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Implementation of the PDCA Cycle with Overall Equipment Effectiveness (OEE) In Machining Companie

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ABSTRACT

This research was conducted in an industry engaged in Machining. The downtime target is set at 10.47 minutes per day for all production machines used with the lowest downtime on CNC machines. The PDCA cycle was applied in this researc through the OEE approach. Method selection Performance measurement is very important for company to achieve goals company. As for one method performance measurement that is widely used by companies, especially have a lot implemented by Japanese companies capable of solving problems equipment, namely the Overall Equipment Effectiveness/OEE. The formulation of the problem in this study is the occurrence of large downtime on CNC machine. This study aims to analyze the root causes that cause the level of effectiveness of CNC machine using the Six Big Losses analysis, then the proposed improvements that can be implemented by the company to increase the OEE value on the CNC machine. The results of this study are: Overall Equipment Effectiveness (OEE) obtained on CNC which is equal to 57%, the average value of the Availability Rate ratio is 95%, the average value of the Performance Rate ratio is 60%, the average value of the Rate of Quality ratio is 100%. Using the Six Big Losses approach and analyzing it using the Pareto Diagram method, Reduce Speed Losses with a result of 67%. This Reduce Speed Losses factor is analyzed using a cause and effect diagram (Fishbone Diagram) and Root Cause Effect Analysis (RCFA) and the 5W + 1H method as a proposed improvement given to the company.

Keywords: PDCA, OEE , maintenance, Six Big Losses, CNC

1.INTRODUCTION

This increasingly high competition also requires companies to be able to operate with maximum productivity through the implementation of various production optimization strategies in addition to the right brand and marketing strategy to win the competition [1]. Maintenance is a function in a manufacturing company that is as important as other functions such as production. Maintenance activities are focused on maintaining facilities and equipment that can support the smooth running of the production process, especially by reducing bottlenecks or even none at all. Thus, the resulting product can be delivered to the customer on time [2].

This research was conducted at a company engaged in Machine Works. Which produces semi-finished goods in the form of Oil Pump Casing belonging to one of the companies. There are 3 production lines namely Mass Production, made by order, and fabrication processes with the main machines namely: CNC machines, and milling machines. Line 1 works on the turning process of pump casing products to produce pump casing products according to the size requested by the customer. The process that occurs on machine 1 is turning the outer front of the product to a predetermined size, then for machine 2 it is turning on the inside up to a predetermined size, then on machine 3 it is turning on the top and bottom of the product until it is according to the size that has been determined, and on the fourth machine that is working on the

milling process or making holes on the front side of the product. The downtime target was set at 10.47 minutes per day for all machines in line 1. However, in reality, the downtime generated by production machines is still far from the target set, especially on CNC machine number 3. This has resulted in the achievement of production output, especially on machines line 1 often does not meet the target. The downtime data that occurred can seen in Figure 1 below.

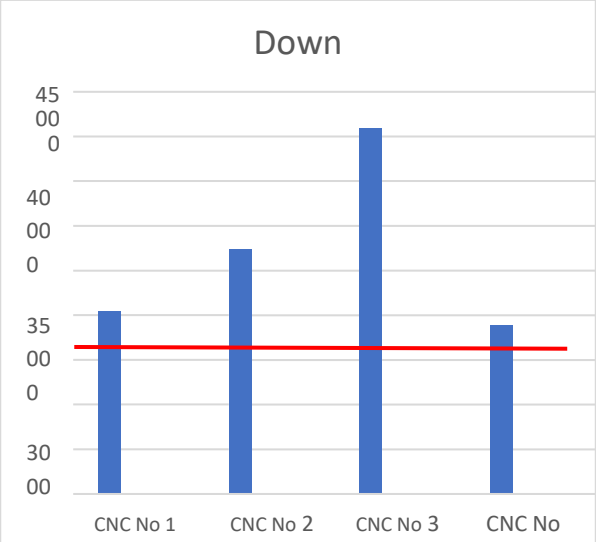

Fig 1 : Downtime Machines

The stages in the PDCA cycle are detailed in several stages, namely [3] :

1. Develop a plan/Plan
2. Carry out the plan/Do
3. Checking or examining the results achieved /Checck
4. Perform adjustment actions when needed (Action)

Fishbone Diagram is a visual tool to identify, explore, and graphically describe in detail all the causes associated with a problem. The basic concept of the Fishbone diagram is that the fundamental problem is placed on the right side of the diagram or on the head of the fishbone framework. The (OEE) method is a method commonly used to measure the level of performance of an existing production system and to find out the reasons for the low level of machine effectiveness [4]. This study aims to analyze the root causes that cause the level of effectiveness of the No. CNC machine. 3 using the Six Big Losses analysis, then the proposed improvements that can be implemented by the company to increase the OEE value on the No. CNC machine. The OEE value for both the manufacturing and service industries is heavily influenced by human factors, tools and systems [5]. The factor that affects the performance or the biggest loss of the grinding machine is the Quality Ratio caused by the Startup reject and Reject that occurs on the machine [6].

2.RESEARCH AND METHODOLOGY

Data collection methods used in this study are [7]:

1. Observation. This observation was carried out by researchers acting as outsiders, with the aim of understanding and exploring the problems that occur with CNC Machine as one of the production tools in the company.
2. Interview. Interview technique is one way of collecting data in research, ecause it deals with data, interviews are an important element in the research process
3. Literature review. Literature study is a method that is carried out by quoting or using references from literature studies to obtain supporting information according to the issues discussed.

Data processing is carried out with the following steps

The Plan Stage:

1. Calculation of Availability.
2. Performance Calculation. Performance is the ratio of product quality produced multiplied by the ideal cycle time to the time available for carrying out the production process (Operation Time).
3. Calculation of Rate Of Quality.
4. Calculation of OEE
5. Calculation of Six Big Losses. The purpose of calculating Downtime Losses, Speed Loss, and Defect Losses is to determine the overall effectiveness value of OEE. From this OEE value, steps can be taken to improve or maintain that value [8].
6. Pareto Diagrams and Cause Effect Diagrams. The input used must be adequate, in this case valid in terms of source, quantity and validity and able to provide results that can represent problems in real conditions [9].

The Do Stage

7. Root Cause Failure Analysis. After analyzing using Pareto Chart and Fishbone Diagram, this method is used to find the most dominant root causes from the results of fishbone diagram analysis [10].

The Check Stage

8. The analysis is carried out on the calculation results of Availability, Performance, Rate Quality Of Product, OEE and Six big Losess consisting of Breakdown losses / Equipment failure, Set-Up and adjustment losses , idling and minor stoppages losses, Reduced speed losses, Process defects , Reduce yield Loses [11] .

The Action Stage

9. In the action stage, quality control results are stored to prevent the recurrence of the same problem and minimize the number of failures in the future by setting standards for the company after improvement [12]

4. DATA COLLECTION AND PROCESSING

4.1. The Plan Stage : Machine Run Time Data

The data taken includes working time, downtime, reject product, good product, ideal cycle time, and others [13]. Machine working time data can be seen in Table 1 below :

Table 1 The working time of the machine

No	Machining Time (Second)	No	Machining Time (Second)
1	32.000	14	23.300
2	21.000	15	30.400
3	30.400	16	34.000
4	32.100	17	33.000
5	35.000	18	35.400
6	30.000	19	20.800
7	30.400	20	33.500
8	22.000	21	32.600
9	29.000	22	36.000
10	26.800	23	33.400
11	33.400	24	29.800
12	35.000	25	22.600
13	26.800	26	32.800

Machine downtime data can be seen in Table 2 below :

No	Total Downtime (Second)	No	Total Downtime (Second)
1	1495	14	1684
2	1430	15	1696
3	1491	16	1743
4	1403	17	1646
5	1534	18	1659
6	1581	19	1654
7	1587	20	1685
8	1403	21	1674
9	1493	22	1684
10	1469	23	1790
11	1464	24	1754
12	1445	25	1479
13	1462	26	1498

Table 2.Total Machine Downtime

Planned Downtime is the time to check the machine, which is 25 minutes (1500 seconds)/day. The time is obtained from the results of interviews with operators. In this study the ideal cycle time for one production. Data obtained from interviews with operators. Where can be obtained a time of 1036 seconds per pcs.

Data Processing

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Data processing is done by calculating :

1. Loading Time = Machining Time – Planned Downtime
2. Operation Time = Loading Time – downtime
3. $$\text{Availabilty} = \frac{\text{Operating time}}{\text{Loading Tine}} \times 100\%$$
4. $$\text{Performance} = \frac{\text{Processed amount} \times \text{Cycle Time}}{\text{Operation Time}} \times 100\%$$

5. Rate of Qualkity =
   Processed amount – Deffect amount x 100%
   Processed amount
6. Overall Equipment Effectiveness (OEE) value = Availability x Performance x Quality
   The results of the OEE calculation can be seen in Table 3 below :

Table 3. OEE Calculation

No	*Availability (%)*	*Performance %()*	ROQ (%)	OEE (%)
1	95	42	100	40
2	93	55	100	51
3	95	42	100	40
4	95	56	100	53
5	96	57	100	55
6	95	49	100	47
7	95	53	100	50
8	93	61	100	57
9	95	52	100	49
10	95	64	100	61
11	95	49	100	47
12	96	53	100	51
13	95	64	100	61
14	92	73	100	67
15	95	67	100	64
16	94	64	100	60
17	95	63	100	60
18	95	60	100	57
19	92	79	100	73
20	95	60	100	57
21	95	74	100	70
22	95	57	100	54
23	94	68	100	64
24	94	65	100	61
25	93	78	100	73
26	95	64	100	61

7. Calculation of six big losses consists of :
   a. Downtime Losses.Downtime Losses are time losses caused by machines not operating while production activities are in progress. With this loss, production activities are hampered, due to equipment damage or machine setup.

   b. **Equipment Failure Losses** =
   Downtime x 100%
   Loading time
   Set Up & Adjusment Losses =
   Set Up Time x 100%
   Loading Time

   c. Speed Losses, are time losses when the machine is operating, but the machine does not operate at the standard speed that has been planned.
   Idling and Minor Stoppage Losses (IMSL). This is a loss caused by the machine stopping for a moment.
   IMSL = Non Productive Time x 100%
   Loading timne
   Reduced Speed Los (RSL) is a loss that occurs due to a decrease in engine speed so that the machine cannot operate optimally.
   RSL =
   Operation time-(Cycle Time x Production total)x100%
   Loading Time

   d. Quality Losses, are loss caused by production machines producing products but not in accordance with the standard specifications of the company.
   Defect Losses, are due to production products where these products have deficiencies (defects) after leaving the production process.
   Defect Losses
   = ideal cycle time x total deffect x 100%
   Loading Time
   Reduced Yield Losses. Losses at the beginning of the production time until it reaches a stable condition. losses resulting from a situation where the product produced is not up to standard, because there is a difference in quality between when the machine is first turned on and when the machine is stable in operation.
   Reduced Yield =
   Ideal Cycle Time x
   Ideal cycle time x total p deffect x 100%
   Loading time

Percentage Results on Six Big Losses
After calculating the Six Big Losses, the next step is to calculate the total time losses from the value of each factor in the Six Big Losses [14]. The

results of the Overall Equipment Effectiveness (OEE) value obtained Table 4.

Table 4. Total Time Losses CNC Machine 3

No	Six Big Losses	Losses Time Total (Second)	%	Cumulative
1	Reduced Speed Losses	979,97	67	67
2	Equipment Failure Losses	146,84	10	77
3	IMSL	175,34	12	89
4	SU & AL	168,59	11	100
5	Defect Losses	0	0	100
6	Reduced Yield Losses	0	0	100

Based on the Six Big Losses calculation above, it can be seen that the biggest losses are due to the low Overall Equipment Effectiveness value on CNC machine No. 3 is reduced speed losses with a presentation of 67.

Fishbone Diagram.

There are several causes that result in a low OEE value, namely the availability rate, performance rate, and quality rate . The main factor that causes the low OEE value is the existing Performance Rate, after knowing the Total Time Loss it can be concluded that Reduced Speed Loss is the most dominant loss among other losses. The causes are analyzed using a cause-and-effect diagram which is categorized into 5

categories, namely machine, man, material, method, and environment [15]. Figur 2 below is the root cause of reduced speed loss.

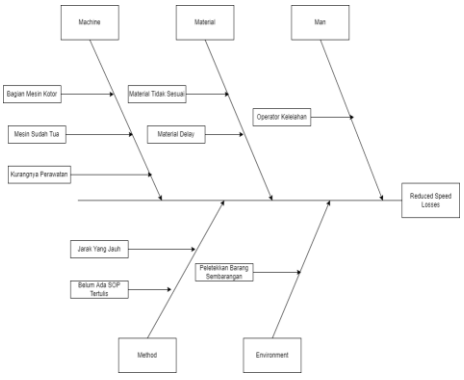

Fig 2 : Cause-Effect Diagram of Low OEE Value of CNC Machine

4.2. The Do Stage

Root Cause Failure Analysis Approach

Furthermore, the causes factored by the machine were analyzed again using RCFA [16] with the 3 why's analysis model which can be seen in the Table 5 follows.

Table 5. *Root Cause Failure Analysis* Mesin *CNC* 3

Factor	Why 1	Why 2	Why 3
Machine	The engine is dirty because there is a lot of dross left over from turning	he axis or the arm of the machine is disturbed due to the dross of the remaining turning	Machine operators clean the dross once a week
	Machines that have been used for too long	The level of engine performance is not too optimal anymore	It takes a long time for one turning process product

4.3.The Check Stage

Proposed Improvements can be seen Table 6 below :

Table 6. Proposed Improvements

Factor	What	Why	Where	When	Who	How
Machine	Dirty Machine Parts	Dross from the rest of the scattered material	CNC machine No 3	Every Production Process Has Been Completed	Operator	Clean the side parts of the machine and also on the front of the machine drill bit from dross and waste material.
Man	Old machine	Age of the machine is too long so that production cannot maximum	CNC machine No 3	Production time	Production manager	Recalculating production capacity so that the machine does not work excessively
Method	Less of maintenan	Maintenance Is Done Only	CNC machine No 3	After maintenance schedul	Operator	Implement planned maintenance, such as:

	ce	During Breakdown		e		Perform routine and periodic checks on CNC machines.Maintain the condition of the facilities used on a scheduled basis so that the equipment is not easily damaged.
	Distance between Far Enough Machine	The layout of production machines that are still not organized with neat	Production area	When production layout relayout	Production Manager	Re-layout of the production machines used
Material	Material Not In Accordance With Machine Specifications	Material Not In Accordance With Machine Specifications. The material does not match the specifications of the machine used	CNC machine	Materoial selection	Production manager & operator	Controlling operators to process products with materials according to machine specifications /material selection before processing production.
	Delay in availability of raw material	Material documents less regularyty	Production area	During the procurement process & material	Staff PPIC	Checking the ordering of raw materials and also their delivery, so that no delay occurred.
Environment	Laying semi-finished goods that are not on place	Processed products are laid haphazardly	Production area	When relayout production layout Production	Production manager	Provides a special place beside the machine to place products that have been processed so that they look neater. (reset layout production site)

4.4.The Action Stage

At the action stage, the things that were done can be are :

1. Make a schedule for cleaning the machine from adhering dirt
2. Recalculating production capacity so that the machine does not work excessively
3. Implement planned maintenance, such as perform routine and periodic checks on CNC machines. Maintain the condition of the facilities used on a scheduled basis so that the equipment is not easily damaged.
4. Re-layout of the production machines used
5. Material selection before processing production.
6. Checking the ordering of raw materials and also their delivery, so that no delay occurred
7. Provides a special place beside the machine to place products that have been processed so that they look neater. (reset layout production site)

4. CONCLUSSION

After processing data and analyzing CNC Machine No. 3 with the Overall Equipment Effectiveness (OEE) method and the Six Big Losses (SBL) Approach, then it can be concluded as follows :

1. The Availability Rate percentage value is 95%, the Performance Rate percentage value is 60%, and the Rate of Quality ratio percentage value is 100%. Thus the average value of OEE was 57%. In this category, the value of the machine in production performance is considered reasonable and there is still room for improvement to bring the production process to world class with an OEE value of 85%.
2. After further calculating and analyzing the Six Big Losses associated with the low OEE,obtained one of the factors, namely Reduced Speed Loss. With the value of Reduced Speed losses itself is 67%.

3. In the analysis using a causal diagram (fishbone diagram) with the problem of Reduced Speed losses that appears, it is found that the influencing factors are as follows:
   a. Machine: Dirty engine parts, Old machines, and Lack of maintenance
   b. Man: Operator fatigue and Inexperience
   c. Method: Standard Operating Procedures that are already obsolete
   d. Material: Material does not comply with machine specifications and delayed raw materials
   e. Represents losses caused by damage to machinery and equipment.
   f. Set up & Adjustment Losses. This is a loss that occurs because after the setup is done, the equipment/machine is damaged and because of the stolen time, the setup time is long.

The recommended improvements are as follows :

1. After finishing processing the product, the operator immediately cleans up the dross-dross resulting from turning. In order not to interfere with machine performance, reduce production capacity per day, so that the risk of disruption to the machine can be reduced, and inspect periodically and apply Planned Maintenance at least once a month to the production machines used.
2. Implementation of a work shift system will be more optimal in reducing the occurrence of overtime work which causes operator fatigue and Provides an understanding of how to operate CNC machines used during the production process.
3. Create Standard Operating Procedures according to existing machine specifications, so that operators can operate these machines properly and correctly and Relay out or re-layout the production machines used in line 1. So that the distance between the machines can be closer and can optimize the production process.
4. Conduct regular evaluation of raw material inventories and also carry out significant control over the production process and carry out control over the ordering of raw materials and also their delivery, so that there are no delays.
5. Creating special storage to place products that have been processed so that they are scattered and also to place the tools needed for the production process.

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