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Effect of Pressure Differences on Sludge Filtration Process Efficiency by Using Plate Filter Press

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Abstract - *Waste treatment in the industry produce sludge from the settling of solid material as a by product of the treatment process. The resulting sludge can't be thrown away in large quantities because it can cause problems if there is still water content in it especially for industrial centers located around residential areas. So that filtration is carried out on the sludge from the Sedimentation Tub at the WWTP know in the area of Lamper, Semarang with the aim of reducing the volume of sludge by separating the water from the sludge before being discharged. The results of the analysis of the sludge filtration in the Settling Basin at WWTP obtained the value of cake resistance at a pressure of 75 kg / m² of 4.42E + 11 m/kg, at a pressure of 90 kg/m² of 5.62E + 11 m/kg and at a pressure of 104 kg/m² of 6.74E + 11 m/kg. The results of the analysis on the resistance value of the filter medium obtained a value of 1.59E+12m⁻¹ at a pressure of 75 kg/m², 1.23E+12 m⁻¹ at a pressure of 90 kg/m² and 1.61E+12 m⁻¹ at a pressure of 104 kg/m². While in the analysis of water content, at a pressure of 75 kg/m² obtained a value of 35.437%, at a pressure of 90 kg/m² obtained a value of 35.024%, and at a pressure of 104 kg/m² obtained a value of 34.024%. Efficiency The optimal pressure is 104 kg/m².*

Keywords *– Sludge, Filtration, Pressure*

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1. Introduction

At present, the industrial centers in Indonesia have developed rapidly. These developments of course will certainly have a positive impact but it is also undeniable that a negative impact will also be caused. Each production process in an industry will produce waste that requires a processing unit before finally being disposed of to avoid the impact of environmental pollution. However, the waste treatment units in these industries will create a new problem, namely the generation of sludge from the settling of solid material as a by-product of the waste treatment process [1].

The resulting sludge cannot be thrown away in large quantities because it can cause problems if there is still water content in it especially for industrial centers located around residential areas, so a special sludge treatment process is needed. The main purpose of sludge treatment is to reduce the volume of sludge by separating water from the sludge before disposal. Reduction of water content and the volume of sludge is important, because the water in the waste contains more concentrated pollutants [2].

One of the treatments of sludge from waste water treatment can be done by using plate filtration. In Indonesia, many industries use filter press systems for the process of filtering and refining materials. The advantages of this type are easy to use, flexible, and low maintenance costs [3].

In the filtration process, chemical and physical reactions may occur, so many interrelated factors that will affect the quality of the filtration results and efficiency. These factors include filtration discharge, size and material, presence of auxiliaries, turbidity concentration, water level, temperature, and pressure [4]. Pressure is one of the factors that is very influential on the filtration process, with the difference in pressure in the filtration process will affect the number of filtered cakes and the quality of the filtration results [5].

This research will study the optimization of filtration of the sludge from the sedimentation tank in tofu waste

treatment in the Central Lamper area, Semarang using a plate filter with differences in the use of pressure to reduce sludge water content and an analysis is performed by calculating the values of α and Rm from the use of pressure optimal to find out how the influence of the pressure difference applied to the sludge condition after filtration.

This is the filtration equation in Constant Pressure Filtration [6]:

$$\frac{dt}{dV} = \frac{\mu\alpha C_s}{A^2(-\Delta P)}V + \frac{\mu}{A^2(-\Delta P)}R_m = K_p\text{V+B}.....(1)$$

Where,
R_m is filter medium resistance (m^{-1})
α is cake specific resistance ($^m/_{kg}$)
ΔP is *pressure drop* (N/m^2)
A is filter area (m^2)
μ is viscosity (Pa.s)
C_s in (kg solid/m^3)
K_p in $^s/_{m^6}$, dan
B in $^s/_{m^3}$

2. Methodology

Materials that used in this research is sludge from the settling basin in the tofu waste treatment at the WWTP in the Central Lamper area, Semarang.

- Dependent Variables
  Filtration Time = 30 minutes
  Volume of mud = 15 liters
  Coagulant = PAC
  Coagulant concentration = 40 g / L
- Independent Variables
  Filter Press Pressure = 75 kg/cm^2; 90 kg/cm^2; 104 kg/ cm^2

This research conducted using Plate Filter Press, bucket, jerry can, viscosimeter ostwald, measuring glass, beaker glass, stopwatch, porcelain cup, scale, digital balance, oven, watch glass, filter paper, clamp, baking pan, and plastic.

Figure 1 is the Plate Filter Press along with the information.

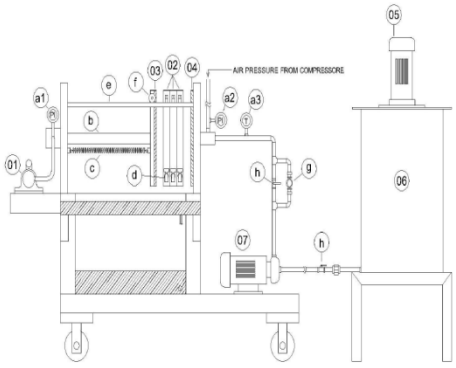

Figure 1. Plate Filter Press

Information:
01. Manual Hand Jack Hydraulic
02. Intermediate Plate
03. End Plate
04. Head Plate
05. Motor Agitator
06. Chemical Tank
07. Centrifugal Pump
a1. Hydraulic Pressure indicator
a2. Sludge Pressure Indicator
a3. Temperature Indicator
b. Lever as Rod
c. Pedal
d. Faucet
e. Support Rail
f. End Plate Wheel
g. Flow Meter
h. Bypass Valve Flow Meter

Experiment in this research was carried out at the Chemical Engineering Operations Laboratory, Vocational School, Diponegoro University. This experiment consists of 3 stages as follows:

A. Preparation

In the preparation stage of the experiment, the Plate Filter Press tool is ensured in a condition that is ready for use, where the tool has been connected with an electrical connection, the mixing tank does not leak, the filter cloth on the plate has been installed correctly and in good condition, and ensures the compressor is working.

B. Execution

Mix the mud sample with coagulant according to the dose and put it in the feed tank. Turn on the stirring motor to get a homogeneous suspension. Set the filter press pressure according to the variable then turn on the pump. Pressure is maintained throughout the process. Record time and take samples every 3 minutes.

C. The Filtrate Analysis

Take the filtrate every variable for 3 minutes and put it in a measuring cup. Calculate the density and viscosity of the filtrate. Cake each plate is taken to analyze its water content by drying on each pressure variable.

3. RESULTS & DISCUSSIONS

3.1. Experimental Results

The experimental results that will be analyzed are the cake specific resistivity value (α) and the filter medium resistance value (Rm). After obtaining the value of α and Rm, the pressure effect on the value of α and Rm will be obtained. The practicum data obtained is presented in table 1, where we get the value of the volume of the filtrate at each pressure which is variable for each variable in 3 minutes. This value is needed in the analysis of the values of α and Rm to find the value of Kp in the formula $\alpha = \frac{Kp\ A^2(-\Delta P)}{\mu Cs}$ and find the value of B in the formula $Rm = \frac{B\ A(-\Delta P)}{\mu}$, the solution namely by using the equation y = ax +

b obtained from the linear graph of the relationship between t and t / V.

The results obtained in the experiment show a relationship between the volume of filtrate obtained in filtration at variable pressures 75, 90, and 104 kg / cm2 every 3 minutes until the filtration time is constant. Where from experiments I, II, and III sequentially obtained value of t / V which decreases, because the volume of filtrate obtained is increasingly decreasing at high pressure. The existing theory proposed that the higher the operating pressure used, the smaller the t / V value [7]. This is because, the higher the operating pressure in the filtration process, the more solids that form the cake on the filter, causing blockage on the filtration plate which is characterized by the longer time needed to store the filtrate so that the obtained T / V is smaller. Comparison of the results of the three pressure variables can be seen from the graph in Figure 2.

Table 1. Experimental Results Data

Pressure 75 kg/cm²			Pressure 90 kg/cm²			Pressure 104 kg/cm²		
t (s)	V (m³)	t/V	t (s)	V (m³)	t/V	t (s)	V (m³)	t/V
0	0	0	0	0	0	0	0	0
180	0,005	36.000	180	0,004	45.000	180	0,0004	450.000
360	0,007	51.428,571	360	0,0068	52.941,176	360	0,00085	423.529,4
540	0,00855	63.157,894	540	0,00825	65.454,545	540	0,0012	450.000
720	0,00955	75.392,670	720	0,00925	77.837,837	720	0,00144	500.000
900	0,01023	87.976,539	900	0,01015	88.669,950	900	0,00166	542.168,7
1.080	0,01082	99.815,157	1.080	0,01075	100.465,116	1.080	0,00181	596.685,1
1.260	0,01116	112.903,225	1.260	0,01115	113.004,484	1.260	0,00195	646.153,8
1.440	0,01157	124.459,809	1.440	0,01155	124.675,324	1.440	0,00208	692.307,7
1.620	0,01193	135.792,120	1.620	0,0119	136.134,453	1.620	0,00224	723.214,3
1.800	0,01223	147.179,067	1.800	0,0122	147.540,983	1.800	0,00233	772.532,2

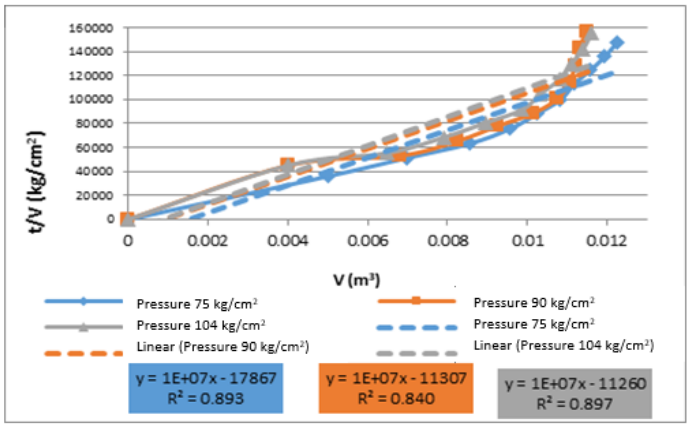

Figure 2. Effect of Pressure on the Volume of Filtrate

3.2 Effect of Cake Resistance Value (α)

From the results of filtration experiments using filter press plates obtained data to calculate the value of the cake resistance shown in Figure 3, where from the calculation results obtained cake resistance value (α) for a pressure of 75 kg / cm² that is equal to 4.42 x 1011 m/kg , for a pressure of 90 kg / cm² of 5.62 x 1011, for a pressure of 104 kg/cm² of 6.74 x 1011 m/kg. From the three variables of each experiment the highest α value was obtained at the highest pressure at 104 kg/cm² with a value of 6.74 x 1011 m / kg. When analyzed from the graph the relationship of the value of α with the pressure in Figure 8 and the results show that with the higher pressure the value of α is getting higher [8]. From this value it can be concluded that the greater the pressure the greater the value of the cake resistance (α) obtained. This is consistent with the existing theory of fixed pressure filtration, in equation α:

$$\alpha = \frac{Kp\ A^2(-\Delta P)}{\mu Cs}$$

It means that at the same time, the greater pressure drains more mud, so that the cake is formed more quickly. The more mud retained in the cloth provides the greater resistance so as to prevent solids from being carried in the filtrate [9].

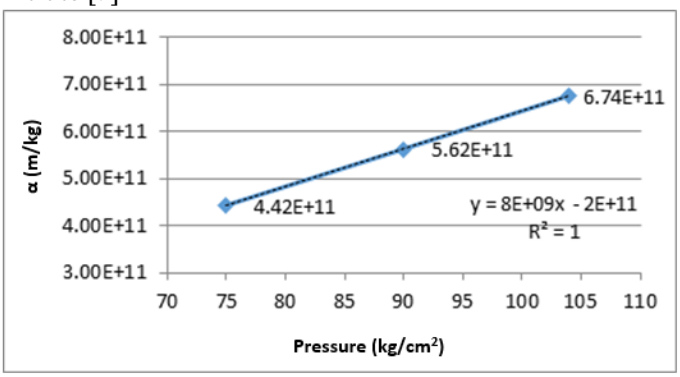

Figure 3. Effect of Pressure on the value of α

3.3 Effect of Medium Filter Resistivity Value

The experimental results shown in Figure 4 show the relationship between the value of Rm and the pressure variable. The results obtained on the variable with the highest pressure will get the value of Rm (medium filter resistance) as well. The Rm value obtained for each pressure variable is at 75 kg / cm^2 pressure, the Rm value is 1.59 x 1012 m^{-1}, at 90 kg / cm^2 pressure the Rm value is 1.24 x 1012 m^{-1} and at 104 kg pressure / cm^2 the Rm value is 1.62 x 1012 m^{-1}. From the three variables of each experiment the highest Rm value was obtained at the highest pressure at 104 kg / cm2 with an Rm value of 1.62 x 1012 m^{-1}.

The effect of pressure on the filtration process showed that the greater the pressure exerted, the greater the resistance value of the filter medium (Rm) obtained [8]. This is in accordance with existing theories for fixed pressure filtration, which means that when the pressure is increased, the value of Rm will be greater so that it can filter/separate solids completely. Based on the graph in Figure 4 compared with the results of the journal, it can be concluded that the greater the pressure exerted, the greater the value of the resistance of the filter medium (Rm) obtained. This is consistent with the existing theory for fixed pressure filtration, where the equation is:

$$Rm = \frac{B\,A(-\Delta P)}{\mu}$$

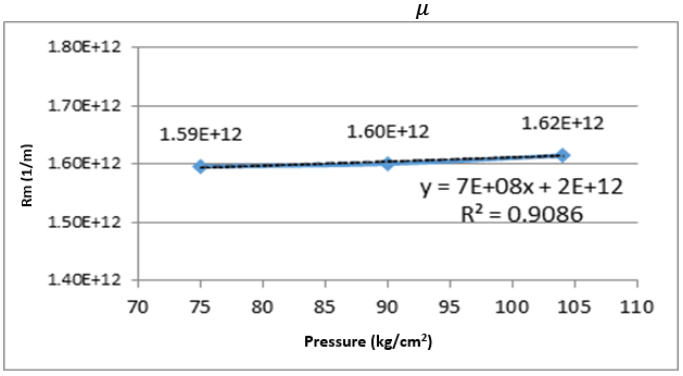

Figure 4. Effect of Pressure on the value of Rm

In this experiment the pressure which obtained the optimum value of Rm (medium filter resistance) is 104 kg / cm^2 for the filtration process using a filter plate filter.

3.4 Analysis of Water Content

The water content of the filtration cake is calculated by comparing the mass of the total cake filtration result before drying and after drying each of each variable. In the experimental results shown in Figure 5, shows the relationship of the value of water content with the variable determined pressure, which variable with high pressure will obtain a small water content value. For experiments using a pressure of 75 kg/cm^2, the water content value was 35.437%, in the second experiment with a pressure of 90 kg/cm^2 the water content value was 35.024% and in the third experiment with a pressure of 104 kg/cm^2 the water content value was 34.024%. This shows that if the pressure used in the plate filtration process is high, the filter's ability to filter sludge is much better. It was explained that when the applied pressure increased, it would provide the form of more compacted filter cake so that the water content contained in the cake gets smaller [10].

From the results of measurements of water content carried out in experiments on Pressure, 75 kg/cm^2, 90 kg/cm^2, 100 kg/cm^2 and comparison with the journal, it can be seen a decrease in water content at a higher pressure. This proves that the filtration process carried out has succeeded in reducing the water content in the sludge so that the sludge can be processed into further disposal with reduced levels of pollution. This shows that plate filtration can be used as a means of handling sludge before being discharged into the environment with the main aim of sludge treatment is to reduce the volume of sludge by separating water from sludge before disposal [2]. Reduction of water content and volume of sludge is important, because in the water present in the waste contains more concentrated pollutants [11].

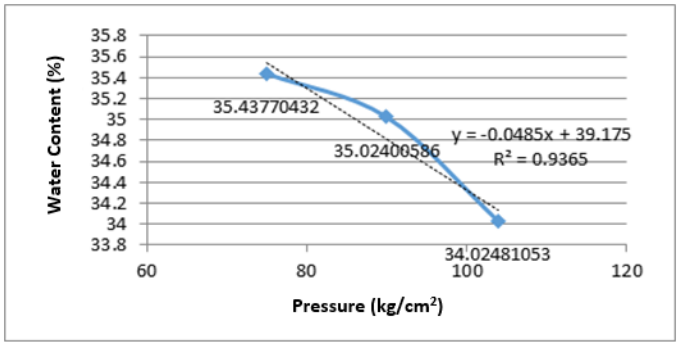

Figure 5. Effect of Pressure on the value of water content

Then from these experiments also obtained values of water content on each plate. For variable 1 pressure 75 kg/cm^2 the value of water content at plate 1 41.46%, plate 2 38.38%, and plate 3 21.15%, while at a pressure of 90 kg/cm^2 the value of water content at plate 1 35.55%, plate 2 35.09%, and plate 3 34.26% and at a pressure of 104 kg/cm^2 the value of water content at plate 1 was 35.3%, plate 2 37.11%, and plate 3 28.97%. In the filtration process using a filter press plate shows that the more plates, the less cake will be retained on the last filter plate [12], where the highest number of cakes will be retained on filter plate 1, this is because the mud will first be pressed in this initial plate. In this experiment the optimum pressure to reduce the volume of water in the sludge is 104 kg/cm^2.

4. Conclusion

Sludge is a lot of solid obtained from the results of the process of solid-liquid separation from industrial waste. The resulting sludge cannot be thrown away in large quantities because it can cause new problems, so a special sludge treatment process is needed. The main purpose of

sludge treatment is to reduce the volume of sludge by separating water from the sludge before disposal. Reduction of water content and volume of sludge is important, because in the water present in the waste contains more concentrated pollutants. One way that can be done is physical and chemical processing through mechanical dewatering (filtration with filter press plates) using chemical conditioning (certain types of coagulants / flocculants).

Dependent variables include sludge volume, type of coagulant, coagulant concentration, filtration time and number of plates. While the independent variables include variations in pressure, the results of these experiments have the aim to find out the optimum pressure in the sludge treatment process of tofu waste treatment at WWTP to reduce the volume of water in mud as an effort to reduce pollution to the environment. Experimental analysis with the optimum type of pressure was obtained at a pressure of 104 kg/cm^2, with a value of 74 6.74 x 1011 m/kg, an Rm value of 1.62 x 1012 m^{-1} and a total water content of cake at 34.024%.

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