ANALYSIS OF NEEDLE PIN ADAPTER DYNAMICS IN THE IGBT MODULE ENDTEST PROCESS

Final Assignment

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I, the undersigned, declare that the contents of all or part of my final assignment entitled**: "Analysis of Needle Pin Adapter Dynamics in the IGBT Module Endtest Process"** is **the result of my own work, completed without using unauthorized materials, and is not a work of art. other parties that I acknowledge as my own work.** All references cited or referenced have been written in full in the bibliography. If it turns out that my statement is not true, I am willing to accept sanctions in accordance with applicable regulations.

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The Final Assignment is prepared to fulfill one of the requirements for obtaining a degree of Bachelor of Applied Engineering (S.Tr.T)/Associate Expert in Engineering (AMd.T.)
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Analysis Of Pin Needle Adapter Dynamics In The IGBT Module Endtest Process

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***Abstrak*— Needle Pin merupakan jarum yang terletak pada adaptor dinamis dan berfungsi untuk memberikan tegangan pada pin modul IGBT pada saat proses Endtest. Banyak proses pengujian yang tidak selesai tepat waktu karena beberapa proses tidak berjalan sesuai jadwal, terutama pada proses Endtest karena adanya penundaan yang mengakibatkan downtime yang lama, salah satunya karena permasalahan pada dinamika pengujian. Kerusakan pada adaptor dinamis terutama disebabkan oleh pin jarum yang terbakar dan macet. Penulis menggunakan metode tulang ikan/diagram Ishikawa untuk mengetahui faktor dan akar penyebab peniti jarum terbakar. Penyebab utama dalam penelitian ini adalah pin modul yang terkontaminasi. Penelitian ini menemukan nilai P1 Rata-rata downtime mesin sebelum perbaikan adalah 68,83 menit, min 30 menit dan maksimum 115 menit dan persentasenya sebesar 71,69%. Dan nilai P2 Rata-rata downtime mesin setelah perbaikan adalah 55,08 menit dan min 20 menit dan maksimal 85 menit dan persentasenya 57,37%. Berdasarkan matriks, rentang perbandingan P1 dan P2 adalah 14,32%.**

Kata Kunci : Downtime, Needle pin dan Endtest.

***Abstract*— Needle Pin is a needle located on the dynamic adapter and functions to provide voltage to the IGBT module pins during the Endtest process. Many testing processes are not completed on time because some processes do not run according to schedule, especially in the Endtest process due to delays which result in long downtime, one of which is due to problems with testing dynamics. Damage to the dynamic adapter is mainly burnt and jammed needle pins. The author uses the fishbone method/Ishikawa diagram to find out the factors and root causes that cause burnt needle pins. The main root cause in this research is contaminated pins module. This research found that the value of P1 The average machine downtime before repair was 68.83 minutes, min 30 minutes and maximum 115 minutes and the percentage was 71.69%. And the value of P2 The average machine downtime after repairs was 55.08 minutes and the min was 20 minutes and the maximum was 85 minutes and the percentage was 57.37%. Based on the matrix, the comparison range for P1 and P2 is 14.32%.**

Keywords: Downtime, Needle pin and Endtest.

I. INTRODUCTION

IGBT or Insulated Gate Bipolar Transistor is a combination of the high input impedance of a metal oxide semiconductor field effect transistor (MOSFET) and the high current density of a bipolar device that shows great advantages in the field of high mid-frequency high power fields. The structural design of medium power IGBTs allows operation at higher frequencies. 600 V, 50 A devices capable of hard-switching [1]. It is easily useable in high voltage and high current applications. IGBTs are used in wind turbines, automotive, railway, household appliances etc[2]. The process of making an Insulated Gate Bipolar Transistor (IGBT) has several complex processes, one of which is the Endtest process. Where the author conducted research, Endtest is one part of testing the process of making the resulting IGBT module.

This test starting from electrical testing and physical testing of the IGBT module. The process goes through several testing stages, namely, lagetest (orientation of module test), marking, dynamic testing, ISO, static, pinlehre (module pin position test) and visual checking of the module. This test is the final process before packing which is useful for separating damaged or defective IGBTs based on a catalogue of failures before being sent to the recipient. To ensure the module is able to withstand large voltages, electrical testing will be carried out. In dynamic testing, the module is given a large voltage and where the adapter will measure and provide a voltage of 600 V and given a temperature of 120 degrees Celsius and in a dynamic state. The adapter will provide voltage through the Needle Pin.

Needle pin or IC probes are widely use in the semiconductor or the packaged and test industries [3]. Needle pins are a type of electrical connector mechanism used in the electronics testing industry, to check resistance, short circuit, capacitance, and check whether an assembly has been made correctly [4]. Pins are made with the spring inside, or outside the pin body. In the real application, spring is compressed, providing us the smaller length [5]. This needle pin will be given a voltage as a connection to the module pin when the test is carried out and the needle pin used must also have strong resistance because it will be given a large voltage of approximately 600 volts. This research refers more to the analysis of dynamic needle pin adapters in the Endtest process.

Needle Pin needs to be confirmed in condition before testing the module. Burned and jammed needle pins occur because the module pins are dirty. This research will analyse common problems, one of which is burning pins and what factors cause burning pins. This will simplify testing schedules, downtime, and daily throughput. With so many resources available, these three processes need to be considered so as not to cause waste of all production resources.

Based on research conducted by Claudia, J. in 2018 entitled "Reducing Downtime on Offset Machines at PT X The analysis carried out is used to determine the biggest cause of machine downtime with the help of the Pareto diagram [6]. The method used is felt to be less effective and prioritizes problems that often occur.

On this basis, the aim of this research is to identify, analyse and reduce the causes of problems with the dynamic needle pin adapter during the testing process. It is hoped that the results of this research can avoid unscheduled downtime.

II. METHODE

A. Planning Flow

In carrying out analysis on needle pins, the author needs to create a flow chat to make it easier to plan and be able to carry out analysis in a structured manner. The process steps can be seen in Figure. 1. Make plans in a structured and systematic manner so that improvements can be made with organized guidelines and can make it easier to observe problems that occur.

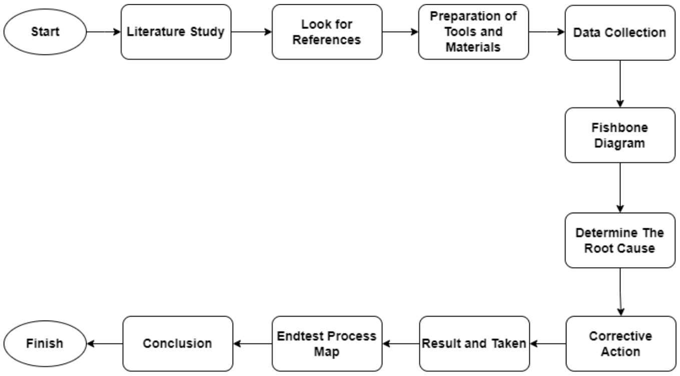

Figure 1. Planning Flow

The initial stage is to hold discussions with technology and shift leaders regarding problems that occur as well as observations during the process and see the problems that occur and determine the problems that will be discussed. After that, look for references related to this research based on decision sources such as reference books, manuals and others related to the problem to be discussed. After determining the problem to be discussed, the author then prepares the tools and materials needed during the research, starting from the software and hardware used.

The analysis was carried out using a type of quantitative analysis. Because the analysis carried out is data taken directly. The use of quantitative research aims to present the results in detail and the results of the analysis can be used as improvements or updates to the Endtest process. This analysis includes field research, analysing by conducting a direct examination of the research object. Implementation is carried out by:

a. Interviews
b. Observations.

In collecting data on machine downtime values, the author took data from daily reports for 6 months in 2023 and 2024 and every week only 4 working days 24 hours per day and collected data directly in the field. In carrying out the analysis the author used a fishbone diagram to find out the cause of the problem of burning pins. Fishbones are also used to solve the problem of burnt pins.

After getting the data, the next step is to carry out a cause and effect analysis using the Ishikawa Diagram / cause effect diagram. The purpose of this analysis is to find out what causes the activities that contribute the most to needle pin burns. After collecting the data obtained and determining the dominant factors and root causes causing burns on the pins, the author carried out a series of actions in the form of improvements to reduce machine downtime during the testing process.

The Endtest Process Map is a tool to make it easier for operators to carry out operations/activities in a production process or other processes. The purpose of this map is to make it easier for operators to operate things and find out the problems that will be discussed in this research.

B. Endtest Process Map and Plan Analysis

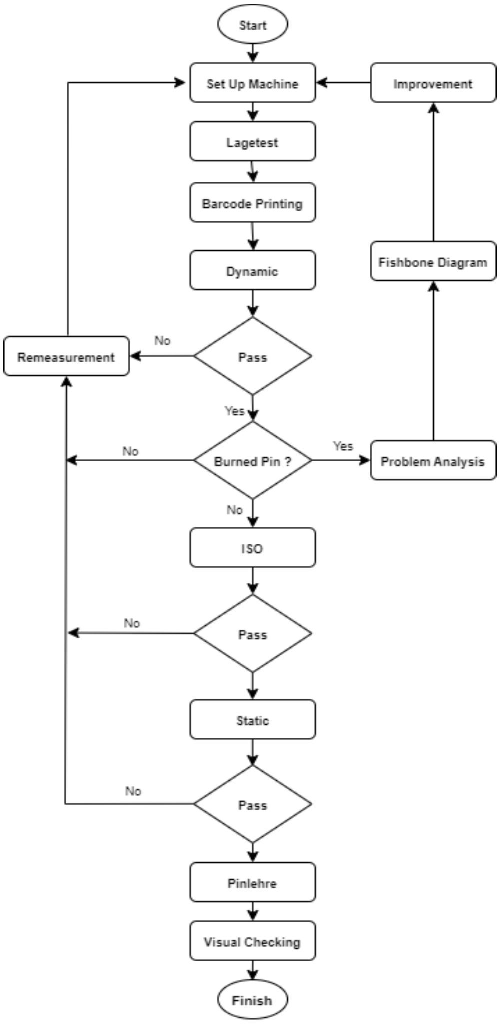

Figure 2. Endtest Process Map

The initial stage starts from setting up the machine according to a predetermined program and starting to tune the machine. After that, the module will be placed on the conveyor and the camera will inspect the orientation of the module in the machine according to the program during the lagetest process. Then the module will be provided in the form of barcode labelling with laser marking on the module frame. During the barcode printing process towards the dynamic test, the conveyor will heat the module/preheat to avoid thermal shock before the dynamic test.

After that, the module that has been labelled with a barcode will be measured and given a voltage of 600 Volts and given a temperature of 120 degrees Celsius and is in a dynamic state. If the module is unable to withstand the amount of load applied, the module will come out of the machine and a re-measurement will be carried out. During the dynamic measurement process, problems sometimes occur in the form of needle pin burnt. This problem will be discussed and analysed in this research.

The next test is ISO, this test is a life/quality protection test using The standard ISO 26262 is an adaptation of IEC 61508: Functional safety, to comply with the functional safety of road vehicles [7]. In this process, voltage is applied to all module pins and measures how much current flows to the motherboard. This is useful because if a lot of current flows to the motherboard, it will conduct current and can electrocute the receiver. If the measurement fails, the module will come out of the machine and the measurement will be carried out again.

Static tests are tests that measure parameters. In this measurement, the module pins are not provided with high voltage and high current simultaneously and ensure whether the module is safe from ESD. If the measurement fails, the module will come out of the machine and the measurement will be carried out again. When pinlehre drops, which serves to ensure that the pins on the module function properly, the pins are in the correct position. The camera also reads the barcode with a laser scanner and checks whether the module is detected at each test station. Visual checking is a process of whether there are defects in the module or not and according to standards based on a failure catalogue. Checking starts from the module baseplate, module frame, rivets, pins, barcodes, glue and terminals.

C. Detect Burnt Needle Pins

Checking the adapter after replacing the module must always be carried out to avoid rejection of the output due to burnt needle pin. The ways to detect burnt needle pins during production are:

- Detected from the machine
  The machine will give a signal in the form of a red indicator lamp and an alarm will sound indicating an error has occurred on the machine. And the monitor will display an error, for example a module pin that is burned and is connected to the dynamic adapter needle pin. So we have to reset the alarm that sounds and make sure the machine is stopped to check the condition of the module pin and needle adapter pin. In this case, usually the needle pins and also the module pins are definitely burned and you have to replace the needle pin with a new one and remove the rejected module in the reject tray to continue the testing process.

Figure 3. Test Failure Display

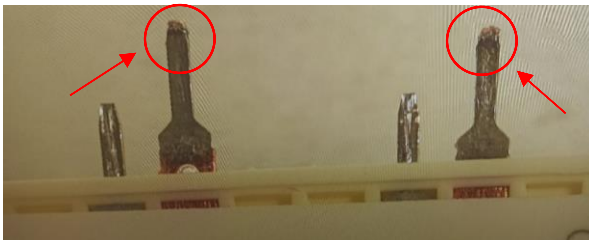

Figure 4. The Pin Lifted and Burned

- When changing the adapter before setting up the machine
  When changing new items/lots we need to make changes starting from the new program, adapter and pinlehre. When changing the adapter you want to use, we must check and clean the needle pin on the adapter by looking at it visually, brushing the needle pin with a wire brush and pressing the needle pin to ensure it is not jammed. In this case, sometimes we find that the needle pin is burned and jammed, we have to replace the needle pin with a new one to avoid the potential for defects that impact the output.

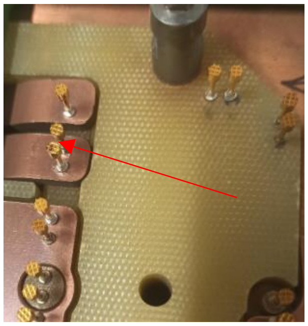

Figure 5. Burned Needle Pin On Adapter

Figure 6. Burned Needle Pin on Adapter

III. RESLUTS AND DISCUSSION

This research focuses on analysing the root causes of burnt needle pins and the downtime value resulting from this problem. Therefore, the author conducted this research in order to reduce the occurrence of downtime or improvement and create a series of corrective actions and compare data before and after improvement during the Endtest process.

A. *Data Before Improvement*

The process of collecting downtime data that occurs on the Endtest machine before repairs are carried out. Data collection was carried out for 3 months starting from October – December 2023. The results of downtime during the process can be seen in the following table 1.

Table I
DATA BEFORE IMPROVEMENT

Month	**Weeks**	**Dynamic**		**ISO (Minute)**	**Static (Minute)**	**Change Material (Minute)**	**Maintenance (Minute)**	**Total**
		Burned	**(Minute)**					
October	Week 1	4	40	0	95	220	0	355
	Week 2	4	72	0	150	295	0	517
	Week 3	8	115	0	180	205	0	500
	Week 4	6	70	0	0	275	0	345
November	Week 5	4	66	0	180	240	40	526
	Week 6	5	82	0	17	280	0	379
	Week 7	2	43	10	0	300	135	488
	Week 8	7	105	0	30	253	0	388
December	Week 9	3	48	0	225	195	0	468
	Week 10	5	65	0	20	325	60	470
	Week 11	7	90	0	28	227	0	345
	Week 12	2	30	0	0	194	0	224
Total		57	826	10	925	3009	235	5005
Summarise	Min	30						
	Max	115						
	Average	68,83						

Based on the data above, the total downtime during the first 3 months was 5005 minutes. In this research the author only took data on downtime due to burning pins and the number of burning pins. The average machine downtime before improvement collected during the first 3 months has a time lag of 68.83 minutes and a minimum of 30 minutes and a maximum of 115 minutes and 57 pins burned. This time lag greatly influences the scheduled module testing schedule

From the results of data that has been analysed using monitoring, it was found that process delays in the form of machine downtime were caused by problems with the dynamic adapter, especially burning needle pins during the Endtest Process. Therefore, corrective action is needed to reduce machine downtime. Downtime in manufacturing needs to be improved because of its relationship to business productivity and profitability [8]. In fact, several studies have also identified that downtime analysis can be carried out in the small and medium industrial sectors, which implement preventive maintenance inspections [9]. Therefore, reducing downtime in the production process has become a necessity because this also serves to maximize machine uptime.

B. *Fishbone Analysis*

Fishbone diagrams can be used to analysed problems at both individual, team and organizational levels. There are many uses or benefits from using this Fishbone Diagram in analysing problems into several related categories, including humans, materials, machines, work methods and design.[10] This diagram can analyse problems with dynamic pin adapters to find out the factors and root causes of these problems so that the process can run more smoothly, quickly and according to the specified schedule.

Based on the results of interviews with the company and field observations carried out by operators, technicians and technologists, several problem factors that occurred with the dynamic pin adapter, especially on the Endtest machine for producing IGBT modules, were obtained. The author summarizes the root of the problem in the form of a fishbone diagram.

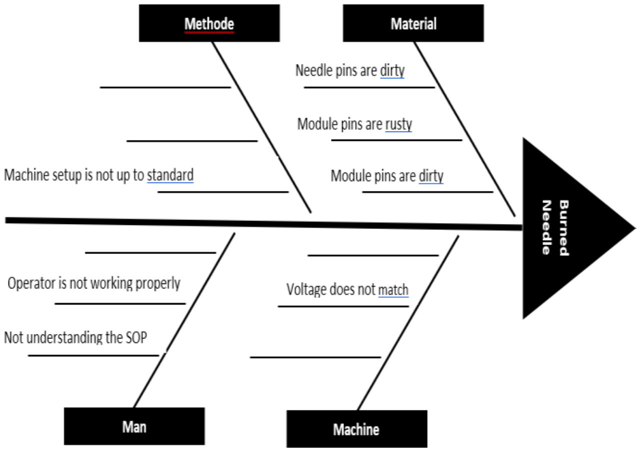

Figure 8. Fishbone Diagram

C. *Root Cause Analysis*

Table II
ROOT CAUSE ANALYSIS

Item	Root Cause	Hypotheses	Verification	Remarks
Machine	Voltage does not match	Voltage to high	The voltage is in accordance with standard specifications of 600 Volt DC	No
Material	The module pins are rusty	Stored too long	Storage time is in accordance with the testing schedule for the module to be tested (< 2 weeks)	No
	Module pins contaminated	The pin was contaminated in the previous process (Potting Process)	There is contamination on the module pins caused by the jig lid assembly	Yes
Man	Not understanding the SOP	Many abbreviations and vocabulary that operators do not understand	The trainers have been given training and explained the SOP well by the trainer for 2 weeks	No
Method	Machine operating schedule	The machine runs non-stop for 7x24 hours	Adapter inspection every time a new lot/item is changed	No

From table 2. above, it can be seen that there are several factors that cause potential burn needle pin adapters, namely as follows:

a. Man
- Not understanding the SOP, Some operators still do not fully follow the SOPs that apply in the company, starting from machines that do not speak English, complicated operations and old machines so that operators feel bored and tired of operating the machine as they please and follow the bad habits of other operators. This causes some operators not to understand the importance of similarities in the production process and the impact of errors that occur, one of which is a burnt needle pin.

b. Machine
- Voltage does not match, The voltage used to test the module must be in accordance with the data sheet, if it is different it will cause the module pins to burn and explode making a loud sound because it cannot withstand excessive voltage and if the voltage is too low it will cause an error in the machine and the module will automatically come out of the machine. If the machine is temporarily damaged, then product testing to the next process will be disrupted and can cause unwanted downtime.

c. Method
- Machine operating schedule**,** the testing schedule is busy, resulting in the machine having to run non-stop every day. In addition, the dynamic adapter is checked only when a new lot/new item is changed and the machine will be stopped when this occurs or when the machine is routinely checked.

d. Material
- The module pins are rusty**,** This is because the process before final testing and the module pins are not coated with tin so they can oxidize and rust. Usually if the module is inserted into the machine it will cause the module pin and needle pin to stick and can cause the needle pin to burn because the oxidized module pin is exposed to high voltage.
- The Module pins contaminated, Dirty module pins are usually caused by the potting process during assembly of the module cover, plastic dirt from the tray/burrs and a dirty work area environment so that dirt can stick to the module pins and usually if it gets into the machine module pins it will burn the plastic and burn the needle pins. This is the main cause of burnt needle pins.

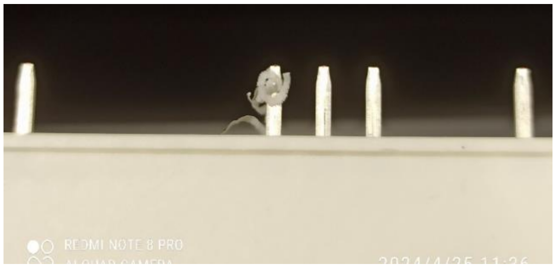

Figure 9. Burrs On Module Pins

After knowing the factors causing the problems that occurred with the dynamic needle adapter pin, the Endtest machine was used to produce the IGBT module. So the next step is to determine the potential causes of the problem and determine the most dominant cause of the problem. Based on the results of interviews and discussions conducted by researchers with the company and field observations, the most dominant causes of several existing problems were obtained. The dominant factor is **The module pins contaminated** due to the lid assembly process before the

Endtest process. because as a result of the material being contaminated with dirt/grinding, it can cause the needle pin to burn and if this happens then repairs must be carried out which will take a long time, causing the machine to stop producing and machine downtime.

D. Corrective Action

Corrective actions are steps that are taken to remove the causes of an existing nonconformity or undesirable situation. The corrective action process is designed to prevent the recurrence of nonconformities or undesirable situations. It tries to make sure that existing nonconformities and situations don’t happen again. It tries to prevent recurrence by eliminating causes. Corrective actions address actual problems [11].

After collecting the data obtained and determining the dominant factor causing burns on pins, it is **the module pins contaminated** because the result of material contaminated with dirt/burrs can cause burning of needle pins and result in machine downtime to repair them. So the author carried out a series of actions in the form of improvements to reduce machine downtime during the testing process. The actions taken by the author in analyzing are as follows:

- Clean the module pins
  Clean the module pins with a wire brush and visually check the module, first take the module and visually check the module and place the module on the input conveyor then clean the dirty module pins with a wire brush before entering the machine to be tested and clean the adapter every lot change.

Figure 10. Wire Brush

- Checking the needle pin every 1 hour
  Visually checking the dynamic adapter is done to see whether the needle pin is in good condition or not and brush the needle pin with a wire brush. This is done to detect burnt needle pins and this method is also done to reduce product defects that occur due to burnt needle pins.

E. Data After Improvement

The process of collecting downtime data that occurs on the Endtest machine after repairs. Data collection was carried out for 3 months starting from January – March 2024. The results of downtime during the process can be seen in the following table.

Table III
DATA AFTER IMPROVEMENT

Month	Weeks	Dynamic		ISO (Minute)	Static (Minute)	Change Material (Minute)	Maintenance (Minute)	Total
		Burned	(Minute)					
January	Week 1	1	20	0	0	173	120	313
	Week 2	3	50	40	57	265	0	412
	Week 3	5	85	0	0	310	0	395
	Week 4	4	71	0	35	278	0	384
February	Week 5	2	30	0	40	235	0	305
	Week 6	5	80	45	15	290	0	430
	Week 7	4	85	0	75	254	0	414
	Week 8	2	30	0	0	180	0	210
March	Week 9	3	40	0	70	235	0	345
	Week 10	2	35	0	30	242	60	367
	Week 11	3	65	15	0	225	0	305
	Week 12	4	70	0	0	160	120	350
Total		38	661	100	322	2847	300	4230
Summarise	Min	20						
	Max	85						
	Average	55,85						

Based on the data above, the total downtime for the second 3 months was 4230 minutes. In this study the author only took data on downtime due to burned pins and the number of burned pins. The average machine downtime after improvement collected during the second 3 months had a time lag of 55.08 minutes and a minimum of 20 minutes and a maximum of 85 minutes and 38 pins burned.

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Table IV
TIME DIFFERENCE

Weeks	Before Improvement (Minute)	After Improvement (Minute)	Time Difference (Minute)
Week 1	40	20	20
Week 2	72	50	22
Week 3	115	85	30
Week 4	70	71	-1
Week 5	66	30	36
Week 6	82	80	2
Week 7	43	85	-42
Week 8	105	30	75
Week 9	48	40	8
Week 10	65	35	30
Week 11	90	65	25
Week 12	30	70	-40
Total	826	661	165

Based on the experiments after improvement in Table 4, from the results of data collection, the results of the time difference between before and after repairs are obtained in the table above. The time difference is 165 minutes.

F. Matrix

Calculations are required to get the percentage results for the first and second periods of delay. The calculation results for the first period and second period can be seen below.

Note :
P1 = Percentage of downtime in Period 1 (Before Improvement)
P2 = Percentage of downtime in Period 2 (After Improvement)
x̄= Average downtime by week.
Total weeks = 12 weeks
Total day by week = 4 days

Formula :

$$P = \frac{\bar{x}}{\text{Total time in 1 periode}} \text{ x } 100\%$$

Total time in 1 period = 24 hours x total week x total day by week

x̄ = Average downtime x total weeks

P1 :

$$P1 = \frac{\bar{x}}{\text{Total time in 1 periode}} \text{ x } 100\%$$

x̄ =68,83 x 12 weeks =825,96

Total time in 1 period = 24 x 4 x 12 = 1152 hours

Percentage P1 = $\frac{825,96}{1152}$ x 100% = 71,69 %

In the first period (P1) or before improvement x or the average in 12 weeks was 825.96 and the total in 1 period was 1152 hours. So the percentage for the first period (P1) is 71.69 %.

P2 :

$$P2 = \frac{\bar{x}}{\text{Total time in 1 periode}} \text{ x } 100\%$$

x̄ = 55,08 X 12 weeks = 660,96

Total time in 1 period = 24 x 4 x 12 = 1152 hours

Percentage P2 = $\frac{660,96}{1152}$ x 100% = 57,37 %

Range = Index P1 – Index P2
= 71,69 % – 57,37 %
= 14,32 %

In the second period (P2) or after improvement was seen x or the average delay time in 12 weeks was 660.96 and the total in 1 period was 1152 hours. Then the P2 downtime percentage is 57.37%. This shows that when corrective action was taken from the analysis results, the percentage of downtime decreased compared to the results before corrective action was taken.

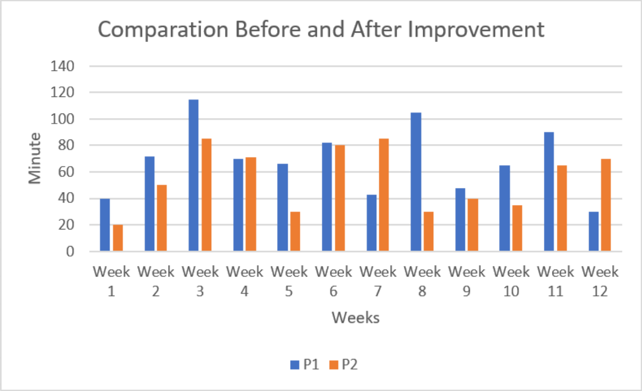

Figure 12. Comparison Before and After Improvement Implementation Chart

This is shown by the range between P1 in blue and P2 in orange, namely 14.32%, which shows a percentage reduction in machine downtime of 14.32%. The length of downtime that occurs can be caused by the length of time a technician arrives to repair it and the type of charge/lot being tested.

IV. CONCLUTIONS

Based on the research that has been carried out, the following conclusions are obtained:
After carrying out this research, the author was able to find out the factors and root causes of needle sticks using a fishbone diagram, where based on the results of interviews and discussions conducted by researchers with the company which was outlined in a fishbone diagram, several factors and root causes were obtained. . The dominant cause of burns on pins.
It appears that there are several factors that cause the needle adapter to potentially catch fire, namely as follows:

a. Men
- Not understanding the SOP

b. method
- Machine operation schedule

c. Machine
- Voltage does not match

d. Material
- Module pins are contaminated
- Dirty module pins

The dominant root cause in this research is that the module pins were contaminated due to the lid assembly process before the Endtest process. Because the material is contaminated with dirt/burrs, it can cause the needle pin to burn during testing. And the author carried out a series of corrective actions to reduce the occurrence of burns on needle pins, where the author carried out data collection in research to carry out comparative measurements of machine downtime values, the process of collecting data on downtime that occurred on the machine. Endtest machine before repairs are made. Data collection was carried out for 3 months starting in October – December 2023 (P1). The average machine downtime before repair was 68.83 minutes, min 30 minutes and maximum 115 minutes.

The results of the fishbone diagram, the main cause is contaminated module pins. So the author carried out a series of actions in the form of improvements to reduce the burning of needle pins which could cause machine downtime during the testing process. The actions taken by the author are:

- Clean the module pins
- Check the needle pin every 1 hour

Based on experimental data after repairs, it was found that the average machine downtime after repairs was slightly lower than the average machine downtime before repairs. Data collection was carried out for 3 months starting in January – March 2024 (P2). The average machine downtime after repair is 55.08 minutes and the min is 20 minutes and the maximum is 85 minutes.

In the first period (P1) or before improvement x or the average in 12 weeks was 825.96 and the total in 1 period was 1152 hours. So the percentage for the first period (P1) is 71.69%.

In the second period (P2) or after improvement was seen x or the average delay time in 12 weeks was 660.96 and the total in 1 period was 1152 hours. Then the P2 downtime percentage is 57.37%.

Range = P1 Index – P2 Index
= 71.69 % – 57.37 %
= 14.32 %

This is shown by the range between P1 and P2, namely 14.32%, which shows a percentage reduction in machine downtime of 14.32%.

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