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"Productivity Improvement of Casting Industry Using Kaizen and 5S Techniques – A Case Study on Ebenezer Alloys"

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Abstract: *Nowadays, manufacturing industries all over the world are interested in profit maximization with maintaining their level of quality and increasing their market share in the competitive market. The purpose of our project is to study the sand casting process, casting defects and metal loss in various operation carried out during the casting process in foundry. Sand casting process is the simplest process and most widely used in the foundry to produce the different range of component. However it involves lot of parameters to control for the production of a good quality component. The casting industry in our case study faces the problem of defects and metal loss which decreases the quality of the component and increases the cost. To improve their productivity is a challenging task and for that we will implement the quality techniques such as "Kaizen" and "5S" with as minimum amount of expense as possible and with maximum benefits for the industry. We will also work on changing the plant layout of the industry because the company is not properly utilizing their plant resources with the present layout. We will also give some mould box design suggestions in order to improve quality and yield of their castings and reduce their metal loss and thereby improving their productivity. Hence our overall aim is to increase the productivity of industry.*

Keywords: *Productivity Improvement, Kaizen, 5S, Plant Layout, Casting Industry, Systematic Layout Planning*

I. INTRODUCTION

In the present day scenario, the major production of metallic components is done by the casting process. Casting is one of the best methods for production of mechanical components since it provides good strength and reliability of components. There are various casting processes by which the production of metallic components is done. The various processes are such as Induction casting, Die casting, Investment die casting (wax pattern), centrifugal casting, permanent mould casting, sand casting, etc. Out of them sand casting method is widely used and employed for manufacturing the metal castings. Sand casting is also employed because it is much cheaper and simpler as compared to other types of casting processes.

Nowadays, manufacturing industries all over the world are interested in profit maximization with maintaining their level of quality and increasing their market share in the competitive market. The purpose of our project is to study the sand casting process, casting defects and metal loss in various operation carried out during the casting process in foundry. Sand casting process is the simplest process and most widely used in the foundry to produce the different range of component. However it involves lot of parameters to control for the production of a good quality component. The casting industry in our case study faces the problem of defects and metal loss which decreases the quality of the component and increases the cost. To improve their productivity is a challenging task and for that we will implement the quality techniques such as "Kaizen" and "5S" with as minimum amount of expense as possible and with maximum benefits for the industry. We will also work on changing the plant layout of the industry because the company is not properly utilizing their plant resources with the present layout. We will also give some design suggestions in order to improve quality and yield of their castings and reduce their metal loss and thereby improving their productivity. Hence our overall aim is to increase the productivity of industry.

II. LITERATURE REVIEW

According to R.S. Agrahari et al in their article 'Implementation of 5S methodology in the small scale industry: A Case Study' (2015) has mentioned 5S as a tool for cleaning, sorting, organizing and providing the necessary groundwork for workplace improvement. They carried out the 5S implementation at V.M. Auto Pvt. Ltd. Satpur, M.I.D.C. Nasik. They concluded that the standards of the company reached a better level and probability of errors got reduced [1]. According to Ayush Khandelwal et al in their article '5S Implementation and its effect on Physical Workload' (2014) had carried out the implementation of 5S in a paper conversion machinery manufacturing plant. Their study stated that the time consumed and the energy expenditure was drastically reduced after the implementation of 5S in the industry, which in turn had a positive effect on the productivity [2]. According to Asayehgn Desta et al in their article 'Analysis of Kaizen Implementation in Northern Ethiopia's manufacturing industries' (2014) had carried out the analysis of three factories where Kaizen Implementation was done. The study found that after the implementation of Kaizen the three case companies have reduced the costs of production, improved their quality, reduced the lead time and have achieved a better customer satisfaction [3]. According to Vipulkumar C. Patel et al in their article 'Review on implementation of 5S in various organizations' (2014) had mentioned that 5S rules bring the great changes in the company, like process improvement by costs' reduction, increasing of effectiveness and efficiency in the processes, maintenance and improvement of the machines' efficiency, safety, security, quality and reduction of the industry pollution. They also mentioned that 5S will foster teamwork, discipline and will increase the sense of responsibility and compassion for company in the minds of the employees [4]. According to Shaman Gupta et al in their article '5S and Kaizen concept for overall improvement of the organization: A case study' (2014) had carried out the implementation of 5S and Kaizen in laboratory glass ware and research apparatus manufacturing industry. They concluded that 5S helps in creating a useful and well looking organization. They also concluded that Kaizen creates an atmosphere where employee suggestions are valued and they bring out the very best from a person. They also stated that 5S and Kaizen should not be looked just as a housekeeping exercise as it has more value than that [5]. According to P.M. Rojasra et al in their article 'Performance Improvement through 5S in a Small Scale Industry: A Case Study' (2013) had carried out the implementation of 5S methodology in Krishna Plastic Company, Udhyognagar, Amreli, Gujarat and their study stated that the efficiency of the production system in the case company improved from 67% to 88.8% in successive weeks of their study. The authors stated that 5S is a tool which helps to reduce all types of manufacturing wastes and subsequently improves the productivity [6]. According to Harsha Lingareddy et al in their article '5S as a tool and strategy for improvising the workplace' (2013), had carried out the implementation of 5S in company manufacturing the metal door. The authors stated in their article that 5S is a strategy which helps to minimize the time of manufacturing and also increases the area of the workplace. They also stated that 5S helps in process development by cost reduction and assists in reducing the waste. They conclude that when each stage of 5S is reached the quality and the productivity of the firm increases [7]. According to S.B. Khedkar et al in their article 'Study of Implementing 5S Techniques in Plastic Moulding' (2012) had carried out the implementation of 5S methodology in the S.P. Plastic Industry MIDC, Hingna Road, Nagpur. The authors stated that implementation of 5S will impact the instructors and the workman of the industry that work within the selected place. They also mentioned that 5S helps to build a stronger work ethic within the workman and engineer who would be expected to continue these 5S practices [8]. According to T. Karkoszka et al in their article 'Kaizen philosophy a manner of continuous improvement of processes and products' (2009) had mentioned that Kaizen is a philosophy which can be implemented to any organization whether small, medium or large scale industry. They implemented the Kaizen concept in the General Motors Factory at Poland and concluded that the Kaizen concept helps in achieving improved safety, quality and productivity. They also concluded that Kaizen helps in avoiding the useless movement and in increasing the working capability of the employees [9].

III. PROBLEM SPECIFICATION

3.1. Poor Storage Facility:

'Ebenezer Alloys' are not utilizing their plant in an efficient manner. The raw material is stored in the plant in an unplanned manner. The raw material storage and the pattern storage get mixed up which causes a lot of problems. Also the area for packaging is very close to the material storage which causes the hindrance in movement.

Figure 1. Poor Storage Facility

3.2. Untidy Workshop:

'Ebenezer Alloys**'** is having very untidy workshop. The entire equipment, tools and all other accessories have blackened due to the presence of dust and due to the fumes of the furnace. Since the machineries have blackened it is difficult to do maintenance and repair work in the industry.

3.3. Improper Arrangement of Patterns:

The patterns are not arranged properly in the workshop i.e. they are arranged in the most random manner. There is no specific system of the storage of the patterns. The frequently used patterns and seldom used patterns are not differentiated and wood patterns, aluminium patterns and thermocol patterns are kept together.

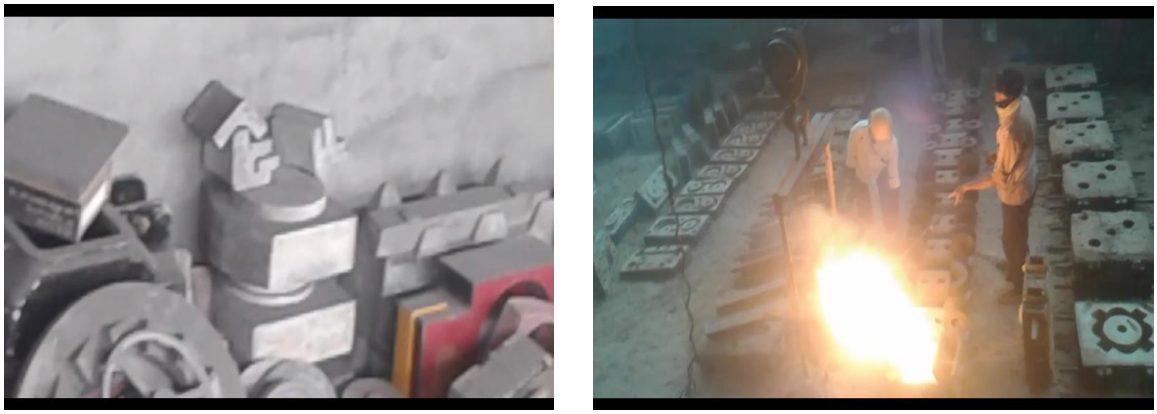

Figure 2. Improper Pattern Arrangement and Ergonomics Problem

3.4. Ergonomics Problem:

When observed from the shop floor level the height of the furnace is less than the height of a worker, hence heat expelled from the furnace increases the temperature of the surrounding. Also there are no safety preventions in the industry for the workers in the industry. There is no uniform dress code of the workers.

3.5. Use of Unskilled Workers:

The industry uses the unskilled workers for making the mould box. They do not have the proper knowledge of the sand casting process and rules of the mould box design. They design the mould box by giving the straight gating and riser system.

3.6. Inefficient Use of Resources:

'Ebenezer Alloys' are not fully utilizing their resources in the best manner. Their plant layout is also ineffective and they have not arranged the inter-related machines in the suitable manner. Also they have not provided enough space for storage and packaging. Since the inter-related equipments are placed at some distance, the workers have to travel some distance to carry out the operations.

IV. DATA COLLECTION AND DATA ANALYSIS

4.1. Manufacturing Sequence:

At Ebenezer Alloys, the manufacturing sequence is a standard one and every time the same procedure is followed. At one section of the plant, the mould boxes are made and the molten metal is poured into these mould boxes so that the casting product may be produced. At another section the casting products are removed from the mould boxes after they are properly cooled. After this the casting products are surface finished in another section. Then they are packed in the packaging unit where their weight is also checked. At the end they are temporarily stored in a place until the products are dispatched to the clients.

4.2. Existing Plant Layout:

The following figure shows the existing plant layout of the Ebenezer Alloys and it is followed by a table which shows the dimensions of the various equipments and areas mentioned in the plant layout.

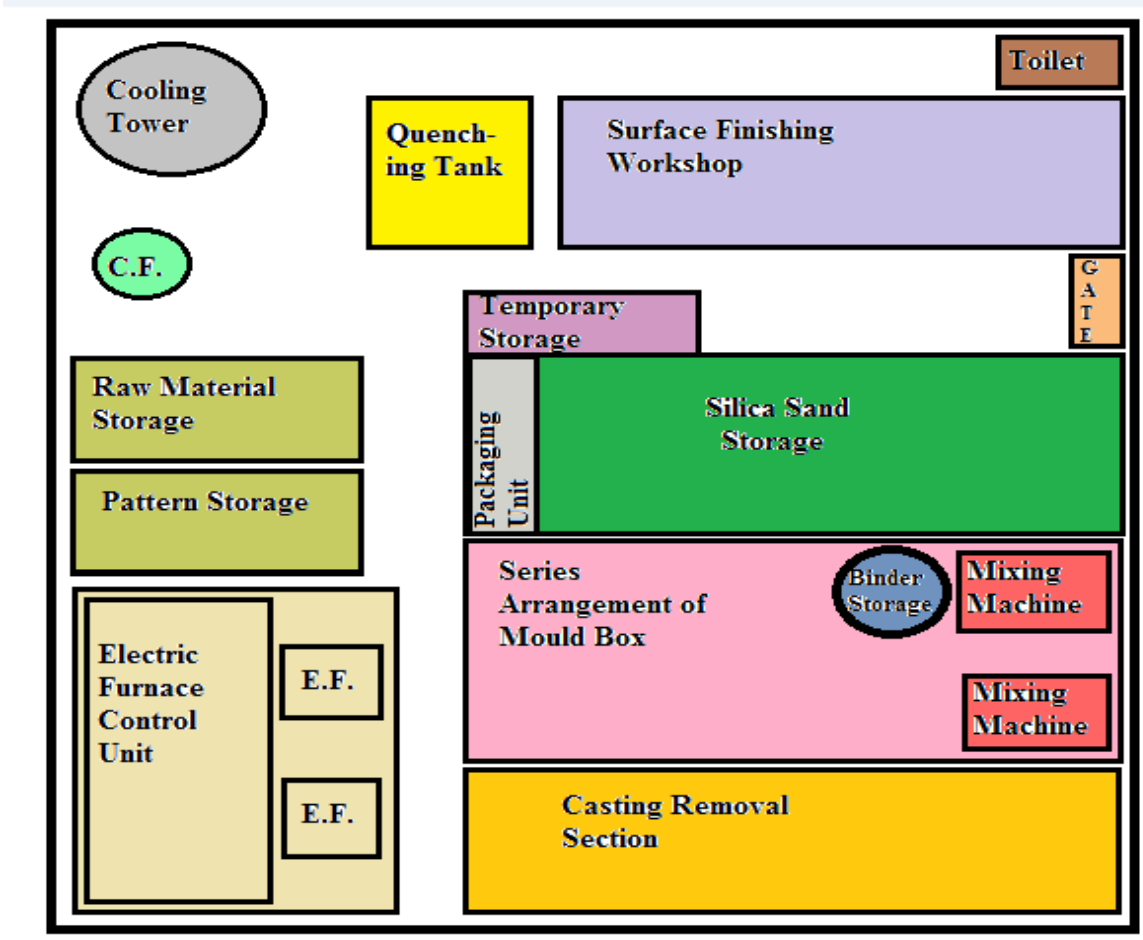

Figure 3. Existing Plant Layout

Table 1. Dimensions of Equipments

SR. NO.	NAME OF EQUIPMENT / UNIT	WIDTH (METRE)	LENGTH (METRE)
1)	COOLING TOWER	3.25	3.14
2)	TOILET	1.50	1.00
3)	QUENCHING TANK	2.88	3.85
4)	SURFACE FINISHING WORKSHOP	8.00	10.00
5)	CRUCIBLE FURNACE	2.40	2.28
6)	RAW MATERIAL STORAGE	4.00	6.00
7)	PATTERN STORAGE	4.00	6.00
8)	CASTING REMOVAL SECTION	10.00	4.00
9)	ELECTRIC FURNACE AREA	6.00	10.00
10)	MIXING MACHINE (2 NOS)	1.00	1.00
11)	SERIES ARRANGEMENT OF MOULD BOXES	9.00	8.00
12)	BINDER STORAGE	0.50	0.50
13)	SILICA SAND STORAGE	8.75	6.00
14)	PACKAGING UNIT	1.25	6.00
15)	TEMPORARY STORAGE	3.78	2.50
16)	GATE / ENTRANCE	-	6.00

4.3. Time Study:

The time taken by each worker to handle raw materials, semi - finished goods and finished goods are shown in the following table. Also the table shows the number of operators required carrying out a particular operation and it also shows the number of working hours of each and every equipments and machines in the factory.

Table 2. Time Study Table

O/P. No.	Machine / Operation Name	No. of Operator	No. of Components Manufactured	Man Working Time	Machine Working Time
1)	Sand Mixing Machine	1	1 Batch = 200kg	4 hour	4 hour
2)	Weighing of Raw Material And Finished Products	1	-	1-2 hour	1-2 hour
3)	Electric Furnace	2	1 Batch = 1200 kg	1 hour	3 hour
4)	Mould Box Making	4	1 Batch = 42 Boxes	3 hour	-
6)	Casting Removal Process	2	1 Batch = 42 Castings	2 hour	-
7)	Molten Metal Pouring and Ladle Handling	3	1 Batch = 42 Pouring	2.5 hour	-
7)	Welding Machine	1	-	4 hour	4 hour
8)	Grinding Machine	1	-	4 hour	4 hour
9)	Gas Cutter	1	-	4 hour	4 hour
10)	Cooling Tower	-	-	-	3 hour

4.4. Relationship Chart:

A relationship chart is a chart which shows the relationship between each department. Hence, with the help of the relationship chart, one can easily find the inter departmental importance and its relationship. Hence relationship chart helps to design an optimum layout by considering the interdependency and inter relationship between various components.

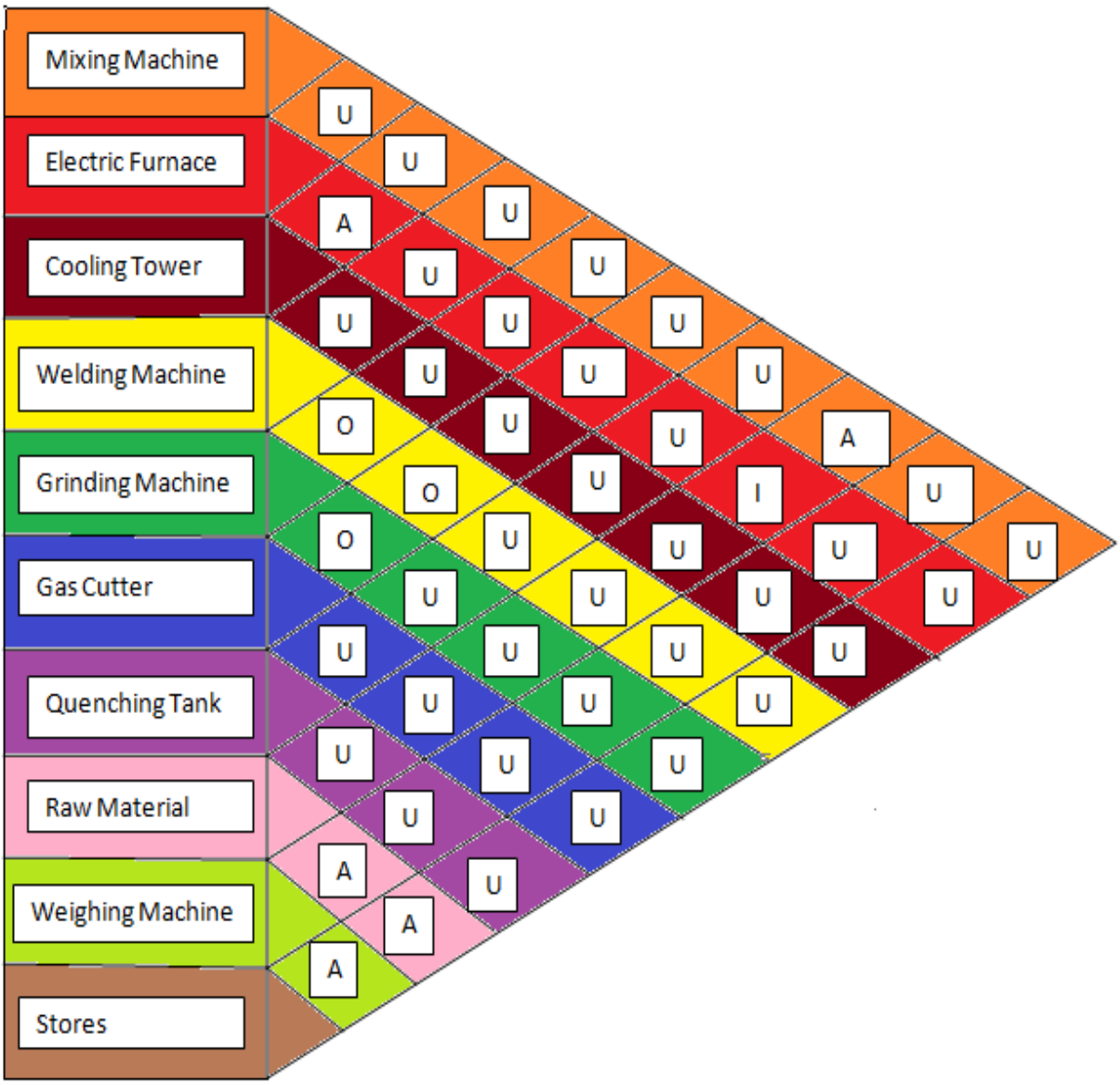

Figure 4. Relationship Chart

A	ABSOLUTELY NECESSARY
I	IMPORTANT
O	ORDINARY CLOSENESS OK
U	UNIMPORTANT

Figure 5. Notations Used in Relationship Chart

4.5. Flow Process Chart For Mould Box Making:

Figure 6. Flow Process Chart For Mould Box Making

4.6. Flow Process Chart For Metal Casting:

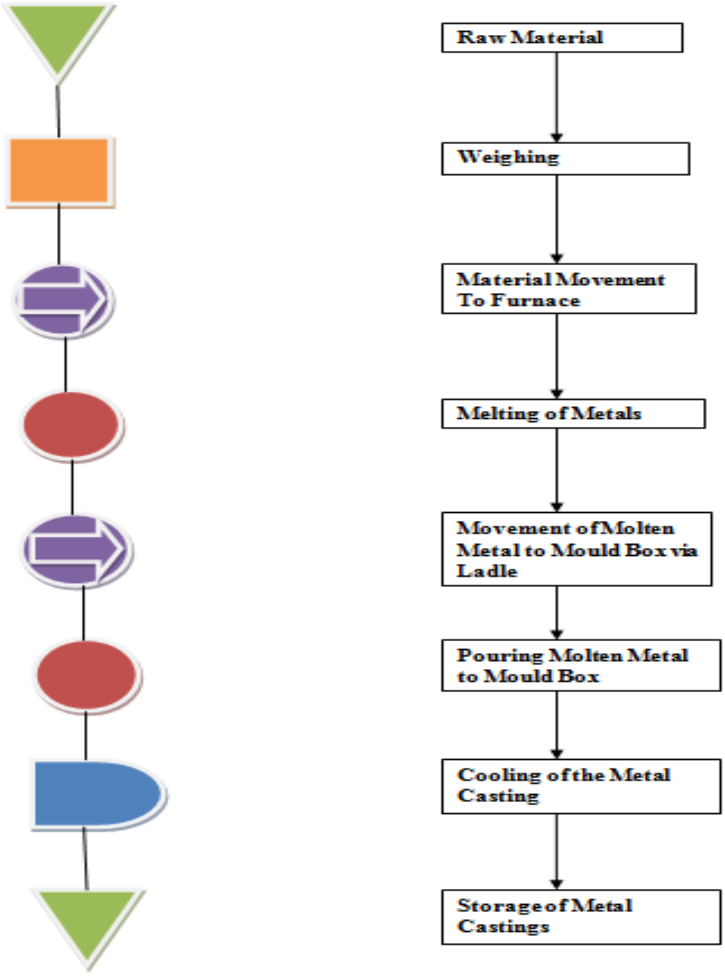

Figure 7. Flow Process Chart For Metal Casting

4.7. Solution Based On S.L.P. Technique:

The 2nd S (Seiton) of 5S says that all tools, accessories, equipments,etc should be arranged in a proper sequence to use them in an optimum manner.When we analyzed the current plant layout,we found that in current plant layout the machineries are not arranged in an optimum manner.To prepare a new plant layout, we used the relationship chart of the S.L.P. Technique and we also used the the flow process chart to understand the flow of raw – materials to finished goods.We were also able to know the inter – dependency of each equipment and different process carried out to obtain the final product.Thus after analyzing the current plant layout with the help of the S.L.P. Technique and flow process chart we were able to develop two alternative plant layout.

4.7.1. Suggested Plant Layout – 1:

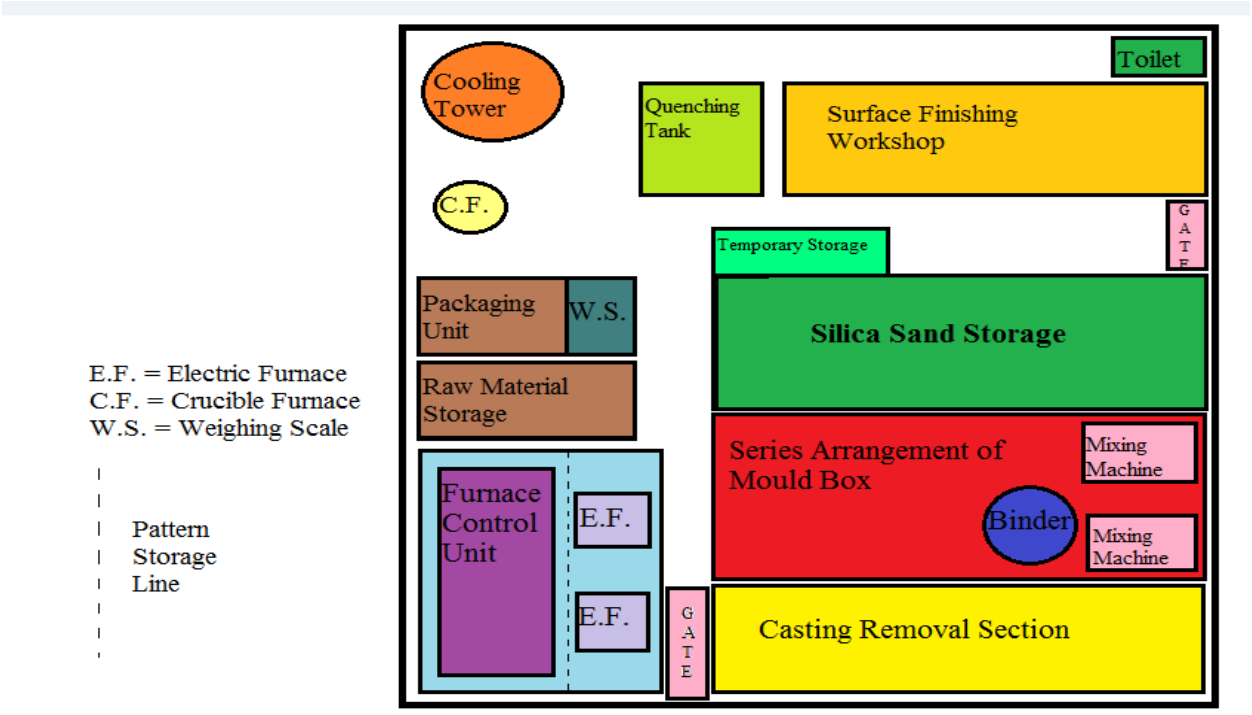

Figure 8. Suggested Plant Layout – 1

FROM	TO	DISTANCE TRAVELLED IN SUGGESTED LAYOUT - 1	DISTANCE TRAVELLED IN EXISTING LAYOUT	DIFFERENCE
Raw Material	Electric Furnace	7 m	11 m	4 m
Pattern Storage	Mould Box Make Area	6 m	12 m	6 m
Silica Storage	Mixing Machine	7 m	7 m	0 m
Electric Furnace	Mould Box Cooling Area	9 m	9 m	0 m
Mould Box Cooling Area	Casting Removal Area	6 m	6 m	0 m
Casting Removal Area	Surface Finishing Area	28 m	28 m	0 m
Surface Finishing Area	Packaging Unit	10 m	16 m	6 m
Packaging Unit	Weighing Scale	1 m	8 m	7 m
Total Distance Travelled		74 m	97 m	23 m

Figure 9. Comparison of Distance Travelled

4.7.2. Suggested Plant Layout – 2:

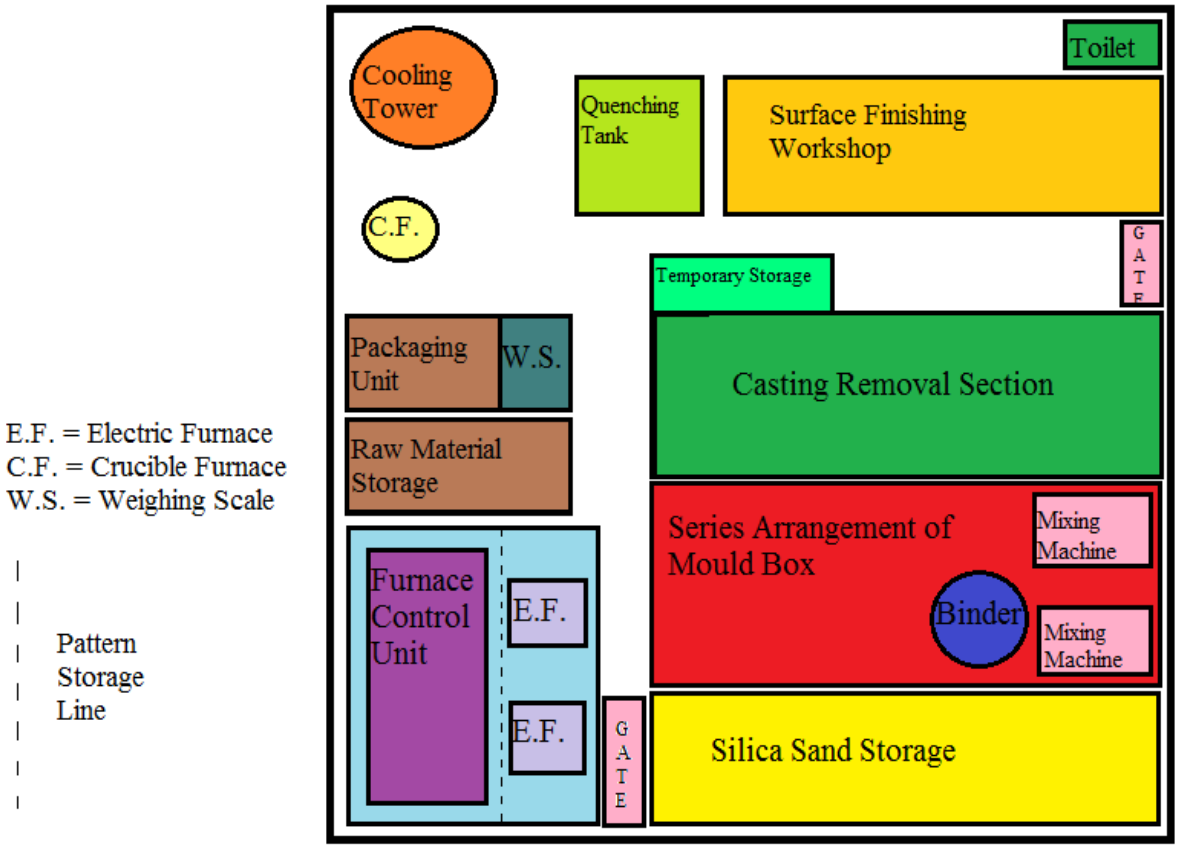

Figure 10. Suggested Plant Layout – 2

FROM	TO	DISTANCE TRAVELLED IN SUGGESTED LAYOUT - 2	DISTANCE TRAVELLED IN EXISTING LAYOUT	DIFFERENCE
Raw Material	Electric Furnace	7 m	11 m	4 m
Pattern Storage	Mould Box Make Area	6 m	12 m	6 m
Silica Storage	Mixing Machine	3 m	7 m	4 m
Electric Furnace	Mould Box Cooling Area	9 m	9 m	0 m
Mould Box Cooling Area	Casting Removal Area	5 m	6 m	1 m
Casting Removal Area	Surface Finishing Area	10 m	28 m	18 m
Surface Finishing Area	Packaging Unit	10 m	16 m	6 m
Packaging Unit	Weighing Scale	1 m	8 m	7 m
Total Distance Travelled		51 m	97 m	46 m

Figure 11. Comparison of Distance Travelled

V. "5S" IMPLEMENTATION DATA

5.1. Seiri Implementation

Figure 12. Seiri Implementation Comparison

Table 3. Seiri Rating Table

Week No.	Duration	Unnecessary Tools Rating	Defective Goods Rating	Operating Condition Rating	Elimination of Waste Rating	Relative Information Rating	Total Rating
Before	11/01/2016	3.2/5	2.1/5	3.2/5	2.2/5	3.3/5	14.0/25
After	14/03/2016	3.7/5	3.8/5	3.8/5	3.5/5	4.1/5	18.9/25

5.2. Seiton Implementation:

Figure 13. Seiton Implementation Comparison

Table 4. Seiton Rating Table

Week No.	Duration	Sequence Rating	Material Arrangement Rating	Tool Arrangement Rating	Arrangement Consistency Rating	Working Efficiency Rating	Total Rating
Before	11/01/2016	2.6/5	2.4/5	2.5/5	2.2/5	2.8/5	12.5/25
After	14/03/2016	3.2/5	3.8/5	4.4/5	3.8/5	3.6/5	18.8/25

5.3. Seiso Implementation:

Figure 14. Seiso Implementation Comparison

Table 5. Seiso Rating Table

Week No.	Duration	Machine Cleanliness Rating	Process Path Cleanliness Rating	Working Environment Rating	Clean Consistency Rating	Safety Rating	Total Rating
Before	11/01/2016	2.2/5	1.5/5	2.0/5	1.1/5	2.2/5	9.0/25
After	14/03/2016	3.6/5	2.5/5	3.4/5	1.4/5	2.6/5	13.5/25

5.4. Seiketsu Implementation:

Seiketsu mentions about standardizing the process, so that we can effectively maintain the above processes.So, we marked the surrounding area of furnace with the yellow lines and we also named the racks for the stored patterns so that we can differentiate them. Seiketsu mentions about maintaining the above three process implementations.

Table 6. Seiketsu Rating Table

Week No.	Duration	Total Rating = (S1+S2+S3)/3
Before	11/01/2016	11.83/25
After	14/03/2016	17.06/25

5.5. Shitsuke Implementation:

Shitsuke mentions that one should train their employees to stay in the disciplined manner and one has to maintain all other S in this stage. So, on the basis of the 5^{th} S , we appointed the floor supervisor as the team leader and explained him about the importance of 5S and how to maintain this. We, also appointed one of the senior employee as a store in-charge and his duty is to check whether the other employees are keeping the patterns in their proper place or not and based on that he even had the right to fine those employees.

Table 7. Shitsuke Rating Table

Week No.	Duration	Total Rating = (S1+S2+S3+S4)/4
Before	11/01/2016	11.83/25
After	14/03/2016	17.06/25

5.6. Efficiency Rating:

After the implementation and rating of 5S concept, we calculated the Efficiency of the plant. The following table shows the Efficiency of the plant before and after the implementation of 5S concept. After the implementation we found that the Efficiency of the plant increased from 47.33% to 68.25% and hence we achieved a notable increase in the Efficiency of the plant after the 5S Implementation.

Table 8. Efficiency Rating Table

Week No.	Duration	(S1+S2+S3+S4+S5)/125	Efficiency
Before	11/01/2016	59.16/125	47.33
After	14/03/2016	85.32/125	68.25

VI. CONCLUSION

Here on the basis of Systematic Layout Planning Technique we have studied and analyzed the layout and working process of the Ebenezer Alloys. We have idenitified the degree of necessity of placing the equipments close to each other with the help of S.L.P. method. We tried to eliminate the wasteful elements and activities from the plant and we on the basis of S.L.P. were able to suggest two plant layouts. In the first layout we were able to reduce the distance travelled by 23 metre and in the second layout we were able to reduce the distance travelled by 46 metre. We also concluded that by implementing "5S" and "Kaizen" techniques the searching time is reduced, the various defects are reduced, the plant becomes more neat and clean, the quality of workplace is increased and the workers become more enthusiastic and passionate about their work. By implementing "5S" in our case industry the efficiency of the plant increased from 47.33% to 68.25%. Hence the overall productivity of Ebenezer Alloys increased.

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