http://journal.uir.ac.id/index.php/JGEET

E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 9 No 3 2024

RESEARCH ARTICLE

Technical Assessment Of Mud Handling Planning With Dredger Pump In Mining Front Area Of Pt. Makmur Lestari Primatama, Southeast Sulawesi, Indonesia

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Received: Apr 11, 2024. Accepted: Aug 01, 2024.
DOI: 10.25299/jgeet.2024.9.3.16829

Abstract

The high intensity of rain can affect mining activities because rainwater will be collected and stored in the area with the lowest elevation. In mining areas that have the lowest elevation point, namely the pit area, this will have an impact on mining activities. The pit area will not be disturbed if water or eroded slopes will enter and be accommodated in well-made drainage and vice versa if drainage is not formed properly, water and mud will be retained and accommodated in the pit area. If the water and mud are left unchecked, the water will overflow and mining will be temporarily halted, affecting the previously planned mining system. In this case, the pit whose water has been pumped out leaves the mud at the bottom of the pit trapped, so action is needed to remove the mud from the pit area and the need for qualified tools according to the existing mud criteria. The mud at PT Makmur Lestari Primatama has an SG criteria of 1.39 (top elevation mud) - 1.5 (bottom elevation mud) with mud grains of 0.005mm to 2mm, it can be concluded that the mud has liquid mud criteria to hard mud. So that the determination of a tool to be able to move mud using a pump, the selection of this pump There are three important parameters: Grain size, Specific Gravity, and also variations in material concentration that must be considered because they can affect the total head or flowrate. The difference between the Slurry pump and the dredger pump is in the pumping process, the dredger pump is able to pump hard mud with the help of a little water while the slurry pump is difficult to pump hard mud because it requires quite a lot of water to pump it. Therefore, a dredger pump is chosen to move the mud in the mining area so that it can pump liquid mud to hard mud, the selection of this dredger pump is based on pump specifications including max capacity 120-200m3/h, solid handling 35mm - 60mm, speed 1180 RPM, and effieciency 46%-51%. The planning analysis of the use of dredger pumps uses the Bernoulli equation and the amount of mud that must be pumped using the USLE method. Based on the results of a series of studies that have been carried out, researchers found that the total potential erosion is 8,574.2 tons/year, the total actual erosion is 7,716.8 tons/year, and the total volume of mud that must be pumped is 5,074.86m3 with a slurry weight of 1,448.2 kg/m3. So the most ideal dredger pump for this purpose is Dragflow HY85A with a capacity of 210m3/h, pumping hours of 16.6 hours / day, pumping duration of 2 days 15 hours and efficiency of 40% using HDPE type 10 inch diameter pipe.

Keywords: Dredger Pump, Sludge, Pump Planning, USLE, Bernoulli

1. Introduction

1.1 Sub Introduction

High rainfall can affect mining activities because rainwater will be stored and collected in active mining areas which can disrupt mining activities and make mining activities temporarily stop. The cessation of mining activities is based on several factors including: the stopping of heavy equipment due to rainy hours, the absence of a good drainage system, one of which is the absence of a sump that is useful for collecting runoff water and eroded soil, and so on.

In the study of the drainage system applied to the mining front area, a review needs to be carried out by considering several factors, including: the planned mine progress plan, the rain catchment area, rainfall, and the specifications of the pump used in the mining front area. This is done to ensure that the mining conveyance system implemented is working effectively. This drainage system is necessary during mining activities to prevent water runoff from entering the pit area. The water runoff that enters the sump area is not only rainwater but also soil eroded by rain and other materials.

This precipitated sludge settles in the sump, which is only designed to hold water, preventing the sump's real discharge capacity from being met. Sludge in the sump must be removed and sent to the mudshell using a pump. This mudshell serves as a refuge for various particles.

This sump can only hold water, so mud and other deposited materials must be immediately transferred to the mudshell area. This mudshell area serves to accommodate the mud deposited in the sump area. The removal of silt can be done using an excavator or a pump dredger. However, in this condition, the excavator cannot be used properly in the mining front area where the mud is deposited because the excavator must move to The Introduction should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines. follow the mud area to be dredged. Therefore, a planning analysis of the use of a dredger pump that is suitable for the mud conditions in the area is carried out.

mud can be known by Particles mixed with water are called TSS, and usually consist of sand, clay, gravel, and other materials. Portable TSS meters can be used to measure the TSS content in water in mg/l, which is equal to how many milligrams of solids are present in one liter of water.

2. Location

PT Makmur Lestari Primatama is located in North Konawe, precisely in Langgikima District, North Konawe Regency. With coordinates 3°17'06"S 122°16'53"E the company is 101.17 km from Haluoleo Airport.

3. Material and Methods

Research methods conducted at PT Makmur Lestari Primatama, using quantitative methods and field observations. Quantitative method research uses primary and secondary data processed with statistics.

1. Sludge Density Testing Density testing was carried out using distilled water as a comparison. Before testing, temperature measurements were taken first. Determination of sludge volume Calculation of sludge volume can be done using the USLE (Universal Soil Loss Equation) method, which is used to calculate potential and actual erosion. Determination of dredger pump selection Determination of pump selection is in accordance with the type of material available at the research site, the dredger pump is determined according to the volume of mud to be pumped.
2. Dredger pump A centrifugal pump, this dredger pump sucks solids that are rocks, gravel, or mud at the bottom of the sump. These sucked solids are flowed directly to the mud shell using a pipe. This dredger pump works with a pump and impeller. The impeller is installed in the pump area and connected to the motor. This allows the pump to suck water or mud and then flow to the disposal area, also known as the mud shell. TSS was tested at the PIT sites in West Boston and East Boston during this water sampling. This TSS test used the following equipment Partech TSS meter and Water container
3. The mud sampling was done to determine density. This sample takes place directly in the PIT area, which is the research location, specifically West Boston PIT and East Boston PIT.
4. The sampling location point is determined based on the research; sampling is conducted in places with moist mud or a small amount of water content in order to depict the actual condition of the PIT, which contains water and mud. Mud samples are collected from the bottom of the PIT to determine bed load (bottom sediment). Meanwhile, the sample used to assess viscosity is suspended load (mud float), which is obtained by simply placing the bottle into water where no mud has been deposited.
5. The settling velocity of this sludge can be determined using the Stokes formula for solids below 40% and Newton's equation for solids above 40%. The settling speed is determined by sampling from PT Makmur Lestari Primatama and evaluating it in the laboratory. In PT. Makmur Lestari Primatama, sludge volume was determined using the USLE (Universal Soil Loss Equation) approach with known potential and actual erosion.

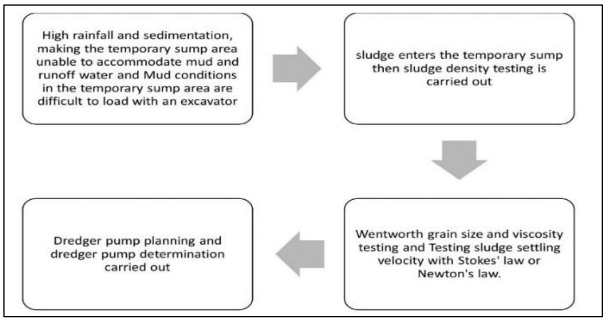

Fig 1. Research Flow

4. Overview

Mud handling in mining areas can be handled in two ways, viz: excavators and dump trucks and also mud pumps. The mud pump can pump mud from the mining front area to the mudshell area without the need for blending. There are 3 important parameters in mud pumping: Grain size, Specific Gravity, and also variations in material concentration that must be considered. The amount of total head or flowrate can be influenced by these 3 parameters so that, how much mud will be pumped is obtained. Particle diameter or grain size testing can be carried out in accordance with SNI 3423 concerning "soil grain size analysis testing, so that the diameter of the mud at the location is obtained according to the wentworth method. Specific Gravity testing is done in the laboratory by testing the ratio of the weight of the mud volume to the weight of the water volume. After testing, the soil type category is obtained, as follows:

Table 1. Soil Type and Specific Gravity

Soil type	*Specific gravity*
Gravel	2,65 – 2,68
Sand	2,65 – 2,68
Inorganic silt	2,62 – 2,68
Organic loam	2,58 – 2,65
Inorganic loam	2,68 – 2,75
Humus	1,37
Peat	1,25 – 1,80

(Hardiyatmo, Juli 2002)

USLE calculations are carried out to obtain potential and actual erosion values that are likely to become silt in the sump area.

The actual sedimentation test is carried out using the TSS data obtained first. From the TSS data, the value of residual weight, volume of sludge solids, percent solid to sludge volume will be obtained. This sedimentation test is influenced by several factors, including:

a. Rainy day
b. Soil hydrology condition
c. Soil erodibility factor
d. Slope length and slope inclination
e. Tillage factor

The selection of the dredger pump must be adjusted to the needs, in the application of the pump selection field there are several criteria including:

a. Length of pipe from inlet to outlet
b. Size of pipe used
c. Total head
d. Pipe pressure to be used
e. Pump discharge to be generated
f. RPM to be used

4. Equation

Sedimentation rate testing was carried out with potential and actual USLE calculations. USLE calculation is done with the formula:

$$E_{pot} = EI \times LS \times K \times A \quad (I)$$

Explanation:

Epot = Potential erosion (Ton/year)
K = Soil erosion factor (KJ/ha)
Ls = Topography factor
A = Area (km^2)

$$E_{akt} = E_{pot} \times C \times P \quad (II)$$

Explanation:

E_{akt} = Actual erosion (Ton/year)
C = vegetation cover factor
P = Land use

The determination of the dredger pump is done by calculating using the pump Bernoulli equation as follows:

$$H = h_s + h_f + h_v + h_l \quad (III)$$

Explanation:

H = Total pump head
H_s = head static
H_f = head friction
H_v = head velocity
H_l = head loss

To get the percent of solid in determining the settling time using either Stoke's law or Newton's law can use the following calculation:

$$\%\ solid = \frac{Volume\ of\ Solids}{Q\ Total} x100\% \quad (IV)$$

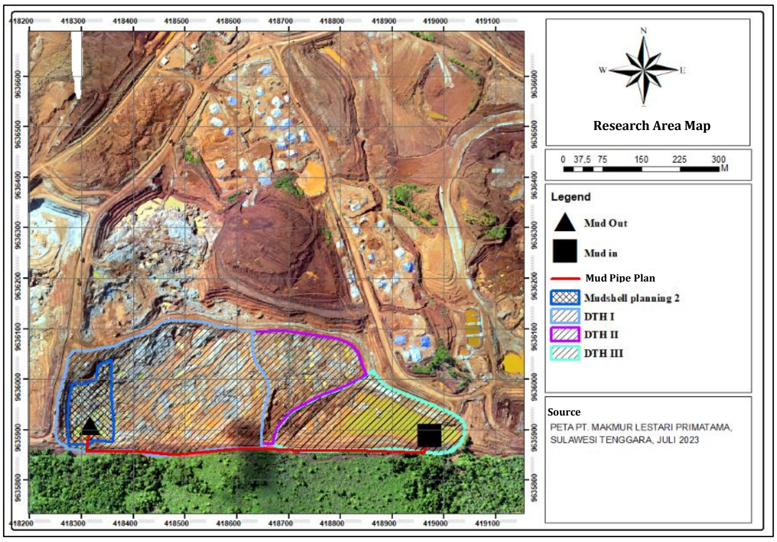

Fig 2. Map of the research area

5. Results and Discussion

Good mine drainage means that the water flow into the mining front area must be the same as the water flow out or the water pumped out of the mining front area. In terms of this condition, it is not only water that must be removed from the mining front area but there are silt deposits that must be moved or removed to facilitate mining activities. The method to generate an estimate of planned rainfall uses the Gumbel method analysis.

The rainfall data used in this Gumbel method is annual series rainfall data from 2018 to 2022. So that the rainfall intensity is obtained, namely 39.681mm/hour. With these rainfall results, according to BMKG the rainfall category is in the yellow zone 20-50mm / day which means moderate rain.

After obtaining the results of the rainfall plan, the rain catchment area that is the place of research can be determined. The catchment area is divided into 3 locations, namely West Boston Pit, East Boston Pit I and East Boston Pit II. From the determination of the catchment area (from figure I), the results of the area of each DTH are as follows:

Table 2. Rainfall Catchment area

Area	Extensive
West boston pit	89.730,21 m^2
East boston pit I	38.649,02 m^2
East boston pit II	26.649,82 m^2

The catchment area is determined in order to obtain the runoff water discharge and the volume of water and silt. The addition of groundwater, the amount of soil erosion, and the decrease in evaporation value can generate runoff water discharge. The runoff water discharge in the west boston and east boston pit areas is obtained as follows:

Table 3. Water runoff discharge and soil erosion

Area	Debit
West boston pit	7,840.6 m^3/day
East boston pit I	3,377.1 m^3/day
East boston pit II	2,328.7 m^3/day

Fig 3. Specific gravity and density tests

With the following water runoff discharge results, the actual sedimentation results are obtained. The mud at the research site has a type of latosol, latosol has another name laterite. Latosol is a soil that has a reddish color due to the oxidation of iron contained therein, has a high laterite content and has a coarse soil texture that affects drainage. Calculation of actual sedimentation results using TSS (Total Suspendid Solid) primary data. To obtain this actual volume, specific gravity testing was carried out at both locations (figure 3) so that the following results were obtained:

Table 4. Specific Gravity test results

	Specific gravity
Mud upper limit	1,39
Mud lower limit	1,5

Density and viscosity tests were conducted at the Chemistry Laboratory to determine the field's true density and viscosity based on the mud samples collected before. The mud sample was taken at the following coordinates:

Table 5. Sample coordinates for Boston West and Boston East

Location	S	E	Elevation
West Boston	3.293645^{0}S	122.266494^{0}E	36 Mdpl
East Boston	3.293721^{0}S	122.271047^0 E	39 Mdpl

Results the density test yielded the following findings in both pits:

Table 6. density results from mud testing

Location	Density	Average Density	% Solid
West Boston	1,4 gr/ml	1,45 gr/ml	4%
East Boston	1,5 gr/ml		1,5%

from the % solid obtained, it is known that the test is carried out by the stoke law method, which is <40%, this is done to calculate the deposition time in each research area. therefore the deposition time is obtained as follows:

Table 7. sludge settling time

Area	Settling Time
West Boston	2,3 Hours
East Boston	1,5 Hours

From the density and specific gravity test, the soil category at the West Boston and East Boston locations is known. With these results, the soil category is categorized as peat and humus. After obtaining the density and specific gravity, the actual volume calculation is carried out using the USLE method and the method using the TSS results so that the actual volume of sedimentation is obtained:

Table 8. Potential and actual erosion with USLE method

Location	Potential Erosion (tons/year)	Actual erosion (tons/year)
West boston	3,961.5	3,565.4
East boston I	2,730.1	2,457.1
East boston II	1,882.5	1,694.3
Total	8,574.2	7,716.8

Calculation of the actual volume of daily sedimentation using TSS data taken at the research location. TSS data collection using the Portech tool, so that the TSS results in West Boston are 520mg/l and East Boston 223mg/l. so that the following results are obtained:

Table 9. Actual volume of sedimentation

Area	Sedimentation Volume
West boston	3.429,86 m^3/day
East boston I	1.106,97 m^3/day
East boston II	538,03 m^3/day

Data on the total volume of sedimentation that will be pumped is 5,074.86m^3 with a slurry weight of 1,448.2Kg/m^3. To determine the dredger pump that will be used, testing the mud grains that will be pumped first. This test was carried out in the laboratory with the results obtained as follows:

Table 10. Mud grain test results

Mud grain test results				
	West boston		East boston	
Sand	15,5%	0,5–2mm	12%	0,5–2mm
Silt	48,5%	0,075mm	50,5%	0,075mm
Clay	36%	0,005mm	37,5%	0,005mm

From the lab test results above, it is known that the mud in the West Boston pit area is categorized as 15.5% sand, 48.5% silt, and 36% clay, so the diameter in that area is from 0.005mm to 2mm. This result is the same as the East Boston area. So it can be concluded that the mud in the research area has a mud type of clay to sand, for this sand has a category of fine (0.5mm) to medium (2mm). A dredger pump was planned to facilitate the transfer of mud from the mining front area to the prepared mudshell area.

This mud transfer is carried out using excavators and dump trucks, but this is less effective because the mud in the area is dominantly included in the silt, clay and there are few elements of sand. Mud with this class has characteristics that are liquid, merge with water and also have hard rock elements. If removal is carried out using a dumptruck, blending must be done first so that more time is needed and the condition of the mining front area does not allow excavators and dumptrucks to enter the area.

A dredger pump was connected to the excavator arm and driven by an auxiliary hydraulic line. Once in operation, the pump is capable of moving high concentrations of tailings, eliminating the need for a large amount of water to remove the slurry from the pump. By using a discharge pipe, the material is directly drained or discharged to the mudshell area. This is the most efficient solution when compared to excavators and dump trucks as blending is required to move the muds.

From the pump selection criteria, the selection of dredger pumps that can be used in the research area there are two types of dredger pumps that can be used in the research area, including:

Table 11. Specification of Dredger Pump Type

Capacity	120 – 200 m^3/h
Eficiency (max)	46%
Max head	40 m
Solid handling	35 mm/1.4 in
Power	33 kw/44,8 hp
Speed	1180 rpm

(Dragflow)

Table 12. HY85 Dredger Pump Specifications

Capacity	200-240 m^3/h
Eficiency (max)	51%
Max head	30 m
Solid handling	60 mm
Power	50 kw/67 hp
Speed	1180 rpm

(Dragflow)

After obtaining the pump specifications, calculations are carried out to select the ideal dredger pump to be used at that location. This calculation requires planning for the length of the pipe, the length of the pipe is planned by plotting the polyline using Arcmap 10.8 software. From the plotting, the following data is obtained:

Table 13. Pipeline planning for dredger pump

East Boston-Mudshell pipeline planning	
Pipe length	126m
Pipe type	Hdpe
Pipe coefficient	140
Pipe diameter	10inch
Cross-Sectional Area	0,051m^2
Velocity in the pipe (V)	0,6 m/s

From this pipe planning, calculations can then be made to determine the appropriate pump used in the West Boston pit and East Boston pit. The target for this pumping is required to be completed within 3 days with 16.6 hours of dredger pump working hours. Determination of these working hours is calculated from the table below:

Table 14. Work Plan Hours

Pa (physical availability)	90%
Rest hour and meal (2 shift)	3 hours
Shift Change Time	2 hours
Maintenance Time (10%)	2,4 hours
Total Effective Work Hours	16,6 hours

Pump calculations are carried out to determine the total head, pump working hours, pump working days, and pump efficiency. Calculation testing was carried out with HY-50 dragflow pump:

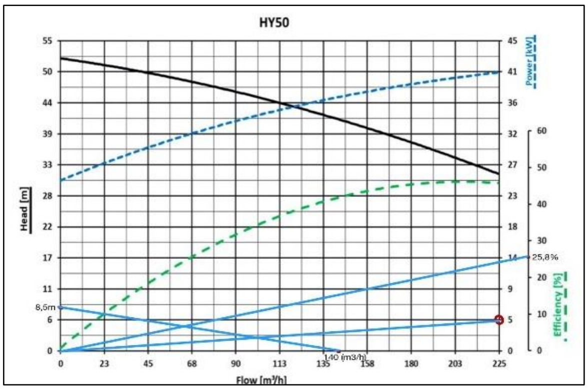

Fig 4. HY50 curve with 140 m^3/h capacity

Dragflow HY-50 with a Pump Capacity of 140m^3/h was able to pump the sludge within 72 hours which is 4 days and 6 hours of pumping with an efficiency of 25.8% and a Total Head of 8.5m.

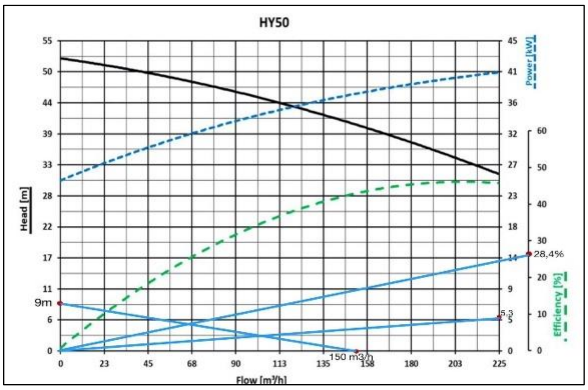

Fig 5. HY50 curve with 150 m^3/h capacity

Dragflow HY-50 with a Pump Capacity of 150m^3/h was able to pump the sludge within 67 hours which is 4 pumping days with an efficiency of 28.4% and a Total Head of 9m.

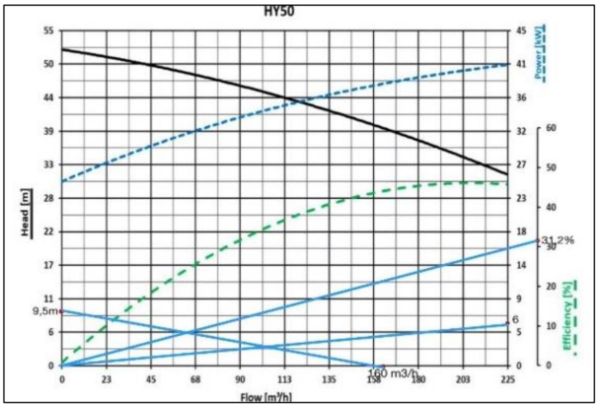

Fig 6. HY50 curve with 160 m^3/h capacity

Dragflow HY-50 with a Pump Capacity of 160m^3/h was able to pump the sludge in 63 hours which is 3 days and 13 hours of pumping with an efficiency of 31.2% and a Total Head of 9.5m.

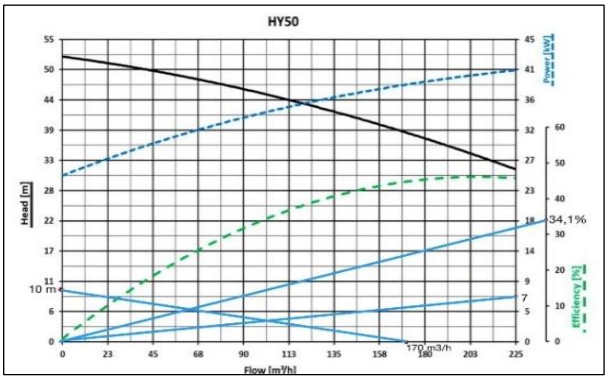

Fig 7. HY50 curve with 170 m^3/h capacity

Dragflow HY-50 with a Pump Capacity of 170m^3/h was able to pump the sludge in 59 hours which is 3 days and 8 hours of pumping with an efficiency of 34.1% and a Total Head of 9m.

Calculation tests were carried out on the HY85A dredger pump, the following results were obtained:

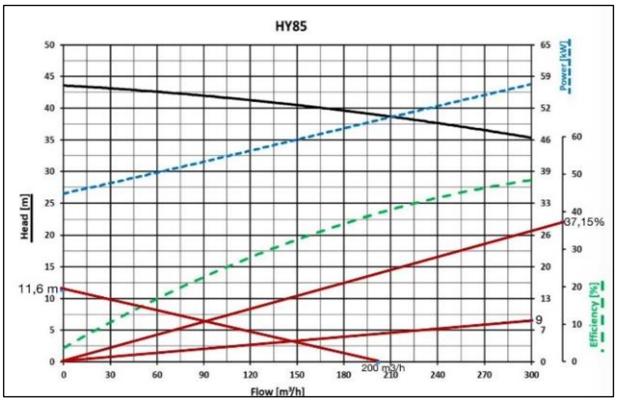

Fig 8. HY85 curve with 200m^3/h capacity

Dragflow HY-85 with a Pump Capacity of 200m^3/h was able to pump the sludge within 50 hours which is 3 pumping days with an efficiency of 37.15% and a Total Head of 11.6m.

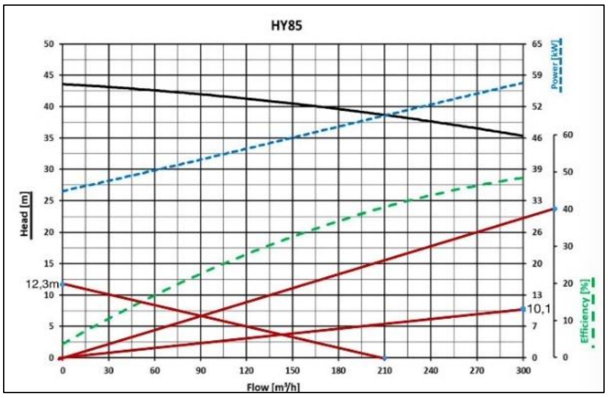

Fig 9. HY85 curve with 210 m^3/h capacity

Dragflow HY-85 with a Pump Capacity of 210m^3/h was able to pump the sludge within 48 hours which is 2 days and 15 hours of pumping with an efficiency of 40% and a Total Head of 12.3m.

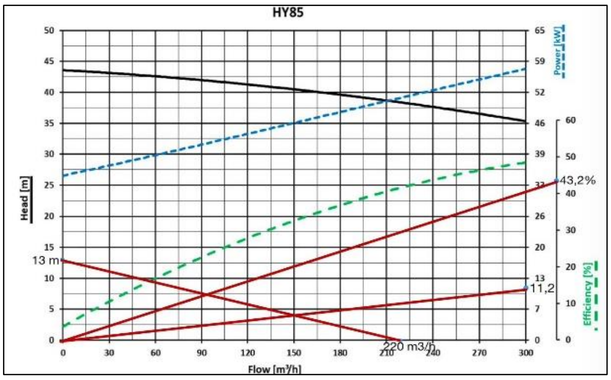

Fig 10. HY85 curve with 220 m^3/h capacity

Dragflow HY-85 with a Pump Capacity of 220m^3/h was able to pump the mud within 46 hours which is 2 days and 13 hours of pumping with an efficiency of 43.2% and a Total Head of 13m.

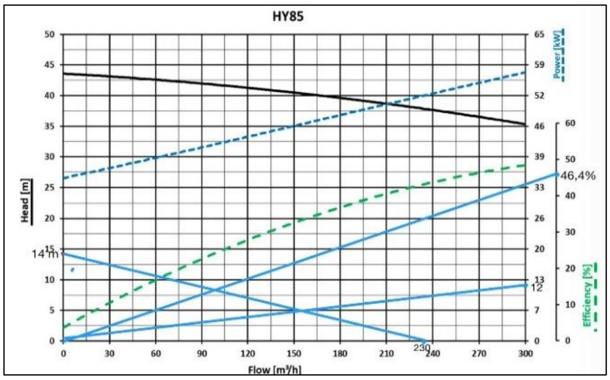

Fig 11. HY85 curve with 230m^3/h capacity

Dragflow HY-85 with a Pump Capacity of 230m^3/h was able to pump the sludge within 44 hours which is 2 days 10 hours of pumping with an efficiency of 46.4% and a Total Head of 14m.

Conclusion

The results of the current research revealed that the total volume of sludge that must be pumped is 5,074.86m^3 with a slurry weight of 1,448.2Kg/m^3, using HDPE type pipes with a pipe diameter of 10 "inch and a dredger pump that is suitable for use in this pumping using Dragflow HY85A with a capacity of 210m^3/h with pumping 2 days 15 hours and efficiency 40% and total head 12,3m. using Stoke's law to determine the settling time in the west boston pit and east boston pit areas with a settling time of 1.5 hours in the east boston area and 2.3 hours in the west boston area and the highest specific gravity was found to be 1.5.

Acknowledgments

The researcher is grateful to Trisakti University for chemical laboratory testing facilities to support the research being conducted. The researcher also thanked KTT and all staff of PT. Makmur Lestari Primatama for all the assistance provided in the research and facilitating researchers to conduct research both data collection and sampling and also thanked the researcher's supervisors who assisted in this entire research. Thank you to the Editor of the Journal of Geoscience, Engineering, Environment, and Technology for publishing it in an accredited journal with Sinta 2 ranking.

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