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Leading To Higher Productivity Following Lean Methodology In Foundries By Applying Value Stream Mapping.

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ABSTRACT:- As casting is a continuous & sequential process, it involves many steps. The time taken in each step is different. So we have to calculate the value added time and non value added time.. In a competitive market every organization is striving hard to achieve the best quality of product along with minimum cost of production. Lean Manufacturing is a simple but systematic approach to minimize wastes, reducing the unnecessary cost improves the efficiency of overall process by maximum utilization of the resources .It is based on identifying and reducing waste in each step of the process. Value Stream Mapping (VSM) is an analyzing technique to study the complexity of each steps and time taken in each steps .Then streamline work processes using the mechanism of Lean Manufacturing. Author visited a fabrication industry of medium size, which having a foundry in its work area. VSM helps to monitor, identify, present and decrease waste in the processes. Any activity which does not add any value in the final product called waste and our ultimate aim is that it must be eliminated. VSM can serve as a guide line for Lean Manufacturing.

***Keywords*:-** Lean Manufacturing, analyzing technique, Value Stream Mapping**,** Cast steel, guide line.

I. METHODOLOGY

To carry out the proposed research work through data collection, small and medium sized foundries to be visited.

Author visited many micro, small and Medium enterprises of Cast Steel and study the complexity of casting process. Author got the permission of regular visit of a plant for his study , named as –Vishal Iron & Steel Corporation, 35/C , Industrial Area , Bhilai.

Expected outcome of the research to focus on the plant layout which involve the process of pouring metal inside the mould, cooling of the casting**,** shakeout, and transport to the cleaning and cut burr processes.
Praveen Tandon & Dr. Ajay Tiwari et. al. [12] say that it is the general perception that the foundry industries are inherently more efficient and have a relatively less requirement for major improvement activities.

Praveen Tandon & Dr. Ajay Tiwari et. al. [13] says that to reduce the production cost and improve the quality of the product, suitable methodology is to be adopted. This involve is to study the various steps of casting process at the micro level. Study of the industrial layout of the of the casting area is one of the most important task to reduce the pouring time and thus reduce the ultimate production time of the job
In the foundry industry most important step is the pouring of the molten metal in the mould, therefore the most sensitive parameter is the pouring time. Pouring time is mainly depending on the plant layout.
Praveen Tandon & Dr. Ajay Tiwari et. al. [14] say that as casting is a continuous & sequential process, it involves many steps. The time taken in each step is different. So we have to calculate the Takt Time.

Step 1 Identify the bottleneck of the product for case study. Product is a machine component named as “Grizzly” made of Cast Steel and the product family is the bottleneck product corresponding to customer Bhilai Steel Plant.
Step 2 Causes for bottleneck
2.1 This product possesses more casting weight up to 45 kg which is greater than any product or product family on the production line.

Step 3 Selection of the value stream mapping tool.

1.1 The Value Stream Analysis Tool (VALSAT) [1] is done to select the proper tool.

The value stream to be reviewed is first identified and through a series of preliminary interviews with managers the wastes are found out and ranked based on the weight age to a particular waste.

Table 1: The Seven Value Stream Mapping Tool

Wastes / Structure	Mapping Tools						
	Process Activity Mapping	Supply Chain Response Matrix	Production Variety Funnel	Quality Filter Mapping	Demand Amplification Mapping	Decision Point Analysis	Physical Structure (a) Volume (b) Value
Overproduction	L	M		L	M	M	
Time Waiting	H	H	L		M	M	
Transport	H						L
Inappropriate Processing	H		M	L		L	
Unnecessary Inventory	M	H	M		H	M	L
Unnecessary Motion	H	L					
Product Defects	L			H			
Overall Structure	**L**	**L**	**M**	**L**	**H**	**M**	**H**
Origin of Tool	Industrial Engineering	Time compression/ Logistics	Operations Management	New Tool	Systems Dynamics	Efficient Consumer Response / Logistics	New Tool
Notes: H = High correlation and usefulness M = Medium correlation and usefulness L = Low correlation and usefulness							

Step 4 Case details

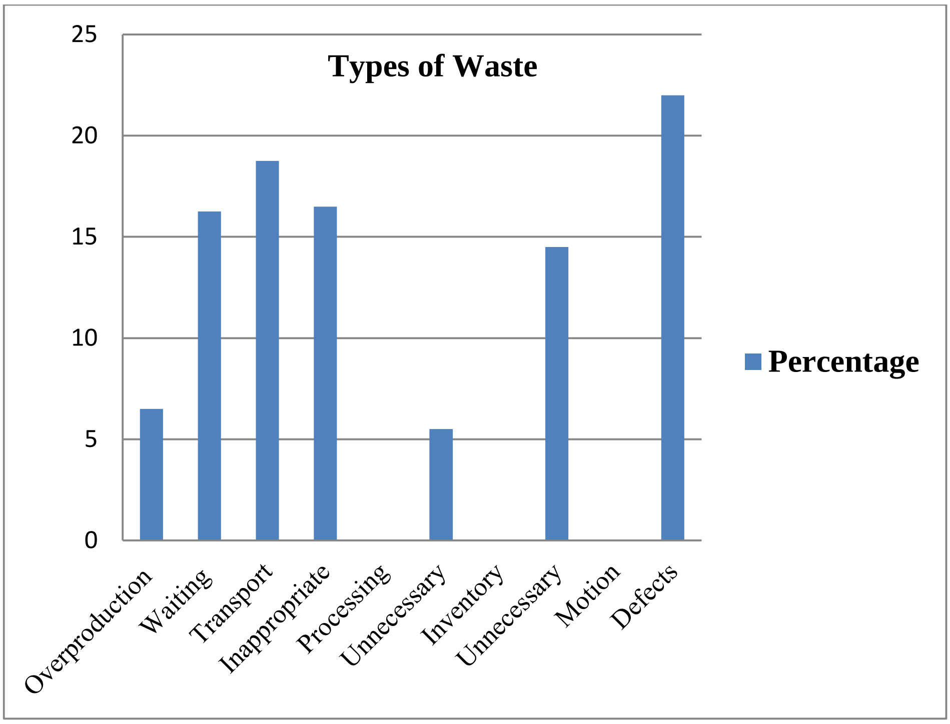
The time study for all the foundry operations was carried out for 45 days by using stopwatch as a recording technique. The data is collected for the *bottleneck product per machine per shift per component.* The statistical bar charts are drawn to reveal the product details and analyze the problem.

Step 5 Study of the manufacturing process flow

The foundry division of Vishal Iron & Steel Corporation, production line is semi automatic dedicated to flow the product. The process flow is shown in Fig. 2.The process starts from raw material along with component movement of material and information to produce final castings through various processes takes place from supplier to end customer.

S.No.	Type of Waste	Percentage
1	Overproduction	6.5
2	Waiting	16.25
3	Transport	18.75
4	Inappropriate Processing	16.5
5	Unnecessary Inventory	5.5
6	Unnecessary Motion	14.5
7	Defects	22
	Total	100

Table 1: Percentage of wastes



Sand Casting Steps:

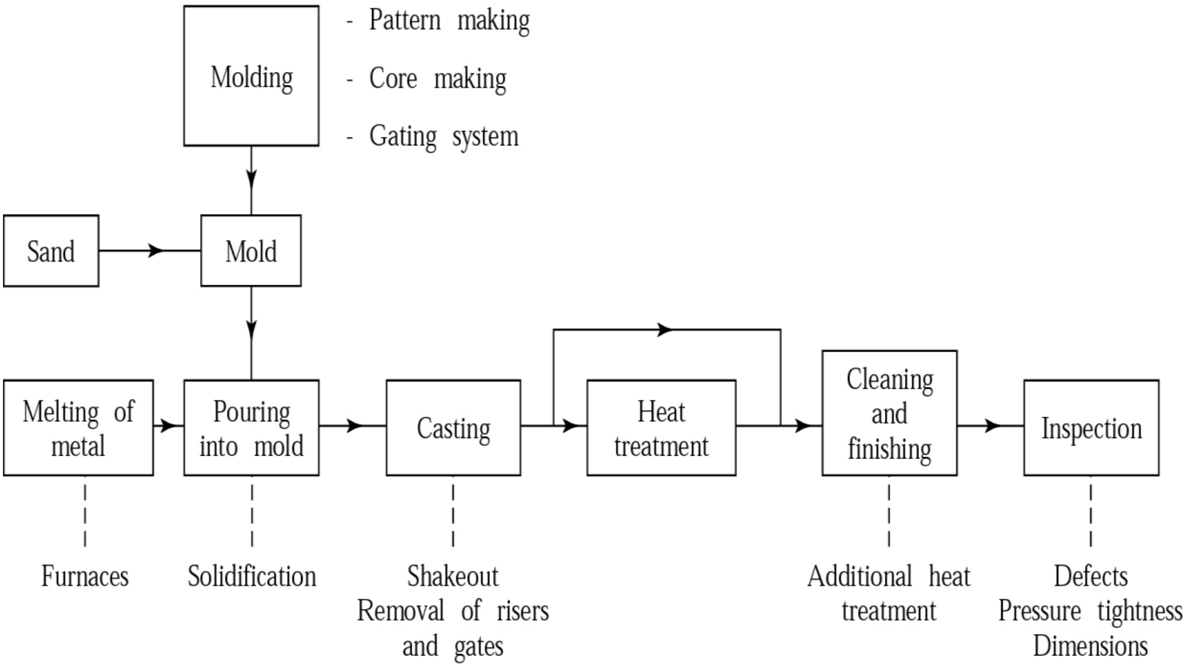


Fig 2: Flow Chart of Sand Mould Casting

Step 7 waste ranking methods Based on the VALSAT analysis and the time study analysis the waste ranking algorithm is employed and it shows the wastes that really need to be minimized .

Step 8 Identification of Value Stream The value stream is identified and it comprises of all the activities that are Value added and Non Value added. It gives systematic procedure to tackle the improvement opportunities with lean techniques to satisfy the customer demand with increase in productivity.
Step 9 Mapping the Process Activities Process activity mapping involving the preliminary analysis of the process [1] followed by the detailed recording of all the items required in each process is done for bottleneck product Grizzly *per machine per shift per component* on KOYO automated line.

2.1Current State Map

The time study is carried out by the stopwatch for 45 days on the shop floor of the foundry. We have gone through each and every process on the production line 1 by recording the travelling distances of men, materials, time taken by each activity, number of operators and workers
right from raw material to final product dispatch.
Current state map is prepared keeping in view of the lean manufacturing principles. A few assumptions are also made for preparation of current state map. From past sales data at the industry under study, it is known that maximum demand of product Grizzly 240 may reach up to 280 per month.
The current state map captures information at a particular instance, which may vary from shift to shift. For the sake of analysis, the shift and operator-wise variation
(which may be there) is not considered. Effective numbers of working days are 26 per month, number of shifts per day is three and working hours per shift are eight. Available working time per day is 86400 seconds.
As per [3] Takt time can be calculated as
Takt time= {(Available working time per day (seconds)/customer demand per day (units)}
= {(86400/(280/26)} = 8022 seconds. (133.7 minutes)
From current state map, value added time as a % of total time in plant = {(11454/ (12 Day X 24 hrs/day X 60 min/hr)} =0.662 or **66.2%%.**

2.2 Future State Map

For future state map the following areas in which wastes like WIP, Inappropriate processing, bad layout etc. are identified and presented separately in corresponding process. After that the wastes are converted into standard wastes and techniques of waste elimination are described in latter part. First the processes in which the identified wastes exists are, a) Pattern Making, b) Core Making, c) Moulding, d) Shot Blasting, e) Fettling

Identification of Wastes in the above foundry processes:

I) Pattern Making

1. Patterns must be finished, edges, burrs should be removed.

II) Core making

1. Three cavity core boxes for component 1 were not enough to complete production requirement.
2. Core Box of 2 cavities & core for component 2 was solid creating gasses problem in castings and not enough to complete production requirement.
3. One cavity core box for component 3was not enough to complete the production requirement.
4. Core weight is more for Slip which is 1.570 kg

III) Moulding

1. Spillover of dust in turn affecting the environment in mould sand plant.
2. Moulding sand hopper was damaged so that sand leakage was more in the mould making section.

IV) Cleaning &Fettling

1. Mixing up of different parts due to bad layout.
2. Poor housekeeping leads to low productivity.
3. High transportation of parts.

Classification of wastes into standard forms and techniques of elimination adopted:-

From future state map, value added time as a % of total time in plant = {11 788/ (9.5 Day X 24 hrs/day X 60 min/hr)} =0.862 or **86.2 %.** The future state map indicates **average 20% waste reduction** in the critical areas of unnecessary inventory, transportation and waiting. The concept of supermarket came into picture to reduce the in process inventory or WIP. A “supermarket “ is
nothing but a buffer or storage area located at the end of the production process for products that are ready to be shipped (Rother and Shook, 1999).

On the other hand, producing directly to shipping means that only the units that are ready to be shipped are produced. Currently xyz foundry produces all the components of Coal Sorting Machine Spheroidal Graphite Iron products (S.G Iron) and sends them to a holding area where they are stored with other products waiting to be shipped.

- Transportation, I- Inspection, S-Store, D- Delay

S.No.	Step	Flow	Machine	Dist (m)	Time (Min)	People	Process Details	Remark
1	Raw Material	S	Raw Material Stock Yard					
2	Component Drawing	I			480		Supplied by Customer with order	
3	Mould & Pattern Designing	O	Pro E		4800	2	10 days(one shift/ day)	
4	Pattern Making	O	Carpenter Tools		6100	6	Wood Pattern prepared .	
5	Core Sand Transfer To Core Making Machine	T	Trolley	20	10	2		
6	Core Sand Preperation (Wait For Mix)	**D**	Blending machine		120	1	Sand Box Time	**Delay**
7	Core Making	O			15	2	2 days (one shift / day)	
8	Core Hardness Testing	I	Scratch Hardness Tester		2	-	Performed by Engineer	
9	Sand Preperation For Mould (Wait For Mix)	**D**	Mixer		240	2	New Sand And Binder Is added	**Delay**
10	Mould Sand Transfer	T	Hopper, screw conveyor	15	30	1		
11	Mould Making	O	Box		430	3	4 mould at a time	
12	Mould Drying	D	---		840	-	left for natural drying whole night	
13	Mould Finishing	D	CO2 Gas Cylinder		30	1+1	Special paint and CO2 gas	
S.No.	**Step**	**Flow**	**Machine**	**Dist (m)**	**Time (Min)**	**People**	**Process Details**	**Remark**
14	Raw Material Transfer To Furnace	T	Crane	20	5	1+2		
15	Melting	O	Electric Furnace	--	240	1		
16	Inspection of Molten Metal	I	Lab		20	1	Lab Technician	
17	Pouring Into Crucible	D	__	--	2	6	Unskilled labour	
18	Moving Crucible to Mould	T	Manual	10	2	6		

19	Molten Metal Pouring into Mould	O	Manual	--	2	6		
20	Cooling of Casting	D	-	-	1080	---	Natural cooling	
21	Knock Out Of Mould	O	Vibrator		16	2		
22	Degating and Cleaning	O	Hammer Chisel		40	2	Rotary Brush	
23	Loading The Trolley	**D**						**Delay**
24	From Knock Out To Hardness Testing Machine	T	Trolley	12	30	2		
25	Hardness Testing Of Casting	I	Brinell Hardness Tester		120	1		
26	From Testing Machine To Fettling Shop	T	Trolley	10	20	1		
27	Fettling Of Casting	O	Grinder		120	4		**Delay**
28	Final Inspection	I	Performed by engineer		10	1		
29	Oil Dip	O			25	1		
30	From Oil Dip To Store	T	Trolley	15	7	2		
31	Loading To Truck For Dispatching	**D**	Crane	-	120	1+1		**Delay**

Flow	Total
T - Transportation,	**7**
I- Inspection,	**5**
S-Store,	**1**
D- Delay	**8**
O- Operation	**10**
	31

However, this is done based on a push system, and components can wait a long time in this area before being shipped. The introduction of supermarkets is necessary only at the finishing end where large amounts of inventory exist between different workstations. In addition to the shipping supermarket recommended after final inspection, three additional supermarkets are needed to create a continuous flow. Instead of Kanban pull, manual push system is employed to fill the supermarket to their required capacity. Kaizen continuous improvement programmes were carried out at pattern making, core making, mould making and fettling departments with Total Productive Maintenance (TPM) and 5s as explained above .First In First out (FIFO) concept was employed before degating, sand blasting and fettling

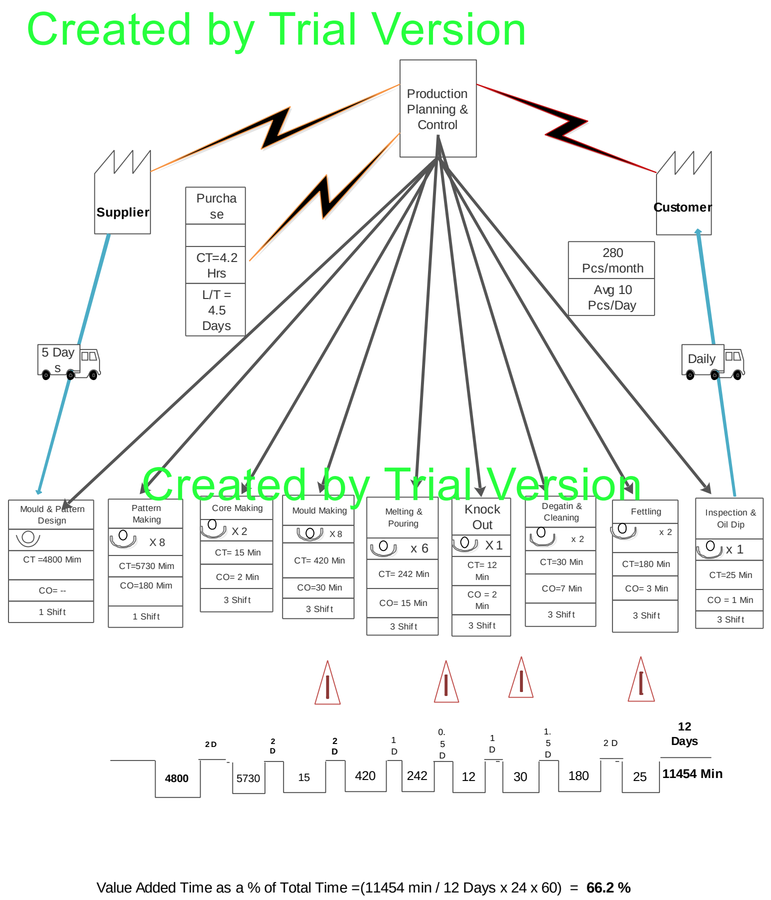


Fig. Current State Map

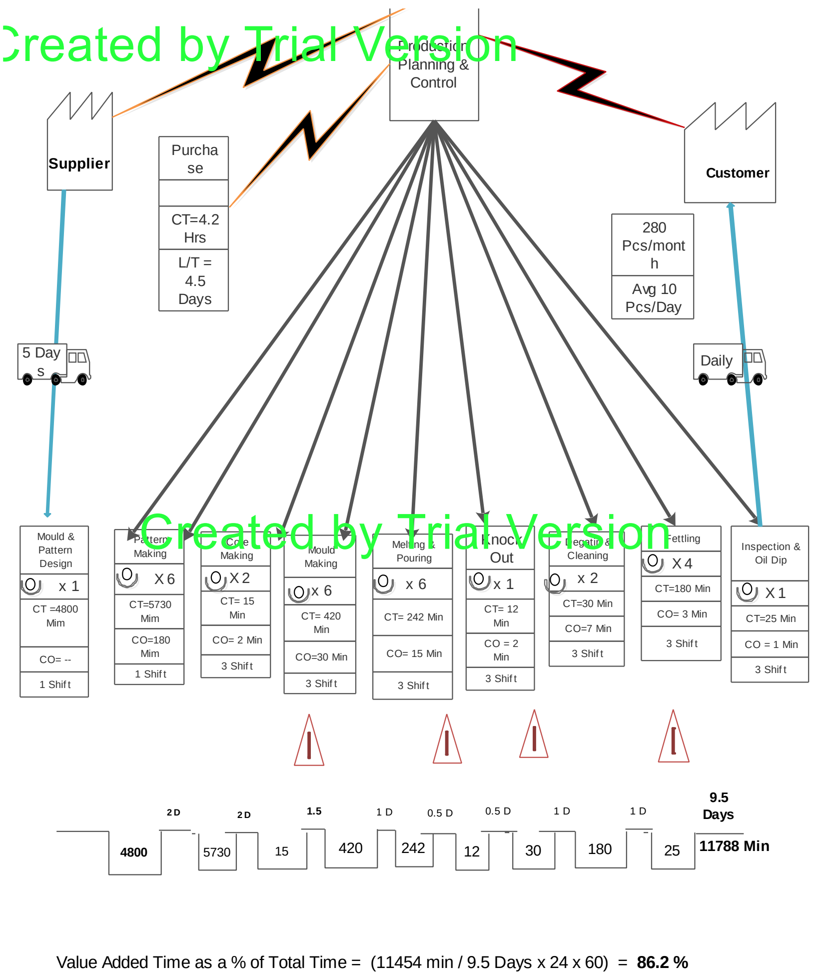


Fig. Future State Map

V. RESULT/ EXPECTED OUTCOMES OF RESEARCH WORK

Expected outcome of the research to focus on the process of pouring metal inside the mould, cooling casting, shake-out, and transport to the finishing area, cleaning and cut burr processes. At the foundry industry where the research collected data, the scenarios simulated suggested to explore alternatives to reduce the time of pouring times through an improvement in industrial lay out and workload balancing including worker's multi skilling training.

The results of study shows 20 % waste reduction in the areas of unnecessary inventory, transportation and waiting. It is however to be noted that there is a significant cost to complete any required changes but the increased throughput against takt time will pay back for investment.

VI. CONCLUSION

According to the study of the manufacturing process, it was found that the long distance could be reduced for moving raw materials and the problem about useless area could be solved.

By studying Value Stream Mapping we observed that non-value added time is reduce by approximately 20%.Also,the Work In Process (WIP) is reduced and thereby lead time is reduced by 40% to 50% approximately .This proves the utility of Value Stream Mapping Technique.

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