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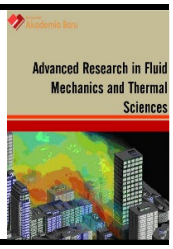

Portable Grease Trap for Wastewater Management System: A Conceptual Design Approach

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ABSTRACT

Irresponsible human attitude towards food waste management has led to water pollution all over the places especially in the public sewers. The abundance of small solid particles like fat, oil and grease (FOG) can still pass through the sink filter during daily dishwashing, which might cause clogging of the piping system. This research aimed to develop a conceptual design of a passive grease trap for wastewater management system. The process of determining the best design was done through customer survey, house of quality, morphological chart, and pugh method. The final concept has a reasonable size of 300 mm x 430 mm x 300 mm, a mass of approximately 7 kg that can be considered as light and portable. The grease trap system is divided into 3 partitions. The first partition functions as a solid filter. The second partition functions as oil filter as water is denser than oil. The last partition function as depositing remaining waste prior to the entry of water into public sewer. The proposed design is economical since the material used is only PVC and mild steel.

1. Introduction

Restaurants and domestic household discharging wastewaters into public sewers have been a problem for many years and it becomes greater with a large number of full-service and fast food restaurants being built both in large cities and rural communities [1-5]. These restaurants typically discharge a large amount of fat, oil, and grease that would reduce the capacity of public sewers over time. Once fats, oils or grease (FOG) enter the sewer lines, it cools, solidifies and sticks to the inner wall of the pipes, trapping food particles and other debris. After some time, these strong masses keep on developing until it blocks the stream of waste water and causes sewage to move down. This situation has led to the need for a grease trap, a device placed on kitchen cleaning appliances such as sinks, woks, and any other drains that collect grease [6]. The large amounts of oil from food

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production in kitchens and restaurants can overwhelm the septic tank or treatment facility, causing a release of untreated sewage into the environment. High viscosity fats and cooking greases solidify when cooled, and can combine with other disposed solids to form blockages in drain pipes. Legitimate size, establishment, utilize, and support of an oil trap will guarantee partition and maintenance of FOG from wastewater before it enters the sewer framework. This project focuses on concept generation and conceptual design in developing grease trap system based on customer requirement and engineering specification. A grease trap is a device to set on kitchen cleaning apparatuses, for example, sinks, woks, and other channels that gather grease. Wastewater has been treated since many years ago using different techniques such as membrane separation technology, biological treatment, coagulation and etc. [7-9]. Grease trap otherwise called grease interceptor, grease recuperation device or grease converter is a plumbing device intended to catch most oils and solids before they enter a waste water transfer framework. There are many types of grease trap. One of them is hydromechanical. These units depend on the standards of warmth and gravity to isolate the FOG from the waste water. Regularly these units are made of carbon steel or plastic. Hydromechanical oil traps control the stream of water permitting the hot water to cool. The confuse gets the FOG and keeps it inside the oil trap. These oil traps must be cleaned physically and regularly. The estimating of the Hydromechanical units are communicated in poundage and in gallons every moment (GPM) stream. The second type of the grease trap is passive. This type of grease trap uses compartments of two or more and uses the larger amount of water flowing to slow down the water inside the trap. This allows for FOG to become buoyant and to separate. These grease traps are efficient, allowing 90% of FOG to be collected out of the water. The third is an Automatic Grease Removal Unit (AGRU). This kind of oil trap uses mechanical and electrical parts to really skim FOG out of the water. These frameworks are small yet very proficient. Most AGRU units can take out 99% of FOG from water.

There are few common problems that faced by a grease trap, which can prevent it from operating effectively. One of the problem is clog in crossover. It occurs when FOG or debris build up in the crossover line between the two compartments. If the crossover pipe is clogged, the liquid level in the first compartment will be too high while the level in the second compartment will be normal. The water may even be overflowing in the first compartment. A study done by Arthur & Blanc [6] shows that FOG entering the wastewater system cause a number of problems, that they clog the system by restricting capacity, blocking and damaging pipes. This increases both the time and money required for cleaning maintenance. Also, if not fully removed and treated, the FOG can deplete oxygen in receiving waters. The additional capacity and energy is required at wastewater treatment works to handle excess FOG entering the system. By the same token, clog in outgoing also another common problem which interrupts the flow. If there is a clog in outgoing line of grease trap interceptor, the grease trap will start to overflow in both compartments. . The clog in the outgoing line can become very serious. If never pump the waste on cycle, it will cause clog and make sure to dispose the wastewater on cycle. Clog in incoming line also one of the common problem that faced by a grease trap. So, clog in the incoming line cause the restaurant's lowest plumbing fixture to become backed up. At the heart of this issue is an excessive buildup of debris and FOG in the line that channels everything into trap. This will clog the crossover, incoming, and outgoing lines. In this can check if the depth of the grease cap by using pole and if goes all the way to the bottom, it is the time for pump the grease. Shaffar [10] suggested that blockage "hot spots" can be grouped into three categories, grease loading, design or structural issues and sewer cleaning effectiveness.

2. Research Method

The project started by conducting customer's survey in defining customer's needs. The requirements received was generally in terms of maintenance, material, portability, ease to handle and function. The needs were compared to engineering characteristics in producing product design specification using House of Quality (HOQ). Concept generation was started by defining function analysis in the morphological chart. In morphological chart, ideas were generated by combining options to create new concept of product. In the end, the best concept was chosen from the analysis using Pugh Method [11-13].

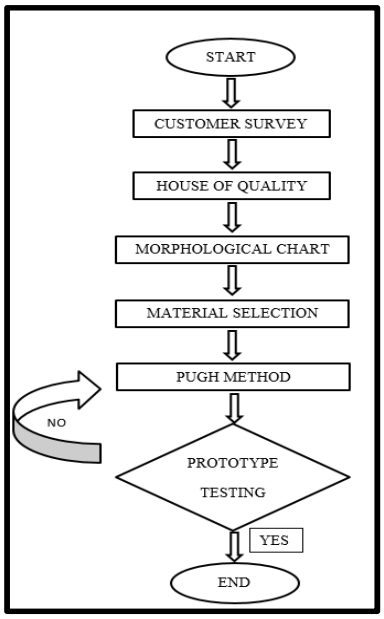


Fig. 1. Flowchart in developing portable grease trap system

3. Results and Discussion

Dispersion in the beginning, most important data are collected and then included into the project questionnaire. The questionnaire consisted of twenty questions that being gave to fifty one respondents which are the owners of the restaurant regarding their FOG disposal into the drainage, how frequent is the service to remove the blockage in sink pipeline and also the time took for services. After all the data were being compiled and gathered, it can determine the suitable concept in oil draining. The respondents of this questionnaire are from various restaurants at Klang, Shah Alam, Bandar Hilir, Ayer Keroh and Batu Berendam. Each question is analysed by the answer from respondent in percentage. The answers from the questionnaire are various, which is all based on their experiences and individual suggestion in this restaurant business. Figure 2 below shows that the every 51 restaurants that been surveyed use grease trap in their restaurants. This indicated that the role of a grease trap in restaurant is very important. Next on Figure 3, the survey shows that apart of using the grease trap heavily, it is also important to clean it accordingly. It shows that all owners clean the grease trap at least once a week. In Figure 4, the data shows that 96% of the respondents maintain the grease trap system by doing it themselves. Only 4% of them maintained the system

using the waste hauler licensed by the ministry of environment.

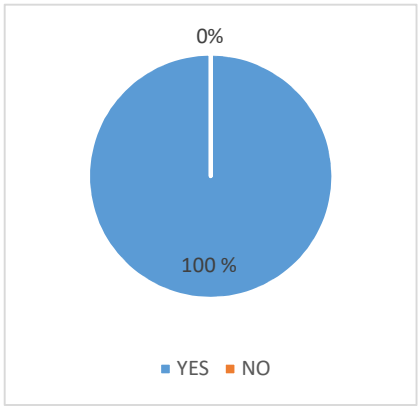


Fig. 2. Restaurants with grease trap system

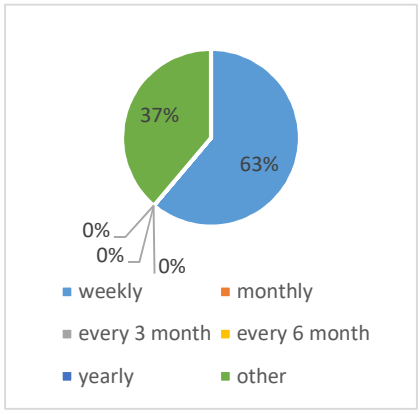


Fig. 3. Frequency of maintenance

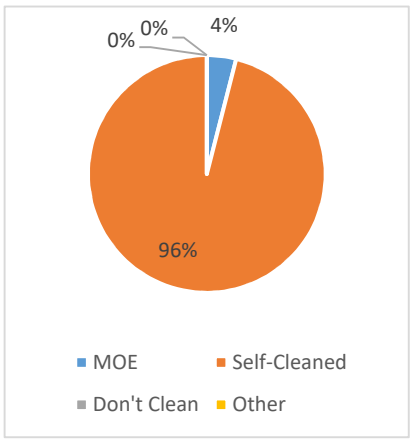


Fig. 4. Cleaning process

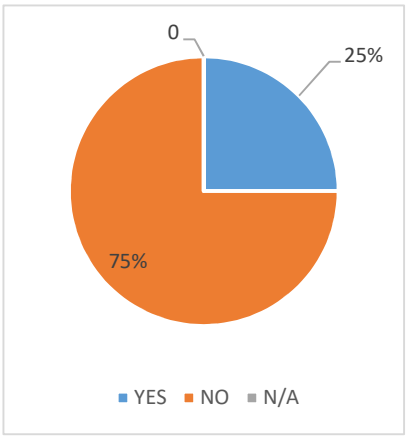


Fig. 5. Experienced sewage blockage

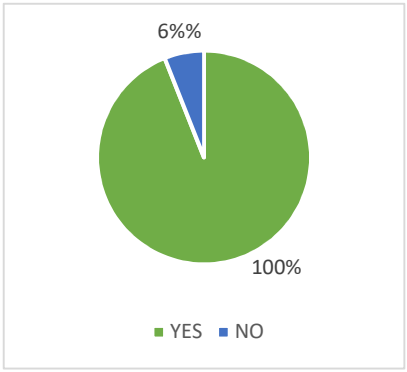


Fig. 6. Importance of oil separator

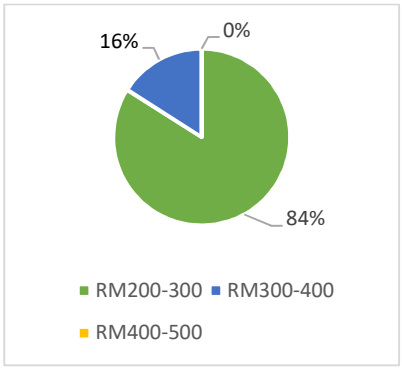
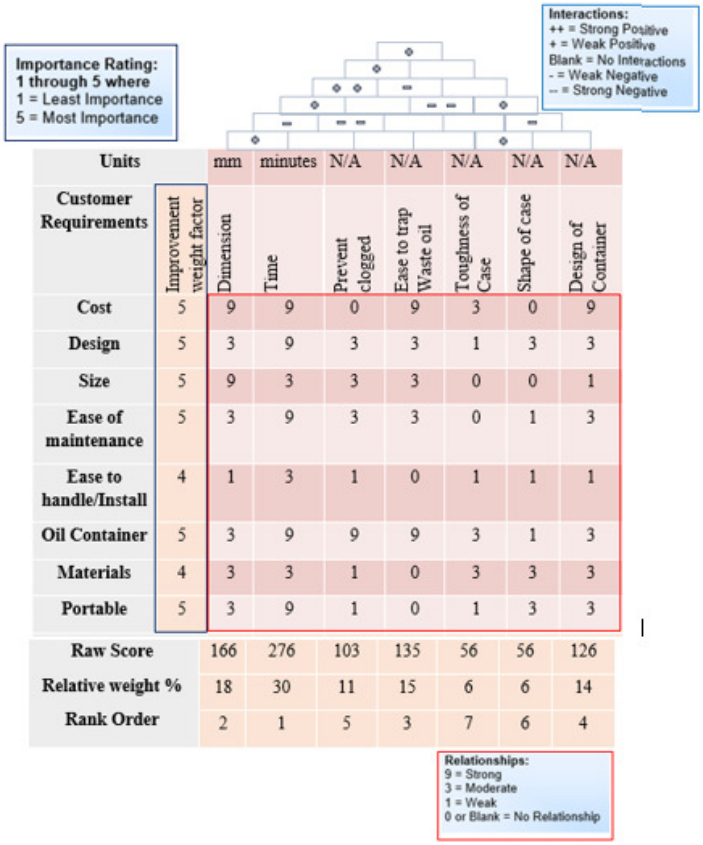


Fig. 7. Acceptable price

In Figure 5, one fourth of the restaurants have experienced sewage blockage despite using grease trap system. This result shows that there is possibility of inefficiency among all the grease trap systems used by the restaurants owners. One of the most important components is the separation

of fat oil and grease from each other in order to ensure smooth flow from the inlet to the outlet. In Figure 6, it shows that majority of the respondents, which is 94%, agree that the inclusion of oil separator is important as preventive maintenance. However, none of them are willing to spend more than MYR 400 to have the grease trap with oil separator as shown by Figure 7.



Units		mm	minutes	N/A	N/A	N/A	N/A	N/A
Customer Requirements	Improvement weight factor	Dimension	Time	Prevent clogged	Ease to trap Waste oil	Toughness of Case	Shape of case	Design of Container
Cost	5	9	9	0	9	3	0	9
Design	5	3	9	3	3	1	3	3
Size	5	9	3	3	3	0	0	1
Ease of maintenance	5	3	9	3	3	0	1	3
Ease to handle/Install	4	1	3	1	0	1	1	1
Oil Container	5	3	9	9	9	3	1	3
Materials	4	3	3	1	0	3	3	3
Portable	5	3	9	1	0	1	3	3
Raw Score		166	276	103	135	56	56	126
Relative weight %		18	30	11	15	6	6	14
Rank Order		2	1	5	3	7	6	4

Fig. 8. House of quality

All of the customer requirement are analysed using House of Quality to identify the most important engineering characteristics in fulfilling the customer's needs. Maintenance time, grease trap dimension and ease to trap the waste are rated the most important criteria to be realized. According to Morphological Chart, there are altogether 5 functions and 4 options to be matched in developing new concepts. From Table 1, there was three selected final concept from the morphological chart which are:

Table 1
Morphological chart in constructing concepts

	Option 1	Option 2	Option 3	Option 4
Weight of devices	5kg	7kg	9kg	11kg
Type of material	Stainless steel	Plastic	Mild steel	Aluminium
Maintenance	Once a week	Daily	Once a month	3 month
Baffle	Two	Three	One	Four
Shape of case	Square	Rectangle		
Place of device	Below sink	Near drain	In soil	

Three concepts mentioned above was then evaluated and selected by using Pugh Method. Compared to the datum and customer survey, one final concept has been developed into a parametric design for grease trap as shown in Figure 9.

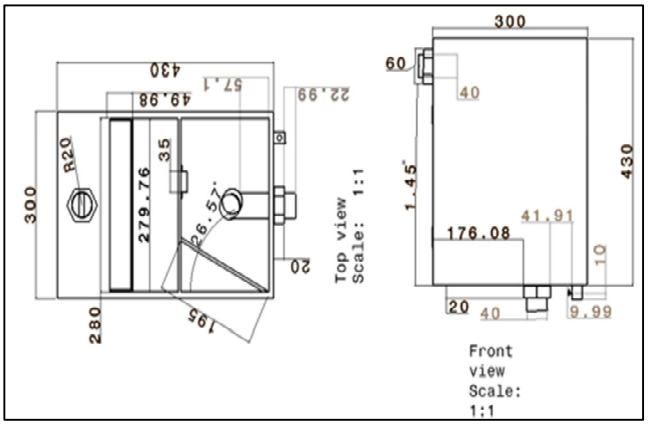


Fig. 9. Parametric design of selected concept

This concept was built based on gravitational law and Bernoulli law. Oil which has lower density tends to move above the water level if placed in the same container. The pressure of static fluid depends upon the depth of the fluid, given that fluid density and acceleration of gravity remain constant. Thus, oil will remain at the water surface and water will be transferred through the baffle located at the bottom part of the container. The newly developed prototype is considerably smaller compared to the previous design of Rahmiana *et al*.,[14] and Tarek *et al*., [15]. Moreover, the materials used for the prototype as shown in Figure 3 are mild steel and PVC that are easily available in the market and the prices are considerably low. The superiority of this grease trap prototype is portability. It can be moved easily to other places without lifting. Most of the passive grease trap must be lifted for maintenance and cleaning processes as well as to transfer it to another place. It is ergonomically not good for the user. The leftover foods can be moved once all the fluid in the container was flowing out.

4. Conclusion

This paper presents an inclusive review on a new conceptual design of grease trap system has been developed according to customer requirements. The combination of HOQ, Morphological Chart, and Pugh Method has produced not merely a lightweight but also portable prototype of grease trap system which is user-friendly because the installation process is easy and contaminated water inside the system can be disposed easily by opening the nozzle.

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References

[1] Akpor, O. B. "Wastewater effluent discharge: Effects and treatment processes." In *Int. Conf. Chem. Biol. Environ. Eng*, vol. 20, pp. 85-91. 2011.

[2] Husain, Iman AF, Ma'an Fahmi Alkhatib, Mohamed Saedi Jammi, Mohamed ES Mirghani, Zaki Bin Zainudin, and Asif Hoda. "Problems, control, and treatment of fat, oil, and grease (FOG): a review." *Journal of oleo science* 63, no. 8 (2014): 747-752.

[3] Montefrio, Marvin Joseph, Tai Xinwen, and Jeffrey Philip Obbard. "Recovery and pre-treatment of fats, oil and grease from grease interceptors for biodiesel production." *Applied Energy* 87, no. 10 (2010): 3155-3161.

[4] Nisola, Grace M., Eul Saeng Cho, Ho Kyong Shon, Dan Tian, Dong Jun Chun, Eun Mi Gwon, and Wook Jin Chung. "Cell immobilized FOG-trap system for fat, oil, and grease removal from restaurant wastewater." *Journal of environmental engineering* 135, no. 9 (2009): 876-884.

[5] Dumore, Nilesh S., and Mausumi Mukhopadhyay. "Removal of oil and grease using immobilized triacylglycerin lipase." *International biodeterioration & biodegradation* 68 (2012): 65-70.

[6] Arthur, S., and J. Blanc. "Management and recovery of FOG (fats, oils and greases)." *CREW Project CD2013/6. Available online at:< crew. ac. uk/publications>.(Aug. 2015)* (2013).

[7] Lan, W. U., G. E. Gang, and W. A. N. Jinbao. "Biodegradation of oil wastewater by free and immobilized Yarrowia lipolytica W29." *Journal of Environmental Sciences* 21, no. 2 (2009): 237-242.

[8] Yu, Li, Mei Han, and Fang He. "A review of treating oily wastewater." *Arabian journal of chemistry* 10 (2017): S1913-S1922.

[9] Mueller, S. A., B. R. Kim, J. E. Anderson, A. Gaslightwala, M. J. Szafranski, and W. A. Gaines. "REMOVAL OF OIL AND GREASE AND COD FROM OILY WASTEWATER BY ADSORPTION." *Proceedings of the Water Environment Federation* 2001, no. 9 (2001): 522-528.

[10] Shaffer, J. "Is FOG Getting Too Much Blame for Sewer Blockages?." *Trenchless Technology* 17, no. 12 (2009): 40-42.

[11] Schmidt, Linda C., and George E. Dieter. *Engineering design: By George E. Dieter and Linda C. Schmidt*. Creative Publisher, 2015.

[12] Hussin, M.S. Firdaus, Mohd, Y. Halyani, Muhammad, I.H.C. Abdullah, and Omar, M. Rafi. "Flexible shield for impact resistance purpose: a conceptual design approach." Proceedings of Mechanical Engineering Research Day, 134-135. 2017.

[13] Eman, U. N., H. M. S. Firdaus, M. Y. Halyani, Zulhasnizam Hasan, and R. F. Farhana. "Optimization of Stiffened Square Plate Topographically under Uniform distributed Pressure." In *MATEC Web of Conferences*, vol. 97, p. 01071. EDP Sciences, 2017.

[14] Zein, Rahmiana, S. Refilda, N. Lidya, Mukhlis, N. Syukrya, S. Neneng, N. Heric. "Novel two stage vertical flow biofilter system for efficiency treatment of restaurant wastewater." Research journal of pharmaceutical, biological, and chemical sciences, vol. 7, no. 5. 71-79. 2016.

[15] Aziz, Tarek N., Leon M. Holt, Kevin M. Keener, John W. Groninger, and Joel J. Ducoste. "Performance of grease abatement devices for removal of fat, oil, and grease." *Journal of Environmental Engineering* 137, no. 1 (2010): 84-92.