



Performance Analysis of Reflow Oven Machine through Overall Equipment Effectiveness (OEE) and Six Big Losses

Final Project

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2026**

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Batam, 12 Februari 2026



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APPROVAL

**The Final Assignment is prepared to fulfill one of the requirements
for obtaining a degree in Bachelor of Applied Engineering
(S.Tr.T)/Associate Degree in Engineering (AMd.T.)
in
Batam State Polytechnic**

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Seminar Date: January 2026

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Performance Analysis of Reflow Oven Machine through Overall Equipment Effectiveness (OEE) and Six Big Losses

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Abstract—The development of the manufacturing industry demands increased efficiency and effectiveness in the production process. One important factor that influences productivity is the performance of production machines, including reflow oven machines used in the soldering process of printed circuit board (PCB) components. In recent years, monitoring the performance of production machines has become the main focus in the industry. This research proposes to analyze the performance of reflow oven machines using the Overall Equipment Effectiveness (OEE) and Six Big Losses methods to determine the level of equipment effectiveness and the main factors causing reduced productivity. Data were collected through direct observation of operation, downtime, and the quantity of defect products over several months on three reflow oven (R.O) machines. OEE calculations are based on three main components, which are Availability Rate (AR), Performance Rate (PR), and Quality Rate (QR). Then, the OEE results are analyzed further to identify Six Big Losses that have an effect on machine efficiency. The analysis results show that the average OEE value of three machines is in the category of needing improvement because from observations that have been carried out for several months on three machines, based on observations conducted over several months on three machines, only one month met the company's OEE standard of 85.00%, on month I which is 87.12%. The analysis results indicate that the average OEE value of three machines in three months observation is in the category of needing improvement.

Keyword: OEE, Reflow Oven Machine, Six Big Losses

I. INTRODUCTION

The manufacturing sector's explosive growth encourages companies to constantly enhance the effectiveness and efficiency of their production procedures. To fulfill the needs of a market that is becoming more and more competitive, industries are working to increase both the amount and quality of their output. Improving the company's performance all around is one

strategy for achieve this goal [1]. To overcome this, one of the methods used to measure engine effectiveness is the Overall Equipment Effectiveness (OEE) method [2].

Reflow soldering is an important step of surface mounted technology (SMT) [3]. In the reflow soldering process, a reflow oven is used to heat the assembled boards to an appropriate temperature for the specified period of time at the proper heating rate [4]. Reflow soldering is a technique that temporarily applies solder paste to contact pads of numerous surface mount components [5]. Reflow soldering is a process widely used to mount surface-mounted electronic components on a PCB. This process aimed to create strong solder joints at the base [6]. Currently, the most popular and effective technique to achieve solder-paste reflow is convection heating, as infra-red heating has become a deprecated technology [7]. The reflow soldering is a key procedure of the SMT and has direct impact on the yield and reliability of integrated circuit boards [8]. So reflow oven is the most convenient method of soldering [9].

Overall Equipment Effectiveness (OEE) is defined as a measure of total equipment performance. That is, the degree to which the equipment is doing what it is supposed to do [10]. A method called Overall Equipment Effectiveness, or, OEE, can help you better understand how well a manufacturing area is performing, and identify what is limiting higher effectiveness [11]. In addition, Overall Equipment Effectiveness (OEE) is used as an opportunity to increase productivity in the company, which is ultimately used as a step in making decisions [12]. OEE is nowadays considered as one of the most important performance metrics being used by manufacturing organisations not only for monitoring the productivity and quality of production performance but also as an indicator and driver of performance improvements. OEE is essentially the result achieved by multiplying these three components together, availability(A), performance(P) and quality (Q) [13]. OEE is a measure of the total effectiveness of equipment performance, while the Six big losses are derived from OEE which consists of: breakdown losses, set-up/adjustment losses, idling and minor stop losses, reduced speed losses, rework losses and defect losses [14].

Furhermore, determining the factors that cause a decrease in the effectiveness of equipment or plant as a whole can be seen from the six big losses to determine the six types of losses that can reduce the level of effectiveness of a machine that must be avoided by every company [15]. Six Big Losses are six categories of losses that must be avoided by every company because those losses can reduce the level of effectiveness of machines [16]. Six Big Losses (SBL) support the entire perspective of effectiveness during the implementation of OEE [17]. Calculation of Overall Equipment Effectiveness (OEE) and Six Big Losses, does not only focus on how to optimize the effectiveness of equipment or materials supporting work activities, but also pay attention to how to increase the effectiveness of workers or operators who will later take control of the equipment that seeks to identify production losses. Six Big Losses serves to find out what factors cause a decrease in engine efficiency [18]. So this research was conducted to measure the level of effectiveness of the reflow machine using the Overall Equipment Effectiveness (OEE) method, analyzing the causes of the six big losses of the reflow machine using a pareto diagram.

II. METHOD

The research method used to assess the reflow oven machines' performance using the Six Big Losses framework and the OEE approach. The research design, data collection methods, performance indicator definitions, and analytical approaches utilized to measure AR, PR, and QR are all included in the methodology. Additionally, the Six Big Losses analysis is used to determine which loss categories are most important in reducing OEE.

A. Design

The selection of sample machines is the first step in the process, which is followed by the systematic collection of production and loss data. To benchmark overall machine effectiveness, OEE is computed and critically examined. The Six Big Losses methodology is then used to categorize and analyze loss functions in order to determine the major cause of loss.

Here is a flowchart of the method I will be using in on this final project.

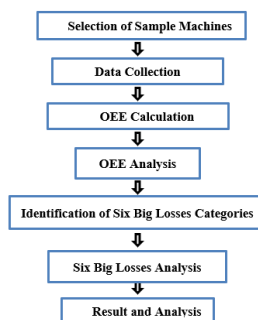


Figure 1. Methodology Framework for OEE Evaluation and Six Big Losses Identification.

B. Overall Equipment Effectiveness (OEE)

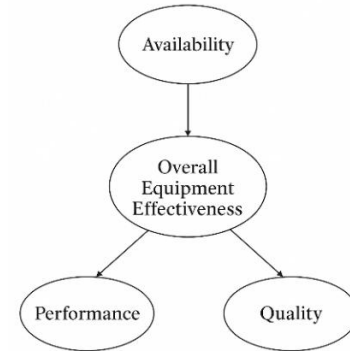


Figure 2. Components of OEE

Three main factors make up the OEE calculation, they are availability (A), performance (P) and quality (Q).

1. Availability calculation, the ratio indicating the utilization of the time available for the operation of the machine or equipment. The required data is downtime and loading time, using the following calculation formula:

$$AR = \frac{\text{Loading time}}{\text{Downtime losses}} \times 100\% \quad (1)$$

2. Performance calculation, which is the ratio that indicates the ability of the equipment to produce the goods. The required data are total production, cycle time, and operation time, using the calculation formula is as follows:

$$PR = \frac{\text{Process amount} \times \text{Ideal cycle time}}{\text{Operation time}} \times 100\% \quad (2)$$

3. Quality calculation, namely the ratio that shows the ability of the equipment to produce goods in accordance with the standards specified. The required data is the total production and the number of defects, using the calculation formula is as follows:

$$RQ = \frac{\text{Process amount} - \text{Defect amount}}{\text{Process amount}} \times 100\% \quad (3)$$

4. Calculation of overall equipment effectiveness (OEE), obtained from the multiplication of the three categories. So that, the formula used for calculation is as follows:

$$OEE = \text{Availability} \times \text{Performance} \times \text{Quality} \quad [19] \quad (4)$$

C. Six Big Losses

There are usually production machine losses in the manufacturing process. The manufacturing machine losses are then classified into six major production losses or Six Big Losses. The primary goal of the six big losses is to eliminate or reduce all production system losses to increase OEE. The focus on eliminating the six big losses includes:

1. Equipment failure or breakdowns

Equipment failure can also be referred to as unplanned downtime, caused by machines pausing due to machine failure activities or machine damage that occurs abruptly and unexpectedly.

$$\text{breakdown losses} = \frac{\text{total breakdown}}{\text{loading time}} \times 100\% \quad (5)$$

2. Set up and adjustment losses

Set up an adjustment losses can also be referred to as planned downtime, which is when the engine stops as a result of a previous plan. This setup also involves the machine configuration procedure, which is required to produce items that fulfill requirements.

$$\text{setup \& adjustment loss} = \frac{(\text{setup \& adjustment loss})}{(\text{loading time})} \times 100\% \quad (6)$$

3. Idling and minor stoppages

Idling and minor stoppages are also transient issues or minor issues that cause the engine to stop briefly. Idling stops are often just 3-5 minutes long.

$$\text{idling and stops losses} = \frac{\text{nonproductive time}}{\text{loading time}} \times 100\% \quad (7)$$

4. Reduced speed losses

Reduced speed losses are losses due to differences in the planned speed of the time with the real speed that occurs.

$$\text{Reduce speed} = \left(\frac{\text{actual p. time} - \frac{\text{Ideal cycle time} \times \text{output}}{\text{Loading time}}}{100\%} \right) \times 100\% \quad (8)$$

5. Rework losses

Rework losses is a loss caused by a product that needs to be redone. The product is being reworked because it does not satisfy product output criteria, but it can still be enhanced by reprocessing.

$$\text{Rework losses} = \frac{\text{Ideal cycle time} \times \text{rework}}{\text{Loading time}} \times 100\% \quad (9)$$

6. Defect losses

Scrap losses are losses due to defects arising from products or not meeting product output standards so that the product is declared unable to be reworked [20].

$$\text{Scrap losses} = \frac{\text{Ideal cycle time} \times \text{scrap}}{\text{Loading time}} \times 100\% \quad (10)$$

III. RESULT AND DISCUSSION

Based on the data processing and analysis collected with direct observation of several reflow oven machines. All the data obtained was analyzed fully to determine the actual condition of the research object and answer the research problems set out previously using the OEE and Six Big Losses methods.

A. Raw Operational Data

The OEE value will describe the total effectiveness of the three reflow ovens in the system soldering area during the period three months on 2024. Analysis of OEE calculations consists of three factors which include: calculations of AR, PR, and QR.

TABLE I
RAW PRODUCTION DATA OF REFLOW OVEN MACHINES (MARCH-MAY 2024
OBSERVATION)

Month	Machine	Planned Time (min)	Downtime (min)	Output Total (pcs)	Output Good (pcs)	Ideal Cycle Time
March	R.O 18	14505	14430	43104	42962	9,3
	R.O 49	14369	14201	21093	20971	18,6
	R.O 23	14598	14553	20766	20664	18,6
April	R.O 18	13930	12312	36035	35937	9
	R.O 49	14070	12075	17608	17533	18
	R.O 23	14130	12130	17566	17502	18
May	R.O 18	14210	13965	40372	40204	9,3
	R.O 49	14430	14135	19242	19135	18,6
	R.O 23	14335	13950	18591	18507	18,6

Table I summarizes the raw operational data used for calculating the OEE of three reflow oven machines observed for three months in 2024. These data are utilized to calculate the availability, performance, and quality components using the equation (1), (2), and (3) which are further analyzed and discussed thru graphical representations in the following paragraphs.

B. OEE Calculation Results

In order to compute OEE metrics, this research collected all field observations of three R.O machines for three months in 2024. Including production time, total production, planned and unplanned downtime, ideal cycle time, breakdown time, set up and adjustment, idling and minor stoppage, and defect data.

1. Month I

Here is the sorting of the percentage values for AR, PR, QR, and OEE from three machines in the first month.

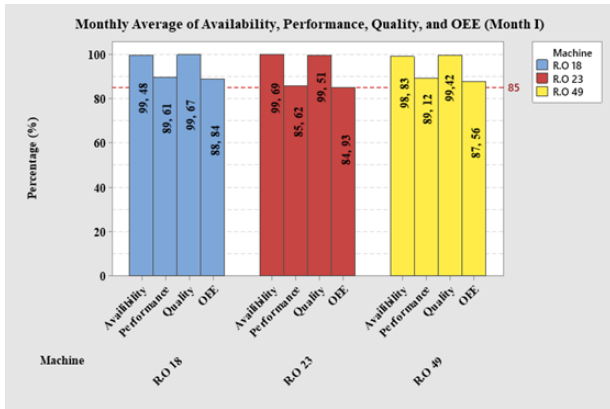


Figure 3 AR, PR, QR, and OEE percentages for the month I

Based on the OEE calculation results in Figure 3, Month I is the only period where machine effectiveness reached an average of 87.12%, exceeding the company's standard of 85.00%. Analysis of supporting parameters shows that this achievement was driven by three factors:

- **AR**, in Month I: In the first month, all three machines showed very high availability indices, with R.O 18 (99.48%), R.O 23 (99.69%), and R.O 49 (98.83%). These high figures are confirmed by the data in Table II, where Equipment Failure Losses were at their lowest point during the observation period. For example, R.O 23 experienced only 0.30% downtime. This indicates that in Month I, machine reliability was in prime condition with minimal unplanned downtime.

- **QR**, All machines in Month I recorded quality rates above 99% (R.O 18: 99.67%, R.O 23: 99.51%, R.O 49: 99.42%). The low Defect Losses (averaging 0.28% in total) indicate that the temperature parameters in the reflow oven have been very well calibrated to produce products that meet standards.

- **PR**, Although idling and minor stoppages are the biggest losses overall (24.72%), in the first month this parameter was successfully managed so that the Performance Rate remained at the standard threshold, averaging above 85%. As a comparison, in the following months (Months II and III), the drastic decline in OEE was caused by the deterioration of this performance index due to minor disruptions and a decrease in machine speed.

2. Month II

The results for the second month will be shown thru the following figure:

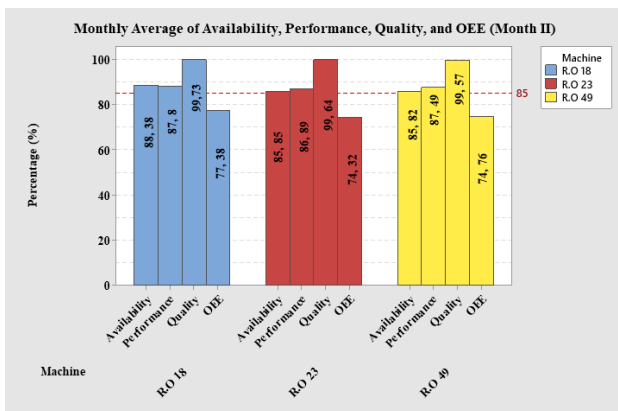


Figure 4. AR, PR, QR, and OEE percentages for the month II

In Month II, the average OEE plummeted to 75.49%, significantly below the 85% standard. Analysis of the three main parameters revealed the following dynamics:

- **AR**, The availability index decreased to the 85% – 88% range. This was due to a surge in Equipment Failure Losses (machine breakdowns). For example, the R.O. 18 machine experienced damage losses of 14.57%, which was the highest figure during the observation period. This indicates that unplanned downtime was the main obstacle to machine availability this month.

- **PR**, the performance index, also experienced pressure with a value in the range of 86% – 87%. This decrease was triggered by an increase in speed loss and minor stoppages.

- **QR**, QR remains the strongest parameter with a value above 99%. Although the overall effectiveness (OEE) is low, the quality of the products produced still meets standards, so quality losses (defect losses) are not a major cause of failure in Month II.

3. Month III

This is shows the comparison of availability, performance, quality, and OEE for the three machines in Month III.

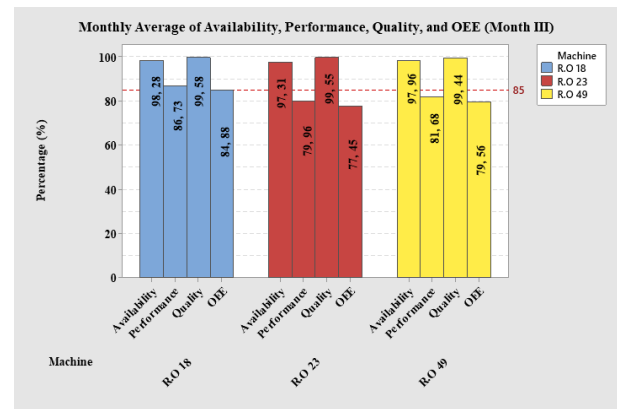


Figure 5. AR, PR, QR, and OEE percentages for the month III

Month III saw an increase in OEE to 80.65%, but it still failed to meet the company's target.

- **AR**, The availability index was successfully restored and stabilized above 97%. This indicates that the machine damage issues that occurred the previous month have been successfully resolved.

- **PR**, PR was the main contributing factor to the low OEE in the third month. Significant decreases were observed in the R.O. 23 machine (79.96%) and the R.O. 49 machine (81.68%). Based on the Six Big Losses analysis, this was caused by high Reduced Speed Losses, which averaged a total of 15.36%, and Idling and Minor Stoppages, which accounted for 24.72%. The machine is operating far below its standard speed.

- **QR**, Consistent with previous months, QR remained consistently high above 99%. Stable quality control focus ensured that rework remained minimal at 0.06%.

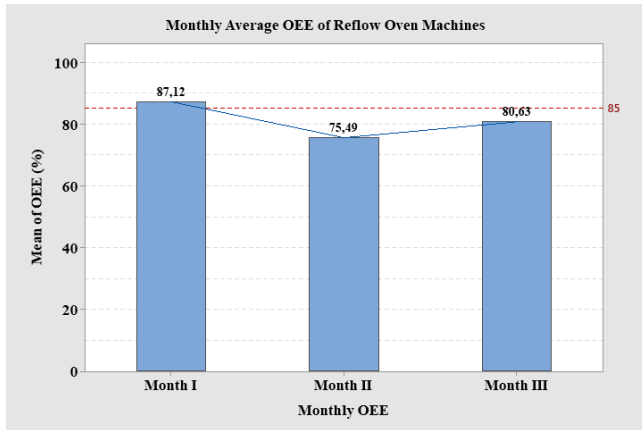


Figure 6. Calculation of OEE of Reflow Oven Machine in three months

Based on the average OEE fluctuation graph in Figure 6, it can be concluded that the overall machine performance falls into the "needing improvement" category because it is unable to maintain target consistency. The data shows that only Month I (87.12%) was the only period that successfully met and exceeded the company's OEE standard of 85.00%. Conversely, in Month II (75.49%) and Month III (80.65%), machine effectiveness significantly decreased and failed to reach the set target. This fluctuating trend indicates a sustained deviation in performance from company standards, necessitating further analysis of the Six Big Losses to identify the root causes in the machine availability and performance parameters.

C. Calculation of Time and Percentage of Six big losses on Reflow oven machines

OEE analyze highlights six major losses that cause equipment production not working properly. The six major losses include; Equipment Failure Losses, Set Up and Adjustment Losses, Idling and Minor Stoppages Loss, Reduced Speed Losses, Rework Losses, Defect Losses.

TABLE II
EQUIPMENT FAILURE LOSSES

Machine	Month	Loading Time (min)	Down time (min)	Breakdown Losses
R.O 18	March	14.880	75	0,50%
	April	14.400	2098	14,57%
	May	14.880	245	1,65%
<i>Average</i>				5,57%
R.O 49	March	14.880	168	1,13%
	April	14.400	1995	13,85%
	May	14.880	295	1,98%
<i>Average</i>				5,66%
R.O 23	March	14.880	45	0,30%
	April	14.400	2000	13,89%
	May	14.880	385	2,59%
<i>Average</i>				5,59%
Average Total				5,61%

Analysis of Breakdown losses is the damage that occurs to equipment, requiring unscheduled repairs. Tabel II shown the percentage value of losses due to reflow oven machine breakdown, which was computed using equation (5).

TABLE III
SETUP & ADJUSTMENT LOSSES

Machine	Month	Loading Time (min)	Setup Time (min)	Setup Time Losses
R.O 18	March	14.880	375	2,52%
	April	14.400	470	3,26%
	May	14.880	670	4,50%
<i>Average</i>				3,43%
R.O 49	March	14.880	168	1,13%
	April	14.400	330	2,29%
	May	14.880	450	3,02%
<i>Average</i>				2,15%
R.O 23	March	14.880	282	1,90%
	April	14.400	270	1,88%
	May	14.880	545	3,66%
<i>Average</i>				2,48%
Average Total				2,68%

Analysis of Setup & Adjustment losses is the time lost for installation, setup and adjustment of machine parameters to obtain the required specifications. The percentage value was calculated using equation (6) can be seen as follows in table III.

TABLE IV
IDLING AND MINOR STOPPAGES

Machine	Month	Loading Time (min)	Ideal Cycle Time (min)	Output (pcs)	Target (pcs)	Idling & Stops Losses
R.O 18	March	14.880	0,3	43.104	50.220	14,35%
	April	14.400	0,3	36.035	48.600	26,18%
	May	14.880	0,3	40.372	50.220	19,85%
<i>Average</i>						20,13%
R.O 49	March	14.880	0,6	21.093	26.040	19,95%
	April	14.400	0,6	17.608	25.200	31,63%
	May	14.880	0,6	19.242	26.040	27,41%
<i>Average</i>						26,33%
R.O 23	March	14.880	0,6	20.766	26.040	21,27%
	April	14.400	0,6	17.566	25.200	31,81%
	May	14.880	0,6	18.591	26.040	30,04%
<i>Average</i>						27,70%
Average Total						24,72%

Idling & Minor Stoppages Losses occur when the equipment continues to operate even without producing. From the table above the value and the average value of Idle&Minor stoppage is 24,72% that's calculate with equation (7).

TABLE V
REDUCED SPEED LOSSES

Machine	Month	Loading Time (min)	Operating Time (min)	Total Product (pcs)	Ideal Cycle Time (min)	Reduced Speed Losses
R.O 18	March	14.880	14.805	43.104	0,3	12,59%
	April	14.400	12.302	36.035	0,3	10,36%
	May	14.880	14.635	40.372	0,3	16,96%
Average						13,30%
R.O 49	March	14.880	14.712	21.093	0,6	13,82%
	April	14.400	12.405	17.608	0,6	12,78%
	May	14.880	14.585	19.242	0,6	20,43%
Average						15,68%
R.O 23	March	14.880	14.835	20.766	0,6	15,96%
	April	14.400	12.400	17.566	0,6	12,92%
	May	14.880	14.495	18.591	0,6	22,45%
Average						17,11%
Average Total						15,36%

Reduced Speed Losses analysis is a loss that occurs due to equipment being operated under the standard speed. The percentage value can be seen as follows in Table V, which was calculated by equation (8).

TABLE VI
REWORK LOSSES

Machine	Month	Loading Time (min)	Ideal Cycle Time (min)	Rework Losses (pcs)	Rework Yield
R.O 18	March	14.880	0,3	15	0,03%
	April	14.400	0,3	19	0,04%
	May	14.880	0,3	16	0,03%
Average					0,03%
R.O 49	March	14.880	0,6	19	0,08%
	April	14.400	0,6	7	0,03%
	May	14.880	0,6	11	0,04%
Average					0,05%
R.O 23	March	14.880	0,6	21	0,08%
	April	14.400	0,6	28	0,12%
	May	14.880	0,6	27	0,11%
Average					0,10%
Average Total					0,06%

The percentage value of Reduce yield/ Rework yield for reflow oven machines is shown in Table VI, which accumulated from equation (9).

TABLE VII
DEFECT LOSSES

Machine	Month	Loading Time (min)	Ideal Cycle Time (min)	Total Defect (pcs)	Defect Losses
R.O 18	March	14.880	0,3	127	0,26%
	April	14.400	0,3	79	0,16%
	May	14.880	0,3	152	0,31%
Average					0,24%
R.O 49	March	14.880	0,6	103	0,42%
	April	14.400	0,6	68	0,28%
	May	14.880	0,6	96	0,39%
Average					0,36%
R.O 23	March	14.880	0,6	81	0,33%
	April	14.400	0,6	36	0,15%
	May	14.880	0,6	57	0,23%
Average					0,24%
Average Total					0,28%

Defect Losses analysis of equipment time wasted to produce bad product. The value of defect for reflow oven machine is as in Table VII, which was calculated by equation (10).

The results of the value of Six big losses for Reflow oven machines that the author has done are in the Figure.7

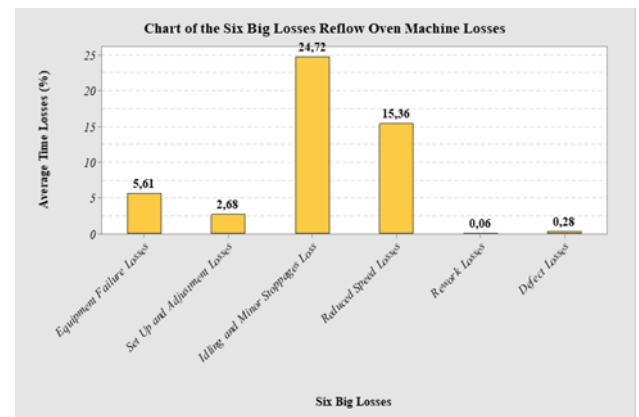


Figure 7. Six Big Losses Percentage

The Results of the Six Big Losses analysis show that the highest Losses is at Idling and Minor Stoppages Loss of 24,72 %. Second is Reduced speed Losses followed by Equipment Failure/breakdowns, Setup & Adjustment, Defect losses, Rework/Reduced Losses. The root cause of the overall low machine effectiveness is Idling and Minor Stoppages Loss (24.72%), which often occurs due to module replacement or operator breaks. The focus of improvement should be directed toward engine speed stability and reducing minor disturbances to maintain consistent performance as in Month I.

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**FORMULIR LOGBOOK BIMBINGAN DAN PENGAJUAN
SEMINAR PROPOSAL ***

Nama : Ester S. Samosir
 NIM : 3222101052
 Pembimbing I : Fitriyanti Nakul, S.Pd., M.Si.
 Pembimbing II* : -
 Judul : Performance Analysis of Reflow Oven Machine through Overall Equipment Effectiveness (OEE) and Six Big Losses

No	Hari/Tgl	Rincian Kegiatan	TTD Pembimbing I & II	
1	06 Nov 2023	Bimbingan umum bersama teman seperdosbingan		-
2	17 Nov 2023	Bimbingan mengenai judul masing masing yang digunakan setelah berdiskusi pembagian judul dan metode yang akan digunakan		-
3	30 Nov 2023	Bimbingan proposal membicarakan alur penulisan sesuai template proposal yang telah ditentukan prodi EM.		-
4	06 Des 2023	Bimbingan proposal, penjelasan metode jangka pendek observasi mesin, sampling mesin, data production.		-
5	18 Des 2023	Bimbingan proposal dan revisi metode OEE, revisi mengenai penjelasan lebih lengkap untuk teknis penelitian.		-
6	28 Des 2023	Bimbingan proposal revisi abstrak, background, problems, objectives, advantages, limitation yang akan dianalisa, bibliography		-
7	09 Jan 2023	Bimbingan proposal dan revisi metodologi diagram alir/ flowchart, revisi format bibliografi.		-
8	19 Jan 2024	Seminar proposal dengan dosen pembimbing		
9				
10				

Berdasarkan hasil bimbingan yang telah dilaksanakan selama 1 bulan dan telah disetujui oleh dosen pembimbing untuk mengajukan sidang, maka dengan ini saya mengajukan diri sebagai peserta Seminar Proposal /Sidang Tugas Akhir.

Batam, 12 Februari 2026

Peserta



Ester S. Samosir

Nim: 3222101052

**FORMULIR LOGBOOK BIMBINGAN DAN PENGAJUAN
SIDANG TUGAS AKHIR***

Nama : Ester S. Samosir
 NIM : 3222101052
 Pembimbing I : Fitriyanti Nakul, S.Pd., M.Si.
 Pembimbing II* : -
 Judul : Performance Analysis of Reflow Oven Machine through Overall Equipment Effectiveness (OEE) and Six Big Losses

No	Hari/Tgl	Rincian Kegiatan	TTD Pembimbing I & II	
1	Jumat, 31 Okt 2025	- Penjelasan template yang digunakan untuk final project, dan penjelasan setiap sub nya.		
2	Selasa, 30 Des 2025	-Perbaiki abstrak dengan mengambil poin penting di setiap bab. -Menampilkan data penelitian di dalam bentuk grafik agar kecenderungan data dapat terlihat. -Menambahkan daftar pustaka (minimal 20).		
3	Kamis, 22 Jan 2026	- Perbaiki penulisan singkatan di abstrak - Perbaiki equation agar dibuat ke citation. - Revisi chart per month agar lebih rinci/kompleks - Revisi penjelasan per month data agar lebih spesifik.		
4	Senin, 26 Jan 2026	- Desiminasi Project Akhir dengan dosen pembimbing melalui zoom - Revisi, deep analysis terhadap chart yang mencapai standart OEE perusahaan.		
5				
6				
7				
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Berdasarkan hasil bimbingan yang telah dilaksanakan selama 1 bulan dan telah disetujui oleh dosen pembimbing, maka dengan ini saya mengajukan diri sebagai peserta Sidang Tugas Akhir*.

Batam, 12 Februari 2026
 Peserta



Ester S. Samosir
 Nim: 3222101052