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Chapter 3

Autonomous Grease Trap Maintenance System Based on Internet of Things (IoT)

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ABSTRACT

The untreated kitchen wastewater generated from the commercial kitchen operation without a proper disposal method has been causing several sewer piping clogging cases in recent years. The irregular schedule of executing grease trap maintenance will lower the efficiency of removing the fat, oil, grease (FOG), and food particles in wastewater before going to the sewage treatment system. An autonomous grease trap maintenance system was designed based on the internet of things (IoT) to monitor wastewater conditions and automatically carry out the cleaning maintenance task to the grease trap. This system uses the turbidity and ultrasonic sensor to monitor the wastewater while a centrifugal pump will pump out the wastewater when it triggers the sensors. The system was connected with the Blynk Application to able remotely monitored. The "1/4 rule" of grease trap regulation was implemented using the pump to discharge the wastewater to avoid exceeding 25 percent of grease trap volume. Turbidity testing was performed to determine the turbidity ADC (Analog-to-Digital Converter) turbidity values using different concentrations of Chinese calligraphy ink mixed with tap water. As a result, the autonomous grease trap has reduced the turbidity value of wastewater from 2305 Nephelometric Turbidity Unit (NTU) to 1269 NTU after conducting maintenance service. The wastewater removal efficiency of the autonomous grease trap unit is about 81.64 percent. According to the local authority, it is convenient, efficient, saves cost, and fulfills the maintenance requirements.

Key Words: FOG, Grease trap, Nephelometric Turbidity Unit, Wastewater Management

1. INTRODUCTION

The growing technology has made every work easier, time-saving, and more efficient. Internet of things (IoT) has transformed the way people live. It is one of the growing technologies in the modern world. IoT connects devices, collects data, transforms it into useful information, and distributes it through the organization with the internet (cloud) (IoT For All, 2021).

The municipal authorities have enforced the law Street, Drainage, and Building Act 1974, requiring all commercial restaurants to install grease traps in the kitchen. An RM1000 fine is to issue to those who ignore this implementation (TheStar, 2005). A grease trap is a water filtering device to separate the fat, oil, grease (FOG), and food particles in the wastewater to the public sewer pipeline and sewage treatment system. It is to prevent the pipe from being clog. Moreover, implementing a grease trap requires a maintenance cleaning service to ensure FOG and food particles are removed from the grease trap. However, the stinky odor of the grease trap is unpleasant, making it harder for the maintenance staff to carry out the maintenance work.

Autonomous Grease Trap Maintenance System Based on the Internet of Things (IoT) is brought up to resolve the common problem of sewage piping clogging. As the title stated, the grease trap maintenance system will be autonomous, which helps reduces the burden for maintenance staff. This system can monitor the condition of wastewater at the actual time and automatically discharge the wastewater in the grease trap into a sewage tank. This autonomous system also monitors the water quality and water level of grease trap receiving from the turbidity and ultrasonic sensors to notify the users. The autonomous maintenance service is implemented according to the "1/4 rule" of local authority requirements. This means the floating grease and food particles cannot exceed 25 percent of the grease trap volume. In this research, testing of the sensors and software design will be carried out to ensure the functionality of the Autonomous Grease Trap Maintenance System based on IoT is working without any problem.

2. LITERATURE REVIEW

2.1 Grease Trap

The grease trap is a plumbing device to intercept and separate the free-floating fat, oil, grease (FOG), and food debris from the water, preventing it from flowing through the drainage pipe to the sewage treatment plant. The purpose of using grease traps is to prevent the clogging of waste lines. There are three major types of grease trap in the commercial market, which are Hydromechanical Grease Interceptor (HGI), Gravity Grease Interceptor (GGI), and Automatic Grease Removal Unit (AGRU). A different grease trap or interceptor types have different performance specifications, such as dimension, capacity, grease removal efficiency, and features. This project is focused on the HGI grease trap shown in figure 1. HGI is the most common type of commercial kitchen operation like restaurants, cafes, or hotels. This is often installed in the kitchen underneath the sink or on the floor. It uses the physical principle to separate grease, water, and high-density food debris in different layers due to the density. The FOG, which is less dense than water, will float at the top of the water surface while the heavy food debris will sink at the bottom of the grease trap. As a large amount of grease and debris accumulate in the system, trapping the grease and solids decreases. Therefore, it requires cleaning it manually and frequently to ensure this trap works properly in filtering the grease and solids (Thermaco Inc, 2019).

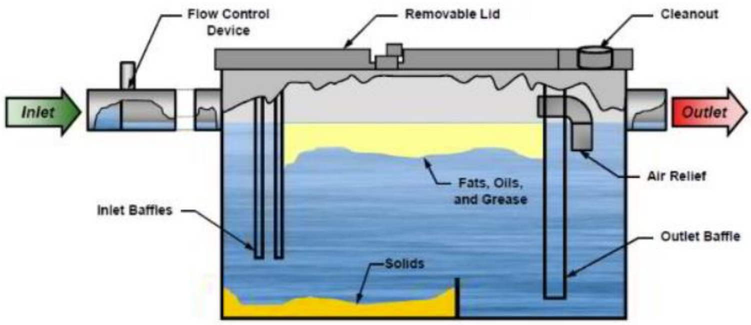

Figure 1: Hydromechanical Grease Interceptor (Hall's Septic Services Inc., 2021)

2.2 Application of Internet of Things (IoT) in Maintenance

IoT is a concept that connects all of the devices in our life with the internet. This system can transfer data over a network to those devices without requiring human-human or human-machine interaction (Gillis, 2019). A common IoT system consists of four fundamental components: sensor or devices, connectivity, data processing, and user interface (McClelland, 2017).

The main reason for implementing IoT to manage the devices by predictive maintenance (PDM). Predictive maintenance is to monitor the condition and performance of devices during normal operation to minimize the possibility of failures. IoT system enables wireless connection between humans and machines, monitoring the devices for pending failures and notify users when a part of the device is required for replacement. The sensors will ensure the good condition of the device and stop the device when abnormal conditions arise. Hence, the users can accurately predict the failure of the device based on the device condition report, and the maintenance engineer can solve the problems of the devices without spending time on inspecting (O'Brien, 2019).

2.3 Turbidity, Water Level Characteristic, and Fat, Oil and Grease (FOG) Removal Efficiency

Turbidity is the cloudiness of a fluid that contains the suspended solid particles that are unable to observe by naked eyes. It is an important parameter to determine the quality of water. The measuring unit for turbidity in Nephelometric Turbidity Unit (NTU). Siahaan *et al.* (2018) have studied the concentration of ink droplets to the water against NTU using their own designed Arduino UNO-based water turbidity meter. According to their studies, the higher the concentration of ink droplet in the water, the higher the value of NTU.

A research study done by (2018) developed an Arduino Uno-based water turbidity monitoring system to measure the water and turbidity's water level. Next, Al-Gheethi *et al.* (2019) had developed a fat, oil, and grease (FOG) trap as a primary treatment of raw kitchen wastewater based on the gravity separation principle. The optimization of the FOG separation process was determined using the response surface methodology (RSM) based on the water flow rate and the peak time of kitchen wastewater. This is to determine the best optimization removal of FOG.

In summary, this project is a new design unit for the grease trap to filter the fat, oil, grease, and food particles by using a centrifugal pump to control the Arduino microprocessor and monitor the condition of wastewater. It will comprise results from previous studies from different researchers to justify the findings of autonomous grease trap such as turbidity, water level characteristic, and removal efficiency.

3. METHODOLOGY

3.1 General System Design

The autonomous grease trap maintenance system was built using five components: turbidity sensor, ultrasonic sensor, microcontroller (Arduino WeMos D1 R2), centrifugal pump, and software application (Blynk Application) shown in figure 2. Both sensors will collect the control parameters for the input and then transfer the parameters as input data into Arduino. The Arduino microcontroller will process the input parameters into useful information. Once processed, it will automatically analyze the data according to the coding uploaded and send the processed data to the Blynk application as a user interface to display the output values getting from the turbidity sensor and ultrasonic sensor. It will initialize the centrifugal pump to discharge the water when the input parameters contradict the program statements.

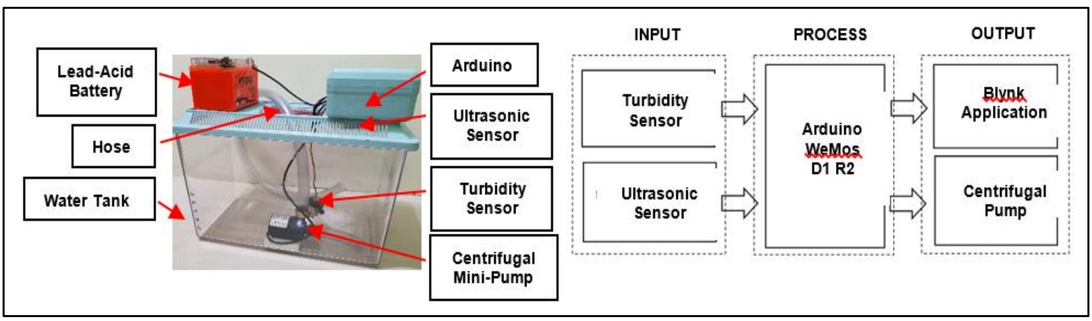

Figure 2: Autonomous Grease Trap Maintenance System and Block Diagram of the System

3.2 Software Design

Figure 3 shows the flowchart of the program design of the Autonomous Grease Trap Maintenance system. The Autonomous Grease Trap Maintenance system starts with three major components: turbidity sensor, ultrasonic sensor, and centrifugal pump. These components will be switched on, and the sensors begin to indicate the value of turbidity percentage and water level percentage in the smartphone application. When the value of sensors fails to meet the required statement of turbidity percentage (<50%) and water level percentage (>70%), the centrifugal pump will receive the command signal and automatically pump out the dirty water.

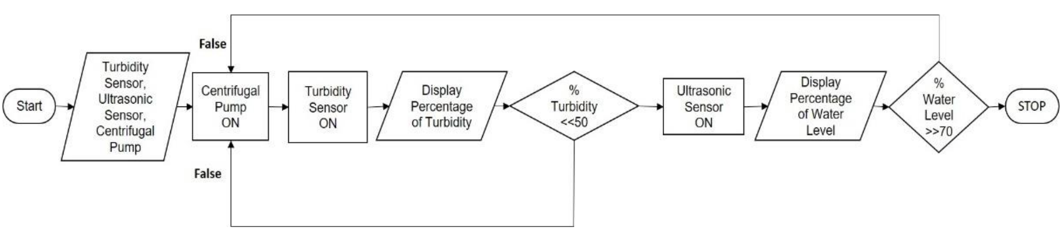

Figure 3: Flowchart of software design

3.3 Turbidity Sensor and Ultrasonic Sensor Testing Procedure

The turbidity sensor in this system is to determine the amount of light transmitted through the Chinese calligraphy ink mixing with the tap water. The water tank was filled with 5 liters of tap water, and measurement of turbidity value was checked through the Blynk application to ensure there are no connection problems. A droplet of Chinese calligraphy ink will be dropped into the tap water and stirred to mix it evenly with the tap water. The turbidity value shown in the Blynk application will be recorded down. The process is repeated by increasing the number of droplets.

The ultrasonic sensor testing is to determine the water volume or water level. The water tank is ensured to be empty in the beginning. The measurement value of the water level is checked through the Blynk application. Then, 1 liter of tap water was poured into the water tank, and the data were recorded from the Blynk application. The testing is repeated by increasing the volume of tap water.

4.0 RESULTS AND ANALYSIS

Figure 4 shows the turbidity testing result, and it is found that the turbidity (NTU) is inversely proportional to the voltage (V). The turbidity testing results proved that the higher the turbidity of the water, the lower the output voltage generated from the remained light passing through the wastewater. The percentage error between the actual and standard values of the turbidity sensor is 2.77 percent. As shown in figure 5, the ultrasonic testing result indicates the water level ADC is inversely proportional to the water volume of the water tank.

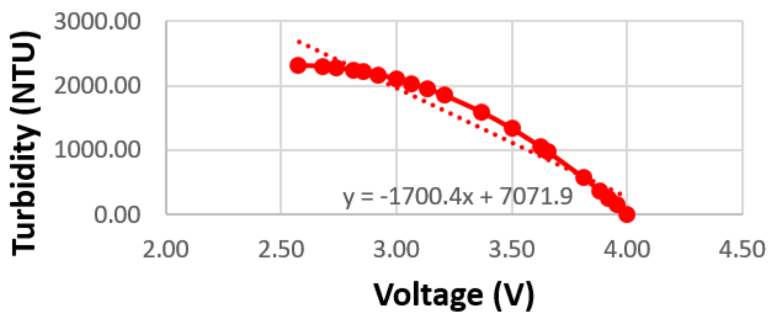

Figure 4: Turbidity Analysis

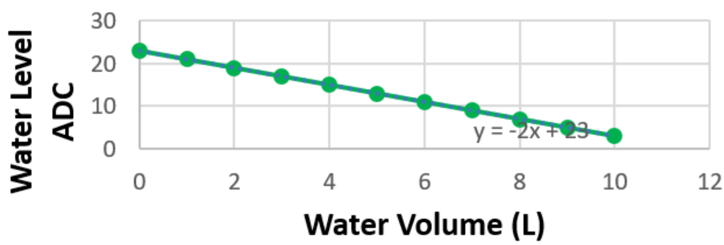

Figure 5: Ultrasonic Testing Analysis

Figure 6 shows the relationship between water turbidity and the time when the system operates. The water quality of the grease trap is dark and dirty, where the wastewater turbidity value is about 2305 NTU. After finishing discharging the wastewater, the turbidity value of the grease trap has dropped to 1269 NTU. As a result, the wastewater removal efficiency of grease trap with implementing the automatic maintenance system is about 81.64 percent.

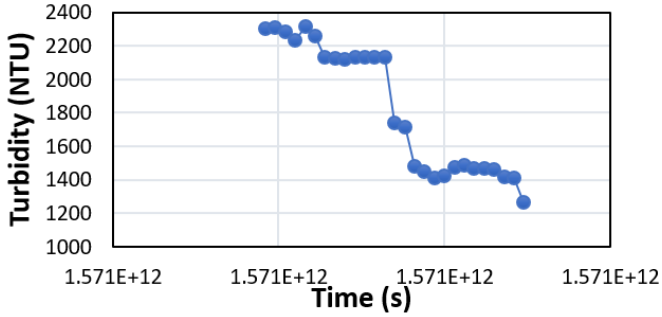

Figure 6: Relationship between water turbidity and operating time

5. CONCLUSION AND RECOMMENDATION

In conclusion, the autonomous grease trap maintenance system is built by two following sub-systems: water quality monitoring system-based IoT and automatic sewage discharge system. The turbidity sensor was found to react to every droplet of Chinese calligraphy ink and immediately send every signal to the monitoring system. Besides that, the ultrasonic sensor test results show that the sensor parameter (ADC) decreases when the water level increases. Next, the clean-up maintenance has followed the "1/4 rule" to ensure the sewage does not exceed 25 percent of volume to satisfy local authorities requirements. The designed system can be remotely monitored with the Blink Application. To improve the current design, the implementation of other measurement parameters such as density, pH level, conductivity, and others would help to increase the accuracy of water quality measurement. Different wastewater parameters can assist in monitoring the wastewater quality when one of the sensors indicates the error.

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