

Original Research Paper

## Damage Control of Liquid Waste Pumping Machines in Palm Oil Companies

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**Abstract:** PT. X is a company that works in the field of oil palm plantations and has a palm oil production capacity of 60 tons per hour. The products of palm oil that have been produced are Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). The various kinds of waste produced by the company as a result of the palm oil industry process are liquid waste, palm kernels, fiber and seed shells. Liquid waste is used as organic fertilizer for oil palm plantations which will be sent through a liquid waste pump machine. Damage that occurs to the liquid waste pump machine will inhibit the delivery of liquid waste to the plantation, thus affecting the yield of palm oil from the plantation itself. This study describes the application of repair and preventive maintenance policies for liquid waste pump machines by looking at the frequency of damage to the liquid waste pump engine and predicting the delivery of liquid waste to the pump engine for the next period as well as providing solutions for handling damage that occurs in the liquid waste pump engine. From the results of calculations on data processing, the results of how to control the causes of damage that occur in the liquid waste pump machine can be overcome by using the Preventive Maintenance Method within a period of 1 month and maintenance of every component in the liquid waste pump machine within 1 cycle, namely 357.27 hours with a repair time of 5.82 hours. Controlling other causes of damage is to add a filter to the liquid waste pool so that stones, leaves and liquid waste husks do not hinder the suction pipe of the liquid waste pump machine.

**Keywords:** Industrial Maintenance System, Reliability, Weibull Distribution.



## 1. Introduction

Palm oil is one of the plantation commodities that provide benefits and hope to improve the country's and regional economy from the non-oil and gas sector [1] [2] [3]. The prospect of development and economic value generated from the oil palm plantation business has been able to contribute in improving the community's economy. The resulting product is in the form of Crude Palm Oil (CPO) vegetable oil which is a raw material for the food industry, pharmaceutical industry, cosmetics and so on [4].

Palm oil productivity can produce up to 6 tons/ha of oil, meanwhile, other vegetable oil sources such as coconut, soybean, and olive only produce less than 4.5 tons/ha. The part of the oil palm plant that has high economic value is the fruit that is arranged in a bunch called fresh fruit bunches (FFB). The part of the oil palm fruit in the flesh or mesocarp produces CPO oil as much as 20%-24%. Meanwhile, the core produces Palm Kernel Oil (PKO) as much as 3%-5% [5].

The results of CPO and PKO from a fresh fruit bunch of oil palm require various stages of the process, where the process is carried out at the Palm Oil Mill (PKS). There are so many various companies in Indonesia that focus on business in the palm oil sector, one of which is the PT. X. is located at Batu Ampar Mill, Kotabaru, in South Kalimantan. Palm oil mills also produce solid and liquid waste. An industrial company is required to properly manage the industrial waste so as not to pollute the surrounding environment. Waste generated from palm oil companies, among others, is stump, shell, fiber, solid, and liquid waste [6].

Palm oil liquid waste consists of water from boiling oil palm which can be used as organic fertilizer in oil palm plantations. Liquid waste will be sent to oil palm plantations using a liquid waste pump machine, therefore the liquid waste pump machine is one of the main components in the process of sending liquid waste to oil palm plantations as organic fertilizer.

One of the inhibiting factors in the process of sending liquid waste using a pump engine is the occurrence of damage to the liquid waste pump engine itself caused by various internal and external factors. This study aims to control the damage to the liquid waste pump machine in palm oil co

Production planning is an activity to determine the product to be produced, the quantity needed, when the product must be completed and the required sources. Production control is an activity that determines the ability of the resources used to fulfill the plan, the ability of production to run according to plan, make improvements to the plan. So it can be concluded that production planning and control is planning production activities so that what has been planned can be carried out properly [7].

The definition of production planning and control above can be concluded that a company is required to have good industrial planning and control so that a company gets maximum, efficient and effective production results [8]. The various functions of production planning and control are as follows:

1. Forecasting product demand expressed in terms of product quantities as a function of time.
2. Monitor actual demand, compare it with previous demand forecasts and revise the forecast if deviations occur.
3. Determine the size of an economical order for raw materials to be purchased.
4. Establish an economical inventory system
5. Determine production requirements and inventory levels at a given time.
6. Monitor inventory levels, compare them with inventory plans and revise production plans at specified times.
7. As well as making a detailed production schedule, assignment and loading of machines and labor.

From the various production planning and control functions above, if applied to the palm oil industry company, the company must know and predict how palm oil production will be today and in the future by paying attention to the oil palm fruit season itself and how to overcome what if there is a lack of oil palm fruit entered for production by the company. Talking about palm oil industry companies, not only PKO and CPO are produced, but there is also waste that is the result of the palm oil industry process itself, one of which is liquid waste produced.

One oil palm tree itself requires 20-30 liters of water for its daily needs. If the oil palm lacks water, it will result in the production of oil palm fruit, therefore the season for the abundance of oil palm fruit will usually occur during the rainy season and vice versa. Liquid waste from the production of oil palm itself can be used as organic fertilizer which is good for the oil palm plant itself and oil palm

plants can get enough water from the liquid waste used. So the liquid waste functions as fertilizer and also as a water supply for the daily water needs of the oil palm plant itself.

In the process of using liquid waste for oil palm plantations, it takes a long process so that liquid waste is safe for plantations and the environment itself, which takes 60 days to be stored in liquid waste ponds, where each pond is 100 m long, 25 wide. The depth of the pool is 4 m with a maximum volume of 10000 m<sup>3</sup> for each pond. PT. X has six liquid waste collection ponds that are actively used and two liquid waste ponds that are not actively used. After being collected, the liquid waste will be sent to the plantation using a pump machine through pipes with a diameter of 6 inches.

## 2. Literature Review

### 2.1. Pumping Machines Used in Liquid Waste Delivery Ponds

PT. X is a branch company that works in the plantation and food sector. PT X has a maximum FFB processing capacity of 60 tons per hour which can produce liquid waste of approximately 60% of its FFB processing capacity per hour [9]. This causes the company to be able to take advantage of how the liquid waste produced can be used as well as possible by making the liquid waste as organic fertilizer for oil palm plantations owned by PT. X so that oil palm plantations can produce maximum fruit and good quality. The daily requirement of liquid waste used for oil palm plantations to meet the needs of organic fertilizer is approximately 500 m<sup>3</sup>.

PT. X has six active pools and two inactive pools, each of which has a length, width and height of 100 m x 25 m x 4 m to accommodate 10,000 m<sup>3</sup> of liquid waste produced. Liquid waste will be accommodated in available waste ponds for a period of 60 days in order to meet the standards for the use of organic fertilizers and not pollute the environment around oil palm plantations. Liquid waste that is ready to be sent to oil palm plantations will be channeled through irrigation channels to a liquid waste delivery pond with a length, width and height of 3 m x 3 m x 2 m with a 1 m high barrier inside. The barrier functions as a barrier so that it is easy to clean the liquid waste input pipe when there is inhibition by leaves or liquid waste husks [10].

In the liquid waste delivery pond there are two centrifugal pump machines with the specifications of each machine, namely 55 kW as the number one pumping machine and 30 kW as the number two pumping machine.



Figure 1. Liquid Waste Centrifugal Pump Machine

The maximum pressure in the fluid flow that occurs in the centrifugal pump machine is not more than 15 bar, this is in order to extend the service life of the liquid waste centrifugal pump machine component.

## 2.2. Linear Regression Method

In delivering liquid waste to oil palm plantations using a pump engine that has a specification of 30kW engine power and the type of pump used is a Centrifugal pump. The delivery of liquid waste to oil palm plantations will be related to the available liquid waste, therefore predicting the state of liquid waste for the next period needs to be done in order to find out whether the pumping machine can perform its maximum performance on the delivery of liquid waste carried out [11]. Liquid waste forecasting can be done using the Linear Regression Method [12]. The formula for linear regression is as follows:

$$Y = a + bx \quad (1)$$

$$a = \frac{\sum XY - b \sum x}{n} \quad (2)$$

$$b = \frac{n \sum XY - \sum X (\sum XY)}{n \sum X^2 - (\sum X^2)} \quad (3)$$

where,

- $Y$  = Forecasted value
- $a$  = Constant (Intercept)
- $b$  = Coefficient of Linear Regression
- $x$  = Affecting Variables (time: Year, Month, Day)
- $n$  = Amount of data

## 2.3. Repair Policy Method

The Repair Policy method is a maintenance system that is carried out when a breakdown occurs [13]. This method can be searched using the following formula:

$$TCr = B . Cr \quad (4)$$

$$B = \frac{N}{Tb} \quad (5)$$

$$Tb = \sum_{\tau}^n pi . Ti \quad (6)$$

where,

- $TCr$  = Expected cost of repair
- $B$  = Average number of breakdowns per month for N tools per machine
- $Cr$  = Cost of repairs
- $Tb$  = Average runtime per tool before crash
- $N$  = Number of tools or machines

## 2.4. Methods of Preventive Maintenance Policy

The Preventive Maintenance Policy method is a maintenance system that is carried out on a scheduled basis without waiting until a machine is damaged [14] [15]. This method can be searched using the following formula:

$$TMC(n) = TCr(n) + TCm(n) \quad (7)$$

where,

- $TMC(n)$  = Total cost of maintenance per month
- $TCr$  = Repair fee per month
- $TCm$  = Monthly preventive maintenance costs

The steps to be taken are as follows:

- 1) Calculate the expected cumulative breakdown number of breakdowns ( $B_n$ ) for all machines during the preventive maintenance period ( $T_p = n$  weeks)
- 2) Determine the average number of breakdowns per month ( $B$ ) as a ratio of  $B_n/n$
- 3) Estimated repair costs per month:

$$TCr(n) = \left(\frac{Bn}{n}\right)Cr \quad (8)$$

- 4) Estimated preventive maintenance costs per month:

$$TCn(n) = \frac{N.Cm}{n} \quad (9)$$

- 5) Total cost of maintenance:  $TMC(n) = TCr(n) + TCn(n)$

### 2.5. Cumulative Distribution Function

The Cumulative Distribution Function (CDF) is a function that adds up the probability values to a certain event as already known the number of possible values is 1. The use of CDF is to determine the probability (probability) in a random experiment [13]. CDF has the conditions that  $0 \leq F(t) \leq 1$  and  $F(t)$  is a non-decreasing function (the function of the data is not monotonous/random data) while the CDF function is as follows:

$$F(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^\beta} \quad (10)$$

where,

- $F(t)$  = Cumulative Distribution Function (%)
- $t$  = time (hour)
- $\theta$  = Parameter Shape of the Weibull Distribution
- $\beta$  = Scale parameters of the Weibull Distribution

### 2.6. Reliability

The reliability function  $R(t)$  is a reliability function to determine a component system or sub-system running according to its capabilities at a certain time. The functions of reliability are:

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^\beta} \quad (11)$$

where,

- $R(t)$  = Reliability (%)
- $t$  = Time (hour)
- $\theta$  = Parameter Shape of the Weibull Distribution
- $\beta$  = Scale parameters of the Weibull Distribution

### 2.7. Failure Rate

The level of failure or the level of damage is the main requirement of a component item or subsystem which at certain intervals will fail. The functions of the failure rate are:

$$h(t) = \frac{\beta}{\theta} \left(\frac{t}{\theta}\right)^{\beta-1} \quad (12)$$

where,

- $h(t)$  = Failure rate
- $t$  = Time (hour)
- $\theta$  = Parameter Shape of the Weibull Distribution
- $\beta$  = Scale parameters of the Weibull Distribution

### 2.8. Mean

The average life time can be taken from the Weibull distribution using the following function:

$$E(t) = \theta \Gamma\left(1 + \frac{1}{\beta}\right) \tag{13}$$

where,

$E(t)$  = Average Life (hour)

$t$  = Time (hour)

$\theta$  = Parameter Shape of the Weibull Distribution

$\beta$  = Scale parameters of the Weibull Distribution

$\Gamma$  = Gamma function, taken from the Gamma Function Table

### 3. Methodology

The research location was conducted at PT. X Kelumpang Hilir District, Kotabaru Regency, and South Kalimantan Province. The data used in this study include primary data and secondary data, where primary data comes directly from the object of research while secondary data comes from journals and library books. The flow chart of the research carried out is shown in Figure 2.

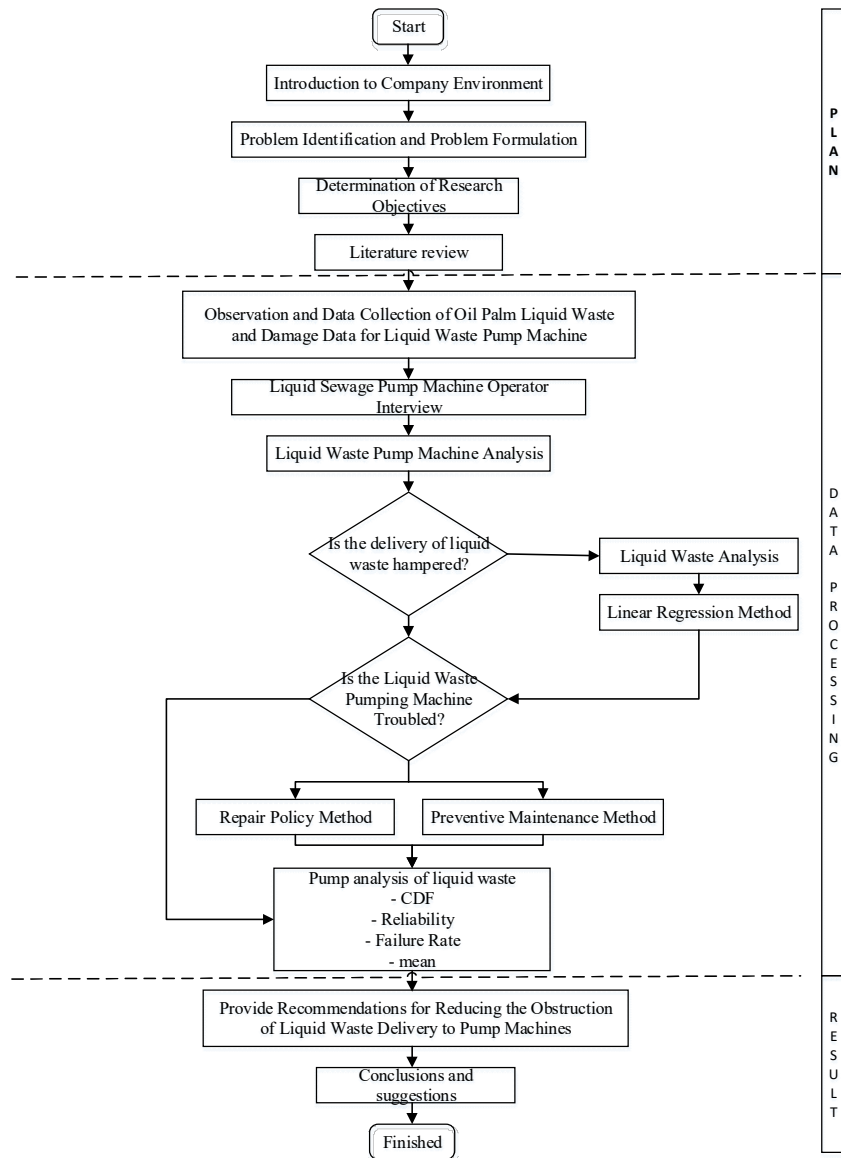


Figure 2. Research Method

#### 4. Finding and Discussion

In determining the forecasting of liquid waste in the next period, it is necessary to collect past data, namely data obtained when the research was carried out, data on liquid waste shipments obtained during the 45 days of the study are shown in Table 1.

Table 1. Waste and FFB Delivery in the Production Process

No	Date	TBS P	Output L	No	Date	TBS P	Output L
1	1/9/2015	140 ton	321 ton	24	29/9/2015	711 ton	249 ton
2	2/9/2015	591 ton	206 ton	25	30/9/2015	733 ton	305 ton
3	3/9/2015	477 ton	334 ton	26	1/10/2015	342 ton	235 ton
4	4/9/2015	455 ton	318 ton	27	2/10/2015	488 ton	185 ton
5	5/9/2015	466 ton	344 ton	28	3/10/2015	517 ton	234 ton
6	7/9/2015	746 ton	346 ton	29	5/10/2015	670 ton	225 ton
7	8/9/2015	567 ton	338 ton	30	6/10/2015	563 ton	227 ton
8	9/9/2015	524 ton	522 ton	31	7/10/2015	586 ton	228 ton
9	10/9/2015	587 ton	478 ton	32	8/10/2015	607 ton	234 ton
10	11/9/2015	537 ton	296 ton	33	9/10/2015	538 ton	186 ton
11	12/9/2015	557 ton	291 ton	34	10/10/2015	655 ton	228 ton
12	14/9/2016	768 ton	121 ton	35	12/10/2015	742 ton	122 ton
13	15/9/2016	774 ton	269 ton	36	13/10/2015	748 ton	128 ton
14	16/9/2016	640 ton	224 ton	37	15/10/2015	806 ton	83 ton
15	17/9/2016	518 ton	246 ton	38	16/10/2015	708 ton	127 ton
16	18/9/2016	491 ton	177 ton	39	17/10/2015	756 ton	249 ton
17	19/9/2016	477 ton	268 ton	40	19/10/2015	971 ton	210 ton
18	21/9/2016	896 ton	277 ton	41	20/10/2015	998 ton	244 ton
19	22/9/2016	670 ton	288 ton	42	21/10/2015	915 ton	264 ton
20	23/9/2016	611 ton	290 ton	43	22/10/2015	903 ton	220 ton
21	25/9/2016	514 ton	235 ton	44	23/10/2015	680 ton	103 ton
22	26/9/2016	550 ton	277 ton	45	24/10/2015	946 ton	45 ton
23	28/9/2016	785 ton	211 ton				

Next is to perform forecasting calculations using the minitab application which can be seen in Figure 3.

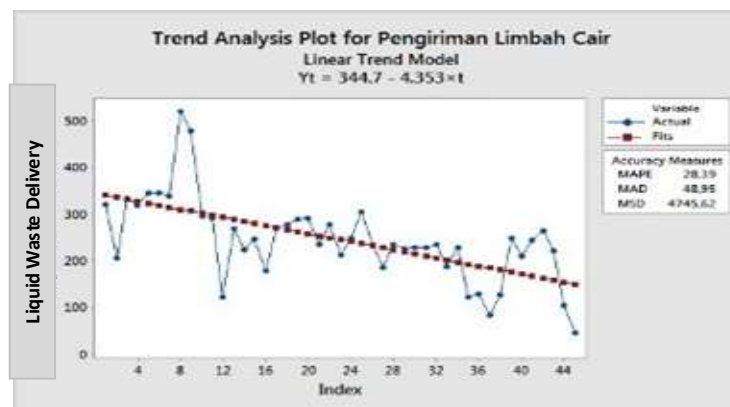


Figure 3. Linear Regression Graph

The results obtained using the Linear Regression Method are  $Y = 344.7 - 4.353x$ . By looking at the results of the calculation of Linear Regression with the Minitab Application, it can be predicted that the delivery of liquid waste in the next period, namely  $x = 46$ , is as follows:

$$\begin{aligned}
 Y &= a + bx \\
 &= 344,7 + (-4,353 \times 46)
 \end{aligned}$$

$$= 344,7 - 200,238$$

$$= 144,462 \text{ m}^3$$

#### 4.1. Data Analysis of Oil Palm Liquid Waste Pump Machine

Damage to the liquid waste pump engine over a period of 41 months can be seen in Table 2.

Table 2. Total Damage

Period	Total Damage
Maret 2021	1
Desember 2013	8
Februari 2014	1
Februari 2015	1
Maret 2015	4

By looking at the damage that occurred, it can be seen in the Pareto diagram below where the most frequent damage in each year will be seen in Figure 4.

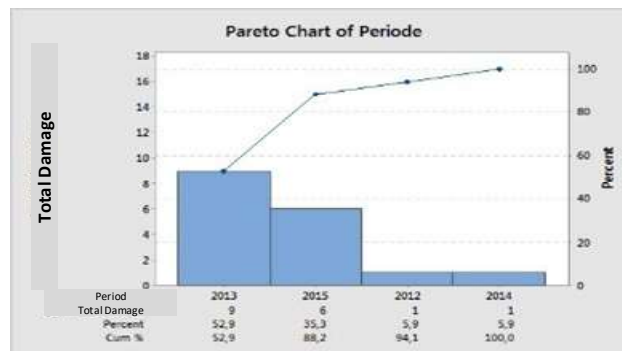


Figure 4. Pareto Diagram of Damage to the Pump Engine

It can be seen that the most damage occurred in 2013 which was 9 times. The percentage of damage that occurred during 41 months on the liquid waste pump machine can be seen in Table 3 below.

Table 3. Percentage of Damage

No	Same Type of Damage	Total Damage	Damage Percentage
1	Bearing	3	17,65%
2	Ball Vaalve	2	11,76%
3	Bolt Ring	1	5,88%
4	Bolts and Nuts	3	17,65%
5	Oil	1	5,88%
6	Glan Packing	1	5,88%
7	Shaft	2	11,76%
8	Mechanical Seal for Kew Pump	1	5,88%
9	O-Ring	1	5,88%
10	Pressure Gauge	1	5,88%
11	Wheel for Transfer Carriage	1	5,88%
Total		17	100%

#### 4.2. Determiation of Repair Maintenance Costs

The calculation of Repair Maintenance for the liquid waste pump machine is as follows:

- 1) The company's labor costs Rp. 7,511,- per hour, this calculation is obtained by using data on the average regional minimum wage of South Kalimantan during 2012, 2013, 2014 and 2015



which is Rp. 1,502,125,- per month, where the company's working days in a month are 25 days and working hours are 8 hours.

- 2) The cost of the spare parts used is the cost of the components (parts) that are replaced.
- 3) The number of workers needed to repair the machine is 3 people, with 8 hours of repair time.

From the description above, it can be obtained:

$$Cr = \{(\text{Sparepart time to repair} \times \text{amount of labor} \times \text{labor cost per hour}) + \text{material cost per spare part}\}$$

$$Cr(1) = \{(8 \text{ hours} \times 3 \text{ persons} \times \text{Rp } 7,511 \text{ per hour}) + \text{Rp } 2,432,462\} = \text{Rp } 2,612,717 \text{ per breakdown.}$$

### 4.3. Estimated Repair Policy Cost

The costs incurred in this repair policy are repair costs and downtime costs:

$$TMC(\text{Repair Policy}) = TCr + TCd \tag{14}$$

Therefore, when the liquid waste pump engine is damaged, production does not stop, so the total cost of downtime does not exist ( $TCd = 0$ ). Before we determine  $TCr$ , we must first calculate the average machine run-time ( $T_b$ ), then calculate the average breakdown per month or  $B$ . The costs incurred in this repair policy are repair costs and downtime costs:

- 1) Repair Costs

$$CR_1 = \text{Rp } 2,612 / 717$$

- 2) Average run-time per machine before Failure

$$T_b = T_1p_1 + T_2p_2 + T_3p_3 + \dots + T_{41}p_{41}$$

$$= 1(0.06) + 2(0) + 3(0) + \dots + 41(2.41) = 27 \text{ months}$$

- 3) Estimated Repair Policy cost per Downtime:

$$TCr_1 = \frac{N}{T_b} \cdot Cr_1 = \frac{1}{27} \times \text{Rp } 2,612,727, -$$

$$= \text{Rp } 96,767$$

So, the estimated cost of Repair Policy per Towntime is

$$TMC_1 = TCr_1 + TCd = \text{Rp } 96,767 + \text{Rp } 0$$

$$= \text{Rp } 96,767$$

For further calculation results can be seen in Table 4.

Table 4. Repair Policy Calculation Results

No	Cr	TCr	TMC
1	Rp 2.612.717	Rp 96.767	Rp 96.767
2	Rp 3.817.705	Rp 141.396	Rp 141.396
3	Rp 2.468.513	Rp 91.426	Rp 91.426
4	Rp 51.051	Rp 1.891	Rp 1.891
5	Rp 56.051	Rp 2.076	Rp 2.076
6	Rp 61.051	Rp 2.261	Rp 2.261
7	Rp 331.051	Rp 12.261	Rp 12.261
8	Rp 3.818.860	Rp 141.439	Rp 141.439
9	Rp 103.160	Rp 3.821	Rp 3.821
10	Rp 97.660	Rp 3.617	Rp 3.617
11	Rp 3.321.922	Rp 123.034	Rp 123.034
12	Rp 7.180.255	Rp 265.935	Rp 265.935
13	Rp 320.264	Rp 11.862	Rp 11.862
14	Rp 908.721	Rp 33.656	Rp 33.656
15	Rp 60.064	Rp 2.225	Rp 2.225
16	Rp 730.064	Rp 27.039	Rp 27.039
17	Rp 9.640.255	Rp 357.046	Rp 357.046
<b>Total</b>		<b>Rp 1.317.754</b>	<b>Rp 1.317.754</b>

### 4.4. Determining Preventive Maintenance Costs

The calculation of preventive maintenance costs ( $C_m$ ) for each machine is as follows:

- 1) The company's labor cost is Rp. 7,511,- per hour, this calculation is obtained by using the data on the average regional minimum wage of South Kalimantan during 2012, 2013, 2014 and

2015 which is Rp. 1,502,125,- per month, where the company's working days in a month are 25 days and working hours are 8 hours

- 2) The number of workers needed to repair the machine is 3 people, with 8 hours of preventive time.
- 3) The preventive action taken is enough to clean the input pipe blockage and check every part of the liquid waste pump machine.

$C_m = \text{time for maintenance} \times \text{amount of labor} \times \text{labor cost per hour}.$   
 $C_m = 8 \text{ hours} \times 3 \text{ persons} \times \text{Rp } 7,511 \text{ per hour} = \text{Rp } 180,255 \text{ per machine}.$

1) Estimated Cost of Preventive Maintenance Policy

Preventive Maintenance Policy for  $n = 1$  month  
 Preventive Maintenance Policy for  $n = 1$  month

Estimated cumulative amount of damage ( $B_1$ ) =  $Np_1 = 1(0.06) = 0.06$  damage per month

Average amount of damage per month ( $B$ ) = 0.06 damage per month

Estimated repair costs per month ( $TC_{r1}$ ) = Rp 153,689 per month

Estimated preventive maintenance costs per month ( $TC_{m1}$ ) = Rp 180,255 per month

Total maintenance cost per month ( $TMC_1$ )

$TMC_1 = TC_{r1} + TC_{m1} = \text{Rp } 153,689 + \text{Rp } 180,255 = \text{Rp } 333,944.$

2) Preventive Maintenance Policy for  $n = 2$  months

Estimated cumulative amount of damage ( $B_2$ )

$B_2 = N(p_1 + p_2) + B_1p_1$

$= 1(0.06 + 0) + 0.06 \times 0.06 = 0.062$  damage per month

Average amount of damage per month ( $B$ ) = 0.031 damage per month

Estimated repair costs per month ( $TC_{r2}$ )  $TC_{r2} = B \cdot Cr_2 = 0.031 \times \text{Rp } 0 = \text{Rp } 0$  per month

Estimated preventive maintenance costs per month = Rp. 90,127 per month

Total maintenance cost per month ( $TMC_2$ )

$TMC_2 = TC_{r2} + TC_{m2} = \text{Rp } 0 + \text{Rp } 90,127 = \text{Rp } 90,127$  per month

For the calculation of Preventive maintenance policy  $n = 3$  months to  $n = 41$  months on the liquid waste pump machine can be seen the following Figure 5.

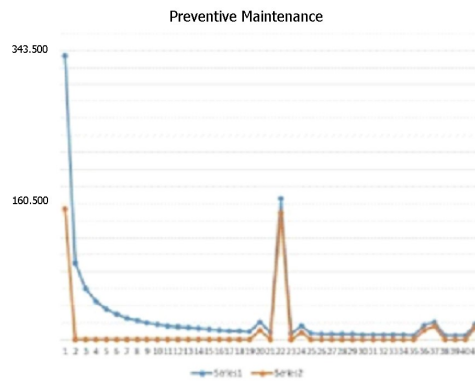


Figure 5. Preventive Maintenance Chart

**4.5. Life Time of Liquid Waste Pump Machine**

The Life Time of the liquid waste pump machine can be seen in the following Table 5.

Table 5. Life Time of Liquid Waste Pump Machine

Life Time (in hours)			
497,22	461,97	354,18	193,39
381,53	474,75	364,91	254,83
384,79	429,25	342,76	338,53
390,02	444,17	355,58	220,36
348,68	453,47	346,29	206,63
347,21	505,47	282,28	246,58
316,07	569,97	231,47	322,49
285,12	528,74	186,93	396,47
339,50	488,39	172,16	372,97

Results of the Weibull distribution can be seen in Figure 6 while the Weibull Distribution image is shown in Figure 7.

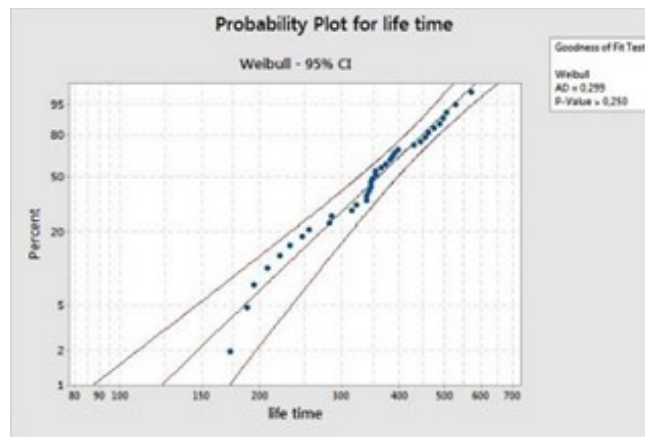


Figure 6. Weibull Distribution Plot Data Life Time Liquid Waste Pump Machine

From Figure 6, can be explained from the percentage of 95% CI (Confidance Interval) is the range between two values where the value of a sample mean is exactly in the middle or one of the parameters used to measure how accurately the mean of a sample represents (includes) the mean value real population. The CI value can be expressed in terms of the probability that several samples in 100 times of sampling the population mean value will actually be included in a sample mean. For 95% CI means that if I take a 100 sample data, then my 95 sample probability will include the true population mean value.

The Life Time data above is then processed into the Weibull Distribution and Identification Distribution using the Minitab 17.0 software.

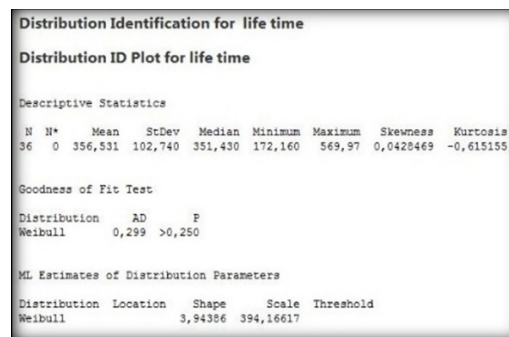


Figure 7. Distribution Plot of Life Time Data Identification on Liquid Waste Pump Machine

The Goodness of Fit test is a test of the compatibility between the results of certain observations (frequency of observations) and the frequency obtained based on the expected value (theoretical frequency).

- 1) From the Weibull distribution above, it can be seen that the Goodness of Fit Test results in AD = 0.299, the Anderson Darling Test is used to determine the distribution of the sample data (normally distributed data). The hypothesis of Anderson Darling is:  
 $H_0$  = data follow a normal distribution  
 $H_1$  = Data does not follow normal distribution with 5%  
 Meanwhile, the decision-making theory on the Anderson Darling hypothesis is taken if  $H_0 \geq p\text{-value} > \alpha$  and is rejected if  $H_0 \geq p\text{-value} > \alpha$ .
- 2) The results of the Weibull distribution on the Goodnes of Fit for  $p\text{-value} > 0,250$ . Since the  $p\text{-value}$  of the Weibull distribution plot above is 0.250 for the Life Time data of the liquid waste pump machine, it is greater than the value of  $\alpha$  (which is set at 0.05), it can be concluded that the Weibull distribution can be used as a representation of the data group. The representation here means that the data used can be accepted because the data used as a reference is in a concrete form.

From the identification distribution list for the Life Time data of the liquid waste pump machine, the output obtained is 36, the Mean value is 356.531, and deviation standard value is 102.740. The value of the standard deviation is not too large, it shows that the diversity of the data is not too large, which means that the data is homogeneous (the characteristics are the same). The AD value of 0.299, this value is relatively small, which means that  $H_0$  is accepted or the data is normally distributed, but from this AD value it cannot be decided with certainty whether the data is normally distributed or not because there are no definite parameters to determine that the data is normally distributed. Then there is a  $p\text{-value} > 0.250$  ( $> 5\%$ ) the  $p\text{-value}$  means that  $H_0$  is accepted and  $H_0$  is stated that the data is normally distributed. After the value of the two parameters of the Weibull distribution ( $\theta$  and  $\beta$ )  $\theta$  is the scale parameter in the Weibull distribution with a value of 394.16617 and  $\beta$  is the shape parameter of the Weibull distribution with a value of 3.94386. Then there is a median of 351.430 as the middle value of the processed data, the minimum value from the Minitab results is 172.160 and the maximum value from the data is 569.97. Skewness is the level of asymmetry of a distribution with a skewness result of 0.0428469. Kurtosis with a result of -0.615155, kurtosis (difficulty of data distribution) is a measure of the high and low peak of a distribution. After the values of the two parameters of the Weibull Distribution ( $\theta$  dan  $\beta$ ) have been known, it is continued with calculations to obtain the CDF, reliability, failure rate and mean values for the Liquid Waste Pumping Machine.

1) *Cumulatif Distribution Function*

The Cumulative Distribution Function (CDF) for the Weibull Distribution is as follows:

$$F(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^\beta} \tag{15}$$

It has been mentioned that the value of  $\beta = 3.94386$  and the value of the scale parameter  $\theta = 394.16617$ . Researchers took the time to operate or live in, namely the average time of the liquid waste pump machine = 356.531 hours. The CDF calculation is as follows:

$$F(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^\beta} \tag{16}$$

$$F(t) = 1 - e^{-\left(\frac{356,531}{394,16617}\right)^{3,94386}}$$

$$F(t) = 1 - 0.51$$

$$F(t) = 0.49$$

From the above CDF calculation, the value is 0.49. Based on the CDF requirements, namely  $0 \leq F(t) \leq 1$ , it means that the CDF value which is less than 1 or a value below half of 1 means that the device is still in normal condition.

2) *Reliability*

The reliability function for the Weibull Distribution. The equation is as follows:

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^\beta} \tag{17}$$

Where the value is stated that the value of  $\beta = 3.94386$  and the value of the scale parameter  $\theta = 394.16617$ .

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^\beta}$$

$$R(t) = 0.51$$

The results show that the probability that the liquid waste pump machine can run or perform its functions for 356.531 hours is 0.51.

### 3) Failure Rate

The failure rate (Hazard Rate) or the level of damage (Failure Rate) is a conditional probability of a component failing within the smallest interval of failure rates.

$$h(t) = \frac{\beta t^{\beta-1}}{\theta} \tag{18}$$

$$h(t) = \frac{3,94386}{394,16617} \frac{356,531^{3,94386-1}}{394,16617}$$

$$h(t) = 0.01(0.7429)$$

$$h(t) = 0.0074$$

The average liquid waste pump engine life is up to 356,531 hours with a failure rate of 0.0074.

### 4) Mean

The average of the Weibull distribution can live as follows:

$$E(t) = \theta \Gamma\left(1 + \frac{1}{\beta}\right) \tag{19}$$

$$E(t) = 394,16617 \Gamma\left(1 + \frac{1}{3,94386}\right)$$

$$E(t) = 357.27$$

Based on the calculation of the average value above, which is 357.27, it can be interpreted that the liquid waste pump machine can run for 357.27 hours.

## 4.6. Liquid Sewage Pump Machine Analysis

With the results of the calculations above, the discussion in the study obtained the length of time for handling damage with the Preventive Maintenance Method as shown in Table 6.

Table 6. Damage Handling Time

Same Type of Damage	Average Repair Time	Pump Engine Reliability
Bearing	5,82 hours	CDF = 0,49
Ball Valve		Reliability = 0,51
Bolt Ring		
Bolts and nuts		Failure Rate = 0,0074
Oil		
Glan Packing		
Shaft		Mean = 357,27 hours
Mechanical seal for kew pump		
O-Ring		
Pressure Gauge		
Wheel for transfer carriage		

While the comparison of costs used by using Repair Policy and Preventive Maintenance can be seen in the following Table 7.

Table 7. Expenditures

Cost	TMC	TCr
Repair Policy	↑Rp 357.046,-	↑Rp 357.046,-
Method	↓ Rp 1.891,-	↓ Rp 1.891,-
Total	Rp 1.317.754,-	Rp 1.317.754,-
Preventive Policy	↑Rp 333.944,-	↑Rp 153.689,-
Method	↓ Rp 4.506,-	↓ Rp 0,-
Total	Rp 1.147.960,-	Rp 364.142,-

#### 4.7. Company Regulation

The regulations that can be used in carrying out the maintenance of the Liquid Waste Pump Machine so that it can work optimally can be seen in the table below.

From the Table 8, it can be concluded that with regulations on Liquid Waste Pumping Machines can reduce various damages that will occur in the future so that the pump machine will work optimally and can minimize the costs that will be incurred by the company for the liquid waste pump machine used in delivery of liquid waste as organic fertilizer for oil palm plantations.

Table 8. Regulation of Liquid Waste Pumping Machine

No	Regulasi	Keterangan		
1	Periodic maintenance on the Liquid Waste Pump Machine	maintenance is done once a month		
2	Maintenance of all components of the Liquid Waste Pump Machine	Treatment is carried out in 1 cycle, which is 357.27 hours		
3	Costs incurred in choosing a treatment method	Repair Policy Method	TMC	Rp 1.317.754,-
			TCr	Rp 1.317.754,-
		Preventive Maintenance Method	TMC	Rp 1.147.960,-
			TCr	Rp 364.142,-
4	Adding a filter to the pool	it is important to add a filter to the liquid waste pond so that stones, leaves and husks do not enter the input pipe so that they are not clogged		

#### 5. Conclusion

The conclusion of this research is how to control the causes of damage that occur in the liquid waste pump machine can be overcome by using the Preventive Maintenance Method within a period of 1 month and maintenance of every component in the liquid waste pump machine within 1 cycle, namely 357.27 hours with a repair time of 5.82 hours. Controlling other causes of damage is to add a filter to the liquid waste pool so that stones, leaves and liquid waste husks do not hinder the suction pipe of the liquid waste pump machine.

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