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# Utilization of magnetic devices to improve the performance and reduce gas emissions of Otto engine

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**Abstract.** Utilization of magnetic instrument is one effort to improve the performance and reduce exhaust emission produced by Otto engine. The experiments are done by varying the engine speed and variation of magnetic instrument mounting distance to the inlet valve when entering the combustion chamber. A magnetic instrument is installed in the intake manifold, before heading into the combustion chamber. The experimental results show that it is found that there is an increase in thermal efficiency and decreasing of fuel consumption when the engine uses 2500 gauss magnetic instrument ranging from 5.99 to 22.02%. The emissions of exhaust gas produced also reduced for CO and HC levels about 6-20%.

## 1. Introduction

The general energy source in the world is fossil energy especially fuel oil. Currently, Indonesia is still very dependent on fossil energy. Fossil energy still supplies almost 95% of Indonesia's energy needs. About 50% of the fossil energy is petroleum, and the remainder is gas and coal. Fossil energy is non-renewable energy and will run out in the next few years. The National Energy Data of 2015-2050 states that Indonesia's fossil energy potential, including petroleum, natural gas, and coal can only last for ten years, 31 years and 80 years from now if no new fossil energy reserves are found [1, 2]. In addition to being exhausted, fossil energy also has a negative impact on the environment. Greenhouse gas emissions from burning fossil energy have an effect on global warming that causes climate change. The primary cause of this is the imperfection of combustion in the combustion chamber, in addition to the friction losses incurred between engine components. Incomplete combustion will have an effect that reduces the engine's working ability [3, 4, 5]. Besides, incomplete combustion results in increased fuel consumption and exhaust emissions.

A variety of efficiency improvements for combustion engines have been carried out regarding fuel intakes, such as electronic fuel injection technology, improved combustion such as the use of twin spark plug, the fuel valve regulation system with VVT-i and VTEC method, increased air intake with the addition of turbocharger or supercharger. One way to improve the performance of combustion engines developed today is the fuel magnetation system. The working principle is to magnetize the fuel oil that flows from the oil pump to the intake manifold by using a device containing a specific magnetic force [6]. So, before being burned in the combustion chamber, the fuel is already magnetized. Research conducted at the Kobe University Energy Laboratory using a direct injection



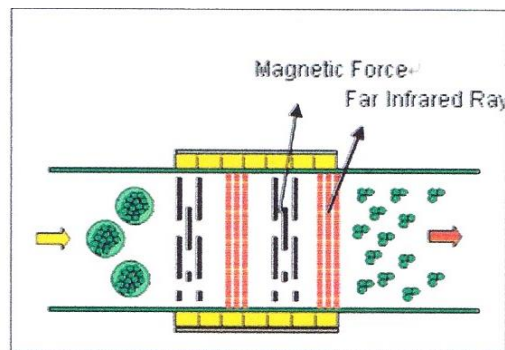
diesel type Yanmar NF-19SK showed a decrease in fuel consumption by 13-14% under normal load conditions when using a magnetizer [7].

## 2. Research Study

### 2.1. The magnetic effect in fuel oil

If the atoms are placed in a uniform magnet, the electrons that surround the nucleus become spun. This rotation causes the occurrence of a secondary magnetic field that is opposite to the direction of the given magnetic field. For engines that use fuel oil so when the fuel is still in the fuel tank, the hydrocarbon molecules that are the main constituents of fuel oil tend to attract each other and form clumped particles. This grouping will continue, causing the hydrocarbon molecules not to be separated or there is not enough time to separate each other when reacting with oxygen in the combustion chamber [8]. The unfortunate result is a pure burning imperfection with the presence of HC content in the flue gas.

The presence of a permanent magnetic field strong enough in the diamagnetic hydrocarbon molecule will cause rejection reactions between hydrocarbon molecules to form an optimal distance between hydrocarbon molecules. This will increase the interaction between hydrocarbon molecules with oxygen. The atomic particles that make up the hydrocarbon molecule will be affected by the magnetic field so that the direction will be more aligned or oriented in the course of the magnetic field [9]. The use of magnets is intended to save fuel consumption through magnetization process. The magnetization process is required to allow the fuel to bind oxygen more easily during combustion processes and to reduce unburned hydrocarbons fueled by the combustion process [10].



**Figure 1.** Magnetization effect for fuel [11]

This is due to the size of the molecular structure of the fuel will turn into smaller bonds due to magnetization. The smaller size of these molecules will directly affect the more natural burning process in the combustion chamber. In other words, the process of magnetization in fuel will make combustion more perfect [12].

As the fuel passes through the manifold, the magnetizing forces inside the magnet attached to the fuel line lead to the breaking of the carbon bond in the fuel into small parts of the ionic bond. The negative pole of the magnet will attract the positive ions while the negative ion will be tempted by the positive pole of the magnet so that positive ions and negative ions will flow regularly after passing through the magnetic field. This small and regular bond makes oxygen easy to react with fuel to the combustion process [13]. The effect of fuel will be more efficiently burned in the combustion chamber or the occurrence of complete combustion.

### 2.2. The parameter of performance

The main parameters of the internal combustion engine are the power, specific fuel consumption and thermal efficiency [14, 15]. The engine speed and torque greatly affect the power produced by the internal combustion engine. In general, there are two types of power, namely the shaft power and the

indicator power. The shaft power or the effective power is the power produced by the engine on the output shaft which calculated by the equation:

$$\dot{W} = \frac{2\pi \cdot N \cdot \tau}{60000} \quad \text{kW} \quad (1)$$

The parameter N is the engine speed (rpm), and  $\tau$  is the torque (Nm).

The specific fuel consumption (SFC) is the amount of fuel used by the engine per unit of power for each hour of operation. It can be said that specific fuel consumption is an indication of engine efficiency to produce power from the fuel combustion. The SFC value can be determined from:

$$Sfc = \frac{\dot{m}_f}{\dot{W}} \cdot 3600000 \quad \text{g/kWh} \quad (2)$$

Where  $\dot{m}_f$  is fuel flow rate (kg/s).

The efficiency of thermal of the internal combustion engine is the ratio between the output energy and the fuel combustion energy as followss:

$$\eta_t = \frac{\dot{W}}{\dot{m}_f \cdot Q_{HV} \cdot \eta_c} \quad (3)$$

The parameter  $Q_{HV}$  is the calorific value (kJ/kg), and  $\eta_c$  is the efficiency of combustion which the value of 0,97.

### 3. Methodology

#### 3.1. Materials

Testing is done by using pertalite fuel. The instrument equipment which added between the intake manifold and the combustion chamber is a 2500 gauss magnetic instrument. The main specification of the magnetic device is the Indonesian FT-15 production model, has a magnetic force of 2500 gauss with a polar distance of 0.75 cm and a dimension of 50 mm x 20 mm.

The measuring instrument used is the analyzer of emissions (accuracy  $\pm 90-98\%$ ). The calorimeter bomb is used to know the fuel calorific value. The torque meter equipment is used to measure the torque of engine.



**Figure 2.** a) calorimeter

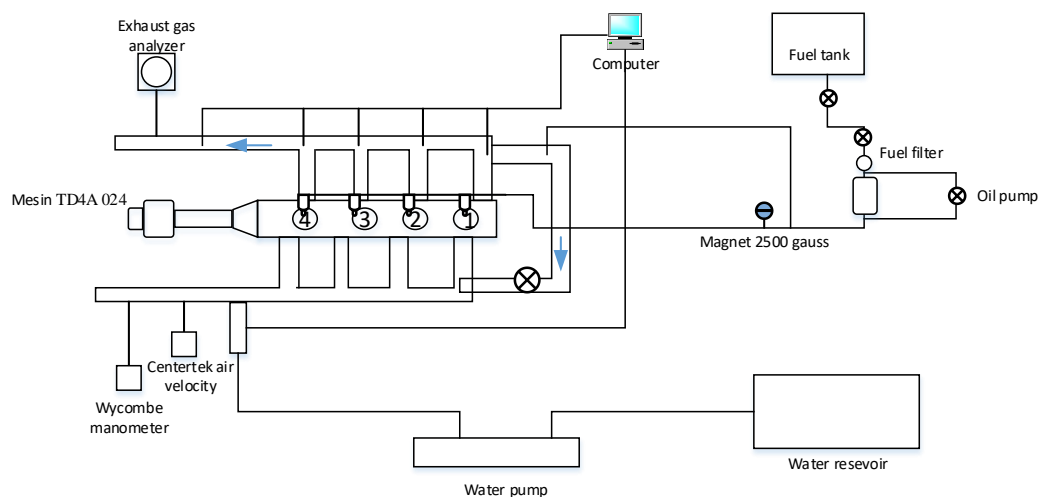
b) analyzer of emission

**Table 1.** The specification of Otto engine tested

Engine type	TecQuipment TD4A 024 / SOHC
Diameter x stroke	73 mm x 80,5 mm
Cylinder number	4
Capacity	1486 cc
Compression ratio	10 : 1
Maximum power	30 kW / 4,900 rpm
Torque power	80 Nm / 4500 rpm

### 3.2. Experimental scheme

The Otto engine calibrated is connected to measuring instruments and supporting instruments. The 2500 Gauss magnetic support instrument is placed between the intake manifold and the combustion chamber, which is varied within 10 cm, 20 cm and 30 cm from the combustion chamber. This is done to determine the effect of the installation of 2500 gauss magnetic field against the performance of the Otto engine. Gas analyzer gauge is placed on the exhaust pipe. Besides that, there are also variations of engine rotation consisting of 2000 rpm, 2500 rpm, 3000 rpm, 3500 rpm and 4000 rpm. The instrument of the measuring is connected to data acquisition with a computer system to record the changing conditions that occur, such as the composition of the exhaust emissions produced, the fuel flow rate, the engine produced torque and the required air flow rate to the combustion chamber. An experimental scheme of this research can be seen in Figure 3.

**Figure 3.** Experimental scheme

## 4. Results and Discussions

### 4.1. Engine performances

The maximum torque was obtained 51.31 Nm when engine using a magnetic instrument 2500 gauss with a distance of 30 cm at 4000 rpm. The minimum torque was obtained 32.12 Nm when testing without using magnetic instrument 2500 gauss at 2000 rpm. The average torque generated in these experiments ranges from 41.34 Nm. The torque generated when the engine uses a magnetic instrument

2500 gauss with a distance of 30 cm larger due to torque parameters influenced by combustion energy. The combustion energy produced is higher because the combustion process becomes better when using a magnetic instrument 2500 gauss. Figure 4 shows the engine torque during experiments.

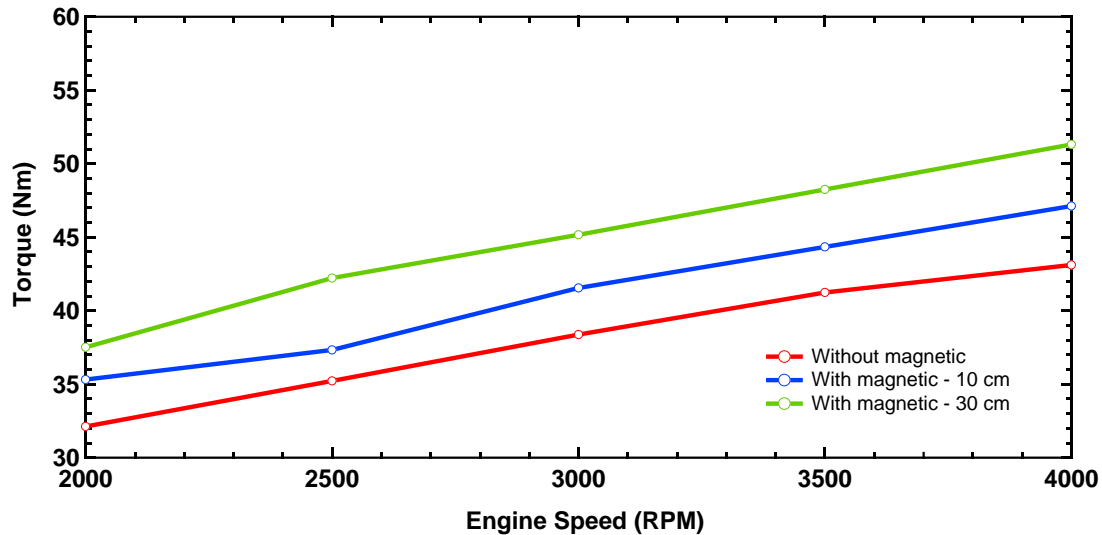


Figure 4. Engine torque during experiments

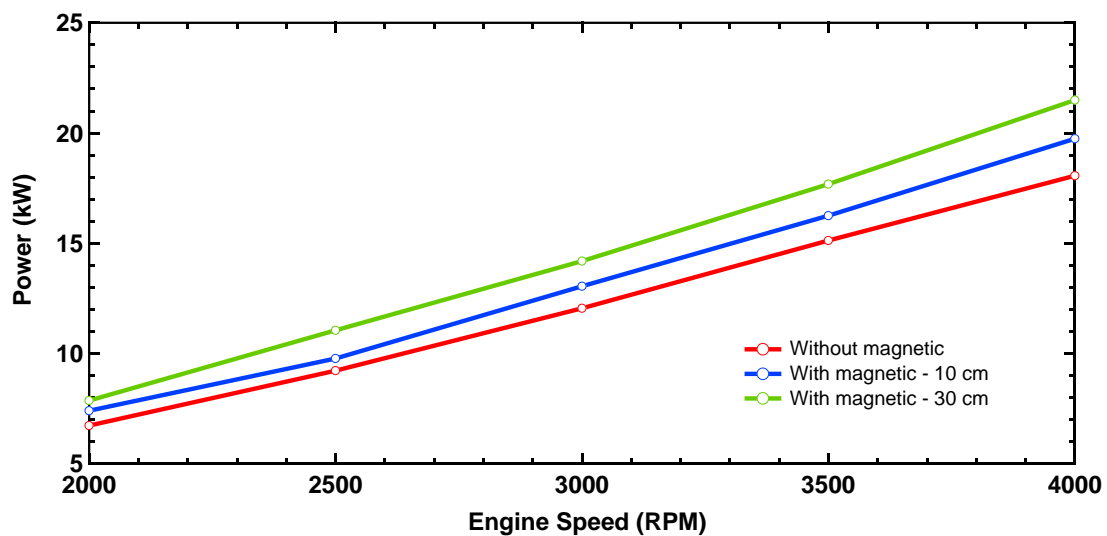
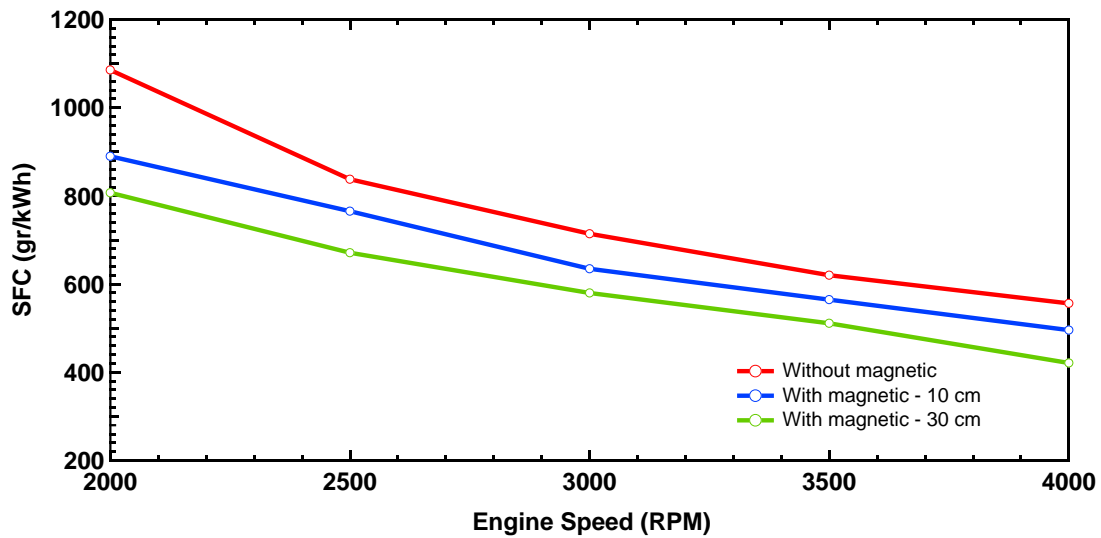
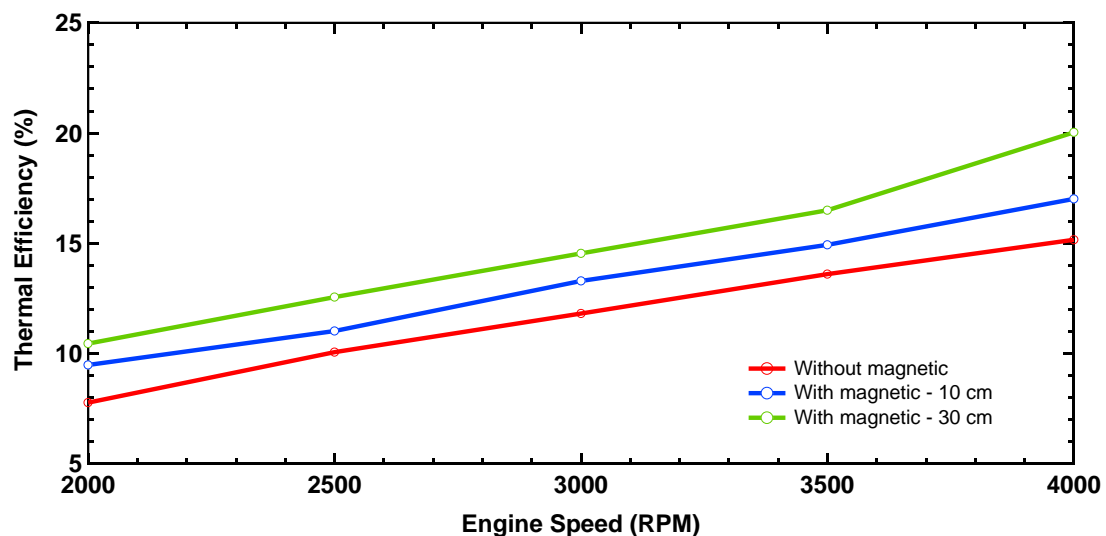


Figure 5. Engine power during experiments



**Figure 6.** Specific fuel consumption during experiments



**Figure 7.** Thermal efficiency during experiments

Figure 5 shows the engine power generated during the experiments. Based on the experimental data obtained that the maximum power is 21.49 kW at engine speed 4000 rpm when using magnetic device 2500 gauss with a distance of 30 cm. The minimum power is obtained at 6.73 kW when engine without using a magnetic device 2500 gauss at the engine speed of 2000 rpm. Increased engine power when the engine using magnetic 2500 gauss ranged from 5.99 to 13.10%. The parameters that most affect the engine power generated is the torque. As it is known that when the torque gets more significant, then the power produced is more significant. Figure 6 shows the specific fuel consumption of otto engine produced during the experiments. The maximum SFC value is obtained 1085,58 gr / kWh when engine without using magnetic device 2500 gauss at 2000 rpm. The minimum SFC value is obtained 420.91 g/kWh at 4000 rpm when the engine uses 2500 gauss magnetic instrument with a distance of 30 cm. The average value of SFC resulting from the experiment was 676.81 g/kWh. The decrease of SFC when the engine uses 2500 gauss magnetic instrument ranges from 8.62 to 18.05%. The SFC when the engine uses 2500 gauss magnetic device decreased. One of them caused the resulting combustion process to be better when the engine using a magnetic device 2500 gauss. This

makes the required fuel less than when the engine is operated without using a 2500 gauss magnetic device for the same conditions. The thermal efficiency obtained during the testings is shown figure 7. Experimental results indicate that the maximum thermal efficiency of 20.03% when the engine using magnetic instrument 2500 gauss with distance 30 cm at 4000 rpm. The minimum thermal efficiency is 7.77% with engine speed at 2000 rpm when the engine without using 2500 gauss magnetic instrument. The average thermal efficiency value resulting from the experiments was 13.21%. The efficiency of thermal increase when the Otto engine using magnetic 2500 gauss is ranged from 9.44-22.02%. The thermal efficiency parameters of combustion engines influenced are the power, the fuel flowing rate to cylinder and the fuel calorific value.

#### 4.2. Exhaust gas compositions

In this study is measured the levels of exhaust emissions produced by the engine with and without using a magnetic instrument 2500 gauss. Table 2 shows the exhaust emission levels produced by three conditions.

**Table 2.** Measurement data of exhaust gas

Condition	Engine speed (rpm)	Emission			
		CO <sub>2</sub> (%)	CO (%)	HC (ppm)	O <sub>2</sub> (%)
Without magnetic	2000	2.82	3.30	171	23.87
	2500	3.11	3.38	173	23.93
	3000	3.50	3.42	178	24.02
	3500	3.82	3.61	189	24.06
	4000	4.10	4.36	192	24.09
With magnetic 10 cm	2000	2.93	2.67	168	21.34
	2500	3.23	2.72	169	22.21
	3000	3.65	2.70	167	23.05
	3500	3.95	2.80	169	21.43
	4000	4.25	2.95	171	21.47
With magnetic 30 cm	2000	2.95	2.69	165	23.34
	2500	3.32	2.83	170	22.21
	3000	3.72	2.74	169	23.05
	3500	3.97	2.86	165	22.43
	4000	4.31	2.93	170	22.49

The exhaust emissions studied in the exhaust gas by using the Sukyong SY-GA 401 emission meter. As it is known that emissions of carbon monoxide arise because at the time of burning process occurs lack of oxygen. The lack of oxygen supply causes incomplete combustion where the C atom lacks O<sub>2</sub> to CO<sub>2</sub>. It shows that without using a 2500 gauss magnetic instrument, the Otto engine produces the most CO for each variation of engine speed. Emissions reduction in CO levels occurs when the engine uses a magnetic instrument 2500 gauss which ranges from 6-12% when compared without using a magnetic instrument 2500 gauss. As for the emission of HC, the exhaust gas is due to lack of oxygen so that the combustion process takes place imperfectly because many carbon atoms that do not get enough oxygen to form HC gas. From the measurement result of measuring instrument obtained minimum HC level when engine using magnetic device 2500 gauss with distance 30 cm. The maximum HC emission levels are achieved when the engine without using a magnetic instrument



2500 gauss for each variation of engine speed. The reduction of CO<sub>2</sub> emission ranges from 8-20% when the Otto engine uses a 2500 gauss magnetic instrument.

## 5. Conclusions

Testing of the performance of the Otto engine with a magnetic support instrument 2500 gauss using pertalite fuel has been carried out. The experimental data indicate that there is an increase in power, decreased specific fuel consumption and increased thermal efficiency ranging from 5.99 to 22.02% when the engine uses a magnetic instrument 2500 gauss. This is due to the magnetic properties of 2500 gauss that can improve the quality of the fuel so that the combustion process that occurs in the combustion chamber becomes better than without using a magnetic instrument. The exhaust emissions levels generated is a decrease in CO and HC ranging from 6-20% during use magnetic instrument 2500 gauss.

## Acknowledgments

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