UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF HYDROPHOBIC OIL SKIMMER FOR GREASE TRAP SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Nowadays, the problem that may be concern by public is fat, oil and grease (FOG) issues. The number of FOGs continues to increase every year as the number of restaurants increases. When certain waste is disposed of directly into the drainage system, the FOG may build up around the plumbing system of the wastewater system facility. Efficient development of the grease trap will reduce the impact of the problem and prevent the FOG contaminant in the sewage system. The objective of this project is to design and fabricate the concept of oil skimmer for grease trap. Oil skimmer is equipment that remove or separate oil from water on the fluid surface. Other that, the evaluation of the skimmers depends on the best material and structure so that retention time can be reduced. To ensure that the aim of the project is achieved, the grease trap skimmer was designed based on engineering design methods such as house of quality (HOQ), Pugh method and morphological chart. Thus, a study was conducted to explore the influence of roughness on the selected materials. They were roughened by using 150 grid abrasive paper. Contact angle and surface roughness characterization were evaluated by self-fabricate contact angle measurement tools and Profilometer Surftest SJ-410. It was found that roughness strongly influenced the wettability of the selected materials due to air trap and its geometrical structured. The results reveal that acrylic skimmer are most efficient between aluminium, paraffin and polystyrene.

DEDICATION

My parents, my supervisor, my co-supervisor and to all my friends.

Thank you for all the support and ideas.

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CHAPTER 1

INTRODUCTION

1.1 Background

In a developing country, one of the unpleasant situation for environment department in every country is fat, oil and grease (FOG) issues. Food service establishments (FSE) such as fast food restaurant and cafeteria usually produce a lot amount of FOG. The problem involved happens almost in every stage of collecting, transporting, final management and treatment of the sewage to the wastewater treatment plants (WWTPs) (Nor Shafizah et al, 2012). The factor contribute in increasing number of FOG produced by year because people change their eating habits and increasing number of food outlets (William et al, 2012). The remaining waste from FOG is consist of cooking oil, animal fats, meat, margarine, lard, butter and sauces. When all these waste discharge directly into the plumbing system facility, it may lead FOG build-up around sewer system facility's plumbing system.

Large industries such as palm oil mills also contribute to FOG increase in Malaysia. Based on the Malaysian Palm Oil Board (MPOB), in 2008 the total plantation area oil palm was 4,487,957 hectares (Agamuthu P, 1995). Back then in 2005, there was 423 palm oil mills has been built and the production capacity reach roughly 89 million tonnes of fresh fruit bunch (FFB) per year (EBIS, 2015). As the production capacity increase, it also increase pollution level because the waste produced. Palm oil mill effluent (POME) is a wastewater produced from palm oil processing activities which requires

compelling treatment before release into water because of its exceedingly contaminating properties. The process involved briefly oil extraction from the palm fruits, washing and cleaning up processes. The content in the POME is cellulosic material, fat, oil, and grease. If the contaminated mixture discharge into sewer system without any treatment, it may cause pollution problems (IWK, 2010).

Studies showed that in developing country, FOG per capita is increasing every year compared to non- developing countries. It showed 50 kg/year FOG produced in 2015 while in non- developing countries only around 20 kg/year for average per citizen. According to Indah Water Konsortium (IWK) report, sanitary sewer overflows (SSOs) cases happened in Malaysia because of the FOG. In 2010, IWK received 22,184 blockage enquiries. (IWK, 2010).The statistic at 2014 created by Majlis Perbandaran Kemaman (MPK) said that 60 % of oil waste from premise such as restaurant and night market release 26460 liter untreated water mixing with oil to the open water or sewer system. The amount of oil waste in 2014 reached 9,525,600 litre (Keener et al, 2008). The highest percentage of sewage sources in Malaysia at 2011 come from public sewage treatment plant indicate 36.3 % as it shown in figure 1.1. One of the contents in the public sewage is FOG waste.

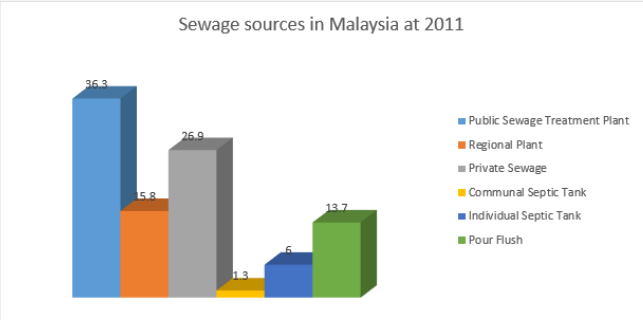

Figure 1.1: Various sewage system in Malaysia
Sources: Indah Water Portal, 2011

Usually people tend to speculate FOG mixture produced by solidification process of cooking oils when the oil poured down into sewer lines. However, the process formation of FOG is not easy as one might expect. Basically untreated oil waste that came from Food service establishments (FSE) and large industries discharges to sewer lines reacts with calcium in wastewater. The FOG deposits reacts through saponification reaction that leading to the formation of the calcium-based fatty acid salts. The FOG deposits physical properties includes metallic soaps consisting of (saturated) fatty acids and calcium (Keener et al., 2008). The theory has been proved by He et al (2011) when an experiment using the same conditions as sewer lines in run the laboratory. The findings from these experiments is the reaction between free fatty acids (FFAs) and calcium chloride had developed hardened FOG deposits by saponification process.

Previously there are study of processes and development to remove FOG from wastewater such as grease trap filters, ultrafiltration, microbial cultures and grease trap. The most popular pretreatment to remove FOG used by Food service establishments (FSE) is grease trap (Arthur et al, 2015). Grease trap is a plumbing device designed to separate oil and water before discharge in a wastewater pipes system. Other term for grease trap is grease converter, grease interceptor and grease recovery. Usually grease trap installed on food services premises because they produce large amounts of FOG deposits that can interfere a septic tank or treatment facility. The installation of oil traps at food premises is the most practical step in addressing the problem of river water pollution from food waste. For example Malaysia government very emphasize the installation of grease trap especially in all food premises. In order to extend licenses of restaurant, grease traps must be fully function. Usually all types of grease trap using the same principle which is densities. Oils often have lower density than water, which is the

reason the oil can float on water when the mix is allowed to settle for some time (also called retention time). Upper layer in waste water contains floatable deposits such as FOG, middle layer usually filled with organic matter and the very bottom layer consists of food particles (Nidzamuddin et al, 2015).

There are 3 types of grease trap which are hydromechanical, gravitational and automatic. Hydromechanical using heat and gravity to separate water waste. The water waste will be streamed into the tank and heated. The reasons of FOG can be separate from water is because FOG are denser than water. The main disadvantages of using this type of grease trap is it has to be clean manually and regularly to avoid FOG waste fulfill inside the tanks. Second type of grease trap is gravity grease separator. This type of grease trap using concept of gravitational which have more than two compartment to slow down the speed of flowrate. When the water flowrate speed decrease, it allows FOG to become more buoyant and separate. Gravitational grease trap is more efficient compared to hydromechanical because has the ability to trap more than 90% of water waste. Thirdly, automatic grease trap or automatic grease removal unit (AGRU). Automatic grease trap required electricity to perform its job. It is combination of mechanical and electrical concept to separate FOG from water. The size is smaller compared to hydromechanical and gravitational grease trap. It also able to separate 99% of FOG from water which make it the most efficient grease trap and required less maintenance.

1.2 Problem Statement

Rapid urbanization changed the characteristics most of people diet habit as they more likely to eat fast food from fast food restaurant and impact on FOG number (Husain et al, 2014). FOG are produced by-products of cooking. FOG deposits contains matter such as cooking oil, grease, meat, margarine, lard, butter and sauces. FOG components enter sewer system by two different way which are directly release into sewer or grease trap failure. Grease trap failure means the grease trap cannot separate water and oil effectively. When the FOG deposits enter sewer system, the worst scenario is the FOG could stuck in the pipeline. The effect from this matter is imbalance pressure and flow between two compartments. As the FOG concentration increase, it can result blockage everywhere inside sewer system (Williams et al, 2012). Arthur & Blanc said that when the FOG entering inside sewer system, the system will experience restricting capacity and damaging pipes as the FOG solidifies on the surface of the sewer. Other that, FOG deposition can create corrosion reaction on sewer pipes under anaerobic conditions thus reduce life span of the pipe. The problem can impact on total expenditure to be spent hence waste a lot of time for the next maintenance action.

The development of grease trap is the only way to control and eliminate the FOG from enter directly into sewer system. The method is installing grease trap in the sink outlet. Inside grease trap there are some important major component which is filter, skimmer, inlet pipe and outlet pipe. In the present, the problem of grease trap mostly from the skimming and filtering process. Skimming process is the process which the floating oil transfer into the filter. Skimmers can be categorized into 5 types which are weir, suction, elevating, sorbent and submersion. Sorbent (oleophilic) skimmers is the most

popular types of mechanical recovery techniques. Mechanical recovery function is to remove or eliminate oil from the surface of water using skimming device and to store the collected fluids. The skimmers with oleophilic sorbent surface shaped like disc, drums, belts, brushes or ropes are suitable for rougher water as in the sewer system. (Fingas, M, 2011) The problem involves from these skimmer is the skimmer not so efficient and cannot transfer every floating oil inside the grease trap tanks to the filter.current template.

1.3 Objectives

1. To design the concept of oil skimmer for grease trap
2. To fabricate the prototype of oil skimmer for grease trap
3. To measure retention time in separating fats, oils and grease from wastewater.

1.4 Scope of Research

1. The designing process methods based brainstorming, morphological chart, House of Quality (HOQ) and Pugh method.
2. The fabrication of grease trap prototype focus on the shape and materials choose.
3. The measurement based on time taken for the oil fully skim from the water.

CHAPTER 2

LITERATURE REVIEW

2.1 Grease Trap

Grease trap is a plumbing device designed to separate oil and water before discharge in a wastewater pipes system. Grease trap are highly needed for avoiding waste such as fats, oils and grease (FOG) from clogged up pipes through sewer system which could impact on environmental pollution issues. Blocked pipes with FOG waste results in flash floods during rainy seasons. FOG waste contains cooking oils, animal fats, cheese and butter. Grease will undergo through solidification process at normal temperature in sewer system. Grease trap usually installed on food premises as those place produce high amount of FOG in a day. Basic working principles of grease trap are when the outflow from the food premises enter grease trap. The solid particle will drowned to the bottom while the lighter particles such as grease and oil floats. The reasons of grease floats to the top surface because the density of oil is less than the solid food particles. The grease trap container will capture FOG waste when the water contains waste when flows through the container and acts as a reservoir. After that the wastewater forced through the crossover pipe while FOG waste and solid particles left in the container. Crossover pipe function as a double layer filter which preventing and removing the solids from water. When the wastewater filtered, it can safely release to sewer system. Grease trap with full capacity will discharge grease and wastewater into the sewer system.