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### RESEARCH ARTICLE

#### EXHAUST GAS EMISSIONS ANALYSIS OF DUAL FUEL ON STATIONERY DIESEL ENGINE

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#### Abstract

The analysis of exhaust gas from diesel engine using dual fuel was examined. The objective of this research is to measure the exhaust gas emissions from single cylinder diesel engine using dual fuel (diesel fuel and biogas). The experimental study was conducted on single cylinder diesel engine with variable of engine speed and volume of biogas intake into combustion chamber. The results show that CO emission were 2.99% volume higher than the conventional fuel. The CO<sub>2</sub> emissions were decrease by 9.53% when using dual fuel. The HC emissions of dual fuel were high in the case of high in-cylinder temperature at the high load condition. Moreover, the opacity of exhaust emission was decrease by 14.3% at 50 psi load, but slightly increase at 100 psi.

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#### Introduction:-

Recently the alternative fuel is a substitution of conventional fuel. The alternative fuel also already used in domestic activity. Biogas is a gas product material from microorganism activity. Biogas is one of alternative fuel as environmental friendly. The objective of this research is to know the exhaust gas emissions of single cylinder diesel engine using dual fuel (diesel fuel and biogas). Biogas is characterized based on its chemical composition and the physical characteristics which result from it. It is primarily a mixture of methane (CH<sub>4</sub>, 50-70%) and inert carbonic gas (CO<sub>2</sub>, 30-40%) (Kadarwati, 2003). Biogas is gases resulting from specific treatment processes, starting from various organic waste - industries, animal or domestic origin waste etc. The experimental material of biogas in this research is from Lembang, West Java- Indonesia. Table 1 shows the characteristics of biogas research material.

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**Table 1:- Biogas Specification**

Name of Chemical	Percentage
CH <sub>4</sub>	10.76%
CO <sub>2</sub>	13.63%
O <sub>2</sub>	8.33%
H <sub>2</sub> S	0 ppm
Energy	154 Btu

Emissions is an important major species in combustion because of its contribution to air pollution. In the combustion of fuels that contain of nitrogen, oxygen, carbon and sulfur are formed by chemical mechanisms or routes that involve some gases from the air (Sudrajat, 2011). The thermal mechanism dominates in high-temperature combustion over a fairly wide range of equivalence ratios, while the composition mechanism is particularly important in rich combustion. It appears that some gases play an important role in the production of emissions in very lean, low-temperature combustion processes.

### Research Methodology:-

In experiments, we evaluated the effects of the variation of biogas, the fuel delivery advance angle of the auxiliary fuel pump and the scavenging pressure on four poisonous emissions: hydrocarbon (HC), carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>). The direct cylinder diesel engine was examined in the experiment. Table 2 show the specification of engine.

**Table 2:- Diesel Engine Specification**

Items	
Stroke	4 stroke
Cooling system	Water Cooling
Cylinder	Single Cylinder
Cylinder Dimension	75 x 80 (mm)
Combustion System	Indirect
Maximum Power	7hp/2600 rpm
NCR	6 hp/2600 rpm
Starting System	Motor DC
Engine Dimension (P x L x T)	589 x 341 x 463 (mm)
Weight	65 kg

The engine speed parameter is set on 2000 rpm and the load of engine set at 50 psi and 100 psi. The engine is run at desired engine speed at the beginning of each setup. Then, the load is exerted to the engine after stable operating condition is achieved. The data is taken after the load exerted where the speed measurement remain stable for at least five minutes. The engine is run using conventional diesel fuel at the beginning to obtain base data for comparison. For test dual fuel data measurement, the engine is run with diesel fuel for beginning. After ten minutes running on diesel fuel, the valve supplying the diesel fuel to the engine is controlled, the valve for supplying biogas into the engine is opened. All the testing procedures are repeated for three times for the same condition.

### Results and Discussions:-

Figure 1 shows the effect of the Biogas inlet flow on emissions. It is shown that CO were recorded to increase with increased biogas input. However, the CO emissions on 100 psi engine load higher than 50 psi. This tendency was more evident as increased the load mean increase the burned of fuel quantity. The CO emissions on this experiment, based on the Emissions Indonesian Regulation is still in standard. A significant reduction in CO emission was shown between 50 psi and 100 psi at 2000 rpm engine speeds. This reduction may be explained by the extra fuel oxygen. At high load, sufficient oxygen is not available in the engine cylinder. Therefore, the beneficial effects of dual fuel as an oxygenated fuel are seen at full loads. CO compete for the available oxygen in the rich combustion regime at full engine load. At partial loads, there is no appreciable difference between the fuels due to the dominant premixed lean combustion with excess oxygen and there is more stable CO variation.

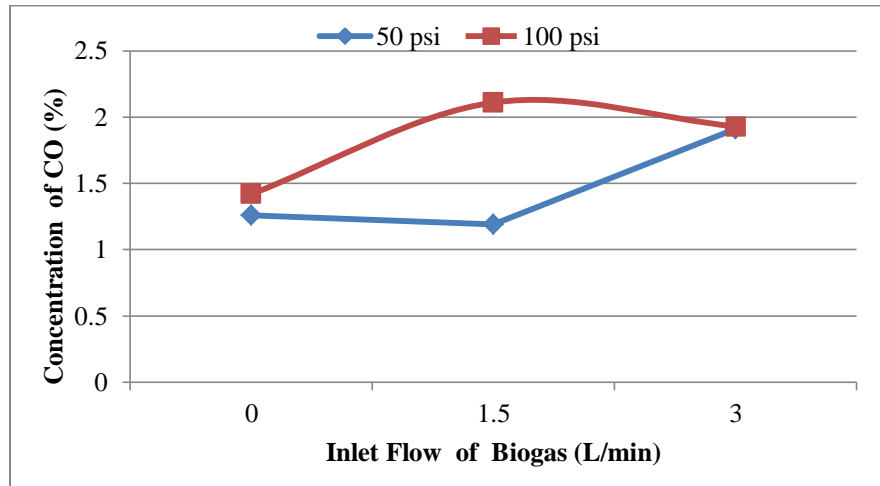


Figure 1:- CO emissions at 2000 rpm engine speed

The CO<sub>2</sub> emission shown in figure 2. It shows that the concentration emission of CO<sub>2</sub> decreases by increased of biogas input. Concentration of CO<sub>2</sub> shows the direct process of combustion in engine. The Air Fuel Ratio (AFR) around 12% - 15%, this affect to the rich combustion.

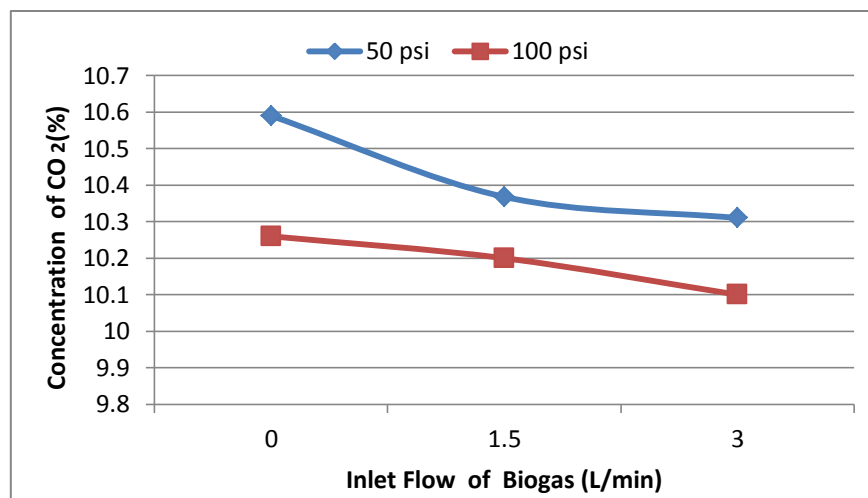
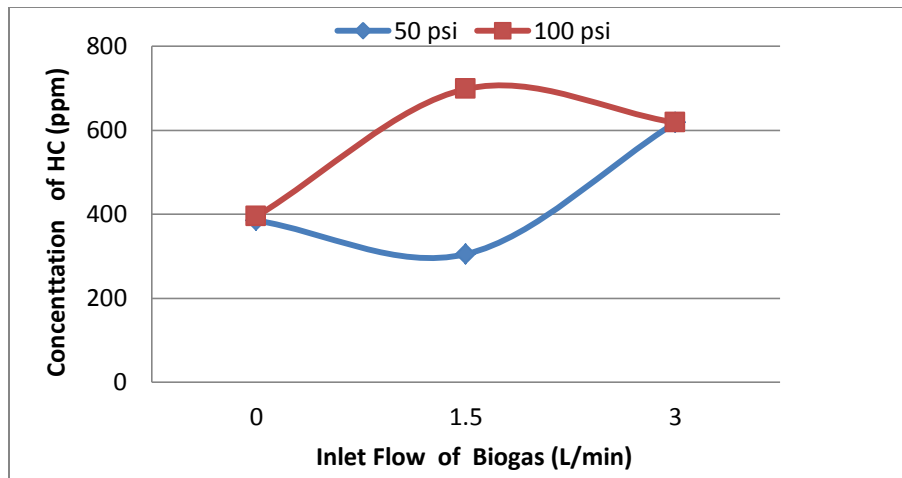
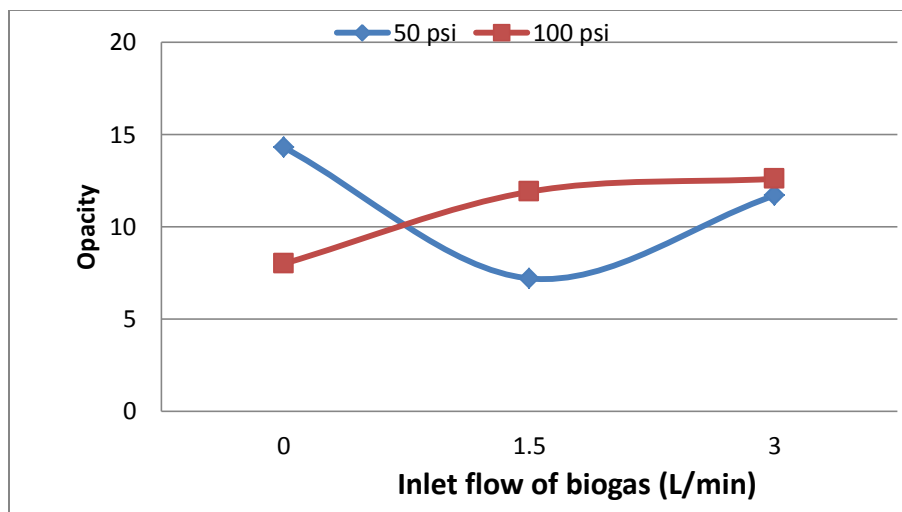


Figure 2:- CO<sub>2</sub> emissions at 2000 rpm engine speed



**Figure 3:-** HC emissions at 2000 rpm engine speed

The HC emissions of dual fuel were high in the case of high in-cylinder temperature at the high load condition as shown in figure 3. The Indonesian regulation of exhaust emissions is 250 ppm in maximum, however the data shows HC emissions by dual fuel in this experiment were more than 250 ppm in both engine load.



**Figure 4:-** Opacity at 2000 rpm engine speed

The smoke of the engine fueled with dual fuel increased with increasing biogas percentage in dual fuel at 50 psi engine load. This could be explained by the biogas fuel oxygenating the smoke during the combustion process. The maximum torque speed of the engine, 2000 rpm, was also maintained with the dual fuel. The addition of biogas to the diesel fuel initially increased the torque and the power due to the possible reasons of high temperature of combustion.

### Conclusions:-

In this paper, biogas produced from Lembang West Java Indonesia has been tested in a diesel engine. The experimental results are described that the CO were recorded to increase with increased biogas input. However, the CO emissions on 100 psi engine load was higher than 50 psi. This tendency was more evident as increased the load mean increase the burned of fuel quantity. The HC emissions of dual fuel were high in the case of high in-cylinder temperature at the high load condition. Biogas as alternative fuel can be partially used in diesel engines without any engine modification.

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