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A Simple Distillation Process Produce Fuel from Plastic Waste using Incorporate Heat Source

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Abstract

This paper is a study of a simple distillation process. Its objective is to compare fuel production from plastic waste, its data collecting is from the factory and simple data calculated a suitable evaluation on the simple distillation plant built before calculation. The experiment with a simple distillation process is separated into three sections. The first section is a simple distillation process of distillation producing diesel using heat source by biomass. The second section is distillation process which produces fuel using heat source by burner. The third section uses heat source by burner incorporate with biomass. The experiment reveals that the result of the second section is the most efficient. In comparison with the experiments and the simple calculation, the result on the efficiency of work has error less than 5% and it is sufficient for the next experimental process. Thus, the study and design on a simple distillation process produces fuel from plastic waste has to concern mainly on design heat exchangers, flow rate and optimized temperature. Further study on this plant can be developed throughout the county due to its low cost and efficiency.

Keywords*: Distillation Process, Plastic Waste, Diesel, Heat Exchangers*

NOMENCLATURE

q_H	heat transfer at moment [W]
$\dot{m}$	mass flow rate [kg/s]
c_p	specific heat capacity [kJ/kg K]
T_{in}	temperature inlet [°C]
T_{out}	temperature outlet [°C]
ε	efficiency

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1. INTRODUCTION

1.1. Background [1]

Although global warming is scientifically accepted, its cause is still disputed. Nordell (2003) suggested a most natural explanation; that this warming is a result of heat emissions from the global consumption of non-renewable energy. Global warming means that heat has been accumulating in air, ground, and water since 1880. During the same period heat was released into the atmosphere by heat dissipation from the global use of fossil fuel and nuclear power. Any such thermal pollution must contribute to the warming. A comparison of accumulated and emitted heat show that heat emissions explains 55% of the global warming. Moreover, the amount of emitted heat is underestimated, since the non-commercial use of fossil fuel is not included, e.g. gas flares, underground coal fires, oil used in production of plastics, and also biofuel (wood) consumed at a greater rate than the growth. Here, the task was to estimate the heating caused by one of the non-commercial energy sources, the use of crude oil in plastic making.

1.2. Definition [1]

Plastic covers a range of synthetic or semisynthetic polymerization products. Plastics are polymers: long chains of atoms bonded to one another. All plastics are polymers but not all polymers are plastics; there are actually few natural polymers. Nature has always produced polymers such as cellulose, the DNA molecule and proteins. Plastic production was inspired by Nature's polymers. Plastics may contain other substances than polymers in order to reach a mean performance; certain types of plastic are suitable for packaging (25% of the US plastic production – 37% of the European plastic production), others for building and construction (22% in US – 20% in EU), and others for toys and medical stuff (13% in US – 9% in EU), transportation (5% in US – 7.5% in EU), furniture (4% in US – 3.5% in EU), electronic stuff (4% in US – 7.5% in EU) etc.

Today, plastics frequently replace most traditional materials such as wood, metal, glass, leather, paper and rubber because they can be lighter, stronger, corrosion resistant, very durable and a better insulator. These properties often make plastics more economical to use than other materials. They are used throughout industry and business; they influence the way we dress, the way we enjoy ourselves and the way we live. Many plastics have become household names - nylon, polyester and so on.

Plastics can be produced from oil or gas that has undergone chemical processing, and consists of synthetic polymers

1.3. Objective

The objective of A Simple Distillation Process Produce Fuel from Plastic Waste using Incorporate Heat Source is to study on fuel production from plastic waste as well as to study on the ability to save energy of A Simple Distillation Process Produce Fuel. Therefore, the research aims at the development of A Simple Distillation Process Produces benzene and diesel and the increase of A Simple Distillation Process's efficiency. Its objective is to compare fuel production from plastic waste, its data collecting is from the factory and simple data calculated a suitable evaluation on the simple distillation plant built before calculation.

2. THEORY

Principles of Distillation [2]

Simply, distillation is the process in which a liquid is vaporized (turned to steam), recondensed (turned back into a liquid) and collected in a container.

Fractional Distillation of Crude Oil [3]

Boiling Points and Structures of Hydrocarbons

The boiling points of organic compounds can give important clues to other physical properties. A liquid boils when its vapor pressure is equal to the atmospheric pressure. Vapor pressure is determined by the kinetic energy of molecules. Kinetic energy is related to temperature and the mass and velocity of the molecules. When the temperature reaches the boiling point, the average kinetic energy of the liquid particles is sufficient to overcome the forces of attraction that hold molecules in the liquid state. Then these molecules break away from the liquid forming the gas state.

Vapor pressure is caused by equilibrium between molecules in the gaseous state and molecules in the liquid state. When molecules in the liquid state have sufficient kinetic energy, they may escape from the surface and turn into a gas. Molecules with the most independence in individual motions achieve sufficient kinetic energy (velocities) to escape at lower temperatures. The vapor pressure will be higher and therefore the compound will boil at a lower temperature.

Boiling Point Principle [3]

Molecules which strongly interact or bond with each other through a variety of intermolecular forces cannot move easily or rapidly and therefore, do not achieve the kinetic energy necessary to escape the liquid state. Therefore, molecules with strong intermolecular forces will have higher boiling points. This is a consequence of the increased kinetic energy needed to break the intermolecular bonds so that individual molecules may escape the liquid as gases.

The Boiling Point Can Be A Rough Measure of The Amount of Energy Necessary to Separate A Liquid Molecule from Nearest Neighbors. [3]

Molecular Weight and Chain Length Trends in Boiling Points

A series of alkanes demonstrates the general principle that boiling points increase as molecular weight or chain length increases (table 1.).

Table 1. Boiling Points of Alkanes [3]

Formula	Name	Boiling Point C	Normal State at Room Temp. +20 °C
CH_4	Methane	-161	gas
CH_3CH_3	Ethane	- 89	
$CH_3CH_2CH_3$	Propane	- 42	
$CH_3CH_2CH_2CH_3$	Butane	-0.5	
$CH_3CH_2CH_2CH_2CH_3$	Pentane	+ 36	liquid
$CH_3(CH_2)6CH_3$	Octane	+125	

QUES. State whether the compounds above will be a gas or liquid state at room temperature (20 °C). Hint: If the boiling point is below 20 °C, then the liquid has already boiled and the compound is a gas.

The reason that longer chain molecules have higher boiling points is that longer chain molecules become wrapped around and enmeshed in each other much like the strands of spaghetti. More energy is needed to separate them than short molecules which have only weak forces of attraction for each other.

Focus on Fossil Fuels [3]

Petroleum refining is the process of separating the many compounds present in crude petroleum. The principle which is used is that the longer the carbon chain, the higher the temperature at which the compounds will boil. The crude petroleum is heated and changed into a gas. The gases are passed through a distillation column which becomes cooler as the height increases. When a compound in the gaseous state cools below its boiling point, it condenses into a liquid. The liquids may be drawn off the distilling column at various heights.

Although all fractions of petroleum find uses, the greatest demand is for gasoline. One barrel of crude petroleum contains only 30-40% gasoline. Transportation demands require that over 50% of the crude oil be converted into gasoline. To meet this demand some petroleum fractions must be converted to gasoline. This may be done by "cracking" - breaking down large molecules of heavy heating oil; "reforming" - changing molecular structures of low quality gasoline molecules; or "polymerization" - forming longer molecules from smaller ones.

For example if pentane is heated to about 500 C the covalent carbon-carbon bonds begin to break during the cracking process. Many kinds of compounds including alkenes are made during the cracking process. Alkenes are formed because there are not enough hydrogens to saturate all bonding positions after the carbon-carbon bonds are broken.

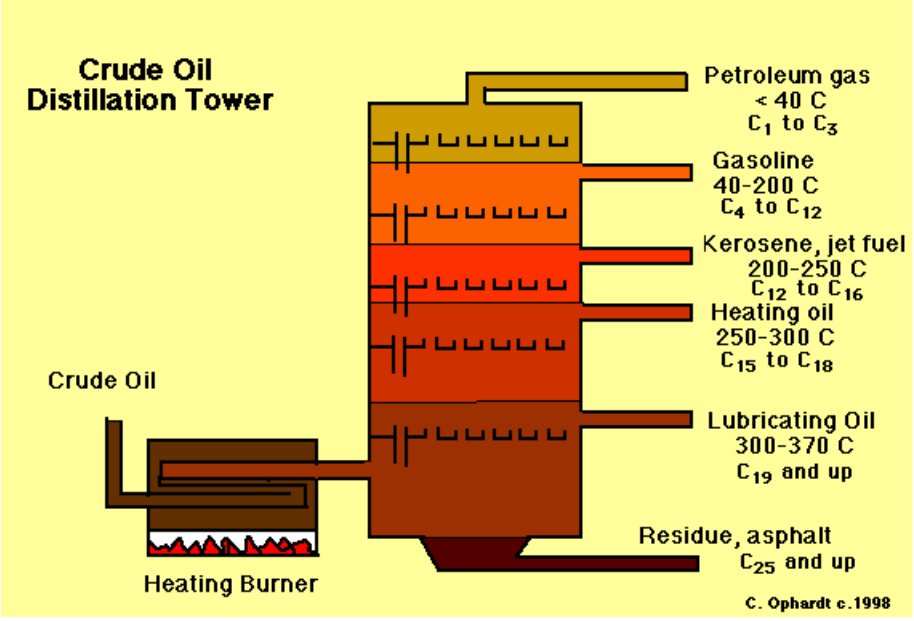

Figure 1. The Crude Oil Distillation [3]

The Calculating Energy

The actual heat transfer may be computes by calculating either the energy lost by hot fluid or the energy or the cold fluid, as show in equation (1). [3], [4]

$$q_H = \dot{m}C_p(T_{in} - T_{out}) \tag{1}$$

Effectiveness – NTU Method

We define the heat-exchanger efficiency as [4]

$$\text{Efficiency } (\varepsilon) = \frac{\text{actual heat transfer}}{\text{maxmum possible heat transfer}} \tag{2}$$

The actual heat transfer may be heat transfer may be computed by calculating either the energy lost by the hot fluid or the energy gained by the cold fluid. Consider the counter-flow exchanger.

$$q = \dot{m}_h c_h (T_{h1}\text{-}T_{h2}) = \dot{m}_c c_c (T_{c1}\text{-}T_{c2}) \tag{3}$$

The fluid which might undergo this maximum temperature difference is the one having the minimum value of $\dot{m}c$ since the energy balance requires that the energy received by one fluid be equal to that given up by the other fluid; if we $\dot{m}c$ go through the maximum temperature difference, this would require that the other fluid undergo a temperature difference greater than the maximum, and this is impossible. So, maximum possible heat transfer is expresses as.

$$q_{max} = (\dot{m}c)_{min}(T_{hi} - T_{ci}) \tag{4}$$

The minimum fluid may be either the hot or cold fluid, depending on the mass-flow rates and specific heats. For the counter-flow heat exchanger,

The subscripts on the effectiveness symbols designate the fluid which has the minimum value of $\dot{m}c$,

$$\varepsilon_c = [\dot{m}_c c_c (T_{c1}\text{-}T_{c2})] / [\dot{m}_c c_c (T_{h1}\text{-}T_{c2})]$$
$$\varepsilon_c = [(T_{c1}\text{-}T_{c2})] / [(T_{h1}\text{-}T_{c2})] \tag{5}$$

In a general way the effectiveness is expressed as

$$\text{Efficiency } (\varepsilon) = \frac{\Delta T(\text{minimum fluid})}{\text{maxmum temprature difference in heat exchanger}} \tag{6}$$

3. EQUIPMENT AND EXPERIMENT

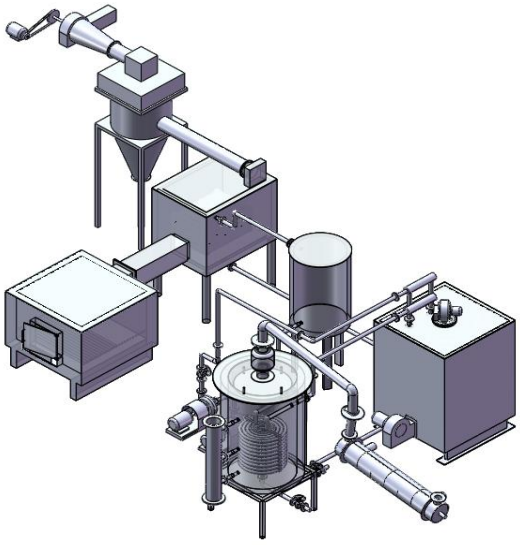

Figure 2. The distillation plant produce fuel from plastic waste. [7]

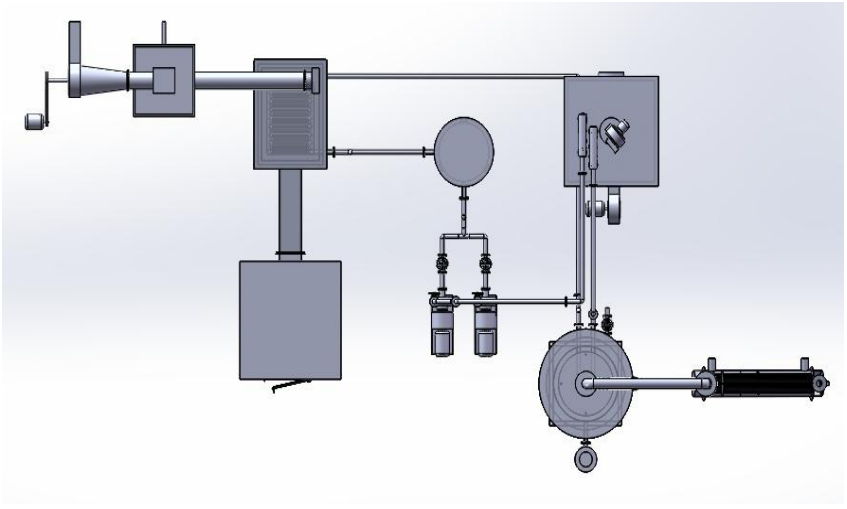

Figure 3. The diagram The distillation plant produce fuel from plastic waste. (Top View)

Experiment Methods

The experiment with a simple distillation process is separated into three sections.

The first section is a simple distillation process of distillation producing diesel using heat source by biomass:

1. Prepare the plastic in the tank of the system.
2. It is burn the firewood.
3. Open the valve for water to flow into heat exchanger.
4. Test fuel

The accuracy of data collection should rely on repetition experiment.

The second section is distillation process which produces fuel using heat source by burner:

1. Prepare the crude oil from plastic in the tank of the system.
2. It is turn on the burner.
3. Open the valve for water to flow into heat exchanger.
4. Test fuel

The accuracy of data collection should rely on repetition experiment.

The third section uses heat source by burner incorporate with biomass:

1. Prepare the crude oil from plastic in the tank of the system.
2. It is turn on the burner incorporate with biomass.
3. Open the valve for water to flow into heat exchanger.
4. Test fuel

The accuracy of data collection should rely on repetition experiment.

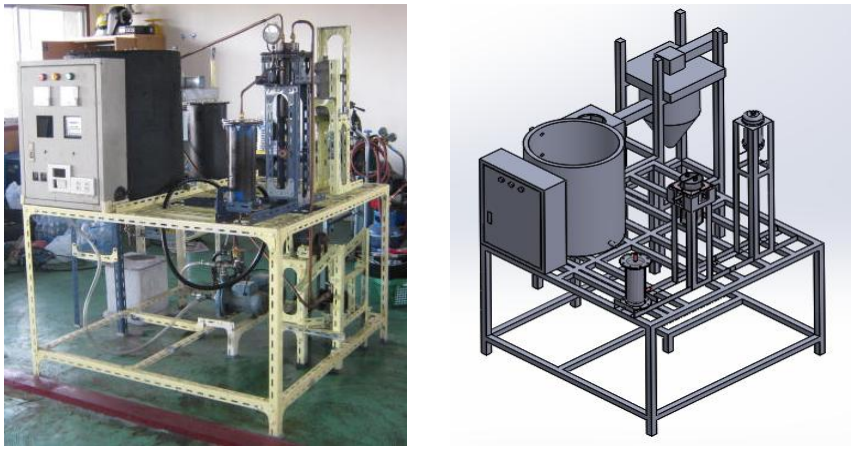

Figure 4. new plant design for compered calculating with Fig 2.

Figure 5. Spiral coil in Heat Exchanger. [7]

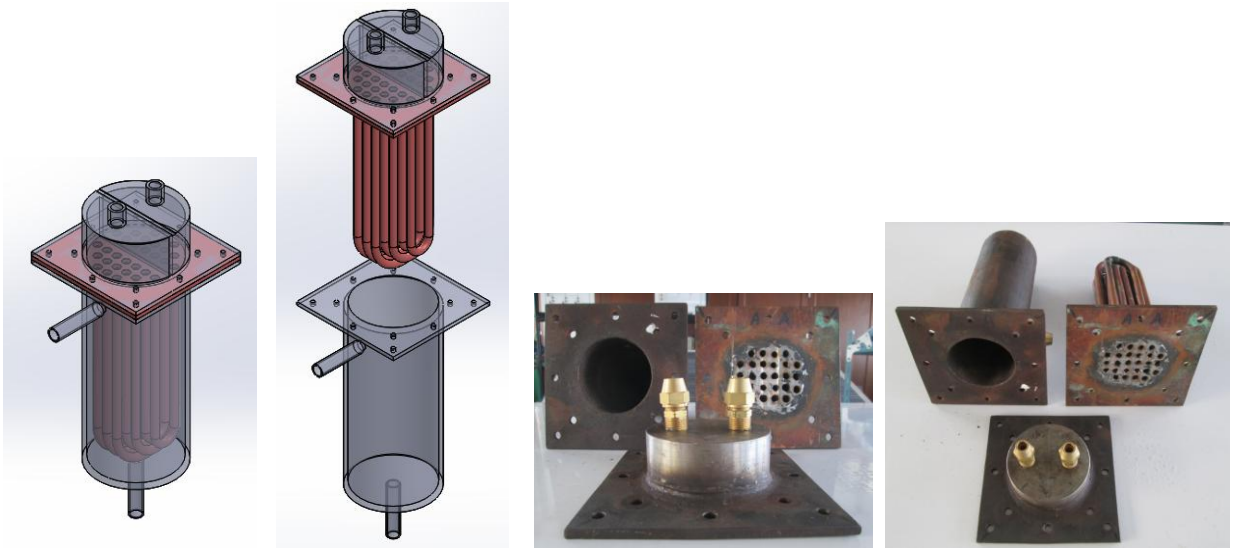

Figure 6. Heat Exchanger for compered calculating with Fig 5.

Figure 7. Shell and Tube Heat Exchanger. [7]

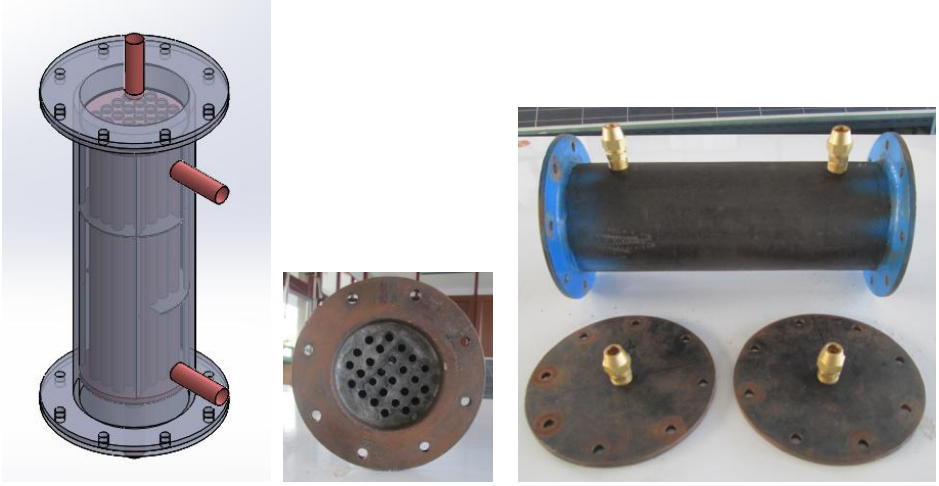

Figure 8. Shell and Tube Heat Exchanger for compered calculating with Fig 7.

4. RESULT S AND DISCUSSION.

The experiments using the crude oil from the plastic waste [7], is a distillation process producing the diesel is temperature about 270 °C, produces diesel 160 litre/hour. Its data collecting is from the factory and simple data calculated a suitable evaluation on the simple distillation plant built before calculation. The experiment with a simple distillation process is separated into three sections.

The first section is a simple distillation process of distillation producing diesel using heat source by biomass 60 kg/hr, heating values of biomass equal 10,365 kJ/kg. and heating values of diesel equal 30,224 kJ/kg. It is compared using heating values of diesel equal per heating values of fuel input, it had efficiency equal 6.5%.

The second section is distillation process which produces fuel using heat source by burner using diesel 5.4 L/hr., heating values of diesel equals 30,224 kJ/kg. It is compared using heating values of diesel equal per heating values of fuel input; its efficiency equals 20.4%.

The third section using heat source by burner incorporate with biomass. burner using diesel 5.4 L/hr. and biomass around 60 kg/hr. In comparison with heating values of diesel equal per heating values of fuel input, its efficiency equals 4.9%.

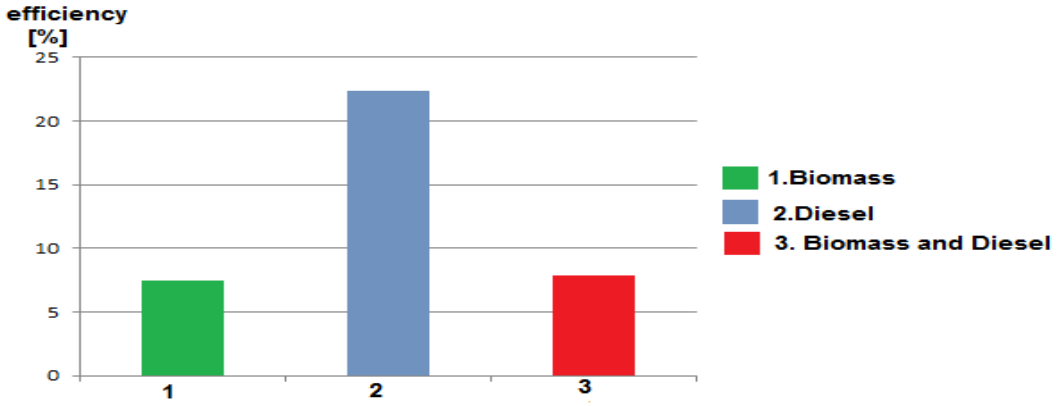

Figure 9. efficiency of experiments.

The experiment reveals that the result of the second section is the most productive**.** In comparison with the experiment and the simple calculation, following by equations **(1)-(10)** the result on the efficiency of work has error less than 5% and it is sufficient for the next experimental process. Thus, the study and design on a simple distillation process produce fuel from plastic waste has to concern mainly on design heat exchangers, flow rate and optimized temperature. Further study on this plant can be developed throughout the county due to its low cost and efficiency.

We know the size of the distillation plant if it changes flow rate in system by pump, we can calculate a quality of fuel.[4,5,6] Thus, the study and design on a simple distillation process has to concern mainly on flow rate and optimized temperature.

5. CONCLUSION

A study of a Simple Distillation Process Produce Fuel from Plastic Waste using Incorporate Heat Source is a distillation process producing the diesel at 270 °C, and it can produce diesel 160 litres/ hour. The first experiment section can produces diesel by using heat source from biomass 60 kg/hr. In comparison with

heating values of diesel equals per heating values of fuel input, its efficiency equals 6.5%**.** The efficiency of second section equals 20.4%, and the efficiency of third section equals 4.9%**.**The experiment reveals that the result of the second section is the most efficient**.** In comparison with the experiment and the simple calculation, the result on the efficiency of work has error less than 5% Thus, the study and design on a simple distillation process produce fuel from plastic waste has to concern mainly on design heat exchangers, flow rate and optimized temperature. Further study on this plant can be developed throughout the county due to its low cost and efficiency.

REFERENCES

[1] Bo Nordell., *THE USE OF CRUDE OIL IN PLASTIC MAKING CONTRIBUTES TO GLOBAL WARMING*, Bruno GERVET, Renewable, 2007.
[2] *http://www.deltat.com/pdf/Principles%20of%20Distillation.pdf*
[3] *http://www.elmhurst.edu/~chm/onlcourse/chm110/outlines/distill.html*
[4] Cengel, Y. A., *Thermodynamics, 3rd ed*, New York: McGraw-Hill, 1998.
[5] Holman, J.P., *Heat Transfer, 8th ed*, Singapore: McGraw-Hill, 2001.
[6] Jones, W. P., *Air Conditioning Engineering, 5th rd*, Great Britain: Butterworth Heinemann, 2001.
[7] Kosart Thawichsri and Wanich nilnont, " Simple Distillation Process Produce Fuel from Plastic Waste," *International Symposium on the Fusion Technologies between Korea and Thailand 2013 (ISFT20132),* August 1-3, 2013, Nonthaburi, Thailand.
[8] *http://www.em-group.co.th/Technology_Biomass.html*
[9] *http://cta.ornl.gov/bedb/appendix_a/Lower_and_Higher_Heating_Values_of_Gas_Liquid _and_Solid_Fuels.pdf*