# DESIGN AND EFFICIENCY STUDIES ON SKIMMERS IN AN ACTIVE GREASE TRAP

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***ABSTRACT***

*The objectives are to study the nature of fat, oil and grease and the correlation of retention time in separating these elements from wastewater. In addition, the assessment of the skimmers in term of the best material and shape in order to shorten the retention time. There are three types of grease traps which are passive, active and bio-remediation and the focus of this study is merely on the active grease trap. There will be three types of material will be tested for the skimmer, which are polyethylene foam, high-temperature nylon and clay. An active grease trap with a combination of three type materials for the skimmer were fabricated and experiments were conducted. From the collected data, the third skimmer (clay) has proven to be the best skimmer with 97.7% of oil were collected while the lowest is 70% which produced by the high-temperature nylon. In addition, clay has shown better consistency in collecting oil based on the three experiments with three different amounts of oil. From the obtained data, it can also be concluded that another factor that crucially affecting the result is in the grooves which were fabricated for the clay skimmer.*

***KEYWORDS****: Fat, oil and grease; Wastewater; Active grease trap; Clay skimmer; High temperature nylon skimmer; Polyethylene skimmer*

## 1.0 INTRODUCTION

Grease trap is plumbing mechanism proposed to trap waste before they enter a wastewater disposal system. Waste can be in three different forms; solids (fats), liquids (oils) and liquid-solid (grease) or known as fat, oil and grease (FOG) at normal room temperature. Usually this

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grease trap will be installed after the sinks either below the sink, as shown in Figure 1, or else will be planted into the ground.

Figure 1. Example of grease trap installed under the sink

General wastewater usually contains small amounts of oils which enter into a septic tank or treatment facility to form a floating scum layer. This scum layer is very slowly digested and broken down by microorganisms in the anaerobic digestion process (Aziz, 2010). However, very large amounts of oils from food waste in kitchens or restaurants can overwhelm the septic tank or treatment facility, resulted in problem of untreated sewage. Furthermore, high viscosity fats solidify when cooled, and can combine with other disposed solids to form blockages in drain pipes as shown in Figure 2.

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Figure 2. Blockages in Drain Pipe

In general, there are three types of grease trap as shown in Figure 3. In addition, the first type is also known as Passive Grease Trap (PGT) and the second and third one is also known as Active Grease Trap (AGT). The first one is a compartment grease trap or known as 'Weir Type' is a kind of grease trap which usually placed close to the FOG source (Middleton & Starr, 1995). In addition, it has a compartment where the trapped grease is held and after a certain time, the compartment needs to be removed or cleaned in order to expel the trapped grease. This type of grease trap restricts flow and removes 85-95% of the incoming

FOG and the sizing is based on the size of the compartment sink, dishwasher, pot sinks and mop sinks. This kind of grease trap is also known as (PGT) or Passive Grease Trap since there it has been operated by the gravitational law (Batten & Kyles, June.2009).

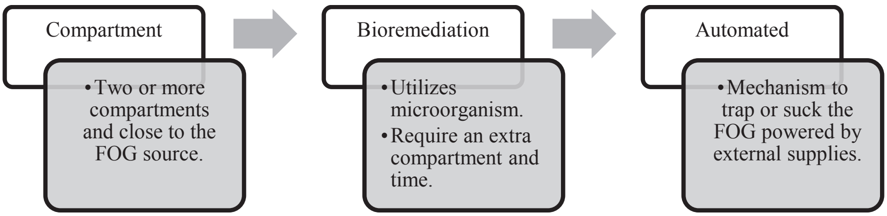



Figure 3. Types of Grease Trap

The second types are known as bioremediation grease trap. This type of grease trap utilizes microorganism to digest the trapped grease, converting it to water soluble, bio-degradable fluid which safely discharged into the drainage system. This type of grease trap accompanied with bio reactor, which filled with immobilized enzyme such as *candida rugosa* and *pseudomonas cepacia* (Oya, 2007). On the same hand, bioremediation grease trap requires an extra compartment and time (2-5 hours) for the digesting process to happen or known as 'residence time' (Ozama, 1999).

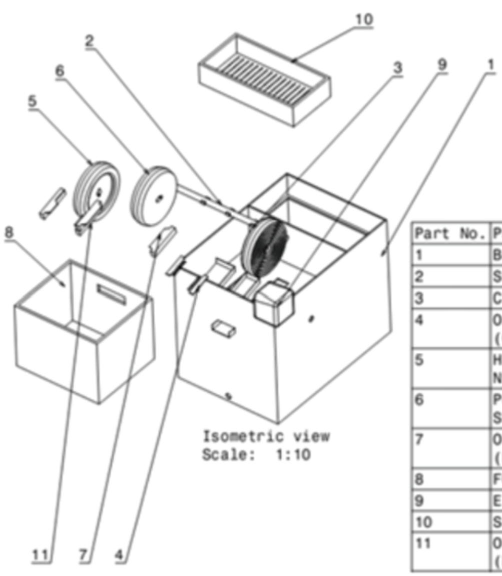
The third type is the automated version of grease trap or an active grease trap. Typically, automated grease trap has hydrostatic pressure, skimmer device or automatic draw-off system to remove or suck the FOG. In some, there are also a temperature-controlled grease trap in which the trapped grease is heated and turned into liquid grease that later been pumped out into a separate tank (Holloway Jr., Held, Roach, & Mielbeck, 1995). This type of grease trap usually smaller than others because it does not need a bigger compartment since the grease trap coming in is usually being processed at upon arrival.

### 1.1 Skimmer in an Active Grease Trap

Most of the passive grease trap are using the gravity method in which oil and water takes time to set aside . This method is very effective, but it will be a problem when shorter retention time (time for FOG and wastwater to separate) is required. These scenarios occurred usually during peak hours and festive season when wastewater from the washing process coming too quickly and continuously into the sink outlet. In addition, the emulsifier is also a problem because when there is an emulsifier effect in the FOG, separation process will be slower and retention time will be longer (Aziz, 2010). Typically the skimmers which were used are less effective because of the several factors such as skimmer's material and the shape and design of the skimmer. Hence, there is a need to shorten the retention time by designing a more effective skimmer. The objective of this study is to measure the performance of three types of skimmer (clay, polyethylene an high-temperature nylon) in the active grease trap.

## 2.0 MATERIALS AND METHODOLOGY

In order to fabricate the grease trap prototype, the material and tool selected should be appropriate to be used. It is all started with part modelling in CATIA software drawing and later converted into drafting documents in which an important drafting file like isometric, orthographic and exploded views (shown in Figure 4). In making the active grease trap, the material known as plastic Perspex is used in fabricating this prototype because its transparency and durability. Meanwhile, the connection between the Perspex is done using the plastic glue and silicone which is used to prevent leakage as well as to strengthen the bond connectivity.




| Part No. | Part Number | Type | Qty. |
|---|---|---|---|
| 1 | Body Grease Trap | CATPart | 1 |
| 2 | Shaft | CATPart | 1 |
| 3 | Clay Skimmer | CATPart | 1 |
| 4 | Oil Collecter (Clay) | CATPart | 2 |
| 5 | High Temperature Nylon Skimmer | CATPart | 1 |
| 6 | Polypropylene Form Skimmer | CATPart | 1 |
| 7 | Oil Collector (Polypropylene) | CATPart | 2 |
| 8 | FOG Collector | CATPart | 1 |
| 9 | Electric Motor | CATPart | 1 |
| 10 | Strain Bucket | CATPart | 1 |
| 11 | Oil Collector (Nylon) | CATPart | 2 |

Figure 4. Exploded view of the active grease trap prototype

One of the crucial task in developing this prototype is the construction of the baffles as shown in Figure 5. Another important component is called an oil collector, shown in Figure 6, which function is to collect and channel the FOG into the designated container. Using galvanized metal to start with, the correct measurement needs to be traced and later cut and bent using the bending machine. In the process of producing the oil collector, smaller part needed to be bend because of the limitation in the bending angle. To join these parts, spot welding joining method was used to ensure the connection is perfect and leakage-proof. Spot weld method is a process of using resistance welding electric current that will produce high heat in connecting two overlapping metals.

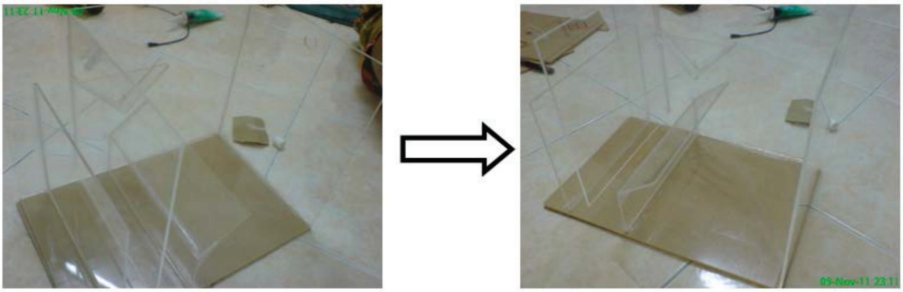


Figure 5. Baffles construction

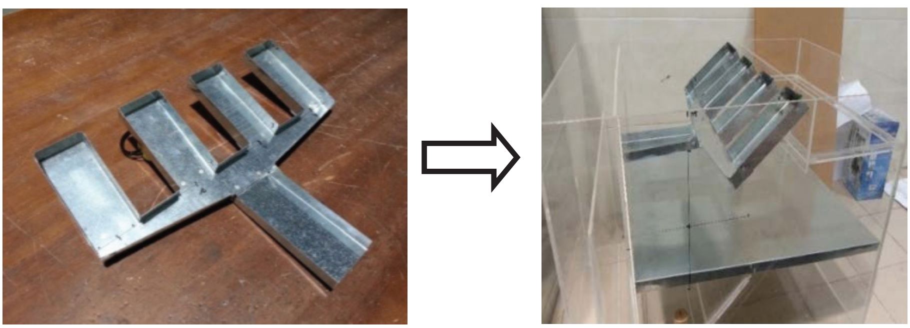


Figure 6. Oil Collector

## 2.1 Construction of Clay Skimmer

Regarding the skimmer, the disc-shape tool to collect the FOG in a grease trap, there will be three types of skimmer that will be used in this experiment. To be specific, there are clay, high-temperature nylon and polyethylene foam as shown in Figure 7. The last two skimmers are not hassle to be fabricated. The high-temperature nylon can be bought in any local hardware store while the polyethylene can be found in the automobile accessories store in which this material is used as a heat absorbent to avoid heat from the engine transferred into the passenger area of a car (Broje & Keller, 2006).

The hardest skimmer to made is clay as it requires a delicate process of shaping to baking the material to the desired skimmer. This clay skimmer needs to be processed because clay has a characteristic where it is hard but fragile. To make this clay skimmer, first a true dimension and most important part, the angle of the groove need to be is calculated. The groove is crucial in improving the efficiency of the skimmer (Broje & Keller, 2007). Since, the clay making process is rather a craftmenship work  and not a technical process, it was decided that the clay-making process was handed to the local claymaker called “Clay House”.

To produce this clay skimmer, the artist had shape the skimmer according to dimension and given angle. After finishing the shaping process, the middle of the skimmer needs to be crafted for the shaft and lock area. Later, the clay need to be dried for several days. After the clay skimmer is completely dry, around 4 to 5 days the clay need to go through the baking or combustion process. This combustion process should be done twice. First combustion process took about three hours at 400°C and then let the skimmer cool for two days before doing the next combustion process. In the second combustion process it takes around seven to nine hours. This combustion process is risky because it could crack the clay due to the sudden heat changes to the trapped wet area inside the clay. So as a precaution step the combustion process must be undertaken with correct approach in which the temperature changes must be made constant and slow. The final version of the clay skimmer can be seen in Figure 8 while Figure 9 shows the final assembled of the three skimmers altogether.


Figure 7. Skimmer 1,2 and 3

Figure 8. Clay before and after combustion process

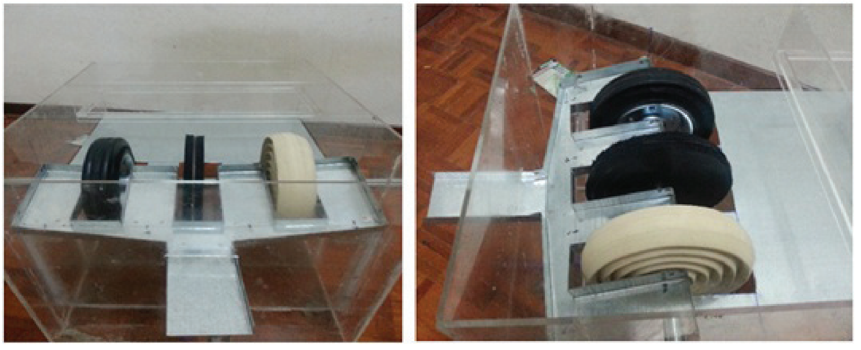


Figure 9. All three assembled skimmers

## 2.2 Experimental Set Up

The experiment is set up to find the percentage of oil collected from the wastewater in addition to finding the best material to be used as a skimmer. The apparatus used to bethe prototype of the grease trap, cooking oil, clean tap water, stop watch and beaker to measure the collected oil. The most important aspect is to control the constant variables such as the skimmer's rotation per minute in which were kept at 40 revolutions per minutes. In addition, the surrounding temperature need to be controlled in which the experiment is done during the same period of the day. The manipulated variables which were controlled are the percentage of oil in water and the type of skimmer. For each type of the skimmers, three experiments have been executed and each experiment consisted of 1 ,2 and 3 liter of oil in the water.

The experiment was conducted by using one skimmer at a time as shown in Figure 10. First, water filled in the grease trap up to the level that has been labelled and then 1 liter of oil is poured to imitate the wastewater from the sink resulted from domestic kitchen usage.


Figure 10. The oil collector and skimmer in position

The shaft rotated with constant rotation at the rate of 40 per minute and the stopwatch started simultaneously to record the time. The shaft was stopped after 3 minutes and the readings of the oil at coming out from the outlet is collected in the beaker, as shown in Figure 11, were recorded.


Figure 11. Measuring oil in process

The steps were repeated for the same skimmer by changing the quantity of oil in water (with 2 liters and 3 liters, consequently). All the data were recorded. Afterwards, all the process was repeated but the skimmer is changed to skimmer 2 and finally skimmer 3.

## 3.0 RESULTS AND DISCUSSIONS

All the collected data for Skimmer 1, 2 and 3 were tabulated in Table 1, 2 and 3, respectively. Table 2 shown the nylon as the skimmer and comparatively is the worst skimmer than skimmer 1 and 3. Clay has shown that its skimmer able to maintain at least 90% of oil collected within the three experiments.

Table 1. Data for polyethylene foam skimmer (Skimmer 1)

| Experiment No. | Oil inserted at input (milliliter) | Time (minutes) | Oil collected at output (milliliter) | Oil collected (%) |
|---|---|---|---|---|
| 1 | 1000 | 3 | 870 | 87.0 |
| 2 | 2000 | 3 | 1880 | 94.0 |
| 3 | 3000 | 3 | 2900 | 96.7 |

Table 2. Data for high-temperature nylon skimmer (Skimmer 2)

| Experimen t No. | Oil inserted at input (milliliter) | Time (minutes) | Oil collected at output (milliliter) | Oil collected (%) |
|---|---|---|---|---|
| 1 | 1000 | 3 | 700 | 70.0 |
| 2 | 2000 | 3 | 1750 | 87.5 |
| 3 | 3000 | 3 | 2600 | 86.7 |

Table 3. Table for clay skimmer (Skimmer 3)

| Experiment No. | Oil inserted at input (milliliter) | Time (minutes) | Oil collected at output (milliliter) | Oil collected (%) |
|---|---|---|---|---|
| 1 | 1000 | 3 | 900 | 90.0 |
| 2 | 2000 | 3 | 1900 | 95.0 |
| 3 | 3000 | 3 | 2930 | 97.7 |

The resulting graph, as shown in Figure 12, on the obtained data showed that oil collected at the outlet versus oil inserted at the inlet. Clay showed the highest quality for having the highest collected oil while polyethylene foam skimmer is the second best collector after clay skimmer. But both the clay and the polyethylene show a very close result, but clay has shown better consistency compares to polyethylene and nylon. In addition, Experiment 2 and 3 with the amount of oil 1 and

2 liter, respectively has shown better consistency in the collection of the oil. For all the skimmers, slight percentage increments of oil collected were shown from experiment 2 to 3, where 2.7% for both skimmer 1 and 3, while decrease as much as 0.8% has been observed in skimmer 2 . But for the experiment 1 (with 1 liter of oil), a leap of percentage can be observed with skimmer 2 (nylon) shown 17.5% increment of oil being collected while 7.0% and 5.0% increment can be observed in skimmer 1 and 3, respectively.

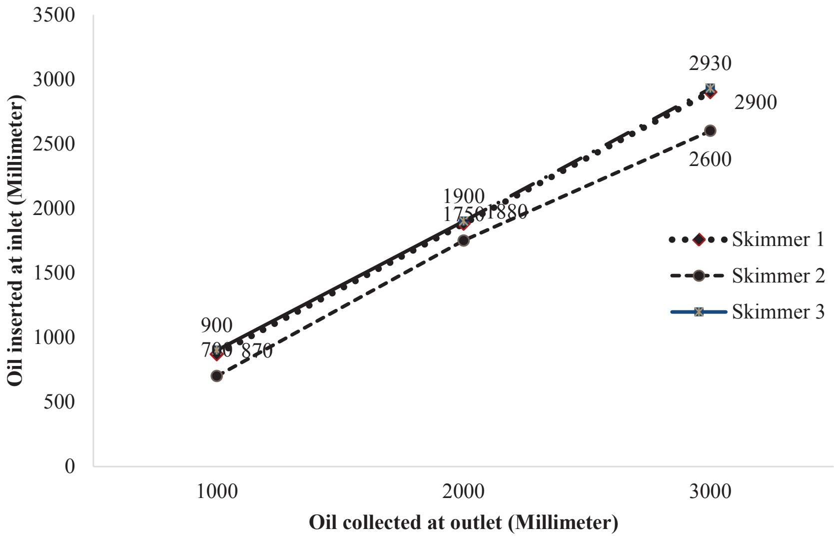



Figure 12. Graph of inserting oil versus collected oil by the different skimmers

From this experiment, it can be concluded that these three types of skimmer with different materials are proven to scoop the oil from water with high efficiency. It is because from the data oil collected percentage, the lowest result for the collected oil is 70% which the only result that is not 80% and above. Possible cause for this low percentage is an error during the process of oil collection or the retention time has not been met up yet. The error may also occur due to the oil been collected may contain water, which affect the quantity of oil been measured.

### 3.1 The Selection of Best Skimmer

Clay is the best material for the skimmer. This is evident from the results of experiments in which clay can collect and separate more oils than other skimmers as shown in Figure 14. Clay is divided into two types, primary and secondary clay. The clay used to make this skimmer is the secondary one. Among the features of the secondary clay is that it is a malleable clay, brown in color and has a maturing temperature of 9000°C to 14000°C. The important property are water-tight and water-proof. By increasing the temperature of the combustion process, the clay will be harder in structure, thus helping to make the clay more water-tight. In addition, clay is also proven in the world market because it is widely used to be an absorbent agent. What distinguishes the clay used to make the skimmer in this experiment is that the clay being used is in solid form while the clay on the market is in the powder form (Rudnick, 2013).

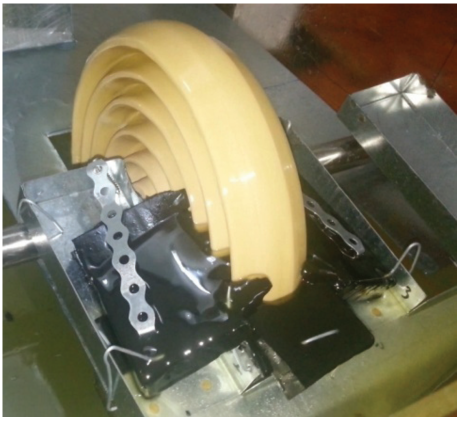


Figure 14. Clay skimmer test run set up

## 4.0 CONCLUSION

The process started using CAD (Computer Aided Design) drawings and followed by the manufacturing process. The manufacturing processes were divided into four sections which comprises of grease trap body construction, oil collector construction, skimmer construction and assembly construction. The most crucial factor in the body construction is the fabrication and assemble of the baffles. While for the oil collector, the part has to be divided into little pieces due to the bending machine limitation. If this product were to be manufactured and commercialized, the design for manufacturing (DFMA) has to be improved. In addition, the fabrication of the skimmer, especially the clay skimmer is very crucial.

The clay skimmer proven to be effective in collecting oil from wastewater but again the aspect of manufacturability has to be taken into consideration. The tedious process started from molding or carving the clay into the desired shape required artistic talent rather than a technical expert. Secondly, the carved material has to be dried in several days before being baked twice. The drying process has to be fully done as any water molecule trapped inside the clay would cause cracking and eventually will propagate and damage the clay skimmer.

In addition, the other two skimmers showed that both could be considered to be potential skimmers. The availability and the hassle free process in manufacturing would be factors to be counted in. Nonetheless, the clay skimmer has shown consistency during the experiment comparable to the other two skimmers. The effectiveness in collecting the oil from the wastewater is crucial because given the short retention time, the particular grease trap could scoop more oil in a shorter cycle. This is crucial when the grease trap is in the peak hours of usage, such as during the festive seasons.

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