CHAPTER 2

MATERIALS AND METHODS

2.1 Apparatus and instruments

2.1.1 Multi Gas Detector Portable Fuel Gas Analysis consists of;

1) Control Unit
2) Analyzer Box
3) Probe

All parts are from Testo 350XL, U.S.A

2.1.2 Tested engine, manufactured by Febix International Co., Ltd, consists of;

1) Yanmar TF 75-LM, Yanmar S.P. Co., Ltd., Thailand
2) Aluminium single point load cell, Vishay Tedea-Huntleigh model No. 1263, Vishay Intertechnology Inc., U.S.A
3) Tested engine controller, Febix International Co., Ltd., Thailand
4) Generator, Elecking super generator CC 7.5, N.K. L Machinery Ltd., Part.
5) Heater

2.1.3 Tested engine, manufactured by Febix International Co., Ltd, consists of;

1) ISUZU TF 4JB1, ISUZU Co., Ltd., Thailand
2) Aluminium single point load cell, Vishay Tedea-Huntleigh model No. 1263, Vishay Intertechnology Inc., U.S.A
3) Tested engine controller, Febix International Co., Ltd., Thailand
4) Heater
5) Computer controller

2.1.4 Bomb calorimeter consists of;

1) Jacket
2) 18 to 30 °C thermometer graduated to 0.01 °C
3) 2,000 mL graduated cylinder
4) Bracket
5) Bucket stirrer
6) Vibrator
7) Calorimeter bucket
8) Lead wire
9) Bomb ignition unit
10) Oxygen charger

All parts are from Parr instrument company, U.S.A

2.1.5 Hydrometer apparatus consists of;

1) Glass hydrometer
2) Hydrometer cylinder

2.1.6 Flash point tester consists of;

1) Pensky-Martens close cup apparatus

Thermometer: - Low Range : -7 to 110 °C, Graduation 0.5 °C

- High Range : 90 to 370 °C, Graduation 2 °C

2.1.7 Cloud and pour point bath consists of;

1) Thermometer
2) Cork
3) Test vessel
4) Gasket

5) Seta-Lec cloud and pour point refrigerator

All parts are from Stanhope-Seta Ltd., UK

2.1.8 Setavis^{TM} kinematic viscometer model no. 83541-3, Stanhope-Seta Ltd., UK

2.1 Chemicals

1) Milli-Q water

2) Ethanol (C_2H_5OH) 99.5%

2.3 Software

Statistical calculations were performed using the SPSS software version 17 (SPSS Inc., Chicago, IL, USA,) supported by Department of Statistic, Faculty of Science, Chiang Mai University.

2.4 Sampling method

2.4.1 Sample selection

1) An agricultural diesel engine (Yanmar TF 75-LM)

Two community biodiesel fuel (CBFs) plants located in Umong and Sankhampeang in Lamphun and Chiang Mai Provinces, Thailand were selected and named as UMO, SAM and SAN, respectively. A conventional diesel and biodiesel fuel 98% (2:98) (hereafter named DIE, B2-PTT or BBDF-2) and conventional diesel with biodiesel blend 95% (5:95), B5 or BBDF-5–derived from PTT local gas station, was served as a control (Appendix B). Source of fuel tested for agricultural diesel engine and high speed diesel engine were presented in Table 2.1.

2) A high speed diesel engine (ISUZU 4JB1)

Sankampeang community biodiesel located in Chiang Mai provinces, Thailand were selected and produced biodiesel fuel samples. All biodiesel fuel samples were collected from various places but were prepared and produced at Sankampeang community only. Because of various biodiesel fuel samples were divided into two groups based on their sources. The first group biodiesel fuel sample produced from used mix oil were collected from household and local market, used palm oil were derived from food industry was taken after they were used twice for potato ship frying purpose.The latter was collected after they were used several times for various materials frying purposes and community palm oil (Appendix B). Used mix oil (UOL), used palm oil (UPO) and palm oil (CPO) was collected from community biodiesel by using transesterification process.

A community biodiesel named as CBF100%-UMO, CBF100%-UPO and CBF100%-CPO. The second group petroleum diesel or pure diesel, biodiesel blend with diesel and diesel are a conventional 97% (hereafter named DIE 100 or B0- PTT, BBDF3 is B3-PTT) –derived from PTT local gas station, was served as a control.

Table 2.1 Source of fuel tested for agricultural diesel engine and high speed diesel engine

No.	Name /Symbol	Production scale	Ratio	Fuel Types	Engine Tested
1	Umong / UMO	Community scale	CBF-100	use palm oil	Agricultural diesel engine
2	Sankhampeang / SAM	Community scale	CBF-100	used mix oil	Agricultural diesel engine
3	Sankhampeang / SAN	Community scale	CBF-100	palm oil	Agricultural diesel engine
4	Biodiesel blend with diesel / DIE,B2	Conventional scale	CDF-98	palm oil	Agricultural diesel engine
5	Biodiesel blend with diesel / PTT B5 or (BBDF-5)	Conventional scale	CDF-95	biodiesel blend palm oil	Agricultural diesel engine
6	Used mix oil / UOL	Community scale	CBF-100	used mix oil	High Speed Diesel engine
7	Used palm oil / UPO	Community scale	CBF-100	use palm oil	High Speed Diesel engine
8	Community palm oil / CPO	Community scale	CBF-100	palm oil	High Speed Diesel engine
9	Diesel / Diesel 100, DIE100 or B0	Conventional scale	CDF-100	petroleum diesel	High Speed Diesel engine
10	Biodiesel blend with diesel / PTT B3 or (BBDF-3)	Conventional scale	CDF-97	biodiesel blend palm oil	High Speed Diesel engine

2.4.2 Tested engine preparation and operating conditions

1) An agricultural diesel engine (Yanmar TF 75-LM)

The experiments were carried out using an agricultural diesel engine (Yanmar TF 75-LM). The main characteristics of tested engine are cited in Table 2.2. The diagram of sampling equipment is shown in Figure 2.1. The tested engine was operated at room temperature and was conducted at engine speed of 1,800 rpm under full engine loads. The operation and maintenance of tested engine were followed from the operation manual [45]. The fuel was supplied to the engine by external tank of 1-L capacity, which could be easily drained with the assistance of three-way stop valve for changing of fuel. For every change of fuel, the fuel line was purged out of the residual fuel. A 20-mL glass burette was also set up in parallel to fuel tank and was used for measurement of fuel flow rate. Engine performance test including fuel consumption, engine power and torque were observed to ensure the stabilizing of engine performance. Testing of tested fuel effectiveness was performed in triplicate, and the average results are reported herein. All engine performance experiments were carried out at Department of Mechanical Engineering, Faculty of Engineering, Rajamangala University of Technology Lanna.

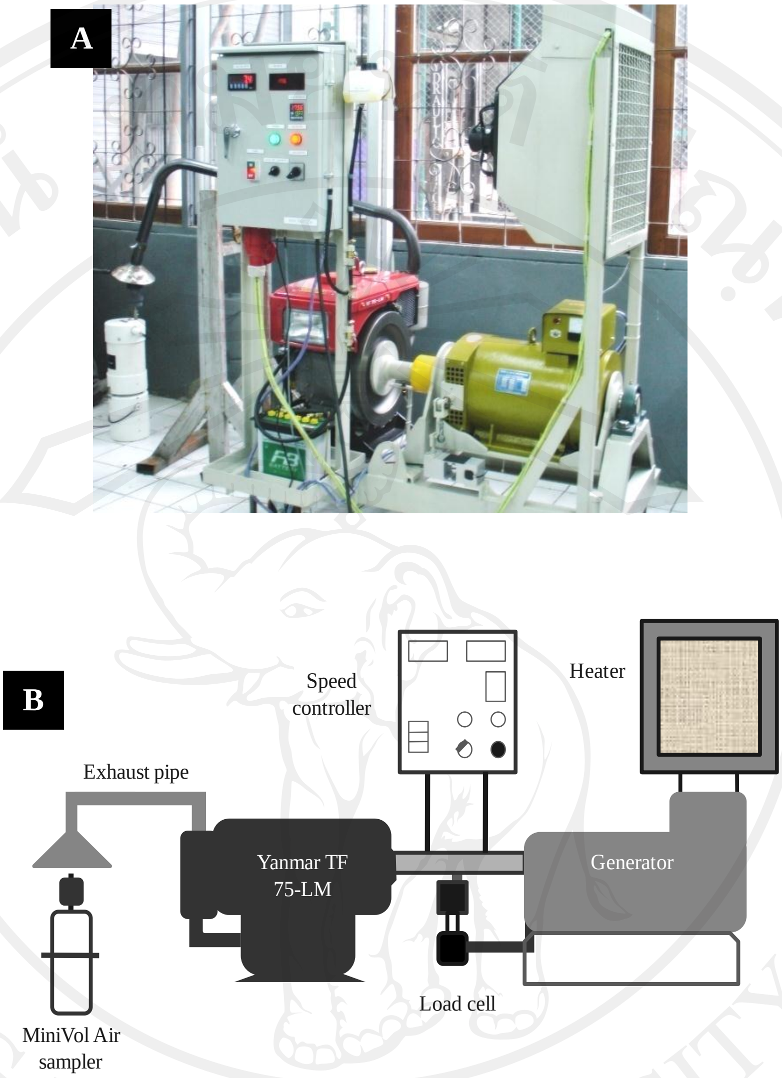

Figure 2.1 Photograph of Yanmar TF 75-LM (A) and schematic of tested engine (B)

2) A high speed diesel engine (ISUZU 4JB1)

The experiments were carried out using high speed diesel engine (ISUZU 4JB1). The main characteristics of tested engine are cited in Table 2.1. The diagram of sampling equipment is shown in Figure 2.2. The tested engine was operated at room temperature and was conducted at engine speed of 1,500 rpm under full engine loads. The operation and maintenance of tested engine were followed from the operation manual [45]. The fuel was supplied to the engine by external tank of 1-L capacity, which could be easily drained with the assistance of three-way stop valve for changing of fuel. For every change of fuel, the fuel line was purged out of the residual fuel. A 20-mL glass burette was also set up in parallel to fuel tank and was used for measurement of fuel flow rate. Engine performance test including fuel consumption, engine power and torque were observed to ensure the stabilizing of engine performance. Testing of tested fuel effectiveness was performed in triplicate, and the average results are reported herein. All engine performance experiments were carried out at Department of Mechanical Engineering, Faculty of Engineering, Rajamangala University of Technology Lanna.

Figure 2.2 Photograph of engine ISUZU 4JB1 (A) The system and position of tested engine (B)

Table 2.2 Characteristics of tested agricultural and high speed diesel engine

Item	Engine Specifications	
Engine Model	Yanmar TF 75-LM	ISUZU 4JB1
Engine Type	Four strokes, water-cooled	Four strokes, water-cooled
Aspiration Type	Natural Aspiration	Natural Aspiration
Injection Type	Indirect injection	Direct injection
Number of cylinder	1	4
Bore × Stroke	80 × 87 mm	93 × 102 mm
Displacement	437 cc	2.8 liter
Compression ratio	23.0 : 1	18.2 : 1
Max Power	5.52 kW @ 2,200 rpm	70 kW @ 3,800 rpm
Max Torque	26.48 Nm @ 1,600 rpm	220 Nm @ 1,800 rpm

2.5 Determination of physical properties of tested fuel samples

The properties of tested biodiesels including specific density, cloud point, pour point, flash point and gross heating value were evaluated according to American Society for Testing Material (ASTM) standards method listed in Table 2.3. However, due to a limitation of the instrument, ASTM D1298 procedure was slightly modified for density test using hydrometer. The experiment was carried out at room temperature. For the kinematic viscosity could not determine due to a limitation of the instrument.

Hydrometer is an instrument comprised of a vertical scale inside a sealed glass tube weighted at one end. Tested fuel was transferred to hydrometer cylinder which was placed in a vertical position and free from air currents. Hydrometer was gently lowered into the fuel sample and it was then pressed about two division scales into the liquid and being released. The hydrometer scale was recorded by means of which the hydrometer floated freely away from the walls of the cylinder and then the principal surface of the liquid cut the scale. All procedure of fuel properties were tested at the Department of Chemical Engineering, Faculty of Engineering; Burapha University.

Table 2.3 Standard method for fuel properties determination

Parameter	Unit	Reference
Specific density at 15°C	Kg/m^3	ASTM 1298
Cloud point	°C	ASTM D2500
Pour point	°C	ASTM D97
Flash point	°C	ASTM D93
Gross heating value	MJ/kg	ASTM D240

2.6 Multi gas detector for analysis of exhaust pipe emission

Multi gases system provides complete simplicity, extreme versability and absolute expandability. The modular system Testo 350XL contains of 3 main components are control unit, analyzer box and probe, as present in figure 2.3 and 2.4, it can be seen the example of toxic and green house gases reporter by multi gas analyzer (Testo 350 XL), as present in figure 2.5 and exhaust emissions were measured CO, CO_2, NO, NO_2 and NO_X.

Figure 2.3 Photograph of multi gas detector portable fuel gas analysis

(A) (B) (C)

Figure 2.4 Photograph of multi gases components (A) Control unit (B) Analyzer box (C) Probe

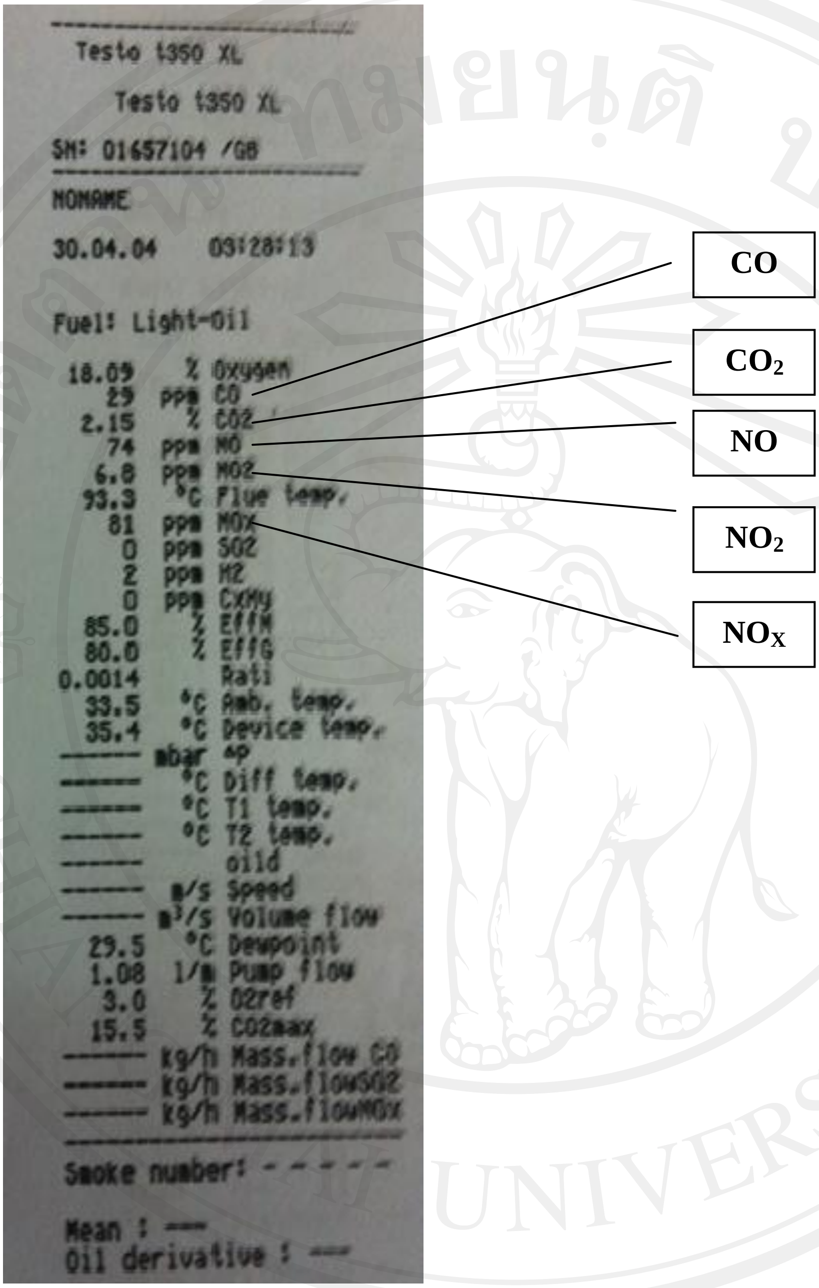

Figure 2.5 The example result of toxic and green house gases reporter by multi gas analyzer (Testo 350 XL)

2.7 Engine performance

The engine performance (fueled) with CBFs and CDFs were study in characteristic of brake specific fuel consumption (BSFC) and thermal efficiency (TE) at speed around 1,800 rpm for agricultural diesel engine and 1,500 for high speed diesel engine under full load condition. Brake specific fuel consumption ratio and thermal efficiency percentage of various tested fuels in agricultural diesel engine and high speed diesel engine from each test were showed and discussed in the next chapter**.**

2.8 Data analysis

For each sample, the total gases concentration was obtained from summary of the concentration of gases compounds. A summary of available total gases emissions data are represented in table and calculated the average, standard deviation, percent emission exchange and analysis by statistical. The concentrations of gases emissions were presented as arithmetic means and standard deviation of triplicate experiments per each test. Moreover, toxic and green house gases emission from each test were discussed on data and their toxicity in the next chapter.