IMPROVEMENT OF OEE BY REDUCING LOSSES AND APPLYING TPM

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ABSTRACT:
In the recent era of industrialization the occurrence of wastages and losses in manufacturing industry has increased. There are many types and reasons found for losses and wastages, non-availability of machines, manpower, raw material in time, operators, tooling problem are some of the main reasons for the waste. The wastes that are related to company are most important as they affect the company at cost of time, reputation of the company as well as the costumer belief. Zero oriented concepts are becoming most essential in industries. In this present situation the concept of TPM has been adopted by many industries to reduce the loss and waste. The main objective is to increase the OEE and productivity of the machine and to reduce the breakdown losses. The study is mainly carried out on CNC machines were the breakdown conditions are checked and analyzed. Fish bone diagram, Pareto chart and why-why analysis has been used for analyzing and inspecting the reasons of break down losses. The primary aim was to reduce idle time and working towards optimizing the performance of the machine by reducing the breakdown losses, it was achieved by the best utilization of time for improving the maintenance and inspection, taking into consideration the recommendation and experiences. By implementing this there was reduction in break down loss to some extent, maintenance cost and productivity of the CNC machine is increased. The OEE is found to be increased by 10-12%.

Keywords: Waste/Loss, TPM, Breakdown loss, Fish-bone diagram, Pareto chart, why-why analysis, Maintenance, Productivity, OEE.

Introduction:

In the present era of manufacturing industry the main focus is on product quality, production time and cost, due to this machine maintenance has become most important part so as to increase reliability and to reduce loss due to machine breakdown, so now-days it has become mandatory for the industries to introduce a quality and maintenance system in the company to increase the productivity, quality and reduce loss. A good quality and maintenance system contributes to efficiency, service, quality, safety, on time delivery, and customer satisfaction. In order to achieve all these analysis and implementation of TPM is a must. TPM was originated in Japan in the year 1971 by M/s Nippon Denso Co. Ltd. of Japan, a supplier of M/s Toyota Motor Company as the holistic approach to equipment maintenance that aims to achieve perfect production by avoiding breakdowns, slow running, defects, accidents, etc. TPM can be defined as the combination of operation maintenance, equipment management and available resources, which altogether is known overall equipment efficiency (OEE). The OEE calculation is simple and general hence it can be applied to any industry. It is the combination of Just in Time, Total Quality Management and Preventive maintenance.

OEE= A x PE x Q

Where A- Availability of machine, PE- Performance efficiency and Q- Quality rate.

The main goal is to ensure that the performance of the equipment is satisfactory by eliminating six major losses, to zero. TPM requires team

work i.e., the contribution of whole organization right from management to workers only then the best possible results are obtained. The JIPM has put forward five goals of TPM which are the minimum requirements for development i.e., improving equipment effectiveness, maintenance efficiency and effectiveness, equipment management and maintenance prevention, improve the skills of all people, involving operators in routine maintenance. The objective behind improving the equipment effectiveness is that each part of the equipment can be utilized to its best. Nakajima has mentioned in his book that TPM increases equipment effectiveness through two types of activity mainly i.e., quantitative includes increasing the equipments total availability and improving productivity in given time and qualitative includes reducing the no. of defective products and optimizing the process. The concept of zero breakdown and zero defects are used to increase the equipment effectiveness. A case study in conducted on a leading manufacturing industry, the company was about to implement the TPM so as the prior work of implementation of TPM case study is done. This case study is conducted on CNC machine for reducing the breakdown losses. The primary objective of the study was to find out the major breakdowns which decrease the productivity of machine as well as industry and to suggest effective measures to minimize the effect. Six months data was taken into consideration and with help of fish-bone diagram the root cause for the breakdown was identified and a effective measure to overcome it was suggested.

Case study:

WEIR BDK pvt. Ltd company is Multinational Company situated in Gokul road, Hubli. The BDK™ range of isolation valves have proven their capabilities across various sectors, primarily in Power, Steel, Chemical, Refineries, Pharmaceutical and Fertilizers industries. Many CNC machines were involved in manufacturing and machining of various kind of valves and are supplied to various govt. and private sectors. For the case study of Total Productive Maintenance analysis we have undergone detailed study of WIDMA 5162 CNC machine. We have noticed total 17 types of loses according the month wise.

Before TPM:

Different type of loses in last 6months (in minutes):

Types of loses	Mar	Apr	May	Jun	July	Aug	Total loss
L1 Break down loss	2940	2548	2885	300	152	1240	10065
L2 set up loss	320	1425	87	540	1130	1010	4512
L2A Adjustment losses	395	1195	143	662	1195	1019	4609
L3 Tool change loss	911	1870	1185	1550	1020	1345	7881
L4 Minor stoppage loss	62	78	0	99	165	112	516
L5 Quality Adjustment loss	0	40	0	65	30	10	145
L6 Rework loss	0	395	0	30	50	50	525
L7 Plan shed down	480	320	190	1200	1125	559	3874
L8 start-up loss	0	60	0	0	0	0	60
L9 Power failure	60	130	50	280	160	355	1035
L10	0	0	0	160	1750	2095	4005

external material loss							
L11 Internal material loss	0	0	0	735	320	160	1215
L12 Development loss	1785	490	0	0	1320	214	3809
L13 no tool	314	90	925	232	467	320	2348
L14 No OPERATOR	1320	1540	20	2405	1535	3735	10555
L15 Inspection loss	510	562	130	608	508	580	2898
L-16 Tool Breakage loss	0	0	20	20	0	20	60
L17 Plant level meeting & Training	110	0	10	249	300	130	799

*Total defective items found in 6 months out of 3150 components are 548 components.
*In each shift of 8hrs around 7/8 valves are machined in WIDMA 5162 CNC machine.
*For each component processing average time is 42mins.

Combining all the losses into 3 respective types:

Availability loses	Break down loss
	Set up loss
	Adjustment losses
	Tool change loss
	Power failure
	No operator
	No tool
Performance loses	Minor stoppage loss
	External material loss
	Internal material loss
	Plant level meeting & Training
	Development loss

Quality loses	Quality Adjustment loss
	start-up loss
	Tool Breakage loss
	Inspection loss
	Rework loss

Total loss time:
1. Availability: 41005mins
2. Performance: 10344mins
3. Quality: 3688mins

OEE before TPM:

1) Availability losses:-

$$\frac{\text{Available time - down time}}{\text{Available time}}$$

$$\Rightarrow \frac{72000 - 7743}{72000}$$

$$= 0.89$$

2) Performance losses:-

$$\frac{\text{Std cycle time x quantity of products}}{\text{Operating time}}$$

$$\Rightarrow \frac{37 \times 1258}{(72000 - 7743 - 1420)}$$

$$=0.74$$

3) Quality losses:-

$$\frac{\text{Quantity of products – defective products}}{\text{Quantity of products}}$$

$$\Rightarrow \frac{3150 - 548}{3150}$$

$$=0.82$$

Total OEE = P x A x Q

= 0.81 x 0.64 x 0.82
= 0.42 x 100
= **42%**

Reasons identified about the major losses:

SI	PROBLEM	No. times	Solution	Primitive actions
1	Platform housing cooling not taking place	5	Water jacket was cleaned by acid	Periodic checking of water hardness by pH method neutral pH value from 6.5 to 7.5
2	Punch displacement Cylinder movement	8	Punch displacement/ new assembly was done	Check pilot operated pressure valve range from 80 to 100 kg/cm2
3	Ram movement in the working area	4	Pilot valve pressure drop to 60bar so pilot valve has changed 100bar achieved	Periodic interval of oil Quality monitoring. Chain slipping is analysed.
4	Loading arm gear box failure	9	Gear box has replaced	Proper tuning of proximity sensor position Distance

				from < 5mm sensing board
5	Ram movement not taking place	10	Motor coupling changed	Ensure maintenance to carried out by giving hand/manual torque to the Motor. Chain slipping is analyzed.
6	Bolster tool clamping thread worn -out	11	Bolster has replaced	changing of bolster studs and proper clamping method by using torque Wrench. Edge roller is analyzed.
7	Displacement cylinder piston rod thread end cut	5	Displacement cylinder has changed	Checking of tightness of the Guide ways bolts. Edge roller is analyzed
8	Stripper actuating cylinder problem	3	O – ring has been replaced	maintenance of O-ring and seal kits and observe oil leakage
9	Play in tool clamping	3	92 Number Disc springs & 5 Number steel balls replaced	Tool clamp proximity setting done properly
10	Air x 4.2 low pressure fault	2	Set the air regulator to 7kgs	Every 7 days air regulator need to check.
11	ATC Jammed	11	Removed the arm bolts released the tools & refitted bolts	Chain slipping is analyzed.
12	Abnormal noise in spindle	6	Spindle draw bar refitted and set proxy switch	Chain slipping is analyzed.

ROOT CAUSE ANALYSIS:

Root cause analysis is the collection of different approaches, tools, techniques, diagrams, theories used to uncover the problem. It is carried out in mainly 4 phases as follows,

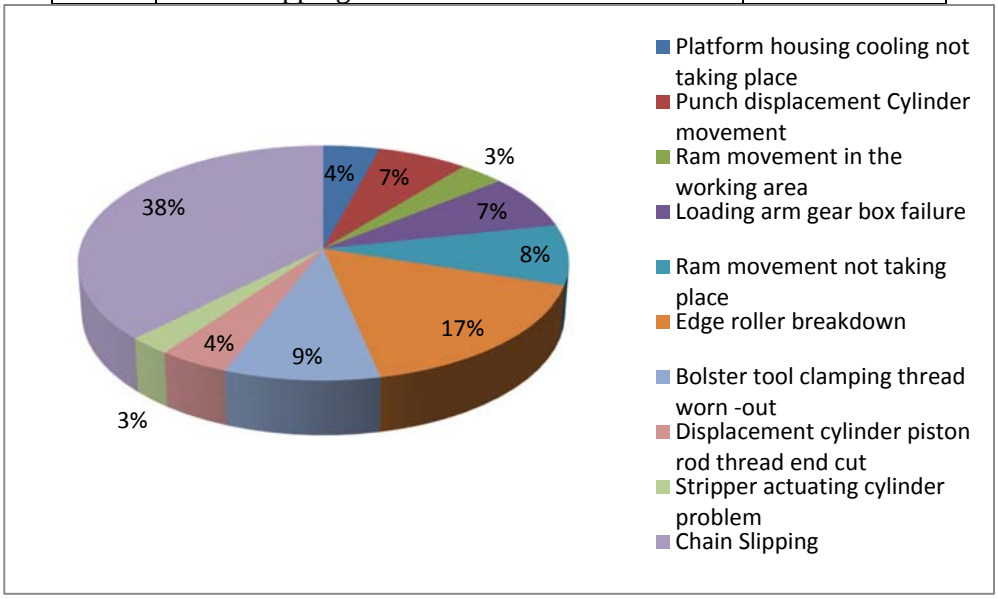
1) Problem identification
2) Identify the cause
3) Identify effective solution
4) Recommendation of best solution

1) Problem identification:

The decrease in productivity and efficiency of the machine was seen; hence the research was conducted to know the reasons behind the decrease in productivity, neglecting the factors like man, machine, and materials it is necessary to reduce the breakdown of the machine as they are most common causes for decrease in the efficiency and productivity. The breakdown data was collected for 6 months (March'16- Aug'16)

Sl. No	Problem	No. Of times
1	Platform housing cooling not taking place	5
2	Punch displacement Cylinder movement	8
3	Ram movement in the working area	4
4	Loading arm gear box failure	9
5	Ram movement not taking place	10
6	Edge roller breakdown	20
7	Bolster tool clamping thread worn -out	11

8	Displacement cylinder piston rod thread end cut	5
9	Stripper actuating cylinder problem	3
10	Chain Slipping	45



Pie chart for breakdowns

From the data collected and pie chart analysis it was found that chain slipping and edge roller breakdown has occurred maximum times, contributing about 38% and 17% respectively. Hence to reduce the down time and increase productivity it is necessary to find root cause of the problem and find the solution for these breakdowns.

2) Identify the cause and solution:

Identifying the root cause is most critical part and it is done by different methods like fish-bone diagram, Pareto chart, why-why analysis. These are some of the basic tools of quality control. Cause and effect diagram is the visualization tool for categorizing the potential causes of a problem in order to identify its root cause. The cause and effect diagram looks like skeleton of fish hence it is known as fishbone diagram.

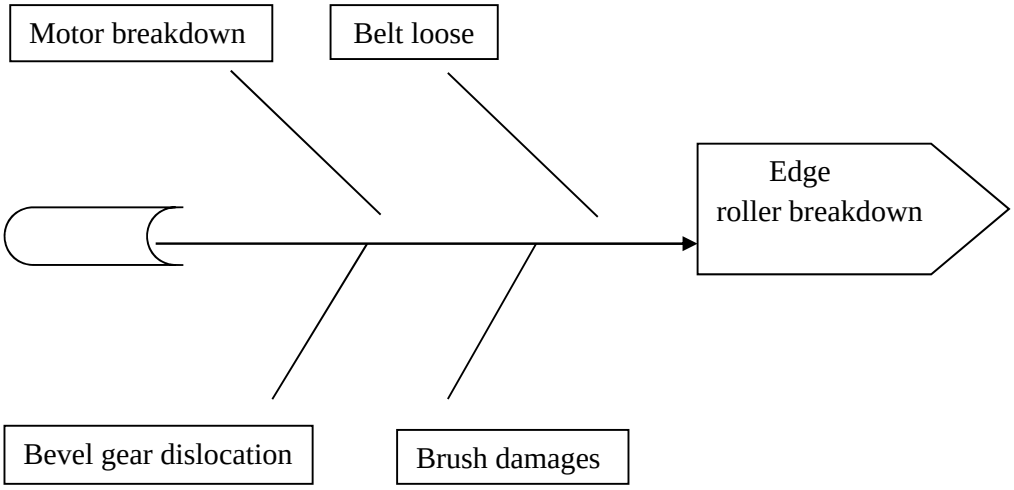
Pareto chart is most common used basic tool of quality control. It is also known as Pareto distribution diagram, it is basically a vertical bar graph in which values are plotted in decreasing order of relative frequency. These charts are extremely useful for analyzing what problem/cause need to treat with higher priority.

Why-why analysis is the method of questioning that leads to identification of problem. It is conducted to identify solution to problem that addresses its root cause. It also helps to identify how to really prevent the issue from happening.

I) Root cause analysis for edge roller breakdown.

Edge roller is the separate unit used for rolling up of edges of the component produced in the industry. It is pulley-belt arrangement, gears, motors, brush, and shaft. Its frequent breakdowns has is the main reason for time loss and decrease in productivity.

Fishbone diagram:



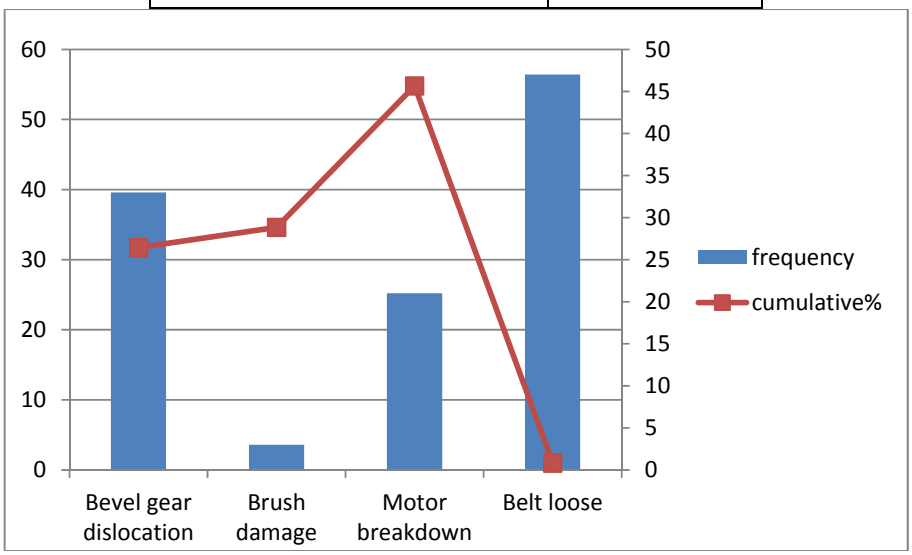
Fish bone diagram for roller edge breakdown

The above fish bone diagram shows the causes for roller edge breakdown. The causes may be one among the 4 above mentioned.

Pareto chart:

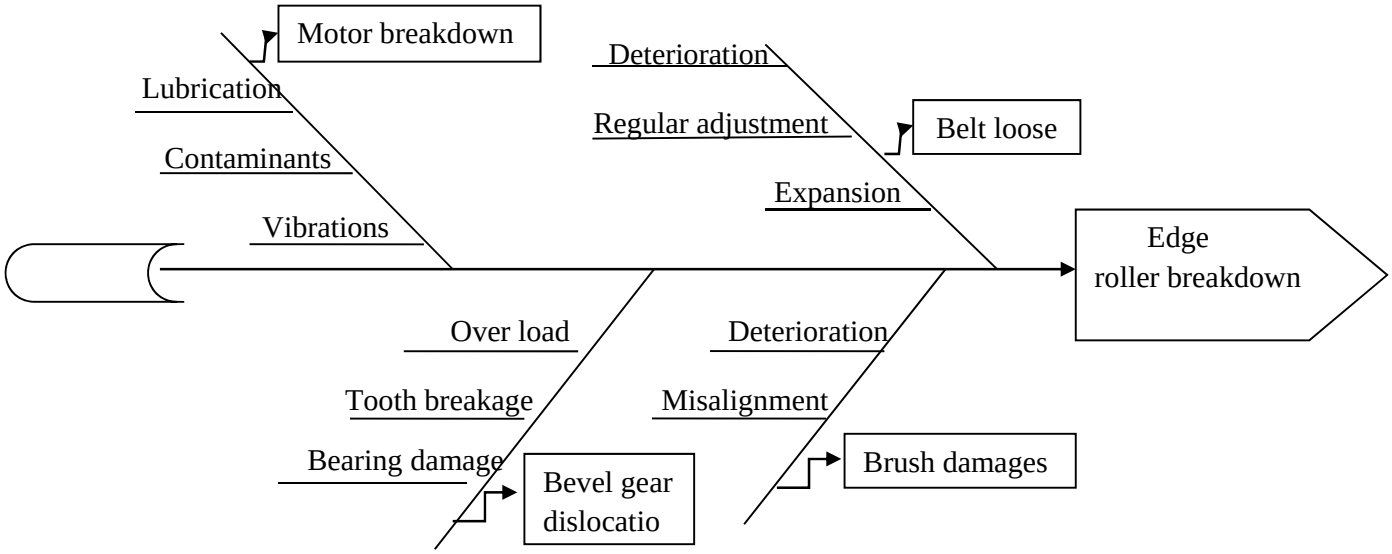
The data collected is ad follows

Causes	Frequency
Bevel gear dislocation	33
Brush damage	3
Motor breakdown	21
Belt loose	47



Pareto chart for edge roller breakdown

From the above Pareto chart it is clear that belt loose and bevel gear dislocation are major causes for the breakdown of edge roller.



Final fish bone diagram for edge roller breakdown

After the detailed study it was seen that deterioration, thermal expansion of the belt and adjustment made in regular interval of time were the reasons for belt expansion. Readjustment of belt cannot be avoided as the belt as has to be adjusted according to size to achieve proper thickness of rolling, but were as deterioration and expansion can be avoided using higher quality belt than the existing one. Major cause for edge roller was the breakdown caused due to gear dislocation; it is occurred due to overload, tooth breakage, bearing damage. Bearing damage is mostly due to overheating and improper loading acting on it. As there is necessary of regular adjustment of belt due varying size. If proper alignment checking is done during the adjustment of machine then breakdowns can avoided

II) Root cause analysis for chain slipping breakdown*:*

Conveyor belt is a most important part of CNC manufacturing. This chain carries the components. Any breakdown to this unit causes the entire stoppage of production.

Why-why analysis for chain slipping*:*

1) Why? There is decrease in productivity of machine

Machine breakdowns being the main reason for decrease in productivity, chain slipping is one of them

2) Why? Causes for chain slipping

Different causes for chain slipping are: Pinion breakage, vibration, Chain loose, contamination

3) Why? Reasons for these causes

Pinion breakage: Pinion struck at sprocket, improper design, improper checking

Vibration: lower tension of chain, wear and tear of machine part

Chain loose: chain stretching

Contamination: improper cleaning

4) Why? Reason for pinion to get stuck in sprocket

Contamination between sprocket and pinion, over speed, Mould withdrawn from pinion

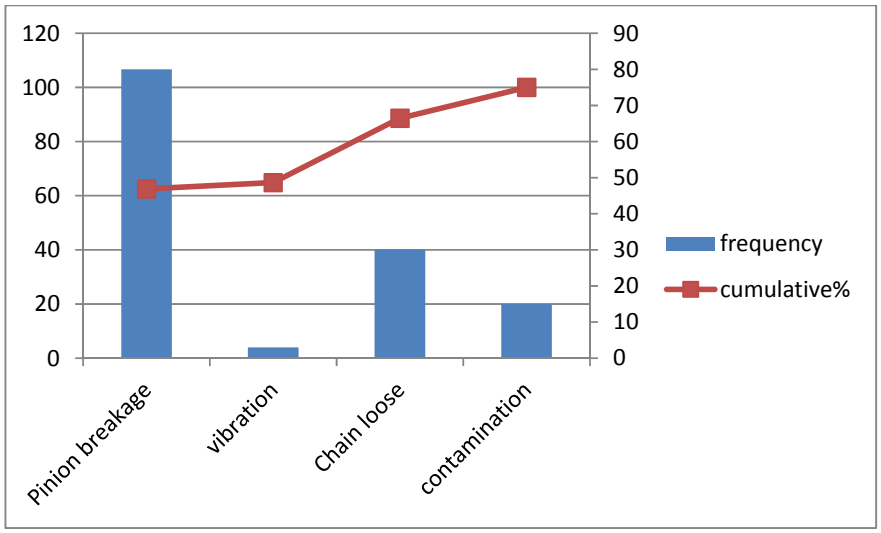
5) Why? Reason for withdrawal of mould from pinion

Hitting of the rack on pinion, improper tightening of pinion.

Pareto Chart:

The data collected is as follows:

Causes	Frequency
Pinion breakage	15
Vibration	1
Chain loose	3
Contamination	1.5



Pareto chart for chain slipping breakdown

After performing why-why analysis and Pareto chart analysis it was found that pinion breakage is the major cause for chain slipping and the root cause for it is also identified. After the detailed study the causes for breakdown of chain slipping are found. Chain becomes lose due the stretching or wearing and wearing of other parts as well. It is found that Lower tension of the chain due stretching is the reason for vibration. It was also found that improper cleaning of equipment after the use leads to contamination and it further leads to chain slipping. These problems can be avoided by adapting preventive and predictive maintenance techniques. The major root cause for chain slipping was the breakage of pinion and the reasons for the breakage were found to be improper design, improper checking methods and pinion getting stuck in the sprocket of the machine, the reasons for this were found to be contamination, over speed and movement of pinion without the mould. Inspection method can be implied to avoid improper design and improper checking. The proper implementation of tightening mechanism can avoid the withdrawal of pinion from mould.

3) Recommendation of best solution:

From the cause and effect diagram, Pareto chart for edge roller and why-why analysis and Pareto chart for chain slipping the root causes for both the breakdowns were found. For edge roller belt deterioration and improper alignment was found to be the root cause. A higher edge belt like EPDM belt is recommended, which withstand the temperature and load and has good longer life. Another reason was found to be improper alignment, for this the workers need to be trained properly to check the alignments after every adjustment. The checklist should be maintained strictly so that the checking of alignments is not missed. After checking the alignments proper tightening of the screws is also must hence it should take care of. The root cause for chain slipping was found to be pinion breakage, the most common reason behind the pinion breakage is seen that improper tightening of the pinion. Manually tightening of pinion should be avoided and proper means tightening should be implements to avoid the breakdown. The best solution to overcome this cause is using of torque wrench for tightening purpose. To avoid the slipping of chain proper lubrication also necessary hence it is better to maintain a proper checklist to check whether the lubrication is done in regular intervals or no.

After Applying TPM:

	OCT	NOV	Total
L1 Break down loss	1125	1445	2570
L2 set up loss	320	87	470
L2A Adjustment losses	395	143	538
L3 Tool change loss	811	1085	1896
L4 Minor stoppage loss	62	0	62
L5 Quality Adjustment loss	50	0	50
L6 Rework loss	0	0	0
L7 Plan shed down	480	190	670
L8 startup loss	0	0	0
L9 Power failure	60	50	110
L10 external material loss	0	0	0
L11 Internal material loss	0	0	0
L12 Development loss	1258	0	1258
L13 no tool	314	625	939
L14 No OPERATOR	1220	20	1240
L15 Inspection loss	310	110	420
L-16 Tool Breakage loss	0	20	20
L17 Plant level meeting & Training	90	10	100

**Total defective items found in 6 months out of 1258 components are 178 components.
**In each shift of 8hrs around 8/9 valves are machined in WIDMA 5162 CNC machine.
**for each component processing average time is 37mins.
1) Availability loss: 7743
2) Performance: 1420
3) Quality: 490

OEE after TPM
1) Availability losses:-

$$\frac{\text{Available time- down time}}{\text{Available time}}$$

$$\Rightarrow \frac{216000 - 41005}{216000}$$

$$= 0.81$$

2) Performance losses:-

$$\frac{\text{Std cycle time x quantity of products}}{\text{Operating time}}$$

$$\Rightarrow \frac{42 \times 3150}{(216000-10344)}$$

$$=0.64$$

3) Quality losses:-

$$\frac{\text{Quantity of products – defective products}}{\text{Quantity of products}}$$

$$\Rightarrow \frac{1258 - 178}{1258}$$

$$=0.85$$

Total OEE = P x A x Q

= 0.89 x 0.74 x 0.82
= 0.55 x 100
= **55%**

Hence there is an increase in OEE.

Conclusion:

The main objective of this paper to understand TPM concept and get the know about TPM. During research in WEIR BDK pvt. Limited we have compare before TPM and after TPM data with respect to OEE and solve major problems by TPM based primitive Action plan we have to reduce many problems and improve OEE. The root cause analysis there is an improvement in the improvement of planned productivity. This is because of proper understanding of the existing method and by employing proper preventive maintenance program. Therefore whenever a breakdown occurs, the root cause of the breakdown has to be found and analyzed. Then solution should be found to improve this system using root cause analysis and other measures, such that similar type of breakdown can be reduced.

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