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Analysis and Implementation of Total Productive maintenance, Kanban and JIT Systems In Small Scale Polymer Industry

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ABSTRACT: The plastic industry has gone through significant changes in the last decade. Competition has increased dramatically. Customers focus on product quality, product delivery time and cost of product. Because of these, company should introduce a quality system to improve and increase both quality and productivity continuously. The objective of this paper is to increase the productivity and quality of work by implementing the TPM (Total Productive Maintenance) Pillars and lean concepts of Just-In-Time (JIT) and Kanban. In this paper, we have taken the case study of small scale manufacturing unit. Implementation of the Kanban system resulted in reduction of inventory to minimum levels besides increasing flexibility of manufacturing. Successful implementation of the Kanban system furthermore reduces operational costs, consequently increases market competitiveness. In a JIT environment, materials are purchased and produced as and when it is needed. Research on Kanban, JIT and TPM generally investigates the implementation and impact of these manufacturing programs in isolation. However, many researchers believe and argue conceptually the value of understanding the joint implementation and effect of manufacturing programs. This study investigates the practices of the three programs simultaneously. We find that there is evidence supporting the compatibility of the practices and that manufacturing performance is associated with the level of implementation of both socially- and technically-oriented practices of the three programs. After implementing TPM Pillars, JIT and Kanban in this industry, we have completed our objective by increasing productivity and Quality of product and also reduced the scrap losses of this industry. We have found good improvements in the OEE value also.

Keywords: TPM, JIT, Kanban, OEE (Overall Equipment Efficiency), Productivity, Maintenance.

I. INTRODUCTION

1.1 Total Productive Maintenance (TPM):

Total Productive Maintenance is complete solution of all industry to increase the productivity. The name of Total Productive Maintenance pillars are shown below. And also its objectives and benefits are described below.

1.1.1 Eight Pillar Of TPM:

a) Initial Flow Control Activity
b) Focused improvement (Kobetsu Kaizen)
c) Autonomous Maintenance (Jishu Hozen)
d) Quality Maintenance (Hinshitsu Hozen)
e) Planned Maintenance
f) Environment, Health and Safety
g) Admin TPM
h) Education and Training

1.1.2 Objective Of TPM:

a) Involve people in all level of Organization.
b) Achieve Zero Brake down, zero defects, Zero Speed loss & Zero Accidents.
c) Increase Production.
d) Increase associate morale and Job Satisfaction.

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1.1.3 Benefits of TPM:
Increases OPE (Overall Plant Efficiency), Rectify customer complaints, Satisfy the customer‘s needs by 100 %, Reduce the manufacturing cost by 30%, Keep the work place clean, neat and attractive, Achieve goals by working as team, Share knowledge and experience, Higher confidence level among the employees, the workers get a feeling of owning the machine, Improving Reliability,Generate Multi-Skilled employees.

1.2 Kanban:
Kanban, literally meaning "signboard" or "billboard", is a concept related to lean and just-in-time (JIT) production. According to its creator, Taiichi Ohno, Kanban is one means through which JIT is achieved.In the late 1940s,. Kanban uses the rate of demand to control the rate of production, passing demand from the end customer up through the chain of customer-store processes.

1.3 Just-In-Time:
Just in time (JIT) is a production strategy that strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. Just-in-time production method is also called the Toyota Production System.

II. LITERATURE REVIEW

2.1 Total Productive Maintenance:
TPM is an innovative Japanese concept. TPM is most important concept for industrial application. The term ―Total Productive Maintenance was first used in the late 1960‘s by Nipponese, a supplier of electrical parts to Toyota.

In global manufacturing industries, drastic changes have taken place in the last three decades reflected in management approaches, product and process technologies, customer expectations, supplier relationships as well as competitive behaviour (Ahuja et al. 2006). Despite implementation of advanced manufacturing technologies and development of lean production, benefits from these programs have often been restricted due to unreliable or inflexible equipments and methods (Tajiri and Gotoh, 1992). TPM can be defined as a systematic work method aiming to develop disturbance free processes at lowest possible cost through the commitment of all co-workers. OEE is calculated by obtaining the availability of the equipment, performance efficiency of the process and rate of quality products (Dal et al 2000). According to Kennedy (2005), it should be acknowledged that a TPM implementation is not a short-term fix program.

2.2 Kanban System
2.2.1 Operation:
An important determinant of the success of production scheduling based on "pushing" the demand is the quality of the demand forecast that can receive such "push."Kanban, by contrast, is part of an approach of receiving the "pull" from the demand. This is exactly what a Kanban system can help with: It is used as a demand signal that immediately propagates through the supply chain. This can be used to ensure that intermediate stocks held in the supply chain are better managed, usually smaller. Where the supply response cannot be quick enough to meet actual demand fluctuations, causing significant lost sales, then stock building may be deemed as appropriate which can be achieved by issuing more Kanban.
2.2.2 Kanban Cards:
Kanban cards are a key component of Kanban that uses cards to signal the need to move materials within a manufacturing or production facility or move materials from an outside supplier to the production facility. The Kanban card is, in effect, a message that signals depletion of product, parts or inventory that when received will trigger the replenishment of that product, part or inventory.

Kanban cards, in keeping with the principles of Kanban, should simply convey the need for more materials.. In the last few years, electronic Kanban systems, which send Kanban signals electronically, have become more widespread..

2.3 Just in Time (JIT):
2.3.1 Philosophy:
The philosophy of JIT is simple: inventory is waste. JIT inventory systems expose hidden cost of keeping inventory, and are therefore not a simple solution for a company to adopt. The company must follow an array of new methods to manage

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the consequences of the change. In short, the Just-in-Time inventory system focus is having “the right material, at the right time, at the right place, and in the exact amount”-Ryan Grabosky, without the safety net of inventory.

2.3.2 Benefits:

Reduced setup time, Production scheduling and work hour consistency synchronized with demand, Increased emphasis on supplier relationships, Supplies come in at regular intervals throughout the production day, Minimizes storage space needed, Smaller chance of inventory breaking/expiring.

III. ABOUT THE INDUSTRY

M/s. SKYPET POLYMERS produce plastic bottles and caps which are supplied to companies like SABOL and AAVIN. They also produce plastic impellers. The production takes place in two units. In unit A, two injection moulding machines are present and are used to make bottle caps, impellers and preforms for the bottles. In unit B, three blow moulding machines are present where the preforms are blown into bottles, assembled with their caps, packed and despatched. The two units are about 9km apart. Hence, transport facilities are required to move preforms to unit B. The material used in this industry Polyethylene terephthalate (PET) and Polypropylene (PP).

3.1 Processes Carried Out:

The following are the processes carried out:

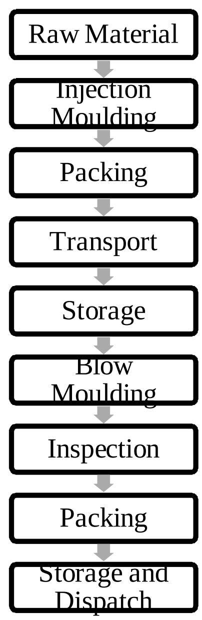

Fig. 1: Processes Carried Out In the Industry

IV. METHODOLOGY

At study time we find the causes of wastages of time and losses in industry. And we use some equations to know that how these wastages of time and losses affect the industry by calculating OEE, which are listed below:

- Total Planned Production Time = Total shift time – Production Break
- Total Operating Time = Total Planned Production Time - Machine down Time
- Final Goods = Total Machine Manufacturing - Total Machine Rejection
- Cycle Time (Time taken to produce one unit) = Total Operating Time/ Total Machine Manufacturing
- Valuable Operating Time per unit = Total Planned Production Time /Total Machine Manufacturing
- Availability = Total Operating Time/ Total Planned Production Time
- Performance Rate = Cycle Time/Valuable Operating Time per unit
- Quality Rate = (Total Machine Manufacturing-Total Machine Rejection)/Total Machine Manufacturing
- OEE = Availability X Performance X Quality Rate

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4.1 Production Data:
Using above mentioned variables and equation we calculate the OEE of this industry for three months that are shown below. After calculating the OEE of this industry we find that the OEE of this industry is less and not up to the mark.

Table 1: OEE Calculation (Before TPM)

Factors/ Month	15 May- 14 June'2013	15 June – 14july'2013	15 July – 16august'13
Total Shift Time	21,600mins	21,600mins	21,600mins
Production Break	900mins	900mins	900mins
Machine Downtime	1800mins	2400mins	2250mins
Total Machine Manufacturing	3000000pieces	3000000pieces	3000000pieces
Total Machine Rejection	60,000pieces	65,000pieces	75,000pieces
Final Goods	29,40,000pieces	29,35,000pieces	29,25,000pieces
Total Planned Production Time	20,700mins	20,700mins	20,700mins
Total Operating Time	18,900mins	18,300mins	18450mins
Cycle Time	0.0063	0.0061	0.0061
Valuable Operating Time Per Unit	0.0069	0.0069	0.0069
Availability	91.30%	88.40%	89.10%
Performance Rate	91.30%	88.40%	88.40%
Quality Rate	98.00%	97.83%	97.50%
OEE	81.68%	76.44%	76.79%

4.1.1 Unit A Layout:

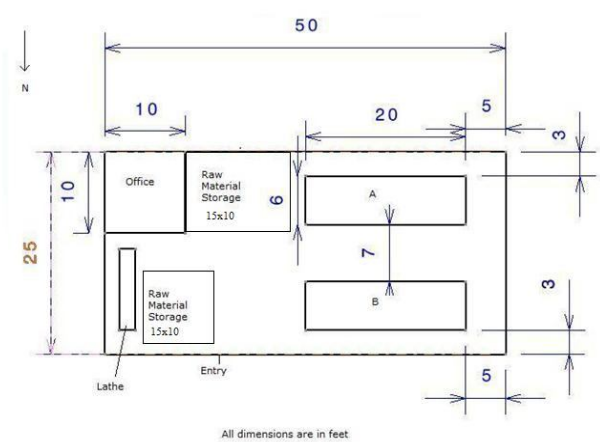

Fig. 2: Layout Of Unit A

4.1.2 Unit B Layout:

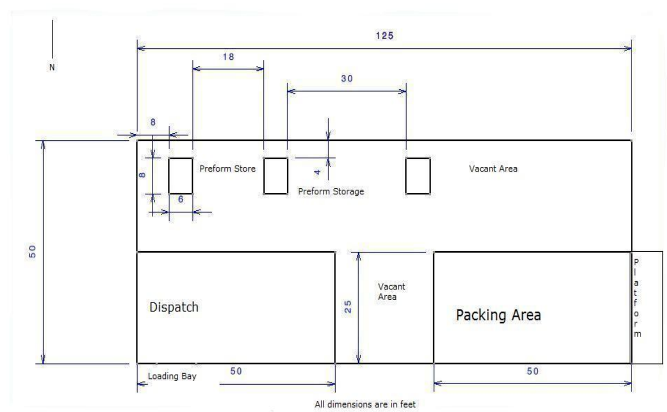

Fig. 3: Layout Of Unit B

4.2 Problems In This Practice:
In Unit A, the raw material, i.e., PET and Polypropylene were not stored in an organized manner. Once storage near the Office wall was filled, material would be stored near the lathe. Such a setup will result in confusion since the different materials are mixed and no proper stock of material can be maintained.There is a lot of cross movement of material, i.e., preform moves through packing area, and also unnecessary movement of material for comparatively long distances. This creates confusion as well as takes a lot of time. A lot of space is also left unused.

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V. IMPLEMENTATION

5.1 Suggestions and Implementation of TPM:

a) There is no sequence of work and these causes to Waste of time. After gives the suggestions Assembly of machines working in line and this cause reduce the time of operation.

b) In these Industry workers has not well skilled in every work. Employee do only one type of work in Industry. This situation create problem at time of working. To solve this problem we create the skilled matrix generation method to improved skill of workers in Industry.

c) In the duration of lunch time (60 min) maintenance personnel must do preventive maintenance of the plant.

d) We have also suggested implementing cleaning of machine and shop floor area before starting the work so that rejection of rework reduces.

e) Before implementation of TPM there is no proper working condition of workers. And after implementation TPM improved the working condition of workers by gives healthy food and purify ground water.

f) Before implementation of TPM there is unplanned stoppages and high down time due to lack of non availability of spare parts as per requirement..

g) At the initial phase of our study many employees consider it is an additional or burden but after implementation they feel that it is a win win situation for industry and employees.

5.1.1 After TPM Implementation:

Table 2: OEE Calculation (After TPM)

Factors / Month	15 Aug- 14 Sept'13	15 Sept – 14 Oct'2013
Total Shift Time	21,600mins	21,600mins
Production Break	900mins	900mins
Machine Downtime	1750mins	1700mins
Total Machine Manufacturing	3000000 pieces	3000000pieces
Total Machine Rejection	60,000pieces	50,000pieces
Final Goods	29,40,000 pieces	29,50,000 pieces
Total Planned Production Time	20,700mins	20,700mins
Total Operating Time	18,950mins	19,000mins
Cycle Time	0.0064	0.0063
Valuable Operating Time Per Unit	0.007	0.0069
Availability	91.54%	91.78%
Performance Rate	91.42%	91.30%
Quality Rate	98.00%	98.33%
OEE	82.02%	82.40%

5.2 Improved Layout Of Unit A:

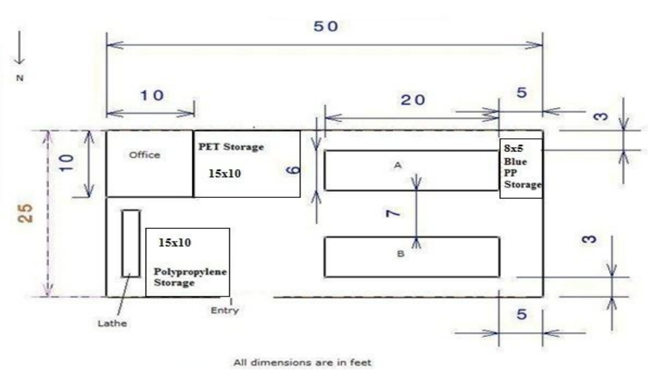

Fig. 4: Unit A After Layout Improvement

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In the improved layout, PET storage is made near the office and Polypropylene is stored near the lathe. Also, bags containing blue coloured pellets of Polypropylene (1 bag of blue pellets is mixed with every 5 bags of white coloured ones for bottle caps) is assigned a separate storage near the west wall.Hence, such a change provides pre-defined storage space and also helps avoid confusion and keep stock of material with ease.

5.3 Improvements In Unit B:

5.3.1 Intermediate Modification:

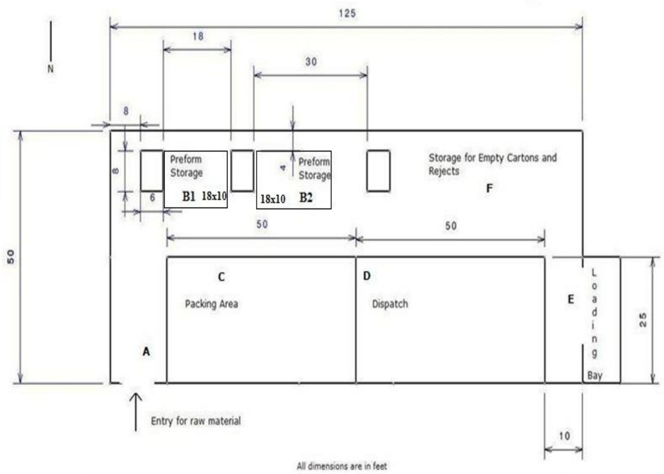

Fig. 5: Modified Layout of Unit B

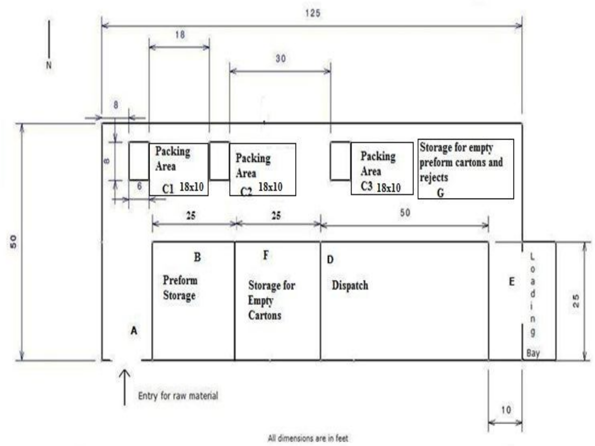

Fig. 6: Final Layout of Unit B

5.3.2 Sequence Of Operations:

- The raw material now enters through the entry at A (Previously F).
- It is then transported to the preform storage at B.
- The preform is then blow moulded and transferred to the packing area at C.
- It then moves to the dispatch area D.
- It is stored here temporarily until the customer’s collection vehicle arrives and is loaded into the vehicle at E.
- The empty cartons as well as rejects are stored at F from where they are disposed.

Objectives Accomplished: Unnecessary movement of material is avoided. The time taken to carry out the processes has reduced.

5.4 Final Layout:

5.4.1 Sequence Of Operations:

- The preform enters through A.
- It is stored temporarily at preform storage B.
- The preform cartons are then moved to where the machines are located.
- The bottles pass through a pre-heater and are blow moulded.
- The bottles are then packed at C.
- Each machine has a separate packing area exclusively for it.
- The packed bottles are then stored at dispatch D.
- A space F is also provided to store polythene bags and cartons used for packing purpose.
- Once the customer’s collection vehicle arrives, it is loaded into it at E.
- The cartons, rejects and other unwanted material is placed at G from where is disposed periodically.

Objectives Accomplished: The layout has been optimized further. Space has been utilized to the maximum.

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5.5 Time Study In Unit B:

5.5.1 Data Collected For Time Study In Original Layout:

Distance covered for movement of cartons to Preform Storages
A – B1 = 120 ft.
A – B2 = 90 ft.
Time taken for movement,
A – B1 = 33s.
A – B2 = 25s
Amount of preform which the unit consumes every 8 hrs.,
= 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)
Time taken to move this load from A,
To B1, where 8 cartons are stored, 33*8 + 25*7 = 439s.
Since manual labour is involved, let us assume 130% of theoretical time is taken = 439*1.3 = 571s = 9min. 0s.
To B2, where 16 cartons are stored, 25*16 + 20*15 = 700s
Since manual labour is involved, assuming 130% of theoretical time = 700*1.3 = 910s = 15min. 10s.
Time taken to move the load = 9min 30s + 15min 10s = 24min 40s.
Time taken for blow moulding = 14s for every 2 bottles.
No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
Time taken for packing = 15 min. for every package containing 50 bottles.
Distance to packing area, from C1 – D = 60 ft.
From C2 – D = 35 ft.
From C3 – D = 10 ft.
No. of bottles packed/person per hour = 60/15*50 = 200 bottles
But, practically, assuming only 80% efficiency, = 160 bottles.
Distance to be travelled to move bottles to loading bay = 50ft. max
Time taken to move 1 package = 20s.
Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s.
But, practically time taken = 5 min. since bottles stacked irregularly.

5.5.2 Data Collected For Time Study In Intermediate Layout:

Distance covered for movement of cartons to Preform Storages
A – B1 = 40 ft.
A – B2 = 70 ft.
Time taken for movement,
A – B1 = 12s.
A – B2 = 20s
Amount of preform which the unit consumes every 8 hrs.,
= 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)
Time taken to move this load from A,
To B1, where 8 cartons are stored, 12*8 + 9*7 = 159s.
Since manual labour is involved, let us assume 130% of theoretical time is taken = 439*1.3 = 207s = 3min. 30s.
To B2, where 16 cartons are stored, 20*16 + 16*15 = 560s
Since manual labour is involved, assuming 130% of theoretical time = 560*1.3 = 728s = 12min. 10s.
Time taken to move the load = 3min 30s + 12 min. 10s = 15min. 40.
Time taken for blow moulding = 14s for every 2 bottles.
No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
Time taken for packing = 12 min. for every package containing 50 bottles.
Distance to packing area,
From machines – D = 10 ft.
No. of bottles packed/person per hour = 60/12*50 = 250 bottles
But, practically, assuming only 80% efficiency, = 200 bottles.

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Distance to be travelled to move bottles to loading bay = 50ft. max
Time taken to move 1 package = 20s.
Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s.
(No time losses since bottles are accessible easily).

5.5.3 Data Collected For Time Study In Final Layout:

Distance covered for movement of cartons to Preform Storages
A – B = 25ft.
Time taken for movement,
A – B = 7s.
Amount of preform which the unit consumes every 8 hrs,
= 27 cartons (i.e., 1 carton of preform/machine per hour x 8 hrs. x 3 machines + bottle caps, i.e., 3 cartons)
Time taken to move this load from A,To B = 24*12 + 23*9 = 495s.
Since manual labour is involved, let us assume 130% of theoretical time is taken = 495*1.3 = 644s. = 11min. approx
Time taken for blow moulding = 14s for every 2 bottles.
No. of bottles produced/hr. = 3600/14 = 500 bottles approx.
Time taken for packing = 10 min. for every package containing 50 bottles. (No movement to packing area necessary).
No. of bottles packed/person per hour = 60/10*50 = 300 bottles
But, practically, assuming only 80% efficiency, = 240 bottles.
Distance to be travelled to move bottles to loading bay = 50ft. max
Time taken to move 1 package = 20s.
Assuming 500 bottles to be shipped, = 20*10 = 200s = 3min 20s(No time loss since bottles are accessible easily).

5.5.4 Change in Productivity:

Operation	Original Layout	Intermediate Layout	Final Layout
Preform Movement			
Per Carton	50s approx.	30s approx.	11s
Per Load	24 min.	15min. 40s.	11 min.
Efficiency Improvement	Nil	35% improvement	54% improvement
Packing			
Per Package	15 min.	12 min.	10 min.
Per Hour	160 bottles	200 bottles	240 bottles
Efficiency Improvement	Nil.	25% improvement	50% improvement.
Movement To Loading Bay			
Per Load of 10 Packages	5 min.	3min. 20s.	3min. 20s.
Efficiency Improvement	Nil	33% improvement	33% improvement

Fig. 8: Improvement in Productivity

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5.5.5 Storage Space Economization:

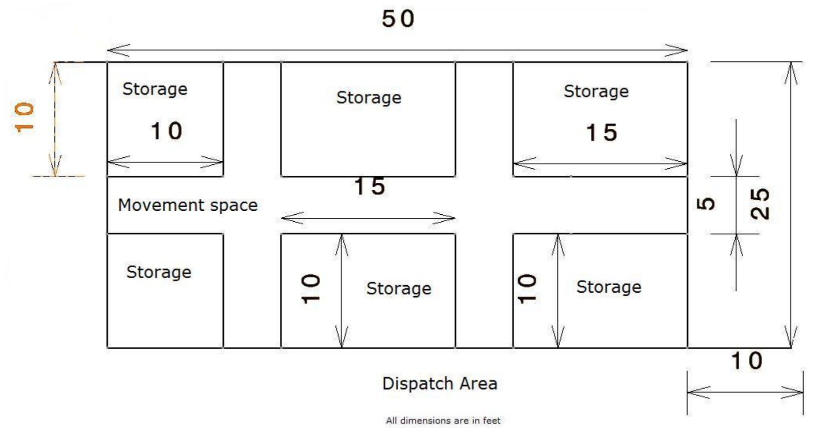

Fig. 7: Optimized Layout of Storage Space

The dispatch area can be split into areas as shown. The displayed layout has provision to store 6 different types of products. A pathway of 5ft is also present for easy access. Two areas can also be combined in case of presence of large quantities of a single item. Hence, by splitting the floor area as such, material movement is fast and takes place without any confusion.

5.6 Implementation Of Inventory Management System:

5.6.1 Usage of a management system to maintain stock:

The industry relied only on physically counting the material to maintain stock. This was a time consuming process and since it was carried out by labors who were not well educated and so, it would not be accurate.

The company produces six different types of products. They inventory includes:

- 1 litre bottles, 500 ml bottles, 5 litre bottles, 2 litre bottles, 250 gm Bottles, 100 gm Bottles

5.6.2 Procedure:

- One card is issued for every 50 preforms shipped from factory 1 to factory 2.
- For every 50 bottles packed, the worker takes a card from the preform bin and places it in the Packing Area bin.
- For every 50 bottles moved to the Dispatch area, a worker takes a card from the Packing area and places it in the bin at the respective section in the Dispatch area.
- For every 50 bottles dispatched, i.e., for every package, the worker takes 1 card from the dispatch bin and places it in the Loading Bay bin.
- Hence, by counting the number of cards, the number of bottles that have been packed, the inventory present in the dispatch area and the quantity that has been shipped can be made note of.
- If there are cards present which have not been transferred to the "Dispatch" bin, the number of rejects can be known.
- At the end of each shift or at periodic intervals, the cards will be returned to unit A and will be recycled.

5.7 Implementation Of Just In Time for Transportation:

5.7.1 Original Practice:

The movement of preform from Unit A to Unit B was highly irregular and would take place every day at unspecified intervals by numerous kinds of transport. This material would then be stored at Unit B regardless of the inventory present. Hence, the quantity present at Unit B would always have large fluctuations. In order to standardize this process, Just-in-Time was implemented so that transportation was done at predetermined intervals and no ambiguity would be present.

5.7.2 Practice after JIT Implementation:

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The process adopted works as follows:

- In unit B, each machine consumes 1 box, i.e., 500 preforms per hour.
- So, per hour, 3 boxes of preform are consumed.
- Unit A produces 1000 preforms per hour.
- It also produces 2100 bottle caps per hour from which flash has to be removed. Hence, it takes 2 hours to produce and pack 2100 bottle caps.
- So, in Unit A, 4 cartons (2000 preforms) are packed every 2 hours along with the caps.
- Unit B operates in two 12 hour shifts and so, it was decided to transport raw material for every shift so that the productivity can be monitored according to a shift basis.
- Unit B will consume 3*12, i.e., 36 boxes of preform per shift.
- Hence, Unit A will ship 36 boxes by a Mini Van one hour prior to the beginning of each shift.
- By implementation of this procedure, unnecessary inventory storage was eliminated and the productivity during each shift was also kept in check.

VI. CONCLUSIONS

By implementing the principles of lean manufacturing in the various processes, standardization was achieved as well as improved productivity in a few areas. The management was satisfied with the results the changes were able to produce. The following goals were accomplished:

- The storage space in Unit A was standardized.
- The productivity in Unit B improved after changing the layout. This was in the areas of packing and material handling.
- The inventory could be maintained better owing to a simple inventory management system.
- The storage space was accessible easier due to the partition.
- The transportation time was also standardized by using Just-in-Time.
- The OEE value was found to be only 75% approximately, now it has improved to 83%.
- A better quality rate has been achieved as a result of implementing TPM.

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