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Application of Value Stream Mapping Tools For Process Improvement a Case Study in Foundry

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ABSTRACT: *A value stream is all the actions (both value added and non-value added) required to bring a product through the main flows essential to every product for the production flow from raw material into the arms of the customer and to design the flow from concept to launch as a lean manufacturing tool. Taking a value stream perspective means working on the big picture, not just individual processes and improving the whole not just optimizing the parts. In this paper three case studies in xyz foundry with results are considered with current state maps and future state maps after following the different steps starting from the detailed time study for mapping the processes from raw material to final product. According to VALSAT (Peter Hines & Nick Rich) three tools namely Process activity mapping, Quality filter mapping and Production variety funnel have shown greater effectiveness to reduce the wastes in foundry. Process activity mapping is a Value stream mapping tool has its origins in industrial engineering. Production Variety Funnel is a Value stream mapping tool has its origins in Operations management. Quality Filter Mapping is a new Value stream mapping tool specially used to focus on the defects produced relating to the physical products.*

Keywords- *Current State map, Future State Map, Process activity mapping, Production variety funnel, Quality Filter Mapping*

I. Introduction

Although lean techniques are available for productivity improvement the foundry is still not able to apply these techniques for its exploitation. The foundry has production sequence of melting, pouring, moulding, degating, shot blasting, fettling, inspection and dispatch. Due to variety of products and operations the existing layout is found as very inconvenient for improvements to reduce the overall material handling costs and improve the overall plant efficiency hence the improvements to be carried out. Defects are more at various stages of foundry including product and scrap defects. Also the lead times for different processes vary and needs detailed analysis. Identification of waste with the study of flow processes is necessary to consider a better flow pattern involving flow layout or transport routing.

Previously many researchers have focused their studies of value stream techniques on food process industries, hospitals, textile industries and so on, but very few of them have focused on core study of production processes or continuous process sector industries. This paper presents the analyzed case study results of value stream mapping tools selected according to VALSAT (Value Stream Analysis Tool) by (Peter Hines and Nick Rich 1997) applied in xyz foundry. The purpose of this paper is to highlight the effective utilization of the tools for process and productivity improvements. All the case studies are presented by considering SLIP YOKE 1180 as a bottleneck product because this product possesses more pouring time and complexity than any other product or product family on the production line 1 called KOYO production line.

II. Process Activity Mapping

Process Activity Mapping is a key tool for the detailed mapping of the order fulfillment process. It is an engineering derived approach that has traditionally only been used for the shop floor of manufacturing companies. However it is used more widely to identify lead time and productivity opportunities for both physical product flows and information flows, not only in the factory but also in other areas of the supply chain. The idea is to map out every step of activity that occurs throughout a process. After mapping the data is used for analysis and action planning. It can be done by identifying the major problems or concerns, understanding the causes of these concerns and developing possible countermeasures. There are five steps to the process activity mapping [1]:

(1) The study of the flow of processes;
(2) The identification of waste;
(3) A consideration of whether the process can be rearranged in a more efficient sequence;
(4) A consideration of a better flow pattern, involving different flow layout or transport routing; and
(5) A consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous tasks were removed.

III. Production Variety Funnel

Production Variety Funnel is a visual mapping technique that plots the number of product variants at each stage of the production process. This technique also generates a series of questions relating to the logical reasons for product diversity and the need to maintain such complexity for the supply chain. The point at which the product variety rises (expands) rapidly is of key concern and it is the buffer (Prior to this point) that creates the flexibility in the production system. In short, with favorable manufacturing and demand characteristics, this buffer point can be used to create high levels of customer service without incurring the penalty costs of stock

Holding further downstream. The map also provides useful data for potential product and inventory rationalization [2].

Sr. No.	Step	Flow	Machine	Dist (M)	Time (Min)	People	OPERATION	Transport	Inspect	Store	Delay	Comments
01	Total		38 STEPS	**390.7**	**14294.837**	**47**	**14**	**13**	**4**	**1**	**6**	
02	Operators				**13497.620**	**13**						
03	% Value Adding				**94.42%**	**27.66%**						

The Production Variety Funnel is used to depict the amount of product variety generated at each stage of the production process. As a value stream mapping tool, it provides following methodology:-

i) Identify the number of different products, manufacturing processes at various stages, and process lead times.
ii) Plot the current state graph with the x-axis representing the process path (lead time) and the y-axis showing the number of products. The process flow is from left to right.
iii) Work towards the future state where the numbers of different products are more or less depending on the inventory.
iv) Identification of the logical point at which safety stocks may be held, the risk of holding safety stock as it will not sell and will leave inventory holding cost.
v) The point can be used to create high level of customer service without falling into the penalty cost of further stock holding.
vi) This tool gives an idea to postpone the manufacturing process rather than to maintain stocks of production at each stage of production process.

3.1 Methodology

Production variety funnel is drawn for bottleneck product SLIP YOKE 1180 *per shift* on KOYO automated line. This approach has been applied by New in the textiles industry. Such a description using the production variety funnel (See Fig.1) allows the mapper to understand how the firm or the supply chain operates and the accompanying complexity that has to be managed. The approach can be useful in helping to decide where to target inventory reduction and making changes to the processing of products. Fig.1 shows the CAD drawing of Production Variety Funnel.

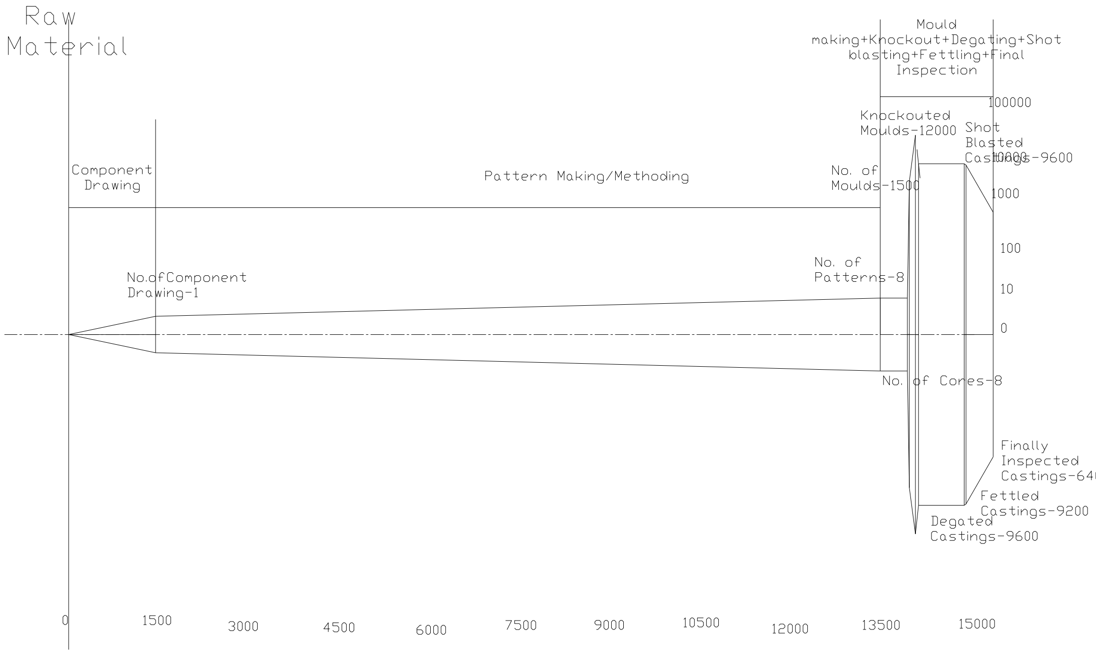

Fig 1.CAD drawing of production variety funnel drawn to the scale

3.2 Findings from the Production Variety Funnel

The point at which the product variety rises is at the number of cores-8 as shown in fig1.It is that point where flexibility in production process is possible. This is a buffer point can be used to create high levels of customer service without falling into penalty cost of further downstream processes.

3.2.1 Raw material Inventory reduction

Initially there was 1000 MT (Metric Ton) raw material inventory which leads to inventory holding costs as well as penalty cost of downstream processes. After the production variety funnel and buffer point identification now raw material inventory is reduced up to 200 MT which avoids further penalty cost.

3.2.2 In- Process Inventory

From fig 1 it is clear that in between core making and mould making the proper inventory of cores is maintained to avoid holding cost.

IV. Quality Filter Mapping

Quality Filter Mapping gives the defect rate along the various stages of supply chain within the or outside the foundry. Castings with defects very often have to be scrapped. This is a major cost for the foundry, both in terms of productivity and, often, reputation. Defects that have slipped through inspection have the highest value as they may not be discovered until they reach the machining stage or, even worse, the end user. Systematic logging of defects may seem time consuming, but is a worthwhile exercise so that the most serious problem can be addressed as the priority. Many foundries spend inordinate amounts of time and money addressing minor issues while not focusing resources on the major defects. Good maintenance, raw material selection and careful metal handling are the three key criteria in defect control [3].

There are mainly three different types of defects [1] namely Product, Scrap and Service. While using Quality Filter Mapping following method is used:-

a) Identify and separate out three different types of defects i.e. Product defects, Scrap defects, and Service defects.

b) Service defects are due to inappropriate delivery (late or early), together with incorrect paper work or documentation.
c) Find out the defect rate in Parts per Million (PPM) for each of the defects.
d) Identify the supply chain of the foundry which consists of distributor, assembler, first-tier supplier, second-tier supplier, third-tier supplier and raw material source.
e) Present the defects graphically where the x-axis represents various stages of the supply chain and the y-axis represents defect rate.
f) Map the three types of defect along the various stages of the value stream, using a parts per million (PPM) or percentage scale. If appropriate, plot with the logarithmic scale [2].
g) If the tool is being used inside a company, use individual departments or work areas instead of different companies. In that case, record product defects where they are passed on to an internal customer or the next department. Service defects would similarly refer to non-product defects passed on to internal customers. Scrap defects would simply refer to any scrap within each particular work area or department [2].
h) Graph will show where defects are occurring and hence identifies problems, inefficiencies and wasted effort.

4.1 Methodology

The foundry needs to find out defects internally; also supply chain study for foundry will not reveal the internal defects that are being analyzed. Therefore this tool is used inside a company using individual departments or work areas instead of different companies. Scrap defects simply refer to any scrap within final three work areas i.e. Shot blasting, fettling and final inspection. The various casting defects for the *month of June 2012* are collected by considering the final inspection after working with quality department for the month and after that current state Quality Filter map is plotted considering three different downstream work areas as shown in Fig. 2.Future state map is considered in Fig.3.The data required for current state Quality Filter Map is shown in Table 2and to that for future state is shown in table 3.Total Production for the month of June 2012 is 3248 having 187 defected castings i.e. 5.76% total defected castings.

Table2 Data Required For Current State Quality Filter Map

TIERS OF SUPPLIER	INTERNAL PROCESSES	INSPECTION STAGES	% OF TOTAL PRODUCTION	PARTS PER MILLION (PPM)
1st	After Shot Blasting	Primary	3.55% of 3248= 115.30	35498.77
2nd	After Fettling + Reshot-Blasting	Secondary	2% of 3248= 64.96	20000
3rd	Final Inspection	Final	0.21% of 3248 =6.8208	2100

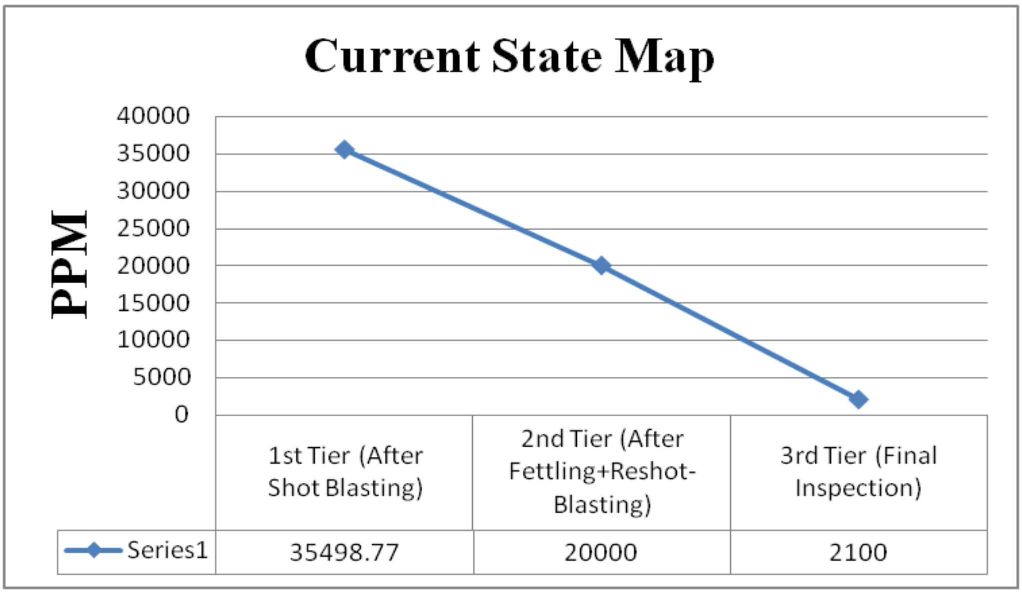

Fig 2 internal structure of current state quality filter map

Table 3 Data Required For Future State Quality Filter Map

TIERS OF SUPPLIER	INTERNAL PROCESSES	INSPECTION STAGES	% OF TOTAL PRODUCTION	PARTS PER MILLION (PPM)
1st	After Shot Blasting	Primary	2.5% of 3248=81.2	25000
2nd	After Fettling + Reshot-Blasting	Secondary	1.36% of 3248= 44.17	13599.14
3rd	Final Inspection	Final	0.14% of 3248 = 4.55	140

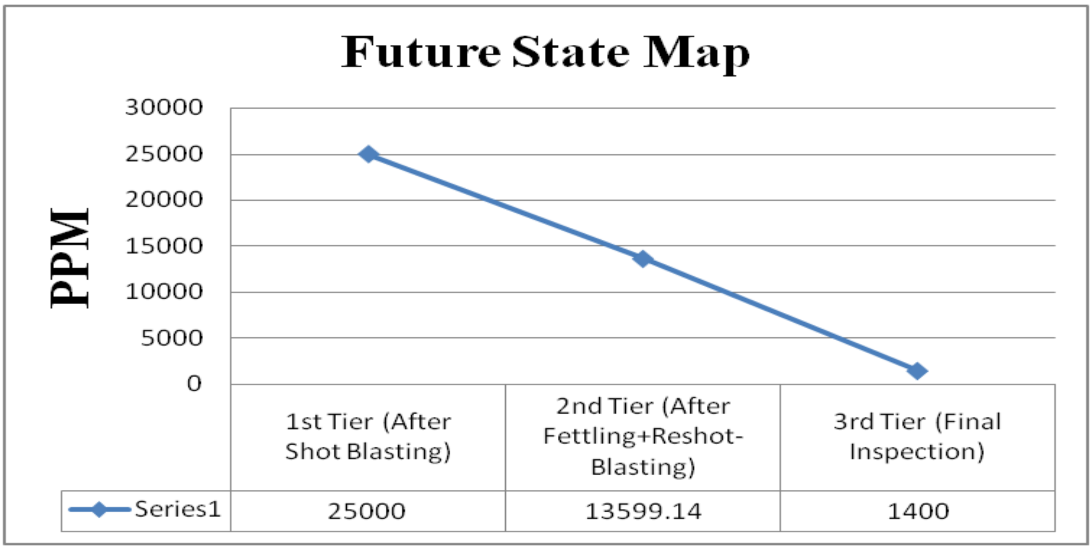

Fig 3 future state quality filter map

V. Findings from the Quality Filter Mapping

This approach has clear advantages in identifying where defects are occurring and hence in identifying problems, inefficiencies and wasted effort. This information is used for subsequent improvement activity as stated below:

- From Quality filter map we realized at which workstation the sources of defects are present.
- Current state analysis showed that at 1st tier there are about 115 defected castings, at 2nd tier it reduces to 65 and after 3rd tier it shows7 defected castings.
- It is obvious that before 1st tier i.e. before shot-blasting during the knock out and prior to knockout during metal pouring into moulds there are more chances for defective castings.
- The metallurgical defects are more dependent on the generic origin sources: melting, moulding, pouring, and finishing. Also the casting defects are very often the result of these variables not being properly controlled.
- After the analysis we observed the causes and workstations responsible for defects. We then focused on controlled the pouring rate, melting time, temperature and microstructure parameters to reduce the defects.
- After future state map 1st tier shows about 81defected castings, at 2nd tier it reduces to 44 and after 3rd tier it gives 5 defective castings. It means that about 2 castings/day are defect free after the analysis.
- Generally in current state map as well as in future state map the defects at final inspection stages are 3.5% of 6 (total defects).
- After knock out the sample is tested for its microstructure and hardness, at this stage it hardly shows any internal defects.
- After controlling the above parameters the defect rate is reduced and minimum scraps are observed.

VI. CONCLUSION

Value stream mapping tools can be used effectively in any kind of sectors as these are the world class manufacturing tools. The analyzed study is case study in foundry industry. The prime objectives of the paper for using value stream mapping tools are as follows,

- To use the tools in identifying, quantifying and minimizing major wastes in a foundry production line.
- To quantify the variety of products generated at each manufacturing processes within the foundry line.
- To formulate practical means of reducing the identified major wastes by reducing excess inventory, defects and unnecessary activities.
- The aim is to reduce lead time for process improvement.
- To quantify by rank the seven wastes of lean within the foundry line.

The results of Process activity mapping shows 23% waste reduction in the areas of unnecessary inventory, transportation and waiting. For Quality filter mapping it is difficult in actual practice to predict or analyze the defects at each foundry processes as the final inspection gives the clear picture of internal defects. But it is possible to reduce the chances of defects at the generic origin sources i.e. at melting, moulding, pouring, finishing and by controlling the melting parameters like pouring time, temperature etc. In this study bottleneck product is identified. The key sources for internal scraps are identified and these are analyzed and improvement is carried out in these areas. After that future state quality filter map with findings are presented. Future state map revealed that about 700 castings per million are saved from defects. It is however to be noted that there is a significant cost to carry out any required changes but the increased throughput against takt time will pay back for investment.

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