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Failure Mode and Effect Aanalysis on Power Plant Boiler

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Abstract

The current electricity demand is increasing, and now the government has involved third parties in the implementation of electricity so that investors compete for building infrastructure in order to apply electricity. Thermal power is one source that has a fast break event point compared to other resources that more interested investors even with all forms of pollution caused. A form of heat power using a vapor pressure is fired into the turbine so that it will cause a rotating force that will turn the generator of an electric generator. thermal power has the ability to generate electricity large, but if there is a failure in operation, then the burden will quickly lose power sources that can cripple production activities.FMEA is one of the most widely used tools for the industry to analyze the root cause of the system so that the system is protected from small and large damage and can disrupt the stability of the industrial operating system. The reliability of the machine must always be maintained so that with this method it is expected to help the power service providers to maintain the availability of its services.With the implementation of FMEA, we get an overview of the steps to be taken for the future so that the reliability of a steam generator boiler system can be improved

Keywords: PowerPlant, Boiler, Thermal Power, Failure mode and effect analysis

1.Introduction

Electricity is a useful form of human life and an important factor of supporting the development of the area. As more and more people, the economic growth and development of the industrial sector led to the need for greater electricity. This is happening to major cities and in rural areas so that electricity supplyes is optimally and freely available. Electricity demands is increasing year by year and the lack of development of new power plants in Indonesia leads to an energy crisis.

Today the government is entrusting the private sector to participate in running electricity, especially for remote areas. Thermal energy is indispensable to investors as it has a relatively quick point compared to other electrical energy management methods. The thermal power commonly used in Indonesia is heating the water so that it becomes a high-pressure steam that will make the turbine generator blades produce electricity that we can use.

In operation, the machine used to heat water is called Boiler. Steam boilers are closed vessels that contain water and will be heated so that certain pressures and temperatures can rotate the steam turbine. Because the heating process can be used to rotate the turbine requires a considerable time for 2-3 hours of a capacity of 100MW, so the failures in the Boiler operation are maintained so that the reliability of the electric power system remains optimistic.

The failure mode and effect analysis are used to identify and analyzed: (1) all failure mode of different parts of the system, (2) effects of this failure mode on the system and (3) how to circumvent the failure and/or moderate the effect of the failed system. FMEA is a step by step tactic to identifying all possible failures of the processes. "Effect Analysis" denotes to studying the consequences of those failures (R.S.Mhetre & R.J.Dhake, 2012). The motivation for undertaking a Process FMEA is to continually develop products and process consistency thereby increasing customer satisfaction (K.G. Johnson & M.K.Khan, 2003).

FMEA presents a methodology for documenting phenomena that will be rooted in the issue as a continuous process of improvement. This is a systematic approach to analysis, definition, budget, and risk assessment. In this case, FMEA that we use in analyzing the major causes of steam powers system failure**.**

2. Literature Review

A failure modes and effects analysis (FMEA) are a methodology in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures(Ambekar, Edlabadkar, & Shrouty, 2013).

FMEA (Failure mode and effect analysis) is the basis of maintenance philosophy aimed at failure-free operation - Reliability Centered (RCM). Its task is to perform the analysis in such a way as to minimizing negative effects and help solve problems effectively or prevent them(Tomašková, 1929).

FMEA (Failure Mode and Effect Analysis) is a systematic method of identifying and preventing process and product problems before they occur. FMEA is focused on preventing damage, improving security, and improving customer satisfaction (Chikhale & Barik, 2015).

Failure Mode and Effect Analysis (FMEA) was first developed as a formal design methodology in the 1960s

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by the aerospace industry with their obvious reliability and safety requirements. FMEA is a systematic method of identifying and preventing system, product and process problems before they occur. It is focused on preventing problems, enhancing safety and increasing customer satisfaction. Ideally, FMEA‘s is conducted in the product design or process development stages, although conducting an FMEA on Existing products or processes may also yield benefits. FMEA is a tool that allows us to prevent System, Product and Process problems before they occur. It reduces costs by identifying system, product and process improvements early in the development cycle. It prioritizes actions that decrease the risk of failure(Rakesh, Jos, & Mathew, 2013).

The main purpose for performing FMEA are to prevent the possibility that a new design, the process fails or system fails to achieve, totally or in part the proposed requirements, under certain conditions such as defined purpose and imposed limits (Sharma & Srivastava, 2016).

Failure mode and effect analysis are an analytical technique (a paper test) that combines technology and experience in people in identifying probable failure mode of product or process and planning for its abolition. FMEA is a “before the- event” action requiring a team effort into easily and inexpensively alleviate changes from design and production (S. Parsana & T. Patel, 2014).

The failure modes (symptoms) translate how a failure appears and which justifies a maintenance action. In this stage, responses are given for questions such as: “How can a specific component fails?” The potential failure modes are expressed in physical terms, more specifically: under fatigue, vibration, wear, leakage, fracture, etc (Management, 2013).

FMEA/FMECA methods are used all over industry for a sort of applications and this flexible method can be executed at diverse steps in the product lifecycle (Lipol & Haq, 2011).

FMEA is carried out by a cross-functional team of experts on various departments. Normally, a team is formed into the planning stage of a new product based on a concurrent engineering approach. The team analyzes each component and subsystem of the product for the failure modes. Then, the potential causes and effects are determined (Sellappan & Palanikumar, 2013).

With the increasing of complexity degree for the industrial systems, there is an importunate need to the application of developed techniques in operating and maintaining of such systems. The failure modes and effect analysis (FMEA) are one of modern technology that is especially applied to complex systems to facilitate the identification process of the systems failure modes and to analyzing of their reasons and effects (Al-khafaji, 2005).

The basic (LTA) uses the decision tree structure shown 1) safety-related, 2) outage-related, or 3) economic-related were noticed. Each failure mode is entered into the top box of the tree, where the first question is posed: Does the operator, in the normal course of his or her duties, know that something of an abnormal or detrimental nature has occurred in the plant? It is not necessary that the operator knows exactly what is awry for the answer to be yes (Afefy, 2010).

The availability of the combined cycle thermoelectric power plants to depend s on the perfect operation of all its systems (gas turbine, heat recovery steam generator and steam turbine). In the combined cycle the gas turbine transforms the chemical energy generated by combustion in mechanical energy to rotate the generator’s shaft. The exhaust gas is used to heat water in the steam generator allowing the operation of the steam cycle (Carazas, Salazar, & Souza, 2011).

The failure of steam boiler due to creep damages mechanism under the estimated normal operating temperature is not expected in operation, and it has been confirmed and studied by the conservative creep analysis showing that the tube should fit for operation for next many years under normal service condition (Purbolaksono et al., 2010).

The failure mechanism of tube boiler is identified due to the short-term overheating as result of the localized flue gas flow following massive clinker formations in primary superheater region of the boiler. Operation of a new type of coal having low ash fusion temperature of 1210 □ which is close to the minimum specification limit of 1200 □ is identified as the main root cause of the failure of coal boiler type (Purbolaksono et al., 2010).

Li and Gao (2010) combined failure mode and critically analysis method (FMECA) and fault tree analysis method (FTA) for reliability-centered maintenance. Mariajayaprakash and Senthilvelan (2014) used the FMEA method and Taguchi method to optimize the process parameters of screw conveyor (sugar mill boiler) with respect to the process stability, reliability, and quality(Mutlu, Altuntas, & Türkdoğan, 2016).

Finite element (FE) analyses on the deformation of the superheater tubes boiler were presented. It was found that temperature was the main factor of the deformation due to restriction of the tube. The locations of the maximum stress induced by the deformed tube were determined(Othman, Purbolaksono, & Ahmad, 2009).

FMEA analyses potential failure modes, main effects of failure, main failure causes, assesses current process controls and determines a risk priority factor of the system. FMEA to be effectual, the FMEA must be iterative to correspond with the nature of the design process itself (Shivakumar, Hanumantharaya, & A, 2015).

FMEA is intended to act as a preventive since it is not a method which is carried out after a failure, with the purpose of satisfying the customer or the requirements of ISO/TS 16949 standard (QS 9000) or ISO 9001 series of standards. A thorough FMEA demands time and provision of necessary resources during the design and process development when design and process changes can be implemented with least difficulty and financial means (Popović, Vasić, & Petrović, 2010).

The Failure Mode Effect Analysis was developed for the U.S. military purposes as a technique for assessment of reliability through determination of effects of different failure modes of technical systems (Dobrivoje, 2011).

3. Methods

Failure mode and effects analysis (FMEA) were first d ›veloped as a formal design methodology in the 1960s by the aerospace industry with their obvious reliability and safety requirements (Bowles and Pel´aez 1995).
There are several techniques developed to perform the risk assessment to mitigate the suffering. FMEA is one of the most widely used risk assessment tools. Recently, FMEA has been adopted in the wide spectrum of fields such as the chemical, aerospace, military, automobile, electrical, mechanical and large-scale industries (Afefy, 2015).
FMEA method is used to evaluate failure of system, design, process, service. Potential faults identification by scoring or scoring each failure mode based on occurrence, severity, and detection(Puspitasari & Martanto, 2014).
In the operation of a boiler are a power plant, all operating components of both human, machine, and operating methods will greatly affect the performance of the engine. In this study calculated the value of Risk priority number of each component in the boiler.
T ıe thermal efficiency of the boiler is defined as the percentage of heat input that is effectively utilized to generate steam (Nagar, 2013).

In the operation of the boiler, all parameters related to operating safety should be maintained and possible. So it is expected that boiler operation failure can be minimized. From FMEA Design we can improve the equipment to be reliable and efficient.
There are two types of FMEA: Design FMEA and Process FMEA. Design FMEA aids in the design process by identifying known and foreseeable failure modes, and t ‌en ranking failures according to relative impact on the product (Rakesh et al., 2013).

4. Result and Discussion

PT.X is a smelter company that has a private power plant with a capacity of 40 MegaWatt which is supplied by Steam turbine and combustion turbine (Combined Cycle). In operation, there is a major component that often occurs the problems listed in table 1. It can be analyzed that in the last four years the frequent failures are on the Boiler side, so to get Failure mode and effect analysis required cause and effect diagram or fishbone diagram. After getting all data onto failure of boiler side then calculated Risk Priority Number / RPN values. Calculate the RPN number by using the formula: (RPN = Severity x Occurrence x Detection).

Table1
Major Component's failure in Steam Powered Power Plant

Year	2013	2014	2015	2016
Boiler	40	42	50	46
Feed Water Pump	10	19	21	20
Electrical	11	9	13	14
Control System	5	7	13	8
Turbine	30	35	33	36
Others	20	26	25	20

In table 1 shown major failure of 4 years from 2013-2016, the most common failure of this system is in the boiler. So we must focus on boiler component to improve the system and reduce the failure of boiler System.

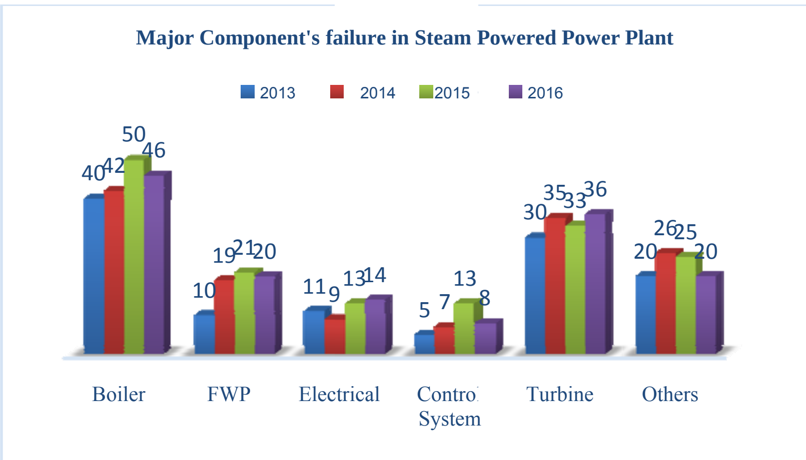

Fig. 1. Major Component's failure in Steam Powered Power Plant

From Fig.1 Shown the graphics of failure of the boiler. Same as Table 1, from 2013-2016 the common failure in a system is in the boiler

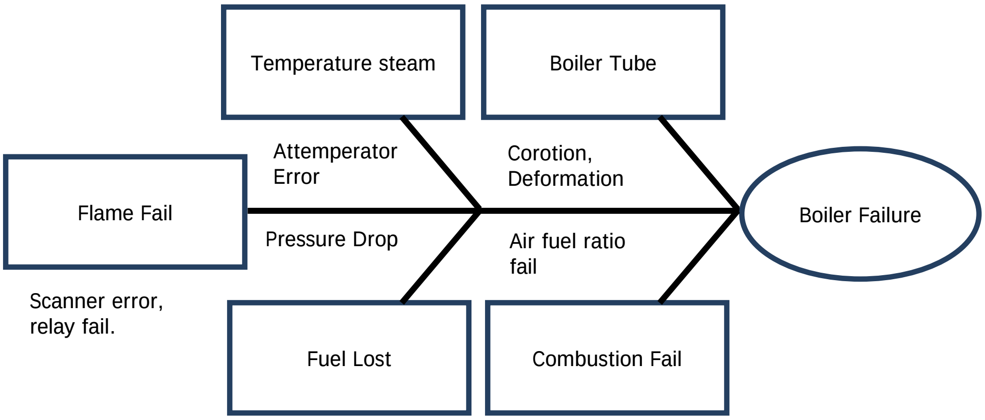

Fig. 2."Cause and effect diagram" For Gas fire boiler to find out cause for failure and their effect

Table 2
RPN Number before implementation FMEA

Potential Failure Mode	Potential effect of Failure	Potential cause of Failure	Severity (S)	Occurrance (O)	Detection (D)	RPN
Boiler Tube	1. Water leakage 2. Level unmaintained 3. Boiler stop 4. Retubing	1. Silica to high 2. Corrosion 3. Combustion ramp to fast 4. Water quality bad 5. Overheating in Super heater	9	8	6	432
Temperature Steam	1. Steam rejection 2. Overpressure	1. Atemperator valve fail 2. Combustion ratio not good 3. Superheater fail	8	4	6	192
Flame Fail	1. Steam not produce properly 2. Combustion does not take place	1. Flame scanner fail 2. Fuel-air ratio not good 3. Electrical fail	7	6	5	210
Fuel Lost	1. Steam not produce proper manner	1. Strainer dirty 2. Pressure regulator fail	8	4	2	64
Combustion Fail	1. Steam not produce 2. Boiler wall damage	1. Fuel-air ratio not good 2. Back fire	5	4	4	80

5. Action to Solve Major Failure

Suggestions for reducing the effects and potential for boiler failure are Shutdown boilers for 2-6 days in case of major failure of cool the iron material. Check the water quality and make chemical and mechanical cleaning on the water and flame sides. Make sure there is no overflow in the water tube and steam system. Burning settings must be correct in order to avoid excessive temperature fluctuations that will cause stress material. The water level should be kept steady so the water does not carry. Focus on the material heating curve, so its mean for the first ignition we must use the slow firing rate to avoid material cracking.

6. Conclusion

The reliability of the boiler operation cannot be separated from the influence of controllers and equipment installed on the machine, and the role of operator and maintenance in analyzing the damage to the machine.

After understanding what causes the engine damage, then there are periodic checks for engine performance and availability of machine operation will increase. Fmea in its implementation will help analyze the causes of failure in general, so service providers will always maintain and maintain the equipment with a structured. Improvement focuses on the highest RPN number from Equipment RPN calculation.
From table no.2 it is concluded that the biggest problem of a steam power plant is in the boiler system, so the focus of maintenance and reliability improvement is on the boiler system. But did not rule out also to always monitor the other items for the entire system maintained its reliability.

Rererences

Afefy, I. H. (2010). Reliability-Centered Maintenance Methodology and Application: A Case Study. *Engineering*, *2*(11), 863–873. https://doi.org/10.4236/engineering.2010.211109

Afefy, I. H. (2015). Hazard Analysis and Risk Assessments for Industrial Processes Using FMEA and Bow-Tie

Methodologies, *14*(4), 379–391.

Al-khafaji, S. K. H. (2005). Design of a Programmable System for Failure Modes and Effect Analysis of Steam-Power Plant Based on the Fault Tree Analysis, *1*(2), 64–85.

Ambekar, S., Edlabadkar, A., & Shrouty, V. (2013). A Review: Implementation of Failure Mode and Effect Analysis. *Ijeit.Com*, *2*(8), 37–41. Retrieved from http://ijeit.com/vol 2/Issue 8/IJEIT1412201302_07.pdf

Carazas, F. J. G., Salazar, C. H., & Souza, G. F. M. (2011). Availability analysis of heat recovery steam generators used in thermal power plants. *Energy*, *36*(6), 3855–3870. https://doi.org/10.1016/j.energy.2010.10.003

Chikhale, S. S., & Barik, M. K. (2015). Failure Mode and Effect Analysis on Base Frame – Case Study. *Journal of Emerging Technologies and Innovative Research*, *2*(4), 1283–1288.

Dobrivoje, Ć. (2011). Fmea in product development phase. *Fmea in Product Development Phase*, 679–686.

Lipol, L. S., & Haq, J. (2011). Risk analysis method□: FMEA / FMECA in the organizations . *International Journal of Basic & Applied Sciences*, *11*(5).

Management, N. (2013). Simple approach to failure modes using a maintenance organisation and management software (1) Marcelo Batista , José Fernandes (1) and Alexandre Veríssimo (1), (1).

Mutlu, N. G., Altuntas, S., & Türkdoğan, İ. (2016). Failure modes and effects analysis for cogeneration unit in a wastewater treatment plant Failure modes and effects analysis for cogeneration unit in a wastewater treatment plant, (September), 0–7.

Nagar, V. (2013). Boiler Efficiency Improvement through Analysis of Losses. *International Journal for Scientific Research & Development*, *1*(3), 1–5.

Othman, H., Purbolaksono, J., & Ahmad, B. (2009). Failure investigation on deformed superheater tubes. *Engineering Failure Analysis*, *16*(1), 329–339. https://doi.org/10.1016/j.engfailanal.2008.05.023

Popović, V., Vasić, B., & Petrović, M. (2010). The possibility for FMEA method improvement and its implementation into bus life cycle. *Strojniski Vestnik/Journal of Mechanical Engineering*, *56*(3), 1–7.

Purbolaksono, J., Ahmad, J., Beng, L. C., Rashid, A. Z., Khinani, A., & Ali, A. A. (2010). Failure analysis on a primary superheater tube of a power plant. *Engineering Failure Analysis*, *17*(1), 158–167. https://doi.org/10.1016/j.engfailanal.2009.04.017

Puspitasari, N. B., & Martanto, A. (2014). Penggunaan FMEA dalam Mengidentifikasi Resiko Kegagalan Proses Produksi Sarung ATM (Alat Tenun Mesin) (Studi Kasus PT ASAPUTEX Jaya Tegal). *J@TI Undip*, *IX*(2), 93–98.

Rakesh, R., Jos, B. C., & Mathew, G. (2013). FMEA Analysis for Reducing Breakdowns of a Sub System in the Life Care Product Manufacturing Industry. *International Journal of Engineering Science and Innovative Technology*, *2*(2), 218–225.

S. Parsana, T., & T. Patel, M. (2014). A Case Study: A Process FMEA Tool to Enhance Quality and Efficiency of Manufacturing Industry. *Bonfring International Journal of Industrial Engineering and Management Science*, *4*(3), 145–152. https://doi.org/10.9756/BIJIEMS.10350

Sellappan, N., & Palanikumar, K. (2013). Modified Prioritization Methodology for Risk Priority Number in Failure Mode and Effects Analysis. *International Journal of Applied Science and Technology*, *3*(4), 27–36.

Sharma, K. D., & Srivastava, S. (2016). Failure Mode and Effect Analysis (FMEA) for Enhancing Reliability of Water Tube Boiler in Thermal Power Plant, *8*(2).

Shivakumar, K. M., Hanumantharaya, R., & A, M. U. M. K. (2015). Implementation of FMEA in Injection Moulding Process, *22*(5), 230–235.

Tomašková, M. (1929). Fmea-Analysis of Restricted Pressure Device for, (508), 46–54.

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