CHAPTER III
EXPERIMENTAL

3.1 Materials and Equipment

3.1.1 Chemicals

Diesel was supported from Rayong Purifier Public Company Limited. Ethanol 95% and 99.5% were obtained by the Royal Chitralada Projects. Ethanol 99.9% was purchased from J.T.Baker. Biodiesel (palm oil methyl ester) was received from the Department of Naval Dockyards, Royal Thai Navy.

3.1.2 Equipment

- Magnetic stirrer
- Vial tubes
- Glassware
- Pipettes
- Water bath
- ASTM testing apparatus

3.2 Experimental

3.2.1 Splash-blending

Diesohol was prepared by splash-blending method. Diesel, biodiesel and ethanol were mixed together into a homogeneous mixture by a magnetic stirrer. The stirring speed was set at 1,000 rpm for 5 minutes. Then, the final blend was kept in a vial tube for observing the physical appearance. The same procedure was carried out with other ratios of diesel, biodiesel and ethanol. Each component was varied from 0% to 100% by volume in 10% increments. In this study, phase behavior of the three-component systems was investigated by using physical state diagram. All the blends from the previous step were kept motionless for 7 days at 10, 20, 30, 40 °C to observe the physical stabilities. After 7 days, the observation data were used to develop the physical state diagrams at different temperatures. The physical state diagram would depict the physical appearances at any ratios of the diesel-biodiesel-ethanol components by using the symbols to describe the characteristics of the blends. However, all the blends were kept motionless further at room temperature for 3 months to observe the long term stability.

3.2.2 Fuel Properties Testing

To study the effect of the three component ratios on the fuel properties, ten blends of diesel with ethanol and biodiesel were selected. They were obtained by mixing diesel, ethanol and biodiesel by volume in the proportions as shown in Table 3.1.

Table 3.1 Component ratio of the sample for fuel property testing

Sample No.	Component ratio (%)		
	Diesel	Biodiesel	Ethanol
1	90	10	0
2	90	5	5
3	90	0	10
4	85	15	0
5	85	10	5
6	85	5	10
7	85	0	15
8	80	15	5
9	80	10	10
10	80	5	15

Laboratory tests were then carried out using ASTM tests standards to determine the following properties; cetane index, flash point, pour point, density at 15°C, and heat of combustion.

3.2.2.1 Density at 15 °C

Density (mass per unit volume at a specified temperature) is a fundamental physical property that can be used in conjunction with other properties to characterize both the light and heavy fractions of petroleum and petroleum products. Determination of the density or relative density (the ratio of the density of a material at a stated temperature to the density of water at a stated temperature) of petroleum and its products is necessary for the conversion of measured volumes to volumes at the standard temperature of 15°C. According to ASTM D 4052, a small volume (approximately 0.7 ml) of liquid sample is introduced into an oscillating sample tube and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with calibration data to determine the density of the sample.

3.2.2.2 Cetane Index

The Calculated Cetane Index is a useful tool for estimating ASTM cetane number where a test engine is not available for determining this property. It may be conveniently employed for approximating cetane number where the quantity of sample is too small for an engine rating. In cases where the cetane number of a fuel has been initially established, the index is useful as a cetane number check on subsequent samples of that fuel, provided its source and mode of manufacture remain unchanged. According to ASTM D 976, the Calculated Cetane Index is determined from the following equation:

$$\text{Calculated cetane index} = -420.34 + 0.016\,G^2 + 0.192\,G\log M + 65.01\,(\log M)^2 - 0.0001809\,M^2 \quad \text{..........(1)}$$

or

$$\text{Calculated cetane index} = 454.74 - 1641.416\,D + 774.74\,D^2 - 0.554\,B + 97.803\,(\log B)^2 \quad \text{.....................(2)}$$

where:

G = API gravity, determined by Test Method D 287, D 1298, or D 4052,

M = mid-boiling temperature, °F, determined by Test Method D86 and corrected to standard barometric pressure,

D = density at 15°C, g/ml, determined by Test Method D 1298 or D 4052,

B = mid-boiling temperature, °C, determined by Test Method D 86 and corrected to standard barometric pressure.

3.2.2.3 Heat of Combustion

The determination of high heating value or heat of combustion can be useful to predict the energy of energy released when a unit mass of fuel is burned in a constant volume enclosure and determined by ASTM D 240, standard test method for heat of combustion of liquid hydrocarbon fuels by Bomb Calorimeter. A sample to be determined by burning a weighted sample in an oxygen bomb calorimeter under controlled condition. The heat of combustion is computed from temperature observations before, during, and after combustion, with proper allowance for thermo chemical and heat transfer corrections.

3.2.2.4 Pour Point

The pour point is an index of the lowest temperature of its utility for certain applications, which is determined by ASTM D 97, standard test method for pour point of petroleum oils. After preliminary heating, the sample is cooled at a specified rate and examined at intervals of 3°C for flow characteristics. The lowest temperature at which movement of the specimen is observed is recorded as the pour point. No wax precipitation problems are encountered above the cloud point. Pour points for most automotive diesel fuels are usually between –15 and 35 °C.

3.2.2.5 Flash Point

Flash point is the lowest temperature at which application of the test flame caused the vapor above the sample to ignite and fire point is the lowest temperature corrected to a barometric pressure of 101.3 kPa (760 mm Hg), which is a temperature above the flash point. There are determined by test method ASTM D 56, which cover the determination of the flash point of petroleum products that below 93°C (200°F) by a manual Pensky-Martens closed-cup apparatus or an automated Pensky-Martens closed-cup apparatus. The flash point temperature is one measure of the tendency of the test specimen to form a flammable mixture with air under controlled laboratory conditions. It is only one of a number of properties, which must be considered in assessing the overall flammability hazard of a material.

3.2.3 Emissions Testing

Finally, the fuel blends with component ratios as shown in Table 3.1 were used to investigate the emissions. The engine studied is a diesel generator model DG3LE. It is a commercial single – cylinder, vertical, 4 – stroke, air – cooled, direct injection diesel engine whose major specifications are shown in Table 3.2.

Table 3.2 Engine specifications

Model		DG3LE
Engine model		ETQ 170 FG
Type		Single – cylinder, vertical, 4 – stroke, air – cooled, direct injection
Output	Continuous (kw)	2.98
	Maximum (kw)	3.36
Bore x Stroke (mm)		70 x 55
Displacement (cc)		219
Cooling system		Forced air cooling by flywheel fan
Lubricating system		Pressure splash, duplex type lubrication
Lube-oil capacity		0.75
Starting system		Recoil manual start / Electric start (optional)
Fuel tank capacity (L)		15
Dry weight (kg)		53
Dimensions (LxWxH) (mm)		690x470x555

The engine was coupled to an electrical generator through which load was applied by increasing the current to supply electrical apparatus that used to adjust load. The load condition in this study was divided into 4 steps which are 0, 30, 60 and 100% load (0, 3, 6 and 10 amp, respectively). The Motorscan Eurogas 8020 emissions analyzer was used to measure the concentration of carbon monoxide (CO), unburned hydrocarbon (HC) and nitrogen oxide (NO_X) of the exhausted gas at different loads. The fuel consumption rate was measured by the volume of fuel dropped in a scaled – cylinder that used to fill the fuel into the engine divided by time. The pictures of diesel generator and emissions analyzer are shown in Figures 3.1 and 3.2, respectively.

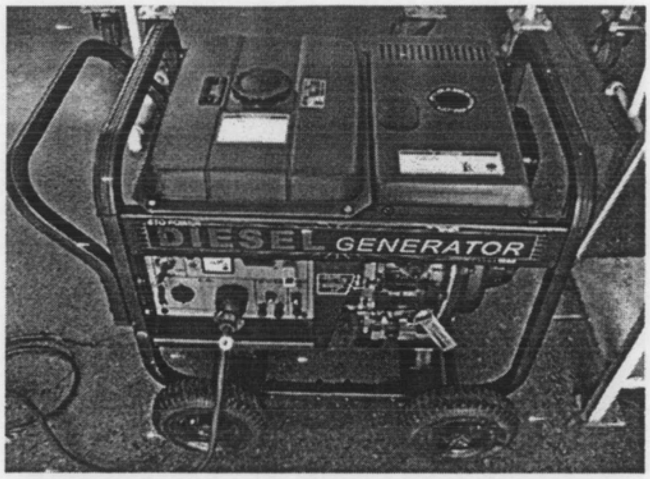

Figure 3.1 The diesel generator model DG3LE.

Figure 3.2 The Motorscan Eurogas 8020 emissions analyzer.