CASE STUDY ON LEAN MANUFACTURING IMPLEMENTATION IN MICRO SCALE FOUNDRY - CHALLENGES & OPPORTUNITIES

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Abstract: This study has been undertaken to identify the Challenges & Opportunities in Lean Manufacturing Implementation in Micro scale Foundry. The foundries represented the archetypal foundry denoted by 3 Ds ie; Dirty, Dark and Dangerous based on conventional processes and manpower. This study explains the efforts to change from Haphazardly & Disorganized Layout to a Designed Production Flow with Increased Production Rate. This Study Aims Firstly on How Many Challenges & Opportunities to be perceived during Successful Lean Implementation Journey. Second, to Create Awareness about Productivity Improvement in Micro & Small Industries by Quality Tools Implementation & Third Introduction & Awareness about Lean Manufacturing.

Index Terms **- Lean Manufacturing, 5s, Foundry, VSM, TPM, 7 Waste, FMEA, Quality Tools, Quality Plan, Yield, Productivity Improvement, Kaizen, Pareto, Ishikawa**

I. INTRODUCTION

"Lean" is a technique which enhances value for customers by making process flow more improved & smooth and eliminating waste. Lean Works for total elimination of waste and bottlenecks from processes to develop breakthrough in customer value. In Lean Manufacturing there is a believe that it is only effective in Medium & Large Scale industries; we can't get same results in Micro & Small Scale industries. This study shows that there is same Scope, hope & willingness of implementation for absorbing the new technologies like lean manufacturing tools, Six Sigma, QC tools, EHS activities, ISO standard implementation etc, if all things comes in their micro budget.

Lean Manufacturing is the key for elimination of waste in every area of production including customer relations, product design, supplier networks and factory management. Lean develop a approach of less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand and targets for day by day productivity improvement through Lean Tools implementation & Continuous Monitoring.

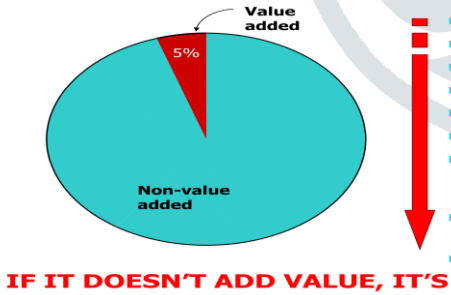


Fig 1. Value add & non value add description

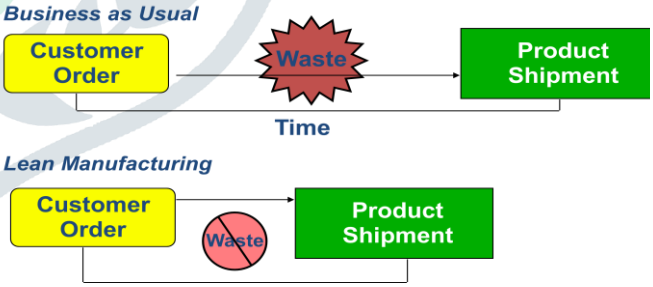


Fig.2 Waste definition

1.1 Lean Tools: Lean has a very extensive collection of tools and concepts. Some of them are as follows

Table.1: Lean Tools

1.	5S	2.	Poka-Yoke (Error Proofing)
3.	PDCA (Plan, Do, Check, Act)	4.	Root Cause Analysis
5.	Single-Minute Exchange of Dies (SMED)	6.	Six Big Losses
7.	SMART Goals	8.	Standardized Work
9.	Takt Time	10.	Total Productive Maintenance
11.	Value Stream Mapping	12.	Visual Factory
13.	Andon	14.	Bottleneck Analysis
15.	Continuous Flow	16.	Gemba (The Real Place)
17.	Muda (Waste)	18.	Hoshin Kanri (Policy Deployment)
19.	Just-In-Time (JIT)	20.	KPIs (Key Performance Indicators)
21.	Kaizen (Continuous Improvement)	22.	Jidoka (Autonomation)
23.	Kanban (Pull System)	24.	Overall Equipment Effectiveness

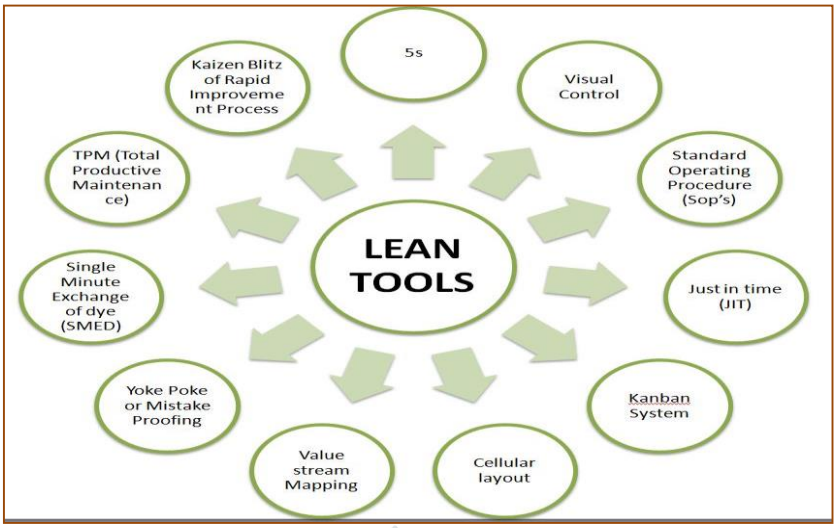


Fig 3 Schematic view of Lean Tools

1.2 Introduction about Plant:

A Foundry is a Micro Scale Conventional & Sand Floor Type Foundry in VKIA, Jaipur. In this Unit a lot of manufacturing Process is done using a line flow concept from one operation to another. There is need to Standardize the Layout, design, Process of the entire plant as well as Machine Shop and Moulding Section etc to Manufacture as per Systematic Flow.

Based on brain storming and preliminary data available with the unit members, 22 problems were identified, evaluated and prioritized by the unit members as Lean problems which were related to Skilled manpower Shortage, Limited floor areas, Sand floor, Poor feed materials control, Poor O&M practices, High Casting Defects, High Melting losses, Low Productivity, Overproduction, Patterns Cracks etc

1.3 Process Flow Chart :

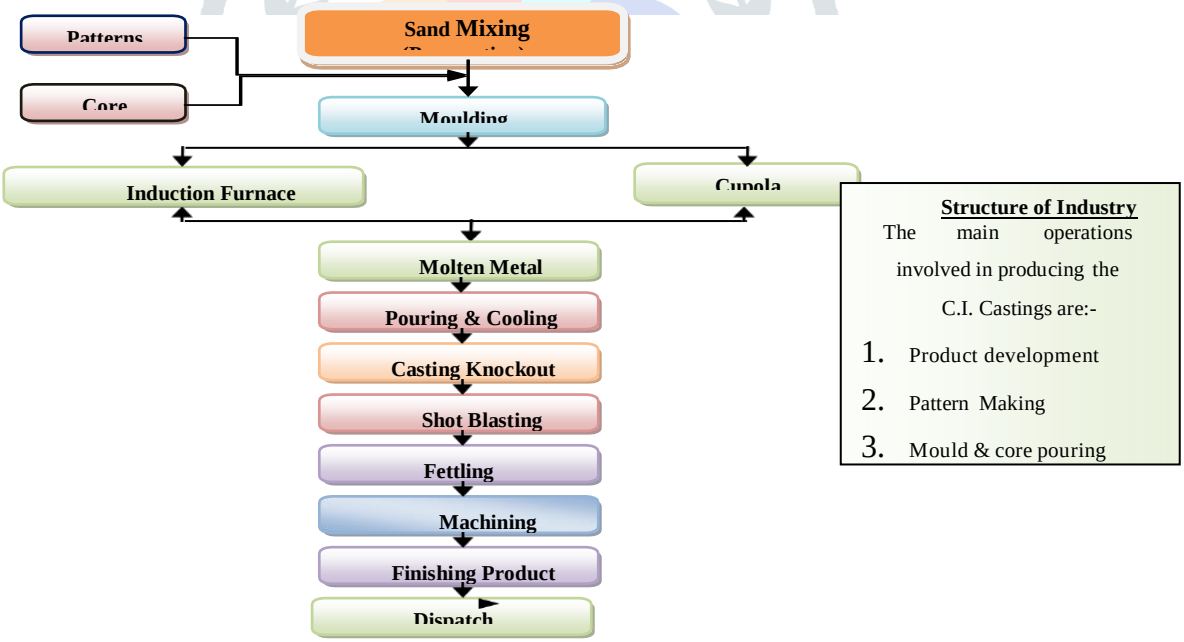


Fig 4 Process Flow Chart

II. RESARCH METHODOLOGY

2.1 Diagnostic Study & Situational Analysis: Firstly Diagnostic Study and Situation Analysis has been done by using Lean Tools i.e. SWOT Analysis, Current State Map,5S audit, Takt Time & Cycle Time Calculation, Waste Identification, Current Level of Quality practices etc.

Table 2: SWOT Analysis

STRENGTH	WEAKNESS
1. Industries have developed expertise in SG & CI Casting. 2. Cordial Relationship with Customers, Supplier and Employees. 3. Uninterrupted Power Supply. 4. Availability of Raw Material & Resources. 5. Some Modern machines. 6. Top Management is flexible.	1. The products are as per Customer's requirement and n case of rejection from the buyer there is no general market for the said products 2. Shortage of Skilled Labors 3. Major Dependency on few customers 4. Limited Casting manufacturing size, big size casting are not viable in current manufacturing system 5. Yet, not taped export market
OPPORTUNITIES	**THREATS**
1. Rapid growth of automobile industry has resulted in incremental demand 2. Government policy supportive, promoting infrastructure and private enterprise 3. General economic growth	1. Stiff Competition from New Foundries 2. Power cost is depended on Government policies 3. Competition from Sheet Fabrication and Forging industries 4. Volatile prices of Raw material

Table 3: Current State Map

S.N.	Activity	Time
1.	Production Starts on	1 June
2.	Production Ends on	30 June
3.	Total Days	30
4.	Holidays	4
5.	Working Days	26
6.	Working Hrs	8 hr
7.	Total Ordered Qty	5000
8.	Per Day Qty	185.185
9.	Takt Time in Minutes	2.59

Fig 5: Takt Time Calculation

Cycle Time Activity

S. N.	Activity	Time Required Hour	Min	Sec	Total Time in Sec.	Man Power
1.	Searching of Right Pattern, Core Box	2	03	20	7400	1
2.	Inspection of Pattern, Core Box		2	30	150	1
3.	Inspection of Raw material		30	30	1830	2
4.	Mould Sand Preparation		30	40	1840	2
5.	Core Sand Preparation		20	20	1220	1
6.	Core Making		5	50	350	1
7.	Mould Preparation & Venting		5	30	330	1
8.	Inspection of Mould		0	50	50	1
9.	Core Drying/Baking	1	10	0	4200	1
10.	Removal of Parting Line		1	20	80	1
11.	Inspection		0	50	50	1
12.	Mould Cleaning & Core Setting		2	10	130	1
13.	Mould Closing & load placement		2	50	170	1
14.	Charge Mix Collection		36	40	2200	3-4
15.	Liquid Metal Preparation (Melting)	1	12	22	4342	3-4
16.	Ladle Preparation & Preheating		19	40	1180	3-4
17.	Inoculation & Pouring		16	40	1000	3-4
18.	Poured Mould Cooling	2	17	20	8240	1
19.	Knockout of Mould		1	56	116	1
20.	Knockout of Risers		6	40	400	1
21.	Primary Inspection		2	30	150	1
22.	Sand Blasting		18	40	1120	1
23.	Visual Inspection		2	50	170	1
24.	Facing		15	30	930	1
25.	Fettling & Grinding		18	10	1090	1
26.	Cross Inspection		4	30	270	1

Fig 6: Cycle Time Calculation

Table 4: 5S Audit

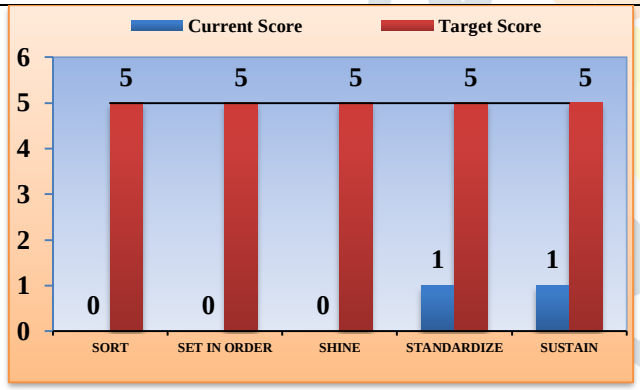


Fig 7 : 5s Audit Sheet (Before)

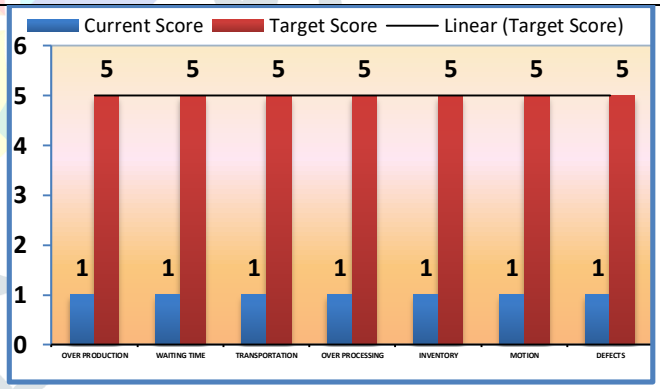


Fig 8: Waste Identification Score

Table 5: Current Level of Quality practices:

Quality Practices	Current Score
Kaizen Suggestion scheme	0
Quality Circles	1
Shop floor meetings	1
Monthly meetings	0
1. Plan, Do, Check, Act (PDCA)	0
2. Why-Why Analysis	1
3. Fishbone or Cause and Effect Diagram	0
4. Simplified Failure Modes and Effects Analysis (SFMEA)	0
Continuous Improvement (Kaizen)	0
Cost of Poor Quality	0

III. IMPLEMENTATION METHODOLOGY

3.1 Implementation Methodology Adopted

After some time, they started believing that there is more to gain in exposing their issues to other unit members. There are three significant realizations

- Mutual Trust
- Extensive information sharing
- Working in synergy is more profitable than aggressively competing with each other.
- A3 Methodology/PDCA Model for Problem Solving:
- A3 "Systematic Problem Solving" is based on the principles of Deming's PDCA (Plan-Do-Check-Act).

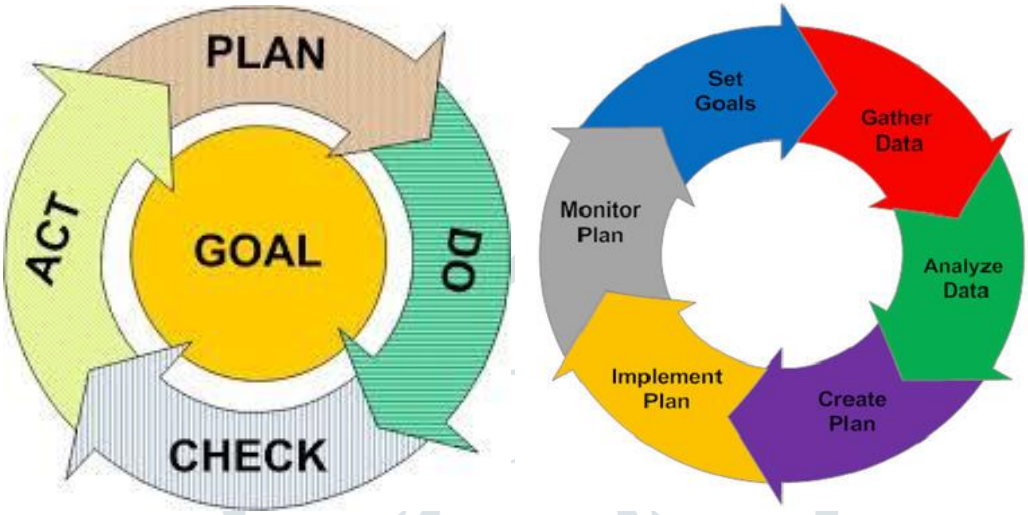


Fig 9: PDCA Cycle

3.2 Project under Implementation

Major Projects for Implementation has been taken are as follows:

1. **5s-Workplace Management** (Lean Tools Used: 5S, Training, Waste Elimination, Red Tag)

2. **Rejection & Quality Control (**Lean Tools : SPC Tools, Run Charts, Histogram, Pareto Chart for Casting Defects, Ishikawa/ Cause Effect Diagram, Control Plan, Failure Mode Effective Analysis, Quality Plan

3. **Daily Work Management System** (Standard Operation Procedures, Identification & Monitoring of Key Performance Indicator, Yield Analysis, Standardization of the Activities, Reduction of inappropriate processing, Job Specification Card, MIS)

4. **Kaizen Journey** (Topics : Productivity & Quality Improvement, Cost Reduction, Workplace Management, Environment, Health & Safety)

5. **Value Stream Mappingv** (Lean Tools : Current State Mapping, Process Mapping, Future State Mapping, Cycle time Calculation, Takt Time Calculation)

6. **Visual Management** (Visual Management Survey, Signage's, Boards)

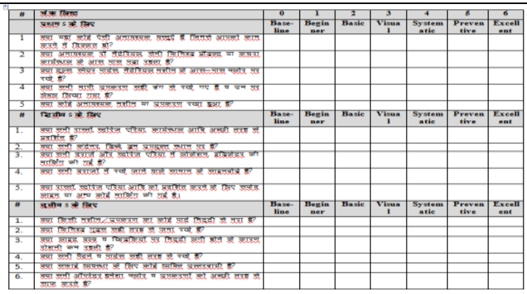
7. **Capacity Building/Trainings** (Topics: Lean concept, Principles, Work Place Management -5S, 7 QC Tools, Work study, Operator Skill Development, 7-Wastes & Techniques to eliminate wastes, Basic tools for Standardized Work)

8. **Inventory Control** (Lean Tools: Inventory Stock Register, Inventory Control Charts, SPC Tools, Classification in Red, Grey, Green Inventory)

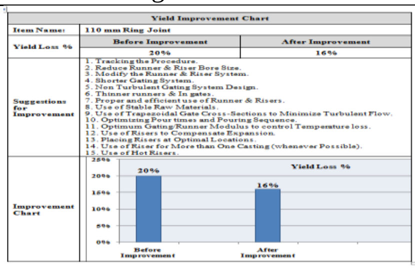
9. **TPM Pillars Implementation (**Autonomous Maintenance Plan, Chart & Checklists, Compressor Checking, Machine Maintenance Register, Machine History Card, Machine Component Sheet**)**

Table 6: Snapshot of Various activities done

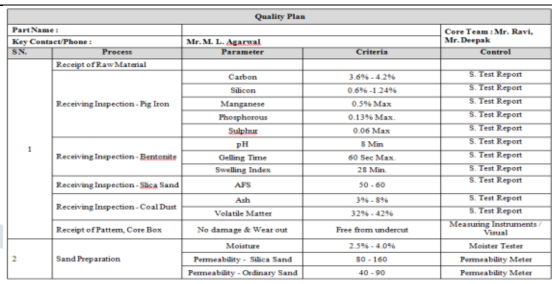
5S organization Structure



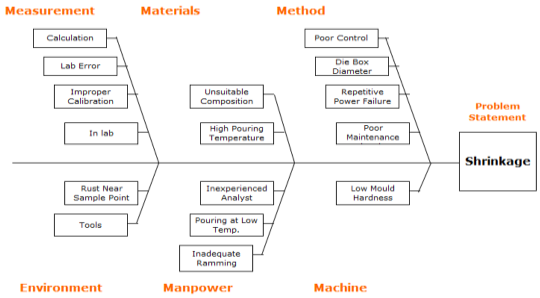
5s Audit Check Sheet



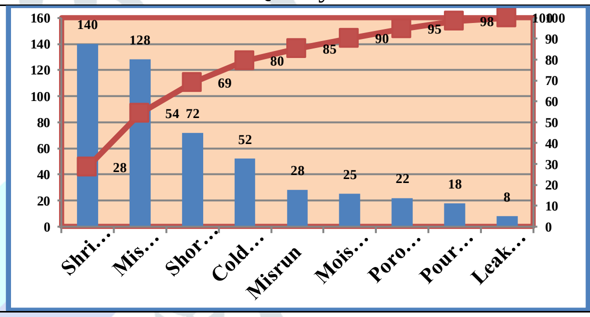
Yield Improvement Chart



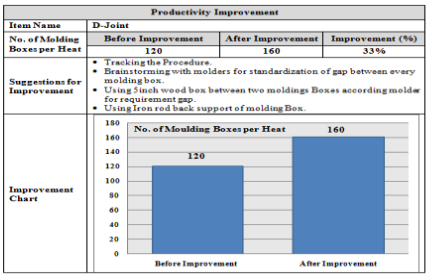
Quality Plan



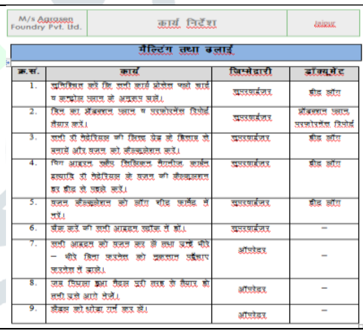
Cause & Effect Diagram



Pareto Chart

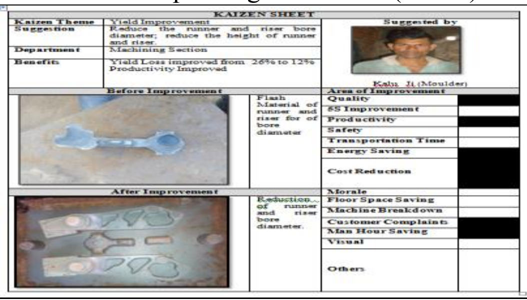


Standardization of Activities

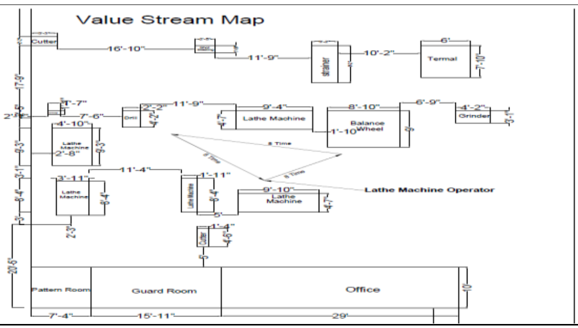


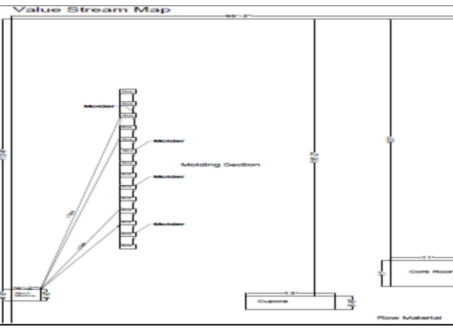
Standard Operating Procedures (SOP's)

Kaizen Award



Kaizen Sheets

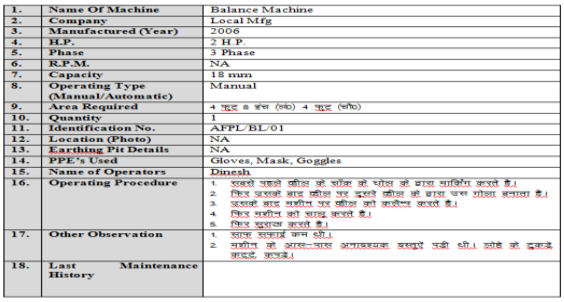




Current State Map	Future State Map

Shop Floor Training

Exposure Visit



1.	Name Of Machine	Balance Machine
2.	Company	Local Mfg
3.	Manufactured (Year)	2006
4.	H.P.	2 H.P.
5.	Phase	3 Phase
6.	R.P.M.	NA
7.	Capacity	18 mm
8.	Operating Type (Manual/Automatic)	Manual
9.	Area Required	4 फुट 8 इंच (लं०) 4 फुट (चौ०)
10.	Quantity	1
11.	Identification No.	AFPL/BL/01
12.	Location (Photo)	NA
13.	Earthing Pit Details	NA
14.	PPE's Used	Gloves, Mask, Goggles
15.	Name of Operators	Dinesh
16.	Operating Procedure	1. सबसे पहले व्हील के चॉक के घोल के द्वारा मार्किंग करते है। 2. फिर उसके बाद व्हील पर दूसरे व्हील के द्वारा उस गोला बनाता है। 3. उसके बाद मशीन पर व्हील को कलैम्प करते है। 4. फिर मशीन को चालू करते है। 5. फिर सुराख करते है।
17.	Other Observation	1. साफ सफाई कम थी। 2. मशीन के आस–पास अनावश्यक वस्तुएं पड़ी थी। लोहे के टुकड़े, कट्टे, कपड़े।
18.	Last Maintenance History	

Machine History Card

ऑटोनोमस मेंटिनेंस चार्ट							
मशीन का नाम	इंडक्शन फरनेस						
माह व वर्ष							
चैक करने योग्य बिन्दु	कैसे	कब	1	2	3	4	5
रोजाना चैक करने योग्य							
पानी के टैंक का लेवल		रोज					
पानी की ड्राईनेस		रोज					
अर्थ लिकेज सर्किट		रोज					
कूलिंग सिस्टम की पावर सप्लाई		रोज					
प्राईमरी व इमरजेन्सी कूलिंग सिस्टम		रोज					
फरनेस के आस पास देखना		रोज					
सारे केबल्स / वायर चैक करना		रोज					
सारे पंखो को चैक व साफ करना		रोज					
हाइड्रोलिक ऑयल लेवल		रोज					
सप्ताह में चैक करने योग्य							
फरनेस के नट व बोल्ट		सप्ता					
कूलिंग टावर के हेड की नोजल साफ		सप्ता					
माह में चैक करने योग्य							
डी–स्केलिंग		माह					
ग्रीसिंग		माह					
ऑयल का लीकेज		माह					
ऑपरेटर / सुपरवाइजर के हस्ताक्षर							

: हाथ से चैक करना : आँखो से देख कर चैक करना : कानों से सुन कर चैक करना

Autonomous Maintenance Chart

IV. RESULTS AND DISCUSSION

Table 7: Comparison of Barriers faced by Large & Micro Unit

S N	Resources	Large & Medium Scale	Small & Micro Scale
1.	Budget	High	Low
2.	Priority	High	Low
3.	Time	More	Comparatively Less
4.	Manpower	More	Comparatively Less
5.	Shop floor area	More & Cemented Floor	Less & Sand floor
6.	Plant Layout	Designed	Limited & Temporary
7.	Organization structure	Clearly Defined	Unstable
S N	**Technical Issues**		
1.	Production Techniques	Latest Technologies like Induction Furnace, Shot Blasting Machine etc	Older Techniques like Cupola, Sand Floor etc.
2.	No. of Senior, Technical & Management personnel	Satisfactory	Shortage
3.	Temporary / contractual work Force	Available	Less
4.	Control of feed materials (shape, size, weight,)	Poor	Accurate
5.	Operating & Maintenance practices	Poor	Best
6.	Blast rate / Lower blast air pressure	Incorrect	Correct
7.	Distribution of air in cupola	Incorrect	Correct
8.	Casting Defects	High	Controlled
9.	Melting loss	High	Controlled
10.	Energy & RM consumption	High	Controlled
11.	Delivery Schedule	Disturbed	Controlled
12.	Productivity	Low	High
13.	Material handling	Low	Controlled
14.	Input costs	Rising	Controlled
15.	Overproduction	High	Controlled
16.	Capability of high precision castings	Lacking	Controlled
17.	Wear & Tear of patterns	High	Controlled
18.	Unused Inventory	High	Less

4.1 Perceived Challenges

The challenges to lean implementation were Perceived costs, employee resistances, Lack of initiative for Capacity building, Activities not standardized, Lack of awareness and technical issues.

- Data collection was indirect as Communication was Verbal and data was not compiled or not recorded. People were not accustomed of data collection techniques and working to in a set time period.
- Cost Perhaps the natural for an SME is reacting by saying, we just can't afford it.
- Employee resistance
- Lack of imitative for Capacity building
- Activities not standardized

- Fear in labors to Adopt latest Technologies
- Illiteracy
- Dependency on manual work
- Rigidity

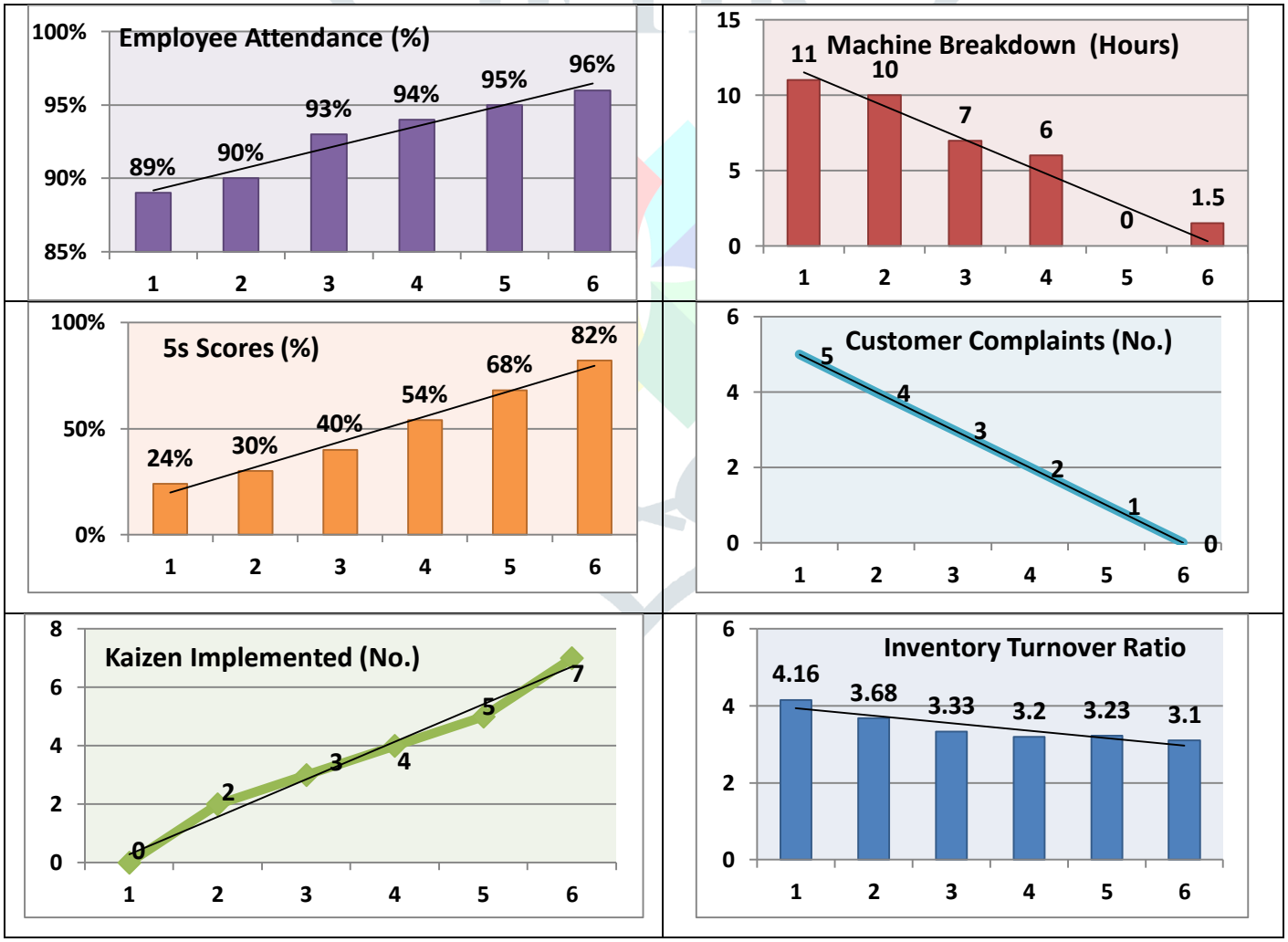
4.2 Benefits

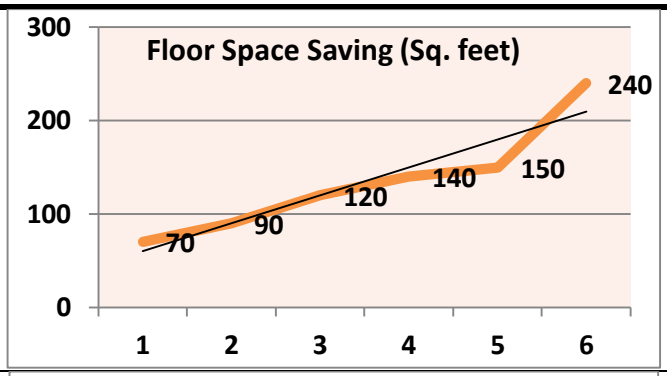
The results were evident that unit has reaped benefits in terms of Higher Productivity, improved Quality, Capacity release, Reduced Cycle /set up time.

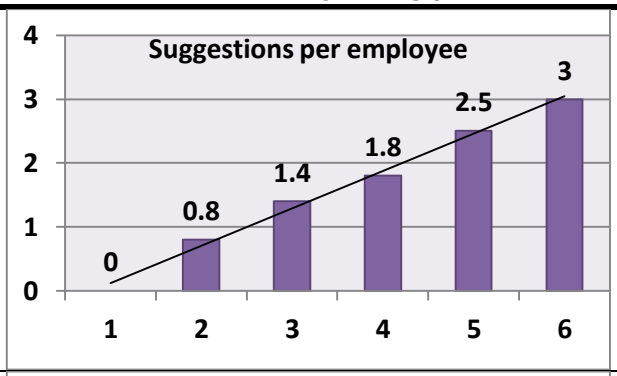
Table 8:Qualitative And Quantitative benefits

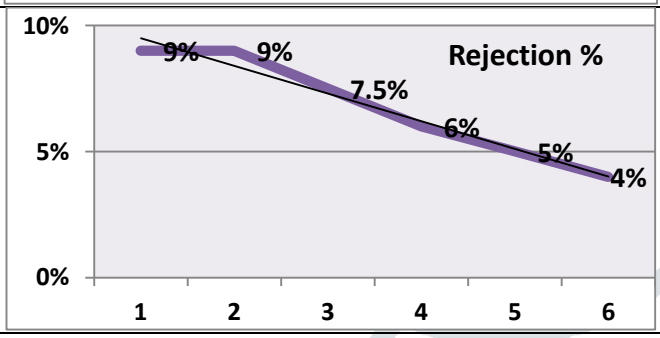
QUALITATIVE	QUANTITAIVE
• Improved work environment • Clean work place • Better safety measures • High employees morale • Rejection Control • Quality Improved • Customer Complaints Reduced • Reliable Process • Unwanted process out • Product Standardization • Visual controls • Reduced inventories	• Floor Space Saved – 15% • 5s Audit Score- 82 % • Reduction in Defects- 18% • Reduction in Over Processing -22% • Control of Rejection-12-15% • Improvement in productivity 10 % • Control of Yield loss 8% • Reduction in Transportation - 20% • Reduction in Motion - 25% • Reduction in Inventory - 4-8 % • Reduction in Machine Accidents-90% • Reduction in Machine Breakdown Hours-30 %

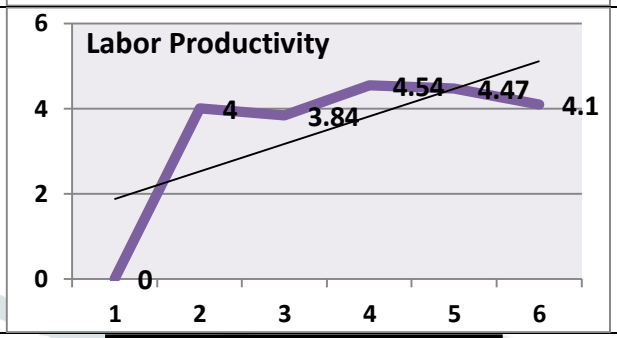
Table 9: Snapshot of Benefits by Various graphs

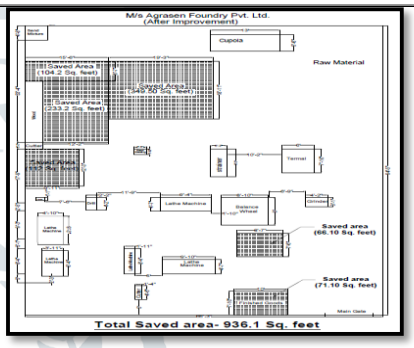












V. CONCLUSIONS

Findings of this Study can be summarized into the following points

- Quality Tools Can be Implemented in every Category of Unit like Micro, Small, Medium or large with some user friendly approach & regional language in every aspect.
- Lean manufacturing is a continuous process, Sustainable lean manufacturing techniques shall enable the foundries to compete in this competitive globalization market.
- This Project is a path towards the sustainable development with implementation of value streaming strategy which improves product value as well as its sustainability.
- In keeping with the present advances in manufacturing, company has made a decision to drastically alter its manufacturing to suit Lean methods of single piece flow rather than continue with the old practices in a medium to high volume production set up. This project details how this change was planned and implemented.
- The incentives to the small scale industries and measures for lean technologies by the government shall accelerate a “Make in India” Vision with a ZED

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