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Durability Studies of Single Cylinder Diesel Engine Running on Emulsion Fuel

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Abstract – *At present, diesel engines are still the most fuel efficient internal combustion engines, and diesel fuel is the dominant fuel used by the commercial transportation, industrial and agricultural sectors. This is because it offers fuel economy, efficient power, durability and heavy-duty application. However, diesel engines are considered a major source of air pollution in cities and urban areas because of their black smoke, nitrogen oxides (NOx), particulate matters (PM), sulfur oxides (SOx), HC (hydrocarbon) and carbon monoxide (CO) emissions. Emulsions fuel are often promoted as being able to overcome the difficulty of simultaneously reducing emissions of both oxidizes of nitrogen (NOx) and particulate matter (PM) from diesel engines. Durability test of using emulsion fuel in diesel electric generator engine need to be done to know the effects due to the long term operation of diesel electric generator using emulsion fuel as an alternative fuel compare to conventional diesel fuel.*

Keywords: Diesel engine, emulsion fuel, durability test, nitrogen oxides

1.0 INTRODUCTION

Diesel engines are obtaining more and more attention in transportation, industrial and application due to their high efficiency [1]. However, they also suffer from high smoke and nitrogen oxides emissions [2]. The introduction of water into diesel engine using water in oil (W/O) emulsions has a number of possible benefits. It has been proved by researches that it can effectively reduce the peak flame temperature and thereby reducing NOx emissions [3]. An emulsion is a mixture of two immiscible fluids. An emulsion takes on the characteristic of continuous phase as shown in Fig.1. Hence, oil phase exhibit characteristics of fuel oil, not water.

However emulsion are inherently unstable. Over time they will separate into the stable states of the dispersed and continuous phase materials. To maintain the composition of an emulsion, surface active agents, or “surfactants”, are incorporated into the production of an oil phased emulsion. In oil phased emulsion, these surfactant agents encase the droplet of water distributed throughout the continuous oil phase and prevent the water droplets from coming together and coalescing. The emulsion types of W/O can be used as an alternative fuel [4].

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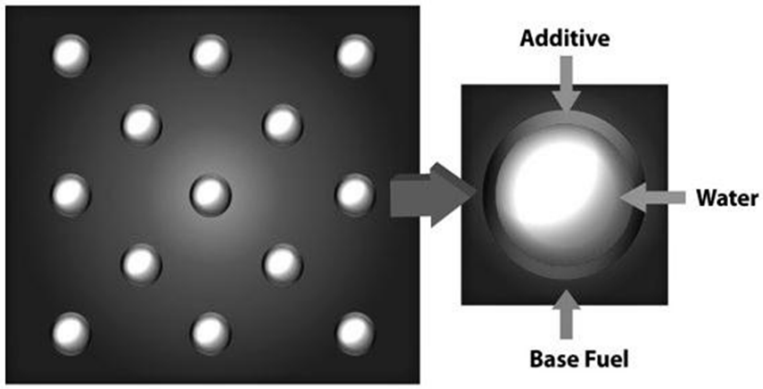

Figure 1: Diagram illustrating W/O emulsion [5]

During the combustion, the droplets of diesel and biodiesel are huge, the combustion time available are not sufficient for them to burn completely. But, for emulsion fuel, their droplets are relatively small due to the micro explosion, so the fuel can be burned completely as in Fig 2. The micro-explosion combustion induces the generation of more fuel particles, promote complete combustion, and reduce the generation of soot, NOx, CO and other pollution materials without deteriorating combustion efficiency [6].

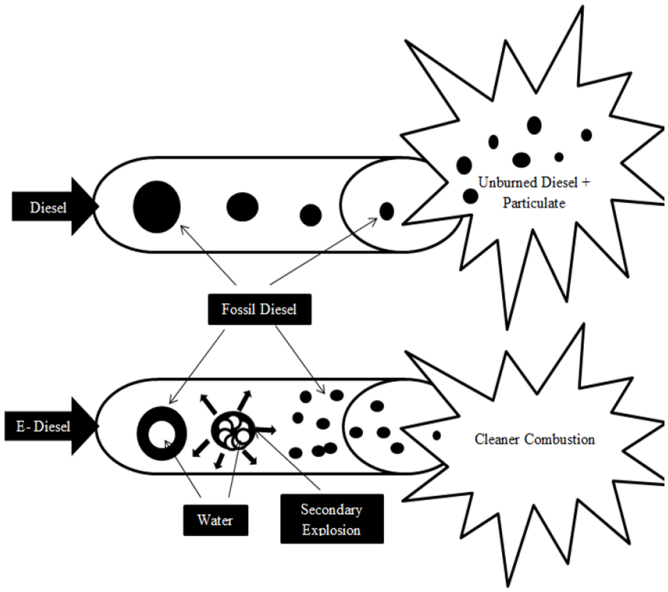

Figure 2: Micro-explosions [7]

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2.0 LITERATURE REVIEW

There are several researches that had been done about the effect of the emulsion fuel on the engine. Most of the research showed that, the emulsion fuel will give better performance and reduce emission of the harmful gases [8]. The fuel gives better performance relative to diesel in regards of engine torque, power, brake thermal efficiency and brake specific fuel consumption. The following Fig. 3 shows the increased torque by using emulsion fuel on the compressed ignition engine.

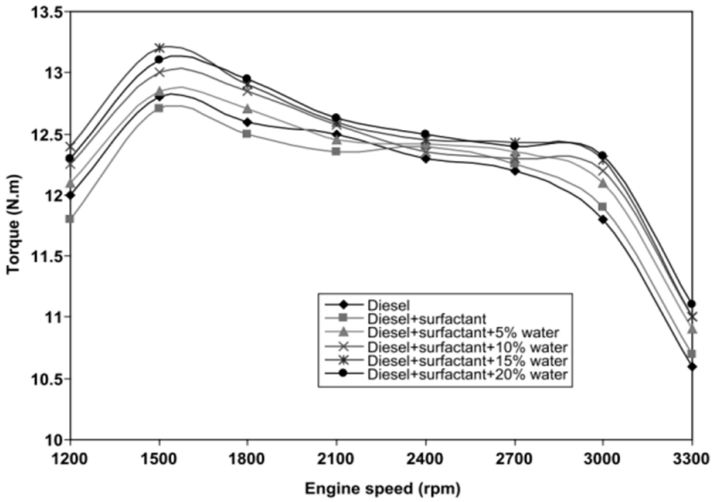

Figure 3: Torque [9]

For emission the effect of 10 and 15% W/O levels of NOx, HC and soot, as well as on the specific fuel consumption (sfc) are mostly showed in Fig. 4.

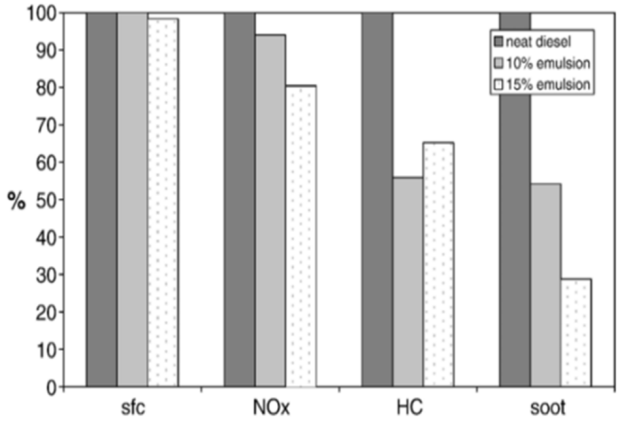

Figure 4: sfc, NOx, HC and soot [12]

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Not so much attention of research about the effects of using emulsion fuel on carbon deposit, wear and lubricant analysis so far for durability test by using emulsion fuel. Only have few research papers [10,11] related and not so much detail about the effect for long term operation on it.

3.0 ENGINE DURABILITY TEST

Durability test that will be conducted is about 300 hour operation by following the standard D2 cycle for the generator from ISO 8178 in table 2. The test will run at about 15 hours per day and the rest time in between each day is for 9 hours.

3.1 Test Fuel and Properties

Starting by make an emulsion fuel for E20 (20% water & 80% diesel) and E40 (40% water & 60% diesel) with the addition a glycerin as a surfactant to hold the water and diesel together for fuel stability. The mechanical mixer will be used to mix the water and diesel at rotation 1500 rpm. The properties of fuel for E20, E40 and conventional diesel fuel (D2) need to be test to determine the significant different for each type of fuel. The properties and methods that will be used are indicated in table 2.

Table 1: Fuel properties and method

PROPERTIES	ASTM STANDARD
Density	D1298
Kinematic Viscosity	D445
Flash point	D92
Heating Value	D240
Cetane Number	D613

3.2 Engine Performance Test

Engine performance test will be run before and after engine durability test to measure and differentiate if any significant drop in engine performance and increase in emissions. To make sure the result is correct; 4 times test will be conduct. In this test, 3 set 5kW generator diesel engine will be used for each type of fuel. The basic engine specifications are shown in Table 3. The engine operating conditions have been selected based on the 3000 rpm, where engine loads were varied in order to represent the actual application of the generator set. The schematic diagram of the engine test setup is on the figure 5.

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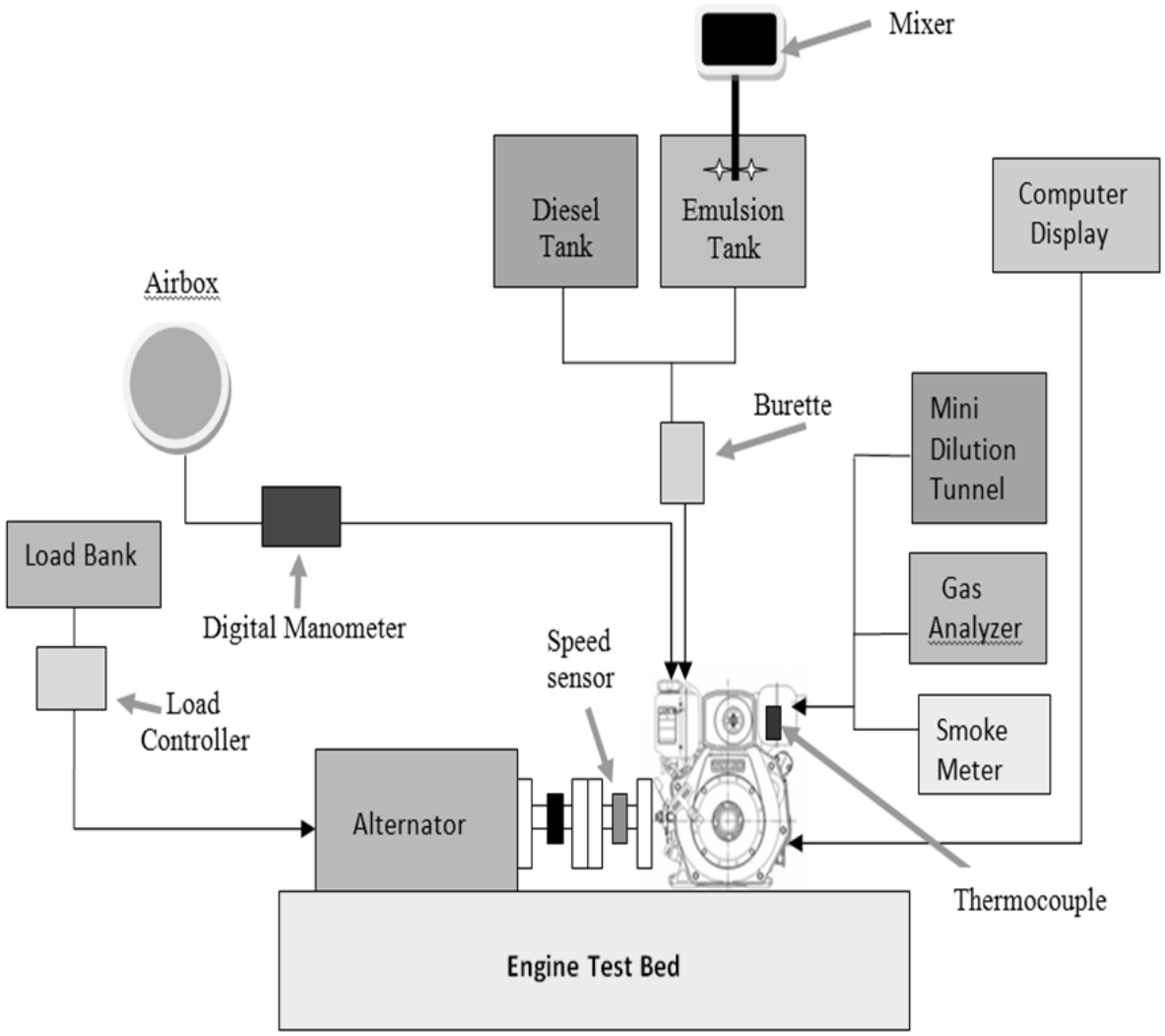

Figure 5: Schematic diagram of the engine test setup

Table 2: D2 cycle for generator from ISO 8178

Step	Load (%)	Time (hour)	Engine Speed (rpm)
1	100	1	3000
2	75	1	3000
3	50	1	3000
4	25	1	3000
5	10	1	3000

Table 3: Specifications of DI diesel engine

Engine Model	SU186FAG
Bore	86mm
Stroke	70mm
Compression ratio	19.7
Displacement	407cc

3.3 Engine Durability Analysis

The effect of long term operation by using emulsion fuel on cylinder wall is of great interest. This will give insight on the effect of water to the engine. More focus will be on the cylinder wall to measure the wear on it by using the Scanning Electron Microscopy (SEM). In addition, the sample lubricant oil from the engine will be collected after 60 hours operation until 300 hours operation. The sample will analyze on total acid number, viscosity and metal debris by using Multi elements Oil Analysis (MOA). Finally the qualitative and quantitative study on carbon deposit formation in combustion chamber will be carried out after the durability test finish for 300 hours.

4.0 SUMMARY

The concern of introduction of water in combustion chamber for long term operation may reduce engine life especially effect the service time for engine itself. Durability test of using emulsion fuel in diesel electric generator engine need to be done to know the effects due to the long term operation of diesel electric generator using emulsion fuel as an alternative fuel compare to conventional diesel fuel.

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