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Reliability Analysis of Rotary Kiln b

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Abstract

PT. XYZ is a company engaged in the production of iron ore into semi-finished products (Iron Reduction). The company's machine has a very important and vital role to support the production process. Rotary Kiln is a place where iron ore reduction occurs, the result of which is called an iron reduction kiln or commonly known as sponge iron. By looking at the constraints, it is fundamental to increase the reliability level of the rotary kiln b PT XYZ production machine. XYZ. The research was carried out on the Rotary Kiln B machine made in Germany which plays a high enough role in the company. The research objective is to analyze the reliability (reliability) of Rotary Kiln b at PT. XYZ. The method used is Reliability with the Mean Time to Repair (MTTR) method. From the calculation of reliability on Rotary Kiln B with an operating time of 289 hours, the results are 0.5371 and MTTR 537.7732. The higher the reliability value, the better the machine used in the operation process.

Keywords: reliability, breakdown, Rotary Kiln, MTTR, uptime.

BACKGROUND

In the industrial world, the product is the main result of a production process that forms a production process system. The production process system consists of input, operation process, and output. A production process system can continue to run, and it requires maintenance activities (maintenance) of production equipment and machines. Maintenance is defined as an activity to maintain factory facilities. It is to repair, adjust, or replace. So that a state of the production operation is run as planned [1].

It is achieved by reducing congestion or constraints as small as possible so that the system can work efficiently. However, negligence often happens, and the maintenance is only performed when any damage occurs in the production system which causes additional maintenance costs. If the maintenance is carried out thoroughly and regularly, it will be useful to ensure the continuity of the production process and the life of the production facility.

PT. Meratus Jaya Iron & Steel is a company engaged in the production of iron ore into semi-finished products (Iron Reduction Kiln / IRK). Machines have very important and vital role to support the production process. Almost all production processes use machines. Any damage or disruption to the production machine can cause the production process to stop. Therefore, well-planned, and good maintenance is very important so that the production process runs smoothly. However, a damage to machine or production equipment is not avoided.

Based on the data on the types of damage and the frequency of the Rotary Kiln b machine, it can be processed into a Pareto diagram as shown in Figure 1 below.

Figure 1. Types of damage and frequency of Rotary Kiln machines b

Figure 1 shows the type of damage for the period (of) August 2013 to June 2014. There are two types (of damage), namely Lump Ore Empty Stock, Cleaning Boulder & Accession and Blocking Transfer Chute, Repair Conveyor.

Lump Ore Empty Stock is the highest type of damage on Rotary Kiln b machines with a total frequency of damage of 6 with a percentage of damage of 50%. Cleaning Boulder & Accession being the second highest type of damage on a Rotary Kiln b machine with a total frequency of damage of 5 with a percentage of damage of 40%. Blocking Transfer Chute has a total frequency of damage of 1 with a percentage of 10% and Repair Conveyor has a total frequency of damage of 1 with a percentage of 10%. So, the main type of damage (of) the Rotary Kiln b machine can be determined, namely Lump Ore Empty Stock on the Stock Yard Raw Material Handling. It becomes the main obstacle to the Rotary Kiln machine b.

The research was conducted on the German-made Rotary Kiln Machine which plays a high enough role in the company. Rotary Kiln is a place of reducing iron ore which results in iron reduction kiln or commonly known as sponge iron. The research choice on the Rotary Kiln is due to production machines that often have problems. Based on the above problems, the researcher conducted research entitled Reliability Analysis (Reliability) Rotary Kiln B (Case Study: PT. Meratus Jaya Iron & Steel).

METHOD

The object of this research is the Rotary Kiln B machine. This research was conducted at an iron ore industrial company located in Sarigadung Village, Simpang Empat, Tanah Bumbu, South Kalimantan, namely PT. Meratus Jaya Iron & Steel.

The data needed for this research are LifeTime data and Rotary Kiln B Maintenance data for the period of August 2013 to June 2014. The program used for reliability analysis was the Minitab 17.0 program. The method used here was the Mean Time To Repair (MTTR) Method with the Weibull Distribution which was useful for finding out how much time it takes to repair the existing system in the period of August 2013 to June 2014.

The research was conducted at PT. Meratus Jaya Iron & Steel, especially on Rotary Kiln machines b. This research went through several stages as in the research flow chart shown in Figure 2 below [4].

RESULTS AND DISCUSSION

Based on the maintenance data on the Rotary Kiln machine, researchers can get the time-to-repair (TTR) data. This TTR data is used as a reference for determining the Weibull distribution parameters [2]. The Weibull distribution is a distribution that describes the shape of the damage rate, and the repair rate) of a component. This distribution is suitable to use in determining the level of Reliability which has the concept of the damage rate and the repair rate in its application.

Three parameters can be used in determining the level of reliability of a component, θ (scale/age parameter), β (shape parameter), γ (characteristic parameter) [6].

Determination of repair time and Weibull distribution parameters are to determine the reliability value of critical components on a Rotary Kiln Machine. To determine the parameters of the Rotary Kiln Machine (θ and β), the Minitab 17.0 software application is applied.

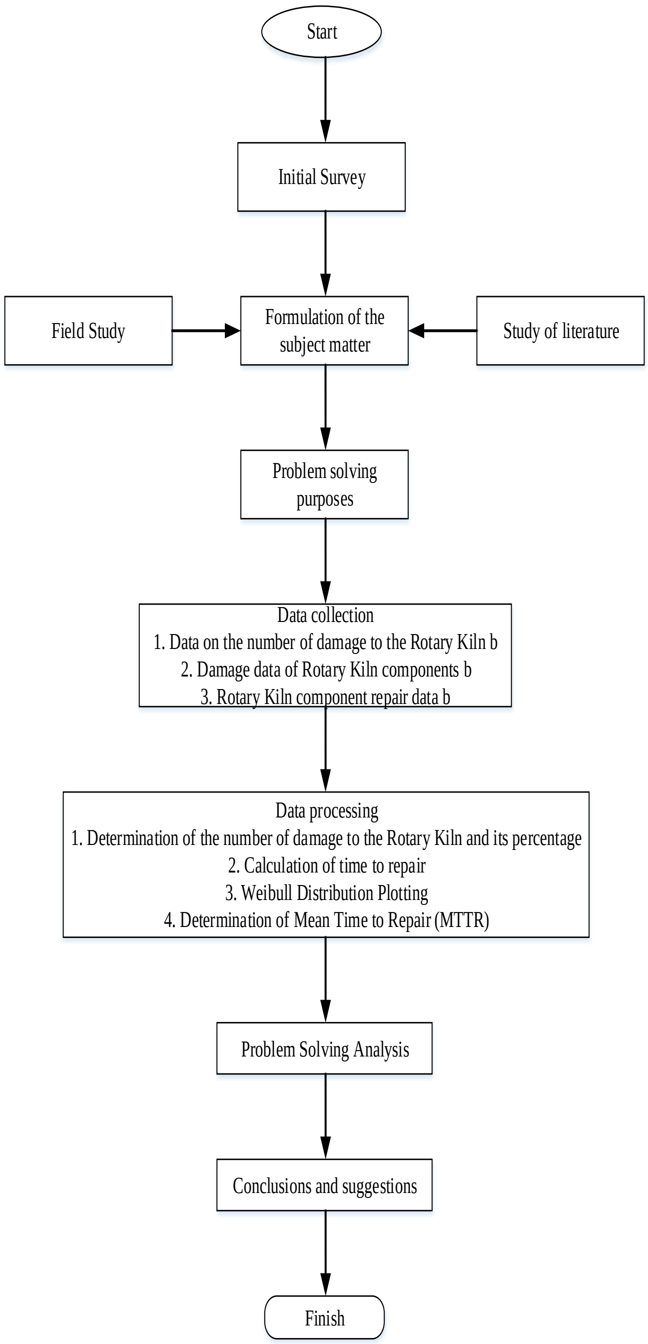

Figure 2. Research Flowchart

To make the Weibull distribution, repair data are grouped on the Rotary Kiln Machine. Based on the TTR data of the Rotary Kiln b machine then it proceeds using the Weibull distribution using the

Minitab 17.0 software. The Weibull Distribution Plot of the Rotary Kiln b Machine is described in Figure 3 as follows:

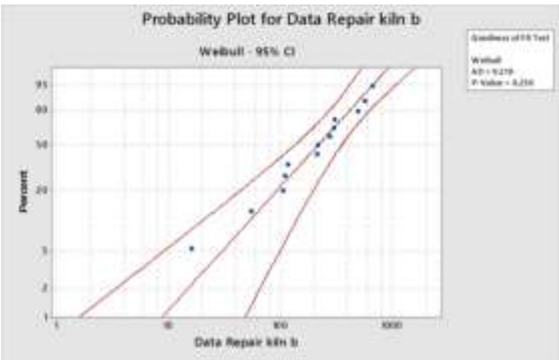

Figure 3. Weibull Distribution Plot of Rotary Kiln Machine b

Figure 3 explains the CI percentage of 95% (Confidence Interval) which is the range between two values where the value of a sample mean is exactly in the middle of one of the parameters used to measure how accurately the mean of a sample includes in the mean value of real population. The CI value can be expressed in terms of the probability of several samples in 100 samplings of the population. It means the value will be included in a sample mean. For 95% CI means that if you take a sample of 100 data then it is likely that my 95 samples will include the true population mean value.

The Goodness of Fit test is a test of suitability or goodness according to certain observations (frequency of observations) and the frequency obtained based on the expected value (theoretical frequency) [5].

a. From the Weibull distribution above, it can be seen that the goodness of fit test results in AD = 0.290. Anderson Darling Test is used to determine the distribution of the sample data (data distribution normally). The hypothesis from Anderson Darling is

H_0 = Data follows a normal distribution

H_1 = Data does not follow the normal distribution with $\alpha = 5\%$

Meanwhile, the theory of decision-making on the Anderson Darling hypothesis was taken if $H_0 \geq$ p-value> α and rejected if $H_0 \geq$ p-value <α. b. Results from the Weibull Distribution on Goodness of Fit for p-value> 0.250. Since the p-value of the Weibull Distribution plot above (i.e. 0.250 for the data time to repair Rotary Kiln machine b, is greater than the α value (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 concrete form. The distribution results of the identification of time to repair Rotary Kiln b data can be seen in Figure 4.

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Distribution Identification for  Data Repair kiln b

Distribution ID Plot for Data Repair kiln b


Descriptive Statistics

 N  N*     Mean    StDev  Median  Minimum  Maximum  Skewness   Kurtosis
13   0  265,308  203,250     217       16      672  0,833399  -0,210024


Goodness of Fit Test

Distribution     AD       P
Weibull       0,210  >0,250


ML Estimates of Distribution Parameters

Distribution  Location     Shape      Scale  Threshold
Weibull                  1,31988  287,60595
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Figure 4. Data identification time to repair Rotary Kiln b

From the identification distribution list for repair data for the Rotary Kiln Machine, the output results obtained by the number of data (n) are 13. The mean value is 265.308, the value is centered on the value of 265.308. The Standard Deviation Value is 203,250. The standard deviation value is not too big, it shows that the diversity of the data is not too big, which means that the data is homogeneous (the characteristics are the same). The AD value is 0.210. This value is relatively small, which means that H0 is accepted or normal spread data. But from this AD value, it cannot be decided certainly whether the data is spread normally or not because there are no definite parameters to determine that the data is spread normally. Then there is a p-value> 250 (> 5%). The p-value means that H_0 is accepted and H_0 is stated that the data spreads normally. After the values of the two Weibull Distribution parameters (θ and β), θ is the scale parameter in the Weibull distribution results with a value of 287.60595 and β is the shape parameter of the Weibull distribution with a value of 1.31988. Then there is a median of 217 as the middle value of the processed data. The minimum value of the Minitab results is 16 and the maximum result of the data is 672. Skewness (slope) is the level of asymmetry of a skewness result distribution of -0.833399. The kurtosis is -0.210024. Kurtosis (data distribution tapering) is a measure of the height of the peak of a distribution. After the values of the two Weibull Distribution parameters (θ and β) are known, the calculation is followed to obtain the Mean Time To Repair (MTTR) value in hours.

$$MTTR= \theta . \Gamma(1 + \frac{1}{\beta}) \ldots\ldots (1)$$

$$MTTR= 287{,}60595 . \Gamma(1 + \frac{1}{1{,}31988})$$

$$MTTR= 287{,}60595 * \Gamma(1{,}76)$$

$$MTTR= 287{,}60595 * (0{,}91237)$$

$$MTTR= 262{,}403 \text{ hours}$$

The above calculation data is the MTTR calculation data on the Rotary Kiln Machine b. MTTR is data on the average repair results for Rotary Kiln b machines from August 2013 to June 2014. Based on the calculation results obtained it is concluded that the average repair time for Rotary Kiln b machines takes 262.403 hours.

(Based on the TTR data for the Rotary Kiln b machine then proceed using the Weibull distribution with Minitab 17.0 software. The Weibull distribution plot of the Rotary Kiln b machine is described in Figure 5. It explains the CI percentage of 95% (Confidence Interval). It is the range between two values where the value of a sample mean is exactly in the middle of one of the parameters used. To measure how accurate the mean of a sample includes the mean value of real population.

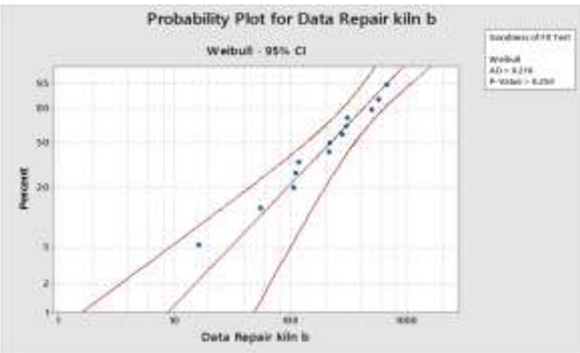

Figure 5. Distribution Plot for Time to Repair Rotary Kiln b Data

Figure 5 explains the CI percentage of 95% (Confidence Interval). It is is the range between two values where the value of a sample mean is exactly in the middle of one of the parameters use. To measure how accurate the mean of a sample includes the mean value of real population. The CI value can be expressed in terms of the probability of several samples in 100 samplings. The value will be included in a sample mean. 95% CI means that if you take a sample of 100 data then it is likely that my 95 samples will include the true population mean value.

The proper and fit test is a test of the suitability or appropriateness of the specific observations (observation frequency) and the frequency obtained based on the expected value (theoretical frequency) [3].

a. From the Weibull Distribution above, it can be seen that the Goodness of Fit Test gets the result of AD = 0.290. Anderson Darling Test is used to determine the distribution of the sample data (data distribution normally). The hypothesis of Anderson Darling is:

H_0 = Data follows a normal distribution

H_1 = Data does not follow the normal distribution with $\alpha = 5\%$

Meanwhile, the theory of decision-making on the Anderson Darling hypothesis was taken if $H_0 \geq$ p-value> α and rejected if $H_0 \geq$ p-value <α.

b. Results from the Weibull Distribution on *Goodness of Fit* for p-value> 0.250. Since the p-value of the Weibull Distribution plot above (i.e. 0.250 for the data time to repair Rotary Kiln b machine is greater than the α value (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 is acceptable because the data used as a reference is in a concrete form. The distribution results of the identification of time to repair Rotary Kiln b data can be seen in Figure 6.

```
Distribution Identification for  Data Repair kiln b

Distribution ID Plot for Data Repair kiln b

Descriptive Statistics

 N  N*     Mean    StDev  Median  Minimum  Maximum  Skewness   Kurtosis
13   0  265,308  203,250     217       16      672  0,833399  -0,210024

Goodness of Fit Test

Distribution     AD       P
Weibull       0,210  >0,250

ML Estimates of Distribution Parameters

Distribution  Location    Shape      Scale  Threshold
Weibull                 1,31988  287,60595
```

Figure 6. Distribution of Identification from Time to Repair Rotary Kiln Data

From the identification distribution list for repair data for Rotary Kiln Machines, the output results obtained by the number of data (n) are 13, the mean value is 265.308, the value is centered on the value of 265.308. The Standard Deviation Value is 203,250. The standard deviation value is not too big, it shows that the diversity of the data is not too big, which means that the data is homogeneous (the characteristics are the same). The AD value of 0.210, this value is relatively small, which means that H_0 is accepted or normal spread data, but from this AD value, it cannot be decided with certainty whether the data is spread normally or not because there are no definite parameters to determine that the data is spread normally. Then there is a p-value> 250 (> 5%) the p-value means that H_0 is accepted and H_0 is stated that the data spreads normally. After the values of the two Weibull Distribution parameters (θ and β), θ is the scale parameter in the Weibull distribution results with a value of 287.60595 and β is the shape parameter of the Weibull distribution with a value of 1.31988. Then there is a median of 217 as the middle value of the processed data. The minimum value of the Minitab results is 16 and the maximum result of the data is 672. Skewness (slope) is the level of asymmetry of a skewness result distribution of -0.833399. Kurtosis with a yield of -0.210024, kurtosis (data distribution tapering) is a measure of the height of the peak of a distribution. After the values of the two Weibull Distribution parameters (θ and β) have been known, proceed with calculations to obtain the Mean Time To Repair (MTTR) value in hours.

$$MTTR = \theta . \Gamma(1 + \frac{1}{\beta}) \ldots\ldots. (2)$$

$$MTTR = 287,60595 . \Gamma(1 + \frac{1}{1,31988})$$

$$MTTR = 287,60595 * \Gamma(1,76)$$

$$MTTR = 287,60595 * (0,91237)$$

$$MTTR = 262,403 \text{ jam}$$

The calculation data is the MTTR calculation data on the Rotary Kiln Machine b. MTTR is data on the average repair results for Rotary Kiln b machines in the period of August 2013 to June 2014. Based on the calculation results obtained it is concluded that the average repair of Rotary Kiln b machines takes 262.403 hours.

Lifetime on the Rotary Kiln machine b, the operating data for the Rotary Kiln b machine during the period of August 2013 to June 2014 are obtained as shown in Figure 7.

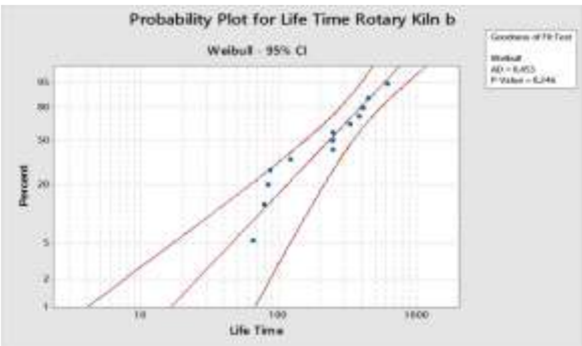

Figure 7. Weibull Distribution Plot of Rotary Kiln b Machine Lifetime Data

Figure 7 explains the 95% CI percentage. It is the range between two values where the value of a sample mean is exactly in the middle of one of the parameters. To measure how accurate the mean of a sample represents the true population means. The CI value can be expressed in terms of the probability of several samples in 100 samplings the population. It means the value will be included in a sample mean. For 95% CI means that if you take a sample of 100 data then it is likely that my 95 samples will include the true population mean value.

The proper and fit test is a test of suitability or appropriateness between certain observations (observation frequency) and the frequency obtained based on the expected value (theoretical frequency).

a. From the Weibull Distribution, it can be seen that the proper and fit test table gets an AD result of 0.453, Anderson Darling Test is used to determine the distribution of the sample data (data distribution normally). The hypothesis of Anderson Darling is:

H_0 = Data follows a normal distribution

H_1 = Data does not follow the normal distribution with α = 5%

Meanwhile, the theory of decision-making on the Anderson Darling hypothesis was taken if $H_0 \geq$ p-value> α and rejected if $H_0 \geq$ p-value <α.

b. Results from the Weibull Distribution in the proper and fit Table for a p-value of 0.246. Since the p-value of the Weibull Distribution plot above (i.e. 0.246 for the Rotary Kiln b machine lifetime data), is greater than the α value (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 using the data used is acceptable because the data used as a reference is in concrete form. The distribution of identification can be seen in Figure 8, which is as follows:

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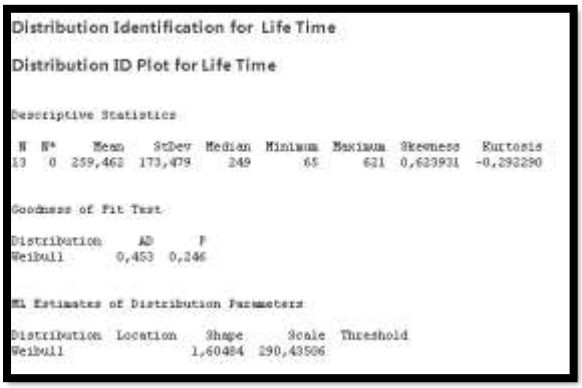

Distribution Identification for Life Time

Distribution ID Plot for Life Time

Descriptive Statistics

N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
13	0	259,462	173,479	249	65	621	0,623931	-0,292290

Goodness of Fit Test

Distribution	AD	P
Weibull	0,453	0,246

ML Estimates of Distribution Parameters

Distribution	Location	Shape	Scale	Threshold
Weibull		1,60484	290,43506	

Figure 8. The Plot of Identification Distribution of Lifetime Data on Rotary Kiln b Machines

From the identification distribution list for the lifetime data of the Rotary Kiln Machine, the output results obtained by the number of data (n) are 13. The mean value is 259,462 where the value focuses on the value of 259,462. Standard Deviation is 173.479. The standard deviation value is not too large, indicating 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 0.453. This value is relatively small. It means that it receives H_0 or normal spread data, but from this AD value, it cannot be decided with certainty whether the data is spread normally or not because there are no definite parameters to determine that the data is spread normally. Then there is a p-value> 0.246 (> 5%) the p-value means that H_0 is accepted and H_0 is stated that the data spreads normally. After the values of the two Weibull Distribution parameters (θ and β), θ is the scale parameter in the Weibull distribution results with a value of 290.43506. β is the shape parameter of the Weibull Distribution with a value of 1.60484. Then there is a median of 249 as the middle value of the processed data and the minimum value obtained from the Minitab 17.0 results is 65. The maximum result of the data is 621. Skewness is the level of asymmetry of distribution with the result of skewness of 0.623931. Kurtosis with a yield of -0.292290, kurtosis (data distribution tapering) is a measure of the height of the peak of a distribution. After the values of the two Weibull Distribution parameters (θ and β) have been known, proceed with calculations to get the CDF value, reliability, failure rate, and mean on the Rotary Kiln Machine b.

1. CDF (Cumulative Distribution Function)

The Cumulative Distribution Function for the Weibull Distribution viz

$$(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^{\beta}} \; ...... (3)$$

From the equation, the value of β = 1.90484 and the scale parameter value θ = 290.43506. Researchers took an average operating time interval of 296 hours. The CDF calculation is as follows:

$$(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^{\beta}} \; ...... (4)$$

$$(t) = 1 - e^{-\left(\frac{296}{290{,}43506}\right)^{1{,}60484}}$$

$$(t) = 1 - 0{,}3567$$

$$(t) = 0{,}6433$$

The calculation of CDF generates the score of 0, 6433. The percentage of damage to the Rotary Kiln Machine is 46.29%.

2. Reliability

Reliability or reliability functions for the Weibull Distribution. The equation is in equation 5.

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^{\beta}} \; ...... (5)$$

The β value is 1.90484 and the parameter scale parameter value is 290.43506.

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^{\beta}} \; ...... (6)$$

$$R(t) = e^{-\left(\frac{296}{290{,}43506}\right)^{1{,}60484}}$$

$$(t) = 0{,}3567$$

The results show that the chance that the Rotary Kiln Machine can operate or perform its function for 296 hours is 0.3567.

3. Failure Rate

The hazard rate or failure rate is the conditional probability of a component failure within the smallest time interval of failure rate.

$$h(t) = \left(\frac{\beta}{\theta}\right)\left(\frac{t}{\theta}\right)^{\beta-1} \; ...... (7)$$

$$h(t) = \left(\frac{1{,}90484}{290{,}43506}\right)\left(\frac{296}{290{,}43506}\right)^{1{,}90484-1}$$

$$h(t) = 0{,}00656.(1{,}0192)^{0{,}90484}$$

$$h(t) = 0{,}00656.(1{,}0174)$$

$$h(t) = 0{,}00667$$

The results obtained by the Rotary Kiln Machine can operate is 296 hours with a failure rate of 0.00667.

4. Mean

The average of the viable weibull distribution is:

$$E(t) = \theta\Gamma\left(1 + \frac{1}{\beta}\right) ...... (8)$$

$$E(t) = 290{,}43506\,\Gamma\left(1 + \frac{1}{1{,}60484}\right)$$

$$(t) = 290{,}43506.\,\Gamma(1{,}6)$$

$$(t) = 290{,}43506.0{,}89352$$

$$(t) = 259{,}5$$

The calculation of the average value results in 259.5. This means that the Rotary Kiln Machine can live for 259.5 hours.

The calculation shows that the CDF value results in 0.6433. This shows that the greater the CDF value greater, the greater the percentage of equipment damage. The larger the CDF value, the smaller the reliability level. The reliability level of the Rotary Kiln b machine is 0.3567. The smaller reliability value, the greater the failure rate.

The failure rate for Rotary Kiln b is 0.00667 failures per time at 296 hours of operation. The smaller the reliability level and the larger the failure rate, the smaller the average running. The rotary Kiln b machine can run with a mean value of 259.5. The smaller the machine reliability and the higher the failure rate, the lower the average engine running. The smaller the failure rate of the Rotary Kiln machine, the smaller average rate of reparation. The average value of reparation of the Rotary Kiln Machine is of 262.403 hours. This adjusts to the level of damage or the weight of damage which is categorized as heavy or moderate or light.

Conclusion

The research concludes that the Rotary Kiln b machine at the time of calculating 296 has a reliability value of 0.3567. The main factor of the reliability value is the usage of the machine. The longer it is used longer, the smaller the reliability value. It is close to 0. This is proven that the mass of use of Rotary Kiln b is more dominant. It is seen from MTTR to repair on Rotary Kiln Machines. The MTTR value on the Rotary Kiln b machine is 262.403.

Suggestion

This research suggests further research on the reliability of operators who use and repair the Rotary machines to maximize the operating work system.

Acknowledgement

We would like to thank PT. Meratus Jaya Iron & Steel, which provides the opportunity for researchers to collect research data.

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