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Design and Construction of Domestic Oil and Fat Waste Processing as a Practical Tool for Practical Application in Waste Processing Technology in the DIII Industrial Chemistry Study Program

Edwin Permana[1], Martina Asti Rahayu[2], Intan Lestari[2], Ali Nurdin Hidayat[3]

[1]Chemical Industry Department, [2]Chemical Analysis Department, [3]Chemistry Department, Faculty of Science and Technology, Universitas Jambi,
Jl. Raya Jambi Muara Bulian, Muara Jambi, Jambi, Indonesia.

Corresponding author
[1]edwinpermana86@unja.ac.id

Abstract: Domestic wastewater is a liquid waste originating from household waste, including bathroom waste, kitchen waste, used water for washing food, and others. Before being discharged into the environment, domestic wastewater must first be processed in the Wastewater Treatment Installation Unit (IPAL) so as not to cause environmental pollution. One of the wastes that can cause water or rivers to smell is the high fat/oil content present in the water. One of the domestic wastewater treatment techniques is with a wastewater treatment installation (IPAL) by utilizing flotation techniques with physical and chemical filtration processes in the process principle. This process aims to remove solid particles that have low density, making it difficult to settle. Additionally, this tool does not require a large area and is easier to clean. In addition, this tool will also be a means of a tool for waste processing technology practicums in the Industrial Chemistry DIII Study Program.

Keywords: Domestic, Technology, Wastewater

Introduction

Wastewater from industrial, domestic, agricultural, livestock, and other processes in the environment because it can affect the quality of the environment. Waste is divided into liquid waste, solid waste, and gas depending on its form and properties. Liquid waste is waste from processes that are no longer used, whether in industrial, household, agricultural, or other activities. Liquid waste that we often encounter in everyday life is household waste or household waste. Household waste is generated in residential areas due to daily human activities.[1]

The many activities carried out by humans can result in domestic or household waste disposal systems such as bathroom and kitchen waste so the waste can cause pollution to occur which can be detrimental to humans. The primary characteristic of domestic waste, which contains many bacteria, viruses, and parasites causes the spread of disease quickly, the detergent content in domestic wastewater increases nutrients, especially phosphorus components and high nitrogen which can cause eutrophication. In addition, the main contaminants from domestic waste come from food ingredients, cooking processes, and the cleaning stage of washing equipment in the form of organic materials and soap or detergent. Organic compounds contained in domestic wastewater are carbohydrates, proteins, fats, and oils.[2]

Oil and fat contained in the wastewater without being treated first before being disposed of will cause negative impacts. Excessive accumulation of

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oil and fat causes blockage of the water drainage. If disposed of into a body of water, oil and fat will float because they have a lower specific gravity than water, resulting in the water surface being covered. Oil and fat that cover the water surface reduce oxygen diffusion, so that microorganisms in the water will be disturbed.[3]

This waste treatment aims to reduce the content of pollutants, especially organic compounds, suspended solids, pathogenic microbes, and organic compounds that cannot be broken down by natural microorganisms. Waste treatment is basically divided into three, including Physical treatment, namely mechanical treatment such as filtering, floating and sedimentation. Chemical treatment, namely treatment with the addition of chemicals, and Biological treatment, namely treatment by utilizing the activity of microorganisms. However, there is also a combined physical and chemical waste treatment such as waste treatment using Dissolved Air Flotation (DAF). [4]

One of the alternative treatments that can be applied to treat domestic wastewater is by using the DAF (Dissolved Air Flotation) process. Dissolved Air Flotation (DAF) is a method that can be used in water treatment. The working principle of Dissolved Air Flotation (DAF) is to float by dissolving air into a fluid with a fairly high pressure and then releasing it at atmospheric pressure. The combination of fine gas bubbles produced from high air pressure and suspended solids or oil results in a decrease in gravity, thereby increasing the buoyancy of various organic components whose density is lighter than water such as oil and fat. For organic and inorganic components whose density is heavier than water, they will experience gravity in the flotation or sedimentation process with the help of the addition of chemicals such as bentonite. According to the method, this method can be called a physical and chemical waste treatment method because there is physical treatment, namely flotation and sedimentation, and chemical treatment, namely the addition of bentonite chemicals to help the flotation and sedimentation process.[5]

It is expected that this process aims to remove solid particles that have low density, making it difficult to settle. In addition, to make a DAF tool does not require a large area and is easier to clean. In addition, this tool is also a means of a tool for waste processing technology practicums in the Industrial Chemistry DIII Study Program.

Materials and Methods

Tools and materials

The equipment and materials needed to make a DAF are as follows

1. Acrylic with a thickness of 4 mm, used to make DAF units consisting of contact zones, separation zones, and settling zones,
2. Compressor.
3. Pipes made of polyurethane and stainless steel
4. Skimmer.
5. Rotameter.
6. Barometer.
7. Valve.
8. Stand made of stainless steel to maintain the Unit.

Tool Design

The design of the tool begins by calculating the dimensions of the saturation tank, DAF tank, pump requirements, and piping requirements. After that, a DAF design scheme is made which is shown in Figure 1 below.

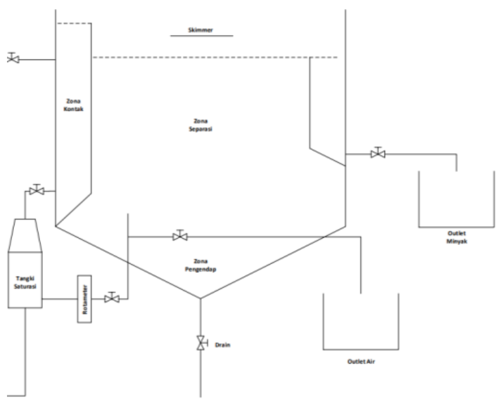

Figure 1. Tool Design

Results and Discussion

This discussion section will discuss the design of the Oil and Fat Separator, which is an effective method for separating dissolved and dispersed particles from wastewater. In this discussion, the design of the tool, description of the tool parts, selection of the right construction materials, tool working procedures, and also troubleshooting or solving problems that may occur during operation will be explained.

Good equipment design is essential to achieve optimal performance in the process of separating particles from wastewater. Proper design involves factors such as the size and shape of the flotation tank, saturation tank, pipes, and air injection system. A detailed description of the equipment parts will provide a clear understanding of the function and role of each component in the process.

In addition, choosing the right construction material is also an important factor in the design of the tool. Various materials such as stainless steel, acrylic, polycarbonate, FRP (Fiberglass Reinforced Plastic), or polyethylene/polypropylene have their own advantages and disadvantages. These considerations will help in choosing the right material for operational needs.

The equipment operating procedures will describe the operational steps required to achieve efficient particle separation. This includes regulating wastewater flow, regulating air injection rates, and monitoring other operational conditions. Possible troubleshooting procedures will also be provided, including common signs of problems, potential causes, and possible solutions.

By combining data obtained from the field, assumptions based on literature, and design adjustments at the laboratory scale, it is hoped that readers can gain comprehensive insight into designs that are suitable for use in the laboratory, and are able to optimize their performance in separating particles from wastewater.

DAF Flotation Tank Design Calculation

Flotation unit design is an important aspect in water treatment systems that use the Dissolved Air Flotation (DAF) method. This flotation unit is used to separate solid particles or dissolved substances from water with the help of dissolved air bubbles. The dimensions of the flotation unit must be considered to ensure optimal efficiency and performance in the separation process.

In calculating the dimensions of a flotation unit, several factors need to be considered, including the surface area of the tank, the volume of the tank, the water flow rate, the size and number of air bubbles, and particle parameters such as the size and specific gravity of the particles to be sedimented.

In calculating the dimensions of the DAF flotation unit which consists of cube and trapezoid shapes, the following are the calculations that can be carried out.

1. Flotation Tank Volume: Volume of cube = 70 cm × 70 cm × 70 cm = 343,000 cm^3 = 0.343 m^3 Volume of trapezoid = 90 cm × 20 cm = 1,800 cm^3 = 0.0018 m^3 Total volume = Volume of cube + Volume of trapezoid = 0.343 m^3 + 0.0018 m^3 = 0.3448 m^3
2. Flotation Tank Surface Area:
Surface area of cube = 6 × (70 cm × 70 cm) = 29,400 cm^2 = 2.94 m^2 Surface area of trapezoid = (90 cm + 70 cm) × 20 cm ÷ 2 = 3,200 cm^2 = 0.32 m^2
Total surface area = Surface area of cube + Surface area of trapezoid = 2.94 m^2 + 0.32 m^2 = 3.26 m^2
3. Water Flow Rate:
Water Flow Rate = 10 liters/minute = 0.01 m^3/minute
4. Bubble Size and Number:

The size and number of air bubbles injected can be determined based on the required air pressure and the characteristics of the particles to be treated. Assume the air bubble size is about 100 microns and the air pressure is about 2-4 bar. So, the dimensions of the flotation tank are to have a volume of 0.3448 m^3 and a surface area of 3.26 m^2, and a water flow rate of 0.01 m^3/min.

The capacity of liquid waste that can be processed is based on several assumptions:

1. Waste flow rate: 10 liters/minute = 0.01 m^3/minute
2. Residence time: 30 minutes = 1800 seconds (assuming residence time in flotation unit)

3. Particle concentration: 100 mg/L (assumption of particle concentration in liquid waste)

The calculation steps are as follows:

1. Calculating the volume of waste that can be processed per minute:
Volume per minute = Waste flow rate = 0.01 m^3/min
2. Calculating the volume of waste that can be processed during the residence time:
Total volume = Volume per minute × Residence time
Total volume = 0.01 m^3/min × 1800 seconds
Total volume = 18 m^3
3. Calculating the mass of particles in liquid waste:
Particle mass = Particle concentration × Volume total
Particle mass = 100 mg/L × 18 m^3
Particle mass = 1800 mg = 1.8 g

Thus, assuming a wastewater flow rate of 10 liters/minute, a residence time of 30 minutes, and a particle concentration of 100 mg/L, the flotation unit can treat liquid waste with a total capacity of 18 m^3 and a particle mass of 1.8 g.

In calculating the dimensions of the DAF flotation unit, the calculation of the volume of the flotation tank was carried out at 0.3448 m^3 and the surface area of the flotation tank was 3.26 m^2. The water flow rate used was 0.01 m^3/min. The assumption of the size and number of air bubbles injected is around 100 microns with an air pressure between 2-4 bar.

In terms of the capacity of liquid waste that can be treated, assuming a waste flow rate of 10 liters/minute, a residence time of 30 minutes, and a particle concentration of 100 mg/L, the flotation unit can treat liquid waste with a total capacity of 18 m^3 and a particle mass of 1.8 g.

Work procedures

The process begins by introducing wastewater containing dispersed oil or solid particles with a density lighter than water into the flotation tank. Then, air is flowed into the air and water mixing tank (saturation tank). Water from the previous process is recycled using a pump to mix with the air in the saturation tank. The injected air comes from the compressor. The mixture of air and water is then flowed into the process tank through a pipe located at the bottom of the process tank.

Very small air bubbles are formed and move upwards towards the water surface in the process tank. At the same time, oil bubbles attach to the air bubbles and move together to the water surface. The movement of air bubbles to the water surface is faster than the very small dispersed oil particles. This is because the density of air is smaller than that of oil. The greater difference in density between air and water causes the upward thrust (buoyancy effect) of the water to increase. In practice, this principle is very useful for accelerating the separation of oil particles from water.

Thus, this separation process uses the principle of density differences between air, water, and particles to separate oil particles from wastewater. Air bubbles that carry oil particles rise to the surface of the water, allowing for efficient and rapid separation.

Tool Parts Description

Knowledge of these parts is essential to operate and maintain the system efficiently. Understanding their functions also helps in troubleshooting and problem solving. Here are some of the parts in the Dissolved Air Flotation (DAF) system and their functions:

1. Flotation Tank
This tank is the main part of the DAF system where the separation process takes place. Wastewater containing dissolved or dispersed particles is fed into the flotation tank. In this tank, injected air bubbles will help lift the particles to the surface of the water.
2. Saturation Tank
This tank functions to mix water from the process tank with injected air. Air mixed with water will form small bubbles that will be used in the flotation process in the flotation tank. In the saturation tank, the process of filling air into the water occurs.
3. Air Injection System
The system consists of an air compressor and an air flow regulator. The compressor produces pressurized air that will be injected

into the saturation tank. The air flow regulator regulates the rate of air injection according to the needs of the flotation process.

4. Air Distribution Pipe

This tube is located at the bottom of the flotation tank and is used to distribute the air bubbles that have formed throughout the tank volume. This tube helps ensure that the air bubbles are evenly distributed in the tank, so that particles can be lifted to the surface of the water efficiently.

5. Flow Controller

Flow controllers are used to regulate the flow of wastewater entering the flotation tank. By regulating the proper flow, the particle separation process will be more effective. Flow controllers can also help maintain the stability of the system operation.

6. Dirt Collector (Sludge Collector)

The sludge collector is where the particles that have been separated from the wastewater are collected. This collected sludge or sludge can then be removed from the system for further processing, such as appropriate treatment or disposal.

7. Pumping System

The pumping system is used to flow wastewater into the flotation tank and regulate the flow in the overall system. Proper pumping is necessary to maintain system performance and ensure optimal separation process.

The above parts are some of the common components found in a tool system. However, it is important to note that the design and configuration of the system can vary as needed.

Selection of Construction Materials

The selection of the right construction material depends on various factors, including the operational environment, the type of water to be treated, the size and design of the tool. In this study, the author chose acrylic as the basic material for several considerations. Acrylic material has several advantages that make it a good choice for making DAF. Here are some of the advantages of acrylic material:

1. Transparency: Acrylic has a high level of clarity, almost like glass, which allows the observer to see the process visually. This makes it easy to monitor and control the process.
2. Corrosion resistance: Acrylic material is resistant to corrosion caused by water, chemicals, and microorganisms. This is important in this application because the unit is involved in direct contact with water and chemicals.
3. Mechanical strength: Acrylic has good mechanical strength, which allows for the creation of strong and durable structures. This is important because it involves the process of separating solid particles from water using physical forces, such as gravity and flotation.
4. Ease of processing: Acrylic can be easily processed, such as cut, shaped, and connected using appropriate joining techniques. This makes it easy to manufacture tools with complex or special designs.
5. Dimensional stability: Acrylic has good dimensional stability, meaning that DAF structures made from acrylic tend to maintain their desired shape and size over time. This is important for maintaining consistent performance and efficiency.
6. Lightweight: Acrylic has a lower specific gravity compared to some other materials, such as metal. Having tools made of acrylic can make installation, maintenance, and moving of units easier. [6]

Despite having many advantages, acrylic materials also have several disadvantages that need to be considered in making tools. Here are some of the disadvantages associated with the use of acrylic materials:

1. Susceptible to scratches: While acrylic is fairly impact resistant, it tends to be more susceptible to scratches than other materials such as glass. This can lead to a decrease in clarity and visual appearance over time.
2. Vulnerable to heat: Acrylic has a relatively high coefficient of thermal expansion, meaning it expands and contracts with changes in temperature. This can cause stress and deformation in the structure of the appliance, especially if there are sudden or extreme changes in temperature.
3. Not resistant to certain chemicals: Although acrylic is resistant to most chemicals,

certain chemicals, such as strong acids or organic solvents, can cause damage or changes to the acrylic material. Therefore, it is necessary to pay attention to the chemical compatibility between the acrylic material and the environment around the tool.

4. Low resistance to wear and scratches: Acrylic has lower resistance to wear compared to some other materials, such as metal. If the solid particles present in the water are abrasive or hard, the acrylic may wear or scratch over time.

5. Size limitations: Acrylic has size limitations compared to some other materials. For very large or complex instruments, it may be necessary to combine multiple acrylic parts or use a more suitable alternative material.[3]

It is important to consider these drawbacks in the context of a particular application and select the appropriate material. Due to the need for laboratory scale, some of the above drawbacks do not cause problems and can operate well.

Troubleshooting

From the results of the tool design, it is necessary to do troubleshooting when the tool has problems while running. These include:

1. Pump condition is dead/unstable

Things to check include:

1) Check water flow
2) Check valve
3) Check voltage

2. Compressor condition is not working

Things to check include:

1) Check the plug
2) Check valve
3) Automatic fuse check
4) Check the olor cable

3. Flowmeter condition cannot read

Things to check include:

1) Check for dirt in the channel
2) Check valve
3) Check the pump

Conclusions

In the design of this waste processing tool, it is hoped that it can be a means for students to carry out Waste Processing Technology Practical activities.

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