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Factors Analysis Of Failure And Reliability Of Electric Functions In Steel Production Processes Using FMEA, FTA, RCA And RBD At PT. Growth Sumatra Industry Medan-North Sumatera

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ABSTRACT

When a machine has a high failure rate, it is necessary to analyze the causes of the failure to the root of the problem so as to determine the appropriate action to improve the performance of a machine.PT Growth Sumatra Industry is a company engaged in steelmaking industry.In the steelmaking line required electric arc furnace machine, continuous casting and rolling mill.The purpose of this research is to identify the factors causing failure and reliability analysis of electric arc furnace using Failure Mode and Effect Analysis (FMEA) method, Fault Tree Analysis (FTA), Root Cause Analysis (RCA) and Reliability Block Diagram (RBD). The application of FMEA analysis can determine the extent to which failure rates occur. Then proceed with the FTA to find out more about the underlying causes of a failure. Then use RCA to find out the real problem that is the main cause of the high loss by making a fishbone diagram. And the latter determines the value of system reliability by using RBD based on trace failure. The object of this research is electric arc furnace machine. Data retrieval was obtained with interview result and maintenance record conducted by company. The data obtained is then analyzed descriptively ie retrieval of data maintenance from the company, the results of data processing included in the table , and displayed in graphical form. The result of the research was obtained by FMEA method obtained RPN value on each of the highest component that is furnace shell body with value reach 180. Then analysis using FTA method got the probability value of system failure period of January 2016 - December 2016 reached 36.94%.

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1. INTRODUCTION

Seeing the development of the State of Indonesia, especially in the industrial sector, steel factories have quite bright prospects in the future. We can see this from the ongoing developments carried out by the Indonesian government, including: construction of buildings, construction of connecting bridges, construction of toll roads, dams, construction of heavy and light industries. All of this is certainly inseparable from the consumption of steel. In an industry, getting optimal profits and minimizing costs is the goal to be achieved from the ongoing production activities. However, the path of the industry to achieve the target is not easy, various obstacles must be faced by utilizing the resources owned by the industry. From a production management perspective,

Constraints related to the technical field, one of which is the availability of resources such as humans who are ready to work by relying on their expertise and capacity, machines and other supporting facilities are in a ready-to-use condition to carry out production operations. To ensure a ready-to-use condition on a machine or other component, a good maintenance management is needed. If a condition is found where a machine has a high failure rate, it is necessary to analyze the causes of the failure to the root of the problem so that it can determine the appropriate action to improve the performance of a machine.

PT Growth Sumatra Industry is a company engaged in the steel making industry. The products it produces are billet steel, angled steel, axle steel, WF steel, wire mesh, plain concrete steel, wire rod and screw steel. In the steelmaking line, an Electric Arc Furnace, CCM (Continuous Casting Machine) and Rolling Mill machines are needed in the process. Among these processes, there is a smelting process using an electric arc furnace, where scrap metal is melted into liquid steel whose composition is according to demand. The melted scrap then enters the CCM machine for the billet printing process and after that the billets enter the Rolling Mill machine for the billet milling process which finally produces steel products. The importance of the role of the electric arc furnace in the steel production process.

2. RESEARCH METHOD

The research method carried out by the author is a case study method based on a field survey. The survey was conducted to find out how the company's electric arc furnace maintenance activities are carried out. As well as conducting a literature study so that the research carried out has strong guidelines.

3. RESULTS AND DISCUSSIONS

3.1 Maintenance Handling In Electric Arc Furnaces

The maintenance system carried out on the electric arc furnace aims to make the machine effective while operating. This is done because the electric arc furnace operates continuously. The author conducted research on an electric arc furnace of the EBT casting type at PT Growth Sumatra Industry Medan. The activities carried out are:

a. Conduct daily, weekly, monthly and yearly inspections.
b. Record the results of activities ranging from preventive to repair.
c. Supervise the work carried out by the factory.
d. Receive damage reports from operators and make work orders.
e. Maintain repair and maintenance activities.
f. Identifying aspects, determining goals, targets and programs.

3.2 Traces of Failure in Electric Arc Furnace Machine

During the production process, several failures have occurred, the following describes the types of failures in the electric arc furnace machine at PT Growth Sumatra Industry:

a. Furnace shell Leaking furnace wall/body

Figure 1. Electric arc furnace wall/body shell Fur

Furnace shell The wall/body of the furnace is the outermost part of the furnace which is made by welding or by forming a steel plate so that it has a cylindrical shape. This wall/body shell furnace serves to cool the body from high temperatures during production. The leak that occurred in the Furnace shell wall/furnace body was caused by sharp scraps being hit when the material was filled and splashes from molten steel.

b. Roof / big lid leaking furnace

Figure 2. Roof / large lid of electric arc furnace

Roff or the top cover of this furnace is shaped like a dome, serves to insulate heat so that the heat does not come out and also so that the dust generated from this smelting process does not come out, because dust is easily sucked in by the dedusting hole, so that dust is not scattered in the air. The leak that occurred on the roof of the large lid of the furnace was caused by the age of use and the splash of molten steel during production.

c. Leaking furnace roof bearing pipe

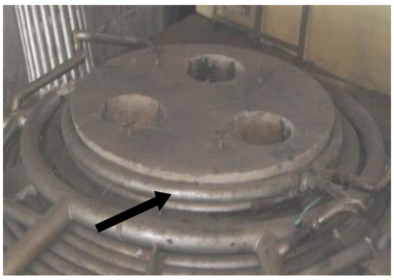

Figure 3. Electric arc furnace small cap bearing pipe

d. Slag door leaking furnace

Figure 4. Slag electric arc furnace door

Slag door This kiln serves as a place for the discharge of slag or steel impurities that float on the surface of the liquid which is then accommodated in the slag pot. The leak that occurred in the slag door of the furnace was caused by splashes of molten steel during production and stuck in the backhoe bucket when taking the slag.

e. Leakinzg electrode buffer cooling pipe

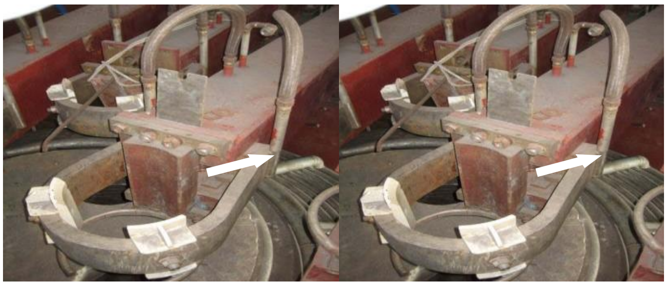

Figure 5. Electric arc furnace electrode support cooling pipe

f. Leaking electrode buffer cooling pipe

Figure 6. Castable refractory (refractory cast cement) electric arc furnace

g. Castablerefractory (refractory cast cement) cracked/cracked

Figure 7. Electric arc furnace roof cooling hose

3.3 FMEA (Failure Mode and Effect Analysis) table

The first step in making the FMEA table is to record any damage that occurs in the electric arc furnace, identify the cause, the possibility of failure that occurs and recommendations for actions that should be taken if the failure occurs. In the cause of failure column, the possibility of failure that occurs and recommended actions, can be entered from 1 item for each component. This is done so that the target for problem solving can be achieved appropriately. The table of FMEA application results in electric arc furnaces can be seen on the appendix page - A. There are several components that have high and low RPN numbers.

It can be seen the criticality level of failure on the electric arc furnace machine, where the higher the RPN value, the more critical the failure. The following is the result of calculating the RPN value from the FMEA table:

Furnace shell body leaking = S x O x D = 7 x 10 x 4 = 280
Roof / big lid leak = S x O x D = 7 x 7 x 3 = 147
Roof cooling bearing pipe leaking = S x O x D = 7 x 7 x 2 = 98
Slag doorleaking = S x O x D = 7 x 8 x 2 = 112
Electrode support cooling pipe = S x O x D = 6 x 7 x 3 = 126
Castable refractory damaged / broken= S x O x D = 7 x 7 x 1 = 49
Roof cooling hose leaking = S x O x D = 6 x 7 x 2 = 84
Leaking furnace shell cooling hose = S x O x D = 6 x 7 x 1 = 42
Leaking electrode buffer cooling hose = S x O x D = 6 x 6 x 2 = 72

It can be concluded from the calculation of the RPN value above that the furnace shell body component has the highest RPN value and the furnace shell cooling hose component has the lowest RPN value. Therefore, the highest RPN value becomes the priority for improvement first and then followed by other components until the lowest RPN value. The level of the RPN value for each component of the electric arc furnace can be seen in the graphic image 8 below:

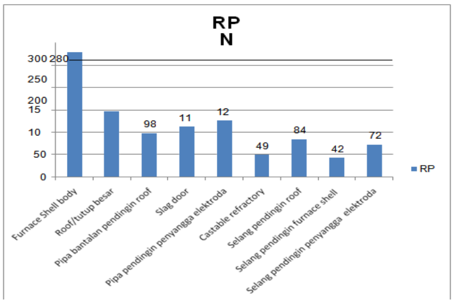

Figure 8. Graph of risk priority number

3.4 Fault Tree Analysis On Electric Arc Furnace Machine

This analysis was carried out by direct observation in the field, maintenance records and conducting interviews with employees involved in this study, which included operators, the workshop section and the quality control section. The results of the interview are one of the possible causes of the difficulty of achieving the desired reliability value target. Furthermore, the data that has been obtained from various parts will make a fault tree on the electric arc furnace machine based on the logic gate symbol and the event symbol.

Table 1. Description of fault tree analysis symbols

No	**Symbol**	**Information**
1	Top Events (T)	Damage to the electric arc furnace
2	P1	Furnace shell wall/body
3	P2	Roof / big lid
4	P3	Slag door
5	P4	Electrode support arm cooling pipe
6	P5	Castable refractory / refractory cast cement
7	P6	Roof cooling hose / large lid
8	P7	Wall/body furnace shell cooling hose
9	P8	Electrode support cooling hose
10	P9	Splashed with iron liquid
11	P10	Error in the process of loading scrap/used iron raw materials
12	P11	Furnace shell cooling system not working
13	P12	No routine checks
14	P13	Material failure
15	P14	Roof cooling system not working
16	P15	Getting stuck in the backhoe bucket when picking up slag
17	P16	Splashed with iron liquid
18	P17	Slag door cooling system not working
19	P18	The life time of the electrode support arm cooling pipe has exceeded the limit
20	P19	Electrode support arm cooling system not working
21	P20	Life time of castable refractory has exceeded the limit
22	P21	Material failure
23	P22	No routine checks
24	P23	Failure due to material
25	P24	Hit by a scrap drop while filling the scrap
26	P25	Material failure
27	P26	No routine checks
28	P27	Material failure
29	P28	Scrap sorting is not thorough and not up to standard
30	P29	Scrap pouring from charging bucket is too high
31	P30	Furnace shell cooling system pump off
32	P31	PLN electricity goes out
33	P32	Life time roof has exceeded the limit
34	P33	Splashed with iron liquid
35	P34	Roof cooling system pump off
36	P35	PLN electricity goes out
37	P36	Slag door cooling system pump dead
38	P37	PLN electricity goes out
39	P38	Electrode support arm cooling system pump off
40	P39	PLN electricity goes out
41	P40	Splashed with iron liquid
42	P41	Error when casting castable refractory
43	P42	The life time of the roof cooling hose has exceeded the limit
44	P43	There was a looseness during installation
45	P44	Furnace shell cooling hose life time has exceeded the limit
46	P45	There was a looseness during installation
47	P46	The life time of the electrode buffer cooling hose has exceeded the limit
48	P47	There was a looseness during installation

To be able to calculate the failure rate from the fault tree analysis above, the assumption of severity values can be used in every possibility, while the values are explained as follows:

Table 2. Severity scale

Rating	Severity	description
0.09	Dangerous without Warning	System failure that produces effects very dangerous
0.08	Dangerous with Warning	System failure that produces effects Dangerous
0.07	Very high	System not operating
0.06	Tall	The system is operating but cannot be started fully
0.05	Currently	The system is operating and safe but experiencing performance degradation that affects the output
0.04	Low	Experiencing a gradual decline in performance
0.03	Very low	Minor effect on system performance
0.02	Small	Little effect on system performance
	Very small	Negligible effect on system performance
0.01	No effect	No effect

3.5 Root Cause Analysis Application on Electric Arc Furnace Machine

This analysis was carried out by direct observation in the field and conducting interviews with employees who were involved in this study, which included operators, the workshop section and the quality control section. The results of the interview are one of the possible causes of the difficulty of achieving the desired reliability value target. To obtain the appropriate analysis results, tools that are relevant to the data that have been collected are needed, so to make it easier to identify the failure of the electric arc furnace, it can be done using the fish bone diagram method, which will later formulate an improvement plan to overcome the root cause of the problem. .

In the interview, several parameters were taken, namely material, machine, human and method, which can be seen on the appendix page – B.

a. Calculation of Reliability Block Diagram

To find the value, all we have to do is take some data that is in the factory. The data is in the form of any damage that has occurred, the data is obtained at the time of the damage. After that we determine how long the machine works, the authors take 50, 70, 90, 110, 130 and 150 hours of work. After that, determine which components we will calculate the reliability of, the author takes nine components, namely the wall/body furnace shell, roof, roof cooling bearing pipe, slag door, electrode buffer cooling pipe, castable refractory/refractory cast cement, roof/cover cooling hose large, furnace shell cooling hoses, and electrode buffer cooling hoses. The author took the nine components mentioned earlier because these components often fail.

Below are the results of the recapitulation of the realreliability value on the electric arc furnace machine based on working hours:

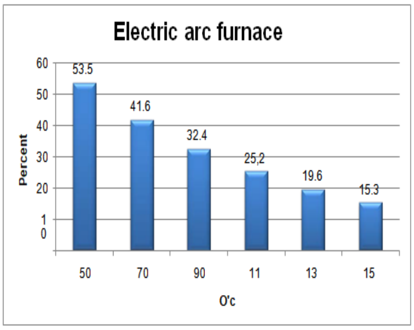

Figure 9. Electric arc furnace reliability graph

From these results, it can be seen that the comparison of the reliability of the electric arc furnace after implementing good maintenance and before performing TPM maintenance properly. Comparison of reliability can be seen in the graphic image 11 below:

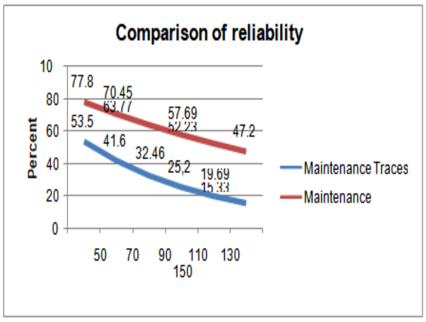

Figure 10. Comparison of reliability based on traces of maintenance with engineering maintenance

From Figure 10, we can see that the electric arc furnace has increased reliability after several ways to improve reliability.

a. At 50 hours of operation, the reliability of the electric arc furnace increased by 24.37% from 53.51% to 77.88%.
b. At 70 hours of operation, the reliability of the electric arc furnace increased by 28.79% from 41.66% to 70.45%.
c. At 90 hours of operation, the reliability of the electric arc furnace increased by 31.31% from 32.46% to 63.77%.
d. At 110 hours of operation, the reliability of the electric arc furnace increased by 32.41% from 25.28% to 57.69%.
e. At 130 hours of operation, the reliability of the electric arc furnace increased by 32.54% from 19.69% to 52.23%.
f. At 150 hours of operation, the reliability of the electric arc furnace increased by 31.92% from 15.33% to 47.25%.

From the reliability calculation above, the electric arc furnace can be said to work reliably at 130 working hours although ideally it is 20 working hours. After 130 hours of work, the electric arc furnace is required to receive extra maintenance, re-checking every component of the electric arc furnace.

4. CONCLUSION

From the analysis that has been carried out, the following conclusions are obtained: The results of the FMEA show that the critical component of the electric arc furnace engine that most dominantly causes damage is the higher RPN value, namely furnace shellbody = 280. The result of FTA shows that the probability of failure of the electric arc furnace is 0.36941 = 36.94%. The results of the RCA show that there are 4 factors that cause the failure of the electric arc furnace machine, namely humans, machines, materials and methods whose root causes are described through fishbone diagrams.

From the results of the RBD calculation, the reliability value of the electric arc furnace is obtained as follows: At 50 hours of operation, the reliability of the electric arc furnace is 53.51%, At 70 hours of operation, the reliability of the electric arc furnace is 41.66%, At 90 hours of operation, the reliability of the electric arc furnace is 32.46%., At 110 hours of operation, the reliability of the electric arc furnace is 25.28%, At 130 hours of operation, the reliability of the electric arc furnace is 19.69%,At 150 hours of operation, the reliability of the electric arc furnace is 15.33%.

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