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Overall Equipment Effectiveness Analyse for Performance of CNC Milling Machine Operation

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Abstract

Overall equipment efficiency (OEE) is a large part of the maintenance system used by Japanese companies; Total Productive Maintenance (TPM). The value of OEE is affected by the often problematic production activities in machinery/production equipment such as damage to machine

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Abstract. Overall equipment efficiency (OEE) is a large part of the maintenance system used by Japanese companies; Total Productive Maintenance (TPM). The value of OEE is affected by the often problematic production activities in machinery/production equipment such as damage to machine components resulting in reduced production, lowering engine production speed, preparation length and adjustment time, resulting in defective products and operating machines but not producing products. This paper will focus on the overall equipment efficiency of CNC Milling machine. The indicators of data parameter are used planned downtime, ideal cycle times, real-time cycles and daily operator reports (daily schedule controls) and direct data retrieval in the field. Where OEE calculation depends on availability, performance of efficiency, and rate of quality. The result has shown that the value of availability is 87%, performance of efficiency is 93% and OEE is 74%.

1. Introduction

The automotive and steel industries use several heavy equipment and control component in facilitating the transportation of components [1-2]. Roller, tube, excavator, etc. include heavy equipment that were often used in handling of component on production line, where heavy equipment and components which produced by machining and casting process [3-6]. For controlling the quality and movement component, it can be done by using PLC, microcontroller and other control system [7-8]. Machining process was requires machine tools such as lathe, milling machine, shape machine, CNC milling machine, drilling machine and other auxiliary equipment [3]. All types of machines and equipment require regular maintenance and repair. The routine of maintenance schedule or repairing process is sometimes could not come and touching the cause of machine utility. This might be affected to the quality and quantity of products. For this reason, the proper use of maintenance in the case of machine tools and auxiliary equipment should applied to meet the quality and quantity of products based on standard [9]. Use of routine maintenance in periodic maintenance scheduling and checking the state of each component in the machine tools (prevention and prediction) so that the improvements can be made to the efficiency of machine tools.

The proposed improvements to machine tools are expected to be implemented effectively and efficiently. Effective and efficient improvements can be made by measuring machine performance and production equipment in the form of overall equipment effectiveness (OEE) [10]. Overall equipment efficiency (OEE) is a large part of the maintenance system used by Japanese companies, total maintenance productive (TPM) [11]. The value of OEE is affected by the often problematic production activities in machinery/production equipment such as damage to machine components resulting in reduced production, lowering engine production speed, preparation length and adjustment time, resulting in defective products and operating machines but not producing products.

This paper will focus on the effectiveness of the entire equipment of weight-bearing activities using the CNC Manufacturing process. The indicators are used the data on planned downtime, ideal cycle times, real-time cycles and daily operator reports (daily schedule controls) and direct data retrieval in the field. Where OEE calculation depends on availability, performance of efficiency, and rate of quality. The value of OEE for each company will meet the world-class standards if they meet the following criteria: 90% availability, 95% performance, 99.9%, quality, so that the average world class standard is 85% OEE.

2. Method

Experimental method is used in this research. Collected data by measurement time of operation process of CNC Milling machine. Analysis data has done by calculated the overall equipment effectiveness (OEE) depend on the time of processing process of product such as work time, delay time, breakdown time (maintenance time), downtime (set up time and adjustment time), availability value (loading time, down time, operation time), cycle time, normal time, standard time, performance efficiency, rate quality and overall equipment effectiveness (OEE).

Calculation of OEE depend on availability, performance efficiency and rate of quality. Calculation formula of OEE can be seen by Equation 1.

$$\text{OEE (\%)} = \text{Availability (\%)} \times \text{Performance efficiency (\%)} \times \text{Quality rate (\%)} \quad [1]$$

Where:

Availability is:

$$\text{Availability} = \frac{(\text{loading time} - \text{downtime})}{\text{loading time}} \times 100\% \quad [2]$$

Performance of efficiency is:

$$\text{Performance efficiency} = \frac{Processed\ amount\ x\ ideal\ cycle\ time}{operation\ time} \times 100\% \quad [3]$$

And rate of quality is:

$$\text{Rate of Quality} = \frac{(processed\ amount - defect\ amount)}{processed\ amount} \times 100\% \quad [4]$$

3. Results and Discussions

In data processing in the overall Equipment Efficiency Survey (OEE) research, data has been collected on CNC Manufacturing machines such as planned leisure data, ideal cycle times, actual cycle times and daily operator reports (daily schedule controls) and direct data retrieval in field.

3.1 Production data of door 3 Assy.

Data production of door 3 assy can be seen in Table 1. Table 1 shows that the total product, gross product and defect for 1 year. As shown in Table 1, the total of gross product is 1101 pieces and defect product is 90 pieces. Product defects depend on 71 pieces rework and 19 pieces scrap.

3.2 Work time and delay time of machine

Availability work time data depend on total work day/month and total work time per day (24 hours). Availability work time can be calculated by formula:

Availability time/month = Total Work D/M x Total Work Time (h) x Time (min)
Availability time/month = 21 day/month x 24 h x 60 min
Availability time/month = 30240 minute

Total annual data can be seen in the Table 2.

Table 7. Normal and standard time of CNC Milling machine operation for annual year

Month	Work element	Cycle Time (minute)	Rating Factor	Normal Time (minute)	Allowance	Standard Time (minute/unit)
March	CNC Milling Machine Operation	123,09	0,15	141,55	22,00%	172,69
Apr		123,36	0,15	141,86	22,00%	173,07
May		123,91	0,15	142,50	22,00%	173,85
Jun		123,08	0,15	141,54	22,00%	172,68
Jul		122,70	0,15	141,11	22,00%	172,15
August		122,77	0,15	141,19	22,00%	172,25
Sept		123,42	0,15	141,93	22,00%	173,16
Oct		123,58	0,15	142,12	22,00%	173,38
Nov		124,44	0,15	143,11	22,00%	174,59
Dec		120,40	0,15	138,46	22,00%	168,92
Jan		123,04	0,15	141,50	22,00%	172,63
Feb		122,41	0,15	140,77	22,00%	171,74

Whereas:

$$\text{Operating speed rate} = \frac{\text{Ideal cycle time}}{\text{Actual cycle time}} \text{ x } 100\%$$

$$\text{Net Operating rate} = \frac{\text{Processed amount x actual cycle time}}{\text{operation time}} \text{ x } 100\%$$

Normal time can be calculated by:

$$\text{Normal Time} = \text{Observation time x } \frac{\text{Rating factor \%}}{100\%}$$

$$\text{Normal Time} = 123{,}09 \text{ minute x } (1+\frac{15}{100})$$

$$= 141{,}55 \text{ minute}$$

Table 7 shows that the value of normal and standard time of CNC Milling machine operation for annual years.

Standard time or ideal cycle time for March is:

$$\text{Standar time} = \text{Normal time x } \frac{100\%}{100\% - \text{Allowance \%}}$$

Standar time = 141, 55 minute x (1+0, 22)

Standar time = 172, 69 minute/unit

Calculation on actual cycle time for March is:

$$\text{Actual cycle time} = \frac{\text{Operation time}}{\text{Processed amount}}$$

$$\text{Actual cycle time} = \frac{20.238 \text{ minute}}{106 \text{ unit}}$$

Actual cycle time = 190,92 minute/unit

Calculation value of actual cycle time, performance efficiency, and quality rate for annual year can be seen at Table 8.

Than calculation of performance efficiency for March is: 74%

$$\text{Performance efficiency} = \frac{\text{Processed amount x ideal cycle time}}{\text{operation time}} \text{ x } 100\%$$

$$\text{Performance Efficiency} = \frac{106 \text{ unit x } 172{,}69 \text{ minute/unit}}{20.238 \text{ minute}} \text{ x } 100\% = 0, 90$$

Average of performance of efficiency is 0.87.

And rate of quality for March is found by using the formula:

$$\text{Rate of Quality} = \frac{(processed\ amount - defect\ amount)}{processed\ amount} \text{ x } 100\%$$

$$\text{Rate of Quality} = \frac{(106\ unit - 8\ unit)}{106\ unit} \text{ x } 100\%$$

Rate of Quality = 0, 92

Tabel 8. Calculation of actual cycle time and performance Efficiency for annual year

No	Month	Operation time (minute)	Processed Amount (unit)	Defect (Unit)	Actual Cycle Time (minute/unit)	Ideal Cycle Time (minute/unit)	Performance Efficiency	Rate of Quality	OEE (%)
1	March	20.238	106	8	190,92	172,69	0,90	0,92	0,78
2	Apr	20.189	102	7	197,94	173,07	0,87	0,93	0,76
3	May	19.044	95	9	200,46	173,85	0,87	0,91	0,72
4	Jun	21.062	100	6	210,62	172,68	0,82	0,94	0,71
5	Jul	15.088	81	8	186,27	172,15	0,92	0,90	0,76
6	August	21.057	97	7	217,08	172,25	0,79	0,93	0,68
7	Sept	20.184	104	9	194,07	173,16	0,89	0,91	0,76
8	Oct	20.131	99	7	203,35	173,38	0,85	0,93	0,73
9	Nov	21.025	88	12	238,92	174,59	0,73	0,86	0,58
10	Dec	19.203	106	6	181,16	168,92	0,93	0,94	0,82
11	Jan	20.212	110	5	183,74	172,63	0,94	0,95	0,83
12	Feb	19.145	103	6	185,87	171,74	0,92	0,94	0,80
Average							0,87	0,92	0.74

3.6 Calculation of Overall equipment effectiveness (OEE)

Ideal condition of OEE is:

1. Availability ≥ 90%
2. Performance Efficiency ≥ 95%
3. Rate of Quality ≥ 99%

Formula for OEE is:

OEE (%) = Availability (%) x Performance efficiency (%) x Quality rate

Calculation OEE for March is:

OEE (%) = Availability (%) x Performance efficiency (%) x Quality rate (%)

OEE = 0, 93 x 0, 90 x 0, 92

OEE = 78%

Average value of OEE is 0.74 and for annual year can be seen at Table 8.

4. Conclusions

From the data processing result with the calculation of availability, performance efficiency, and quality rating, overall equipment effectiveness value (OEE) for annual years can be determined, 74%. Based on the ideal value standard of the Japanese Plant Maintenance Institute (JIPM) is 85%, the value of OEE 74% is considered as reasonable, but indicates that there is substantial space for improvement. The OEE 74% value should be increased by 11% so the production is considered as world class. There are three factors that affect the value of OEE, there are as follows: the value of CNC Milling Machine availability is 93%, the performance of efficiency value of CNC Machining machine is 87% and CNC Milling machine rate of quality is 92%.

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