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Evaluation of the Reliability and Prediction Maintenance on the Air Compressor System in Ammonia Plant PT. Petrokimia Gresik

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ABSTRACT

The air compressor in ammonia plant 101J has pressure of 7 kg/cm². The type of Air Compressor is centrifugal. It is very important role in the supply of air, so necessary to evaluate the value of reliability in the performance. Evaluation relating to the time-frequency component failure or functions. Components of air compressor evaluated is components often run into failure, it is rotor, air filter, journal bearing, thrust bearing, oil lubricant, pressure indicator, and temperature indicator. Overall reliability of the values obtained in air compressor system over 500 hours of operational is 0, 71. Over 1000 hours of operational is 0, 61 and over 1500 hours of operational is 0, 52. The rotor component is the component most often occurs due to unstable due to the impeller, causing unstable centrifugal force. This impact can cause the air compressor trip. In financing of preventive maintenance on reliability get up to 70%, 60% and 50% on components. Rotor obtainable USD 4654; USD 3750 and USD 3433.

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INTRODUCTION

In the formation of ammonia, in PT.Petrokimia Gresik, there is stage supply of air from outside. Instrument air is used for plant instrumentation means that driving pneumatic control valve. The air coming from the air compressor 101J in ammonia plant. Plant air from the compressor is introduced into the utility I particularly sexy unit for absorbed molecules H_2O. The air is then distributed to the user; it is ammonia plant, urea plant, and service unit. The instrument air pressure of 7 kg /cm². Air compressor contained in the instrument air supply system in PT. Petrokimia is a centrifugal compressor types, it is the type of compressor that is capable of providing performance at high efficiency by operating at a pressure range and large capacity (UNEP-2015).

Compressor very important role in the supply of air, so it is necessary to evaluate the value of reliability in the performance of air compressor 101J system. Evaluation with regard to the frequency of failure time or damage to the components. Air compressor 101J in ammonia plant PT. Petrokimia Gresik had a fairly long operational time, from the 90's until today. Air compressor are operating without stopping, thus causing suspicion whether the components in the compressor still has a good performance in performing its functions. Long operational life which may affect the reliability of the air compressor, so do not rule out the frequent breakdowns of each components. The purpose of this final project is to obtain results on the air compressor 101J reliability, obtaining the results of preventive maintenance of the reliability and obtain the results of preventive maintenance cost on the individual components of air compressor 101J system (Unido-2014).

MATERIAL AND METHODS

A. Compressor:

Compressor is mechanical equipment which is used to add energy to the fluid gas or air, so that air or gas can flow from one place to another are continuously (Eliot, 2024). These energy changes can occur due to mechanical motion which compressors function to change mechanical energy into pressure energy in the gas. Most small residual gas formed into heat loss. In this final project, the type of compressor used is a type of centrifugal compressor. Scheme of the type of centrifugal compressors is shown in Figure 1.

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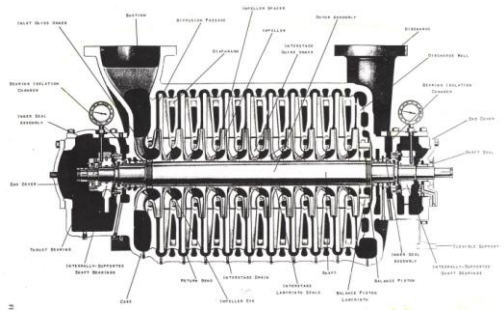

Fig. 1: Components of the centrifugal compressor.

B. Reliability Function:

Reliability function is a mathematical function expressing the relation of reliability with time. Reliability function value is the probability value, and then the value of the function reliability (R) is 0 ≤ R ≥ 1. (Beetling, 1997) is denoted as the reliability function R (t) of the system m if used for t units of time. The concept of time in reliability is time to failure (TTF). Time to failure (TTF) as the elapsed time when it begins operating components to fail.

C. Weibull Distribution:

If the failure time distribution of a component, subsystem or system follows the Weibull distribution, then:

a. Weibull distribution function equation reliability (Dhilon B.2005, Ebeling C.1997)

$$R(t) = \exp\left\{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right\} \quad (1)$$

b. Weibull distribution failure rate.

$$\lambda(t) = \frac{\beta}{\eta}\left[\frac{t-\gamma}{\eta}\right]^{\beta-1} \quad (2)$$

c. Equation average time weibull distribution failure.

$$MTTF = \gamma + \eta\Gamma\left(1+\frac{1}{\beta}\right) \quad (3)$$

D. Normal Distribution:

If the distribution of time between failures of a system to follow a normal distribution (Dhilon B.2005, Ebeling C.1997).

a. Reliability of the normal distribution function equation as follows.

$$R(t) = 1 - \Phi\left(\frac{t-\mu}{\sigma}\right) \quad (4)$$

b. Failure rate equation as follows normal distributionn.

c. $$\lambda(t) = \frac{\exp[-(t-\mu)^2/2\sigma^2]}{\int_t^{\infty}\exp[-(t-\mu)^2 2\sigma^2]dt} \quad (5)$$

d. Equation average time following the failure of the normal distribution

$$MTTF = \mu \quad (6)$$

E. Lognormal Distribution:

If the distribution of time between failure to follow the lognormal distribution, (Dhilon B.2005, Ebeling C.1997).

a. Lognormal distribution function equation reliability.

$$R(t) = 1 - \int_0^t \frac{1}{\sigma t\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{\ln t-\mu}{\sigma}\right)^2\right]dt \quad (7)$$

b. Lognormal distribution failure rate equation

$$\lambda(t) = \frac{f(t)}{R(t)} \quad (8)$$

c. Equation average failure time distribution lognormal

$$MTTF = \exp\left(\mu + \frac{\sigma^2}{2}\right) \quad (9)$$

F. Exponential Distribution:

If the distribution of time between failures of a system follows the exponential distribution, (Dhilon B.2005, Ebeling C.1997).

a. Reliability function equation exponential distribution,

$$R(t) = e^{-\lambda(t\gamma)} \quad (10)$$

b. Failure rate equation for the exponential distribution

$$\lambda(t) = \lambda \quad (11)$$

c. Equation average time exponential failure distribution

$$MTTF = \gamma + \frac{1}{\lambda} \quad (12)$$

G. Maintainability:

a. Maintainability equation for weibull distribution is shown in the following equation

$$M(t) = 1 - e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad (13)$$

b. Maintainability equation for the lognormal distribution is shown in the following equation

$$M(t) = \int_0^t \frac{1}{t\sigma\sqrt{2\pi}}\exp\left[-\frac{(\ln t-\mu)^2}{2\sigma^2}\right]dt \quad (14)$$

c. Equation average time exponential failure distribution

$$M(t) = \int_0^t \frac{1}{\sigma\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2\right] \quad (15)$$

d. Maintainability equation for the exponential distribution is shown in the following equation,

$$M(t) = 1 - e^{-\mu(t\gamma)} \quad (16)$$

H. Preventive Maintenance:

Mathematically Preventive Maintenance can be determined with the following equation (Ebeling, 1997).

$R_m(t) = R(t)^n R(t\text{-}nT)$ *untuk* $nT \leq t \leq (n+1)$ (17)

I. Maintenance Financing:

a. Equation calculations on improvement financing (Fitri, 2010, Sudarta, 2008).

$C_R = C_C + (((C_W + C_O) \times MTTR)$ (18)

Where is:

C_R= cost repair

Cc = cost components

C_W = cost of labor

C_O = cost operational consequences (loss product)

b. Ccalculations on the financing of preventive maintenance using the following equation (Fithri, 2010)

$$C_{PM} = \frac{[(C_M x R_{(t)}) + (C_R x(1 - R_{(t)}))]}{[(t_P x R_{(t)}) + (t_f x(1 - R_{(t)}))]} \quad (19)$$

Where is,

C_{PM} cost of maintenancencue

t_p = time preventive

t_f = time failure

R (t)= reliability during preventive maintenance

Methodology:

The research is done through several stages. These stages according to the flowchart in Figure 2. The study of literature in the form of theoretical understanding of the study process and the identification of the components of air compressor 101J. The main components are reliability analyst that rotor, air filter, journal bearing, thrust bearing, lubricant oil, pressure indicator and temperature indicator. Stages of quantitative method will be evaluated value of reliability, maintainability, availability and preventive maintenance (PM), (Dhilon B.2005, Ebeling C.1997, Musyafa A.2013). In this research, qualitative method are used there are two, the method of Failure Mode and Effect Analysis (FMEA) and the Fault Tree Analysis (FTA).

a. Methods of Failure Mode and Effect Analysis:

Methods Failure Mode and Effect Analysis (FMEA) in this final project is used to determine which component failure, knowing causee of the failure, determine the effect of failure and determine ways of handling the existence of such failures.

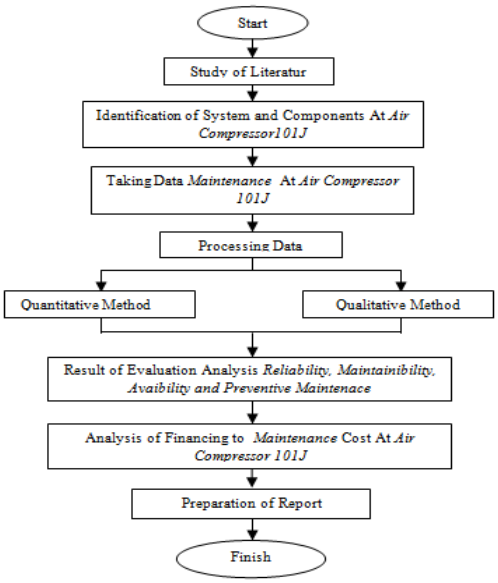

Fig. 2: Flow chart of compressor system research.

b. Methoods of Fault Tree Analysis (FTA):

Methods FTA (Fault Tree Analysis) in this final project are used to identify the failure or trip on the components in a system. The steps are:

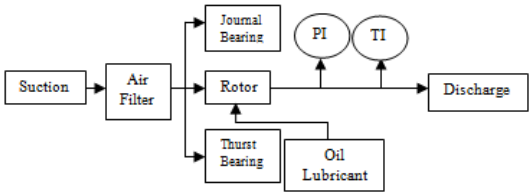

Fig. 3: Process Flow Diagram of compressor system.

- Analyze the process flow air compressor 101J system using Piping and Instrumentation Diagram (P&ID) and make the air compressor system block diagram 101J shown in Figure 3.
- Determine the top event to basic event to see how the workflow components in the system so that the air compressor trip can be known.
- In the last stage of this thesis is to make conclusions based on the calculation of research and analysis that has been done. The results of the analysis in the evaluation in order to answer the purposes of research and advice that can be given to support the development shown in Table 1.

Table 1: Top event-basic event compressor system.

Top Events	*Resultants Events*	*Basic Events*
Air Com-pressor trip		
	Velocity and temperature unstable (overheating)	1. Pressure Indicator failure
		2. Temperature Indicator Failure

	Rotor failure	1. Thrust bearing disturbed
		2. Journal bearing disturbed
		3. No balance
	Pressure Indicator failure	1. error reading transmitter
		2. Setting pressure no stable
	Error reading transmitter	1. Cable not plugged
		2. Signal Loss
	Setting pressure not stable	1. Bolts jammed
		2. Bolts not matching design
	Temperature Indicator failure	1. error reading transmitter
		2. Setting pressure no stable
	Error reading transmitter	1. Cable not plugged
		2. Signal Loss
	Setting pressure not stable	1. Bolts jammed
		2. Bolts not matching design
	Thrust bearing failure	1. Air filter dirty and rusty
		2. Misalignment
		3. Oil Lubricant system failure
	Air filter dirty and rusty	1. Air quality is bad
		2. Many air particle from inlet
	Oil Lubricant system failure	1. Over heating
		2. Leakage
	Journal bearing failure	1. Air filter dirty and rusty
		2. Misalignment
		3. Oil Lubricant system failure
	Air filter dirty and rusty	1. Air quality is bad
		2. Many air particle from inlet
	Oil Lubricant system failure	1. Over heating
		2. Leakage

RESULTS AND DISCUSSIONS

Quantitative evaluation of Air compressor is performed using software Reliasoft Weibull ++ 6 of the data history of damage and repair the components that are in the air compressor 101J system. This evaluation is used to obtain the distribution and the most appropriate parameters for the data time to failure (TTF) and the time to repair (TTR). Distribution and the parameters used to find the reliability function as a function of time {R (t)}, maintainability {M (t)}, and availability {A (t)}. From the calculation of the value of TTF (Time to Failure) and TTR (Time to Repair), determine the distribution of TTF and TTR use Reliasoft Weibull ++ 6.

A. Evaluate of quantitave air compressor system:

a. Quantitative evaluation at rotor component:

- ***Evaluation of Reliability At Rotor:***

The result of the calculation of the reliability of the rotor is shown in the following chart reliability in Figure 4a. No PM and 4b. Using PM. Provided that the rotor component has a reliability rate of 71.70%. The reliability value occurs at the time of operation for 3500 hours or approximately 5 months.

- ***Evaluation of Maintainability and avaibility In Rotor:***

The results of plotting the data obtained TTR lognormal distribution. Maintainability value reaches 100% when it reaches the interval of 1500 hours. The average time of failure for the rotor component of 609,318 hours and the average time of repair for 74 hours. Failure rate obtained a value of 0,00012 at the time of 3500 hours of operation. Availability at rotor component of the air compressor 101J decreased to 0,994702 in operating time of 500 hours.

- ***Evaluation of Preventive Maintenance In Rotor:***

In the reliability evaluation of preventive maintenance, the calculation is done on the reliability value approaching 0.70 or 70%. The rotor component of preventive maintenance performed at intervals of 3000 hours. Evaluation of reliability with preventive maintenance for various values of t(h) can be calculated as shown in Figure 4.b. The analysis is plotted in a graph the relationship between reliability with a cumulative preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the rotor components can be scheduled as much as 8 times for less than 3 years.

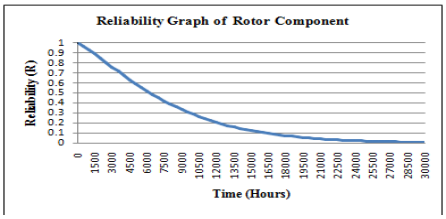

Fig. 4a: Reliability of rotor without PM.

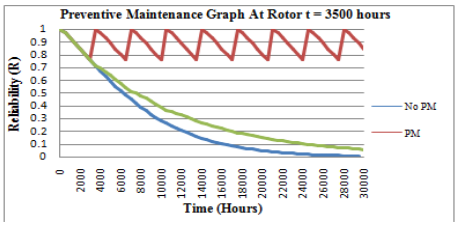

Fig. 4b: Reliability of rotor with PM.

b. Quantitative Evaluation At air filter Component:

- ***Evaluation of Reliability In Air Filter:***

The result of the calculation of the reliability of the water filter, shown in Figure 5.a-b. The results of the reliability calculation and plot graphs, obtained that the components Air Filter has a value of reliability 71 %. The reliability value occurs at the time of operation for 3000 hours or approximately 4 months.

- ***Evaluation of Maintainability and avaibility In Air Filter:***

The results of plotting the data TTR obtained Weibull distribution. Maintainability value reaches 100% when it reaches an interval of 500 hours. The average time of failure for Air Filter component for 6174 hours and the average time of repair for 87 hours. Failure rate obtained a value of 0,000126 at 3500 hours operating time. Availability (viability) component of the air compressor rotor 101J decreased to 0,990882 in operating time of 500 hours.

- ***Evaluation of Preventive Maintenance Air Filter:***

Evaluation of reliability with preventive maintenance, the calculation is done on the reliability values approaching 0, 70 or 70%. Components Air Filter performed preventive maintenance on 2500-hour intervals. The analysis is plotted in a graph the relationship between reliability with a cumulative preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the Air Filter component can be scheduled as much as 10 times over approximately 3 years shown in Figure 5.b.

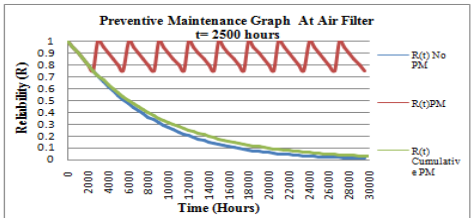

Fig. 5: Reliability of air filter with PM.

c. Quantitative Evaluation In Journal Bearing Component:

- ***Evaluation of Reliability In Journal Bearing Component:***

The result of the calculation of the reliability of the journal bearing, shown in Figure 6a-b. The results of calculation and plot graphs reliability, found that the Journal Bearing component value of reliability 71 %. The reliability value occurs at the time of operation for 9500 hours or approximately 13 months.

- ***Evaluatetion of Maintainability and Avaibility In Journal Bearing:***

The results of plotting the data TTR obtained Weibull 2 distribution. Value maintainability reaches 100% when it reaches an interval of 500 hours. The average time of failure Journal Bearing component for 12972 hours and the average time of repair for 100 hours. Failure rate obtained a value of 6,01E-05 at 9500 hours operating time. Availability component of the air compressor rotor 101J decreased to 0,999514 in operating time of 500 hours.

- ***Evaluation of Preventive Maintenance Journal Bearing:***

Journal Bearing Components performed preventive maintenance on 9000-hour intervals. Evaluation of reliability with preventive maintenance for various values of $t(h)$ can be shown in Figure 6.b. The analysis is plotted in a graph the relationship between reliability with a cumulative preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the components can be scheduled Journal Bearing 3 times for approximately 3 years shown in Figure 6.

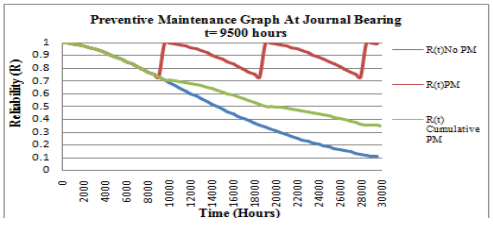

Fig. 6: Reliability of journal bearing with PM.

d. Quantitative Evaluation in thurst Bearing Component:

- ***Evaluation of Reliability In Thrust Bearing:***

The result of the calculation of the reliability of the thrust bearing, shown in Figure 7a-b. The results of calculation and plot graphs reliability, obtained that the thrust bearing component has a value of reliability 71 %. The reliability value occurs at the time of operation for 6000 hours or approximately 8 months.

- ***Evaluation of Maintainability and availability in thrust Bearing:***

The results of plotting the data obtained Weibull distribution TTR 3. Maintainability value reaches 100% when it reaches the interval of 2500 hours.

Obtained an average time of failure for thrust bearing component of 11140.8 hours and the average time repair of 76.8 hours. Failure rate obtained a value of 0.000056482 at 6000 hours operating time. Availability component of the air compressor rotor 101J decreased to 0.9995687 in operating time of 500 hours.

- ***Evaluation of Preventive Maintenance thrust Bearing:***

Evaluation of reliability with preventive maintenance, the calculation is done on the reliability values approaching 0, 70 or 70%. Bearing Components thrust performed preventive maintenance on the time interval 5500 hours. Evaluation of reliability with preventive maintenance is shown in the following graph 7b. The analysis is plotted in a graph the relationship between reliability with a cumulative scheduling preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the thrust bearing components can be scheduled as much as 5 times for less than 3 years shown in 7b.

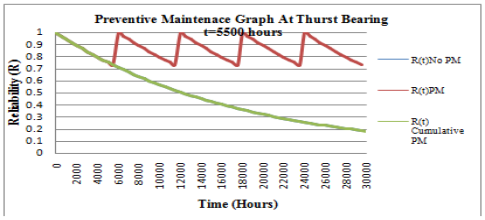

Fig. 7: Reliability of thrust bearing with PM.

e. ***Quantitative Evaluation at Lubricant Oil Component:***

- ***Evaluation of Reliability in Oil Lubricant:***

The results of calculation and plot graphs reliability, found that the Lubricant Oil component has a value of 71 % reliability. The reliability value occurs at the time of operation for 9000 hours or approximately 1 year. The results of calculation and plot graphs reliability, found that the Lubricant Oil component has a value of 71 % reliability. The reliability value occurs at the time of operation for 9000 hours or approximately 1 year.

- ***Evaluation of Maintainability and availability In Oil Lubricant:***

The results of plotting the data TTR obtained lognormal distribution. Maintainability value reaches 100% when it reaches the interval of 1000 hours. The average time of failure (MTTF) for Oil Lubricant component of 12942 hours and the average time of repair (MTTR) of 76, 8 hours. Failure rate values obtained by 3, 2E-05 at 9000 hours of operating time. Availability of the rotor component decreased to 0,999 at the operating time of 500 hours.

- ***Evaluation of Preventive Maintenance Oil Lubricant:***

Lubricant Oil Component performed preventive maintenance at intervals of 8500 hours. Rreliability evaluation of preventive maintenance for various values of *t* (*h*) can be shown in Figure 8.b. The analysis is plotted a graph of reliability with a cumulative preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the components can be scheduled Lubricant Oil is 3 times for approximately 3 years shown in 8.

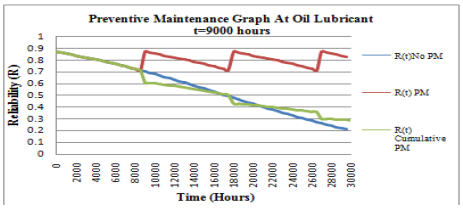

Fig. 8: Reliability Oil Lubricant with PM.

f. Quantitative Evaluation Component:
Pressure Indicator:

- ***Evaluation of Reliability In Pressure Indicator:***

The result of the calculation of the reliability of the pressure indicator is shown in Figure 9a-b. The results of calculation and plot graphs reliability, obtained that the components Pressure Indicator has a value of 70 % reliability. The reliability value occurs at the time of operation for 9000 hours or approximately 1 year.

- ***Evaluation of Maintainability and availability In Pressure Indicator:***

The results of plotting the data TTR obtained weibull distribution. Maintainability value reaches 100% when it reaches an interval of 500 hours. The average time of failure (MTTF) for components Pressure Indicator for 12126 hours and the average repair (MTTR) of 58 hours. Failure rate obtained a value of 4, 32 E-05 at 9000 hours operating time. Availability component of the air compressor pressure indicator 101J decreased to 0,999763 on the operational time of 500 hours.

- ***Evaluation of Preventive Maintenance Pressure Indicator:***

Evaluation of reliability with preventive maintenance, the calculation is done on the reliability values approaching 0, 7 or 70%. %. Pressure Indicator component performed preventive maintenance on a 9500-hour intervals evaluation of the reliability of the preventive maintenance is shown in Figure 9b. The analysis is plotted in a graph the relationship between reliability with a cumulative preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the components Pressure Indicator

can be scheduled 3 times over approximately 3 years.

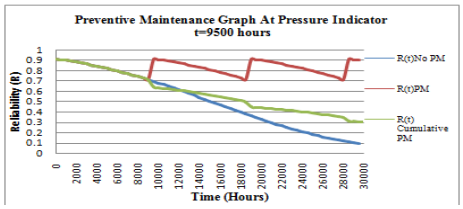

Fig. 9: Reliability of Pressure with PM.

g. Quantitative Evaluation Component Temperature Indicator:

- ***Evaluation of Reliability in Temperature Indicator evaluation:***.

The result of the calculation of the reliability of the temperature indicator is shown in Figure 10a-10b.

The results of the reliability calculation and plot graphs, obtained that the Temperature Indicator component has a reliability value of 73, 3 %. The reliability value occurs at the time of operation for 9000 hours or approximately 1 year.

- ***Evaluation of Maintainability and availability In Temperature Indicator:***

The results of plotting the data obtained TTR weibull distribution. Maintainability value reaches 100% when it reaches an interval of 500 hours. The average time of failure (MTTF) for components Temperature Indicator of 9945.6 hours and the average time of repair (MTTR) of 100.8 hours. Failure rate obtained value of 9, 54 E-05 at 9000 hours operating time. Availability component of the air compressor rotor 101J decreased to 0.999942 in operating time of 500 hours.

- ***Evaluation of Preventive Maintenance Pressure Indicator:***

Evaluation of reliability with preventive maintenance, the calculation is done on the reliability values approaching 0.70 or 70%. %. Component Temperature Indicator performed preventive maintenance on 9000-hour intervals. Evaluation of the reliability of the preventive maintenance is shown in Figure 10b. The analysis is plotted in a graph the relationship between reliability with a cumulative scheduling preventive maintenance and preventive maintenance. The results of calculation of preventive maintenance, it can be seen that the components can be scheduled Temperature Indicator 3 times for approximately 3 years.

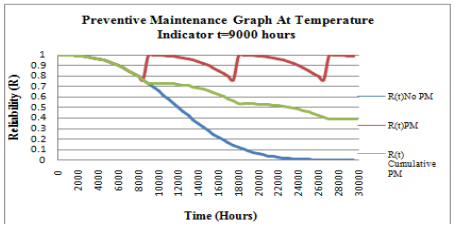

Fig. 10: Reliability of temperature indicator with PM.

h. Calculation of Reliability Systems:

In the block diagram in mind that the air compressor system 101J has a series configuration, so as to calculate the value of the reliability of the system, first determine the value of the reliability of each component. (Montgomery, Douglas C.(1999), Where is:R_1 = R (*Rotor*); R_2 = R (*Air Filter*); R_3 = R (*Journal Bearing*); R_4 = R (*Thrust Bearing*); R_5 = R (*Oil Lubricant*); R_6 = R (*Pressure Indicator*); R_7 = R (*Temperature Indicator*), Thus, R_s = P $(E_1 \cap E_2 \cap E_3 \cap E_4 \cap E_5 \cap E_6 \cap E_7)$ = P (E_1) P (E_2) P (E_3) P (E_4) P (E_5) P (E_6) P (E_7) = (R_1) (R_2) (R_3) (R_4) (R_5) (R_6) (R_7)= 0.933816 x 0.901735 x 0.991551x 0.945083 x 0.85585 x 0.903726 x 0.999286 = 0,61

Based on the same equation, the value of the overall reliability of the air compressor 101J performed at 500 hours and 1500 hours. Value the reliability of each component to the operating hours of 500 hours and 1500 hours can be found in Appendix C. The calculation result shows that the reliability of the overall value of the air compressor 101J system during the operational period of 500 hours was 0,71 and the operating time of 1500 hours is 0,52.

B. Qqualitative Evaluatetin of Air Compressor System:

In this final project, a qualitative method uses two methods, there are FMEA and FTA. FMEA can be shown on the existing worksheet in the appendix of this final project. As for the FTA of this thesis can be shown in Figure 11.

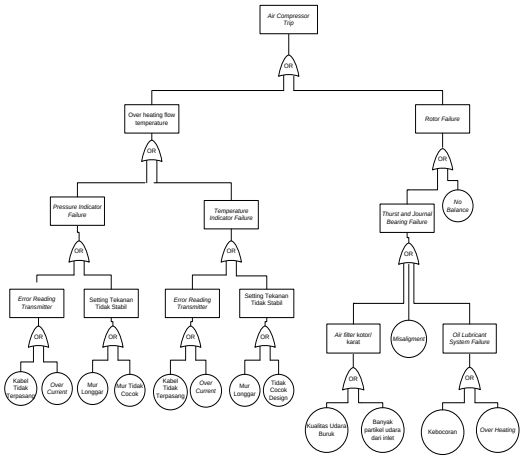

Fig. 11: FTA Process *Air Compressor 101J*

Figure 11. The FTA process during a trip in the air compressor system that will affect the supply of air in the pneumatic system of the instrument. In the picture, when the air compressor trip there are two factors that will affect that poor air quality and the presence of gas in the rotor failure. The reason for poor air quality due to uncontrolled pressure and temperature during the process of air compression Pressure and temperature are measured by each Pressure Indicator (PI) and Temperature Indicator (TI). The cause of the failure of PI and TI due to errors in measurement reading. This is because the cable is not Installed perfectly and over current. The cause of the failure of the second PI and TI are unstable pressure setting. This is due to lose nuts and bolts cannot fit in with the design.

The second factor affecting air compressor trip was a failure on the rotor. Rotor failed to function due to no balance and the failure of the thrust bearing and journal bearing. Thrust bearing and journal bearing failed due to several factors, namely water filter is dirty and rusty, misalignment, and the failure of the oil lubricant system. Air filter is dirty and rusty in because of poor air quality smoked and the number of particles in the air from the inlet. Failure on the oil lubricant due to leaks and overheating, so that the oil loses its lubricating properties.

C. Cost Analysis:

Based on the supporting data to determine the calculation of the cost of failure is obtained from the planning and control section-1 PT.Petrokimia Gresik plant is around the components of costs arising from the occurrence of failure. In this thesis, the components of costs are that the costs arising from the failure to know the damage a component of equipment;

a. Cost of Maintenance (C_M):

Care costs consist of the cost of labor (overtime) and treatment costs for example for: lubricating oil, and the replacement of small parts such as screws, nuts, and bolts. Preventive maintenance activities carried out outside the hours of operation so as not to interfere with the activity of the supply air unit. Because preventive maintenance carried out outside normal working hours, the cost of care workers into overtime, IDR. 625000 for each treatment were performed shown in Table 2.

Table 2: Total of maintenance cost.

Position	Total person	Honor per month IDR x1000	Amount IDR x 1000
Head of Instrument section	1	8500	8500
Head of Instrument team	1	7500	7500
Staff of instrument operation	2	4000	8000
Head of mechanical section	1	8500	8500
Head of mechanical team	1	7500	7500
Staff of mechanical operation	2	4000	8000
Total			48000

b. Cost of Repaired (C_R):

Repair costs incurred as a result of air compressor components that were damaged in need of repair service / repair components. Cost of repaired (C_R) consists of labor costs (C_W), the cost of restoration / replacement of components (C_C) and operational costs due to the consequences of the operation of the machine (C_O).

Table 3: Recapitulation of repair cost

Component	C_c IDR. x1000	C_{ow} IDR. x1000	C_o IDR. X1000	MTTR (h)	C_R IDR. X1000
Rotor	8200	300	20138	74	1520575
Air filter	362	300	20138	87	1778425
Journal bearing	28	300	20138	100	2061992
Thrust bearing	12.5	300	20138	77	1180514
Pressure indicator	3314	275	20138	58	1569613
Temperature indicator	1892	275	20138	101	2043778
Oil lubricant	128	275	20138	72	147163

c. Cost of Labor:

The cost of labour is labour allocated to perform maintenance actions for damage to the components of air compressor equipment. Manpower assigned to handle technical issues is: If one assumes in a month are 160 hours of work with the following details. 1 month = 4 weeks, 1 week = 5 days, 1 day = 8 hours. So the total cost of labour for the company issued amounted IDR.300.000 per hour with the assumption that all operations personnel and team leader can be

assigned to perform activities and maintenance.

d. Consequences of operational (C_O):

At the company known that any repairs and maintenance activities in Ammonia Plant cause operational consequences. Ammonia production capacity of 98,000 tons per year. Ammonia products will be distributed to the urea units to be processed into products Urea with IDR.1800 price per kg. Such information can be lost in the analysis calculations product. Average ammonia plant produce products of 268.5 tons per day or 11187.5 kg per hour. So that the operational consequences that accumulates at IDR. 20137500 per hour.

e. Cost of Repaired (C_R):

f. These costs arise due to damage from air compressor equipment:

Which requires replacement of components? The calculation for the cost of repair (C_R) will use equation (17). Calculation for rotor components requiring maintenance done to damage caused by rotor does not balance, given: Cc = IDR. 8.200.000; Cw = Rp.300.000 a hour ; Co = IDR. 20.137.500 an hour; MTTR = 74 hours, Then obtained CR calculation is: CR = IDR. 8.200.000+ ((IDR.300.000+ IDR. 20.137.500) x 74 hours) = IDR. 1.518.725.000 to recapitulation the results of the calculation shown in Table 3.

g. Determining Cost Preventive Maintenance (C_{PM}):

Previous analyzes have been carried out calculations reliability of each component on the air compressor. In the calculations performed until a span of 30,000 hours. The time span taken reliability value when it reaches 70%, 60%, and 50% for each component. At each value of reliability is analyzed to calculate the cost at the time of preventive maintenance. The cost calculation using equation 18. Following the calculation of the cost of preventive maintenance on the rotor.

Preventive maintenance cost (C_{PM}) on the rotor when the value of the reliability of ≈ 70%

$$C_{PM} = \frac{[(2250000x0{,}717022) + (1.520.575.000 \times (1 - 0{,}717022)]}{[(3500x0{,}717022)] + [6702{,}5 \times (1 - 0{,}717022)]}$$

= IDR .98.020 per hour

Financing on the rotor when the value of reliability ≈ 70% is IDR. 98020.73 x 74 hours = IDR. 7253534. in preventive maintenance with the reliability of 70% was obtained as much as 8 times over 30000 hours, so the total cost is obtained IDR.58028272 or US D 4,654

Preventive maintenance Cost (C_{PM})) on the rotor when the value of the reliability of ≈ 60%

$$C_{PM} \frac{[(2.250.000x0{,}633328) + (1.520.575.000 \times (1 - 0{,}633328)]}{[(4500x0{,}633328)] + [6702{,}5 \times (1 - 0{,}633328)]}$$

= IDR.105.316per hour.

Financing on the rotor when the reliability value of ≈ 60% is IDR.105.3167 x 74 hours = IDR. 7.79342 million. In preventive maintenance with the reliability of 60% was obtained for 6 times over 30000 hours, so the total cost is obtained IDR. 46.760.519.9 or US $ 3,751

Preventive maintenance Cost (C_{PM}) on the rotor when the value of the reliability of ≈ 50%

$$C_{PM} = \frac{[(2250000x0{,}518589) + (1.520.575.000 \times (1 - 0{,}518589)]}{[(6000x0{,}518589] + [6702{,}5 \times (1 - 0{,}518589]}$$

= IDR.115.677 per hour

Financing on the rotor when the reliability value of ≈ 50% is IDR. 115,677.86 x 74 hours = IDR. 8560.161,2. In preventive maintenance with the reliability of 50% was obtained by 5 times over 30000 hours, so the total cost is obtained IDR. 42,800,805.8 Or US $ 3,433 on the other components can be summarized show in the Table 4. The calculations show that the cost of preventive maintenance on each of the different components. If performed preventive maintenance on the lower reliability value, then the costs involved will be even greater shown in Table 4.

Table 4: Cost of Preventive Maintenance (C_{pm})

C_{pm} at R(t)			
Cost per componen	70%	60%	50%
Rotor	4654	3750	3433
Air filter	9254	6809	5210
Journal bearing	2138	1655	1120
Thrust bearing	1865	1176	823
Pressure indicator	742	513	280
Temperature indicator	447	347	196
Oil lubricant	1447	1228	756

Note: Current change; 1 USD=IDR.12468

Conclusion:

Reliability assessment of each component in air compressor 101J obtained successively at the time of 1000 hours, 3000 hours and 6000 hours. For rotor component R (t) = 0, 93; R (t) = 0, 76 and R (t) = 0, 52. For air filter obtained R (t) = 0, 90; R (t) = 0, 71 and R (t) = 0, 48. For jjournal bearing R (t) = 0, 99; R (t) = 0, 95 and R (t) = 0, 85. For thurst bearing R (t) = 0, 95; R (t) 0, 84 and R (t) = 0, 82. For lubricant oil R (t) = 0, 86; R (t) = 0, 82 and R (t) = 0, 77. For preassure Indicator R (t) = 0, 90; R (t) = 0, 87 and R (t) = 0, 80. Temperature Indicator R (t) = 0, 99; R (t) = 0, 98 and R (t) = 0, 90.

The overall reliability of the system of air compressor 101J during the operational period of 500 hours was 0.71. At 1000 hours operating time was

0.61 and at 1500 hours operating time was 0.52.

In the financing of preventive maintenance performed during reliability value reaches 70%, 60% and 50% respectively were obtained on each component. Rotor earned USD 4654; USD 3750 and USD 3433. Air Filter earned USD 9254; USD 6890 and USD 5210. Journal bearing earned USD 2138; USD 1655 and USD 1120. Thrust bearing earned USD 1865; USD 1176 and USD 823. Oil lubricant obtained USD 742; USD 513 and USD 280. Pressure Indicator earned USD 477; USD 347 and USD 196. Temperature Indicator earned USD 1447; USD 1,228 and USD 756. So the maintenance time guaranteed in reliability 50 % = USD 11818.

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