CHAPTER III

METHODOLOGY

In this chapter, the equipments that used for experimenting will be presented in section 1 for the method of experiments described in section 2.

1. List of Equipments

Table 2. List of Equipments Used for Experiments

Equipments	Function
a) Downdraft gasifier	To produce a producer gas
b) Sterilization and pasteurization combustion set	Measuring sterilization and pasteurization condition
c) Data recorder	To display measured reading temperature
d) Thermocouple	Measuring temperature
e) Airflow meter	Measuring air velocity

1.1. Downdraft Gasifier

Downdraft gasifier is used for oyster mushroom gasification system. The dimension is shown in Figure 8 [11]. It is consisted of 3 main parts.

1.1.1. Fuel Hopper. Fuel hopper is made of 0.3 cm cylinder steel and 5 cm of refectory cement. There are 2 parts, which shows in Figure 9a, 9b.

1.1.2. Combustion and Reduction zone. These zones are made of 0.3 cm cylinder steel and 5 cm of refectory cement. There are 6 nozzles stainless steel, which shows in Figure 9c.

1.1.3. Ash pit. Ash pit is made of 0.3 cm cylinder steel, which shows in Figure 9d.

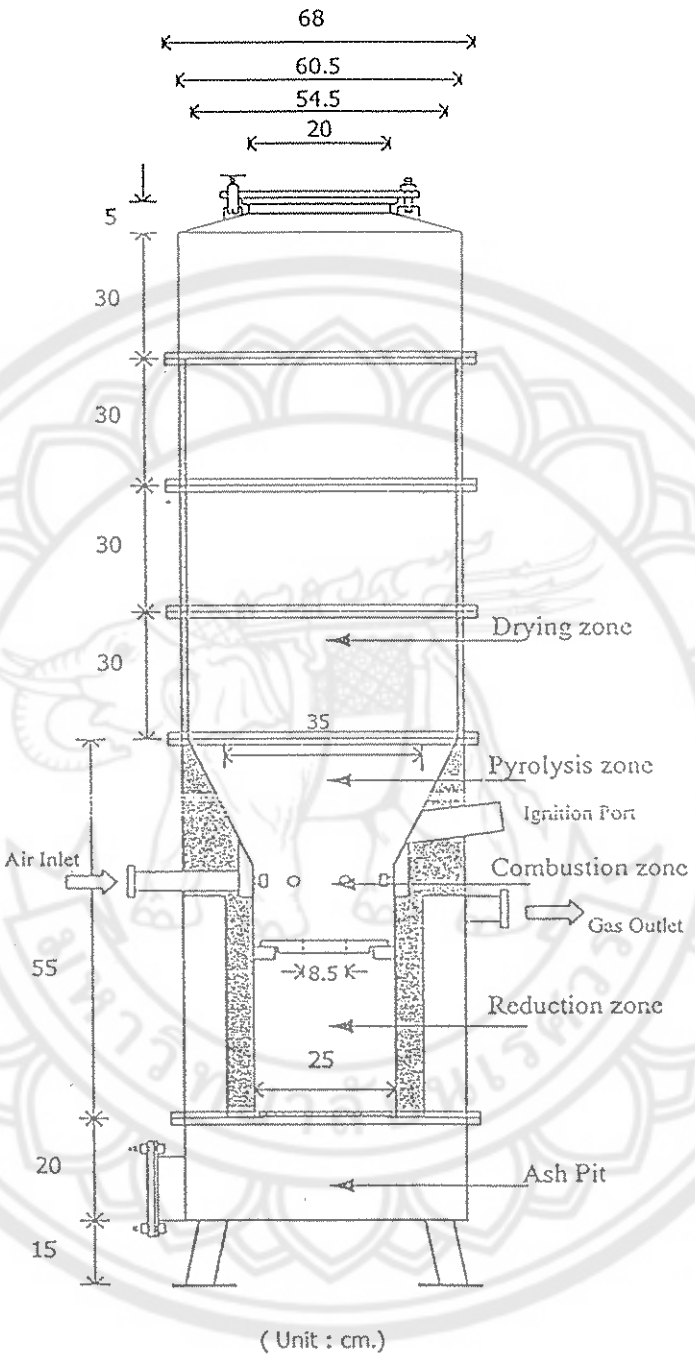
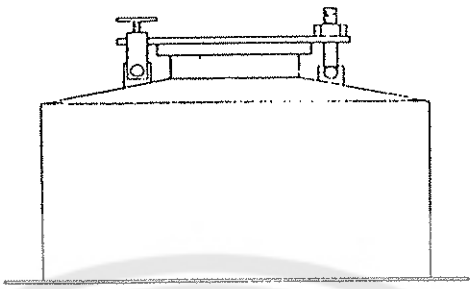
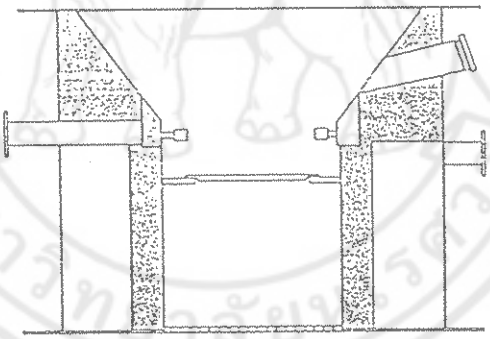


Figure 8 Dimension of Downdraft Gasifier

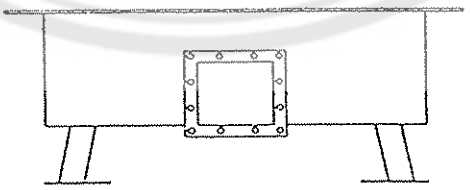


(a) Fuel Hopper

(b) Fuel Hopper



(c) Combustion and Reduction Zone



(d) Ash Pit

Figure 9 Composition of Downdraft Gasifier

1.2. Cyclone Filter

Cyclone filter is made of 0.1 cm cylinder steel which, 10 cm diameter, 40 cm height and 2x4 cm of area inlet cyclone. The calculation of cyclone filter is shown in appendix A. The dimension of cyclone is shown in Figure 10.

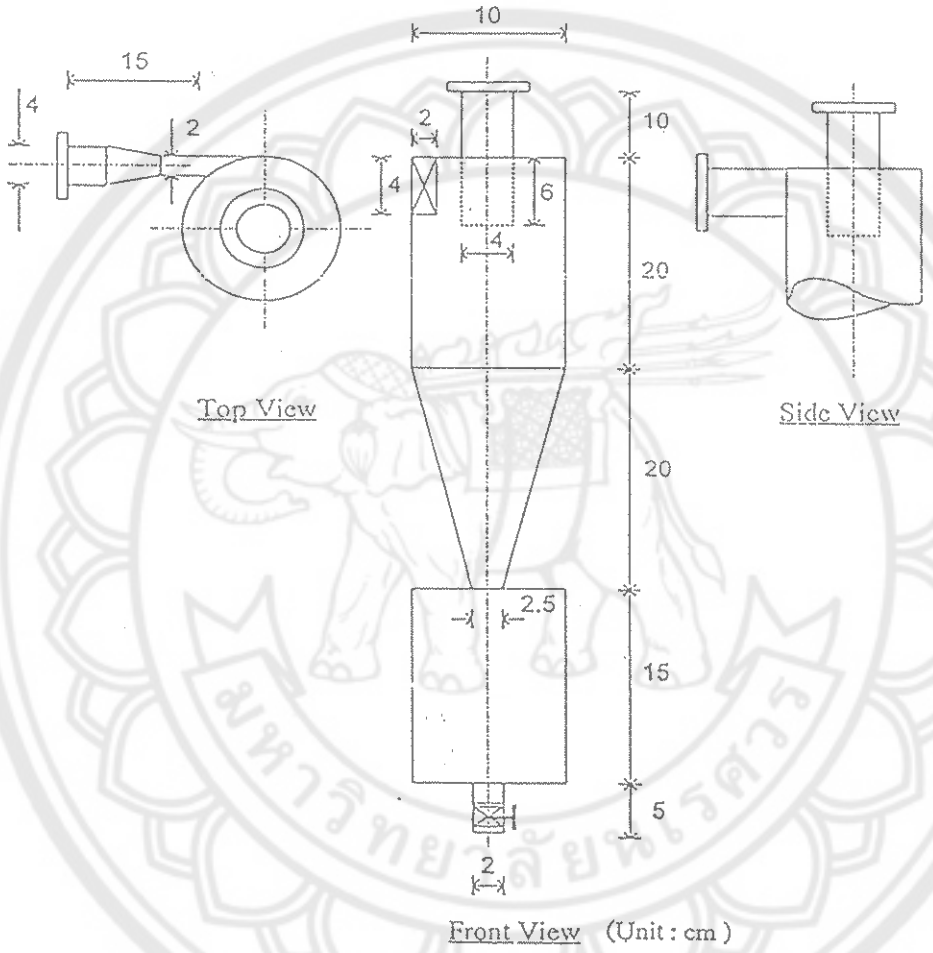


Figure 10 Dimension of Cyclone Filter

1.3. Sterilized and Pasteurized Combustion Set

The sterilized and pasteurized combustion set is consisted of 3 main parts are as following:

1.3.1. Combustion chamber burner. The combustion chamber is developed from the Ecostove [21]. This stove can alternate cook in small pot, in big pot or directly

on panache, less heat loss with no indoor air pollution and 50 % less fuel. This stove is developed to be combustion chamber for sterilized and pasteurized. In this thesis, the autoclave and pasteurize tank are alternate used on the combustion chamber. The burner is used for a producer gas combustion supply in the combustion chamber, the burner design is shown in appendix A. The combustion chamber made of 0.2 cm metal sheet, 2 inch Calcium Silicate is used for insulator. The Figure of combustion chamber is shown in Figure 11.

1.3.2. Autoclave. The Autoclave is used to sterilization the agar media in the condition at 121 $^{\circ}$C and 15 lb/in^2 (1.03x10^5 N/m^2) of pressure.

1.3.3. Pasteurization Tank. The 200 liter metal gallon of oil is used to be the pasteurize tank, which contained 80 clusters of oyster mushroom substrate and 20 liter of water.

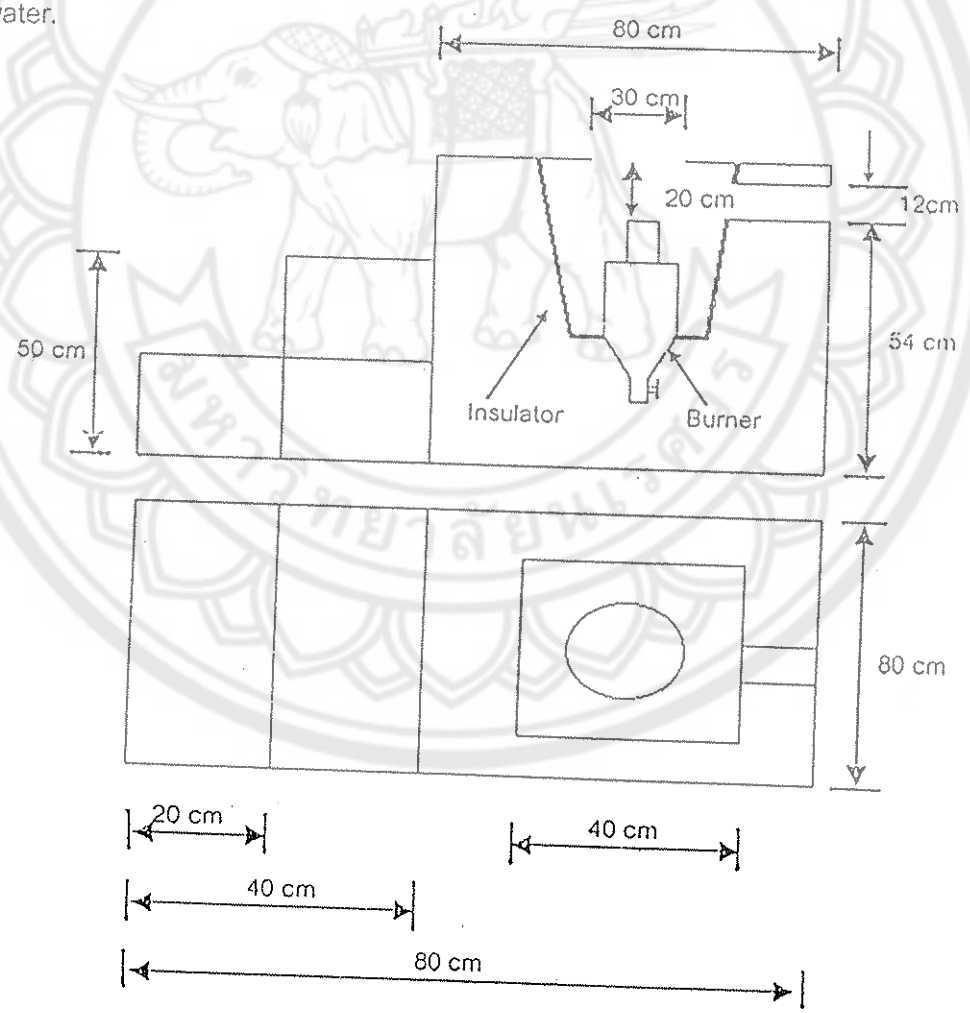


Figure 11 Dimension of Sterilize and Pasteurize Combustion Chamber

1.4. Fuel

The oyster mushroom substrate wastes in Figure 12 are divided into 8 parts to use as fuel for downdraft gasifier. The oyster mushroom substrate wastes ultimate analysis and the substance analysis are shown in appendix C.

Figure 12 Oyster Mushroom Substrate Waste became to Fuel for Downdraft Gasifier

1.5. Data Recorder

Model: Micro-R 1000

Power: 100-240 VAC, 50/60 Hz

In this thesis, the data recorder is used primarily to display the temperature reading from the thermocouples. Although the data recorder has built-in printer, it is not able to print preset intervals and hence, the data recorder is used only as a visual unit. All readings displayed the data recorder has to be painstakingly copied and recorded data by hand.

1.6. Thermocouple

Type: Chromel-Alumel Type K

Rang: -50 to +1200 ^{0}C

Accuracy ± 0.1 ^{0}C

The thermocouples have to be connected to the data recorder when in use and the measured values is displayed in ^{0}C. In this thesis, thermocouples are used to measure the temperature.

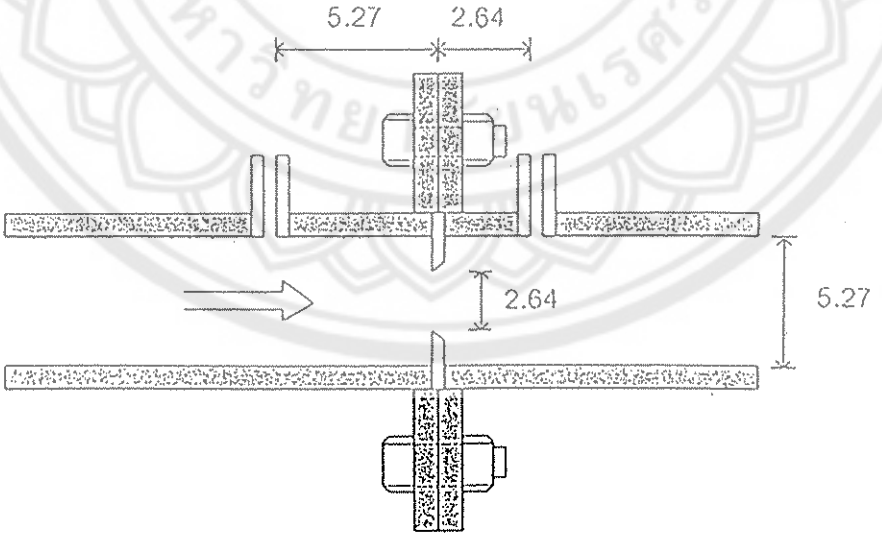
1.7. Airflow Meter

Type: Hot-wire Anemometer

Range: 0.01 to 15.0 m/s

Accuracy: ± 0.1 m/s

The airflow meter is used to measures the velocity of air, combining with orifice plate, which 2.64 cm diameter that shows in Figure 13. The calculation of the water different level in manometer is shown in appendix B.



Unit: cm

Figure 13 Orifice Plate with Radius Tapping

2. Method of Experiment

The important components of the oyster mushroom gasification system are consisted of 4 main parts that show in Figure 14.

a) Blower. For supplying the combustion air.

b) Gasifier. For producing a producer gas, which using oyster mushroom substrates waste as biomass fuel.

c) Cyclone. For cleaning gas by gas velocity cycling mean to separate the small particle form a producer gas.

d) Sterilization and pasteurization combustion set. For sterilizing oyster mushroom agar media by autoclave and pasteurizing oyster mushroom substrate by the pasteurize tank.

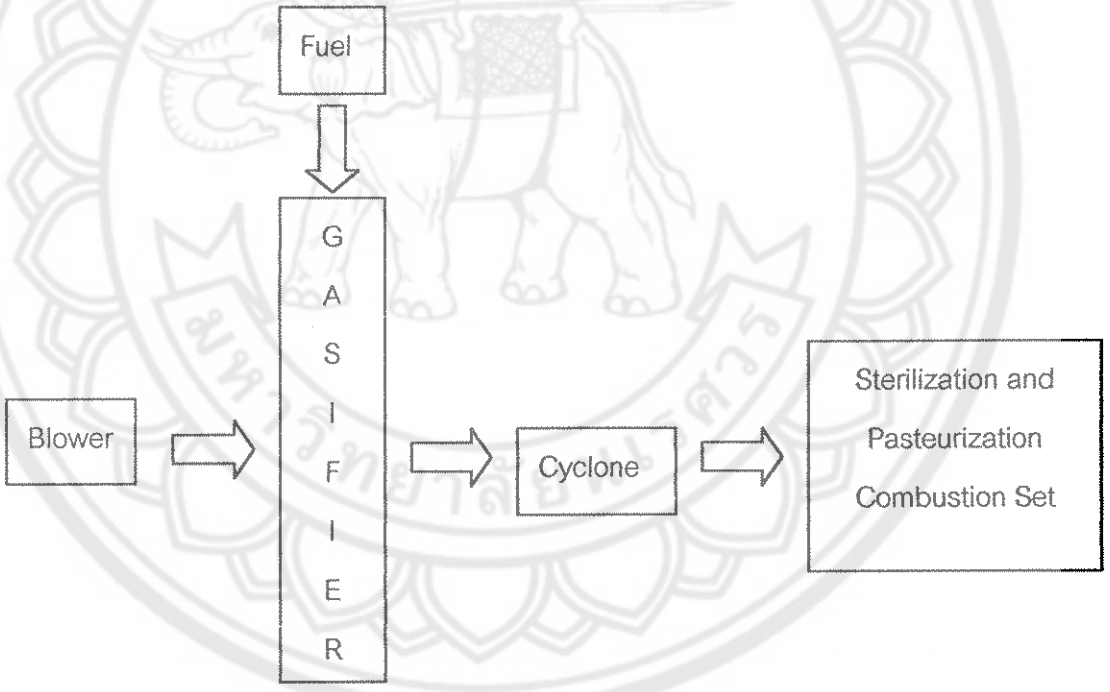


Figure 14 Block Diagram of Gasifier System

The study of a producer gas from downdraft gasifier, the experiments are divided into 2 parts. The procedure of the experiment is shown in Figure 15.

Part 1. To study the effect of airflow rate to a producer gas composition at airflow rate $3x10^{-3}$, $5x10^{-3}$, $7x10^{-3}$ m^3/s (30 °C, 1 atm). The testing time at 300 min/batch and the

downdraft gasifier temperature, combustion zone temperature, reduction zone temperature, drying zone temperature and a producer gas composition are analyzed.

Part 2. To study a producer gas utilization for oyster mushroom agar media sterilization at 121 °C, 15 lb/in^2 (1.03x10^5 N/m^2) at least 30 min and oyster mushroom and oyster mushroom substrate pasteurization at 100 °C at least 120 min.

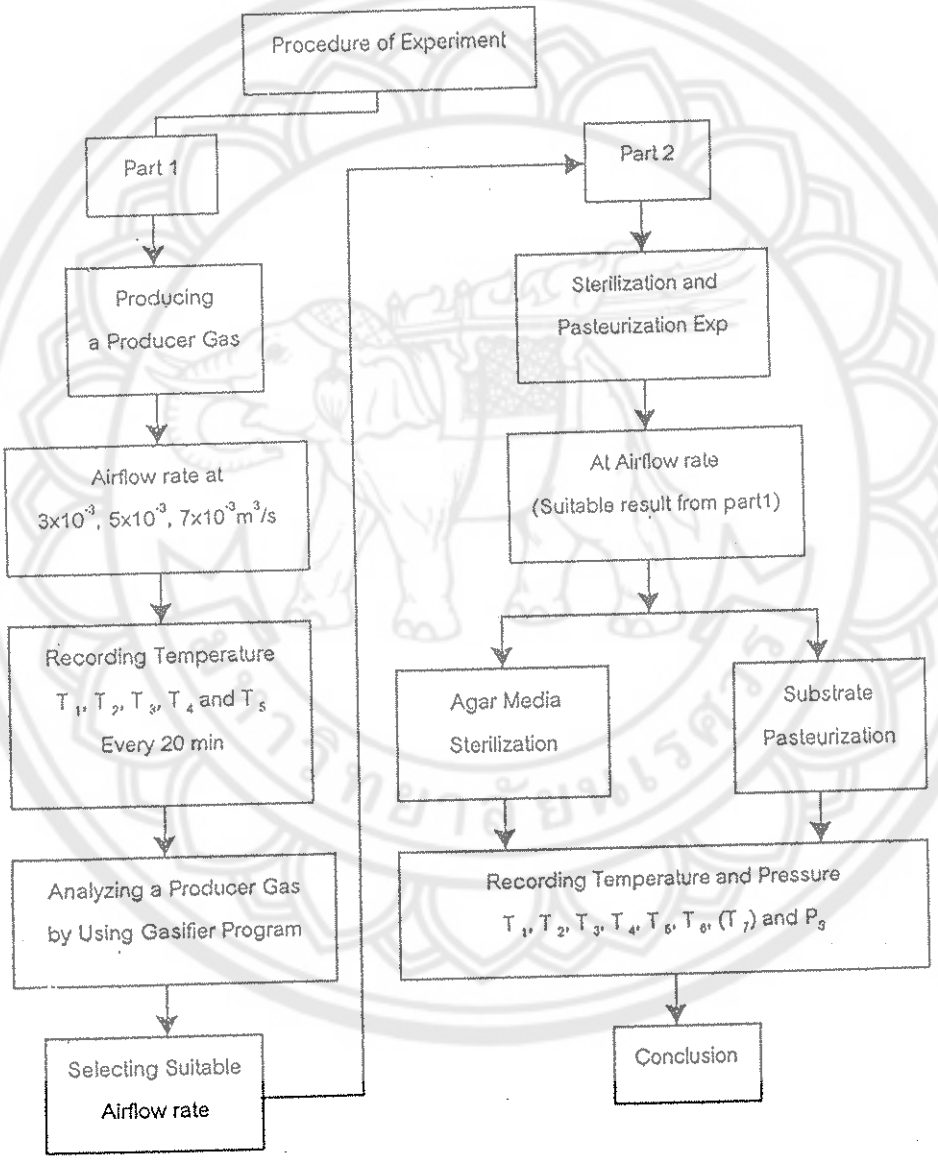


Figure 15 Procedure of Experiment

The important parameters of part 1, variable airflow rate and part 2, oyster mushroom agar media sterilization and substrate pasteurization are shown in Figure 16 and 17.

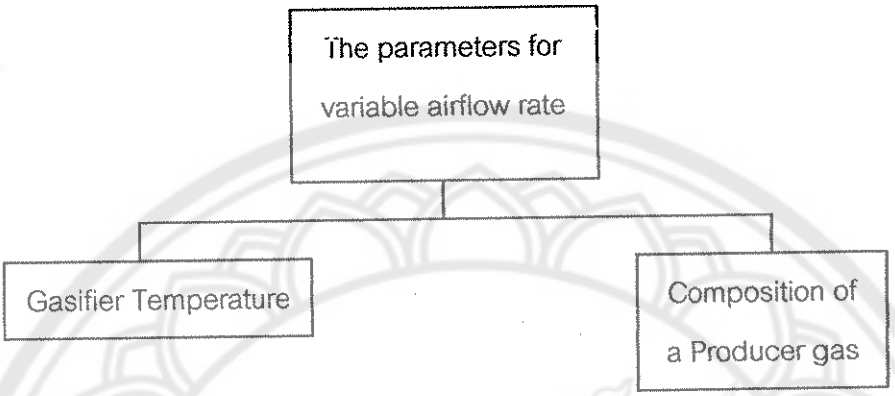


Figure 16 The Important Parameters for Variable Airflow Rate

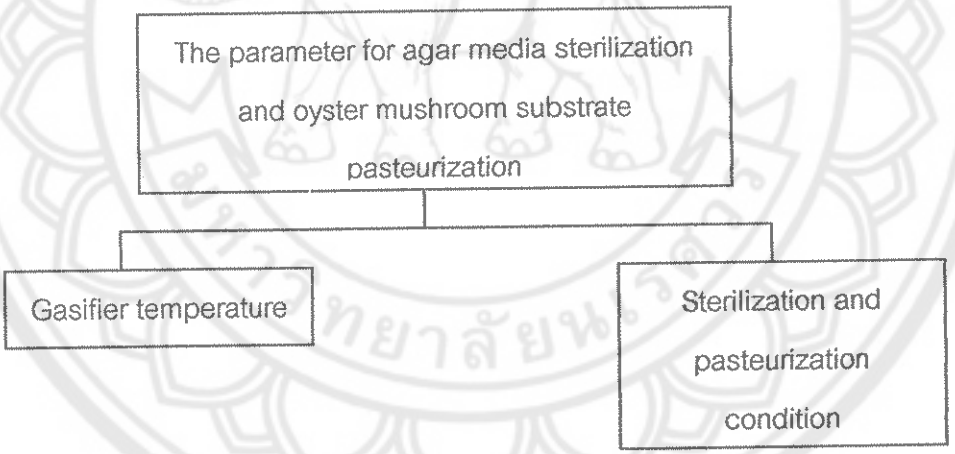


Figure 17 The Important Parameters for Agar Media Sterilization and Mushroom Substrate Pasteurization

For the experimental setup, agar media sterilization and oyster mushroom substrate pasteurization experiments the important parameters are recorded that show in Figure 18, 19, respectively,

Remark

T_1 = Combustion zone temperature

T_2 = Reduction zone temperature

T_3 = Drying zone temperature

T_4 = Air inlet temperature

T_5 = Gas outlet temperature

T_6 = Sterilize temperature

P_s = Sterilize pressure

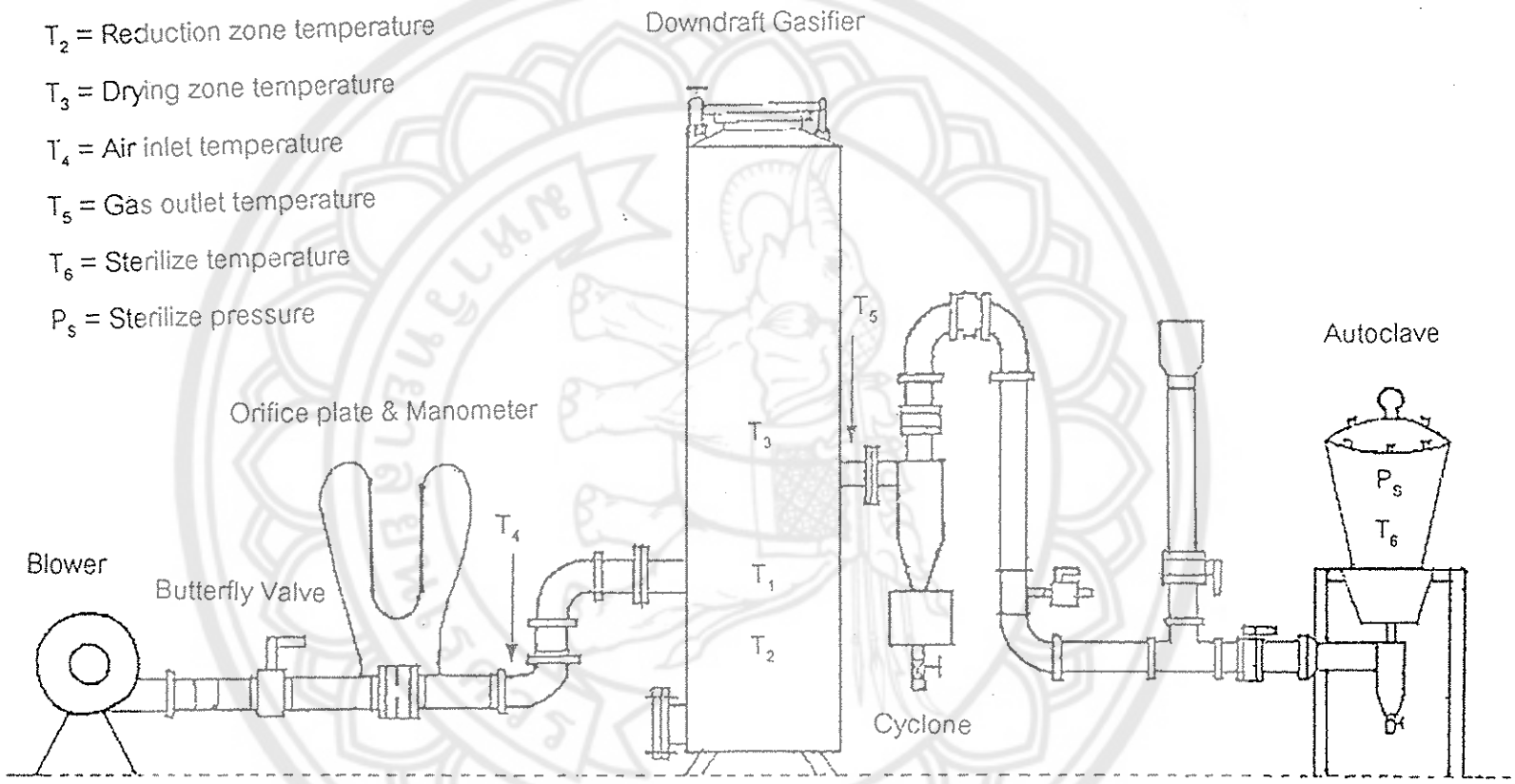


Figure 18 Oyster Mushroom Substrate Wastes Gasification System for Agar Media Sterilization

Remark

T_1 = Combustion zone temperature

T_2 = Reduction zone temperature

T_3 = Drying zone temperature

T_4 = Air inlet temperature

T_5 = Gas outlet temperature

T_7 = Pasteurize temperature

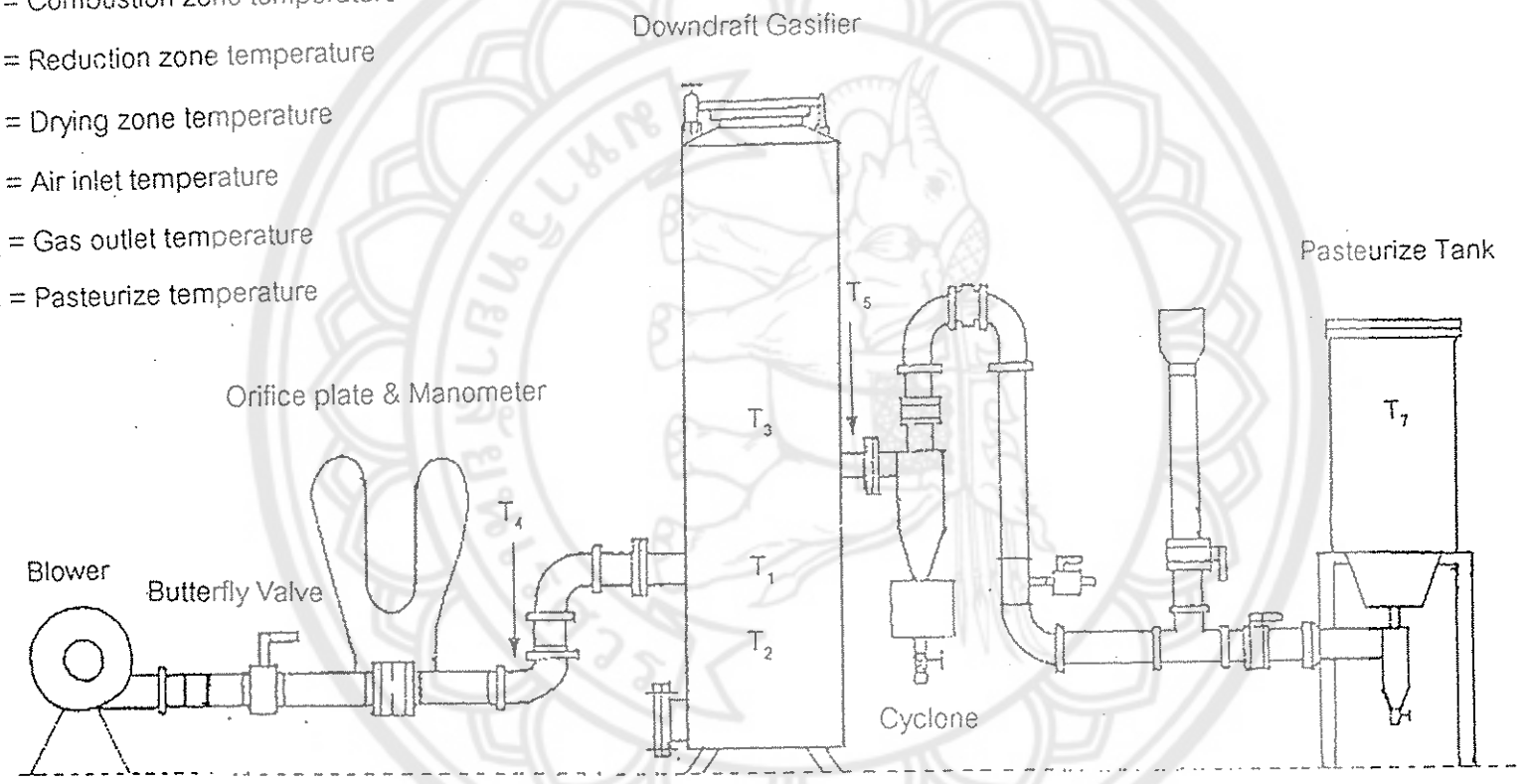


Figure 19 Oyster Mushroom Substrate Wastes Gasification System for Substrate Pasteurization

3. Experimental Setup

After setup the oyster mushroom substrate waste gasification system, the methods of experiments are:

3.1. Variable Airflow rate Gasifier Temperature Experiments

The methods of variable airflow rate experiments are:

3.1.1. Charcoals are contained in the reduction zone. The oyster mushroom substrate wastes are put in combustion zone.

3.1.2. After charcoals ignited 2-5 min, oyster mushroom substrate wastes are fed into fuel hopper. Then the cover rapidly closed.

3.1.3. Airflow rates are varied by butterfly valve control ($3x10^{-3}$, $5x10^{-3}$, $7x10^{-3}$ m^3/s). Then the temperatures in combustion, reduction, drying zone and air inlet are recorded. An auger screw fuel flow control is used to operate continuously fuel flow in combustion zone; it is shown in Figure 20. In this experiment, every 30 min during gasification running an auger screw fuel flow control is operated.

3.1.4. The remaining fuel is clear and the fuel consumption is determined at the end of the run.

3.1.5. Repeat experiments (varied airflow rates) started from (3). In this experiments the testing time are set at 300 min/batch.

3.1.6. A producer gas composition is analyzed by simulation gasifier program.

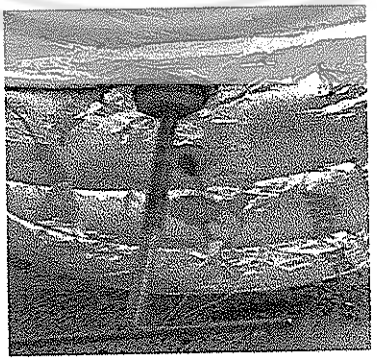


Figure 20 Manual Auger Screw Fuel Flow Control

3.2. Oyster Mushroom Agar Media Sterilization Experiments

Airflow rate is fixed as the best results from 3.1 and the system is shown in Figure 21. The methods of experiments are:

3.2.1. 40 bottles of oyster mushroom agar media are contained in autoclave.

3.2.2. The downdraft gasifier is stared to heat oyster mushroom agar media in autoclave on the condition at 15 lb/in^2 (1.03x10^5 N/m^2) and 121 °C at least 30 min. An auger screw fuel flow control is used to operate continuously fuel flow in combustion zone. In this experiment, every 30 min. during gasification running an auger screw fuel flow control is operated. The temperatures in combustion, reduction, drying zone, autoclave temperature and autoclave pressures are recorded.

3.2.3. Stop gasifier and repeat experiments.

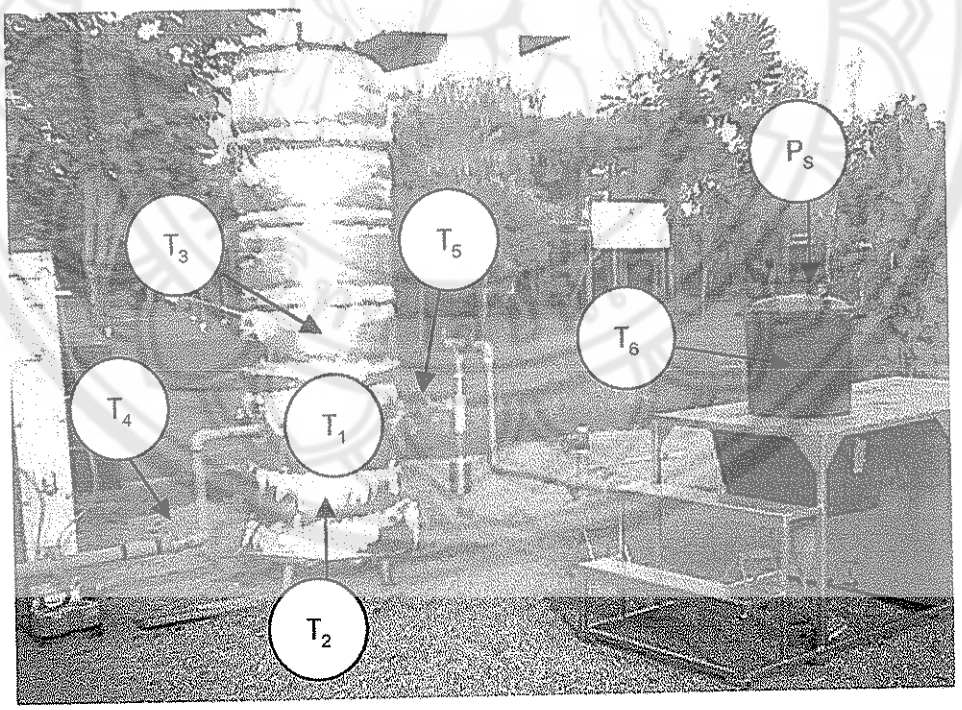


Figure 21 Oyster Mushroom Agar Media Sterilization Experiments

3.3. Oyster Mushroom Substrate Pasteurization Experiments

Airflow rate is fixed as the best results from 3.1 and the system is shown in Figure 22 . The methods of experiments are:

3.3.1. 80 clusters of mushroom substrates are contained in the pasteurization tank with 20 liter of clean water.

3.3.2. The downdraft gasifier is stared to heat the pasteurization tank on the condition that the temperature of water in the pasteurization tank is 100 $^{\circ}$ C at least 120 min. An auger screw fuel flow control is used to operate continuously fuel flow in combustion zone. In this experiment, every 30 min during gasification running an auger screw fuel flow control is operated. The temperature in combustion, reduction, drying zone and pasteurize temperature are recorded.

3.3.3. Stop gasifier and repeat experiments.

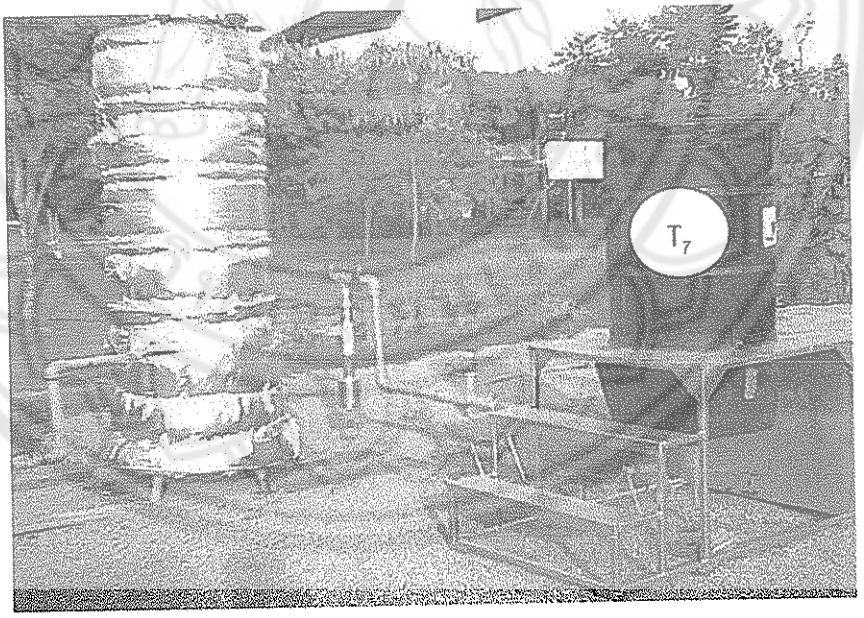


Figure 22 Oyster Mushroom Substrate Waste Pasteurization Experiments