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The Influence of Engine Emission Relating to the Biodiesel

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Abstract

This paper investigated the influence of engine emission by using biodiesel in the combustion, regulated gaseous emissions, unregulated gaseous emissions and particulate emissions are all included. We obtained the following results with the increasing biodiesel in the pure diesel. The emission of HC and CO was decrease while the NO_x and NO_2 emissions increase. Particulate mass concentration in the exhaust was reduced when the engine load increased. But on the other side, the geometry mean diameter(GMD) in the emissions becomes smaller lead to the total number concentration increased. In the case of unregulated emissions from the engine, like formaldehyde, 1,3-butadiene, toluene, xylene decrease, but the acetaldehyde and benzene emissions increase. There are many investigations about biodiesel combustion, we focus on the characteristics of emission from engines after using biodiesel and analyze some of the existing research conclusions. We can draw the future research direction through the summary analysis of the existing conclusion.

Keywords: Biodiesel, Regulated gaseous emission, Unregulated gaseous emission, Particulate emission

INTRODUCTION

As the energy pressure increasing, countries while looking for new green energy and using the biodiesel as a kind of alternative energy sources in these years. One of the reasons is that there are a lot of methods to obtain biodiesel, for example vegetable oil, animal fat and waste cooking oil et al. The other reasons that why biodiesel can be alternative energy are in followings. First of all is that the biodiesel can be mixed with pure diesel directly in various proportions. In addition is that it also can run on without any modification on the engine. And it can also decrease some harmful emissions in a sense.

There are many investigations were done about the influence of the biodiesel on the combustion, performance evaluation and emissions characteristics of diesel engine. While we just concentrate on the characteristics of emissions from the engine in this paper. For the regulated emissions Magín et al got conclusions that the effect of biodiesel combustion, most of the researches can be found that HC, CO and particulate mass emissions can be reduced. But on the other side the concentration of NO_x will be increased [1]. For the unregulated gaseous emissions some researchers have different effects, but it is generally found that the emissions of formaldehyde, toluene, xylene and 1,3-butadiene decrease, however, the emissions of benzene and acetaldehyde increase[2]. AsadNaeem et al, their experiment get the results show that formaldehyde and total carbonyls from the test fuels exhibit maximum BSE at low load, which decreases with the increase in load. formaldehyde, acetaldehyde and methyl ethyl ketone show higher, but aromatic aldehydes (benzaldehyde and tolualdehyde) reflect lower BSE from B20 and B100 as compared to diesel fuel[3]. Avinash et al. in his study, a four-cylinder, compression ignition (CI) engine was used for characterization of unregulated gaseous exhaust emissions and get the results show an increasing trend for some of the unregulated species from blends of biodiesel such as formaldehyde, acetaldehyde, ethanol, n-butane however methane reduced upon using these oxygenated fuel blends except methanol, compared to baseline mineral diesel [4].

Through the summary of the previous literature, we can found that the study the characteristic of biodiesel emissions has done a lot , but most of them concentrated in the regulated emissions. In this study also focus on the particulate mass emissions of an engine with the biodiesel from waste cooking oil(WCO). Furthermore ,with the air environment get worse and worse , particle number limits have been added into the emissions standards of diesel engines [5]. Indicating that in addition to

reducing the concentration of particulate matter, reducing the number of particles in the engine exhaust concentration is also increasingly important. Therefore, the total concentration (TNC) and geometric mean diameter (GMD) are included in this study.

EXPERIMENTAL SETUP AND PROCEDURE

For most of the studies on the effects of biodiesel on engine exhaust, we can see that they all have similar experimental equipment and experimental processes, which will be explained and presented in a representative experimental process. Through the Fig.1, the experimental equipment will be related to the introduction.

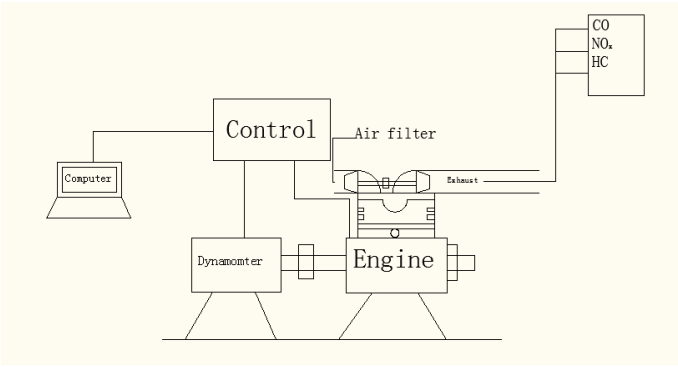

Figure1: Schematic of the experimental setup.

In order to get the corresponding experimental results, most of the experiments will use a four-cylinder naturally aspirated this easy-to-obtain diesel engine. Through the chart we can see that this experimental equipment can not only do experiments on the exhaust gas research, it can also be carried out for the engine performance, fuel characteristics and other related experiments. The fuel comes out of the tank and enters the cylinder for combustion. In this process there will be a corresponding sensor connection to measure the amount of fuel used. Connected to the engine shaft is a torque meter used to measure the output power of the engine, there are corresponding temperature and speed sensors connected with the engine, and can transfer data directly to the computer for easy recording. In the engine exhaust pipe will be connected to the temperature sensor used to measure the exhaust temperature, in addition to the exhaust pipe will be arranged in the relevant gas measuring instrument used to measure the exhaust gas containing the target gas content. For experiments where the measurement requirements are relatively high, the mass spectrometer is also required to connect the mass spectrometer for accurate measurement of low levels of gas. The detection principle of the instrument is based on the analysis of the molecular weight of the gas species. The following Table.1 gives a typical diesel engine performance chart as an example.

Table1: Engine specifications [3].

Items	Value
Number of cylinders	4
Bore	110 mm
Stroke	125 mm
Displacement	4.752L
Compression Ratio	16.8
Rated Power	117/2300 kW@ r/min
Maximum Torque	580/1400Nm@ r/min
Nozzle hole diameter	0.23 mm
Number of nozzle holes	6

For the test process, the first is the preparation of experimental fuel, and the experimental fuel and pure diesel oil in a different volume ratio to get different experimental samples. Before the experiment, all the meters need to be adjusted to ensure that the experimental data is accurate, and that the experimental data record should be in the engine running into a stable state can be used. The engine need to operate at a medium engine load for about 20 min to ensure that all the previous fuel inside the system has been consumed before conducting the subsequent tests. The data collected in each experiment is at least five minutes longer for the engine to work, and at least twice for each experiment to avoid inaccurate results due to equipment or recording [6].

RESULTS AND DISCUSSION

The use of samples of biodiesel have been tested, the experimental data on the line shaping and comparison, if found a group of data deviation is required to re-experimental record

to ensure that the accuracy of the experimental data. In this paper, we focus on the effects of biodiesel combustion on tail gas, and we discuss the following results for some properties of tail gas.

Regulated emissions

Prabu et al. [7] they used a four stroke single cylinder DI stationary diesel engine to study the performance, combustion and emission characteristics of waste cooking oil(WCO). The engine coupled with an eddy current dynamometer by varying the engine load from 0 to 100% with an increment of 25%. Conducting test at a constant speed of 1500 rpm and readings were recorded for each load. In the burette 10 cc fuel consumption time was noted using a stop watch. As per ASTM the physical and thermal properties of WCO and diesel were tested and resulted in Table 2. It shows that the density of the WCO is more than that of diesel by 1.6% and the calorific value of diesel is more than that of WCO by 18.3% which means more amount of WCO needs to be injected into the combustion chamber in order to get the same power output of using diesel fuel. mixed with diesel in different proportions to form different blends such as B20 (20% WCO and 80% diesel), B30 (30% WCO and 70% diesel), B40 (40% WCO and 60% diesel) and B100 (100% WCO).

Table 2: Properties of WCO and diesel[7].

Properties	WCO	Diesel	Testing Procedure
Flash point ℃	130	68	ASTM D92
Fire point ℃	132	76	ASTM D92
Kinematic viscosity at 40 ℃ in (mm2/sec)	5.87	3.9	ASTM D2217
Calorificvalue (MJ/kg)	38.2	45.2	ASTM D4809
Density (kg/m3)	844	830	ASTM EN 14213

Fig. 2 shows a schematic representation of the HC emissions of different samples as the load changes. From the figure we can see that the highest HC emissions of pure diesel, which is due to biodiesel oxygen content is higher than pure diesel caused. On the other hand, as the load increases, all samples of HC emissions are reduced, This may be due to the low cetane number, low cylinder temperature and incomplete combustion, while high load HC decreases with the cylinder temperature rise. Aninidita also got the same experimental results [8].

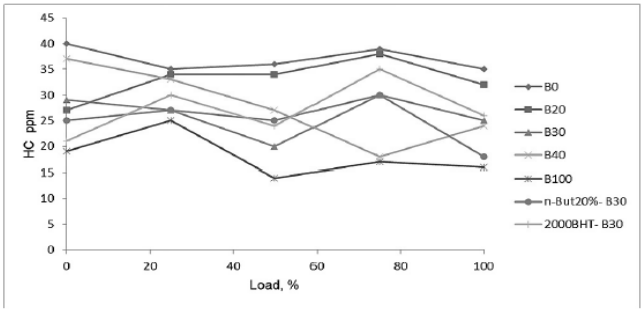

Figure 2: HC emissions with varying loads of different blends[8].

From this figure we can see that the increase in biodiesel content is also a way to improve the oxygen content of fuel, oxygen can help improve the full combustion of diesel. Improve the quality of combustion is the result we need to investigate. We can see the promotion of biodiesel is a positive significance.

CO emissions for different blends of WCO under different loading conditions at 1500 rpm are showed in the following Fig. 3. It can be found that the lower the amount of biodiesel produced at low load, the less CO is produced in the process of increasing the load, and the amount of CO produced by biodiesel is higher than that of pure diesel CO is formed due to combustion in insufficient supply of air and low flame temperature. CO emission increases with load as a result of temperature rise in combustion chamber, air-fuel ratio, lack of oxygen at high speed and lack of time for combustion. Sharon in their experiments also got such a result.

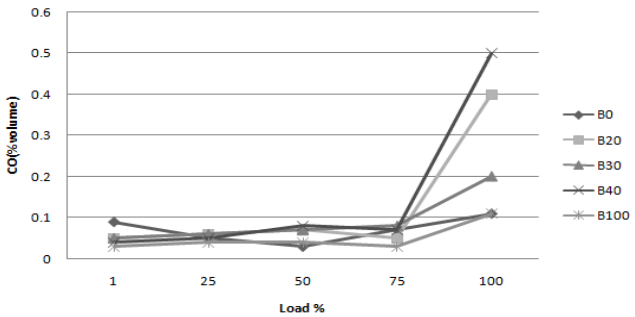

Figure 3: CO emissions with varying loads of different blends.[8]

Alam et al, like many other researchers which reduced CO emissions with respect to two diesel fuels (low and ultra-low sulfur).,The addition of biodiesel under high load conditions will lead to increased CO emissions, Fernando et al[13], who also received the corresponding conclusions. At low load, many researchers have concluded that CO emissions are reduced, and more experiments need to be carried out for high load conditions.

Fig 4 shows NO_x emissions of different blends of WCO with different loads. NO_x emissions increase with the increase in biodiesel, The important parameters which affect the NO_x emissions are flame temperature, ignition delay, availability of O_2 and N_2 in the mixture and fuel bound oxygen [10].With the increase in biodiesel, the result of the increase in NO_x is also consistent with the results obtained by the previous researchers

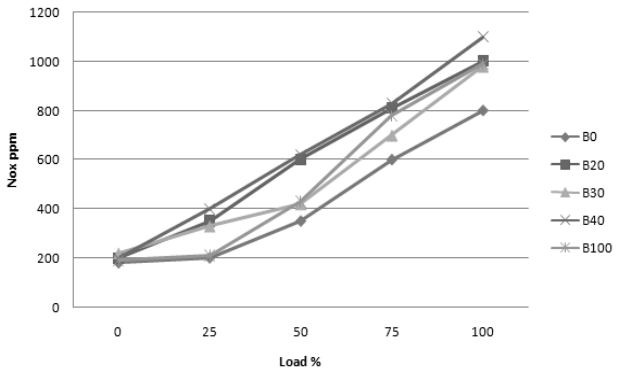

Figure 4: NO_x emissions with varying loads of different blends.[16]

The reason for the increase of NO_x emission after adding biodiesel has been analyzed. First, due to the difference in viscosity, density and compression ratio of biodiesel, the change of the combustion environment is caused by the change of the combustion temperature. Is conducive to generated NO_x. In addition, because some of the biodiesel molecules contain a certain amount of nitrogen, in the process of combustion of nitrogen is oxidized to the corresponding nitrogen oxides. Thus, after adding biodiesel, we also need to study how to reduce the combustion temperature and biodiesel nitrogen removal method.

Unregulated emissions

A large number of studies have shown that for formaldehyde, butadiene, toluene and xylene are with the increase in the amount of biodiesel mixed emissions show a downward trend. This can be seen to join the biodiesel on the environment and human health are good. However, for low load conditions, these unregulated emissions are increasing trends due to lower engine start and lower combustion temperatures. Takada et al and Zervas et al they all get the similar results [11-12]

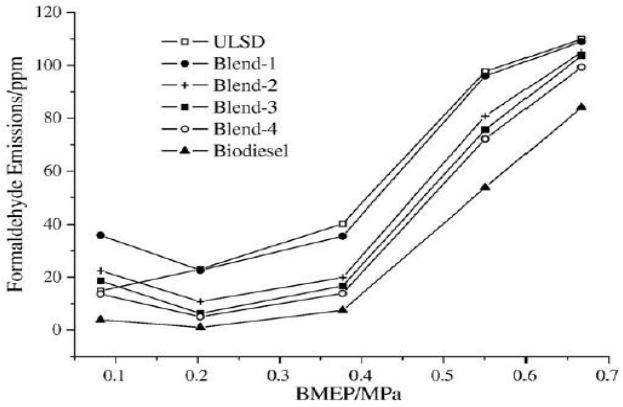

Figure 5: Effect of biodiesel and engine load on acetaldehyde emission.[2]

In Fig. 5, the figures show the results of Yage Di[2].Their experiments were conducted on a 4-cylinder direct-injection diesel engine using ultra-low sulfur diesel, biodiesel and their blends, to investigate the regulated and unregulated missions of the engine under five engine loads at an engine speed of 1800 rev/min. Blended fuels containing 19.6%, 39.4%, 59.4% and 79.6% by volume of biodiesel. Their experiments also confirmed the previous conclusion

With the addition of biodiesel, both high and low load will have a downward trend. And then in the process of load growth will appear emissions fluctuations. The reason for this phenomenon can be summed up, the low temperature of the engine combustion temperature is not enough high acetaldehyde is oxidized to CO. However, when the load increases, the nature of acetaldehyde is not as easy to oxidize formaldehyde, so the load increases in the process of combustion will be the case of fluctuations.

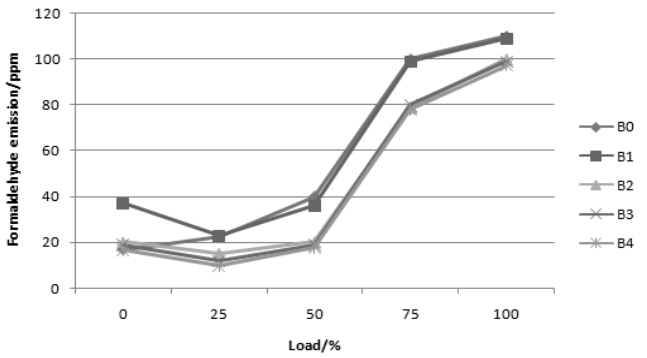

Figure 6: Effect of biodiesel and engine load on formaldehyde emission.[4]

In Fig. 6,the figures show the effect of biodiesel and engine load on formaldehyde emission[2]. From the figure, we can see that the emission of formaldehyde with the biodiesel mixture of the increase gradually reduced. On the other hand, formaldehyde emissions will increase as the load increases. This is also consistent with the conclusion that formaldehyde emissions are similarly reduced when the combustion temperature is low.

Keishi et al.[15] suggested that formaldehyde is formed under low temperature and in the results from the chart can be used to increase the cause of formaldehyde emissions after adding biodiesel. First in the case of low-load operation, due to lower combustion temperature formaldehyde is oxidized into CO. On the other hand the fuel spray spreads to the area of the gas in the cylinder may stop the oxidation stage of the oxidized portion of the formaldehyde in the fuel, especially the higher turbulence within the higher engine speed conditions.

Whether it is acetaldehyde or formaldehyde, are harmful substances on the human body. Formaldehyde has the potential to stimulate the body's respiratory organs, and acetaldehyde is the product of ethanol conversion, in the human body with the possibility of cancer. From the above experimental conclusions can be seen in the diesel oil by adding biodiesel, formaldehyde acetaldehyde are reduced around, which is worthy of biodiesel is one of the reasons.

Particulate Mass emission

People are increasingly concerned about the haze, it can be said that the exhaust gas in the car is also one of the reasons for the formation of haze, which is why in recent years, particulate emissions into the car exhaust emissions management. Most of the previous researchers have focused on the effect of adding biodiesel on the original diesel particulate matter, and this time we have added the size of the particle diameter to the study.

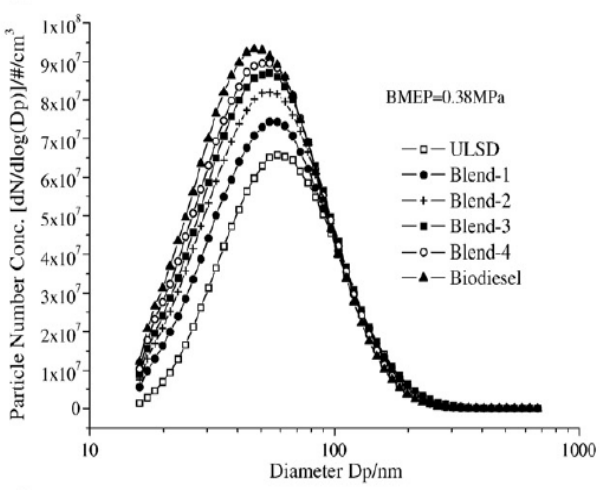

Figure 7: Effects of biodiesel and engine load on particulate mass concentration[2].

For the study of particulate matter exhaust, we also use the author of Yage et al [2]. In the course of their test process is not described in detail, focusing on the analysis of particulate matter emissions. Fig. 7 and Fig. 8 show the effects of biodiesel and engine load on particulate mass concentration and effect of biodiesel and engine load on particulate number concentration and size distribution. From the figure we see that in the pure diesel oil after adding biodiesel, regardless of the level of engine load, particulate matter emissions are reduced. In addition to this can also be seen in the complete burning of biodiesel, the particulate matter emissions is the least. The particulate reduction is associated with the reduction of soot and sulfate in the particulate. The blended fuel has an increase in fuel oxygen but a decrease of fuel carbon, leading to a reduction of soot formed. But we can find from Fig. 8, biodiesel added, the small diameter of the particulate matter has increased. This is not a good thing, we all know that health effects are greater for smaller particles.

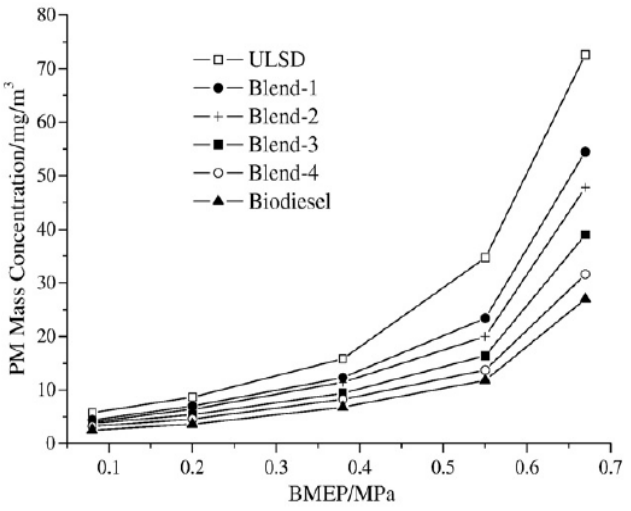

Figure8: Effect of biodiesel and engine load on particulate number concentration and size distribution[2].

Particulate mass concentration in the exhaust was reduced when the engine load increased. But on the other side, the geometry mean diameter(GMD) in the emissions becomes smaller lead to the total number concentration increased. The reason for this is that the addition of biodiesel increases the oxygen content of the fuel due to the addition of biodiesel, which is the combustion of the engine more fully and the burning of the large GDM particles into smaller particles. The number of particles is on the rise. In this case, researchers need to conduct in-depth research on how to reduce the particulate matter produced by engine combustion in future studies. Engine burning is also one of the causes of haze nowadays, so this problem cannot be ignored.

CONCLUSION

This paper investigated the influence of engine emission by using biodiesel in the combustion, regulated gaseous emissions, unregulated gaseous emissions and particulate emissions are all included. From the study of this paper we can get the following conclusions:

1. CO,HC emissions are reduced, This may be due to the low cetane number, low cylinder temperature and incomplete combustion, while high load HC decreases with the cylinder temperature rise.
2. After adding biodiesel, the content of NO_x increased. NO_x emissions are depended on temperature, ignition delay, availability of O_2 and N_2 in the mixture and fuel bound oxygen.
3. For particulate matter, the addition of biodiesel resulted in a decrease in particulate matter emissions compared to pure diesel but a decrease in the diameter of the excreted particulate matter. This is detrimental to the health of mankind, so in the future study should be as much as possible to find a way to completely reduce the particles.

From the engine combustion process can be seen that many substances in the exhaust are harmful to human health, this requires researchers to study the process, can not only study how to select alternative energy products, but also consider how to reduce the combustion of harmful substances in the process, in addition to the scope of management is not within the scope of emissions We cannot give up the study.

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