RISK ANALYSIS AND TREATMENT FOR CUTTING PLASMA PROCESS AT PT.TOYOTA MOTOR MANUFACTURING INDONESIA USED FAILURE MODE AND EFFECT ANALYSIS (FMEA)

Syahrullah [1], Heriyono Lalu [2], Yunita Nugrahaini[3]

[1,2,3] Universitas Telkom, Bandung
syahru1lah@student.telkomuniversity.ac.id[1], **heriyonolalu@telkomuniversity.ac.id[2]**,
yunitanugrahaini@telkomuniversity.ac.id[3]

Abstract

PT.Toyota Motor Manufacturing Indonesia has one work process, namely the Plasma Cutting process, the process is the reuse plate cutting process. In this process, there are still some risks that occur, based on the problem data from January to March 2020, there are 29 risks in the Plasma Cutting process. With these 29 risks, the company has set targets. The purpose of identifying these risks is to determine, recognize, and describe risks, which may be able to assist companies in taking preventive actions (ISO 31000, 2018). There are several factors considered in identifying risks in the Plasma Cutting process, namely the causes, events, and also the consequences and impacts on the output of the process. To find out how big the impact of the risk is, the risk analysis can understand the nature and characteristics of the risk.

One of the methods used to analyze the risk of failure is Failure Mode and Effect Analysis (FMEA). This method can determine the risk rating and can determine the more significant risk which is presented with the Risk Priority Number (RPN) value and provides treatment. for Severity, Occurance, and Detection based on the results of the discussion and the references used. After getting the results of the value scale, the Risk Priority Number (RPN) is calculated which is the result of multiplying Severity, Occurrence, Detection. After the RPN results are obtained, the highest RPN value will be the Risk Priority which will be given a treatment recommendation so that the risk in the Plasma Cutting process can be reduced. Based on the highest RPN value, the results of this study are the results of the proposed treatment for Torch Cable Broken Failure Mode, in which the proposal aims to reduce the risk of the Torch Cable breaking.
Keyword : Risk, Cutting Plasma, Failure Mode and Effect Analysis, Risk Priority Number, Severity, Occurrence, Detection.

I. Background

PT Toyota Motor Manufacturing Indonesia (TMMIN) is a joint-venture company between Toyota Motor Corporation and PT Astra International which is engaged in manufacturing and also exporter of motor vehicles, engines, components, as well as dies & jigs. Being one of the top manufacturing industries in Indonesia, PT. Toyota Motor Manufacturing Indonesia (TMMIN) certainly has a good work system and management system. However, it is possible that all existing systems / work processes do not need to be improved and no improvements are made. It aims to further facilitate the daily work process, and make the production process more optimal and maximal. to find out the risks that may have a negative impact on the course of the process. In knowing the system / work process is necessary or not given a suggestion, a risk analysis is carried out on the system / process..

In January-March 2020 there were 29 findings of problems in theprocess *Plasma Cutting*, the findings of this problem in the time span of January-March 2020 Researchers made observations on theprocess *Plasma Cutting*, Process *Plasma Cutting* is the process of cutting reuse plates, the reuse plates come from the leftover plates from the result of cutting the car body frame. the result of cutting the reuse plate will later be melted down and used as raw material for the manufacture of *engine block* engines. The following are the activities in theprocess *plasma cutting*.

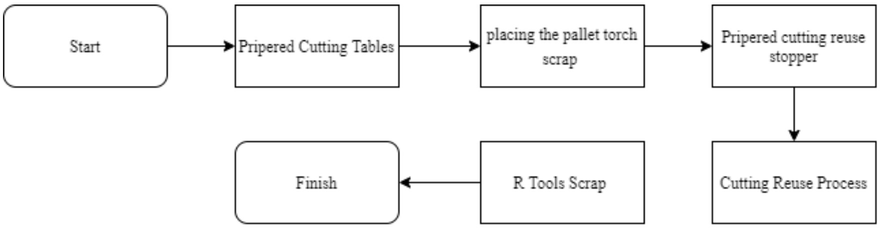


Figure 1. 1 Flow Chart Cutting Plasma Process

Based on Image 1.1 explain the flow of the production process, theprocess *Plasma Cutting.* Based on the picture above that uses a *Flow Chart*, the process flow described there are several activities. Starting from preparing the cutting table such as placing the table according to the layout, and closing the cutting table with pallet scarp, then placing the pallet torch scrap according to the layout, then preparing the reuse cutting stopper, and then the reuse cutting process, reuse cutting is divided into 2, namely cutting Type 51111.21 and Type 51133.34, and the last activity is 5R Reuse scrap, which is to ensure that there are no potential hazards after the cutting process is complete.

During the process *Plasma Cutting* , the company has not identified the impact and root cause of the risk, which will affect the output of theprocess *Plasma Cutting*. The purpose of identifying these risks is to determine, recognize, and describe risks, which may be able to assist companies in taking preventive actions (ISO 31000, 2018). here are several factors considered in identifying risks in theprocess, *Plasma Cutting* namely the causes, events, and also the consequences and impacts on the output of the process. To find out how big the impact of the risk is, the risk analysis can understand the nature and characteristics of the risk.

One of the methods used to analyze the risk of failure is *Failure Mode and Effect Analysis* (FMEA). This method can determine the risk rating and can determine the more significant risk which is presented with the *Risk Priority Number* (RPN) value and provides *treatment*. FMEA can be defined as a systematic method to identify and prevent problems the product or process before it happens (McDermott, 2009), based on the definition above can be concluded that the FMEA has a goal look at the process and product to determine the failure or called *Failure Mode* to identify potential failure modes, effects and emergence detection. Evaluation of FMEA, failure in process *Plasma Cutting* carried out using 3 indicators, namely, assessment and analysis of the impact of risk (*Severity*), assessment and analysis of the causes of risk events (*Occurance*), and assessment and analysis of detection before the occurrence of risk (*Detection*).

Based on this background, this final project aims to perform risk analysis and treatment using Failure Mode and Effect Analysis (FMEA) at the C*utting Plasma*,and provide draft proposals on the treatment chosen, which aims to reduce the occurrence of these risks in the process *Cutting Plasma*.

II. Theoritical Basis

II.1 Risk Definition

Risk is the uncertainty of a process goal. This uncertainty is an effect that has a positive or negative impact. Risk can also be described by an event that has a change in circumstances or consequences (British Standard Institution, 2018).
It can be concluded that risk is the possibility of an event that can be detrimental to the organization or company, but can still be identified by related parties, and it is necessary for the company to overcome these risks so that the process becomes more effective..

II.2 Type of Basic Risk
To distinguish the impact of the level of risk in an organization or company is the initial clarification of the most basic risks. What is meant by *basic risk*, Which is :

1. *Strategic Risk*
   risk includes risks related to the long-term performance of the organization. This includes various variables, such as markets, corporate governance, and stakeholders. Highly variable markets can change in a relatively short time, as can the economic characteristics of the country or countries in which an organization operates. In developing strategies, organizations make an assessment of current market conditions (Roberts, Wallace, & McClure, 2003).
2. *Change or Project Risk*
   A forced change is a materialized requirement to install a new production line to satisfy a sudden and unexpected increase in product demand. This is an example of *Change or Project Risk* that can operate at multiple levels in an organization. Changes imposed by variations elsewhere both within and outside the organization. Or, change planning and organizational engineering as a means to reach a goals (Roberts, Wallace, & McClure, 2003).
3. *Operational Risk*
   Operational Risk can be defined as the risk of direct or indirect loss, which is caused by inadequate internal processes, operators, systems and external events. Operational risk also effectively includes anything that can impact the overall performance of the organization and the organization's ability to create value. Therefore, operational risk includes the event of an error or missed opportunity (Roberts, Wallace, & McClure, 2003).
4. *Unforeseeable Risk*
   type of risk that can sometimes be allowed to reach a certain point by using or creating *contingencies* that are included in the initial plan. In other words, unexpected risk is a type of risk that cannot be accurately estimated before it occurs. (Roberts, Wallace, & McClure, 2003).

II.3 *Risk Assessment*

Risk Assessment is the result of a risk process, risk analysis and evaluation. On the knowledge and views of stakeholders, Risk Assessment must be carried out in a systematic, iterative and collaborative manner available, complemented by further investigation if needed (British Standard Institution, 2018).

Risk Assessment makes an introduction and provides an assessment to determine the significant risks facing the company, project, or strategy. The overall process is a strategy that focuses on better decision making, and is the main input in formulating strategies for Risk Management (British Standard Institution, 2018).

II.4 *Failure Mode and Effect Analysis* (FMEA)

FMEA is an important management tool to be able to identify potential system failures in advance and assess their causes and effects, there by preventing failures from occurring (Liu, 2019). FMEA is also proactive to identify possible failure modes of systems, processes, products, or services, analyze the causes and effects of failures, and eliminate or reduce the most significant risks by proposing risk mitigation actions (Stamatis, 2003). It can be concluded that the FMEA method is a process to identify potential failures of a system, and analyze the causes, impacts and manage control mechanisms and proportionate risk redaction plans to improve system security and process reliability. As an alternative way to analyze risk. The first step is to sequence all possible failures or occurrences of a specific product or system through a *brainstorming session*. After that, do a critical analysis to find out the failure mode by considering risk factors in the form of, *Occurance (O)* which is the cause of the occurrence of risk, *Severity (S)* which is the magnitude of the effect that affects if the risk occurs in a product, system, and process, *and Detection (D)* which is the probability of how easily a failure can be detected.

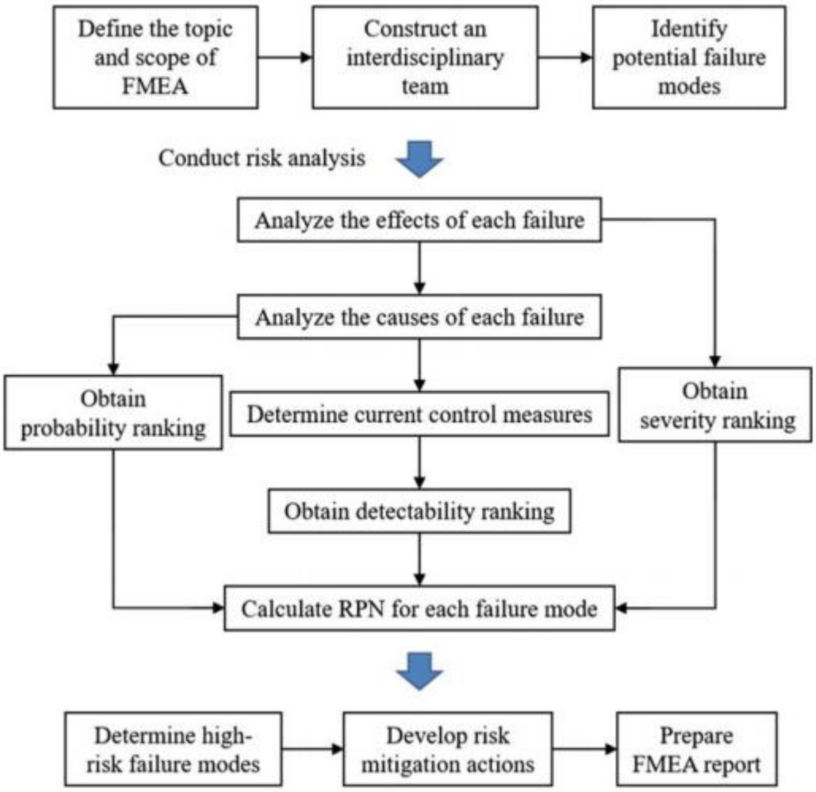


Figure 2. 1 Classification of FMEA (Source : Liu, H. C. (2019). Improved FMEA Mehod for Proactive Healthcare Risk Analysis.

The stages in determining the value of *Failure Mode and Effect Analysis* are as follows:

1. Determining *Severity*, *Occurance*, and *Detection*

To determine the risk priority that will be proposed, FMEA must first define *Severity*, *Occurance*, and *Detection*, and the final result will be *Risk Priority Number*, the following is the scale used in the assessment of S (*severity)*, O *(Occurance)*, and D *(detection)*, and RPN *(risk priority number).*

1) *Severity*

Severity is the first step to calculate how much impact / intensity of events affect the course of the process output. The impact is given a scale from 1 to , where 5 is the worst impact.

Table 2. 1 *Severity* Values

Effect	*Severity Of the Effect*	*Rank*
Extreme	Risk affects cost, time and / or scope, thus making the final product not delivered on time so that it affects the company's image in the eyes of customers	5
Major	Risks affect cost, time and / or scope, and require action to achieve company goals. This may necessitate an activity change management process.	4
Significant	risk of causing delays in activities that are not on critical enterprise paths. In addition, Risk may involve impact on company resources and affect deadlines, budgets and scope of work stations.	3
Moderate	Risk of causing delays in activities that are not on critical enterprise paths. In addition, Risk may involve impacts on company resources, without affecting deadlines, budgets and work station scope	2
Low	Risk causing no minor loss to project objectives, requiring rework or minor corrections in project deliverables, no additional time or budget required.	1

Source : *(Muttaqin & Kusuma, 2018)*

2) *Occurancce*

Occurance is the emergence of the cause of a certain mechanism. In other words, is the probability of a *Occurance* specificon the frequency of occurrence of the potential error. The cause is given a scale ranging from 1 to , where a scale of 5 is the highest probability.

Table 2. 2 *Occurance* Value

Effect	*Probability of Failure*	Skala Kejadian	*Probability of Occurance*
High (3)	Will definitely happen, the level of causal events can be observed regularly with a hazard condition	X > 4	0,309

Medium (2)	Repetition of events, the frequency of occurrence of potential hazards can be predicted. Based on case by case, with a high level of realization the possibility of	3≤x≤4	0.191 ≤ x ≤ 0,309
Low (1)	The cause of the event is difficult to occur, but it is still possible to happen. This is an assumption that the event becomes something unexpected	≤2	0 ≤ x ≤ 0,191

3) *Detection*

Detection is one type of assessment to identify the cause/risk mechanism. The company team should use the evaluation criteria and the basis of the system if some changes are required in a special case. the team must review the potential risk score after scoring and ensure that this rating is still the same.

Table 2. 3 *Detection* Values

Detection	*Probability of Detection*	*Rank*
Undetected	No controller is capable of detecting	5
Very Low	The ability of the controller to detect forms and causes is very low	4
Low	The ability of the controller to detect forms and causes is low	3
High	The ability of the controller to detect forms and causes is high	2
Very High	The ability of the controller to detect forms and causes is very high	1

Source : (Apriyan, Setiawan, & W, 2017)

III. Research Method

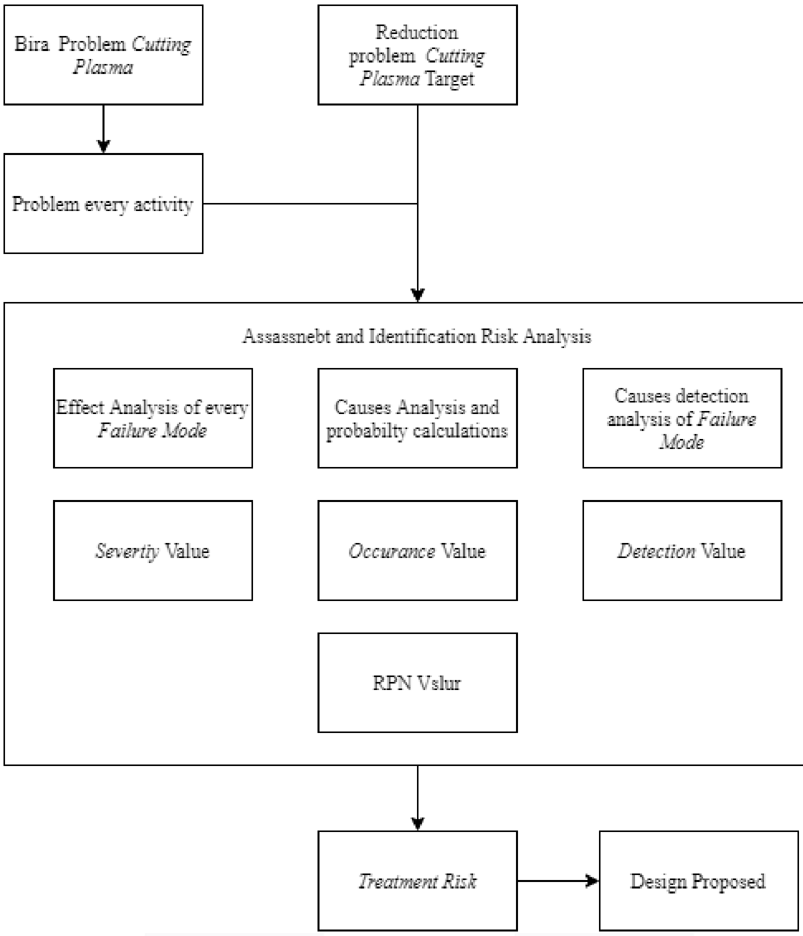


Figure 3.1 Conseptual Model

Based on the conceptual model in Figure 3.1, it can be explained that to carry out a Risk Assessment using the Failure Mode and Effect Analysis method, it takes data on problems in the Plasma Cutting process and target data for reducing problems in the Plasma Cutting process. Plasma Cutting process. The target data for problem reduction and problem data are useful to help researchers, analyze and identify any risks that cause problems in the Plasma Cutting process. After successfully identifying the risks, then an analysis of the effects / impacts of each Failure Mode will be carried out which is the reference for the *Severity* value, analysis of the causes and calculating the probability of events that become the reference for *Occurance* value, analysis of the detection method before Failure Mode occurs which becomes the reference for the *Detection* value. After getting this value, it will enter the RPN calculation, the results of the RPN will be given to find out which risks have the potential to be prioritized, and from the results of the RPN, each Failure Mode can be given Treatment. Based on the treatment, someone will be selected to make a proposed design, in accordance with the Failure Mode which is dominant in making *Plasma Cutting* problems occur frequently. The result will be verified by the company, in order to determine whether the proposal can be followed up or not..

IV. INTEGRATED SYSTEM DESIGN

IV.1 Processing Data

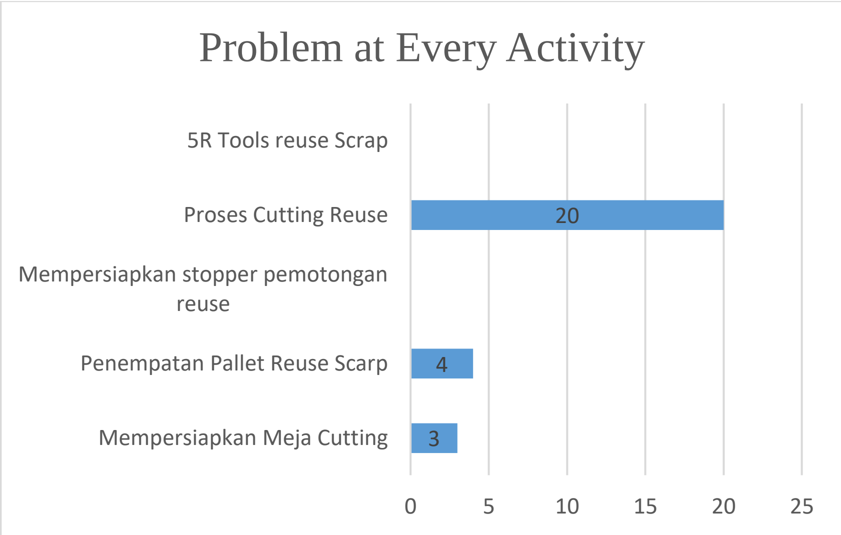


Figure 4. 1 Chart of problem at every activity

Based on Figure 4.2 which explains the problems that exist in each activity in January, February, March, in 2020. The problems listed in table data finding problems in the *Plasma Cutting* work process, then adjusted to each activity. It is known that in the activity of preparing the cutting table there were 3 problem occurrences, in the activity of palletizing reuse scrap there were 4 problems, in the activity of preparing the reuse cutting stopper there were no problems, in the activity of the *Plasma Cutting* process there were 20 occurrences of problems, in the activity of R tools reuse scrap there were no problems. there is a problem. It can be concluded that from every activity in thework process *Plasma Cutting* at PT. Toyota Motor Manufacturing Indonesia, the activity that has the highest average occurrence of problems is activity during the process *Cutting Reuse* with 20 events in 3 months, where the problem is caused by The plasma TIP is damaged and the plasma torch cable is broken.

IV.2 ***Failure Mode and Effect*** **(FMEA) Analysis stage**

IV.2.1 Identify the *Severity*

Table 4. 1 Standard information for Plasma Torch Cable and Plasma TIP

Item	Informasi std	Problem Utama	Dampak Probem	No
KabelTorch Plasma Putus	Std 6 bulan 1x ganti (Harga 1 Set Rp.10.000.000)	PIC baru tidak memahami metode kerja	Line stop produksi membuat pallet reuse tidak mencapai 2 ton	1
	1 hari pallet reuse harus mencapai 2 ton	Posisi Jalur Torch membuat kabel sering ke lipet & tertarik paksa	Kerugian Karena ganti torch RP.10.000.000	

Ganti TIP Plasma	Std 1 bulan 1x ganti (Harga 1 Set Rp.220.000)	Jarak TIP Plasma pada saat memotong reuse terlalu dekat	Line stop produksi membuat pallet reuse tidak mencapai 2 ton	2
	1 hari pallet reuse harus mencapai 2 ton	Settingan tekanan api terlalu besar	Kerugian karena ganti TIP plasma RP.220.000	

Based on Tables 4.1 it can be seen that the process *Plasma Cutting* has some standard information for torch and TIP plasma cable items. The following standard is a standard that becomes a reference in knowing whether the process *Plasma Cutting* suffers a loss, if there is a risk that affects the following standards. In the table it is explained that the standard cost loss and the standard production target were not achieved.

it can be seen that the Plasma Torch cable breaking problem has a countermeasure that replaces the Plasma Torch 2x in 3 months, based on the table 4.1 standard for replacing the Torch Plasma cable is 1x in 6 months, it can be concluded that the impact for 3 months on the problem of the Torch Plasma cable breaking is making the company lose Rp. 10,000,000.

In the problem of damaged TIP Plasma there is a countermeasure that replaces TIP Plasma, this happens 6 times in 3 months, based on Table 4.2 the standard for replacing TIP Plasma is 1x in 1 month, it can be concluded that the impact for 3 months on the problem of TIP Plasma is damaged which makes the company lose Rp. 660,000.

Based on Figure 4.1 there are 20 problems caused by broken Plasma Torch and broken Plasma TIP, this results in a loss in achieving production standards. Based on the standard information described in Table 4.1, which the process for *Plasma Cutting* standard is 1 day pallet reuse, must reach 2000 (KG). The above problems make the achievement of the production process standard not achieved.

Based on explanation above, here's the *Severity* Value Table

Table 4. 2 Result of *Severity* value

No	Activity	Failure Mode	Effect Failure Mode	Severity
1	Cutting Reuse Process	Torch Plasma Cable broken	Line stop production makes pallet reuse not achieved 2 tons	4
			Loss due for changing Torch Plasma Cable RP.10.000.000	

		Plasma TIP damaged	Line stop production makes pallet reuse not achieved 2 tons	3
			Loss due for changing Plasma TIP RP.660.000	

IV.2.2 Identify the *Occurance*

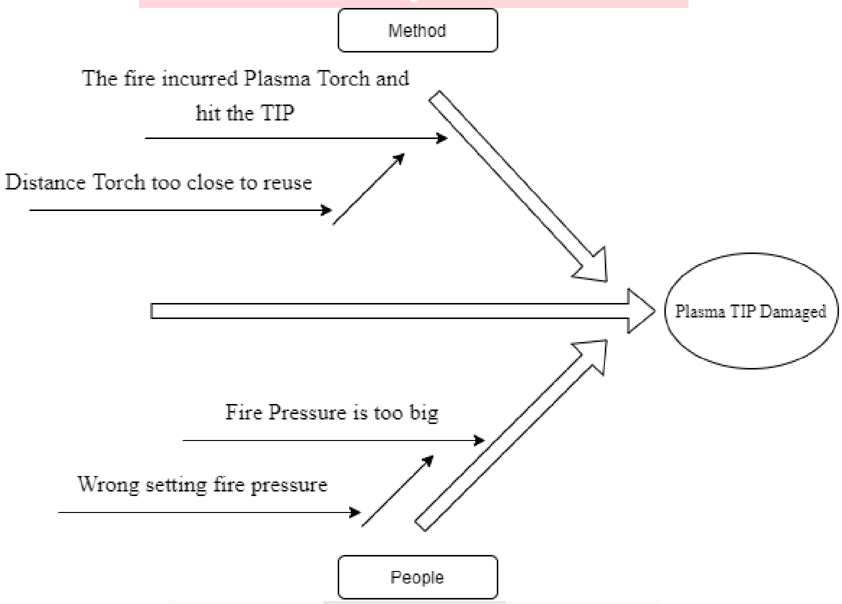


Figure 4.2 Causes Analysis of Plasma TIP damaged

Based on Figure 4.10, it is known that the results of the analysis using fishbone caused the problem in the TIP plasma was damaged. The TIP plasma was damaged due to the method aspect, which is the flame released by the torch hit the Plasma TIP, because the distance of the torch was too close to reuse.

Table 4. 2 Number of Plasma TIP damaged

No	Date	Problem
1	08/01/2020	Fire out not maximal
2	28/01/2020	Plasma TIP Damaged (Fire out not maximum)
3	11/02/2020	Plasma TIP Damaged

4	28/02/2020	Plasma TIP Damaged
5	16/03/2020	Plasma TIP cannot repaired
6	31/03/2020	Plasma TIP cap damaged (hit the pallet)

Based on Table 4.3, it can be seen that in the cutting reuse process, there are 6 problems caused by Plasma TIP damaged from a total of 29 problems in the problem data, with a working day span from January to March.

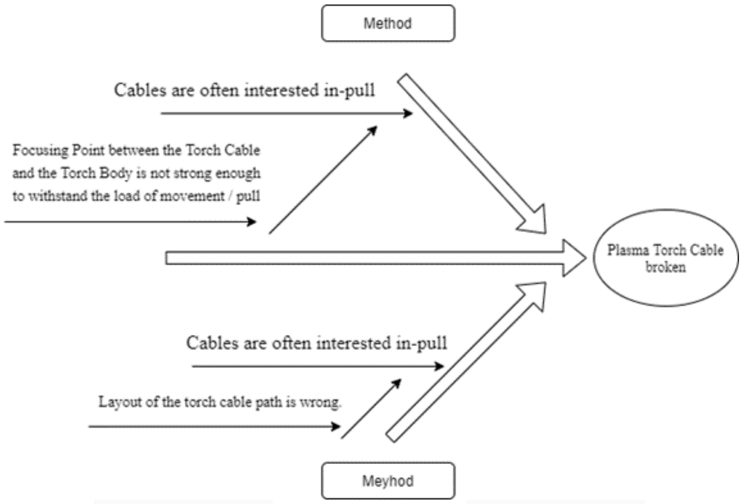


Figure 4.1 Causes Analysis of Torch Plasma Cable broken

Based on Figure 4.13, it is known that the results of the analysis using fishbone caused the problem with the broken torch cable. The torch cable is caused by the method aspect, namely because the cable is often pulled, the torch gun cable which makes the work process less comfortable, is caused by the wrong layout of the torch gun path placement.

Table 4. 3 Number of Plasma Torch Cable broken

No	Date	Problem
1	03/01/2020	Plasma Torch Cable Broken
2	09/01/2020	Fire response does not got out (cable torch broken)
3	17/01/2020	Plasma Torch Cable Broken (Cuttine Line stop)
4	21/01/2020	Installation of torch is not the maximum (broken)
5	24/01/2020	Plasma Torch Cable Broken
6	06/02/2020	Plasma Torch cable hit a pallet (broken)

7	17/02/2020	Plasma Torch Cable Broken
8	21/02/2020	Plasma Torch Cable Broken
9	27/02/2020	Plasma Torch Cable Broken
10	09/03/2020	Plasma Torch cable is broken it can't be repaired
11	14/03/2020	Plasma Torch Cable Broken
12	18/03/2020	Plasma Torch Cable Broken
13	24/03/2020	Small plasma Torch Cable Broken
14	27/03/2020	Plasma Torch Cable Broken

Based on Table 4.10, it can be seen that in the cutting reuse process, there are 14 problems caused by the Torch Cable breaking, out of a total of 29 problems in the problem data, with a working day span from January to March.

To know the value of *occurance* required represents the probability distribution of the votes. Based on the problem data in the Plasma Cutting process, this data becomes a reference for determining the probability scale of the event criteria. For determining the probability distribution to use, to calculate the probability of the value *Occurance,* using the Poisson Model Distribution.

The Poisson distribution is a probability model which can be used to find the probability of a single event occurring. The occurrence of these events must be determined by chance alone which implies that information about the occurrence of any one event cannot be used to predict the occurrence of any other event. It is worth noting that only the occurrence of an event can be counted (HELM (Helping Engineers Learn Mathematics), 2008)

Based on the explanation above, to calculate probability of the *Occurance* value, will using Poisson Model Distribution. In determining the Poisson Model Distribution, the writer used IBM SPSS software. Variable (x) that used to become the data will be processed using IBM SPSS to find a probability *Occurance* is event data every 1 week for 3 month. The data refers to the problem data at Table Bira problem finding at working process Cutting Plasma.

Based on observations with interviews, the company determined that the scale of problem occurrence in the process *Plasma Cutting* is *High* if the incidence is $x > 4$ events in 1 week. *Medium* if the incidence is $3 \leq x \leq 4$ events in 1 week. *Low* if the incidence is ≤ 2 events in 1 week. Heres the formula to calculate the probability poisson using RStudio based on Journal the Poisson Distribution in R (Foley, 2019)

ppois(q , lambda, lower.tail)

Explanation :

- q : Point value “x” to be calculated, based on modul pratikum at section choosing Discrete and Countinuos Probability Distribution (SIPO, 2020). For using RStudio using ppois formulation, the x of variable q is minus by 1

- lambda : Average value X, which means from the data Bira problem finding at working process Cutting Plasma, known the average of value in 1

- *lower.tail*

a) False : used if the question P(X > x)

b) True : used if the question P(X ≤ x)

based on the information above, then the calculation of the O*ccurance* Value in the Plasma Cutting process is :

1. *High* : P(x ≥ 4) ?

```
> #ppois(x>4)
> ppois(q = 3,lambda = 3,lower.tail = FALSE)
[1] 0.3527681
```

From the results, it *output* is obtained that x ≥ 4 is 0.352. It can be concluded that the probability of occurrence ≥ 0.352 is categorized as *High*

2. *Medium* : P(3 ≤ x ≤ 4)

```
> #ppois(3<=x<=4)
> ppois(q = 3,lambda = 3,lower.tail = TRUE)-ppois(q = 2,lambda = 3,low
er.tail = TRUE )
[1] 0.2240418
```

From the results, it *output* is obtained that 3 ≤ x ≤ 4 adalah 0.224, if the result compare with *High* probability, then the probability of occurance is 0.224 ≤ x ≤ *High* (0.224 ≤ x ≤ 0.352) is categorized as *Medium*

3. *Low* :P (x ≤ 1)

From the calculation of the probability *Medium*, it can be compared that to find the probability of the category *Low* , the probability (*Low* ≤ x ≤ *Medium*), based on the reference p (x ≤ 2) then the probability of 0 ≤ x ≤ 0.224 can be categorized as *Low*.

To calculate the probability of the Plasma TIP being damaged and the Torch Plasma Cable broken also using the average data of events per 1 week. It aims to get the probability which will determine the category of events. The average of the Plasma TIP damaged and Plasma Torch Cable broken refers Table 4.9 and 4.10, known as :

- Average of Plasma TIP damaged in 1 week : 1
- Avarage of Plasma Torch Cable broken in 1 week : 3

1. Plasma TIP damaged

Based on explanation above it can be seen that the average incidence of Plasma TIP in 1 week is 1, then the probability calculation using RStudio is:

Plasma TIP damaged (x = 1)

```
> #dpois(x=1)
> dpois(x = 1,lambda = 3)
[1] 0.1493612
```

Based on the above calculation, it can be concluded that damaged Plasma TIP has a probability 0.149 which can be categorized as *Low*.

2. Plasma Torch Cable broken

Based on Table 4.19 it can be seen that the average occurrence of Torch Cable breaking in 1 week is 2, then the probability calculation using RStudio is :

Plasma Torch Cable broken (x=3)

```
> #dpois(x=3)
> dpois(x = 3,lambda = 3)
[1] 0.2240418
```

Based on the above calculation, it can be concluded that the Plasma Torch Cable broken has a probability of 0.224 which can be categorized as *Medium*.

Based on the calculation of the *Occurance* Value and probability of the Plasma TIP damaged and the Torch Plasma Cable broken. The result of *Occurance* value is shown in the Table below.

Table 4. 4 Result of *Occurance* value

No	Aktivitas	*Failure Mode*	*Cause Failure Mode*	*Occurance*
1	Cutting Reuse Process	Plasma TIP damaged	The fire incurred Plasma Torch and hit the TIP	Low (1)
			Fire Pressure is too big	
		Torch Plasma Cable broken	Cables are often interested in - pull	Medium (2)
			The Focusing Point between the Torch Cable and the Torch Body is not strong enough to withstand the load of movement / pull	
			Layout of the torch cable path is wrong.	

IV.2.2 Identify the *Detection*

Detection is one type of assessment for the detection of causes/risk mechanisms. Which uses the evaluation criteria and the basis of the system if some changes are required in special cases. Determination of the best control is done as early as possible during the process.

Steps to identify or detect the Occurrence of Plasma TIP damaged and Plasma Torch Cable broken, what is done is to collect information to control the presence of *Cause of Failure* which causes the Plasma TIP damaged and Plasma Torch Cable broken. The results of the assessment for controlling the causes of *Failure Mode* can be seen in the table. This assessment was obtained apart from field observations as well as from the results of discussions and interviews with the PIC and the head of the PIC who is responsible for the relevant department.

Table 4. 5 Result of *Detection* value

No	Aktivitas	*Failure Mode*	*Cause Failure Mode*	Pendektesian	*Detection*
1	Proses Cutting Reuse	TIP Plasma rusak	1. Api yang dikeluarkan torch menabrak TIP plasma 2. jarak Torch terlalu dekat dengan reuse	1. Visual Control : Operator melihat apakah tekanan api keluar secara maximal atau tidak, jika iya operator melakukan controlling pada TIP Plasma, seperti pemasangan TIP, Tipe TIP, dan bentuk TIP, sudah sesuai tau belum. 2. Preventive Control : Perusahaan membuat pencegahan dalam pergantian TIP Plasma, dengan membuat standar pergantian item selama 1x dalam 1 bulan.	3
2	Proses Cutting Reuse	Kabel Torch Plasma putus	1. Layout Penempatan jalur kabel torch salah 2. Titik Tumpu Kabel Torch dengan Torch Body tidak kuat menahan beban	1. Preventive Control : Perusahaan membuat pencegahan dalam pergantian Kabel Torch, dengan membuat standar pergantian item selama 1x dalam 6 bulan.	4

IV.2.3 Calculations *Risk Priority Number* (RPN)

After knowing the *severity*, *occurrence*, and *detection* values for each failure mode, ascore is calculated *Risk Priority Number* (RPN). RPN is an indicator to measure the risk of failure mode and determine the priority level of improvement that must be done first (Kang, Sun, Sun, & Wu, 2016). After determining the values for *Severity*, *Occurance*, and *Detection*, then the RPN calculation is carried out, the formula to get the RPN value is shown by the equation below..

$$RPN = S \times O \times D$$

where S is the value of *Severity*, O is the value of *Occurance*, and D is the value of *Detection*

Table 4. 6 RPN Value

No	Aktivitas	*Failure Mode*	*Effect Failure Mode*	*Severity*	*Cause Failure Mode*	*Occurance*	Pendeteksian	*Detection*	*RPN*

1	Cutting Reuse Process	Plasma TIP damaged	1. Linne stop production makes pallet reuse not achieved 2 tons 2. Loss due for changing Plasma TIP Rp660.000	3	1. The fire incurred Plasma Torch and hit the TIP 2. Fire pressure is too big	1	1. Visual Control : Operators see if the pressure is maximal fire exits or not, if yes operator to controlling the plasma, such as the installation TIP, TIP type, and the form of TIP, are they appropriate or not.. 2. Preventive Control : The company makes prevention in changing TIP Plasma, by making a standard	3	9

							item change for 1x in 1 month.		
		Plasma Torch Cable broken	1. Linne stop production makes pallet reuse not achieved 2 tons 2. Loss due for changing Torch Plasma Cable Rp10.000.000	4	1. Cables are often interested in - pull 2. The Focusing Point between the Torch Cable and the Torch Body is not strong enough to withstand the load of movement / pull 3. Layout of the	2	1. Preventive Control : The company makes prevention in turnover Cable Torch, by making the standard replacement items for 1x in 6 months.	4	32

					torch cable path is wrong.				

Based on calculations *Risk Priority Number* (RPN), it can be seen that the value for Plasma TIP damaged was 9 and Torch Plasma Cable broken is 32, This is based on the results of the analysis of *Severity*, *Occurance*, and *Detection*. Based on the calculation of the RPN value, it can be concluded that in the process *Plasma Cutting* the most significant risk is the Torch Plasma Cable broken.

IV.2.3 *Risk Treatment*

Based on the analysis of the causes of the *Failure Mode, it* can be seen that the Plasma TIP damage, there are 2 *Cause Failure Modes*. That is, the fire pressure is too high and the Torch is too close to Reuse. In the Plasma Torch Cable broken, there are 2 *Cause Failure Modes*, namely the fulcrum between the Torch Cable and the Torch Body is not strong enough to withstand the load of movement / pull and the Torch Cable Path is wrong.

Based on the explanation above, the *Cause Failure Mode* in each *Failure Mode* will be given a *Treatment Risk*. It is intended that the results of the analysis to get *treatment*, the appropriate *treatment* such can assist companies in reducing the incidence of the problem. The following are the results of *treatment* based on the cause of the problem from the Plasma TIP damaged and the Plasma Torch Cable broken.

Table 4. 7 Risk Treatment

No	Failure Mode	Cause Failure Mode	Risk Treatmen
1	Plasma TIP damaged	The fire pressure is too high	Make work instructions as reminders and will visualized with posters
		Torch distance is too close to reuse	Make work instructions as reminders and will visualized with posters
No	Failure Mode	Cause Failure Mode	Risk Treatmen

2	Plasma Torch Cable broken	The Focusing Point between the Torch Cable and the Torch Body is not strong enough to withstand the load of movement / pull	Make an additional part, namely the Clamp part to streng then the bond between the Torch Cable and the Torch Body
		Layout of the torch cable path is wrong.	Re-layout Cable path

IV.3 Design Proposed of Risk Treatmen

Based on the results of discussions with related companies and the results of the RPN calculation, this final project makes a design proposal for *Treatment* Making additional parts as a reinforcement for the bond between the Torch Cable and the Torch Body mentioned in Table 5.1. This is because the *treatment* is easy to design and can be used for a long time, and based on the RPN value, the broken Torch Cable has the highest RPN score with a value of 32, this is because the broken Torch Cable has an *Effect Failure Mode* which makes pallet reuse not reach the production target. due to Line stop, and made a loss of item replacement of Rp. 10,000,000. Torch cable breaks also has a *Cause Failure Mode*, namely the fulcrum of movement is at the end of the cable that is attached to the torch, this makes the cable move frequently and makes it break quickly.
Based on the explanation above, in this final project, the proposed design is based on *Risk Treatment*, which is making additional parts, namely Clamps as a reinforcement for the bond between the Torch Cable and the Torch Body.

IV.3.1 Design Requirement

Before making a proposed design, the design must have requirements that must be met. In determining the aspects needed to make requirements using the management method. Management is a tool to achieve the desired goals, with good management it will facilitate the realization of the goals. The management elements consist of Material, Method, Man, Machine, Money, and Market which is known as 6M (Arhas & Suprianto, 2019) The following are the requirements for the proposed design by considering aspects based on element management.

Table 4.9 Proposed Designn Requirement

Aspect	Requirement	Puprpose of Requirement
Man	Clamp Dimension	Making dimensions of Clamps not to interfere with grip when holding Torch
Man	Clamp Material	Using non-slip material
Market	Clamp Material	Material easy to get
Machine	Clamp Shape	Can tie Torch Cables and Torch Body
Machine	Clamp Material	Can withstand the heat of the torch cable

Based on Table 4.9 Requirements In the design proposal above, it is explained that to make clamp parts, there are several requirements that must be met. This is so that the clamping part is considered worthy of being proposed. Based on this explanation, heres the specifications are set to satisfy the following requirements.

Clamp Part specifications :

1. Product : Clamp
2. Applications : Suitable for single cables that have low, medium, and high voltages
3. Range Capacity : ables with nominal outer diameter from 50mm to 75mm
4. Clamp Material : Black polyamide (PA66) , fibreglass-reinforced.
5. Temprerature : can be applied from -80˚C to +120˚C. Short-term heating up to +220˚C..
6. Bahan Rangka : Clamps & Bolts
7. Dimensi (in mm)

Unit	Dimension
DØ	40-65 mm
L	90 mm
B	50 mm
I	65 mm
H	66-90 mm
dØ	10,5 mm

Based on these specifications, the design of the proposed Clamp part, which is drawn using SketchUp, can be **seen as follows**..

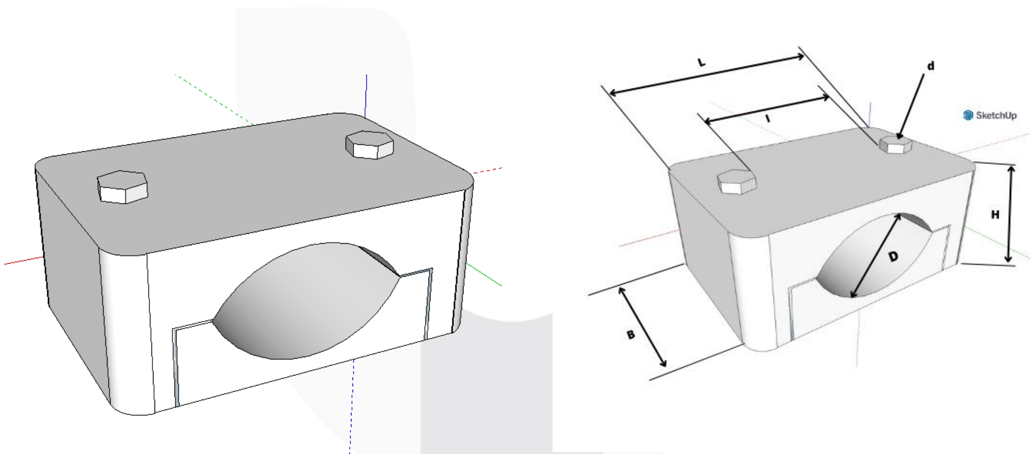


Figure 4. 6 Proposed Design

Based on Figure 4.6 above that is the design of the Clamp part that recommended to strengthen the fulcrum on the Torch Cable with the Torch Body. The figure describes the specifications for the dimensions of the units in the part. for the material used in the clamp part is Black polyamide (PA66). fiberglass-reinforced, based on the Material data sheet from the Journal (PA66), (Wilhelm Herm. Muller GmbH & Co. Kg, 2018) material Black polyamide (PA66) has the following advantages :

1. very high strength
2. resistant to many oils
3. greases and fuels
4. good wear properties
5. good weldable and bondable
6. high dimensional stability
7. good heat deflection temperature

8. very high stiffness

Here is a Figure when the Clamp part is attached to the Torch Cable and Torch Body.

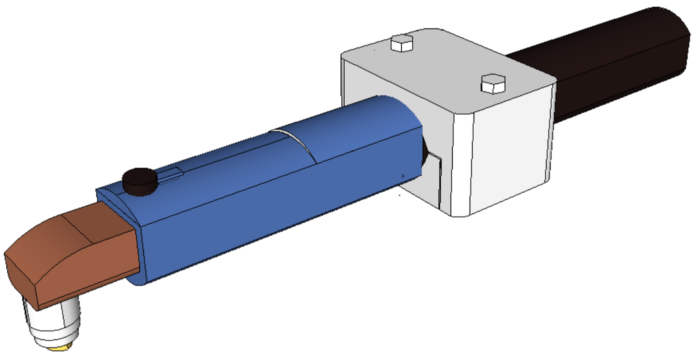
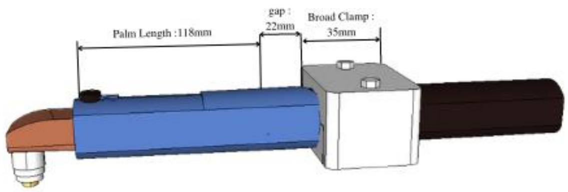


Figure 4.7 Torch Cable that already compare with Clamp

Based on Figure 4.7 above is the result of the proposed design that has been installed on the Torch, the proposed design with *Fail mode* Plasma Torch Cable broken, aims to strengthen the Torch Cable bond with the Torch. In the clamping section there are bolts that function to strengthen or weaken the bond according to conditions, this is The aim is that the clamps can be used repeatedly.

From the results of the proposed design, there are several requirements. This requirement is made so that the proposed design is considered feasible to be used as a *treatment* to minimize *Fail Mode* Torch Cable Breaks. The following is a table of verification of the analysis of the Clamp Parts specifications that satisfy the requirements.

Table 4. 8 Verification of Proposed design result

Aspect	Requirement	Spesification	Spesification Analysis
Man	Clamp Dimension	- DØ = 40-55mm - L = 70mm - B = 35mm - I = 60mm - H =40-55 - dØ = 10,5mm	Dimensional test aims to analyze the results of the length, broad, diameter, and height of the components. Based on the observation of measuring length, broad, and height of the Torch body using a caliper, it is known, the size of the Torch Body is: L: 120mm B: 25mm H: 37mm based on the size and specifications of the size of the Clamp, there is still a difference in the size of 22mm from the hands operator when holding the Torch Body, the following is an illustration of the dimensions:  Based on the illustration above, it can be ascertained that the hand grip with a size of 118mm and a width of 35mm

			Clamp will not be disturbed if the Clamp part is attached as a cable reinforcement because there is a 22mm gap.
Market	Clamp Material	Black polyamide (PA66) , 22iberglass-reinforced	The material is classified as easy to get, because several company sell it. Here's some company that sell Black polyamide (PA66) material : 1. Alibaba 2. Siko New Material 3. Xiamen Keyuan Plastic 4. Akro Plastic
Machine	Clamp Shape	The outer side is rectangular and the inner side is an oval shaped as a tie. Suitable for single cables.	Based on discussion with Company, the shape of proposed design is classified to already fulfill the specification because Clamp Shape is Suitable for single cables.
Machine	Clamp Material	can be applied from -80˚C to +120˚C. Short-term heating up to +220˚C..	Based on the Material data sheet from the Journal (PA66), (Wilhelm Herm. Muller GmbH & Co. Kg, 2018) material Black polyamide (PA66) has the following advantages : 1. very high strength 2. resistant to many oils 3. greases and fuels 4. good wear properties 5. good weldable and bondable 6. high dimensional stability 7. good heat deflection temperature 8. very high stiffness Based on explantion above, material Black polyamide (PA66) can be applied from -80˚C to +120˚C. Short-term heating up to +220˚C..

Based on Table 5.9 above, the specification analysis is explained, the analysis explains that the specifications made for the proposed design have been able to satisfy the requirements. The decision on the proposed design specification has met the requirements will be explained in the company's Validation Table for the proposed design requirements. Here is the Validation Table for the design requirements.

Table 4. 10 Comparative of Existing and Proposed condition

Aspect	Eksisting	Proposed
Improvement (Adding part)	in the existing conditions, during the Cuttin Process, Cable Torch with Torch Body connected often attracted, this will result in the Torch Cables susceptible to interruption. This pull is caused by human factors, sometimes the operator accidentally pulls the Torch Cable.	In the proposed condition, the Torch Cable that has been tied with clamps will be stronger to withstand the load of movement / pull during the cutting process. This can make the Torch Cable more tightly bound and reduce the risk of the Plasma Torch Cable broken. Operators can also easily attach and remove Clamps, if they want to replace the Torch Cable.

V. Conclusion

Based on the results of the study providing risk treatment proposals for the Plasma Cutting process at PT. Toyota Motor Manufacturing Indonesia approach using *Failure Mode and Effect Analysis* (FMEA) following conclusions were obtained :

1. Based on the Figure 4.2 which explain the event of problem that exist in each activity on January, February, March in 2020. At the activity of process *Cutting Reuse* has a 20 events in 3 months, where the problem is by The Plasma TIP damaged and the Plasma Torch Cable is broken as a *Failure Mode*. The causes of *Failure Mode* Plasma TIP damaged is the fire inccuraed Plasma Torch and hit the TIP and Fire Pressure is too big. The causes of *Failure Mode* Plasma Torch Cable broken is The Focusing Point between the Torch Cable and the Torch Body is not strong enough to withstand the load of movement / pull and Layout of the Torch Cable path is wrong

2. The effect of *Failure Mode* in process *Cutting Plasma* is Line stop production makes pallet reuse not achieved 2 ton, Loss due for changing Torch Plasma Cable Rp10.000.000 and Loss due for changing Plasma TIP Rp660.000

3. The largest RPN results obtained were based on the FMEA method, namely calculations with assessment *Severity, Occurance,* and *Detection* are 32 with *Failure Mode* Torch Cable Broken. Torch cable break has an impact on the production target results and the cost of changing items. So that the *Failure Mode* becomes a *Risk Priority* in the Final Project to be given a proposal, which aims to reduce the risk of the Torch Cable breaking, the cause of the Torch breaking occurs because the Torch Cable is often attracted because in the process of cutting reuse, and when holding the Torch, the operator moves the wrist more often, so that the connection point between the Torch Cable and the Torch Body is more often exposed to the load of movement / pull. In addition, for the detection of Torch Cables, it is difficult to detect, therefore, the way to detect broken Torch Cables is using *Preventive Control*, which is to set a standard for changing Torch Cable items 1x in 6 months. This is intended if the Torch Cable breaks at an unknown time, then the company already has a spare item / stock. The details of the RPN values for the *Failure Mode* are as follows:
a. *Severity* value : 4 / *Major* (Risiko mempengaruhi biaya, waktu dan / atau ruang lingkup, dan memerlukan tindakan untuk mecapai tujuan perusahaan. Ini mungkin mengharuskan proses manajemen perubahan aktivitas)
b. *Occurance* value : 2 / *Medium* (Risk affects cost, time and / or scope, and requires action to achieve company goals. This may require a change management process for activities)
c. *Detection* value : 4 / *Very Low* (The ability of the controller to detect the shape and cause is very low).

4. Based on the results of discussions with related companies and RPN calculations, the *Risk Treatment* of each *Failure Mode* which is an alternative proposal to reduce the risk of the Torch Cable broken is to make a design for additional parts, which is Clamp parts, this part aims to strengthen the Torch Cable connection with the Torch body, which when during the cutting process, the Torch Cable and Torch Body can withstand more loads. Movement / pull is stronger.

VI.2 Suggestions

Suggestion for PT Toyota Motor Manufacturing Indonesia :

a. This Final Project can be used as a proposal to strengthen the connection cables within Torch Cable and Torch Body and also to minimize the Fail Mode Plasma Torch Broken at the cutting reuse process.

Suggestions for the next writer :

b. this Final Project only to devise an alternative proposal on *risk treatment* Make additional parts, namely clamp parts as a strengthening bond between the Torch Cable and the Torch Body to minimize the *Fail Mode of the* Torch Cable Broken, the next Writer is expected to make a design proposal for other *Risk Treatments*

REFERENCES

Apriyan, Setiawan, & W, E. (2017). Analisis risiko kecelakaan kerja pada proyek bangunan gedung dengan metode FMEA.

Atikha, S. (2017). Upaya peningkatan produktivitas dengan memnimasi waste menggunaan From to Chart (FTC).

British Standard Institution. (2018). *Risk Management - Guidelines.* BSI Standards Limited 2018.

Dr A. Rakhman, M. (2013). *Matematika Aktuaria.* Tanggerang Selatan.

Dudin, M., & Lyasnikov, N. V. (2017). DIversified approach to quantification of risk that arise in project associated with extraction of hydrocarbon resources in the Arctic. *Journal of Environmental Management and Tourism*.

Geraldin, L. H., Pujawan, I. N., & Dewi, D. S. (2007). Manajemen Risiko dan Aksi Mitigasi untuk Menciptakan Rantai Pasok yang Robust.

H. K., & W. B. (2018). *Hazard Analysis and Risk-Based Preventive Controls, Improving Food Safety Human Food Manufacturing for Food Business.* Andre G.Wolf.

Hopkin, P. (2017). *Fundamentals of Risk Management (4th Edition) : Understanding, evaluating and implementing effective risk management.*

IBM Corporation. (t.thn.). IBM SPSS Advanced Statistics 22.

Kuncoro, M. (2020). *Ekonomika Industri Indonesia Menuju Negara Industri Baru* . Yogyakarta: ANDI.

Liu, H. C. (2019). *Improved FMEA Mehod for Proactive Healthcare Risk Analysis.*

Muttaqin, A. Z., & Kusuma, Y. A. (2018). Analisis Faiure Mode and Effect Analysis proyek X di kota Madiun.

OTC Daihen Corporation. (2006). Owner's Manual for Plasma Cutting Torch. *Manual No : 80A Torch*.

Pramadita, R. M. (2020). ANALISIS TISIKO MENGGUNAKAN METODE VALUE AT RISK PADA BITCOIN DAN IHSG PERIODE 2017-2019.

Putra, Y. R. (2019). PERANCAGAN SISTEM K3 DI PT TRIE MUKTY PRATAMA PUTRA DENGAN METODE FMEA (FAILURE MOE AND EFFECT ANALYSIS).

PUTRA, Y. R. (2019). PERANCANGAN ISTEM K3 DI PT TRIE MUKTY PRATAMA PUTRA DENGAN METODE FMEA (FAILURE MODE AND EFFECT ANALYSIS.

Ridlo, I. A. (2017). Panduan Pembuata Flow Chart.

Roberts, A., Wallace, W., & McClure, N. (2003). Strategic Risk Management. In Journal of Applied Corporate Finance.

Santosa, A. D. (2020). USULAN TREATMENT RISIKO PADA PRSES CUSTOMER VALIDATION BLANJA FOR MIGRANT WORKER DI PT METRAPLASA (BLANJA.COM) DENGAN MENGGUNAKAN PENDEKATAN RISK MANAGEMENT PROCESS.

Stamatis, D. H. (2003). *Failure Mode Effect Analysis : FMEA from Theory to Execution Second Edition.* William A. Tony.

Terje, A. (2016). Risk Assessment and Risk Management : Review of recent advances on their foundation. *In European Journal of Operational Reseacrh*.