Failure Analysis of Econo Dual Module Frame Installation in The Automatic Frame Assembly Process

FINAL PROJECT PROPOSAL

By:

STIFEN TAMA TAMBA
(3222101046)

Electronics Manufacturing Engineering Study Program
Department of Electrical Engineering
Batam State Polytechnic
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Statement of Authenticity of Final Project

I, the undersigned, declare that the contents of part or all of my Final Project entitled: “Failure Analysis of Econo Dual Module Frame Installation in The Automatic Frame Assembly Process” is the result of my own work, completed without using unauthorized materials, and is not the work of other parties that I recognize as my own work. All references quoted or referred to have been written in full in the bibliography. If it turns out that my statement is not true, I am willing to accept sanctions according to applicable regulations.

Cegléd, 13 January 2025

STIFEN TAMA TAMBA

NIM: 3222101046

APPROVAL

The Final Project Proposal is prepared to be used as a work plan for the implementation of the Final Project

By:
STIFEN TAMA TAMBA (3222101046)

Examination Date : 31 JANUARY 2025

Approved by :

Fitriyanti Nakul, S.Pd., M.Si.
NIK: 118197

Failure Analysis of Econo Dual Module Frame Installation In The Automatic Frame Assembly Process

Stifen Tama Tamba[1*], and Fitriyanti Nakul [1]

Batam Polytechnics,Batam,Indonesia
Electronics Manufacturing Engineering Study Program
Electrical Engineering Departement
Batam State Polytechnic
*Email: stifentama4@gmail.com

***Abstract* - In the modern manufacturing era, process automation plays an important role in increasing efficiency and product quality. One of the main components in automation is the Automatic Frame Assembly Process which has a crucial role in installing the frame on the Econo Dual module because it uses robot power to carry out this process, and this certainly follows existing parameter provisions and uses certain programs on the machine. Econo Dual Module is a product resulting from the production of this machine which is used as the object of this research. This research aims to identify the main cause of the high failure rate of frame installation on the Econo Dual module using the Root Cause Analysis (RCA) method and find the solutions to handling the problems. By using a fishbone diagram and 5 Whys analysis, several causes of failure to install the frame on the module were found, including there is no NTC components on the module (which is the main cause and problems that often occur), the presence of bubbles and discontinuity gluing on the module, damaged frame, and solder spatter on the module. After knowing the several causes of the failure, the author found various solutions to minimize the problem according to the provisions of how the problem occurred individually.**

Keywords: Assembly Process, Automatic, Failure Analysis, Module Frame, RCA.

I. INTRODUCTION

Product quality is an important factor in determining an industry's success. High-quality products not only fullfill consumer needs and expectations but also build brand reputation and trust. In an increasingly competitive industry, product quality can be the key differentiator between success and failure. Indriyono Gitosudarmo (2000) stated that "with effective quality control, the number of damaged products can be reduced and if the number of damaged products can be reduced, then quality costs can be reduced as efficiently as possible" [1].

Likewise, in the frame assembly production process, product quality & quality control is very necessary because many problems occur in each process, especially defects in the products resulting from this process. The frame assembly process can be done using 2 methods, done manually and automatically. But here the focus of the research did by the author is only on automatic machines because these machines often experience very crucial problems. There are 3 main processes in the frame assembly process, namely gluing process, frame installation process, and reveting process. The frame assembly process begins with a gluing process on the module or applying glue to the edges of the module with the aim of gluing the frame to the module. Then after gluing, the next process is to install the frame on the module which is assisted by robot power and supported by camera sensors, programs and certain parameters that have been set in the machine. Then, after that the final process that must be gone through is the reveting process, which aims to unite the metal on the frame with the baseplate holes on the module by installing rivets between the frame and the module, so that the frame and module are more unified. So it's not enough to just gluing the frame and module to make it stick better. If the module is not revetting, the frame is very easy to detach from the module. Of these three processes, both have their own failures/problems that often occur. But of these three processes, the most important process and plays an important role is installing the frame on the module, because the process of the machine itself is frame assembly. If the machine fails to install the frame on the module or even does not install the frame on the module, then there is a certain error in the machine or material caused by several causes/factors. Therefore, here the author will focus on explaining the analysis of frame installation failures on the Econo Dual module on automatic frame assembly machines using product quality & quality control. So that failures in each process can be minimized and can increase production both in quality and quantity. To achieve this goal, the author uses the RCA Technic method to solve the problem. The application of the RCA method has been widespread, using a reasoning technique that can produce a systematic, measurable and documented approach to identifying understanding, and resolving underlying causes (Vorley G; 2008) [2]. The following are the main points in the RCA method:

a) Identify the problem
b) Define the problem
c) Understand the problem
d) Identify the root cause
e) Corrective Action
f) Monitor the system

II. MATERIALS & EQUIPMENTS

The main materials and equipment used in the frame assembly process will be explained as follows.

A.) Econo Dual Module

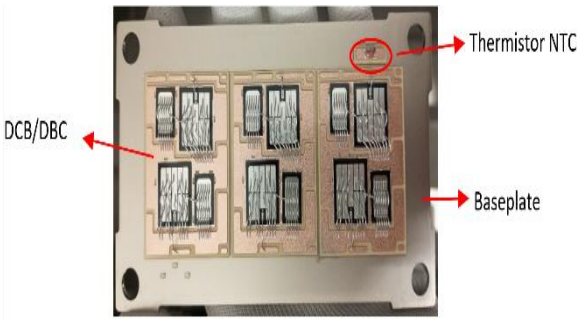


Figure 1. Econo Dual Module

The Econo Dual module consists of DCB, Baseplate, and Thermistor NTC. The bottom side of the power semiconductor devices is attached to a ceramic substrate [direct-bonded copper (DBC)], usually using solder, and the top side is connected using wirebonds [3]. DCB (Direct Copper Bond) is also abbreviated as DBC (Direct Bond Copper) in literature, and the two have the same meaning [4]. The direct bonded copper (DBC) substrate type dominates substrates for high power electronic systems that composed of a ceramic tile bonded and embedded between two copper plates. They are commonly used in power modules because of its good thermal conductive ability and low thermal expansion [5]. Meanwhile the baseplate is the basic part of the module which functions as a DCB container and an NTC thermistor container. And Thermistor NTC (Thermal Resistor Negative Temperature Coefficient) is a thermistor whose resistance decreases as the temperature increases [6]. This means that the hotter the temperature, the lower the resistance.

B.) Econo Dual Frame

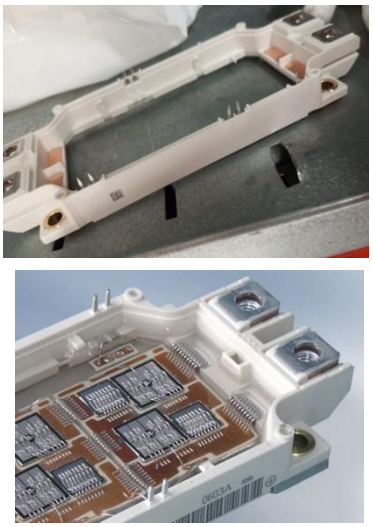


Figure 2. Frame Econo Dual Module

Econo module frames have several types which are differentiated according to the type of module, one of which is the Econo Dual module. Each module has its own characteristic frame shape, both in terms of the number of pins and the size of the frame which is adjusted to suit the size of the module, which differs from one module to another.

C.) Machine

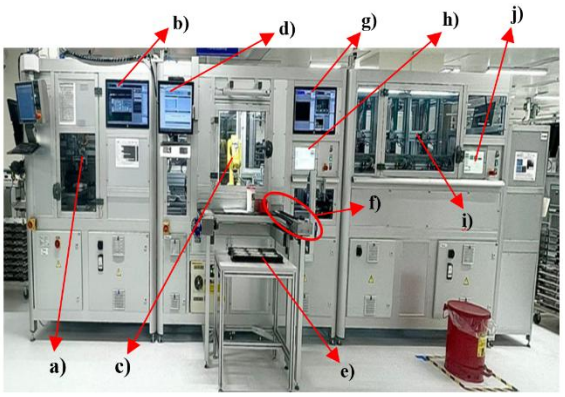


Figure 3. Automatic Frame Assembly Machine

Figure 3 show the mark of the automatic frame assembly machine part that consist of three main process and there are other parts, including:

a) Gluing Process Area.
b) Monitor to display the distance of gluing placement on the edge of the module and what tolerance is allowed to deviate from standard product specifications.
c) Frame Installation Process Area.
d) Monitor to display alarms regarding how many problems occur with the machine and how long the machine stops running temporarily when the machine has a problem.
e) A frame board container that functions as a place for the frame to be taken for manual installation of the frame.
f) Place for manual installation of the frame. This machine part is for installing frames on modules that did not have a frame installed in the previous machine. So after the module is installed on the frame manually, the module is inserted back into the machine through the small door marked with a red circle in the picture for the riveting process to be carried out on the module. This improvisation is usually carried out on modules that are glued but do not have a frame attached when running.
g) Monitor to display the position and condition of the frame in the frame board container.
h) Monitor to display existing problems in the frame installation process machine area.
i) Reveting Process Area.
j) Monitor to display existing problems in the reveting process machine area.

D.) Scanner

Scanner is tools for scanning the wt and this also usually used for report the scrap. This tool is usually found in the track in part machine and in the track out part machine.

E.) WT

Figure 4. WT

WT is a tool that is used as a container for modules to run on the machine. WT has different types of size, shape and number of places to accommodate modules depending on the type of module. The smallest number of places to accommodate modules on a WT is the WT type which has 4 module places and the most is the WT type which has 9 module places. Meanwhile, the WT type used to place the Econo Dual module is the WT type with 7 module places.

III. PROBLEM INVESTIGATION

In this problem investigation, details are shown of what causes frame installation failure and steps on how to report scrap for all damaged modules.

A.) Causes of Frame Installation Failure

a) Gluing Erorr

Gluing is one of the causes of frame installation failure because gluing is an adhesive material between the module and the frame. If there is a problem with the adhesive material then of course the level of adhesion of the frame and modules will be very weak and easily separated, then the frame installation process can be said to have failed. Therefore, when there is a gluing error on the module, the robot will automatically detect it and not install the frame on the module. The gluing error that usually occurs most often is that the gluing is not connected completely at the edge of the module, and other gluing errors that occur are bubbles in the gluing and messy or irregular gluing.

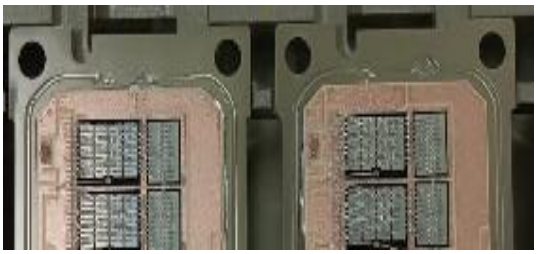


Figure 5. Discontinuity Gluing

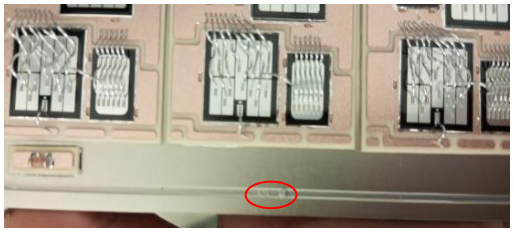


Figure 6. Bubble

b) Damaged Frame

Damage to the frame that occurs is usually characterized by bent or broken frame pins which causes the robot to automatically detect via the camera sensor that the frame is defective or a frame that does not meet the frame specifications and discards the frame due to a fairly hard collision between the frames. with the frame container inthe frame box before being put into the machine or the frame container colliding with the small trolley (as a place for the frame container to run on the machine) when inserting the frame container into the small trolley, resulting in defects in the frame in the frame container.

Figure 7. Bent Pin

c) NTC Missing

The Econo Dual module has module types that use NTC thermistor components and some that don't. Sometimes for the Econo Dual module which uses an NTC Thermistor, several times it happens that there is no NTC component on the module. This is caused by operator negligence who forgot to place this component in the module during the previous process. Therefore, for the Econo Dual module type which uses an NTC Thermistor and it turns out there is no NTC Thermistor on the module, when it is running on the machine, the machine will detect and know that there is no such component on the module which makes the machine order the robot not to install it frame on the module. This is because if there is no NTC Thermistor component on the Econo Dual module type which uses this component, then the module has been declared failed and does not fullfill standard specification product. If a robot installs a module like that, it will be a waste of frames, wasteful of production costs, and a waste of time.

Figure 8. No NTC

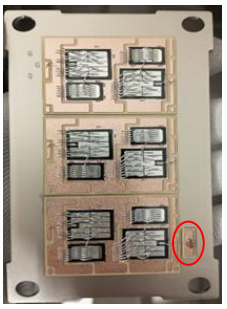


Figure 9. There is NTC

d) Solder Spatter

The presence of solder spatter in the baseplate hole causes the baseplate hole to limit the entry space for the corner of the frame hole to the baseplate hole. So when the machine detects solder spatter in the baseplate hole, the frame cannot be attached to the module. Solder splatter not only occur in the baseplate holes, sometimes they also occur on the DCB. But this does not mean that the frame is not attached to the module, it remains attached to the module. However, the module is already a reject, because the solder spatter on the module does not fullfill the standard product specifications that have been determined.

Figure 10. Solder Spatter

B.) Scrap Report

For every damage to the module in the frame assembly automatic process, everything will be manually booked by inputting the material damage type using Camstar Software. How to use Camstar Software is:

1) Scan the Barcode on the wt at the Camstar Tracking Label using the Scanner.
2) We must see whether we have done Track In and Track Out in the material information section.
3) If so, press OK and enter the number of damaged modules (scrap).
4) Select the type of damage/scrap that occurred on the module.
5) They were completed (The type of damage has been booked).
6) Then in the back of the baseplate we should put code the defect module, module identification number, name of the machine, the date when the defect occurred in the module, initials name or signature (option), and our shift.

IV. METHODS

This chapter explains what research methods are used, what the product specification standards are, the sequence of steps in the frame assembly process, and standar production data values.

A.) RCA Methode

The research method used in this project is using RCA Technique Tools in the form of Fishbone Diagram & Five Whys. Which method is used to achieve the initial objectives to be achieved in this project, including finding the root cause of the problem and finding solutions to minimize the problem. Root Cause Analysis (RCA) is a useful method for identifying the origin of a problem to find the main cause of the problem by using certain steps and tools [7]. But before identifying the root cause of the problem, first find out what is the biggest problem and what problems occur happened. For this, a Pareto chart is needed to solve it. The Pareto diagram shows which problems should be solved first by showing the proportion of the overall problem that each smaller problem consists of. The Pareto diagram principle refers to Pareto's law. Pareto's Law states that a group always has the smallest percentage (20%) that is valuable or has the greatest impact (80%). The Pareto chart identifies 20% of the causes of vital problems to realize 80% overall improvement [8]. The following is a sample of research data obtained by the author presented in the form of a Pareto diagram.

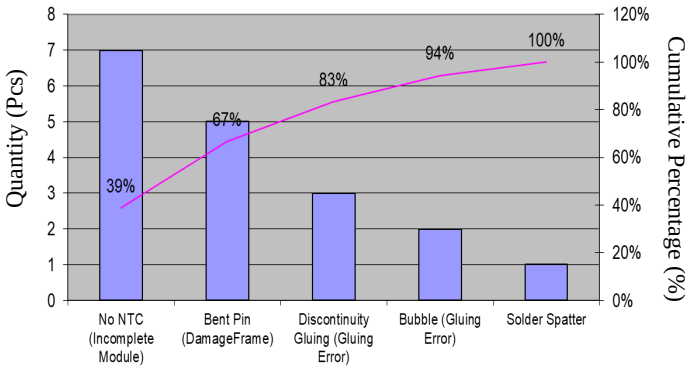


Figure 11. Pareto Chart of Causes of Frame Installation Failure

The above data is one of the data samples obtained by the author which was conducted in a short period. The data was obtained from a temporary experiment at the beginning of the research, which aimed to obtain a hypothesis regarding the main cause of the failure of the installation on the frame. So based on the pareto chart above, the author found that the highest total error obtained was that the NTC was not installed on the module. So for the time being, it can be concluded that the problem that must be resolved first is to focus on checking first whether there is an NTC in the module or not before running it on the machine, so that the process carried out can save time and increase the quantity of products produced.

B.) Product Specification Standards

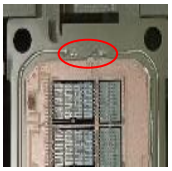
Product specifications are detailed descriptions of a product's characteristics and features, including materials, dimensions, functions, quality, and performance, established to ensure that the product fulfill specified needs and standards. [9]. Product specification standards are very necessary, in order to know whether the product fullfill or does not fullfill the desired spec standards. The following are the standard module specifications after going through the frame assembly process.

a) Gluing

The following are the standard specifications for gluing sizes on the modules found in the monitor machine.

Figure 12. Standard Measure of Distane the Gluing on the module

Acceptable Result:
- No bubble - No Discontinuity


(Rejectable)


(Rejectable)


(Acceptable)

b) Frame

Acceptable Result:

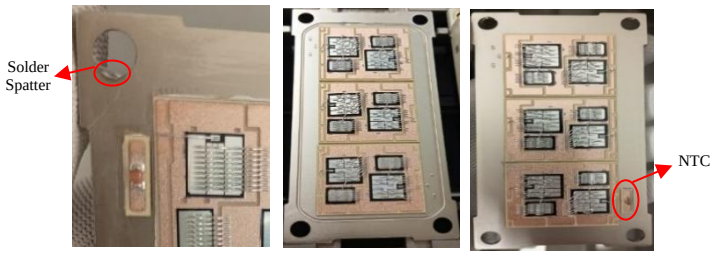
- No bent pin

(Rejectable) (Acceptable)

c) Module

Acceptable Result:

- There is NTC
- No solder spatter in the baseplate hole or no scratch in the baseplate.

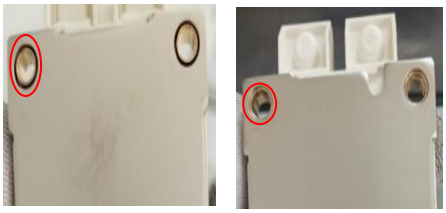


(Rejectable) (Rejectable) (Acceptable)

d) Reveting

Acceptable Result:

- There is no space between the metal on the frame and the hole in the baseplate that is visible from behind the baseplate. The metal on the frame must look tight and blend into the baseplate holes.



(Rejectable) (Acceptable)

C.) Frame Assembly Design Process

The following is an overview of the Frame Assembly Design Process.

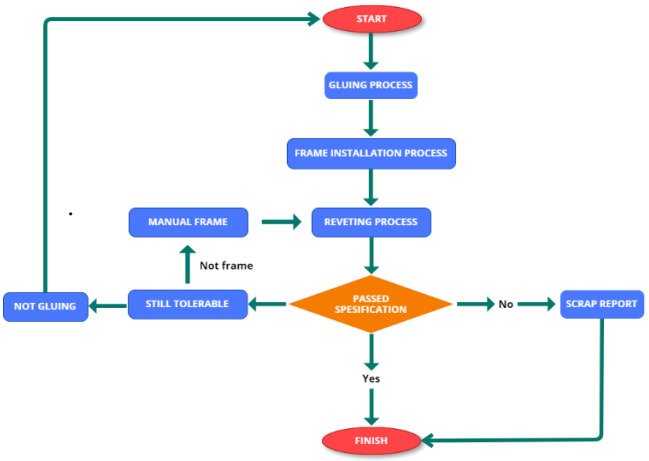


Figure 13. Machine Process

Based on the picture design above, the frame assembly process start with the gluing process, which is then continued with the frame installation process, and ends with the revetting process. After the module has gone through these 3 processes, check and ensure whether the module fullfill the specifications or not. If there is a defect in the module that cannot be tolerated any longer, then create an error/failure report on the module by scanning the barcode on the WT by entering the error code for the type of failure that occurred in the output results and will be stored on the machine monitor. But if the failure can still be tolerated, then improvise. Failures that can still be tolerated are the module not gluing and the module not being attached to the frame. For non-gluing modules, insert the module back into the engine start line, and this will usually work. And for modules that do not have a frame installed, attach the frame to the module manually, and insert the module into the revetting process area from the side of the machine.

D.) Standard Production Data Values

The standard production data values used by author to calculate & analyze data results using the defect rate percentage. By using the defect rate percentage, comparative analysis of data results before and after doing corrective actions can be more easily to read and understand. Here is the formula for calculating the defect rate percentage:

$$\text{Percentage} = \left(\frac{Total\ Unit\ Defect}{Total\ Unit\ Product}\right) \text{x } 100\%$$

But to find out the standards used by most companies regarding defect rates, the author uses the six sigma table as a reference. Six Sigma is a way to measure processes and goals approaching perfection that is presented with 3,4 DPMO (Defect Per Million Opportunities) and is one approach to changing organizational culture (Pande, 2002) [10]. According to Gaspersz (2002) also, Six Sigma is a vision of improving quality towards a target of 3,4 failures per million opportunities for every transaction of goods and services [11]. This means that out of 1 million units of product produced, only 3.4 units are defective and that the company produces products with a customer satisfaction level of 99,9997%. Therefore, to achieve the ideal condition, namely at the 6-sigma sigma level, the number of DPMO's allowed is only 3.4 defective units per 1,000,000 possibilities. The following is a table of DPMO according to Six Sigma levels.

Sigma Level	DPMO	Yield	Capability
1 - Sigma	690.000	30,90%	Non-competitive
2 - Sigma	308.000	69,20%	
3 - Sigma	66.800	93,30%	Industry Average
4 - Sigma	6.210	99,40%	
5 - Sigma	320	99,98%	
6 - Sigma	3,4	99,9997%	World Class

Figure 14. DPMO Table according to Six Sigma Level
Source: Gaspersz, 2002

$$\text{DPMO} = \left(\frac{D}{U\ x\ O}\right) \text{x } 1.000.000$$

Note: D = Total Defect
U = Total Unit Production
O = Total Opportunities that will result in a defect.

In the Frame Assembly process there are 3 main processes, and each process has the potential to cause the product to become defect. This means there are 3 opportunities to cause the product become defect. So it can be said O = 3. So the formula is updated to:

$$\text{DPMO} = \left(\frac{D}{U\ x\ 3}\right) \text{x } 1.000.000$$

V. RESULT & DISCUSSION

In the first 2 months of the research, the results of the research data obtained by the author were as follows:

Month	Bubble	Discontinuity Gluing	Bent Pin	No NTC in the module	Solder Spatter	Total Production
January	25	24	13	53	45	699
February	29	25	17	71	37	828

Figure 15. Table of research data results before corrective action

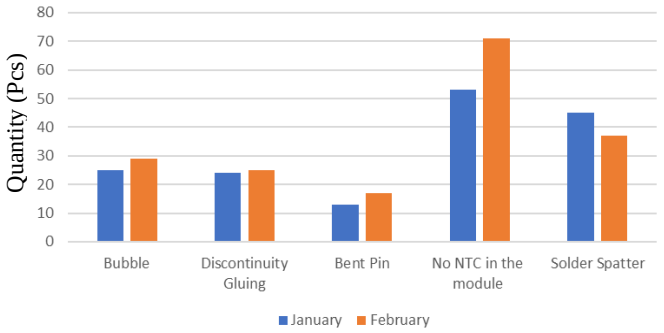


Figure 16. Diagram of research data results before corrective action

From the table and diagram above, it shows that the main cause of the problem is no NTC in the module. This shows that the data results obtained are the same as the data results obtained by researchers in a short period as previously explained in Figure 11, that both show that "there is no NTC in the module" is truly the main cause of the problem that occurred. Before taking corrective action to resolve this problem, it is necessary to first conduct an in-depth analysis of the temporary data results to determine how bad the level of the problem is. The following is the analysis.

(Note: The data used in this analysis is the total data results from January to February).

Known:
Total Production = 1527 unit
Total Defect = 339 unit
Total Good Product = Total Production – Total Defect
= 1527 – 339 = 188 unit
Bubble = 54 unit
Discontinuity Gluing = 49 unit
Bent Pin = 30 unit
No NTC in the module = 124 unit
Solder Spatter = 82 unit

After the data was organized, the percentage of the data results was obtained as follows:

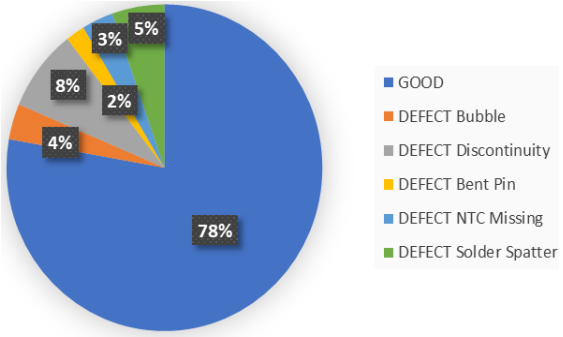


Figure 17. Pie Chart Result Data Before Corrective Action

The percentage results of the pie chart above were obtained using the formula:

Percentage = $\left(\frac{Total\ Unit\ Defect}{Total\ Unit\ Product}\right)$ x 100%

Percentage = $\frac{339}{1527}$ x 100%

Percentage = 22,2%

The 22,2% results obtained were the total defects that occurred and 78% were products that fullfill the specified product specification standards. It can be said that this production process has been running quite well because the total good products are much more than the total defects. But has this production process fullfill the company's standards? And to determine whether this production process can be said to fullfill company standards or not, the author uses the DPMO formula and Six Sigma table as references which have been explained in the Figure 13. And the following is the explanation.

DPMO = $\left(\frac{D}{U\ x\ 3}\right)$ x 1.000.000

DPMO = $\frac{339}{1527\ x\ 3}$ x 1.000.000 = 74.001 units DPMO

If we look at the Six Sigma reference in Table 1, the data results are still in the range of 2-Sigma level and not reached at 3-Sigma level, which is exceed more than 66.800 units DPMO. Where this level does not include the industry average standard. This means that the production process before taking some corrective actions, not fullfill the company's production standard targets.

After knowing the cause of the main problem and the production process does not fullfill company production standard, the next step is to find the root cause of the main problem and taking some corrective action. The cause of the frame is not attached to the module is very critical, so the author decided to identify it by creating a Potential Problem using Fishbone Diagram. The Fishbone diagram (also called the Ishikawa diagram) is a tool for identifying the root causes of quality problems [12]. The function of the Fishbone diagram, it may be referred to as a cause-and-effect diagram [13]. The following is a display of the fishbone diagram obtained by the author after investigating through RCA analysis.

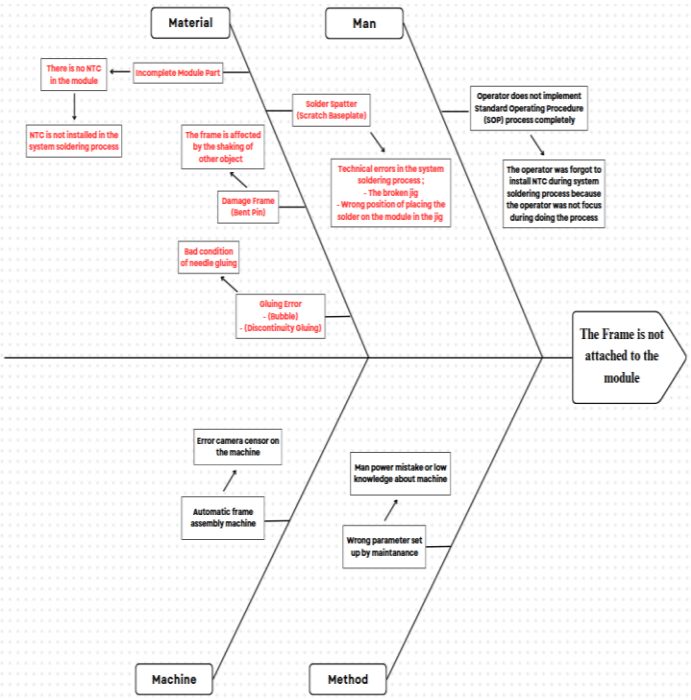


Figure 18. Fishbone Diagram of frame installation failure on module

The red mark in the image above is the cause of the problem of frame installation failure which quite often happened. Most of the causes of failure of frame installation on the module come from material factors. This indicates that material factors are very crucial factors during the frame assembly process. Based on the fishbone diagram above, the root cause of some problem is found. But to find out more deeply about the root cause of this problem, using five whys analysis is one of the best solutions. The 5 Whys tool provided an easy to understand, easy to implement, and therefore less time-consuming tool for determining root cause, which no doubt contributed to the resulting popularity across business sectors [14]. Since the root cause of the problem is no NTC in the module, the focus of the explanation of the five whys is directed at the root cause of "why there is no NTC in the module". The following is a display of the five whys diagram based on the explanation of fishbone diagram.

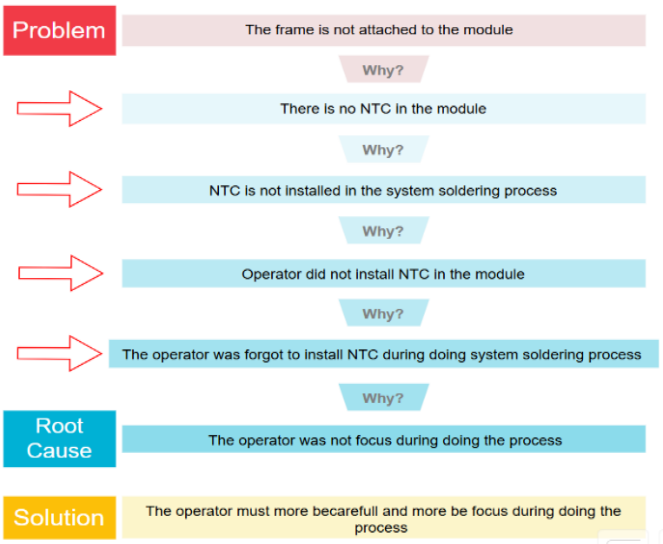


Figure 19. Five Why Analysis "no NTC in the module"

After knowing the root cause of the problem, the next thing to do is to take some corrective actions to solve the existing problem.

1) Handling of NTC Missing (Incomplete Module)

The main problem and the author must solve it first is no NTC in the module. This happens because the operator in the previous process, namely the system soldering process, forgot to install the NTC when soldering components (in the form of DCB and NTC) to the baseplate. If the module without NTC components is run into the machine, the machine will only roll and will not install the frame, because the machine can detect that the module does not fullfill the product specifications standard because it does not have complete components, namely there is no NTC on the module. So, to minimize this problem, the author coordinated with the operator in charge of the system soldering process operations to be more careful and first check whether the module had complete components before giving it to the operator in charge of the frame assembly process operations. And the author also coordinates with other frame assembly operators to first check whether the module has complete components or not, before running it into the frame assembly machine.

2) Handling of discontinuity gluing & bubble

After the author investigated for several months, it turned out that the cause of the machine often experiencing gluing discontinuities was the condition of the needle used in the gluing machine. Sometimes the gluing that comes out of the needle doesn't come out smoothly in the needle hole, so there are parts of the edge of the module that are not gluing or the gluing on the module is not connected completely or what is called a discontinuity gluing. Likewise, the cause of bubbles is also caused by the condition of the needle hole which produces gluing with small bubbles at several points. So the solution that can be done is to routinely check the needle first every time you want to use the machine to find out whether the needle is experiencing obstacles in removing the gluing in the hole or whether there are bubbles in the gluing, and immediately report to the shiftleader to ask for technician/maintenance help to clean the needle. If there is only dirt in the needle hole, it is still possible that the needle can be used. And if necessary, the needle is immediately replaced with a new needle if the previous needle is no longer suitable for use.

3) Handling of bent pin in frame (Damaged Frame)

In solving this problem, it took almost 2 months, before the author was able to find a solution to minimize this problem, because this was the last problem to be prioritized, because this was the problem that occurred the least compared to other problems. Bent frame pins occur due to a collision or friction of another object against the frame pin which causes the frame pin to become bent. This is because the pin frame is very sensitive and bends easily. Therefore, the author coordinates with the person in charge of quality materials to check whether all the frames used are in good condition, and of course the author checks again before putting them into the machine to ensure that the condition of the frames used is in good condition and that there are no bent pins. , and also be more careful when you want to insert the frame into the machine so that there are no hits/collisions on the frame pins.

4) Handling of Solder Spatter (Scratch Baseplate)

Dealing with solder spatter problems is more or less the same as dealing with NTC Missing. This is due to checking the module first whether the module is in good condition or not, and coordinating with the operator operating in the soldering system process, because the causes of solder spatter and NTC Missing defects come from the soldering system process. The only difference is that if the NTC defect is missing, what is checked is whether the NTC is on the module or not, whereas if the defect is solder spatter, what is checked is whether there is solder spatter on the DCB or in the hole in the baseplate. When a module that has solder spatter on the DCB is run on the machine, the frame will remain attached to the module, but the module is still a reject, because modules that comply with standard product specifications must not have solder spatter. Meanwhile, if a module that has solder spatter in the baseplate hole is run on the machine, of course the frame cannot be attached to the module because the baseplate hole limits the entry space for the corners of the frame to the baseplate hole so the frame will not be able to be attached to the module because of the solder spatter in the baseplate hole.

After taking corrective action for 2 months, there was a decrease in defects and an increase in production quantity occur. The data results obtained are also different from those before corrective action. The following are the data results obtained:

Month	Bubble	Discontinuity Gluing	Bent Pin	No NTC in the module	Solder Spatter	Total Production
March	6	6	4	16	11	1488
April	4	3	2	5	2	1824

Figure 20. Table of research data results after corrective action

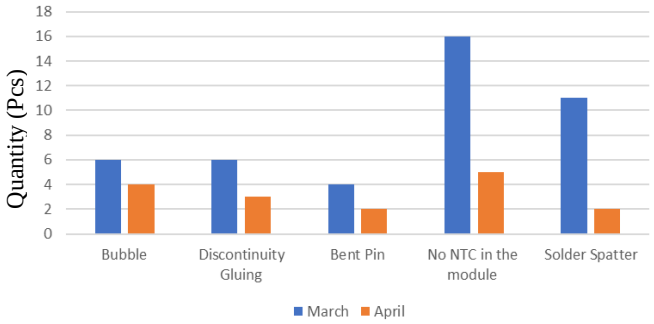


Figure 21. Diagram of research data results after corrective action

Based on the table and diagram above, the results of that data can be described as follows:

(Note: The data used in this analysis is the total data results from March to April).

Known:
Total Production = 3312 unit
Total Defect = 59 unit
Total Good Product = Total Production – Total Defect
= 3312 – 59 = 3253 unit
Bubble = 10 unit
Discontinuity Gluing = 9 unit
Bent Pin = 6 unit
No NTC in the module = 21 unit
Solder Spatter = 13 unit

After the data was organized, the percentage of the data results was obtained as follows:

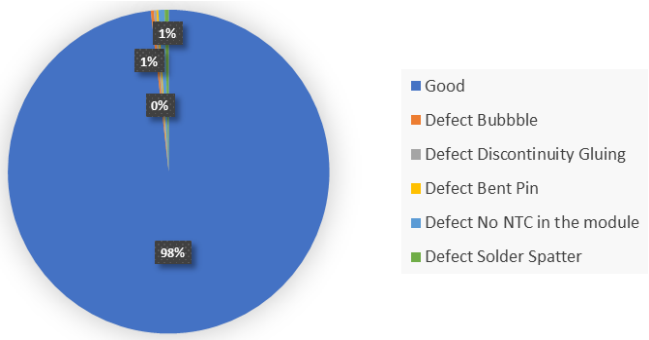


Figure 22. Pie Chart Result Data After Corrective Action

The percentage results of the pie chart above were obtained using the formula:

Percentage = $\left(\frac{Total\ Unit\ Defect}{Total\ Unit\ Product}\right)$ x 100%

Percentage = $\frac{59}{3312}$ x 100%

Percentage = 1,78%

The 1,78% result obtained is the total defects that occurred and 98% is the product that fullfill the product specification standards. This means that the production of the frame assembly process is already considered very good, because the results are almost perfect and even almost close to 100%.

But has this production process fullfill the company's standards? And to determine whether this production process already to fullfill company standards or not, just like the previous analysis, the author still uses the DPMO formula and the Six Sigma reference in the Figure 13. And the following is the explanation.

DPMO = $\left(\frac{D}{U\ x\ 3}\right)$ x 1.000.000

DPMO = $\frac{59}{3312\ x\ 3}$ x 1.000.000 = 5.938 units DPMO

The data results are still within the 4-Sigma level range, where the data results do not exceed the maximum total defect limit of the 4-Sigma level, which is no more than 6210 DPMO units. Where this level has fullfill industrial or company production standards. This means that the production process after taking some corrective actions, has fullfill the company's production standard targets.

VI. CONCLUSION & SUGGESTION

After the research was completed, conclusions & suggestions were obtained from this project research, including:

1) After doing investigation the problem, the cause problem of the failure of the frame installation on the module were there is no NTC components on the module (which is the main cause and problems that often occur), the presence of bubbles and discontinuity gluing on the module, damaged frame, and solder spatter on the module. And the root cause “why there is no NTC on the module” because operator forgot to install NTC to the module during doing system soldering process due to lack of focus when running the process.

2) Using RCA Technique in the form of fishbone and five whys as a research method to find the root cause of the problem. And use Six Sigma as a reference for data analysis. Also taking some corrective action to solve the problem.

3) The corrective actions taken were very effective. Because after taking corrective actions, the quantity and quality of production increased drastically compared to before the corrective actions. Not only that, the production process has also fullfill the industrial or company production standards.

4) The corrective action taken by the author is the first to check whether all the tools and materials used are in good condition or not. And make sure that everything related to the equipment and process must be in accordance with the SOP that has been provided. Then if there is a problem that cannot be solved, coordinate and communicate with skilled people around the environment.

It can be concluded that the investigation of the problem did by the author using the research method used and the analysis of the data results obtained, the author succeeded in solving the problem and achieving the desired research objectives through the corrective actions taken very effectively.

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FORMULIR LOOGBOOK BIMBINGAN DAN PENGAJUAN SIDANG TUGAS AKHIR*

Nama : Stifen Tama Tamba
NIM : 3222101046
Pembimbing I : Fitriyanti Nakul, S.Pd., M.Si.
Judul : ***Failure Analysis of Econo Dual Module Frame Installation on The Automatic Frame Assembly Process***

No	Hari/Tgl	Rincian Kegiatan	TTD Pembimbing I
`1	Kamis/17 Oktober 2024	- Revisi Bagian Abstrak & pemilihan kata keywords yang masih kurang tepat. - Revisi bagian background dikarenakan belum ada mengenai ulasan kekurangan dan kelebihan dari penelitian ini. - Tidak adanya penambahan sitasi pada bagian paragraph yang menjelaskan mengenai penjelasan2 detail berkaitan dengan penelitian ini, sehingga tidak diketahui darimana asal referensi penjelasan tersebut. - Revisi bagian Problem, Objective, Advantage, dan Limitation karena kurang berkesinambungan antara yang satu dengan yang lainnya. - Revisi kerapian paragraf rata kanan dan kiri nya masih belum semua rapi. - Revisi bagian fishbone dikarenakan susunan struktur fishbone nya masih kurang rapi.	
2	Selasa /29 Oktober 2024	- Revisi bagian abstrak karena metode penelitian yang dijelaskan terlalu panjang dan tidak fokus. Jadi hanya menjelaskan dan menyatakan bahwa metode yang digunakan yaitu RCA Methode (Root Cause Analysis). - Revisi bagian abstrak tidak memerlukan kata “expected result”, tetapi menyatakan hasil yang	

		benar2 diperoleh dari penelitian yang dilakukan. - Revisi bagian abstrak dikarenakan banyak kata penguhubung yang tidak perlu digunakan dan kalimat nya terlalu panjang.	
3	Senin/13 Januari 2025	- Perbaikan kalimat pada abstrak dengan ditambahkan nya handling isu dan main cause pada tujuan penelitian. Dan pernyataan result pada abstrak masih kurang tepat. - Penambahan Subheading “Material & Equipment” sebelum penjelasan Econo Dual Module. - Gambar pada mesin terlalu banyak dan terlalu penjelasannya, sehingga perbaikan yang dilakukan yaitu menghapus gambar mesin yang lain dan hanya menggunakan gambar Figure 7 dan fokus penjelasan hanya menjelasakan gambar Figure 7. - Menambahkan sedikit keterangan mengenai gambar Figure 7 menggunakan kalimat penghubung agar gambar dan penjelasan berikutnya terhubung dan nyambung. - Gambar pada Figure 8 dan Figure 9 dihapus karena tidak perlu. - Menambahkan sedikit penjelasan sebelum gambar Figure 7 menggunakan kalimat penghubung agar penjelasan sebelumnya benar benar merefensi dan mengarah ke gambar Figure 7. - Gambar Figure 14, Figure 15, dan Figure 16 dihapus dikarenakan tidak perlu. - Gambar pada methode tidak perlu menggunakan flowchart dan hanya perlu menjelaskan bahwa penelitian yang dilakukan	

		menggunakan metode RCA Tool. - Frame Assembly Design Process sebaiknya di satukan dengan penjelasan Econo Dual Module Frame Assembly Process Procedure . - Sturktur fishbone masih kurang rapi dan perlu diperbaiki. - Gambar Fishbone pada Methode tidak perlu dibuat dan lebih baik dibuat pada Subheading Result & Disscussion. Pareto Chart dan Five Why juga perlu dipindahkan ke Subheading Result & Discussion. - Five Whys masih perlu diperbaiki dikarenakan masih belum memenuhi syarat menjadi unsur five whys. - Tabel Data tidak perlu dibuat dan diganti dengan grafik Histogram. - Kata “After & Before Improvement” diganti dengan kata “Corect Action” - Kata “We can see” pada paragraph Comparison Total Good Product atau pada pargraph yang lainnya diganti dengan kata penghubung yang lebih tepat. - Handling of Problem seharusnya terletak sebelum Sub Heading Result & Discussion. - Conclusion terlalu panjang dan perlu diperbaiki lagi menjadi 3 poin penting yaitu: Penyebab utama yang diperoleh, beberapa tindakan perbaikan yang telah dilakukan, dan perbandingan hasil data produksi sebelum & sesudah correct action. - Referensi yang digunakan masih kurang lengkap dan perlu penambahan beberapa referensi lagi.	

4)	Rabu/22 Januari 2025	- Masih ada beberapa kalimat pada bagian abstrak yang ambigu. Font tulisan pada keyword beda sendiri dengan font tulisan kalimat lainnya. Kata author tidak boleh terdapat pada abstrak. - Tidak menambahkan alasan atau referensi yang kuat mengapa menggunakan RCA methode. - Tidak menambahkan beberapa keterangan terlebih dahulu sebelum masuk ke sub-heading. - Gambar Scanner dihapus dikarenakan scanner adalah alat yang sering dijumpai di banyak tempat. Jadi tidak perlu mencantumkan gambar scanner. - Fishbone, Five Why, dan Handling Problem dipindahkan ke Bab Conclusion dan Suggestion. Dan diurut dengan sistematis bersama analisa datanya - Perbaikan beberapa keterangan pada diagram Fishbone. - Perbaikan analisa Five Whys dikarenakan anlisa Five Whys belum menjelaskan dari segi semua faktor dan hanya menjelasakan 1 fakotor. - Menambahkan standar data produksi dan rumus yang digunakan untuk analisa data pada bagian method.	
5	Jumat/24 January 2025	- Perbaikan pada background dikarenakan masih terlalu kepanjangan. - Kurangnya mencantumkan standar proses produksi perusahaan atau industri, jadi tidak dapat mengetahui dengan jelas apakah proses produksi yang dilakukan sudah sesuai standar proses produksi industri atau belum.	

		- Tidak perlu mencantumkan Percentage Change Formula, cukup mencantumkan Percentage Defect Product. - Penambahan SOP pada Fishbone - Perbaikan Bab Conclusion & Suggestion dan tambahkan kalimat pada Bab tersebut yang menyatakan bahwa penulis sukses mengatasi masalah yang ada selama melakukan penelitian dengan menggunakan metode penelitian yang dilakukan dan acuan analisan yang didapatkan yang disertai beberapa tindakan perbaikan untuk meminimalisir masalah. - Perbaikan penulisan reference atau daftar pustaka. - Perbaikan PPT dikarenakan PPT mengikuti acuan jurnal sebelumnya.	

Berdasarkan hasil bimbingan yang telah dilaksanakan selama 3 bulan dan telah disetujui oleh dosen pembimbing, maka dengan ini saya mengajukan diri sebagai peserta Seminar Proposal /Sidang Tugas Akhir*.

Cegled, 31 Januari 2025

Peserta

STIFEN TAMA TAMBA

NIM: 3222101046

BORANG REVISI PROPOSAL/ PROYEK AKHIR

Nama : Stifen Tama Tamba
NIM : 3222101046
Judul : Failure Analysis of Econo Dual Module Frame Installation In The Automatic Frame Assembly Process
Pembimbing 1 : Fitriyanti Nakul, S.Pd., M.Si.
Pembimbing 2 : -
Penguji 1 : Fitriyanti Nakul, S.Pd., M.Si.
Penguji 2 : -

No.	Pemberi saran/komentar/catatan revisi	Catatan perbaikan saat seminar	Perbaikan yang dilakukan	Paraf pembimbing / Tanggal acc	Paraf penguji / Tanggal acc
1.	Fitriyanti Nakul, S.Pd., M.Si.	Perbaikan pada background dikarenakan masih terlalu kepanjangan.	Merangkum background lebih ringkas agar terlihat mudah dibaca dan dipahami.		
2	Fitriyanti Nakul, S.Pd., M.Si.	Kurangnya mencantumkan standar proses produksi perusahaan atau industri, jadi tidak dapat mengetahui dengan jelas apakah proses produksi yang dilakukan sudah sesuai standar proses produksi industri atau belum.	Mencantumkan standar proses produksi industry atau Perusahaan menggunakan acuan tabel Six Sigma.		
3	Fitriyanti Nakul, S.Pd., M.Si.	Tidak perlu mencantumkan Percentage Change Formula, cukup mencantumkan Percentage Defect Rate.	Menggantikan dengan penjelasan Percentage Defect Rate.		
4	Fitriyanti Nakul, S.Pd., M.Si.	Kurang nya SOP (Standard Operating Procedure) pada diagramFishbone.	Memberikan penjelasan SOP pada diagram Fishbone lebih detail.		
5	Fitriyanti Nakul, S.Pd., M.Si.	Perbaikan Bab Conclusion & Suggestion dan tambahkan kalimat pada Bab tersebut yang menyatakan bahwa penulis sukses mengatasi masalah yang ada selama melakukan penelitian dengan menggunakan metode penelitian yang dilakukan berdasarkan acuan analisan yang didapatkan yang disertai	Meringkas Bab Conclusion & Suggestion menjadi lebih mudah dibaca dan dipahami serta mencatumkan kalimat yang menyatakan bahwa penulis sukses dalam meminimalisir masalah sesuai dengan tujuan awal yang diinginkan dalam proyek ini dengan menggunakan metode penelitian yang		

		beberapa tindakan perbaikan untuk meminimalisir masalah.	dilakukan berdasarkan acuan analisa yang didapatkan dan tindakan perbaikan yang dilakukan sangat efektif dalam meminimalisir masalah.		
6	Fitriyanti Nakul, S.Pd., M.Si.	Perbaikan penulisan reference atau daftar pustaka.	Tidak menggunakan referensi lain selain jurnal dan buku penelitian ilmiah. Dan juga merapikan gaya penulisan reference dengan menggunakan gaya penulisan yang sama yaitu menggunakan "APA style (American Psychological Association style)".		
7	Fitriyanti Nakul, S.Pd., M.Si.	Perbaikan PPT dikarenakan PPT mengikuti acuan jurnal sebelumnya.	Sudah memperbaiki PPT yang mengikuti acuan jurnal yang sudah direvisi.		

Berdasarkan hasil revisi dari bimbingan yang telah dilaksanakan selama 3 bulan dan telah disetujui oleh dosen pembimbing dan dosen penguji, maka dengan ini saya telah menyelesaikan Seminar Proposal /Sidang Tugas Akhir* dan bersedia untuk dipublikasikan.

Cegled, 31 Januari 2025

Peserta

STIFEN TAMA TAMBA

NIM: 3222101046