ADVANCEMENT OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) IN MACHINING PROCESS INDUSTRY

Rasheen Rasheed[1], Shaheen Rasheed[2]

[1]Bachelor Student, Department of Mechanical Engineering,
[2]Bachelor Student, Department of Electronics and Communication Engineering,
[1,2]KPR Institute of Engineering and Technology, Coimbatore, India.

ABSTRACT

Machining is an important process which is carried out in manufacturing industry. Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The manufacturing industry has been experiencing a competitive environment and striving hard to find methods to improve quality, efficiency and productivity. In order to attain all these aspects, the organization should introduce a maintenance system continuously. OEE is one of the performance evaluation methods that are most common in the production industries. In a manufacturing industry, the layout and material flow in the shop floor decides its productivity. To such a great extend the entire utilization of OEE would possibly results in large productivity.

This project work has been carried out as a case study in a machining industry with the objective of reducing the idle time. The problems in the current shop floor are identified there by made a layout and analyzed through simulation. Then the problems which affect the machine efficiency are identified and corrective solutions are implemented. Then with those details the layout is modified, simulated and the results are compared with the current layout. The results revealed an improvement of 4.13% in productivity, which had reduced the cycle time.

Keywords: Idle time; Quality improvement; Major Losses; Manufacturing performance; Overall Equipment Effectiveness; Planning.

1. INTRODUCTION

OEE is an abbreviation for the manufacturing metric Overall Equipment Effectiveness. OEE (Overall Equipment Effectiveness) is a performance metric compiled from three data sources of the machine (or Process) being measured. The three data sources are Availability, Performance and Quality. After the various factors are taken into account the result is expressed as a percentage.

Overall equipment efficiency or effectiveness (OEE) is a hierarchy of metrics proposed by Seiichi Nakajima [1] to measure the performance of the equipment in a factory. OEE is a really powerful tool that can be used also to perform diagnostics as well as to compare production units in differing industries. The OEE has born as the backbone of Total Productive Maintenance (TPM) and then of other techniques employed in asset management programs, Lean manufacturing [2], Six Sigma [3], and World Class Manufacturing [2]. By the end of the 1980's, the concept of Total Production Maintenance became more widely known in the Western world and along with it OEE implementation too. From then on an extensive literature made OEE accessible and feasible for many Western companies and then to the whole part of the world.

2. THE ORGANISATION

The name of the MNC in which the project study is carried out is not discussed and displayed, because of confidentiality. It is an AS9100 certified Indo-American joint venture factory based in Bangalore. The company was developed to produce complex machined turbine engine parts using proven, high-end quality and production systems.

The company is a dynamic supplier of high-quality precision machined components. High quality control is introduced with in-process inspection and monitoring systems being exactly specified for critical dimensions. Complex machining is processed with high tolerance.

3. OVERALL EQUIPMENT EFFECTIVENESS (OEE)

3.1 Objective

The objective of the work is to reduce the idle time of the machine by calculating performance, quality and effectiveness. These three factors are identified by preparing a time sheet for each machine and generated OEE percentage for which the idle time has to be reduced. Rather this would aid to achieve minimum breakdown and to keep the plant in a good working condition at the lowest possible cost. To keep the machine and other facilities in such a condition that permits them to be used at their optimal capacity without interruption.

3.2 OEE

The Effectiveness of the equipment is the Actual Output over the Reference Output. Equipment Effectiveness shows how effectively equipment is utilized. Overall Equipment Effectiveness shows the effectiveness of a machine compared to the ideal machine as a percentage.

OEE = Availability X Performance Rate X Quality Rate.

Availability = Run Time / Planned Production Time.

Performance = (Ideal Cycle Time × Total Count) / Run Time.

Quality = Good Count / Total Count.

3.3 Machining Process:

The machining process carried out in these machines are turning, drilling and milling. There are different components machined in those machines in which these processes are involved. In fact the shapes and material used are different it is difficult to predict the exact production to be achieved in time. So by calculating OEE, it is possible to calculate the exact production rate for each component there by introducing new plans or improved methods it is possible to improve the production rate and machine efficiency. While considering a single job there are different operations carried out which utilize every machines in the shop floor. A step by step planning is processed accordingly the machining is carried out. There by for each process fixed time is allocated. By the end of each process inspection is carried out.

Figure 1. Machined Component

3.4 Inspection

Inspection and dimensional measurement of machined parts plays a vital role in manufacturing. Machined parts are inspected too much tighter tolerances in order to achieve the highest quality finished products.

On a linear step basis the inspection is carried out. Initially the first inspection is carried out over the raw material. Using the swing gage the raw material part is checked for the matching tolerance to be required. After attaining a positive result the raw material to be machined is taken to the machine and took place the machining process. After machining before disengaging the part from the fixture it is waited for the second inspection. After then to get the accurate geometric tolerance and dimensions the machined part is taken to CMM which is the third level of inspection.

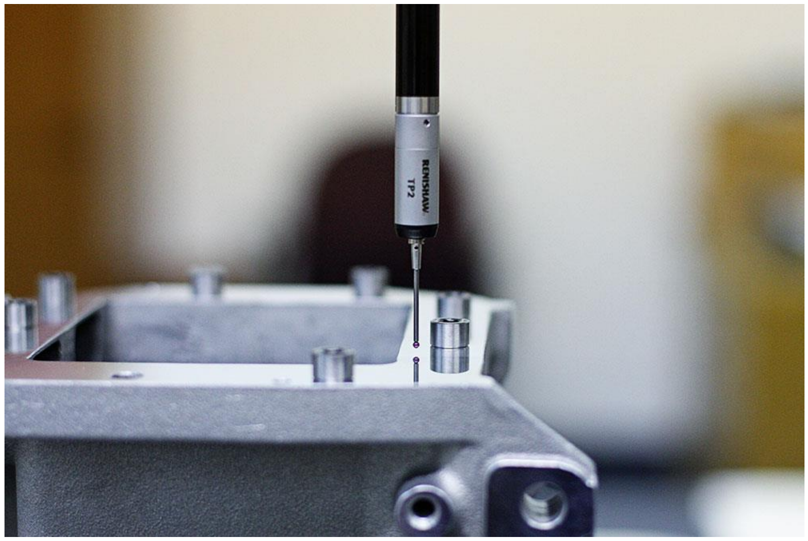


Figure 2. CMM Inspection

METHODOLOGY

3.5 Idle Time

Idle time is non-productive time (during which an employee is still paid) of employees or machines, or both, due to work stoppage from any cause. It is also called waiting time, allowed time, or downtime. The machine at the shop floor considered or analyzed to reduce the idle time by the method of OEE are listed below,

1. TC2
2. VMC 01
3. TC1

3.6 Time Study

Time study is defined as a work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance. A time study has been carried out for all the machines listed by direct observation method and the observed data listed in Table 1. The time sheet includes the machine name, time details, activity carried out, part description and remarks. OEE is calculated for 15 days, there by a time sheet have been generated for 15 days.

3.7 Machine Utilization Table

From the time sheet the time utilized for each specific task are identified. The time utilized for each task are noted down and then compared with the allotted total time there by machine utilization percentage is calculated. A detailed collection of data's have displayed in table.04 for 15 days. The time used for doing multiple operations is calculated and from those timing the machine utilization rate is calculated.

Table 01. Machine Utilization sheet

S. no.	Date	Machine Name	Total Time (min)	Machine Running Time	Work Setting Time	Inspection Time	Maintenance Time	Machine Utilization
1	1-07-16	VMC 01	680	420	75	170	15	72.8%
2	1-07-16	TC-1	780	600	110	45	25	91 %
3	1-07-16	TC-2	780	585	150	25	20	94.2%
4	2-07-16	VMC 01	480	240	160	21	10	83%
5	2-07-16	TC-1	750	435	240	60	15	90%
6	2-07-16	TC-2	660	275	60	295	30	50.7%
7	4-07-16	VMC 01	480	245	160	16	10	84%
8	4-07-16	TC-1	460	202	55	37	20	74%
9	4-07-16	TC-2	460	280	23	16	20	72%
10	5-07-16	VMC 01	450	147	85	140	30	51%
11	5-07-16	TC-1	460	265	90	65	10	77%
12	5-07-16	TC-2	480	280	25	10	30	71%
13	6-07-16	VMC 01	480	300	115	20	15	86%
14	6-07-16	TC-1	630	490	40	30	15	84%
15	6-07-16	TC-2	630	440	130	25	30	90%
16	7-07-16	VMC 01	480	180	45	185	15	60%
17	7-07-16	YCM TC-1	480	360	35	20	15	82%
18	7-07-16	YCM TC-2	540	370	60	40	30	85%
19	8-07-16	VMC 01	510	240	70	105	15	74%
20	8-07-16	YCM TC-1	450	400	30	10	10	95%
21	8-07-16	YCM TC-2	540	350	80	35	30	80%
22	9-07-16	VMC 01	480	230	85	95	15	72%
23	9-07-16	YCM TC-1	510	385	20	30	30	80%
24	9-07-16	YCM TC-2	450	365	20	50	15	81%
25	11-07-16	VMC 01	480	280	25	10	30	71%
26	11-07-16	YCM TC-1	1020	700	75	15	15	76%
27	11-07-16	YCM TC-2	660	210	150	60	20	54%
28	12-07-16	VMC 01	480	180	45	185	15	60%
29	12-07-16	YCM TC-1	660	200	85	360	15	43.1%
30	12-07-16	YCM TC-2	630	490	40	30	15	84%

Calculation

Total time = 8hr for one shift.

$= 8 \times 60$

= 480min
Machine running time = Time utilized by machine for machining.
Work Setting Time = Time required for setting the fixture and other components.
Inspection Time = Time utilized for checking the dimensions
Machine Utilization = (Machine running time + Work Setting Time) / Total time
= (600+110) / 780
= 91.02%
= (245+160) / 480
= 84%

3.8 OEE Calculation for Each Machine

For each machine OEE is calculated and related to find the variation in effectiveness of working. To calculate OEE, some range of working dates have taken and then the data's collected in those dates are noted and calculated to find the average of Overall Equipment Effectiveness.

Calculations

Total production Achieved = Calculated from Time Sheet
Total Target Production = Estimation by the Organization
Machine Utilization = (Machine running time + Work Setting Time) / Total time
Total Ok Production = Components machined with no defects
Performance = Total Production Achieved / Total Target Production
Availability = Total Machine hours utilized / Total Machine hours available
Quality = Total OK Production / Total Production Achieved.

1. For Machine VMC 01:

Total production Achieved = 8
Total Target Production = 10
Total Ok Production = 8
Performance = (8 / 10) × 100 = 80%
Quality = (8 / 8) × 100 = 100%
Availability = (420 + 75) / 680 = 72.8%

2. For Machine YCM TC-1:

Total production Achieved = 10
Total Target Production = 11
Total Ok Production = 10
Performance = (10 / 11) × 100 = 90%
Quality = (10 / 10) × 100 = 100%
Availability = (600 + 110) / 780 = 91.02%

3. For Machine YCM TC-2:

Total production Achieved = 7
Total Target Production = 7
Total Ok Production = 7
Performance = (7 / 7) × 100 = 100%
Quality = (7 / 7) × 100 = 100%

Availability = (585+ 150) / 780 = 94.23%

For different dates OEE has been calculated for each machine separately and displayed in the table5, table6 and table7.

Table 2. OEE Calculation for machine 1

Machine VMC 01									
S. no.	Date	Total production Achieved	Total Target Production	Total Machine Utilization	Total Ok Production	**Performance**	**Quality**	**Availability**	**OEE**
1	1-07-16	8	10	72.8%	8	80%	100%	72.8%	84.2%
2	2-07-16	6	8	83%	5	75%	83%	83%	80.3%
3	4-07-16	4	4	84%	4	100%	100%	84%	94.6%
4	5-07-16	3	4	51%	3	75%	100%	51%	75.3%
5	6-07-16	3	4	86%	3	75%	100%	86%	87%
6	7-07-16	4	4	60%	4	100%	100%	60%	86.6%
7	8-07-16	4	5	74%	4	80%	100%	74%	84.6%
8	9-07-16	5	5	72%	5	100%	100%	72%	90.6%
9	11-7-16	4	5	71%	5	71%	100%	71%	83.6%
10	12-7-16	5	5	60%	5	100%	100%	60%	86%

Table 3. OEE Calculation for machine 2

Machine TC-1									
S. no.	Date	Total production Achieved	Total Target Production	Total Machine Utilization	Total Ok Production	**Performance**	**Quality**	**Availability**	**OEE**
1	1-07-16	10	11	91 %	10	90%	100%	91 %	93.6%
2	2-07-16	6	6	90%	6	100%	100%	90%	97%
3	4-07-16	7	7	74%	7	100%	100%	74%	90%
4	5-07-16	1	2	77%	1	50%	100%	77%	75.6%
5	6-07-16	7	7	84%	7	100%	100%	84%	94.6%
6	7-07-16	5	5	82%	5	100%	100%	82%	94%
7	8-07-16	5	5	95%	5	100%	100%	95%	98.3%
8	9-07-16	4	4	80%	4	100%	100%	80%	95.6%
9	11-7-16	5	5	76%	5	100%	100%	76%	90.6%
10	12-7-16	3	4	43%	4	75%	100%	43%	72.6%

Table 4. OEE Calculation for machine 3

Machine TC-2									
S. no.	Date	Total production Achieved	Total Target Production	Total Machine Utilization	Total Ok Production	**Performance**	**Quality**	**Availability**	**OEE**
1	1-07-16	7	7	94.28%	7	100%	100%	94.28%	98%
2	2-07-16	2	3	50.75%	2	66%	100%	50.75%	72%
3	4-07-16	5	5	72%	5	100%	100%	72%	90%
4	5-07-16	4	5	71%	4	80%	100%	71%	83.6%
5	6-07-16	4	4	90%	4	100%	100%	90%	96.6%
6	7-07-16	6	6	85%	6	100%	100%	85%	95%
7	8-07-16	7	7	80%	7	100%	100%	80%	93.3%
8	9-07-16	5	5	81%	5	100%	100%	81%	93.6%
9	11-7-16	4	5	54%	4	80%	100%	54%	87%
10	12-7-16	4	5	84%	4	80%	100%	84%	88%

3.9 Overall OEE Calculation

Overall OEE is calculated by taking the average of OEE calculated from the table 2,3 and 4 for each machines.

OEE = Availability × Performance × Quality

OEE = 93.25 × 97.8 × 71.35 = 87.46%

Overall OEE = ((87.46 + 92 + 91) / 300) x 100

= 90.1%

Table 5. Final OEE Calculation

S. no.	**Machine No.**	**Performance**	**Quality**	**Availability**	**OEE**
1	VMC 01	82.75%	98.9%	68.42%	83.32%
2	YCM TC-1	90%	100%	71%	87%
3	YCM TC-2	86.6%	100%	75%	87.2%
Over all OEE %					**85.8%**

3.10 Preventive Maintenance

In modern industry, equipment and machinery are a very important part of the total productive effort. Therefore, their idleness or downtime becomes very expensive. Hence, it is very important that the plant machinery should be properly maintained.

3.11 Actual Machining Time

The time utilized for machining each component is related with the estimated time by the organization. The graph presents the time variation for machining each component. The estimated time for machining component is even noted. A wide range of difference in time is identified for each component. The more time utilized by the component is taken average from the minimum time required by the component to get machined.

The estimated time for the components in table 06 is 90 minutes. For different down time different tables have been generated. This variation in time affects the productivity. There for by setting proper time for machining each component by the operator, 3.1% of availability can be increased. This results in increase of 3% in overall OEE.

Reduced idle time = 15 minutes / day

Reduced idle time in a month = 15 x 25 = 625 minutes / day

Improvement in Machine Utilization= 3.1%

To identify the variation of time made by each component three graph is generated for different dates.

Table 06. Machining Time with less down time

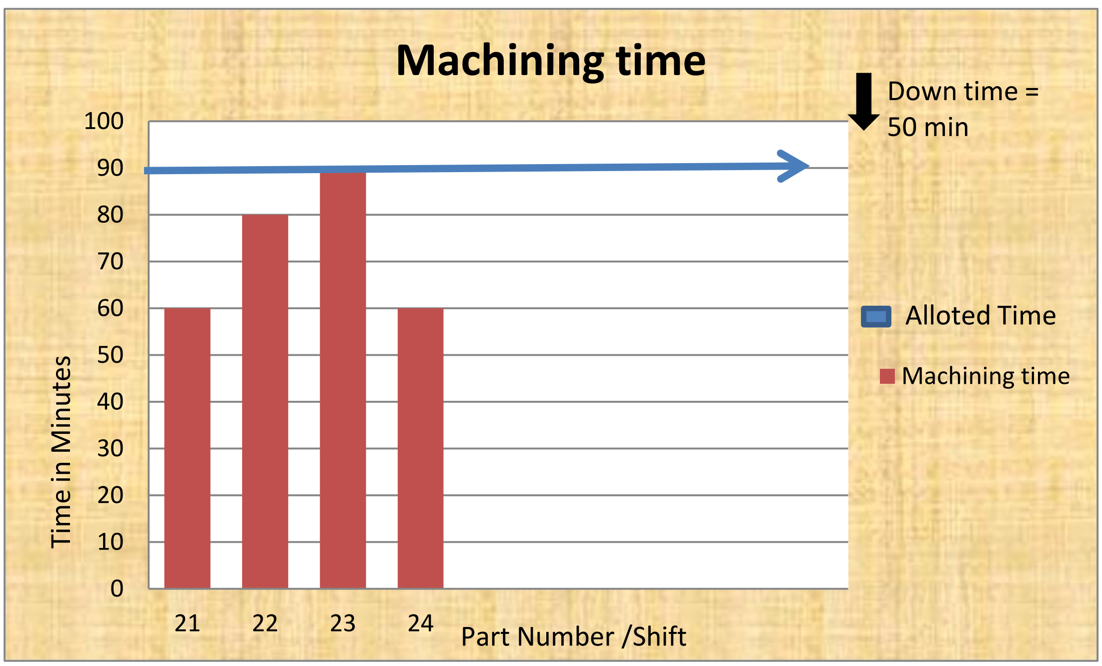


Table 07. Machining Time with high down time

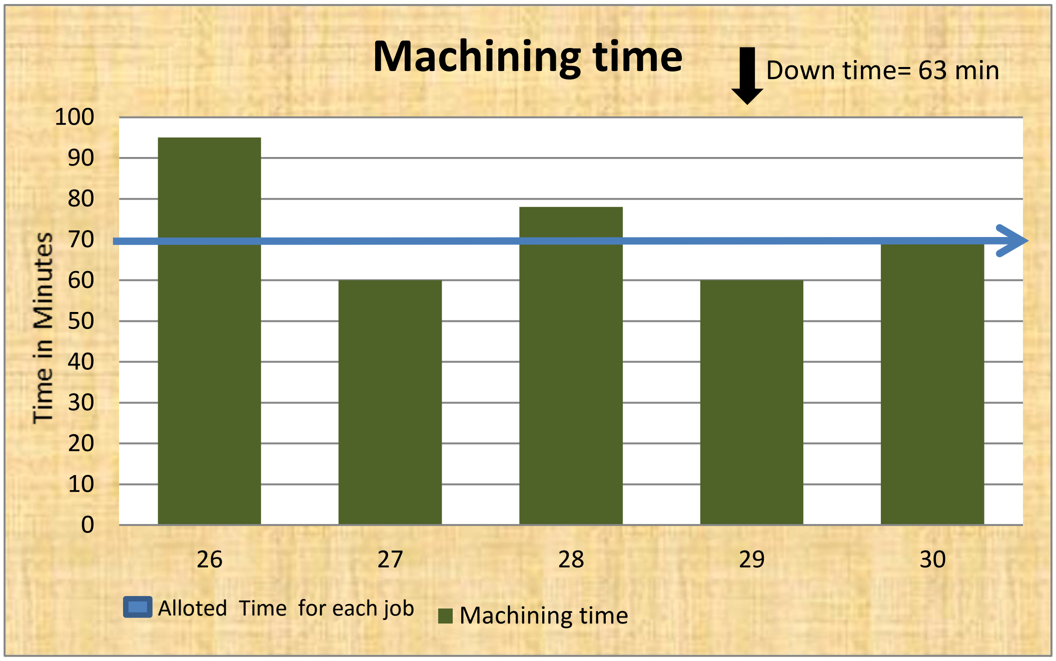
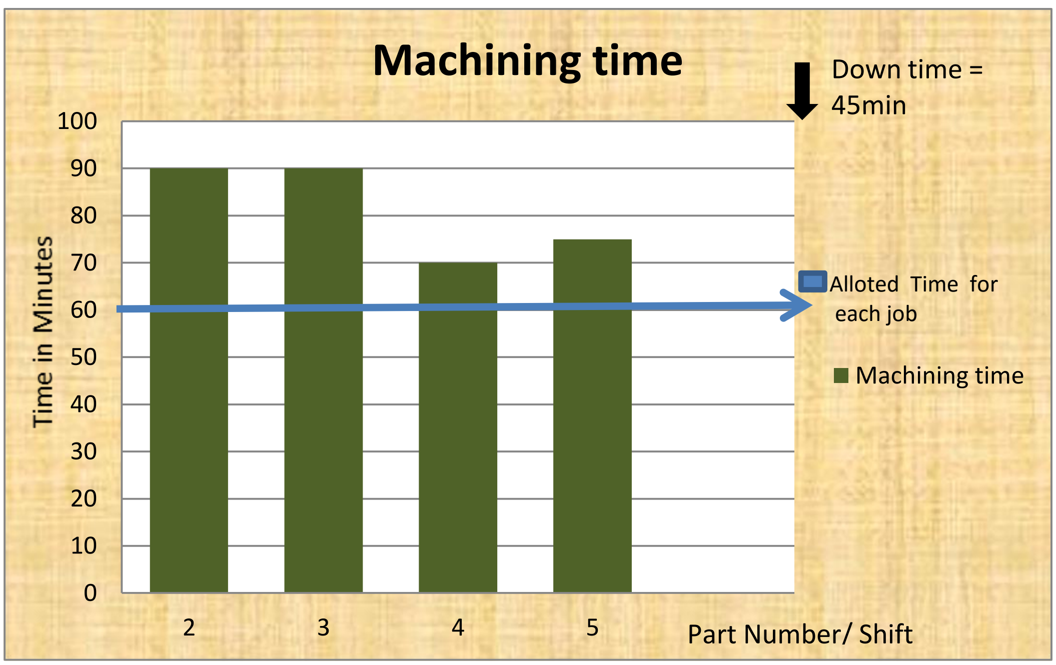


Table 08. Machining Time with moderate down time



3.12 Various Activities Involved in Machining Process

For every day the machine utilization timing is different which leads to different idle time. Each day different components are machined which involves changes in inspection and time required for work setting on the machine depends on the machining process carried out. The different activity carried out in a single day has estimated and made a chart so an easy understanding can be made to analyze, where more idle time had generated.

To find the difference in timing of machine utilization, two charts are generated for the dates 09-07-16 and 05-07-16.

Table 09. Various Activities undergone on 08-07-16

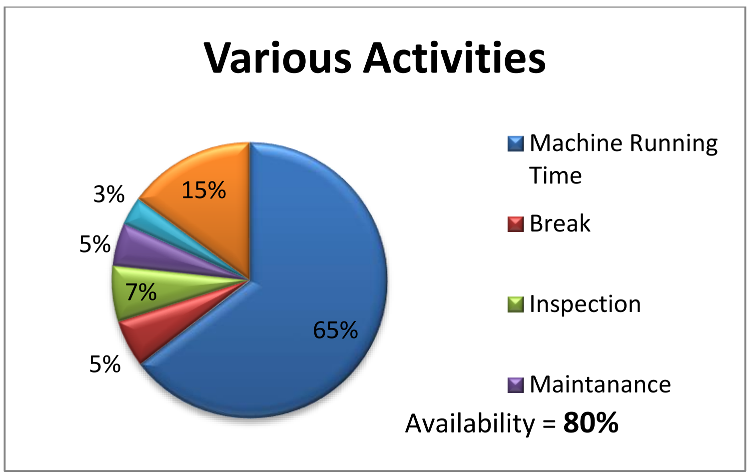
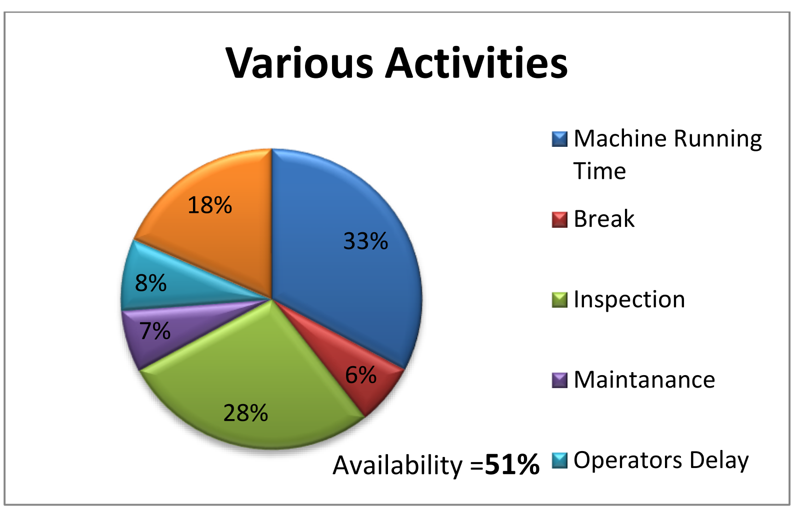


Table 10. Various Activities undergone on 05-07-16



From these two charts it is estimated that a wide idle time had been generated on table.09 when compared with the table. 10. In table.09 the machine running time is more and the

time required for inspection and workers delay is less. So the machine utilization in table.09 is calculated as 80%. In table.10 the machine running time is reduced because of more time utilization in inspection and also due to workers delay. So the machine utilization in table.10 is calculated as 51%. By setting time adjustments for inspection and by suggesting and making awareness to the operators, the inspection and operator delay can be reduced. There by the estimation for all the days in a month it is calculated that, by following those solutions an average of 5.2% improvement is calculated. More over 25 minutes a day is improved by reducing idle time of inspection and workers delay.
Reduced idle time = 25 minutes / day
Reduced idle time in a month = 25 x 25 = 625 minutes / day
Improvement in Machine Utilization= 5.2%

3.13 Production Data

- Plant Operating Time = Shift length x 60 min = 14 x 60 = 840 min/day

Rather if only less number of components to be machined then shift time is neglected and regular working time only is considered so there by,

- Plant Operating Time = Regular time in hour x 60 min = 8 x 60 = 480min/day
- Working days in a month = 25 x 480 = 12000 min/month
- Planned down Time = Cleaning+ Break= 05 + 50 = 55 min/day

Table 11. Working Time

Shift	Timing	Planned Downtime	Remark
I	08.30 am to 05.30 pm	Tea Break- 10:30 ~ 10:40 Lunch- 01:30 ~ 02:00 Tea Break- 4:00 ~ 4:10	Downtime : 50 min

The machines used for machining the components are automated and less labor effort is required. Normally the machine does not run at lunch time. A down time of 50minutes is generated. To reduce this idle time, lunch timing should set by operators according to the machining operation. For a single operation in machining, it might take more than 30 minutes, which would run continuously without any delay. So solution is identified that, after loading the component carryout the matching process. During that machining time let the operator to go for the lunch. So the downtime can be neglected during the break. Even if full break can’t be utilized for machining, more over 20 minutes can be preserved.

Reduced idle time = 20minutes / day
Reduced idle time in a month = 20 x 25 = 500 minutes / day
Improvement in Machine Utilization= 4.1%

3.14 Problem Statement

- Time delay because, Machine Operators Wait for CMM report
- Delay by machine operator
- More time utilization for preventive Maintenance
- At break time machine is not utilized
- More time utilized for work setting
- Lack of awareness to the operators

3.15 Improvement in OEE

After identifying the idle time and by finding the solution for reducing the idle time, it is calculated from the simulation table that a gradual increase in machine utilization is made. From the table
Modified Table:

Table 12. Improved Machine Utilization

S. no.	operation	Idle Time Reduced	Machine Utilization/day
1	Inspection & workers delay	25min	5.2%
2	Cycle time for machining part	15min	3.1%
3	Break	20min	4.1%
Improved Machine Utilization / Day			12.4%

Table 13. Improved OEE

S. no.	**Machine No.**	**Performance**	**Quality**	**Availability**	**OEE**
1	VMC 01	82.75%	98.9%	80.82%	87.4%
2	YCM TC-1	90%	100%	83.4%	91.1%
3	YCM TC-2	86.6%	100%	87.4%	91.3%
Over all OEE %					**89.9%**

From the above table we can see the gradient improvement in OEE (Refer Table.05). Finally an improvement of 4.13% is identified in OEE. So there by the total OEE of three machines are calculated as 89.9%.

4. CONCLUTION

It is essential for a company to improve the production rate and quality of the products. In order to achieve this, the Overall Equipment Effectiveness was improved with low machine breakdown, less idling and minor stops time, less quality defects, increased the productivity rate, worker involvement, increased customer satisfaction and increasing sales. The Overall Equipment Effectiveness of the machine was increased from 85.8% to 89.9%.

5. ACKNOWLEDGEMENTS

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