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Operational Risk Management of Onshore Processing Facility using Risk Failure Mode and Effect Analysis and Fault Tree Analysis

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ABSTRACT

Onshore Processing Facility (OPF) is one of the natural gas processing fields. The gas is dried and distributed to the consumer. The ideal condition of a process plant is to operate continuously until the planned maintenance time. However, unexpected various operational failure problems exist during operation. The impact of operational failures occurred not only on the OPF itself but also on the Refinery Unit Operation process, which may disrupt fuel distribution in West Java and become a national issue. Research is needed to determine the critical risks of various operational failure modes. Finding the critical risk will hopefully simplify the search for the cause of failure without having to analyze all modes of failure that have occurred. A critical risk is obtained using the Reverse Failure Mode and Effect Analysis (RFMEA) method, which is then analyzed further using Fault Tree Analysis (FTA) to get a basic event. Furthermore, a specific treatment of risk could be proposed. Forty-five failure modes have been identified from operational data. Based on this research, five failure modes have been categorized as critical: Pilot Failure, Air Intake problems, Analog Output / Discrete Output (AO/DO) Modules that often hang, Shut Down caused by Gas Engine Generator (GEG) Hunting, and broken glycol pump. By FTA, the cause of these critical risks can be recognized, and mitigation plans are proposed as a risk response plan for known critical risks. The plan is expected to reduce the occurrence of operational failure or reduce the impact of the failure.

KEYWORDS: Risk Management, Onshore Processing Facility, Risk Analysis, FMEA, RFMEA, FTA

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1. INTRODUCTION

PT ONWJ owns the Onshore Processing Facility (OPF). They also have offshore production wells. OPF is one of the natural gas processing fields where the natural gas is dried and distributed to the consumers (industries). Natural gas is used as turbine fuel for power generation gas compressors. Since natural gas is a non-renewable resource, it should be used wisely.

The ideal condition of a process plant is to operate continuously until the planned maintenance time. However, there has been an integrated maintenance system through the SAP system (Systems, Applications & Products in Data Processing). However, from the operational experience in the field, various unexpected operational failure problems still exist during operations. Hence, the disrupted gas supply resulted in the consumers' operation, in this case, the Refinery Unit (RU). Therefore, research on Operational failure analysis at OPF is needed.

The onshore Processing Facility consists of many interrelated equipment and will have many failure modes. The various losses are borne out because of these operational failures, starting from the OPF itself due to loss of sales; offshore gas wells can be disrupted, as well as consumers (in this case RU) because OPF gas is used as fuel for consumer processes. If the RU process gets disrupted, this can be a national issue because the fuel supply in the West Java region could be disrupted.

Based on the data, some equipment has a start-stop (failures) outside the maintenance schedule. It is the job of OPF's Operations & Maintenance division to reduce these failures. In addition to maintaining continuity of gas supply to consumers, it will also extend the life of the equipment itself.

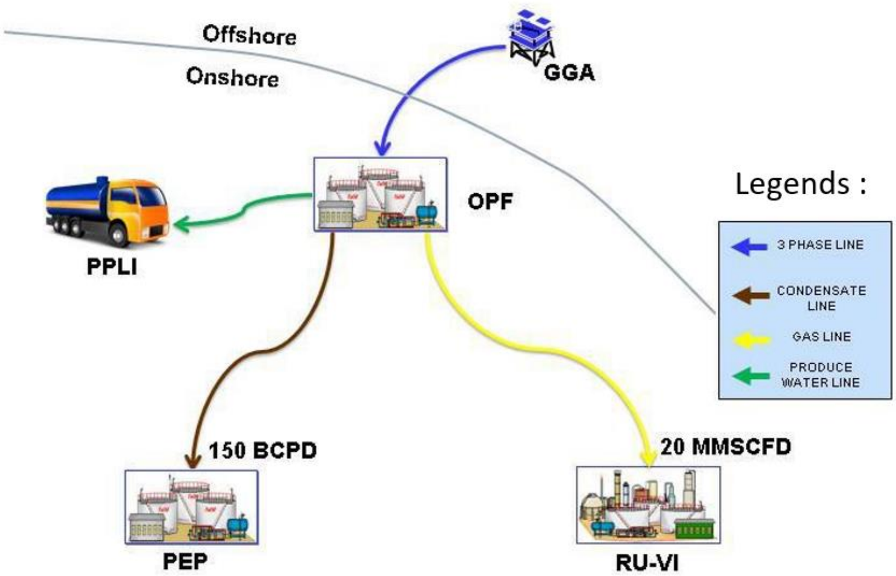

FIGURE 1. Interconnection Pipeline of OPF

Figure 1 shows that the OPF obtains a three-phase flow from an offshore (GGA wells). Then, the three-phase flow is processed by OPF. The primary production of OPF is natural gas, which amounted to 22 MMSCF, which RU directly uses as their process fuel. The second phase of Condensate is channeled to the EP of 150 BCPD, and the last phase of water is processed by PPLI (Industrial Waste Treatment Center). The simplified OPF Process can be seen in Figure 2.

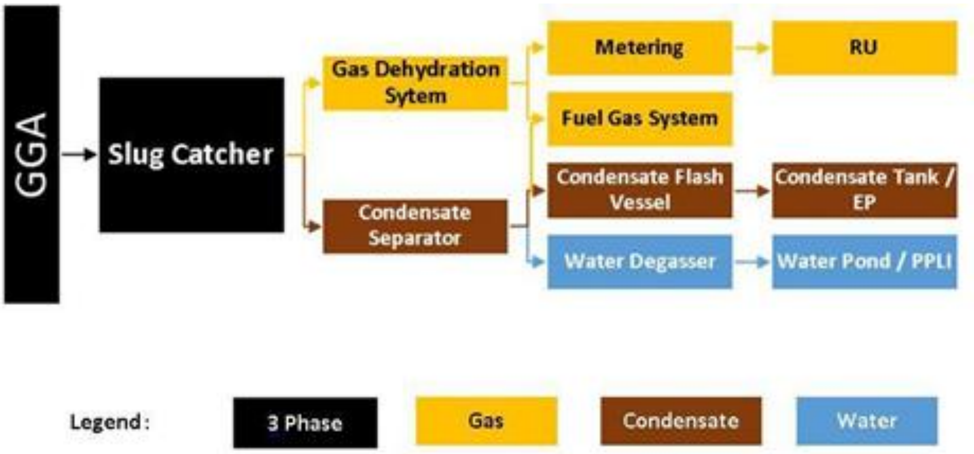

FIGURE 2. Simplify OPF Process

Thus, the greater the company risks due to OPF operational failure. Of the many failure modes in OPF, it is interesting to research the critical risks to propose causes and mitigation.

2. LITERATURE REVIEW

Failure Mode and Effect Analysis (FMEA) is a systematic method of analyzing and ranking risks related to various product or process failure modes, prioritizing corrective actions at the highest ranking, and carrying out evaluations until the results of the improvements are acceptable (Barends et al., 2012).

(Carbone & Tippett, 2004) use a modified FMEA format called Risk Failure Mode Effect and Analysis or RFMEA. Several studies have been undertaken to find critical risks so that strategies to mitigate such risks can be sought, including research on risk analysis in the electronic device industry using RFMEA(Carbone & Tippett, 2004). In addition, Isdarto, 2014 has also used the RFMEA method to conduct operational failure analysis of steam power plants. This method can quickly detect critical processes that require improvement by applying examples to the electronic device industry. The advantage of using RFMEA is focusing more on events with significant losses and developing a risk response plan to reduce the loss.

According to (Cooper, D. F., Grey, S., Geoffry, R. & Walker, 2005), the purpose of risk treatment is to determine what will be done in response to the risks that have been identified. Risk measures the possibility and consequences of not achieving a project's objectives. In contrast, risk analysis is a systematic process for estimating the level of risk identified (Kerzner, 2017). Critical risk can be defined as a possible, significant, near-term risk that causes a project to fail if it is not mitigated (Dorofee et al., 1996). The word 'significant' in the previous definition makes the risk critical. Failure is an asset's inability to do something according to the user's wishes (Moubray, 2001). Therefore, the definition of risk in OPF is that gas is not produced due to disruption of the production process due to a failure. Reducing or minimizing risk is generally the first alternative. There are two strategies to reduce risk; the first is to reduce the possibility of the event and reduce the impact of the event (Gray & Larson, 2011) After the critical risk is identified, the next step is to find the root cause of the problem of critical risk to find the solution.

One of the searches for the root of the problem is using the Fault Tree Analysis method, commonly abbreviated to FTA(Vesely, 2002). FTA analysis is one method that can be used to find the causes of the critical risk so that mitigation can be sought.

3. METHODS

The stages of research in this study were divided into several parts, as shown in the Figure 3:

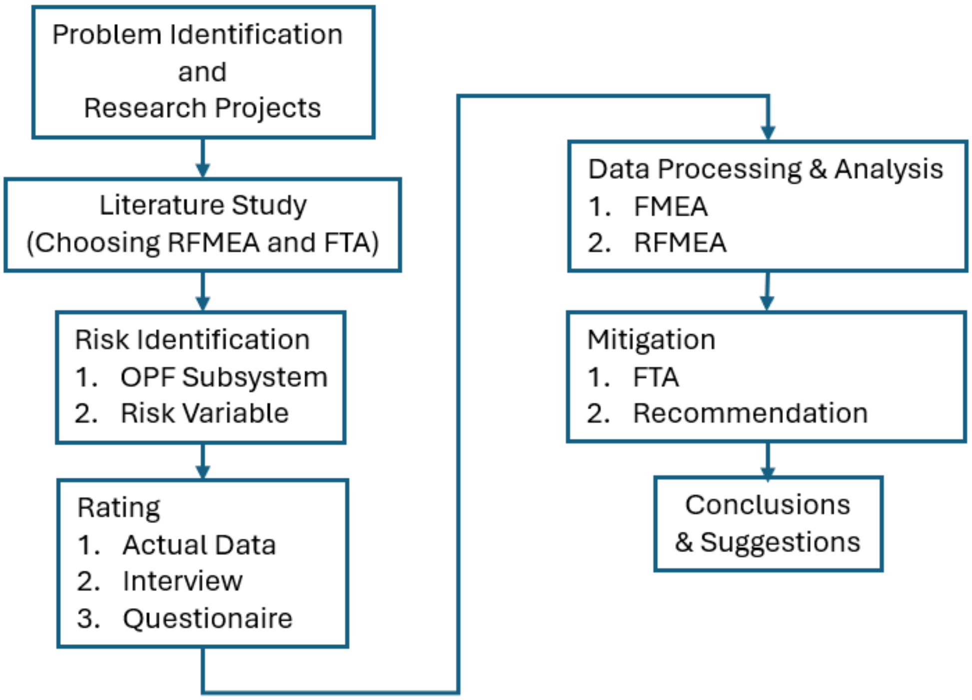

FIGURE 3. Flow chart of research

This semi-quantitative risk analysis process is preceded by identifying OPF operational issues. It is continued by collecting the available data, interviews, and questionnaires to severity points (S), Occurrence points (O), and Detection points (D). After the data obtained begins calculating the Risk Score value, the risk score can be obtained by multiplication between Severity and Occurrence and the RPN value, which results from multiplication between Severity, Occurrence, and Detection. Risk Score and RPN results will be analyzed using Pareto and a scatterplot diagram. With this analysis, we can find the risks categorized as critical. Furthermore, after the critical risk is found, we can search for the cause of the event and the mitigation plan as the risk response plan for the known critical risk using the FTA method. The strategy is expected to reduce the occurrence of operational failure or reduce the impact of the failure.

4. RESULTS

From the data that has been collected, some operational failure modes are found. This failure mode becomes the variable to be assessed to determine which is a critical risk. It is necessary to categorize the failure mode to see the relationship and the order of failure modes more easily with the operational failure of the unit.

Below is the category of variables used in this study by following a list of major tools in subsystems located in OPF.

- Failure on Slug Catcher
- Failure of Gas Dehydration System
- Fuel Gas System failure
- Failure of Air Instrument and air Utility System
- Failure of Reverse Osmosis System
- Failure of the Power Generation System
- Failure In the Water Degasser System
- Failure of Condensate Transfer System
- Failure to Distributed Control System
- Failure on the Switchgear System

Rating System

The rating system is obtained through brainstorming with experts based on field conditions. The rating of occurrence is the quantification of possible risk occurrence. The scale used ranges from 1 - 5, where scale 1 states the probability of occurrence of shallow risk and scale 5 states the probability of occurrence of very high risk. The occurrence value refers to Madarina's study(Madarina, 2016). However, the scale value is reduced from 1-10, become 1-5. The table for the value of occurrence can be seen in Table 1.

TABLE 4. Occurrence Rating

Rating	Consequence Scale	Description
5	Very Likely	An event may occur in almost every condition
4	Likely to Occur	An event may occur in some conditions
3	Equal opportunities between occurred or not	An event may or may not occur in certain conditions
2	Not Likely to Occur	An event may occur in certain conditions but is less likely to occur
1	Very Unlikely	An event that is not possible in certain conditions

The severity rating quantifies the level of impact due to the occurrence of risk. The scale used ranges from 1-5, where scale 1 states that the risk does not affect the system or service, and scale 5 states that risk occurrence will influence the system. The table for the severity value can be seen in Table 2.

TABLE 2. Severity Rating

Rating	Consequence Scale	Description
1	less than $3000	Less impact on the production process
2	$3.000 to less than $10.000	The process remains in control, requiring only minor adjustments
3	$10.000 to less than $50.000	The process is out of control and needs some adjustments
4	$50.000 to less than $200.000	The gas production process continues, but there are many inconsistencies
5	above $200.000	The entire production process cannot run

The value of the detection is the quantification of the control or procedure or existing strategy that governs the function, or that makes a failure can be detected. The detection function here is to see if the available risks can be known before the failure and whether the controls they have can reduce the risk of failure that can occur. The scale used ranges from 1 - 5, which means the higher the scale, the lower the level of control to detect the failure occurrence, as seen in Table 3. Specific to this table shall still be subject to reference from Carbon & Tippet (2004).

TABLE 3. Detection System

Rating	Guidelines
5	No detection method available or known will provide an alert with enough time to plan for a contingency.
4	The detection method is unproven or unreliable, or the effectiveness of the detection method is unknown to detect in time.
3	The detection method has medium effectiveness.
2	The detection method has a moderately high effectiveness.
1	The detection method is highly effective, and it is almost sure that the risk will be detected with adequate time.

A table matrix determines the risk level for calculating the risk score value. The level of risk is defined as the relationship between severity and occurrence. The Matrix Risk Score value can be seen in Table 4.

TABLE 4. Risk Score Matrix

Occurrence	Severity				
	1	2	4	5	6
5	Medium	High	High	High	High
4	Low	Medium	Medium	High	High
3	Low	Medium	Medium	Medium	High
2	Low	Low	Medium	Medium	High
1	Low	Low	Low	Medium	Medium

Source: (Cooper, D. F., Grey, S., Geoffry, R. & Walker, 2005)

Identify Critical Risks by using RFMEA

The Risk Priority Number (RPN) value can be estimated using the following equation considering the severity (S), occurrence (O), and Detection (D) of the obtained data (Lipol & Haq, 2011)

$$RPN = S * O * D \tag{1}$$

Result of RPN value and risk level, then proceed with analysis using the Pareto Diagram for RPN value as seen in Figure 4

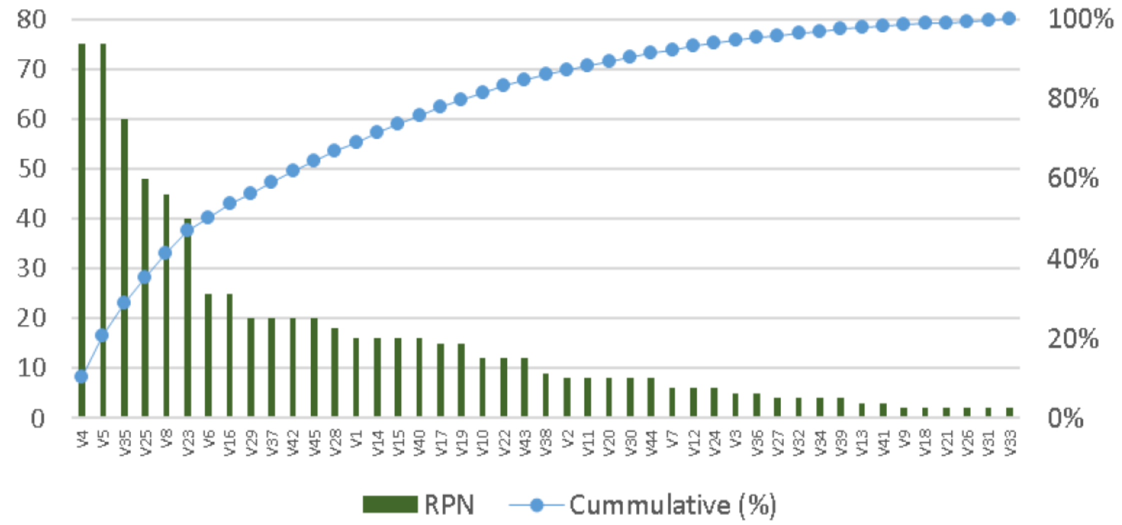

FIGURE 5. Pareto of RPN

Critical risk can be determined based on the risks that have been registered and the known value of each RPN. A risk is categorized as critical if it has an RPN point over the Critical RPN point value. The critical value of the RPN is determined from the average RPN value of all risks.

$$Critical\ RPN\ Points = \frac{Total\ RPN\ (732)}{Number\ of\ Risk\ (45)} = 16.48 \quad (2)$$

Based on the Equation 2 result, 13 variables enter the critical area. Furthermore, the Risk Score value can be estimated using Equation 3:

$$Risk\ Score = Severity\ * Occurence \quad (3)$$

The result of the Risk Score value can be made Pareto riskscore, which can be seen in Figure 5.

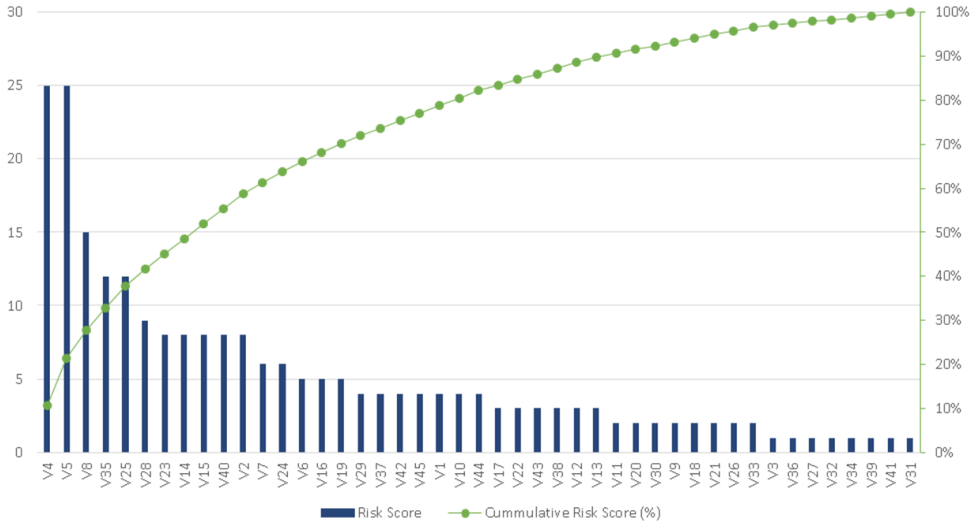

FIGURE 6. Pareto Risk Score

Next is to analyze the critical risk ratio between the Risk Score and RPN using a Scatter Plot Diagram. For the critical category value in the RPN, based on equation 1, the value is 16.48. In contrast, the value entered in the critical risk score category refers to Table 4, which is at least 10 or higher.

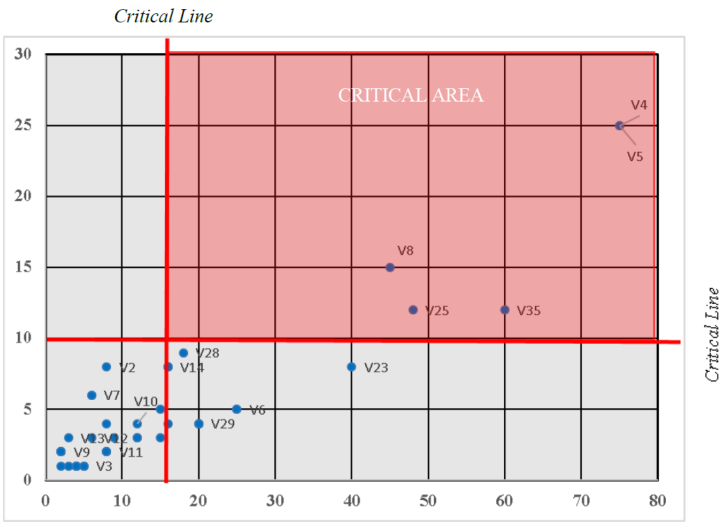

FIGURE 7. Scatterplot Diagram of RPN vs. Risk Score

From the scatter plot diagram shown in Figure 6, 5 failure modes are categorized as critical risk. The five failure modes that are categorized as critical risk can be seen in Table 5

TABLE 5. Critical Risk Based On Rfmea

Code	Failure Variable	Risk Score	RPN
V4	Pilot Failure	25	75
V5	Air Intake Problem	25	75
V35	AO/DO Modules Hang	12	60
V25	S/D due Hunting	12	48
V8	Glycol Pump Broken	15	45

Basic event using FTA

The FTA diagram is based on five critical risks of a total of 45 identified failure modes, which is a graphical model consisting of several parallel and sequential fault combinations that may cause the start of a specified event failure. In the FTAs established, each risk is determined as a top event. In the end, will be obtained which is the cause of the occurrence of top events (critical risk), so the appropriate steps can be taken to solve the problem of the occurrence of critical risks. Essential events obtained have considered the causes of problems from various sides (personnel, methods, machines)

Pilot Failure

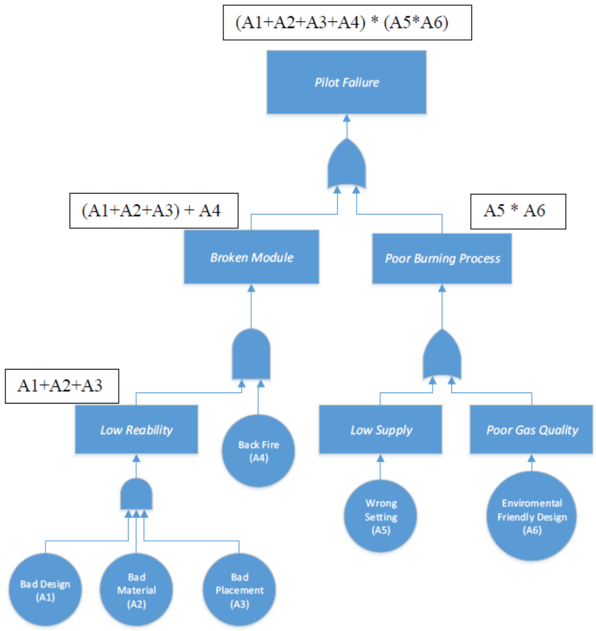

FIGURE 8. FTA Diagram of Pilot Failure

Based on the result of FTA analysis in Figure 7, the obtained cut set is {A1, A2, A3, A4), {A5}, and {A6}.

Air Intake Problems

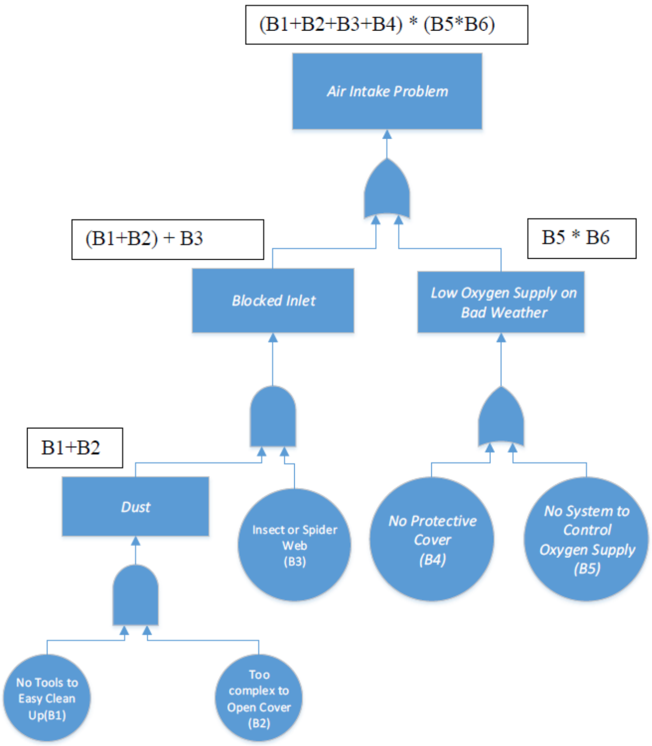

FIGURE 9. FTA Diagram of Air Intake Problems

Based on the result of FTA analysis in Figure 8, the obtained cut set is {B1, B2, B3), {B4}, {B5}.

AO/DO Modules Hang

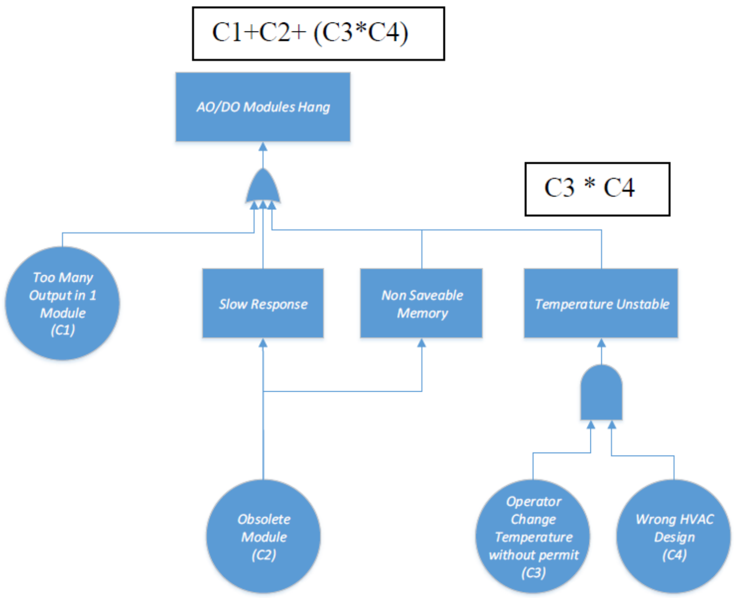

FIGURE 10. FTA Diagram of AO/DO Modules Hang

Based on the result of FTA analysis in Figure 9, theobtained cut set is {C1}, {C2}, {C3}, {C4}.

GEG Hunting

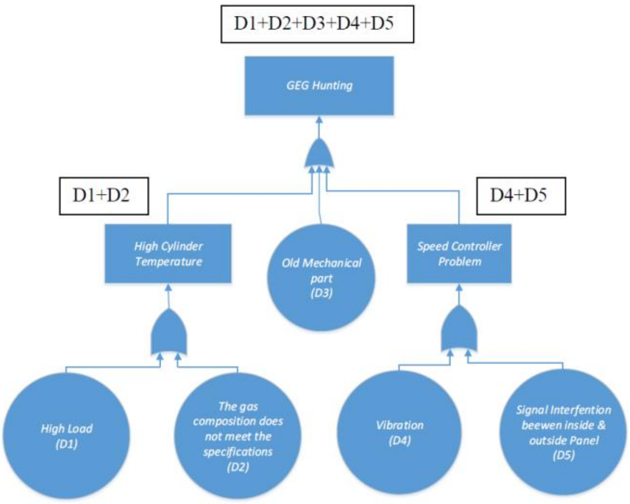

FIGURE 11. FTA Diagram of GEG Hunting

Based on the result of FTA analysis in Figure 10, theobtained cut set is 5 {D1), {D2}, {D3}, {D4}, {D5}.

Glycol Pump Broken

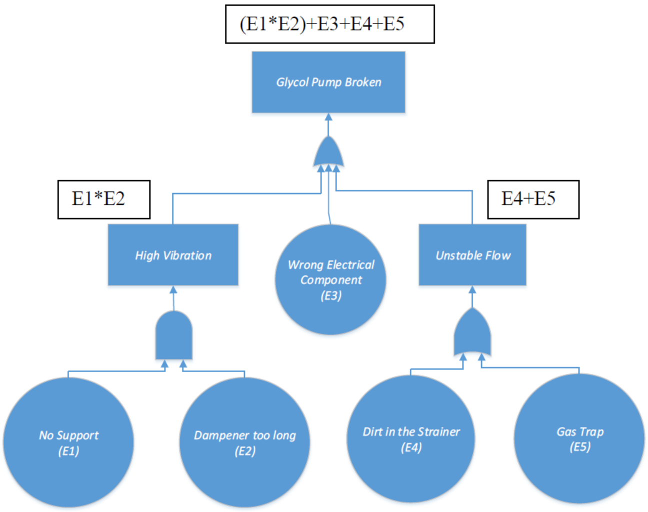

FIGURE 12. FTA Diagram of Glycol Pump Broken

Based on the result of FTA analysis in Figure 11, theobtained cut set is 4 {E1, E2), {E3}, {E4}, {E5}

Mitigation and Suggestion

Pilot Failure

The Broken Module is caused by poor design, inappropriate material, and module placement too close to the combustion chamber. The three cut sets can be completed by creating a more robust module design. The results of the field study are suggested for:

- Move the module into the panel that is outside the combustion chamber.
- Replace the cables with a stainless coated ceramic as an insulator
- Replace tested reliability modules, such as turbine modules.

From these suggestions, the design concept in question can be seen in Figure 12. As for the backfire, it cannot be solved because it is a natural process of combustion that is in the combustion chamber.

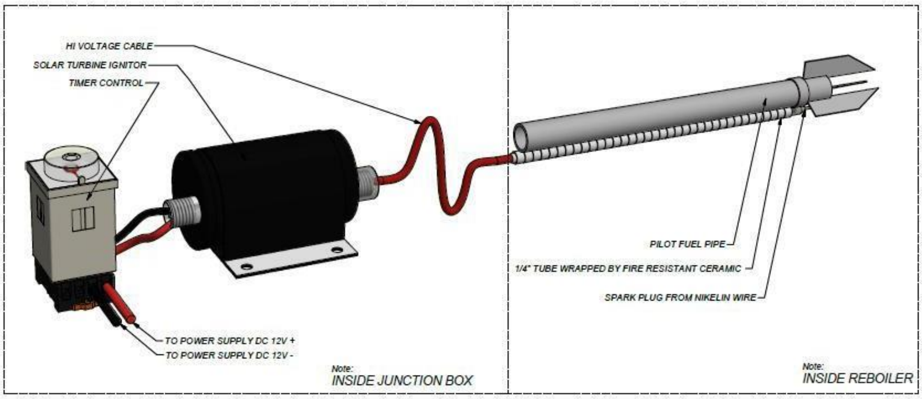

FIGURE 13. Concept of Modified Pilot Module

The problem of setting errors can be solved by providing training or socialization about the correct settings for the pilot. While the environmentally friendly design causes poor combustion quality, we can't do anything because it is designed to be environmentally friendly.

Air Intake Problem

Inlet blockers and a lack of oxygen supply mainly cause air intake problems. Of the three cut sets obtained, the study can be solved by making a device that canclean the air intake without opening the cover, so the cleaning process can be done fast and can be cleaned at any time. The design concept of the tool can be seen in Figure 9.

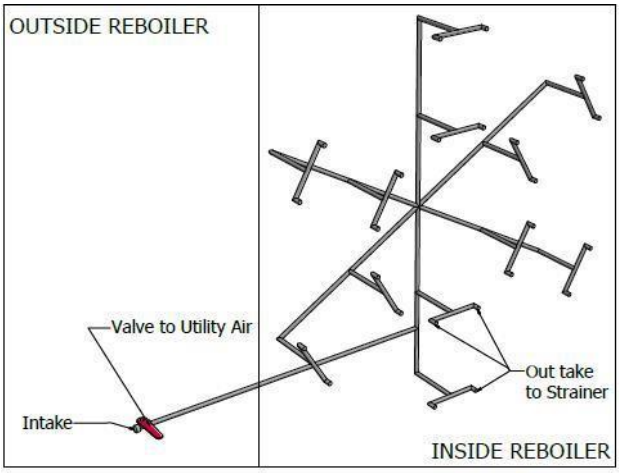

FIGURE 14. Concept of Devices Installed on Air Intake

AO/ DO Modules Hang

In {C1}, the problem can be solved by dividing the equipment in other modules evenly so that no module has too much output compared to the other module. The best solution for the obsolete module is to replace the module with a new one. Still, because the cost and effort must be too big, another solution that can be taken to minimize its risk isto request the correct patch from the manufacturer of the DCS System. The less stable temperature can be minimized by locking the HVAC panel so that the operator cannot easily set the room temperature and change the direction and modification of the flow path damper from the HVAC System.

GEG Hunting

The high load problems can be reduced by lowering theload by turning off unnecessary units. This procedure will also save fuelconsumption. The risks posed by unsuitable gascomposition can be minimized by changing the setting in thecombustion chamber and lowering the temperature in the FuelGas System. The old mechanical components also need to bereplaced, especially the parts associated with combustion, such as carburetors. Problems in the speed controller caused by vibration can be minimized by adding pads and releasing vibration-prone components (such as potentiometers). Otherwise, removing the components at thespeed controller can also minimize signal interference between the controller panel inside the enclosure and controller panels outside the enclosure (switch gear).

Glycol Pump Broken

The vibration problem can be reduced by making a dampener support or replacing the dampener with a shorter one. Examining electrical components also found that they are not following the specifications, so they must be replaced. For dirt in the filter and gas trap, routine maintenance will be done to clean the filter and circulation test from glycol without loading with venting into the air.

5. CONCLUSIONS

Based on the results of data processing and analysis, the authors take some conclusions as follows:

a. Based on the RFMEA method of 45 identified failure modes, five are categorized as critical risk, i.e., pilot failure, air intake problem, AO and DO Modules Hang, shutdown due to GEG Hunting, and Broken Glycol Pump.

b. The cause of each critical risk is found using the FTA method. Pilot Failure is caused by poor design, material, pilot placement, backfire, wrong setting, and fuel system design. The problems with Air Intake are caused by the absence of Air Intake cleaning devices, difficulty opening the Air Intake, Insect's Nest, and the absence of a cover and system for air-in arrangement. AO/DO Modules are often Hang caused by the number of outputs in one module, the module is obsolete, and the temperature is unstable. GEG Hunting is caused by high load, unsuitable gas composition, vibration, and signal interference. Damage to the glycol pump caused by the absence of support and dampener is too high, dirt on the filter and gas trap.

A risk mitigation plan can be made from a basic event, and modifying modules, training, and socialization can solve the pilot's failure. Air intake problems can be handled by making a device to clean the air intake. AO / DO Hang modules can be minimized by finding patches and maintaining room temperature. GEG Hunting can be minimized by lowering the load, adjusting the fuel gas temperature, replacing the mechanical components, and removing the components at the speed controller. The broken glycol pump can be solved by adding support, changing the dampener type, replacing the electrical components, and doing the routine PM.

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