

THE IMPORTANCE OF ENTEPRENEUR IN INDUSTRIAL DESIGN APPROACH (BIO-45D MACHINE)

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ABSTRACT

Food enterprise called chips based on materials such as banana, cassava and sweet potatoes are most popular among the Malay Community. This material will be processed by slicing in small pieces and then fried with cooking oil. The commencement survey shows that Small Medium Entrepreneurs Industry (SMEI) in Batu Pahat, Johore (Malaysia) tossed away the saturated cooking oil since that it was not use anymore. Researcher concluded that this phenomenon can be beneficial by creating a machine which use to convert the cooking oil to bio-diesel yet can be reused as stove and boiler fuel. The innovation of bio-diesel machine is used to develop understanding for student in the area of Industrial Design such as the basic concept, research methodology, design application and to create a product based on Problem Based Learning (PBL). The design of Bio-45D machine was applying on the ADDIE Model and a principle of liquid flows through gravity with the control of Digital Relay Timer and Electrical Relay in order to execute five basic process of producing bio-diesel. The processes involved were pre-heating, mixing between 20% of Methanol and 5% of caustic soda (Natrium Hidroxyde) at controlled temperature of 60°C -70°C, precipitating of glycerin and the deportation of 6%-8% of glycerine silt which produced the bottom of main reactor. In turn, Bio-45D Machine can produce more than 90% bio-diesel, avoid waste by recycling the used cooking oil to bio-diesel, also it can save the cost even in mass production. The design is a combination of knowledge and skills are also relevant to the other sector, such as agriculture and food industries. Furthermore, this Bio-45D machine has been contested at the international level. The best achievement was a Gold Medal, The Best Award in Malaysia Technology Expo 2009 and The World Exhibition On Innovation Research and New Technologies 2009 (Brussels Innova '09).

Keywords: Bio-diesel, Cooking oil, Industrial Design, Research and Innovation

INTRODUCTION

Two important aspects of the research problems in the development of the automatic biodiesel processing machine (Bio-45D) is due to the reason that spilled cooking oil used by operators for Small and Medium Enterprises (SMEs) are numerous and cannot be sold or used again. Environmental pollution is another phenomenon that perplexes the entrepreneurs of the Small and Medium Enterprises (SMEs) as a result from the spilling of used cooking oil. Thus with this problem, it is hoped that that the initiative of entrepreneurs of Small and Medium Enterprises (SMEs) in the area of Parit Raja, Batu Pahat with the researchers of University Tun Hussein Onn Malaysia to develop a recycling machine from used cooking oil into bio-diesel can help solve these problems.

Based on random interviews and a pilot study done by researchers to the entrepreneurs of Small and Medium Enterprises (the industry that produces chips and soy-based foods) around the town of Parit Raja, the result shows that more than 50% used cooking oil has been thrown away immediately.

At the same time, they had to use extensive amount of diesel for the heating of boilers in their factories, which is between 80 and 400 litres per day. As a result, too high a cost is incurred to buy the diesel fuel, whereby prices are increasing from time to time.

At present, there are many biodiesel processor machines that have been produced in Europe such as FF2000 Processor invented by Future Fuels Distribution, United Kingdom, Bio-Pro190 Processor invented by Utah Biodiesel Supply, United States and other biodiesel processors around the world. However, Bio-45D machine is created with its own characteristics, which is not owned by another machine processor, whereby it is automatic, cheaper, having simpler production steps, secure and easily conducted.

J. Van Gerpen in his journal entitled "Biodiesel Production Technology" (2004) stated that in biodiesel production, for the injection process of chemical solution to be secure and the separation of glycerine from biodiesel precipitation is one of the failures that often becomes a problem for individuals to produce biodiesel.

Regarding to this, studies to produce an automatic biodiesel processing machines using cooking oil as raw material with a low cost, which will be suitable for the use of Small and Medium Industrial Enterprises (SMEs) operators is a matter that should be implemented. It is also the hope of the development strategy that this will reduce the operation cost of the company.

EXPERIMENTAL MACHINE/RIG DESIGN

As a same machine is not available locally, thus the University Tun Hussein Onn Malaysia researcher referred the project plan that has been carried out in the United States and in Australia as the guideline for innovation in accordance with situation and local requirements such as in Figure 1.

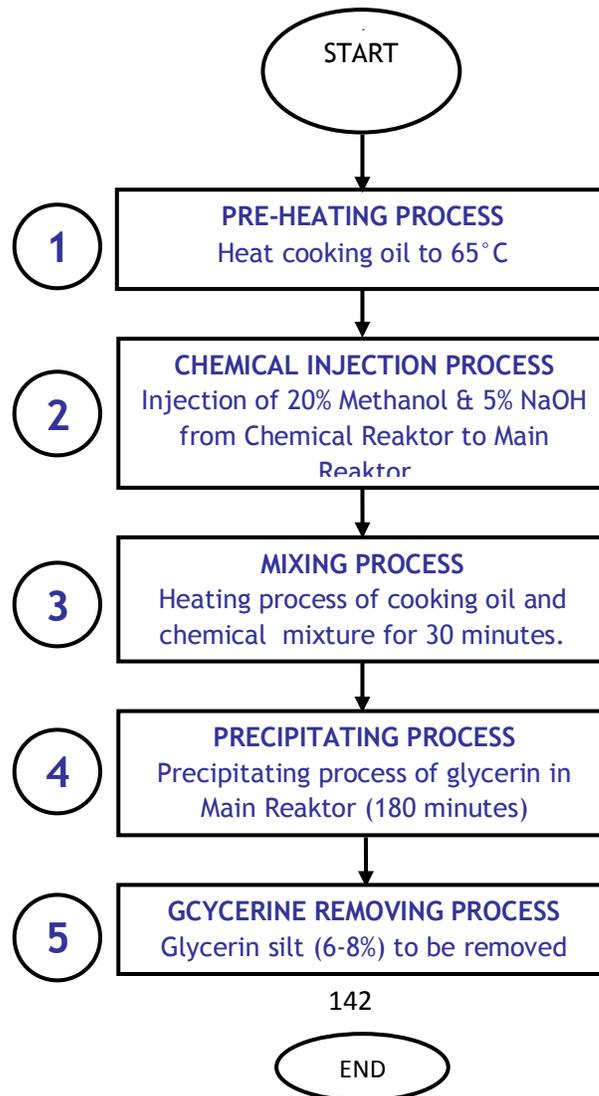
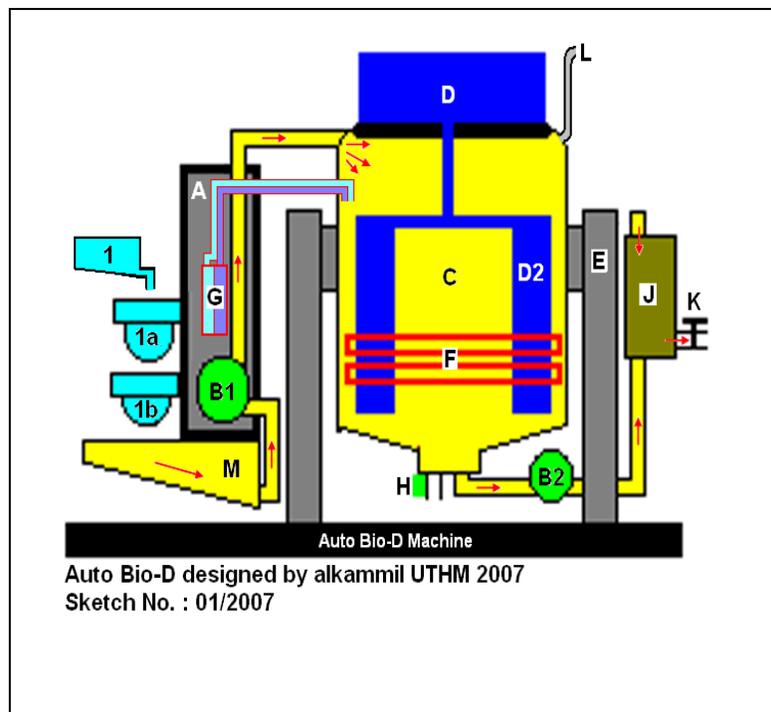




Diagram 1: Biodiesel Process (Bio-45D Machine)



Actual machine Bio-45D



Cross sectioned diagram

Diagram 2 : **Machine Operation**

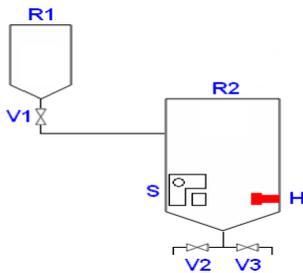


Diagram 2a

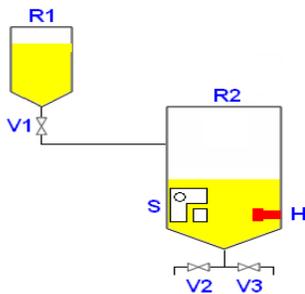


Diagram 2b

Diagram 2a

- R1 : Chemical Reactor
R2 : Main Reactor
V : Solenoid Valve
S : Stirrer
H : Heater

First Process (Diagram 2b)

- Pour 10L of used cooking oil and chemical into PR2 and R1 respectively.
- **RE-HEAT PROCESS** : used cooking oil to be mixed and heated in R2 to 65 °C

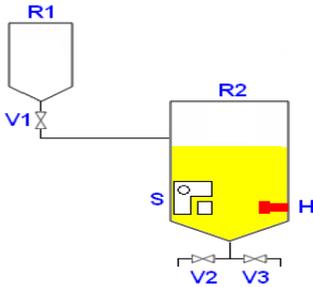


Diagram 2c

Second Process (Diagram 2c)

- When the temperature in R2 have achieved 65°C,
- **CHEMICAL INJECTION PROCESS** : 20% of chemical in R1 will be injected into R2 through V1.

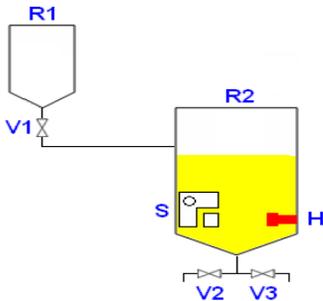


Diagram 2d

Third Process (Diagram 2d)

- After the 20% of chemical in R1 have been injected into R2,
- **MIXING PROCESS** : All the substances will be mixed and heated with a constant temperature of 60-70°C for 30 minutes.

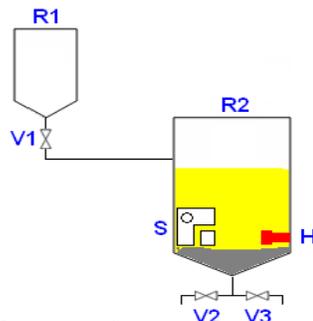


Diagram 2e

Fourth Process (Diagram 2e)

- **PRECIPITATE PROCESS** : Precipitating process of glycerin for about 3 hours.

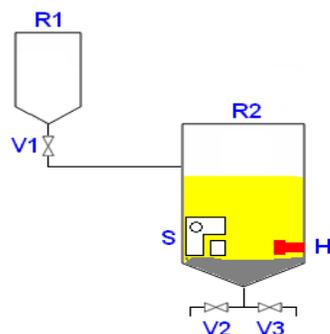


Diagram 2f

Fifth Process (Diagram 2f)

- After the 3 hours of precipitate glycerin process ended;
- **GLYCERINE OUT** : 6-8% of glycerin silt to be removed through V2.

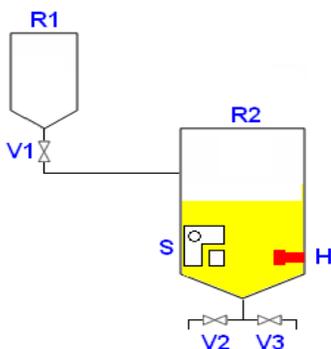


Diagram 2g

Final Process (Diagram 2g)

- When the 'OUT' button is pressed by the user
- **BIODIESEL OUT** : The processed bio-diesel can be removed through V3 into user's tank.

ANALYSIS AND DISCUSSION

Engineering Materials

The data analysis in this study is done to investigate the ability of the Bio-45D machine in conducting five biodiesel production processes automatically, which are the pre-heating process, chemical mixing process, trans-esterification process, precipitation process and glycerine sediment production process. However, before this machine can function automatically, the researcher conducted the analysis of the five processes using the manual system of the machine, and the results of the manual analysis system will be used to set the period of the digital electrical timer in the automatic control system. In addition, the researcher also made a detailed analysis of the technical aspects of machine design, size, control systems, safety, and cost of design and production costs for one liter of biodiesel using the Bio-45 D machine.

In the development of this machine there are four important sections in ensuring that it can function properly. The sections are chemical reactors, main reactor, control space systems and space clearance between the chemical reactor and main reactor. The overall size of the Bio-45D machine body is 960mm x 880mm x 4100mm.

Chemical Reactor

This reactor serves to place the liquid chemicals in which the volume should contain 20% of the main raw materials. The chemical material consists of the mixture between two main chemical materials, namely 2 litres of methanol and 5% caustic soda (NaOH Flake). This reactor was built with a diameter and height of 150mm and 210mm respectively, and it can contain a total maximum volume of 4.9 litres.

The reactor base was built at the height of 730mm from floor level and 130mm higher than the main reactor. It is deliberately designed that the reactor base is 130mm height above the main reactor to allow the liquid solution of methanol and caustic soda to flow with gravity into the main reactor without the aid of a motor pump.

The main reactor is a processing reactor, where in the reactor consists of pre-heating process, mixing process, the process of precipitation, and glycerine production process is carried out. It should be able to accommodate overall liquid materials which is 10 litres of used cooking oil and 20% (5liter) liquid solution of methanol and 5% sodium hydroxide. The main reactor should be able to withstand the heating all the liquid ingredients in a temperature range between 60°C - 80°C. This reactor is developed with a diameter of 350mm and the height of 300mm. This reactor is able to accommodate a maximum liquid volume of 35.3 litres, which was built as high as 300mm from floor level. It exists to enable precipitation of glycerine and the biodiesel fuel that was processed could flow out into a container using gravity without the aid of any motor mixer, thus can save the cost of the machine development.

Preparation using the manual system

Having completed the machine mechanical system, the researcher should make analysis of the machine to know the following:

- The time needed to ensure that the cooking oil to achieve the required average temperature range of 65°C in the pre-heating.
- The time required to flow a mixture of methanol and sodium hydroxide from chemical reactor into the main reactor through Solenoid Valve 2 (V2).
- The percentage of precipitated glycerine on the bottom of the main reactor and the time required to remove all sediment glycerine through Solenoid Valve 3 (V3).
- Analysis of all three of the above done on three different samples of oil density. This is due to the assumption made earlier, that the oil of different density will give different results for the three things that should be analyzed as described above.

Table 1: Information on the density of the sample

No. Samples	Information Samples	Sample density	Notes
Sample 1	Weight of sample: 0.929kg The volume of container: $1.018 \times 10^{-3} m^3$	$\rho = \frac{0.929kg}{1.018 \times 10^{-3} m^3}$ $= 912.57kg/m^3$	Maximum sample density
Sample 2	Weight of sample: 0.924kg The volume of container: $1.018 \times 10^{-3} m^3$	$\rho = \frac{0.924kg}{1.018 \times 10^{-3} m^3}$ $= 907.66kg/m^3$	Sample of medium density
Sample 3	Weight of sample: 0.918kg The volume of container: $1.018 \times 10^{-3} m^3$	$\rho = \frac{0.918kg}{1.018 \times 10^{-3} m^3}$ $= 901.77kg/m^3$	Minimum density of samples

Average sample

After the three samples with the density of 912.57 kg/m³, 907.66 kg/m³ and 901.77 kg/m³ each were tested and analyzed, a summary should be made to set the following:

- The time required by the Bio-45D machine to do the pre-heating.
- The time required by the Bio-45D machine to drain all of the chemical solution into the main reactor through valve 2 (V2).
- The time taken by the Bio-45D Machine for the removal of all glycerine sediment that is produced.

Analysis of the overall temperature of the Bio-45D Machine

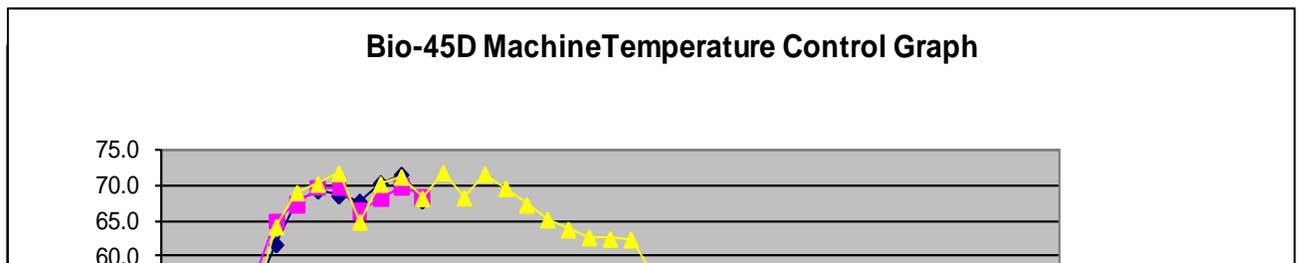


Figure 3: Graphic analysis of the temperature of the entire process

From the graph, it is determined that the ideal time for pre-heating process is 13 minutes. At that time, the three samples exceeded the minimum temperature of the pre-heating (65°C) that has been set, reaching 68.35°C, 68.45°C and 69.4°C respectively. Therefore, the Digital Relay Timer 1 (T1) which controls the process of pre-heating the bio-45D machine should be set for 13 minutes.

Control System

In the design of the Bio-45D machine, the main aspects that should be considered is its control system. This is because the quality of the biodiesel is determined by how the system is being developed. This machine is equipped with two automatic control systems which are the automatic control and manual control systems. In the development of both systems, there is a few electrical control components used. The components are:

- i. Digital Relay Timer
- ii. Analogue Relay Timer
- iii. Relay
- iv. Contactor
- v. Thermostat

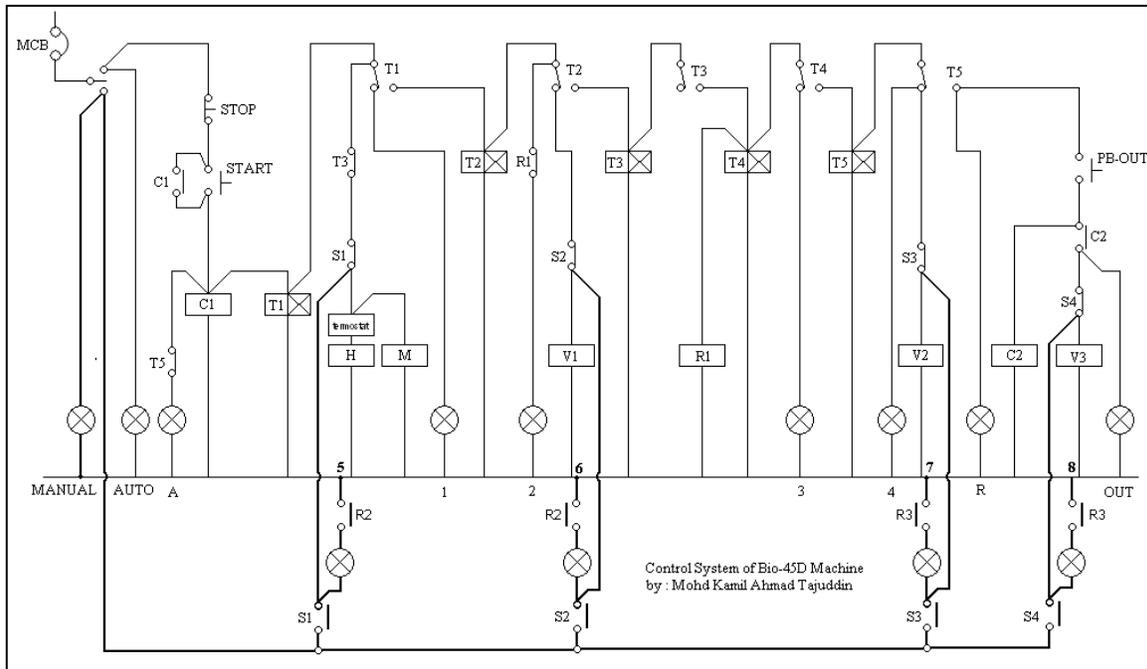


Figure 4: Schematic Circuit for the automatic and manual control system of the Bio-45D machine

The overall results

Some of the results of the analysis in this chapter can be summarised as shown in Table 2 below:

Table 2: Overall Analysis

No. Samples	Time for the flow of chemicals into the main reactor	Density of the sample	Time required for pre-heating process	Percentage of glycerine resulting precipitate	Time to remove the precipitate	Percentage of biodiesel
Sample 1	1 minute 48 seconds	912.57 kg/m ³	11 minutes	6.5%	1 minute 58 seconds	93.5%
Sample 2	1 minute 46 seconds	907.66 kg/m ³	10 minute 36 seconds	6.08 %	1 minute 56 seconds	93.92%
Sample 3	1 minute 45 seconds	901.77kg/m ³	10 minutes 28 seconds	5.33 %	1 minute 52 seconds	94.67%
Conclusion	The time taken was 2 minutes	-	The time taken was 13 minutes	-	The time taken was 2 minutes	Average production of biodiesel is at
Notes	Period of two minutes is set at T2	-	The 13 minute set at T1	-	Period of two minute is set at T5	94.18%

CONCLUSIONS AND RECOMMENDATIONS

During the period of development and analysis of the Bio-45D machine, the researcher has identified several problems and weaknesses that can be addressed from time to time for future purposes. The researcher suggested several recommendations to upgrade the use of Bio-45D machine. The recommendations are:

1. The study is conducted on automatic process as an addition to the Bio-45D machine which is the biodiesel process, where biodiesel is the end product of 'washing' by mixing it with water at high temperature, then mixed and finally the water and oil are separated. This process enables the resulting bio-diesel to also be applied in diesel engine vehicles, and to comply with the standards set by SIRIM and EN14214 in accordance with international standards.
2. In view of the complexity in using electrical control system for the wiring of the machinery, the researcher suggests that in the future, another alternative will be to use programme logic control (PLC). The usage of the PLC will simplify the wiring of the machine, thereby to reduce the risk of damage to the machine.
3. The researcher suggests that the size of the machine design can be designed larger, to ensure that it is appropriate for the needs of the industry.
4. It is also suggested that the control panel employs the use of digital systems, whereby digital systems are more attractive and have a higher commercial value.

The development of the Bio-45D machine control system is specially designed according to the formula proposed by Hexagon Synergy Holding Company. The formula is used and the production process is done manually. The biodiesel product from the formula is implemented by the owner of Al-Falah Farm Pte. Ltd (771942-V of) in their four wheel drive vehicle.

The design of this machine is especially for the SMEs, particularly industrial with chips and soy-based foods, where they use diesel as fuel in the kitchen and at the same time, they have used cooking oil that eventually is just thrown away or sold to detergent manufacturers with the too low of a price. However, due to the relatively low development costs, Bio-45D machine also can be targeted for individual consumption.

Although there are several weaknesses that could be improved from time to time as specified in section 4.0 above, but the researcher still considers that the production of machine design Bio-45D is successful because it can be practically used and has achieved all the objectives of its development.

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