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Embellishing TPM through Facilitating OEE in A Sustainable Manufacturing Concern

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***Abstract*— In this paper we have improved OEE (Overall Equipment Effectiveness) by using Kaizen methodology and we use different layout to improve the productivity in the manufacturing industry by embellishing the concepts of TPM. Today the competition has been increased dramatically, customers focused on quality of product. Because of these, the organization should introduce a quality and productivity continuously. The OEEE is product of equipment availability, performance efficiency of process and quality performance of manufacturing operations. This research aims to improve the plant layout of manufacturing industries to make the optimum space utilization, eliminate the rejection of components and thus by increasing the maximum productivity. The suitable new plant layout eliminates the transportation waste and improves the material flow, which in turn increases the productivity.**

***Keywords*— Plant layout, Total productive maintenance, Overall Equipment Effectiveness, Performance efficiency**

I. INTRODUCTION

Total Productive Maintenance is an innovative Japanese concept. The origin of TPM introduced in early 1950s, when preventive maintenance was introduced in Japan. The concept of preventive maintenance originated in the USA. Preventive maintenance is the concept of daily maintenance designed to maintain equipment in good condition and prevent failure through the prevention of machine fails and periodic inspections. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. In industry sectors, it is important to manufacture the products which have good quality products and meet customers' demand. This action could be conducted under existing resources such as employees, machines and other facilities. However, plant layout improvement, could be one of the tools to response to increasing industrial productivities. Plant layout design has become a fundamental basis of today's industrial plants which can influence parts of work efficiency. It is needed to appropriately plan and position employees, materials, machines, equipments, and other manufacturing supports and facilities to create the most effective plant layout.

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. However, the current business environment and pressures from various parties such as customers, suppliers, governments and so forth have put manufacturing sectors under severe pressure. To operate efficiently and effectively, manufacturing sectors need to ensure no disruption due to equipment breakdown, stoppages and failure. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and quality performance. OEE provides a way to measure the effectiveness of manufacturing operations from a single piece of equipment to an entire manufacturing.

II. LITERATURE REVIEW

"Jagtar Singh, Vikas Rastogi and Richa Sharma in their study "Total productivity maintenance Review the author will also focus on calculating the Overall Equipment Effectiveness (OEE) in one of the two wheeler automobile Industry in India. [1]. "Wasim. S. Hangad, Dr. Sanjay Kumar" TPM – A Key strategy for productivity Improvement in medium scale industries,The author describes about the goal of the TPM program is to increase production while, at the same time, increasing employee morale and job satisfaction. [2]. " Prof. A.Bangar, Hemlata sahu, Jagmohan batham" Improving Overall Equipment Effectiveness by Implementing Total Productive Maintenance in Auto Industry , In this paper we have improved OEE by implementing TPM (Total productive maintenance)by using kaizen methodology [3]. "Amit Kumar Gupta, Dr. R. K. Garg" OEE Improvement by TPM Implementation, In this the author describes about Total Productive Maintenance (TPM) is a methodology that aims to increase the availability of existing equipment hence reducing the need for further capital investment [4].

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"Ram D & Prashant N " Design and Improvement of plant layout, This research aims to improve the plant layout of pipe shell and travelling roller manufacturing industry to make optimum space utilization, eliminate obstructions in material flow and thus obtain maximum productivity [5]. "Sarang G. Katkamwar, Sadashiv K. Wadatkar, Ravikant V. Paropate", Study of Total Productive Maintenance & Its Implementing Approach in Spinning Industries. This paper presents the study and overview for the implementing approach of Total Productive Maintenance in Indian spinning industries. The TPM implementation methodology is suggested for improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment. [6]. "Prof Pradeep Kumar , Dr. K. V. M. Varambally, Dr. Lewlyn L.R. Rodrigues " A Methodology for Implementing Total Productive Maintenance in Manufacturing Industries–A Case Study , Total productive maintenance is practical technique aimed at maximizing the effectiveness of facility that we use within our organization. During high growth era companies are making technical progress in automation and centralization of the plants, which needs large amount of manual work to maintain the automation systems [7]. "One Yoon Seng Muhamad Jantan , T. Ramayah" Implementing Total Productive Maintenance (Tpm) In Malaysian Manufacturing Organisation: An Operational Strategy Study , This paper, therefore, focuses on the two TPM operational strategies, which is osited, will improve the extent of TPM implementation in manufacturing organizations [8]."Aravinth Kumar A, Janagiraman R, Rajenthirakumar D, Sathishkumar K" Lean Operational Principles and Practices Effecting in a Manufacturing Concern , The purpose of this research is to apply the lean tools towards reduction of lead time in a compressor manufacturing industry. It is concluded that with the implementation of lean tools, lead time is reduced and overall equipment effectiveness is improved [9]. " D. Rajenthirakumar A. Aravinthkumar S. Sivagurunathan A.Balasuadhakar " Benefits of Implementing Lean Principles to Real Manufacturing Environment in International Journal for Scientific Research & Development , The main purpose of this technical manuscripts to present the benefits of using lean manufacturing tools and principles on dynamic manufacturing environment [10]. "Aravinth Kumar A , Dr. D. Rajenthirakumar " Lean Implementation through Enhancing Productivity in a Pump Industry in International Journal of Engineering Research, In this paper Lead time is calculated by adding value added and other Non-value added time.

The lean tools that are applied in this project are Kaizen, Layout optimization, setup time reduction and Line Balancing which eliminates inventory which in turn reduces the lead time [11]. "Aravinth Kumar A , Dr. D. Rajenthirakumar " Reducing the Manufacturing Lead Time of Export Pump Components in an Indian Pump Industry in National Journal of Technology , This Paper is a case study explaining about the successful implementation of lean manufacturing tools and techniques in the shop floor manufacturing system at the leading pump industry plant. [12]. "Aravinth Kumar A , Dr. D. Rajenthirakumar " Lean Tools and Techniques Implementation in a Manufacturing Industry in Journal Of Applied Sciences Research , It tells us about the current state or As Is model (where we are) and future state or To Be model (where we want to be) [13].

III. TPM Concept And OEE

TPM stands for "Total Productive Maintenance" and builds a close relationship between Maintenance and Productivity, showing how good care of equipment will result in higher productivity. It is a philosophy of continuous improvement. That develops operators to take care of each machine in their supervision. The main objective of implementing Overall Equipment Effectiveness is to reduce the Manufacturing lead time of critical components being manufactured in press shop. The Overall Equipment Effectiveness improves the productivity of the component and also reducing the set up time of the component feed.

The various tools that to be used are:

- Value stream mapping
- Cause and effect diagram
- Spaghetti diagram
- Line Balancing
- Kaizen – Continuous Improvement

By introducing Total Productive Maintenance we can achieve various objectives such as it avoid the waste in a quickly changing economic environment, and by implementing TPM we can reach the maximum production without affecting the quality of the product. One of the main advantages of implementing this TPM will reduce the productivity cost and it also leads to produce the blow batch quantity at the earliest possible time.

A. TPM Goals:

The various TPM goals are,

a. Down time losses Speed losses.
b. Defects or Quality losses.

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c. Involving operators in daily maintenance.
d. It improves repair level.
e. It increases the preventive level.
f. It develops the improvement level.
g. It improving maintenance efficiency and effectiveness.

IV. Plant Layout Planning

A. Procedure for Plant Layout Design

In order to implement a new process layout the various steps are followed, primarily the present layout was fully studied from this we can improve the layout design when the problem is identified then the machines are planned according to our convenient then after set up an idea the present layout plan is analyzed with the operators and several operations are done to implement the present layout. Then after getting all layout plan suggestion were done and the report were proposed to the authorized person to make the decision for rearrangement the plant layout.

B. Kaizen No: 1 Layout Up gradation

According to the study of the manufacturing process, the details for flow of material from raw material storage to shipping is in irregular pattern and covers the indirect path, which results into more travelling distance. Raw material storage is at outskirt area of plant, which creates problem in material handling and each time worker go outside to bring raw material. By comparing the two layout the present layout takes more time & difficult to do manufacturing, But in the proposed method the travel time is saved and it does not take more time for manufacturing, so by comparing the two different layouts the productivity is increased by using the proposed lay out plan and it is use to improve the quality and productivity in a manufacturing industries. The main aim of introducing this new layout is to reduce the distance covered by the individual department in a manufacturing industry.

C. Cause and Effect Diagram – Kaizen:

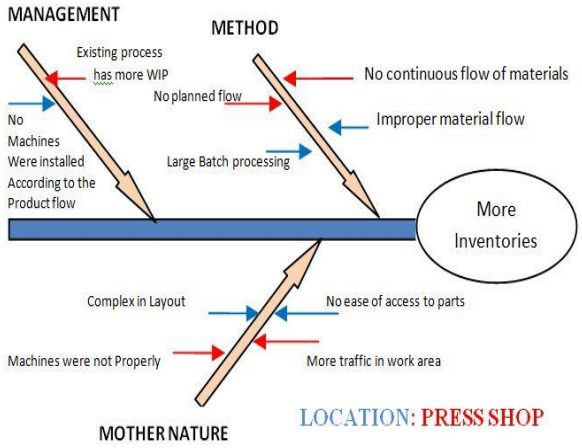

Fig 1: Cause and Effect Diagram

D. Spaghetti Diagram of Present layout:

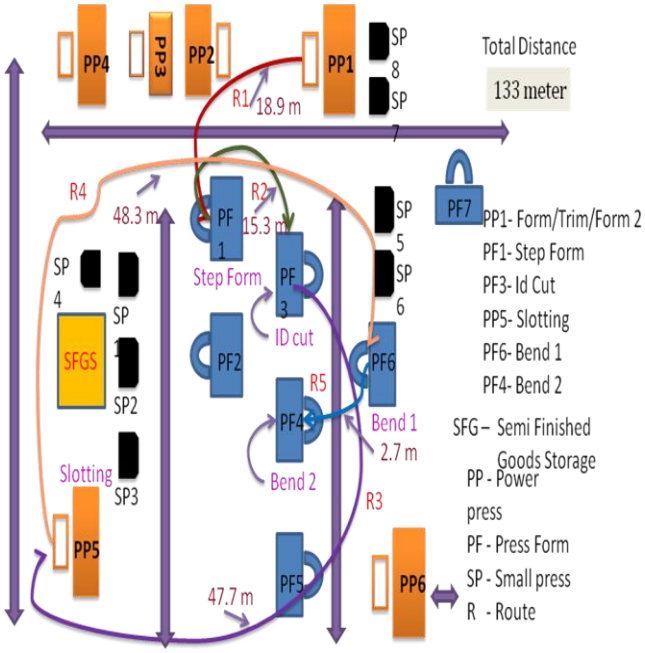

Fig 2: Spaghetti Diagram for Present layout

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Table 1:
Operation processing chart for press shop

PRESS SHOP					
Operation	○	⇨	□	▽	**Distance Meter**
Components from storage					
Form 1 / Trim / Form 2					---
Step Form					18.9
ID Cut					15.3
Slotting					47.7
Bend 1					48.3
Bend 2					2.7
Storage					
	TOTAL				**133 METER**

E. Spaghetti Diagram for Proposed layout:

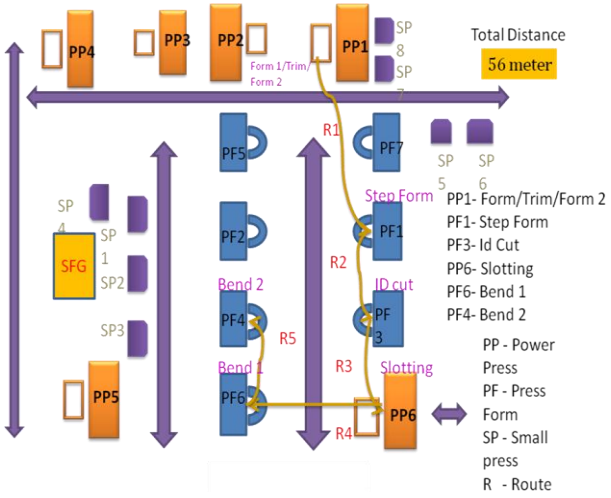

Fig 3: Spaghetti Diagram for Proposed layout

F. Layout up gradation Merits and Outcomes

Due to layout up gradation, the worker can easily communicate with each other, and it also creates the flexibility among the workers and for forklift operators. The materials can be easily handled in the press shop, due to reduce of distance the die handling is easy in the production area. Since the advantage of implementing the layout is to reduce the distance covered in the proposed method when it compared with the ordinary method since the new layout will improve the productivity and manufacturability in the organization.

Fig 4: Comparison of distance in press shop

The above graph clearly depicts the distance travelled in meters and the performance to be done in an company by seeing the graph by implementing the new methodology plan we can able to reduce the distance travelled by a person in the industry. Thus the productivity is increased and the distance also reduced by implementing the new method of plan layout.

V. KAIZEN NO: 2 DIE STAND WITH BIN SET UP

In the industries the die is placed at the too far distance from the place of casting since this may take too much of times to carry the finished product into the bin or die. It may consume more time and manpower to do this. To overcome this problem the die and bin are designed in the same tray contained all facilities such as place to put all the finished good, place to keep the tools etc., since by implementing this we can reduce the time consumption and increase the no of components in the individual shifts. The statistical data and the graph are shown below,

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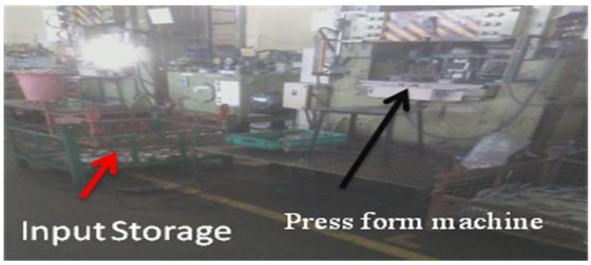

Fig 5: Present Work area

The purpose of setting Die stand and bin setup is for the following reasons, The tray which we used can capable o holding (30 to 50) pieces of 6 inch components and (90 to 100) pieces of 4 inch components at a time, the storage bin which we are placed is not easily reached by the worker. The one of the main purpose is that the Refilling of components in the bin takes more time. Each times the workers wasting 4 to 6 minutes for filling the components in the empty tray. So by introducing the die stand and bin setup the lead time of the component is reduced and the production will increased due to the minimizing the lead time in the shop floor. In this the input storage is placed near the press form machine so the carry out time is minimized.

A. Proposed Die Stand and Bin Set Up Kaizen_2:

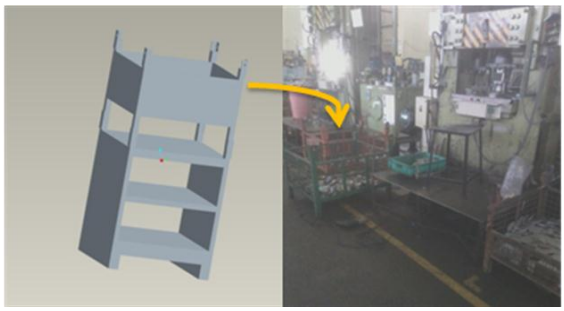

Fig 6: Proposed Stand and Bin Set Up

The above figure shows the model of a stand and bin proposed setup, in this setup it consist of both the bin and rack setup. Since it can used to carry the finished products and keep the tools for the press. By using this setup we can reduces the time of carrying the product by workers.

B. Common Nva's identified In the Industries:

- Die is not readily available near to the machine.
- Unnecessary movement of workers to get parts from the bin.
- Lifting of tray full of parts gives stress to the worker.
- Unnecessary traffic created in the press shop.

C. Elimination of Nva's:

By implementing Die Stand and Bin Set Up the some of the Non Value added Activities are,

a) The motion waste of worker is eliminated inside the manufacturing area. b) The Lifting of tray full of parts by the worker is eliminated due to present of Die and Bin set up. c) The Usage of tray is eliminated. d) Due to bin setup the Value added time becomes more.

D. Cause and Effect Diagram - Kaizen: 2

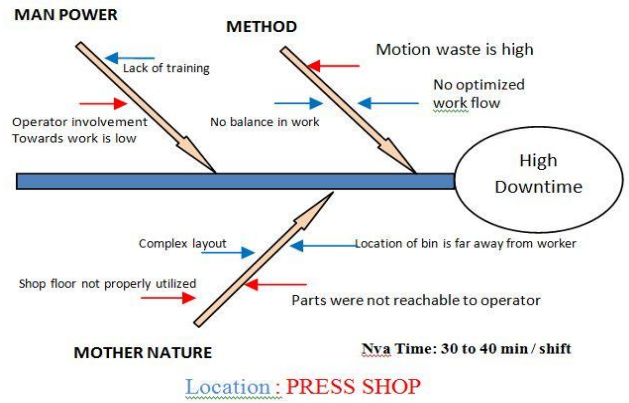

Fig 7: Cause And Effect Diagram – Kaizen method

VI. Problems In The Present State

The problems faced in the present state are, In the old bin setup there is no standard time for die setup because it consume more time. In the olden method the time taken for setting up of die and fixtures varies from 1 hour to 1.30 hours based on the tools availability and the die availability. Due to this delay in timing the work takes place to a greater extend, and the machine must be in stationary state without working on the delay period of time. Other important problem is that the communication between the workers is lacked off the machining should be stopped until the components are transported from the die to the bin.

A. Effects of the Kaizen method:

The various effects of Kaizen methods after implementing the bin set up are, Due to the old bin setup the motion effect of the worker are wasted in a large amount since after implementing the new bin setup the worker effect are reduced. The worker lifting the tray full of product will leads to affect the worker ergonomically in olden bin setup but now after implementing the new set up the lifting of components is reduced. Due to the new set up the storage place is huge to store the components.

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The batch size is also increased when compared with olden setup batch size, the ideal work of the machine also reduced.

VII. Improvements After Die Stand Setup

Table 2:
Components produced after die setup

S.No	Process	Actual Quantity Before	Actual Quantity After	Improvement
1.	Step Form	1560 no's	1680 no's	120/Shift
2.	Id Cut	1560 no's	1680 no's	120/Shift
3.	Bending 1	836 no's	900 no's	64/Shift
4.	Bending 2	836 no's	900 no's	64/Shift

By seeing the above table we can easily understand the statistics of the production before and after the implementation of Die stand and Bin setup, thus the production is increased rapidly and we can also see the amount of components raised in the company. By seeing the above table we are taken a four different process in the first process 120 quantity per shift is increased and in ID cut process the same 120quantity per shift is increased, the other 2 process bending totally 64 quantities is raised per shift. So when we implement this method in the manufacturing industries we can achieve more production.

Table 3:
Time Study Sheet (BEFORE)

S.NO	Details of Setup Tasks	N.O.Workers	TIME	TASK TYPE
1	Calling fork lift near to the machine	2	3 min	I
2	Getting tools to unclamp the die	1	1 min	I
3	Unclamping manually the top and bottom clamps	2	2 min 45 sec	I
4	Loading die to the fork lift	2	2 min	I
5	Fixing Punch holding plate to m/c	2	1min	I
6	Walking to tool room along with fork lift	2	2 min 30 sec	E
7	Placing the die into die rack	2	1 min 40 sec	E
8	New die searching from the rack	3	2 min 40 sec	E
9	Loading new die to the fork lift	3	1 min 30 sec	E
10	Coming back to press shop along with fork lift	2	2 min 30 sec	E
11	Punch holder plate loading to m/c bed	3	2 min	I
12	Spanner search and findings	1	1 min 40 sec	I
13	Tightening the punch using spanners	1	55 sec	I
14	Placing it to the die	1	45 sec	I
15	Ejection rod finding and inserting	1	30 sec	I
16	Ejection rod lowering and raising check	1	15 sec	I
17	Die ejection plate insert over punch	1	25 sec	I
18	Placing die over punch and fixing	1	45 sec	I
19	Placing the die holder plate	1	1 min 40 sec	I
20	Fixing the end clamps and check(back side)	1	42 sec	I
21	Adjusting the die holder plate	1	1 min	I
22	Fixing and tightening of clamps in the top	1	5 min 20 sec	I
23	Fixing the lower clamps to punch holder plate	1	3 min 40 sec	I
24	Trial check by raising and lowering the die	1	12 sec	I
25	Trial piece insert and offset check	1	6 min	I
26	Limit switch adjustmeny and trial run	1	3 min 20 sec	I
27	Quality check and approval	1	12 min	I
	Total Time		1 hr 2 min	

I - Internal task E - External task

Total Time : 62 min. Operators Involved: 4 no's

Table 4:
Time Study Sheet (AFTER)

S.NO	Activities	Parallel Activities	Workers	TIME	TASK TYPE	Improvements
1	Calling fork lift near to the machine(A)	Getting tools to unclamp the die(B)	2	3 min	I	Time saved
3	Unclamping manually the top and bottom clamps(A+B)		2	1 min 50 sec	I	Use nut runner
4	Loading die to the fork lift(A+C)	Spanner search and findings(B)	2	2 min	I	Time saved
5	Fixing Punch holding plate to m/c (B+C)		2	1min	I	
6	Walking to tool room along with fork lift		*	*	E	Eliminated
7	Placing the die into die rack		*	*	E	Eliminated
8	New die searching from the rack		*	*	E	Eliminated
9	Loading new die to the fork lift		*	*	E	Eliminated
10	Coming back to press shop along with fork lift		*	*	E	Eliminated
11	Punch holder plate loading to m/c bed(A+C)		3	2 min	I	
13	Tightening the punch using spanners manually		1	50 sec	I	
14	Placing it to the die (A+C)	Ejection rod finding and inserting(B)	3	1 min	I	Time saved
16	Ejection rod lowering and raising check(A)		1	15 sec	I	
17	Die ejection plate insert over punch(A)		1	25 sec	I	
18	Placing die over punch and fixing(A+B)		1	30 sec	I	
19	Placing the die holder plate(A)		1	1 min 40 sec	I	
20	Fixing the end clamps and check(both side)		1	42 sec	I	
21	Adjusting the die holder plate(A)		1	1 min	I	
22	Fixing and tightening of clamps in the top (A)	Fixing the lower clamps to punch holder plate(B)	2	6 min 30 sec	I	Use nut runner
24	Trial check by raising and lowering the die(A)		1	20 sec	I	
25	Trial piece insert and offset check(A)		1	6 min	I	
26	Limit switch adjustment and trial run(A)		1	3 min 30 sec	I	
27	Quality check and approval(D)		2	12 min	I	
A-Permanent operator, B-Worker, C- Fork lift operator ,D- Quality Inspector		Total Time		45 min		

Total time taken: 45min **Total time saved**: 16min

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If we implement the Die and Bin in the same rack we can improve the productivity and we can reduce the set up time of the individual process, the above graph shows the clear detail of the each individual process and their setup time taken. The WIP & setup time also reduced when it is compared with before statistics each process is reduced by 20% of their setup time.

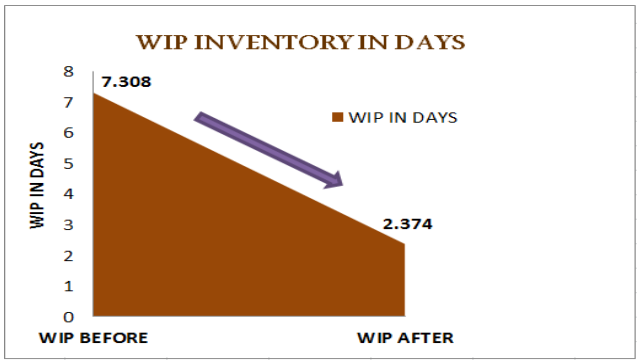

Fig 8: WIP Inventory Comparison

VIII. OEE IMPROVEMENT

OEE – Overall Equipment Effectiveness

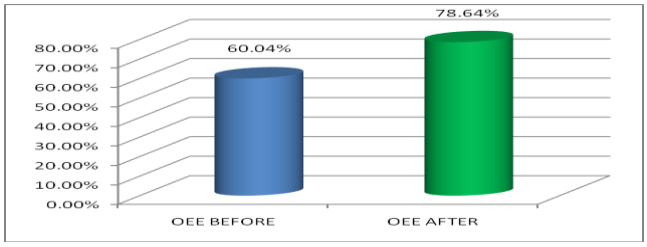

Fig 9: OEE Improvement in Step forming & Id cut process

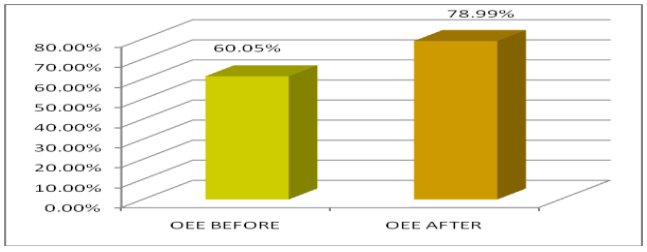

Fig 10: OEE Improvement in Bending process – 1 & 2

A. Overall Equipment Effectiveness Results:

PROCESS – STEP FORM, ID CUT

BEFORE:

1. A = Run time/Total time = 328/420 = 78.09 %
2. P = Total parts/ Target count = 1312/1680 = 78%
3. Q = Good parts/Total parts = 1292/1312 = 98.47%

OEE = A*P*Q = 60.04 %

AFTER:

1. A = Run time/Total time = 375/420 = 89.28 %
2. P = Total parts/ Target count = 1500/1680 = 89.28 %
3. Q = Good parts/Total parts = 1480/1500 = 98.66%

OEE = A*P*Q = 78.64 %

PROCESS – BENDING 1, 2

BEFORE:

1. A = Run time/Total time = 330/420 = 78.57 %
2. P = Total parts/ Target count = 708/900 = 78.66%
3. Q = Good parts/Total parts = 688/708 = 97.17%

OEE = A*P*Q = 60.05 %

AFTER:

1. A = Run time/Total time = 378/420 = 90 %
2. P = Total parts/ Target count = 810/900 = 90 %
3. Q = Good parts/Total parts = 790/810 = 97.53%

OEE = A*P*Q = 78.99 %

Table 5:
Overall Equipment Effectiveness Results

S.NO	PROCESS	OEEE BEFORE	OEEE AFTER
1	Step form & Id cut	60.04 %	78.64 %
2	Bending 1& Bending 2	60.05 %	78.99 %

IX. CONCLUSION

From the analysis of overall equipment effectiveness and the proper implementation of TPM the company has finally achieves reduce downtime of machine, increase output/month, availability, performance efficiency and quality performance which result increase OEE of machine. The main objective of this paper understand TPM concept and to generate awareness among the budding technologies about TPM. TPM methodologies not only increase the effectiveness of the manufacturing system but also increase the effectiveness of the entire organization through mandatory participation and continuously improve Productivity, quality, cost, Delivery, safety health and Morale. After successful implementation of TPM, it is found that Overall Equipment Effectiveness is increased.

Today TPM may be the only thing that stands between success and total failure for some companies; it has been proven to be a program that works. The results shown above can be much more improved by continuing withTPM.

X. Scope Of The Study

Today, with competition in industry at an all-time high, TPM may be the only thing that stands between success and total failure for some companies TPM can be adapted to work not only in industrial plants, but also in construction, building maintenance, transportation, and in variety of other situations. Employees must be educated and convinced that TPM is not just another "program of the month" and that management is totally committed to the program and the extended time frame is necessary for full implementation. If everyone involved in a TPM program does his or her part, a usually high rate of return compared to resources invested may be expected. TPM success requires strong and active support from management, clear organizational goals and objectives for TPM implementation. TPM methodology not only increases the effectiveness of the manufacturing system but also increase the effectiveness of the entire organization as well.

XI. Recommendation

In this case study, by using the lean manufacturing tools and approach, the comparison of the production rate and Overall Equipment Effectiveness of the press shop operations in the shop floor has been pictured out. The research is based on the introduction of die and bin setup and layout changing. The author suggested that by minimizing the distance travelled and reducing the lead time will improves the production rate. In this research work the major consideration was towards the layout optimization and lean techniques applied into real manufacturing environment, but our future research will be integration on TQM, TPM and LM Techniques and comparing the man machine rate, shop floor control system, automation and various other factors.

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