (V)	Arus (A)	Production rate (l / min)	Power (watt)	Energy (joule)	Efficiency (%)
1	9.5	50.5	0.90	479.75	479.75	53.62
2	7.5	50.0	0.70	375.00	750.0	53.36
3	7.0	47.0	0.60	329.00	987.0	52.13
4	7.0	42.7	0.50	298.90	1195.6	47.82
5	6.5	42.0	0.45	273.00	1365.0	47.12
6	6.0	40.0	0.40	240.00	1440.0	47.64
7	5.7	38.0	0.35	216.60	1516.2	46.19
8	5.0	38.0	0.30	190.00	1520.0	45.13
9	4.5	37.5	0.25	168.750	11518.7	42.35
10	4.3	32.0	0.20	137.60	1376.0	41.55

Table 3. Variation test results with number of plates 18

Time (minutes)	Voltage (V)	Arus (A)	Production rate (l / min)	Power (watt)	Energy (joule)	Efficiency (%)
1	9.7	57.5	1.20	557.75	557.75	61.50
2	7.5	57.0	0.90	427.50	855.00	60.18
3	7.1	56.0	0.80	397.60	1192.80	57.71
4	6.5	50.5	0.65	328.25	1313.00	56.60
5	6.0	45.0	0.50	270.00	1350.00	52.93
6	5.7	45.0	0.45	256.50	1539.00	50.15
7	5.5	43.8	0.40	240.90	1686.30	47.46
8	5.0	43.8	0.37	219.00	1752.00	48.29
9	5.0	42.0	0.35	210.00	1890.00	47.64
10	4.5	40.0	0.30	180.00	1800.00	47.64

4-Step motor performance test results

Data on test results using HHO gas for power testing are in Table 4. Torque test results are in Table 5 and fuel consumption test results are in Table 6.

Table 4. Data on power test results against addition of brown gas

Engine speed (rpm)	Power (HP)			
	flow rate brown gas 0 ml/s	*flow rate brown gas 1 ml/s*	*flow rate brown gas 2 ml/s*	*flow rate brown gas 3 ml/s*
4250	5.80	6.10	6.50	6.70
4750	6.70	7.00	7.00	7.20
5250	7.00	7.505	7.80	8.00
5750	7.80	8.30	8.50	8.60
6250	8.30	8.90	9.00	9.20
6750	8.70	9.20	9.30	9.50
7250	8.90	9.10	9.30	9.50
7750	8.60	8.90	9.10	9.40
8250	8.40	8.70	8.80	9.10
8750	7.70	8.40	8.50	8.70

Table 5. Torque test results data against brown gas addition

Engine speed (rpm)	Torque (Nm)			
	flow rate brown gas 0 ml/s	*flow rate brown gas 1 ml/s*	*flow rate brown gas 2 ml/s*	*flow rate brown gas 3 ml/s*
4250	7.61	9.03	10.07	10.38
4750	9.17	9.47	10.47	10.60
5250	10.4	10.51	10.62	10.81
5750	10.38	10.43	10.55	10.62

Engine speed (rpm)	Torque (Nm)			
	flow rate brown gas 0 ml/s	*flow rate brown gas* 1 ml/s	*flow rate brown gas* 2 ml/s	*flow rate brown gas* 3 ml/s
6250	9.86	10.01	10.11	10.32
6750	9.49	9.56	9.67	9.97
7250	8.85	9.03	9.15	9.28
7750	7.94	8.14	8.23	8.37
8250	7.05	7.45	7.58	7.78
8750	6.48	6.78	6.83	6.92

Table 6. SFC test result data

Engine speed (rpm)	SFC (kg/kW.h)			
	flow rate brown gas 0 ml/s	*flow rate brown gas* 1 ml/s	*flow rate brown gas* 2 ml/s	*flow rate brown gas* 3 ml/s
4250	13.03 x 10^{-3}	12.38	10.79	10.04
4750	11.27 x 10^{-3}	10.79 x 10^{-3}	10.02 x 10^{-3}	9.34 x 10^{-3}
5250	10.79 x 10^{-3}	10.07 x 10^{-3}	8.99 x 10^{-3}	8.41 x 10^{-3}
5750	9.69 x 10^{-3}	9.10 x 10^{-3}	8.25 x 10^{-3}	7.82 x 10^{-3}
6250	9.10 x 10^{-3}	8.49 x 10^{-3}	7.97 x 10^{-3}	7.56 x 10^{-3}
6750	8.68 x 10^{-3}	8.21 x 10^{-3}	7.54 x 10^{-3}	7.08 x 10^{-3}
7250	8.49 x 10^{-3}	8.30 x 10^{-3}	7.54 x 10^{-3}	7.08 x 10^{-3}
7750	8.78 x 10^{-3}	8.49 x 10^{-3}	7.88 x 10^{-3}	7.16 x 10^{-3}
8250	9.44 x 10^{-3}	8.68 x 10^{-3}	8.06 x 10^{-3}	7.56 x 10^{-3}
8750	9.81 x 10^{-3}	8.99 x 10^{-3}	8.25 x 10^{-3}	7.91 x 10^{-3}

Discussion

The Effect of the Number of Electrode Plates on the HHO Gas Production Rate

Figure 3 shows a graph of the effect of the number of plates on the rate of HHO gas production. It can be explained that the greater the number of electrode plates, the greater the production rate of HHO gas produced. This is due to the faster electrolysis process and more and more HHO gas will be collected. The largest HHO gas production rate was obtained at a generator with 18 plates, namely 0.59 l / minute.

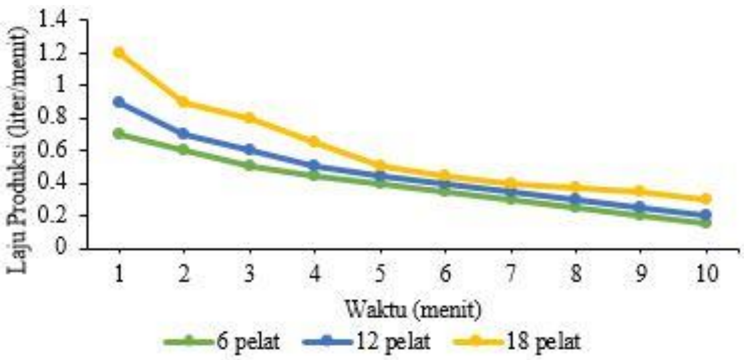

Figure 3. Graph of the effect of number of plates on the production rate of HHO gas

Effect of Number of Electrode Plates on Current and Voltage

The electric current produced from a wet cell type generator using a variety of stainless-steel plates of 6, 12 and 18 is shown in Figure 4, while the electric voltage produced is shown in Figure 5.

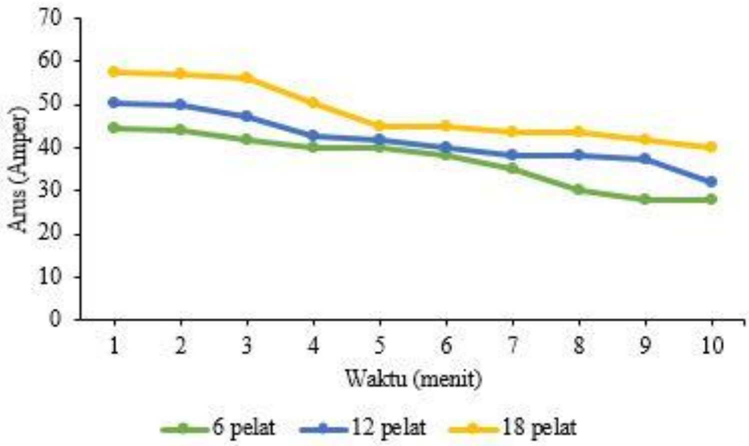

Figure 4. Graph of the effect of number of plates on flow

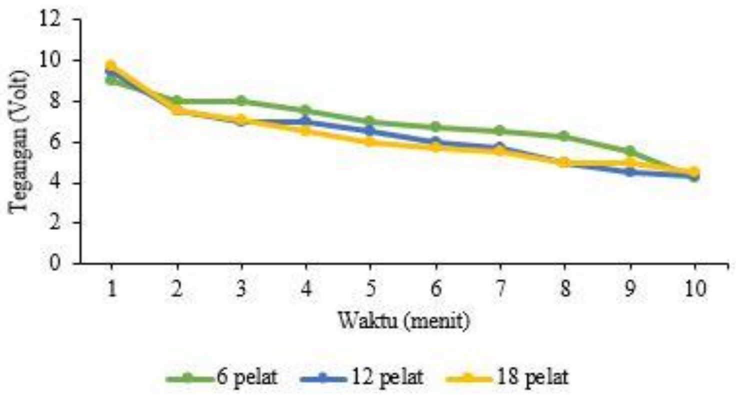

Figure 5. Graph of the effect of the number of plates on stress

Figure 4 shows that the greater the number of electrode plates used, the greater the current required. If we compare it with the voltage, it will be proportional to the waslik. As shown in Figure 5, it shows that the voltage used by the generator decreases with time. This is because the more the number of electrode plates used, the greater the resistance, causing a decrease in the electric voltage.

The Effect of Number of Plates on Power and Efficiency

The effect of the number of plates on the wet cell type generator on the power produced is shown in Figure 6, while the efficiency of fuel consumption is shown in Figure 7.

From Figure 6, it can be explained that the use of the number of electrode plates affects the consumption of electric power, so the more the number of electrode plates, the greater the electric power used by the HHO generator in the electrolysis process. The largest power used in the HHO generator with 18 electrode plates is 557.75 Watt.

Based on the graph of the effect of the number of plates on efficiency as shown in Figure 7. It can be explained that the maximum efficiency achieved by the generator with the number of electrode plates is 18 pieces, which is 61.50%. This is because the number of plates affects the rate and production of HHO gas.

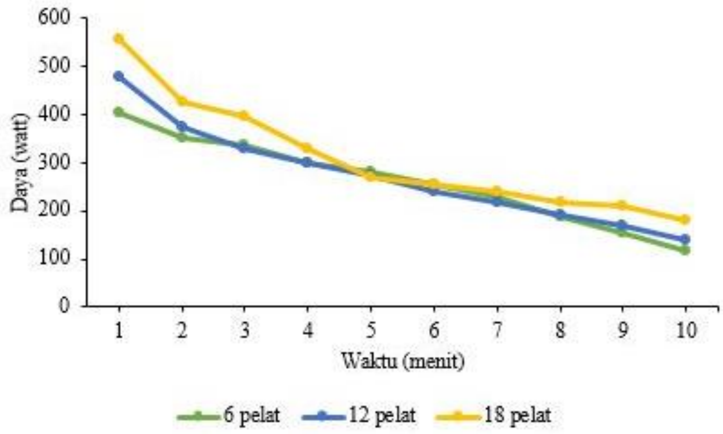

Figure 6. Graph of the effect of number of plates on power

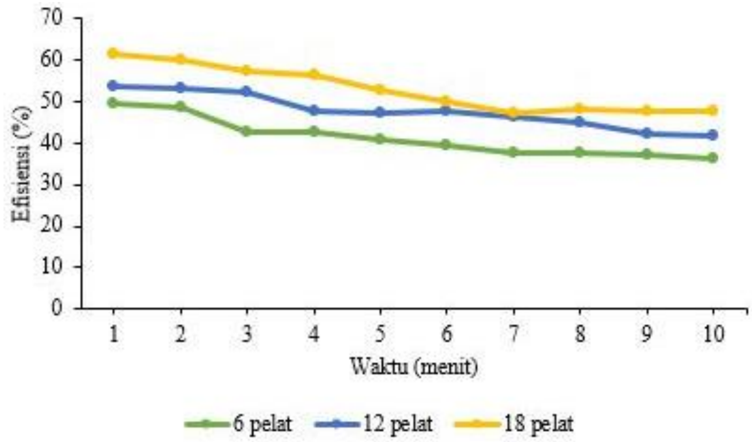

Figure 7. Graph of the effect of number of plates on efficiency

Power with a Brown Gas Variation

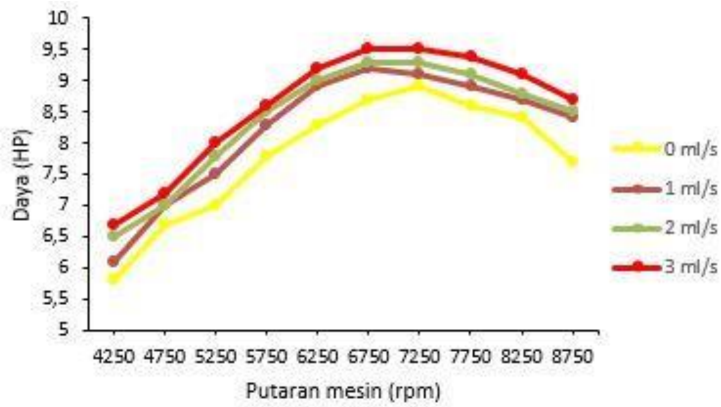

Figure 8. Graph of engine speed against power

In Figure 8, the graph shows the relationship between engine speed and the power generated by the variation of brown gas used in a 4-stroke motor. The results show that at the engine speed range of 4250 rpm to 8750 rpm the maximum power is obtained when using brown gas with a flow rate of 3 ml / s of 9.5 HP. This proves that the variation in the addition of brown gas increases the power generated by the 4-stroke motor. This increase in power is caused by the addition of brown gas which triggers the complete combustion in the combustion chamber, so that the power generated is optimal. When compared with a motor without the addition of brown gas, there is a significant increase in power, which is 10.84%.

Torque with Variation Brown Gas

Figure 9 shows that using the Brown gas variation on the 4-stroke motor increases the torque produced. This can be seen in the engine speed range of 4250 rpm to 8750 rpm, the use of brown gas with a flow rate of 3 ml / s can increase torque by 8.65%. So, there is a correlation between the increase in power, rotation, and torque. This is due to the complete combustion in the combustion chamber of the 4-stroke motor, so that the increase in power will also increase the torque produced.

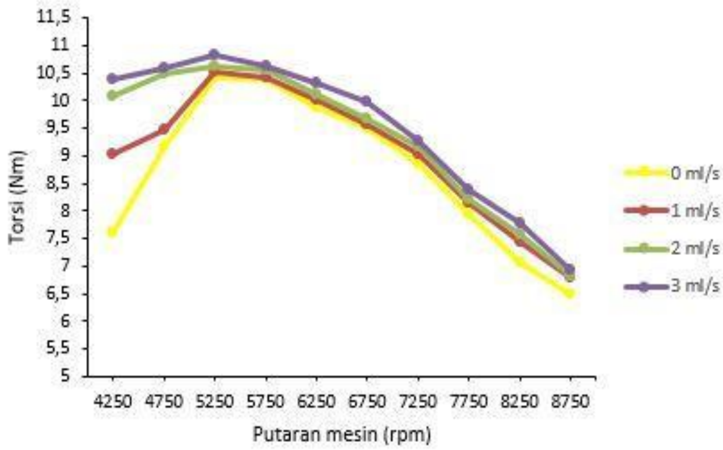

Figure 9. Graph of engine speed against torque

SFC with Brown Gas Variations

From Figure 10, namely the graph of engine speed against SFC, it can be concluded that the addition of brown gas with varying flow rates causes the use of SFC to decrease. This is due to the presence of brown gas mixed with fuel, so that the amount of fuel consumption used in the combustion chamber becomes more efficient. So, with the addition of brown gas into the combustion chamber mixed with fuel, it can reduce fuel use significantly by 19.37%.

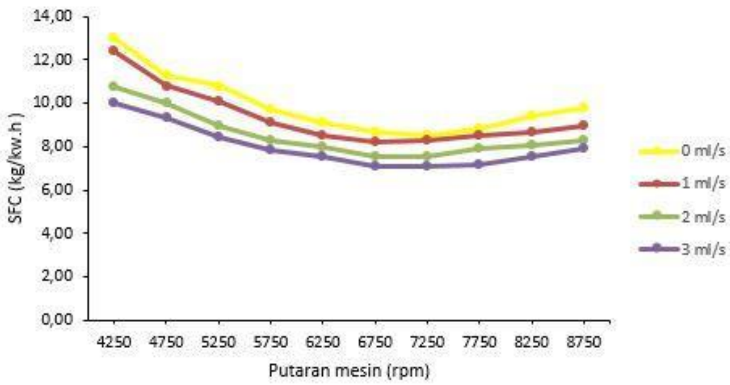

Figure 10. Graph of engine speed against SFC

Conclusion

From the research results it can be concluded that:

1. There is an influence on the use of the number of electrode plates on the production rate, the amount of power used and the efficiency of the HHO generator. The greater the number of electrode plates, the more HHO gas production is produced. In a generator with 18 electrode plates, the largest gas production rate is 0.59 l / min.
2. The number of electrode plates also affects the efficiency of the HHO generator, which is 61.50%.
3. Maximum power and torque resulted from the addition of Brown gas with a flow rate of 3 ml / s, namely 8.59 HP (an increase of 10.84%), and torque of 9.5 Nm (an increase of 8.65%) if compared to the test without the addition of Brown gas.
4. The addition of Brown gas with a flow rate of 3 ml / s at the rotation range of 4500 rpm -7500 rpm, the use of specific fuel (SFC) becomes more efficient by 7.99 x10-3 kg / kw.h

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