FAILURE MODES AND EFFECT ANALYSIS METHOD ON A DRILL STRING COMPONENTS

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Abstract

This research is focused on the Rotary shoulder connection (Bit sub), 5" OD Heavy Weight Drill Pipe and 8 " OD Spiral Drill Collar in the form of pitting thread, galled thread and damage of thread which is conducted by using FMEA (Failure Mode and Effect Analysis) method. The objectives of this research are to determine the risk priority number and a risk ranking (RPN : Risk Priority number) through the data of failure which is occur on pitting thread, galled thread and damage of thread on the Rotary shoulder connection (Bit sub), 5" OD Heavy Weight Drill Pipe and 8 " OD Spiral Drill Collar. The result shows that the risk ranking can be founded with the condition acceptable risk with the RPN criteria < 35 (Low Risk) and RPN in the range of 35 - 124 (medium risk) and the result risk ranking or high risk with criteria RPN in the range of 124 - 1000 the condition is unacceptable. The result from value of RPN after reducing from the three of failure on the Rotary shoulder connection (Bit sub), 5" OD Heavy Weight Drill Pipe and 8 " OD Spiral Drill Collar can be accepted with the criteria of RPN in the range of 35 - 124 (medium risk).

Keywords *: FMEA (Failure Mode and Effect Analysis), Drill String Components, RPN (Risk Priority Number), Maintenance and preventive control.*

INTRODUCTION

Failure or damage in the drilling industry occurred very often. It rises big problem whenever the drilling system stopped. It impacted the companies in terms of time, cost, and process operation. The failure can be minimized by prevention, maintenance, or treatment in particular on the equipment of drilling.

Analysis of FMEA (*Failure Modes and Effecf Analysis*) is an approximation method that is used for solving the problem from failure mode that occur. Failure Mode and Effects Analysis (FMEA) is one of the most popular methods for the systematic prevention of errors. The problem of early defect detection has become so important to result in developing a method for identifying errors in the design phase of the product [1]. A failure modes and effects analysis (FMEA) is 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 [2]. A successful development of FMEA is very important for product manufacturers to deliver high quality products to their customers on time in turn the manufacturers will be able to compete in the global market [3]. The research studies about of FMEA have been carried out before it about failure analysis on the drill pipe due to the twist-off [4].

FMEA helps the engineer to design reliable and safe product by mitigating the anticipated failure modes. The risk associated with each failure mode is evaluated using Risk Priority Number (RPN) which is calculated by multiplying severity (S), occurrence (O) and detection (D) ratings. Severity rating is assigned according to seriousness of an effect of a failure mode. Occurrence rating is based on the failure probability during the product life. Similarly, detection rating is according to ability to identify a risk occurrence [5].

However, the objectives of this research are to Analysis of FMEA (*Failure Mode and Effect Analysis*) on the drill string components such are Rotary shoulder connection (Bit sub), 5” OD Heavy Weight Drill Pipe and 8 ” OD Spiral Drill Collar with the failure of pitting thread, galled thread and damage of thread on the drilling operation. The Failure mode, effect of failure, causes of failure, and Risk level (*RPN : Risk Priority Number*) are identified. The ranking of priority is the method which is used as a strategy to optimize of prevention, treatment, and maintenance on the drilling equipments.

The specific objective of this research is: Define the rotary shoulder conection, drill pipe and drill collar, Describe the failure mode, Describe the failure cause, Prioritize the failure mode, Determine of Risk Level (*RPN : Risk Priority Number*), Find prevention control or maintenance that can reduce the severity, occurance, and detection of the failure mode and Determine of Risk Level (*RPN : Risk Priority Number*) before and after reducing of failure on the components.

RESEARCH METHOD

Data or report on component failure of drill pipe, drill collar, and rotary shoulder connection are collected from documentation of component failu-re from PT. APEXINDO PRATAMA DUTA TBK.

The next step, the data collection of the research is performed using inspection, in which is as a inspection process is performed from PT. Sekawan Eka Sejati. The inspection is performed in the form of visual body inspection, visual connection, dimensional black light connection, and then with performance cleaning prior to inspection inspected by wet magnetic particle inspection (Magnaflux) with the use of black light & OD using white contrast/ 7HF with standard specification from TH. Hill DS1 CATEGORY 3-5 on the component failure which is occurring it. Such as drill pipe, drill collar, and rotary shoulder connection.

And then, The data processing of the research is processed a using FMEA method. FMECA is Technique which is a used for identification, prioritized, and dispelling of potential failure modes on system, design, or process to consumer before it [6]. The steps in FMEA is performed from failure data, the steps are follows :

Step 1 - *Potential Failure Modes Specification*

Identifying of potential failure mode, In this step is identifying potential failure mode, it occurs on the component such as (5” OD Heavy Weight Drill Pipe, 8” OD Spiral drill collar w/6 5/8 REG Connection, and Rotary Shoulder Connection) using the inspection by visual connection, visual body connection, magnetic particle and visual black light, and dimensions of the design is performed by measuring the components which have been done earlier by PT. Sekawan Eka Sejati.

Step 2- *Potential Failure Effects Specification*

Identifying the effect of failure modes, in this step is checking an effect of failure mode on the component, how big the damage to the design or component it occurs [7].

Step 3- *Potential Failure Causes Specification*

Furthermore, Identifying the cause of the potential failure mode, in this step is identifying the cause of the failure mode from condition factor from environmental conditions, or on the system during operating on the components [7]. Occurrence is also the rating value corresponding to the estimation number of frequencies and/or cumulative number of failures which can cause to unsuccessful implementation of RPN [8].

Step 4 – *Determining value of RPN (risk priority number)*

The next step, After completion of identifying potential of failure mode, effect of failure mode, causes of the potential failure mode is determining value of RPN (*risk priority number*) from data of potential failure mode it occur [7]. The RPN is calculating to find a risk level, the calculate of risk level as follows : The calculating of RPN (Risk Priority Number) are shown in equation (1).

$$\boldsymbol{RPN = S \times O \times D} \tag{1}$$

With, (S), Severity to determine a how to big a damage level on the component failure mode data. (O), Occurance to determine a how to big a frequently of the failure in the time. (D), Detection to determine a detection of failure mode on the component with the criteria value of detection [7].

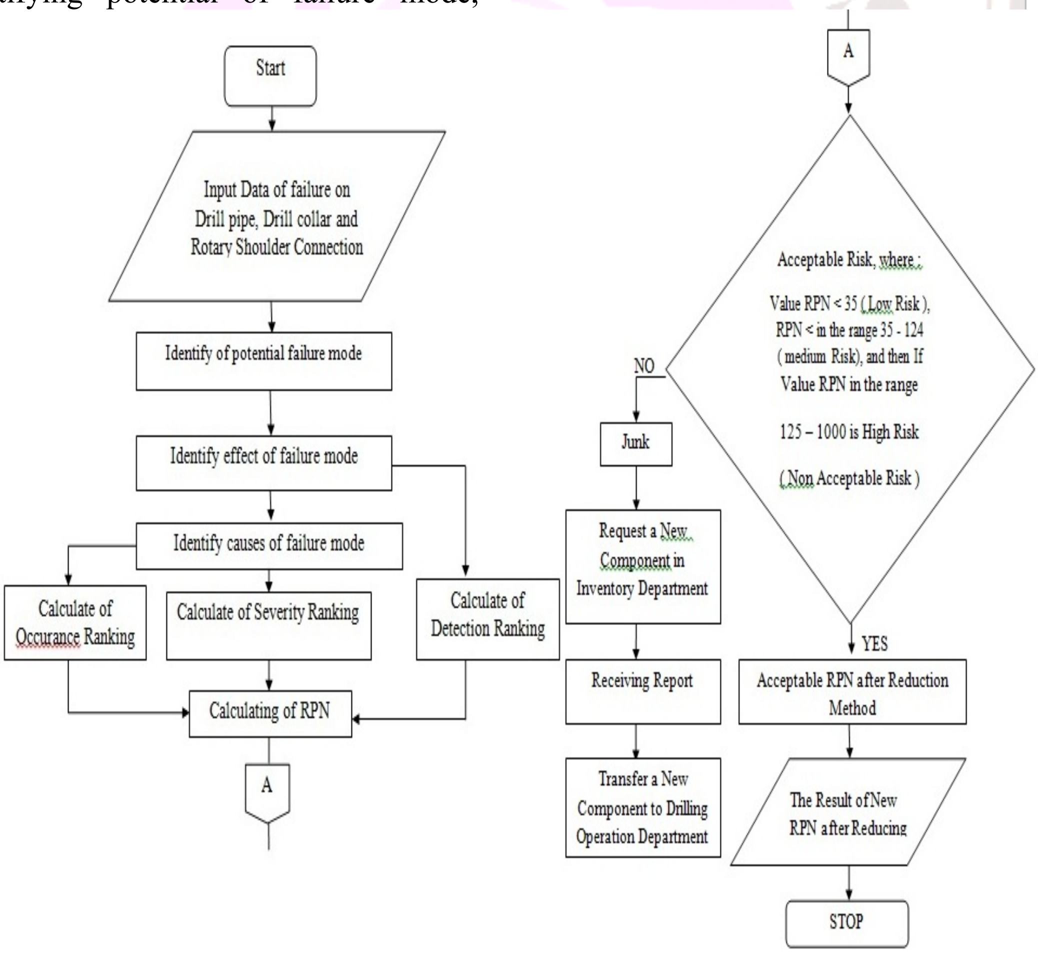

Figure 1. Flowchart Research of Process FMEA

After the find a value of RPN (*Risk Priority Number*), the next step is performed with solution process from value of risk level by doing a possible correction, preventing, the controlling, repairing on component of failure so as to reduced the value of severity, occurance, and detection on the component for can be reduced the risk [9].

RESULT AND DISCUSSION

From the application of FMEA (*Failure Mode and Effect Analysis*) method that is processed from data of failure to fulfill the objective of the research.

The results for identifying of failure mode on the rotary shoulder connection, 5” OD Heavy Weight Drill Pipe, and 8 ” OD Spiral Drill Collar is presented on the Table 1.

Based on the identifying of the Rotary shoulder connection, 5” OD Heavy Weight Drill Pipe, and 8 ” OD Spiral Drill Collar in field with the inspection on the components is found the effect of potential failure mode. Identifying effect of potential failure mode on the drill string component is presented on the Table 3.

Based on the identifying of the Rotary shoulder connection, 5” OD Heavy Weight Drill Pipe, and 8 ” OD Spiral Drill Collar in field with the inspection on the components is found the cause of potential failure mode. Identifying cause of potential failure mode on the drill string component is presented on the Table 2.

Table 1. Identifying of Failure on the components

Identifying of Failure on the components	Pitting thread	Galled thread	Thread damage
Rotary shoulder connection	√	√	√
5” OD Heavy Weight Drill Pipe	√	√	–
8 ” OD Spiral Drill Collar	√	√	√

Table 2. Identifying cause of potential failure mode on the drill string components

Identifying cause of potential failure mode	Potential Cause
Pitting thread	Water, oxygen, CO_2, H_2S, high stress or high temperature, high pH of mud and high of velocity.
Galled thread	Thread damage, handling without protector, cross threading, improper lubricant, dirty connection, defective of Kelly saver.
Thread damage	Miss stabbing connection, handling damage, spinning chain between shoulders, improper pipe jacking.

Table 3. Identifying Effect of Potential Failure Mode

Identifying effect of potential failure mode	Failure Modes	Effect
Rotary shoulder connection	Pitting thread	1. Surface of the box with all parts inside is loss a material in the form of pitting thread. 2. The thickness of the wall surface becomes losses.
	Galled Thread	1. Loss of strength in the sealing (joint connection) on the which other shoulder to shoulder. 2. Failure of the torque (false make-up

Identifying effect of potential failure mode	Failure Modes	Effect
		torque). 3. The connection between shoulder to another shoulder unstable.
	Thread Damage	1. Leaking shoulder seal, washout, string separation, and lost time.
5” OD Heavy Weight Drill Pipe	Pitting Thread	1. Surface of the box with all parts inside is loss a material in the form of pitting thread 2. The thickness of the wall surface becomes losses
	Galled Thread	1. Box is losses of the structural material, erosion, corrosion on the surface of the material. 2. Damages mating 3. False torque 4. Improper make-up 5. Leaking shoulder seal 6. Box break 7. 6.Wash out 8. 7.Drop string 9. Lost time 10. Connection wobble
8 ” OD Spiral Drill Collar	Pitting Thread	1. Surface of the box with all parts inside is loss a material in the form of pitting thread 2. The thickness of the wall surface becomes losses
	Galled Thread	1. Box is losses of the structural material, erosion, corrosion on the surface of the material. 2. Damages mating 3. False torque 4. Improper make-up 5. Leaking shoulder seal 6. Box break 7. 6.Wash out 8. 7.Drop string 9. Lost time 10. Connection wobble
	Thread Damage	1. Leaking shoulder seal, washout, string separation, and lost time.

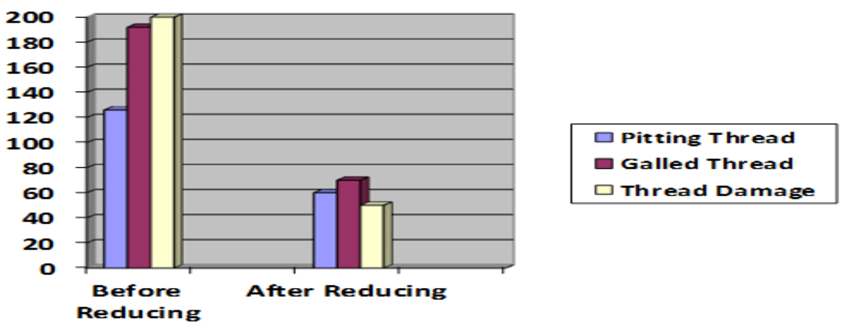

Figure 2. Risk Priority Number (RPN) On the Rotary Shoulder Connection Before and After Reduction

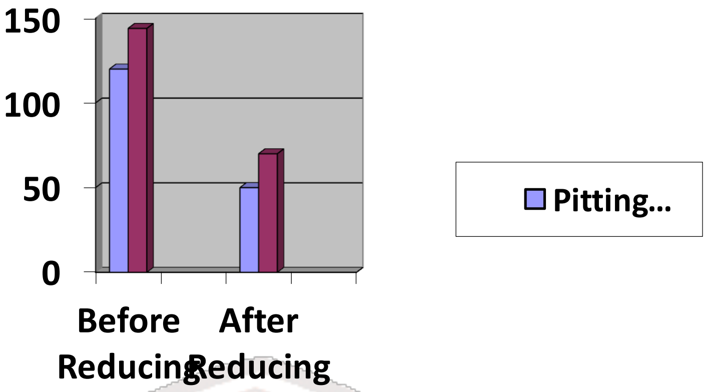

Figure 3. Risk Priority Number (RPN) On the 5" OD Heavy Weight Drill Pipe Before and After Reduction

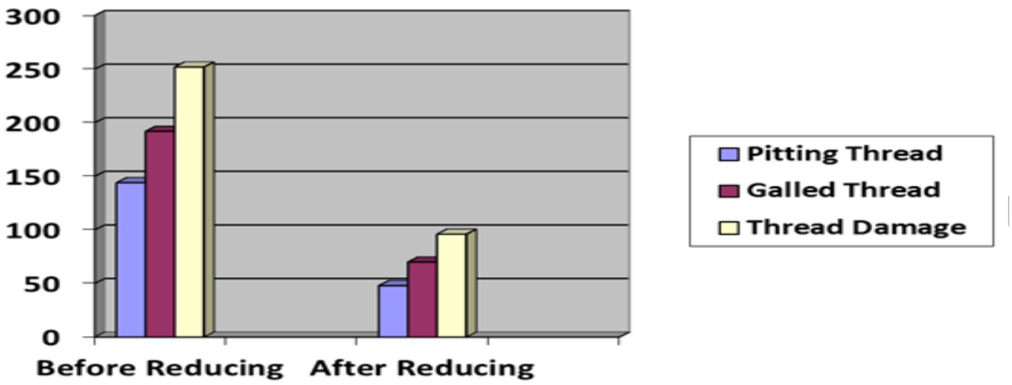

Figure 4. Risk Priority Number (RPN) On the 8 " OD Spiral Drill Collar Before and After Reduction

The result calculation of *RPN* (*Risk Priority Number*) before and after reducing on the drill string components. After completion of identifying potential of failure mode, effect of failure mode, causes of the potential failure mode is determining value of RPN before reducing and after reducing (*risk priority number*) from data of potential failure mode it occur.

The value RPN before and after reducing on the Rotary Shoulder Connection is presented on the Figure 2. The value RPN before and after reducing on the 5" OD Heavy Weight Drill Pipe is presented on the Figure 3. The value RPN before and after reducing on the 8 " OD Spiral Drill Collar is presented on the Figure 4.

CONCLUSSION

From the result of RPN before reducing and after reducing, criteria for the value of RPN before reducing is very high value with criteria high RPN in the range of 125 - 1000, from the case be that the proven value of risk ranking can't acceptable risk. Any value below the minimum risk priority value is considered an acceptable risk with criteria Low RPN < 35 and medium RPN interval 36 - 134.

From the result value of RPN after reducing on the Rotary shoulder connection, 5" OD Heavy Weight Drill Pipe and 8 " OD Spiral Drill Collar can be obtained medium RPN of risk ranking. Therefore, takeable a step in reducing the value of RPN to become minimum risk priority value with the maintenance plan and preventive control of the Rotary shoulder connection, 5” OD Heavy Weight Drill Pipe and 8 ” OD Spiral Drill Collar.

The results of actions taken to reduce the level of of failure and preventive control are as follows. Pitting thread maintain mud pH above 9.5, plastic coating, inhibitor, oxygen scavenger, clean pipe ID and OD on the shoulder connection, dampen stress, monitor with corrosion test ring. Galled thread gives lubrication / compound are clean and not mixed with the other material to reduce friction, reduce the effective weight of the load during joining and then tensioning torque calculated, Lowering the speed lock between the pin and the box during connection, handle pipe only with thread protector, use care in stabbing and make-up, clean connection before use, repair or replace Kelly saver sub, use only recommended rotary tool joint compound. Damage of Thread use care with tripping pipe, handle pipe only with thread protector, use only pipe jack with wide area contact, giving a lubricant for to reduce occur thread galling, Tightening torque of good will avoid blisters or fatal damage to the pin.

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