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FAILURE MODE AND EFFECT ANALYSIS (FMEA) AS TREATMENT OF PREDICTIVE PREVENTION AND LEAKAGE OF BOILER TYPE BALANCE DRAF FAN

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ABSTRACT

Risk analysis aims to prevent the incompatibility of a system used in the testing process including the Boiler system. At the Labuan 2 Steam Power Plant (PLTU) 2, the Boiler component was declared "very often" to have a pipe leak. Failure Mode And Effect Analysis (FMEA) is a method used to analyze the risk of failure. This method is represented by calculating the value of RPN (Risk Priority Number) obtained from the results of the multiplication of S (severty), O (occurrence), and D (detection). The highest analysis results are shown at 480 (in the steam drum component in the form of abnormal steam and water level failure). The cause is human error. Next three levels below are (1) Economizer component, which is 360 causes of combustion side ash erosion, material lifetime, and economizer tube fibration; (2) super heater tube and re-heater tube components which are 320 due to Corrosion, Overheat Flyash erosion, Sub blower erosion, Welding error; and (3) Walltube which is 320 causes of overheating and sub blower erosion. The recommendation for the analysis of FMEA testing to predict mantenance is done by applying remaining life assessment after 8,000 hours / operational.

Keywords: Steam Power Plants, Boilers, Balance Draft Fant, FMEA, Remaining Life Assessment

INTRODUCTION

The Ministry of Industry of the Republic of Indonesia in 2013 enacted regulations relating to the Indonesian National Standard (SNI) for one of the Industrial Steam Power Plants. Through testing laboratories guarantee the conformity of specifications or testing methods with certain requirements can be maintained (SNI ISO/IEC 17025:2008, 2008). In the testing process of course the risk of failure can occur at any time.

Table 1. Data Causes of Testing Failures

Causes of Test Failure	Frequency in Genesis
Trip Unit (died suddenly)	1
Steam Drum Leaks	4
Shutdown the unit to the economizer	3
Shutdown units on Superheated tubes and re-heated tubes	2
Shutdown unit on Walltube	2

This failure can affect the production process and even operational rewards. This is very unexpected, so prevention measures are needed as early as possible. This action can be done with risk analysis. In the research division there is no equipment that has been tested on pipe leaks, even though this is very necessary.

One method of risk analysis that can be applied is FMEA (Failure Mode and Effect Analysis) (Robin E. McDermott, Raymond J. Mikulak and Michael R. Beauregard, 2009). This method is quite developed in the fields of construction, automotive, health, aviation, industry, and so on. Interestingly, FMEA is one of the most effective alternatives used as a preventive analysis in the industry especially

Boiler Work System

Type boiler Balance Draft (Kaya and Eyidogan, 2010) consists of several systems including: (a) coal handling; (b) water system; (c) steam system; (d) air system; (e) fueal gas system; and (f) fuel handling system. The type of balance draft which consists of six systems has some work components to go to the boiler section.

(a) Coal fuel is prepared in storage yard coal to be sorted by screening with a size of 15-20 cm^2. If the size is less than the size of the screening, so the fuel will enter the vibrating feeder component to function as a coal fuel vibrator to obtain capacity according to the standard. The process will be transformed using a conveyor 1 then headed for the chute to be crushed or crushed using coal chruisher aiming for uniform size of coal reaching 2 cm^2. Then, it will be directed to conveyor 2 to separate the metal content to using iron remover. The next step of coal entering the three way chute serves to divide the volume of coal into two lines for the next process.

Coal from the three way is transformed into the conveyor 3 with the help of an unloader plug inserted into the bunker. Bunkers are semi-finished processes. In the process, coal is put into the coal feeder to be heated to avoid excessive water content. The next step is done by grinding again using the grinding mill to get a smaller size of 250 micro meters "like flour". The final step is included in the coal handling system so that the coal from the process is ready for the combustion process in the boiler.

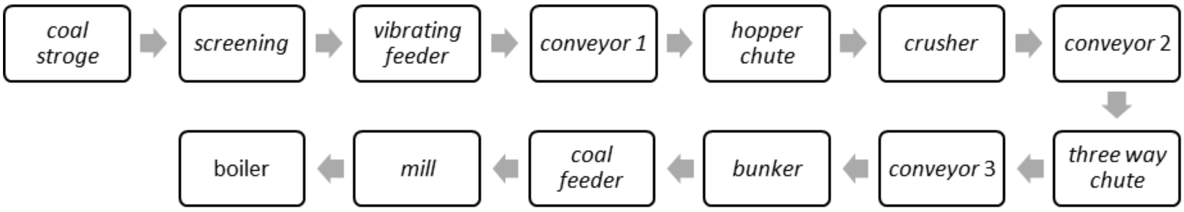

Fig 1. Flow Chart of Coal Handling Process for Preparing Coal with a Size of 250 micro meters of combustion in Boilers

(b) Water system, has several supporting components and is made from water. The characteristics of water used are sea water by pumping into the sediment tank component. This process is intended to cleanse sea water from a mixture of mud and algae impurities. Efforts are made using chemicals namely (a) poly aluminum; (b) chloride; (c) poly achlimide; and (d) sodium hypochloride. This mixture of substances works by binding to sludge and algae that settles and is dumped towards the draining channel.

The process of processing water in sediment tanks is then flowed into the service basin for the purpose of processing and refining. At this stage the metal content in the water will be removed. The results of this processing are called demin water. Then pumping is carried out towards the daerator, which is the initial stage of heating the water. After that the water is pumped using a boiler feed pump towards the feed water station (second heating process). For get a temperature that is "high enough" before entering the steam drum additional heating is required by setting the lower economizer and upper economizer.

Clean liquid fluid and suitable temperature mixed with vapor fluid. This condition is intended to increase the temperature in the comer down position to the waltube (there is a phase change of 100%). Water that does not undergo changes will be returned to the steam drum for reprocessing. The process of phase change is observed in Figure 2.

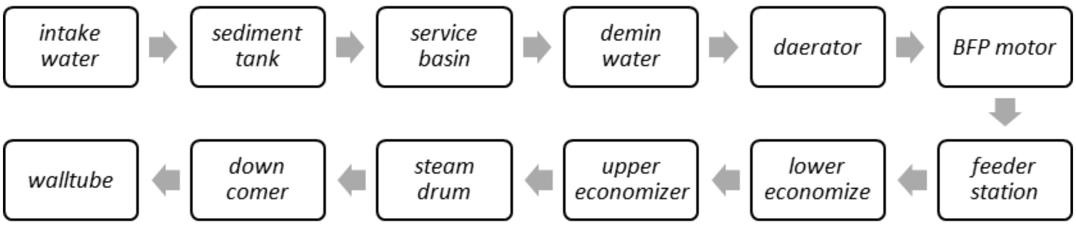

Fig 2. Flow Chart of Water Systems: Process of Changing Water Phase up to 100% with Clean Conditions and High Temperature

(c) Steam systems have several processing stages. Steam fluid in the steam drum has a temperature of 300^{0}C which is flowed into the superheat roof to the superheat cold and superheat panel. Then enter the superheat platen towards the superheat final. Conditions in the final superheat in the form of "wet steam" are used to rotate high pressure turbines. Wet steam then flows to the main boiler and goes to the reheater medium and ends in the final reheater in the form of "dry steam" is used to rotate the turbine (intermediate turbine). This process can be observed in Figure 3.

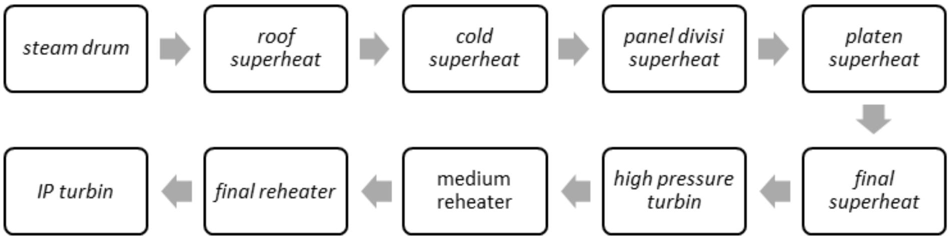

Fig 3. Flow Chart of Steam System: Process of Changing Wet Steam to Dry Steam Used to Rotate Turbines

(d) Air systems have the aim to maintain the stability of the power plant's performance. The intake process is in the form of air by using a forced draft fan (FDF) which is applied using a pipe to the water preheater (APh) area. Air temperature will increase. If this condition is met, then the air is flowed to the air prehetaer middle (APhM) and carried out to prehetare upper water (APhU). This is done to get a higher temperature than air atmosphere, also known as secondary air fan. Then it will be combined with the primary air fan but with volume requirements adjusted to the temperature not too low and not too high. This is aimed at the condition of coal fuel not being burned by the heat of the air temperature. Its main function is to give impetus to coal fuel to enter the boiler for the combustion process.

(e) Fuel gas systems in the form of furnaces (furnance boiler) produce exhaust gases that are environmentally friendly, so that further processing needs to be done. Exhaust gas flows in the water preheater pipe to electrostatic pracipitator (ESP). How ESP works by passing flue gas through an electric field formed between the discharge electrode and the collector plate. The initial condition of the exhaust gas containing dust grains is neutral, but when passing through the electric field ionization will occur which results in the particulate matter being negatively charged. The result will be attached to the collector plate. Periodically the dust is moved by means of rapping (vibration) which causes dust grains to fall into the ash hopper and is transferred to ash silo by a vacuum process. The dust will be blown through the conveyor. Exhaust gas free of dust particulates is blown into the chimney using the indust draft fan. For avoid sulfur in the harmful exhaust gas content, flue gas desulfurization is also used. The process of fuel gas system can be seen in Figure 4.

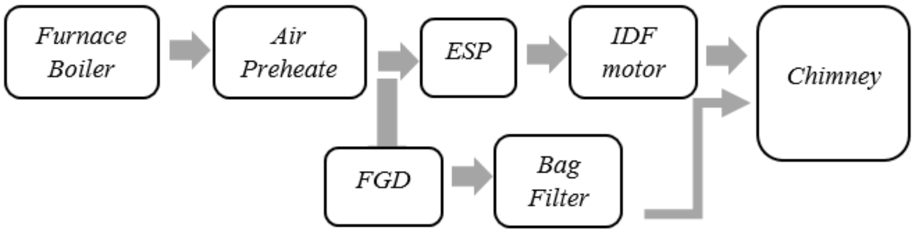

Fig 4. Functioning Fuel Gas System Diagram Eliminating Particulate Dust and Sulfur Elements

(f) Fuel handling system is an oil fuel as an alternative when fuel is insufficient or the treatment process is damaged. The fuel oil used is solar. The oil fuel is flowed through the pipe by pumping it by oil transfer pump to the feed oil pump.

Failure Mode and Effect Analysis (FMEA)

Failure in systems in various fields (Chiarini, 2012)(Ilangkumaran and Thamizhselvan, 2010)(Kolich, 2014) can use analytical techniques (Liao and Ho, 2014) (López-Tarjuelo *et al.*, 2014) (Ahamed Mohideen and Ramachandran, 2014) is FMEA (Segismundo and Augusto Cauchick Miguel, 2008). The opinion is similar to (Robin E. McDermott, Raymond J. Mikulak and Michael R. Beauregard, 2009) that "a systematic method of identifying and preventing product and process problems before they occur". Based on this definition, it can be clarified that FMEA aims to examine the processes and products to determine the possibility of failure that occurs through the identification of potential failures and the consequences and emergence of possibilities.

The solution to this problem is using the FMEA process. Evaluation of failure using FMEA process on temperature testing carried out with three indicators including severity (S), occurrence (O), dan detectio (D) (Robin E. McDermott, Raymond J. Mikulak and Michael R. Beauregard, 2009) and (Murphy, Heaney and Perera, 2011). Determination of the priority mode of failure is obtained by multiplying the three indicators and generating RPN (risk priority number). The RPN shows the priority level of the failure mode obtained from process analysis. Calculation of RPN value with the formula below:

$$RPN = S \times O \times D \quad (1)$$

(Ben-Daya, 2009)

S (severity) indicates an assessment of the level of seriousness of an effect or a result of the potential failure of the process being analyzed. O (occurrence) in the analysis reflects the chance of failure or probability. D value (detection) is the chance of failure that can be detected before the event (failure occurs). The scale used to determine the values of S, O, and D, namely 1 to 10 with a different description, can be seen in the following table.

Table 2. Severty Criteria based on Ratings and Descriptions

Rating	*Severity*	Description
1	No effect	No effect
2	Very small	Neglected effects on system performance
3	Small	Slightly affects system performance
4	Very low	Small effect on system performance
5	Low	Experience a gradual decline in performance
6	Medium	The system operates and safe but has decreased performance which affects output
7	High	The system operates but is not fully operational
8	Very high	The system does not operate
9	Dangerous with warning	System failure that produces harmful effects
10	Dangerous without warning	System failure that produces a very dangerous effect

(Ben-Daya, 2009; Braaksma, Klingenberg and Veldman, 2013)

Table 3. Occurrence criteria based on Ratings and Descriptions

Rating	*Occurrence*	Description
1	There is no	There is almost no damage
2	Low	Very small failure
3		
4	Medium	Failure is rare
5		
6		
7	High	Repeated failure
8		
9	Very High	Often fails
10		

(Ben-Daya, 2009; Braaksma, Klingenberg and Veldman, 2013)

Table 4. Detection criteria based on Ratings and Descriptions

Rating	*Detection*	Description
1	Almost certain	Preventive maintenance will always detect potential causes or failure mechanisms and failure modes
2	Very High	Preventive maintenance has a very high possibility of detecting potential causes or failure mechanisms and failure modes
3	Tinggi	Preventive maintenance has a high possibility of detecting potential causes or failure mechanisms from failure modes
4	Middle to up	Preventive maintenance has the possibility of "moderately High" to detect potential causes or failure mechanisms and failure modes
5	Medium	Preventive maintenance has the possibility of "moderate" to detect potential causes or failure mechanisms and failure modes

Rating	*Detection*	Description
6	Low	Preventive maintenance has a low probability of being able to detect potential causes or failure mechanisms and failure modes
7	Very Low	Preventive maintenance has a very low possibility of being able to detect the cause of a potential failure and failure mode
8	Small	Preventive maintenance has the possibility of "remote" to be able to detect potential causes or failure mechanisms and failure modes
9	Very Small	Preventive maintenance has the possibility of "very remote" to be able to detect potential causes or failure mechanisms and failure modes
10	Not sure	Preventive maintenance will always be unable to detect potential causes or failure mechanisms and failure modes

(Ben-Daya, 2009; Braaksma, Klingenberg and Veldman, 2013)

METODE PENELITIAN

The step of determining the risk analysis using FMEA process in the boiler leak clause of the fan balance draft type is carried out in the following figure 5:

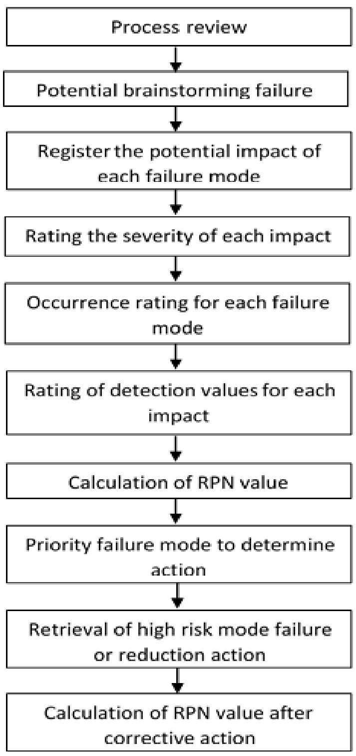

Fig 5. Flowchart of Action Research using FMEA process

The steps in the FMEA analysis step begin by reviewing the process and defining the standard process, then identifying the failure modes that are carried out through the brainstorming process. The brainstorming method was conducted to explore the aspects of influence on testing based on the field of competency experts in their field. The analysis results in the form of a questionnaire measuring potential failure. The analysis results (S, O, and D) are processed using geometric averages (Forman and Selly, 2003) to obtain an average rating value. Then the average value obtained from geometry is multiplied to obtain RPN. The value of RPN is obtained to determine the order of priority risks in the process of implementing broiler leak testing. Priorities with high to low results indicate priority risks that can be used as preventive measures.

$$G = \sqrt[n]{\prod_{i=1}^{n} X_i} \quad \text{--------------------------} \quad (2)$$

(Forman and Selly, 2003)

Information:
G = geometric size average
n = number of samples
Π = multiplying the sample value to i
Xi = Sample value to i

RESULTS AND DISCUSSION

The form of failure on the boiler type balance draft fun is identified on four components or systems with different forms of leakage: (1) steam drum with the form of failure (a) joint welding cracks; (b) upnormal level of steam drums; and (c) leakage level indicators; (2) an economizer with a form of failure in the form of a pipe leak; (3) super heater tubes and heaters with a form of pipe leak failure; and (4) waltube with a failure rate in the form of a pipe leak.

The FMEA test process results in pipeline leakage as follows:

Table 5. Results of Risk Analysis

Sub Equipment	Form of failure	Cause	Effect	S	O	D	RPN
Steam Drum	Upnormal steam and water levels	Human Error	Trip Unit (the unit dies suddenly)	8	6	10	480
	Leak indicator level	Part damage	Derating unit	3	2	9	54
	Crack joint welding	vibration difference pressure	The function of the steam drum is not optimal steam drum leak	8	2	3	48
Economizer	Tube leak on the economizer	Erosion of residual combustion ash, lifetime material, economizer tube economizer	Stop unit (*Shutdown Unit*)	9	4	10	360
Super heater tube dan *Re-heater tube*	Tube leak	Corrosion, *Overheat Flyash erosion, Sub blower erosion, Welding error*	Stop unit	8	4	10	320
Walltube	Tube leak	*Overheat, Sub blower erosion*	Stop unit	8	4	10	320

(Source: Test analysis results, 2017)

The failure in the form of upnormal steam and water levels that occur in the steam dream, in this type of failure has an 8 rating rating severity, which is the effect that will cause the system to not operate, but has a rating of occurrence at level 6, in that form rarely occurs these failures, and detection rates at level 10, namely preventive maintenance will always be unable to detect potential causes or failure mechanisms and failure modes.

Failure in the form of leakage level indicators that occur in the steam drum, in this type of failure has a severity level of 3 rating, this rating results in a slight effect that affects the system performance, but has the value of occurrance at rating 2 which means very small form of failure and has detection rating 9, namely preventive maintenance has the possibility of "very remote" to be able to detect potential causes or failure mechanisms and failure modes.

Failure in the form of joint welding cracks that occur in the steam drum, in this type of failure has a value of severity in the rating to 8, the effect will cause the system can not operate, but has a rating occurrence at level 2, which is very small form of failure, and the level of detection at level 3, namely preventive maintenance has a high probability of detecting potential causes or failure mechanisms of the failure model.

Sequentially the value of the RPN failure rate on the steam drum criterion is upnormal level of steam and water (480) caused by human error due to unit trip; leakage level indicator (54) cause of damage to parts due to derating unit; and joint welding cracks (48) cause of vibration pressure difference due to the function of steam drum is not optimal and steam drum leakage.

The failure in the form of a tube leak occurred on the economizer, in this type the failure was at a rating severity of 9 which caused a system failure with a dangerous effect but it was on the occurrace rating 4, which is a rare form of failure, and has a rating detection at the level 10, so that preventive maintenance will always be unable to detect potential causes or failure mechanisms and failure modes. The RPN value obtained is 360 which is caused by erosion of combustion residue ash, lifetime of the material, the economizer tube consequence is the termination of the unit.

Failure in the form of tube leak that occurs in superheater, reheater, and walltube, has the same value in FMEA. This form of failure has a severity value at the 8th level, this level results in the system not being able to operate, but it has occurrence rate 4 which means that this failure is rare, and the detection value of this type of failure is at the rating 10 which is maintenance preventive will always be unable to detect potential causes or failure mechanisms and failure modes. The RPN value obtained by both 320 is on the tube leak indicator. Super heater tube and reheater tube due to corrosion, overheat flyash erosion, sub blower erosion, welding error. Whereas the Walltube is overhat, the sub blower erosion results in the unit being stopped.

CONCLUSION

Based on the results of the risk analysis of the pipeline leak callus in testing the balence draft fan type boiler, it can be concluded as follows:

(1) The highest RPN value is 480 in the form of upnormal steam and water level failures. Then the economizer is 360 in the form of tube leak failure. Furthermore, Super heater tube and

Reheater tube and Walltube are 320 in the form of tube leak failure.

(2) Based on the results of testing analysis using the FMEA process, the maintenance or prevention priorities that need to be considered are the steam drum components, especially up-abnormal steam and water levels, economizer, super heater tube and reheater, and waltube.

(3) Way to do the predictive maintenance treatment in the components of the pipeline leak clause by applying the RLA (remaining life assessment). RLA is carried out after 8,000 hours / operational with erosion shield installation, pipe thickness checking, and deformation checking.

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