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Analysis of Overall Equipment Effectiveness in Fanuc Line 1 Machines by Minimizing six big losses

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Abstract. The company produces several automotive components in Karawang. For the production process using Fanuc machines on Line1, but the results of evaluating the performance of the engine Fanuc Line1 engine effectiveness is not optimal. It was alleged that due to the planning and maintenance of the management machinery was not good, so that the frequency of damage to the machine was still high, which gave the effect that the production was not achieved. For this reason, the effectiveness of the use of Fanuc line1 is done by using the Overall Equipment Effectiveness (OEE) method with the Six big losses calculation approach so that the level of efficiency can be known. The results showed that the magnitude of the OEE value on Fanuc line1 machines in April - August 2018 amounted to 78.82%, this value is still below the JIPM standard of 85%. The amount of Losses is influenced by reduced speed loss of 57.47% and breakdown loss of 22.79%.
Keywords: OEE, Six Big Losses, Effectiveness, Cause and Effect Diagram

1. Introduction

Manufacturing industries that produce automotive spare parts components always pay attention to the efficiency and effectiveness of the machine in the production process in Casting Parts, GDC, Finishing, Machining, Painting, Receiving. Assembling and Delivery. The machinery of the production process is still wasting until now because it has not met the company's target. Waste is caused by damaged machines so the production process stops. Thus, the handling system of maintenance and maintenance of machines is needed. Company losses caused by waste are known as six big losses. In this study, the object of research is the machining of turning the machine Numerical Control (CNC) Fanuc Line I.

The Overall Equipment Effectiveness (OEE) of a machine or set of equipment is a Key Performance Indicator (KPI) that indicates the equipment's overall operational performance [6]. The research on the machine is because the frequency of engine damage is still high so that the engine performance level is still low. According to Nakajima (1988), Overall Equipment Effectiveness (OEE) is a metric that focuses on how effectively a production operation is carried out [7]. OEE is the most effective measure for driving plant improvement. It continuously focuses the plant on the concept of zero-waste [3].

The method of measuring the performance and effectiveness of the Fanuc CNC line I machine is the Overall Equipment Effectiveness (OEE) method. The measurement method with OEE uses three main factors, namely calculating availability, performance and Quality. The engine has not been effective and efficient. The losses are caused by downtime (breakdown and set up and adjustment), speed losses (idling and minor stoppages) and reduced speed losses, defective losses (process defects) and reduced yield losses [2]. Another disadvantage is that the product is not in accordance with the standard. Therefore, steps are needed that are effective and efficient in maintaining the machine so that there is no damage to

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the engine. This is a problem of the dominant six big losses Based on this background, the formulation of the problem is to find out the causes of waste that occur on Fanuc Line I lathes by measuring the Overall Equipment Effectiveness (OEE) level against the JIPM (Japan Institute of Plant Maintenance) standard including availability rate, performance efficiency rate and rate of qualitya and the calculation of Six Big Losses [2].

In addition, the goal of Total Productive Maintenance according to Nakajima, S., (1988: 2) is zero breakdown and zero defects so that the level of equipment operation increases, costs are reduced, minimum inventory and labor productivity increase.[9]. Total productive maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving total workforce (Bhadury, 2000) [5]. Total productive maintenance (TPM), a resource-emphasized approach moves the paradigm of maintenance by putting emphasis on total employee involvement in the maintenance activities [3].

2. Methodology

The research was carried out beginning with a preliminary study, namely observing, interviewing and identifying problems in the machinery of the production process in the production section. Furthermore, identification of machining process problems, especially on fanuc line 1 for production machinery. Performance measurement on fanuc line 1 machine to see the performance level of effectiveness and efficiency on the machine. Measuring the effectiveness of effectiveness and efficiency with the Overall Equipment Effectiveness (OEE) method. Measurement with meted OEE to see the value of Six Big Losses and the function of availability ratio, performance rate and rate of quality product, so that the OEE value can be calculated. In addition, analysis of the Fishbone diagram method is carried out to determine the causes of the problem, so that the control program can be planned properly [1].

3. Results and discussion

3.1. Calculation of Overall Equipment Effectivenes (OEE)

Calculation of Availability Ratio Value [3].

Loading time is the available time (availabe) minus the planned downtime (company standard) on fanuc line I machines. Factors that cause downtime are caused by program settings, broken components and machine breaks (see tables 1 and 2).

Table 1. Data Loading Time and Downtime

Week	Loading time (Hours)			Downtime (hours)			
	Available	Planned Downtime	Loading Time	Setting Program	Product Reject	Machine Break	Total Downtime
1	78	4	74	2,5	0,3	1	3,8
2	120	6	114	1,8	0,7	0,7	3,1
3	99	5	94	0	3,8	1,2	5
4	155	7,7	147,3	2,6	2,0	6,5	11,1
5	78	4	74	0,7	3,8	0	4,5
6	113	5,7	107,3	2,6	7,7	2	12,3
7	120	6	114	2,3	0,3	2,5	5,1
8	115	5,3	109,7	1,1	0	0,6	1,7
9	42	2	40	0	0	0	0
10	106	5,3	100,7	2,6	8,4	8,3	19,3
11	77	3,7	73,7	1,0	1,5	1,0	3,5
12	120	6	114	0,7	1,3	5,7	7,7
13	106	5,3	100,7	0	1,3	9,8	11,2

Table 2. Calculating Availability Ratio

Weeks	Loading Time (hour)	Total Downtime (Hour)	Operation Time (Hour)	Availability Ratio (%)
1	74.00	3.80	70.20	94,86
2	114.00	3.10	110.90	97,28
3	94.00	5.00	89.00	94,68
4	147.30	11.10	136.30	92,53
5	74.00	4.50	69.50	93,92
6	107.30	12.30	95.10	88,63
7	114.00	5.10	108.90	95,53
8	109.70	1.70	108.00	98,45
9	40.00	-	40.00	100,00
10	100.70	19.30	81.40	80,83
11	73.70	3.50	69.80	94,71
12	114.00	7.70	106.30	93,25
13	100.70	11.20	89.50	88,88
Availability average				93,35

Calculation of Availability is the ratio of operation time to loading time. The availability ratio calculation at week 1 is 94.86%, while the availability average is 93.35%. 1st week calculation as follows:

Availability = (Loading time – downtime)/Loading time x100%
= [(74 – 3,8)/74] x100%
= 94,86%

Calculation of Value of Performance Efficiency Ratio

Calculation of Performance efficiency ratio is the standard operating time to produce a number of finished products divided by actual operating time. The measurement of the performance efficiency ratio in the 1st week is (see table 3):

Product yield = 66 pcs / hour
Ideal cycle time = 0.9 minutes / pcs = 0.015 hours / pcs
Processed amount = 3747 pcs
Operation time = 70.2 hours
Performance efficiency = Processed amount x Theoretical time / Operation time x 100%
= [(3747 x 0.015) / 70.20] x100%
= 80.06%

So the average performance efficiency ratio during April-August 2018 is 80.84%.

Table 3 : Performance efficiency ratio

Weeks	Total Production (pcs)	Ideal Cycle Time (Hour)	Operation Time (Hour)	Performance Efficiency Ratio(%)
1	3747	0,015	70.20	80,06
2	5985	0,015	110.90	80,95
3	4909	0,015	89.00	82,74
4	7247	0,015	136.30	79,75
5	3788	0,015	69.50	81,76
6	5145	0,015	95.10	81,15
7	6189	0,015	108.90	85,25
8	5405	0,015	108.00	75,07
9	1851	0,015	40.00	69,41
10	4940	0,015	81.40	91,03
11	3982	0,015	69.80	85,57
12	5630	0,015	106.30	79,44
13	4700	0,015	89.50	78,77
Average				80,84

Calculation of Quality Ratio Value

Calculation of Quality ratio or rate of quality product is a ratio that shows the ability of equipment to produce products that produce products that comply with standards. The calculation of the quality ratio is (see table 4):

Processed amount = 3747 pcs
Defect Amount = 33 pcs
Quality ratio = [(Processed - Defect amount / Processed amount] x 100%
= [(3747 - 33) / 3747] x 100%
= 99.12%

So the average quality ratio during April-August 2018 is 98.92%.

Table 4. Calculating Rate of Quality Product

Week	Total Production (Pcs)	Total Reject Production (Pcs)	Quality Ratio (%)
1	3747	33	99,12
2	5985	76	98,73
3	4909	28	99,43
4	7247	66	99,09
5	3788	43	98,86
6	5145	47	99,09
7	6189	52	99,16
8	5405	64	98,82
9	1851	20	98,92
10	4940	67	98,64
11	3982	46	98,84
12	5630	72	98,72
13	4700	70	98,51
Average			98,92

Calculation of Overall Equipment Effectiveness (OEE)

The calculation of the OEE value is multiplying the availability ratio, performance efficiency ratio and quality ratio. The results of calculating the OEE value on Fanuc machine Line I are as follows (see table 5):

OEE = availability ratio x performance efficiency x rate of quality product
= 94.86% x 80.06% x 99.12% = 75.28%.

While the OEE average during April-August 2018 is 74.50%.

Table 5 : Calculating OEE

Weeks	Availability Ratio (%)	Performance Efficiency Ratio (%)	Rate of Quality Product (%)	OEE (%)
1	94,86	80,06	99,12	75,28
2	97,28	80,95	98,73	77,75
3	94,68	82,74	99,43	77,89
4	92,53	79,75	99,09	73,13
5	93,92	81,76	98,86	75,91
6	88,63	81,15	99,09	71,27
7	95,53	85,25	99,16	80,75
8	98,45	75,07	98,82	73,03
9	100,00	69,41	98,92	68,66
10	80,83	91,03	98,64	72,59
11	94,71	85,57	98,84	80,11
12	93,25	79,44	98,72	73,13
13	88,88	78,77	98,51	68,97
Average	93,35	80,84	98,92	74,50

Journal of Sustainable Engineering: Proceedings Series 1(2) 2019 doi:10.35793/joseps.v1i2.22

3.2. Calculation of Value of Six Big Losses

The OEE analysis highlights six major losses (six big losses) that cause production equipment not to operate normally. Of the six main losses grouped into three, namely downtime losses, speed losses, quality losses [4]. The following are six major losses, which include:

1. Downtime Losses

The definition of downtime losses is if the production output is zero and the system does not produce anything, a useless time segment. Downtime losses consist of:

a. **The breakdown loss** is a problem that can be used or not. This loss is experienced by it until it has been repaired (see table 6). Calculation of breakdown loss for week 1 as follows:

Breakdown Loss = [down time / loading time] x100%

Breakdown Loss = $\frac{3,8}{74}$ x100 % = 5,18%

Table 6. Calculating Breakdown Time

Weeks	Setting Program (Hour)	Parts Reject (Hour)	Machine Break (Hour)	Total Downtime (Hour)
1	2,5	0,3	1	3,8
2	1,8	0,7	0,7	3,1
3	0	3,8	1,2	5
4	2,6	2,0	6,5	11,1
5	0,7	3,8	0	4,5
6	2,6	7,7	2	12,3
7	2,3	0,3	2,5	5,1
8	1,1	0	0,6	1,7
9	0	0	0	0
10	2,6	8,4	8,3	19,3
11	1,0	1,5	1,0	3,5
12	0,7	1,3	5,7	7,7
13	0	1,3	9,8	11,2
Total				88,08

Table 7 : Calculating Breakdown Loss

Week	Total Breakdown (Hour)	Loading Time (Hour)	Breakdown Loss (Hour)
1	3,8	74	5,14
2	3,1	114	2,72
3	5	94	5,32
4	11,1	147,3	7,54
5	4,5	74	6,08
6	12,3	107,3	11,46
7	5,1	114	4,47
8	1,7	109,7	1,55
9	0	40	0,00
10	19,3	100,7	19,17
11	3,5	73,7	4,75
12	7,7	114	6,75
13	11,2	100,7	11,12
Total	88,3		6,62

b. **Set-up and Adjustment Time.** Calculation of set-up and adjustment loss is required for all machine set-up time data that is the object of research. To find out the percentage of machine effectiveness lost due to the adjudication set-up as follows (see table 7).

Set-up and Adjustment Loss =[set up time / Loading time]x 100%

= [0 / 74] x 100% = 0%

Table 8. Calculating Percentage Set-up and Adjustment

Week	Set-up and Adjustment (hour)	Total (Hour)	Loading Time (Hour)	Set-up and Adjustment (Hour)
1	0	0	74	0
2	0	0	114	0
3	0	0	94	0
4	0	0	147,3	0
5	0	0	74	0
6	0	0	107,3	0
7	0	0	114	0
8	0	0	109,7	0
9	0	0	40	0
10	0	0	100,7	0
11	0	0	73,7	0
12	0	0	114	0
13	0	0	100,7	0
Total		0		0

2. Speed Losses

When the output is smaller than the output at the reference speed, this condition is called speed losses. The categories of speed losses are idling and minor stoppages loss and reduced speed losses.

a. ***Idling and minor stoppages loss***, is a loss caused by the cessation of equipment because there are temporary problems, such as intermittent engines (halting), jamming and idling. Following is the calculation of idling and minor stoppages loss. Based on the machine delay obtained, the factors including non-productive time are the contents of the start check sheet, preparation for production and cleaning equipment. Using the formula above, the percentage of idling and minor stoppages loss (see table 9).

Idling and Minor Stoppages = [Non production time / Loading time]x 100%
= [4 / 74] x 100% = 5,41%

Table 9 : Calculating Percentage Idling and Minor Stoppages Loss

Week	Isi Start Check Sheet (Hour)	Setup machine production (Hour)	Cleaning (Hour)	Total (Hour)	Loading Time (Hour)	Idling and Minor Stoppages (Hour)
1	1	1	2	4	74	5,41
2	1,5	1,5	3	6	114	5,26
3	1,3	1,3	2,5	5	94	5,32
4	1,9	1,9	3,8	7,7	147,3	5,23
5	1	1	2	4	74	5,41
6	1,4	1,4	2,8	5,7	107,3	5,31
7	1,5	1,5	3	6	114	5,26
8	1,3	1,3	2,7	5,3	109,7	4,83
9	0,5	0,5	1	2	40	5,00
10	1,3	1,3	2,7	5,3	100,7	5,26
11	0,9	0,9	1,8	3,7	73,7	5,02
12	1,5	1,5	3	6	114	5,26
13	1,3	1,3	2,7	5,3	100,7	5,26
Total	16,4	16,4	33	66	1263,4	5,52

b. **Reduced speed loss**, is a reduction in production speed from the design speed of the equipment. This measurement of losses compares the ideal capacity with the actual workload (see table 10).

Reduced Speed Losses = [(Operation time – Ideal cycle time x Processed amount)/ Loading time] x 100%

$$\textit{Reduced Speed Losses} = \frac{70,2-(0,015 \times 3747)}{74} \times 100\ \%$$

= 18,91%

Table 10. Calculating Persentase Reduced Speed Loss

Week	Operation Time (Hour)	Ideal Cycle Time (Hour)	Total Production (Pcs)	Loading Time (Hour)	Reduced Speed Loss Time (Hour)	Reduced Speed Loss (Hour)
1	70,2	0,015	3747	74	10,0	18,91
2	110,9	0,015	5985	114	15,1	18,53
3	89	0,015	4909	94	10,4	16,35
4	136,3	0,015	7247	147,3	19,9	18,73
5	69,5	0,015	3788	74	8,7	17,14
6	95,1	0,015	5145	107,3	12,2	16,71
7	108,9	0,015	6189	114	10,1	14,09
8	108	0,015	5405	109,7	21,6	24,54
9	40	0,015	1851	40	10,2	30,59
10	81,4	0,015	4940	100,7	2,0	7,25
11	69,8	0,015	3982	73,7	6,4	13,66
12	106,3	0,015	5630	114	15,9	19,17
13	89,5	0,015	4700	100,7	13,7	18,87
Total					156,2	18,05

3. Defect or Quality Losses

If the production output produced does not meet the quality specifications it is called quality losses, which consist of the following two things:

a. Reduced yield loss, is due to raw material being wasted. These losses are divided into two, namely the loss of raw materials due to product design and manufacturing methods and adjustment losses due to product quality defects produced at the beginning of the production process and when a change occurs (see table 11).

Reduced Yield = [Ideal cycle time x defect amount during setting /Loading time] x 100%

$$\textit{Reduced Yield} = \frac{0,015 x 0}{74} \times 100\% = 0\ \%$$

Table 11. Calculating Percentage Reduced Yield Loss

Week	Loading Time (Hour)	Ideal Cycle Time (Hour)	Scrap (Pcs)	Scrap (Hour)	Reduced Yiel loss (%)
1	74	0,015	0	0	0
2	114	0,015	0	0	0
3	94	0,015	0	0	0
4	147,3	0,015	0	0	0
5	74	0,015	0	0	0
6	107,3	0,015	0	0	0
7	114	0,015	0	0	0
8	109,7	0,015	0	0	0
9	40	0,015	0	0	0
10	100,7	0,015	0	0	0
11	73,7	0,015	0	0	0
12	114	0,015	0	0	0
13	100,7	0,015	0	0	0
Total				0	0

a. **Quality defect (process defect)**, is this loss occurs due to product defects during production. Products that do not meet specifications need to be reworked or made scrap (see table 12).
Process Defect = [Ideal cycle time x defect amount during production/loading time] x 100%
$$= \frac{0{,}015x33}{74} \text{x}100\% = 0{,}67\%$$

Table 12 : Calculating Percentage Quality Defect

Week	Loading Time (Hour)	Ideal Cycle Time (Hour)	Rework (Pcs)	Rework (Hour)	Quality Defect (%)
1	74	0,015	33	0,50	0,67
2	114	0,015	76	1,14	1
3	94	0,015	28	0,42	0,45
4	147,3	0,015	66	0,99	0,67
5	74	0,015	43	0,65	0,87
6	107,3	0,015	47	0,71	0,66
7	114	0,015	52	0,78	0,68
8	109,7	0,015	64	0,96	0,88
9	40	0,015	20	0,30	0,75
10	100,7	0,015	67	1,01	1
11	73,7	0,015	46	0,69	0,94
12	114	0,015	72	1,08	0,95
13	100,7	0,015	70	1,05	1,04
Total			684	10,28	0,81

The effect of the six big losses on the effectiveness of the Fanuc Line I machine, it will calculate the time loss for each factor in the six big losses as seen in the results of calculations in Table 13.

Table 13. Calculating Six Big Losses pada mesin Fanuc Line I

No.	Six Big Losses	Total Time Loss (Hour)	Percentage (%)
1	Breakdown Loss	88,3	27,53
2	Setup and Adjustment Loss	0	0,00
3	Idling and Minor Stoppage Loss	66	20,57
4	Reduced Speed Loss	156,2	48,69
5	Reduced Yield/Scrap Loss	0	0,00
6	Quality Defect Loss	10,28	3,20
	Total	320,78	

From the histogram it can be seen that the factor that has the largest percentage of the six factors is reduced speed losses of 57.47% (see table 14).

Table 14 : Sequencing factors Six Big Losses fanuc Line I machine.

No	Six Big Losses	Total Time Loss (Hour)	Percentage (%)	Percentage Cumulative (%)
1	Reduced Speed Loss	156,2	48,69	48,69
2	Breakdown Loss	88,3	27,53	76,22
3	Idling and Minor Stoppage Loss	66	20,57	96,80
4	Quality Defect Loss	10,28	3,20	100,00
5	Setup and Adjustment Loss	0	0,00	100,00
6	Reduced Yield/Scrap Loss	0	0,00	100,00
	Total	320,78		

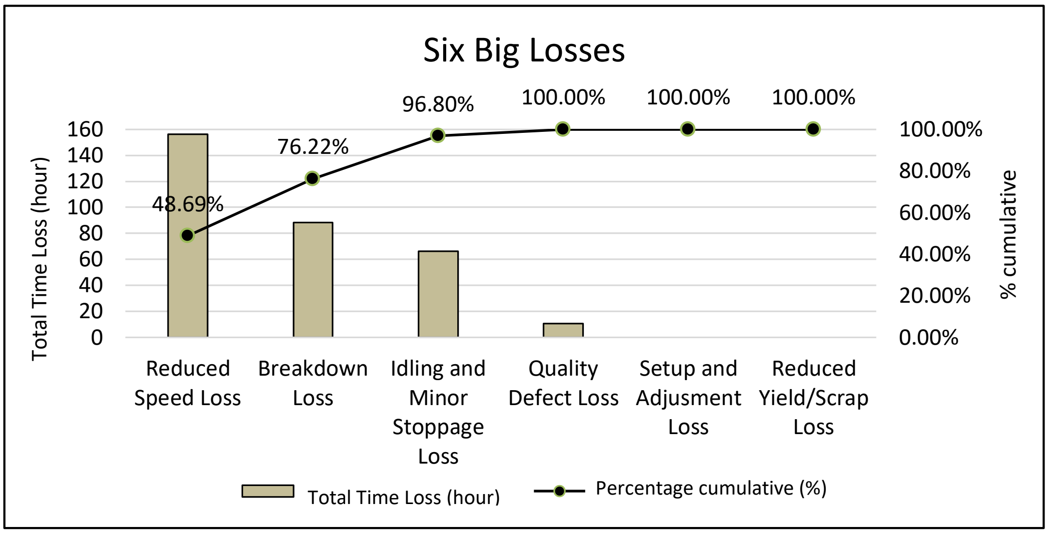

Figure 1: Pareto diagram Percentage of factors Six Big Losses Machine fanuc Line I.

4. Conclusion

The results of this study can be concluded that:

Based on the results of Overall Equipment Effectiveness (OEE), the value of the availability rate is 93.39%, the performance efficiency rate is 80.84%, the rate of quality is 98.92%, and the OEE value is 74.50%, which is still below JIPM's standard of 85%, from low OEE is influenced by the performance efficiency value of 80.84%.

From the calculation of the value of Six Big Losses, the biggest factor affecting Fanuc Line I engine effectiveness is reducing speed loss with an average value of 18.05%, followed by a breakdown loss of 6.62%.

Proposals or recommendations for improvements to improve machine effectiveness Fanuc Line I include: 1. Providing training to operators about machine performance; 2. Cleaning the work area before and after the production process and implementing 5S; 3. Optimizing preventive maintenance; 4. Need to be added to the operator in the maintenance section; 5. Procurement of stock tools and other machine components must be in accordance with the needs.

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