

# Improving Predictability by Blending VSM with KANBAN

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**Abstract—** Value flows in every process, and early days was of focusing on Value Addition at every such intermediate stage of process. However, with evolution of KANBAN, JIT under the umbrella of the Toyota Manufacturing System (TMS) emphasized on eliminating waste i.e. *Muda* (A Japanese Term for Waste, Commonly used in Toyota Management System) and gradually Value Addition is replaced with evaluating Process as a Value Stream and Mapping critical activities.

VSM, has become a significant tool these days to analyze, evaluate Process from Status Quo to carve it future State by eliminating inherent Waste(*Muda*) within the process.

**Keywords—** Kanban, JIT, Muda, TMS, Value Stream, VSM, TPT, Takt.

## I. INTRODUCTION

The Value Stream Mapping have been appealing these days as emerging way to improve from Status Quo to next order. The VSM has found its place of applicability to an Industrial process to a Social Activity.

The work given hereby is a Practical Study of a Die Casting Industry, and grasping of facts summarized in the form of to correlate how does VSM is useful in balancing the production to harmonize Takt thus to improve Predictability of Production for scheduling business cycle.

Die Casting is category different than other manufacturing processes mainly due to very high Tool Changeover time and High initial start-up i.e. Pre Heating of Die, Initial Waste around 50-60 Shots (Nos. Of Parts) by that time the Die is equally heated from all nooks & Corner. Moreover the post Manual Works e.g. Fettling, Trash Cutting, Polishing, Shot Blasting makes it more dependent process on man oriented rather a Machine Driven.

The products in Die casting industries are identified based on their appearance for Die loading as :-

- Runner Products (Minimum occupancy of 50% of Capacity).
- Repeater Products (Minimum occupancy of 25~30% of Capacity).
- Stranger Products (Rare occupancy of 10~25% of Capacity).

The above categorisation is based on their frequency of appearance in production cycle. The Die Casting industry has a trade-off to balancing the VAs over NVAs having a Die Loading for a minimum number of 1000 Shots (useable) as a Production Batch.

Constrained batch of Production size with blending of appearance frequency and high dependence on post operations to converts efforts into a Business Transaction worsen the problem. Therefore Predictability of output and visualization of Production Cycle pace is not possible until a sincere efforts are put resource requirements are optimized to improve on :-

- Takt.
- TPT (Through put Time)

## II. LITERATURE REVIEW

Like the Newton's First Law of Motion the change in the state of a Body is only a result of Forces Applied on otherwise there cannot be a change i.e. for Any Change in State there has to be an External Force working on it. In a process the Force is termed as Value, the Process advances with various value additions only.

This value addition in Manufacturing Process flows like a Stream, this is how Value Stream a terminology evolved. A value stream is summation of all the actions at every point of change or transfer, both Value Added (VAs) & Non-Value Added (NVAs) currently required bringing out a product through the process flows essential for the product [1]:-

- The Design Flow from Concept to Launch.
- The Production Flow from Raw Material into the End Products reaching to Customers.

This looks at the flow of Production activities from Customer Demand back through Raw Material, which is the flow we usually relate to Lean Manufacturing and precisely the struggle area to implement Lean Manufacturing Methods.

Taking a Value Stream perspective that means working on a bigger picture, not just Individual Processes, and improving the whole, not just optimizing a part of it. How Value Stream Mapping (VSM) goes on is as shown below in Figure : 2-1 :-

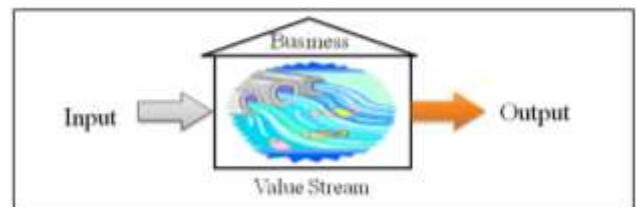


Figure : 2- 1 Flow of Value Stream

Value-Stream Mapping (VSM) is a Pencil and Paper tool that helps to see and understand the Flow of material and information (Together) as a product under process as advances from one stage to the next i.e. its path through the entire Value Stream. What we mean by Value-Stream Mapping is simply Following and Tracing a product's production path from Customer to Supplier to Process to Customer:-

- Draw a Visual Representation of every process as the material and information Flows / Passes through (Current State).
- Examine & Evaluate Flow of Value Stream, to eliminate Muda (Waste) or NVAs.
- Draw a "Future State" map of how Value should flow in Stream.

### 1) The Advantages of Value Stream Mapping:

It helps [2] in visualizing more than just the single-process level, i.e. Assembly, Welding, Machining, Painting, Inspection, Storage etc. in production and the Flow of Process can be seen to determine bottlenecks :-

- It helps to see more than Waste and Mapping helps to see the sources of waste in entire Value Stream.
- It provides a common language for talking about manufacturing processes.
- It makes decisions about the flow apparent, so can be discussed them. Otherwise, many details and decisions on your shop floor just happen by default.
- It ties together Lean Concepts and Techniques, which helps to avoid "Cherry Picking".
- It forms the basis of an implementation plan. By helping in design how the whole door-to-door flow should operate— a missing piece in so many Lean Efforts.
- Value Stream maps become a blueprint for Lean Implementation. Imagine trying to build a house without a blueprint!
- It shows the linkage between the Information Flow and the Material Flow. No other tool does this.
- It is much more useful than quantitative tools and layout diagrams that produce a tally of Non-Value-Added (NVAs) steps, Lead Time, Distance Traveled, the amount of Inventory, and so on.
- Value-stream mapping is a Qualitative Tool by which, helps in describing in detail how facility should operate in order to create flow.
- Numbers are good for creating a sense of urgency or as before/after measures. Value-stream mapping is good for describing what you are actually going to do to affect those numbers

### 2) Material & Information Flow :

Within the production flow, the movement of material through the factory is the flow that usually comes to mind. But there is another flow— of information—that tells each process what to make or do next. Material and information flow are two sides of the same coin. You must map both of them, this is as shown in below Figure : 2-2 :-

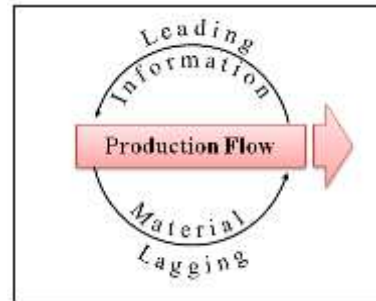


Figure : 2- 2 Information & Material Flow in VSM

In Lean Manufacturing the information flow is treated with just as much importance as the material flow. Toyota and its suppliers may use the same basic material-conversion processes as mass producers, like Stamping /Welding / Assembly / Painting / Machining etc., but Toyota plants regulate their production quite differently from mass producers.

The Learning is, "How cans Flow of Information so that, one Process will Produce only what is required by the next Process & When it needs it?" which in other words can be said shifting to OTIF (On Time in Full) methodology working.

### 3) Selection Methodology for a Product Family :-

One point to understand clearly before starting is the need to focus on one product family. The Customers Cares and Interested about their specific products, not all the Products. So it will not be helping to map everything that goes through the shop floor. Unless it required in-case of a small one Product plant, Drawing Product Flows for all the Products on one map is too complicated. Value-stream mapping means walking and drawing the processing steps (material and information) for one product family from door to door & Beginning to End in the Plant.

"Identify Product families from the customer end of the value stream. A family is a group of products that passes through similar processing steps and over common equipment in downstream processes" [1]. In general, the Product Families should not try to be discerning just by looking at upstream fabrication steps, which may serve many product families in a batch mode. These Learning are to be Tabulated in form of Matrix as shown below in Figure : 2-3, What are the Selected Product Family, how many different finished part

numbers there are in the family, how much is wanted by the customer, and how often.



Figure : 2- 3 Selection Matrix for Product Family for VSM

### III. OBJECTIVE

The objective of this Study to understand Pull Based Replenishment system in a Industry, Challenges associated with in implementation and enhancing the understanding on subject so far, Taught & learnt as Curriculum Studies. This also gives an opportunity to update understanding Practically Shop Floor Realities and take an assessment of Gap between the Academic Methodologies and Industrial Practices.

It also has an objective of establishing acquaintance with the subject, provides a real time Shop Floor Exposure to Students and giving an opportunity to take his learning forward more Focused, Forward and moving from Virtual to Real world of Happening.

#### 1) Fact Finding:

While, understanding the operations at M/s XYZ and co-relating their Business Process with Standard Operating Procedures (SOP), Industries Benchmarking and other Best Practices across the domain. Following gaps were observed :-

- Since the Industry is a Job Worker and the Production is dependent on the Monthly requirements of its Customers. These monthly requirements are issued in the form of Delivery Schedules for the month “Firm Requirements” and other 02 Future month’s as “Tentative Requirements” for Planning of Capacity, Raw Material & other Resources etc.
- The Nature of Business is catering Auto OEMs where the demand itself is based on the Sales forecast and largely dependent on the Market Affecting Factors.
- The Trend Analysis for monthly offtaking by it’s customers indicates there is a large variation in the Indicated Requirements & what has finally resulted in business.
- The entire Laundry List of Products can be categorized as :

- Runner Parts i.e. Fast Moving almost regularly moves every month.
- Repeater Parts i.e. Not fast moving parts but, having trend of movements.
- Visitor Parts i.e. Parts are having very slow Movement and appears as & when demand arises usually with a large interval.

This phenomenon has affected the economics of the company in terms of :

- Piled up Finished Products Stocks.
- Large Nos. of Slow Moving Finished Parts.
- Working Capital Shortages.
- Expenses on Preservation of Parts.
- Rejection of Parts due to Handling & Exposure to atmosphere i.e. Oxidation of Aluminum or White Rusting in common industrial terminology.
- Floor Area Occupied.

### IV. METHODOLOGY

#### 1) Process Flow Chart :

The Steps involved in analyzing current state of Operations based on the Standardization requirements, how the activities are linked with each other and affect directly or indirectly or a Dependent Activities influencing outcome is illustrated in Figure : 4-1 Process Flow Chart for Fact Finding :

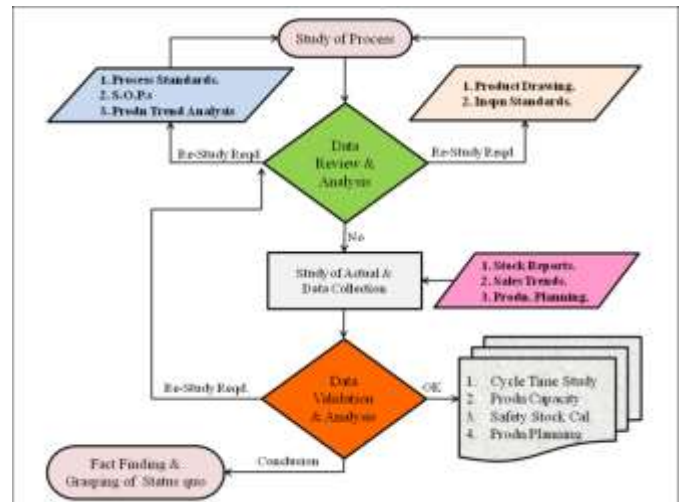


Figure : 4- 1 Study & Analysis Methodology

#### 2) The DMAIC Cycle as Methodology :

For implementing Replenishment / Pull Based (KANBAN) system each and every Business process Element to be Analyzed, Evaluated and Gaps have to be established to improve from.



Each element of DMAIC Cycle [3] has surfaced some Critical & Important aspects of the process to be studied & monitored they are :-

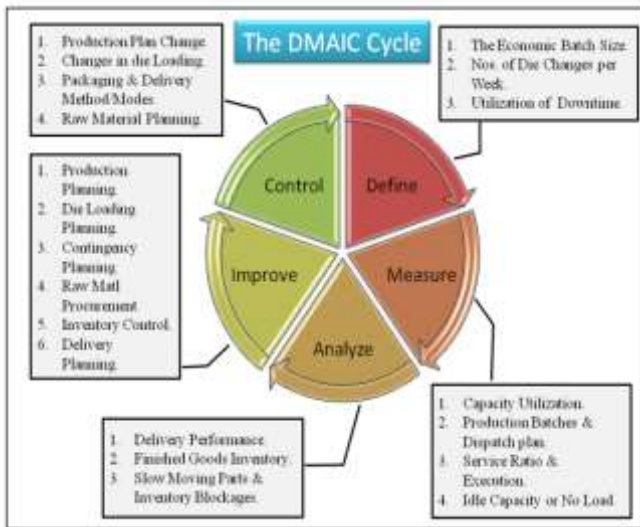


Figure : 4- 2 the DMAIC Cycle

Summing up the above learning into element wise above Critical Area of operations at M/s XYZ as emerged to be taken up for improving from current state to a Futuristic State, these are as shown in above Figure : 4-2:-

- Study of Plant Layout.
- Study of Process Layout.
- Developing Process Relationship of Part to Machines.
- Study of Existing Process for Cycle Time.
- Work out for Takt Time.
- Value Stream Map of Existing Process.
- Production Planning Process :-
- Customer's Order / Delivery Schedule Receiving Process.
- Working out Manufacturing Plan.
- Raw Material Procurement Plan.
- Nos. of Production Shifts.
- Manpower Planning.
- Die Loading Plan.

## V. AT SHOP FLOOR

The layout of M/s XYZ oriented on the basis of Melting Furnace and sub set of Holding furnaces for holding molten metal to ease the operations. The schematic layout of the industry is as given below in Figure : 5-1 :

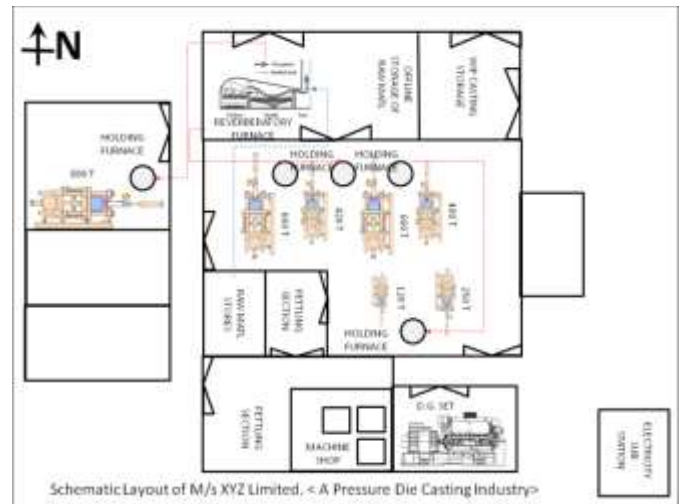


Figure : 5- 1 Plant Layout of M/s XYZ Ltd.

The process flow at M/s XYZ is also as given below in Figure : 5-2 :

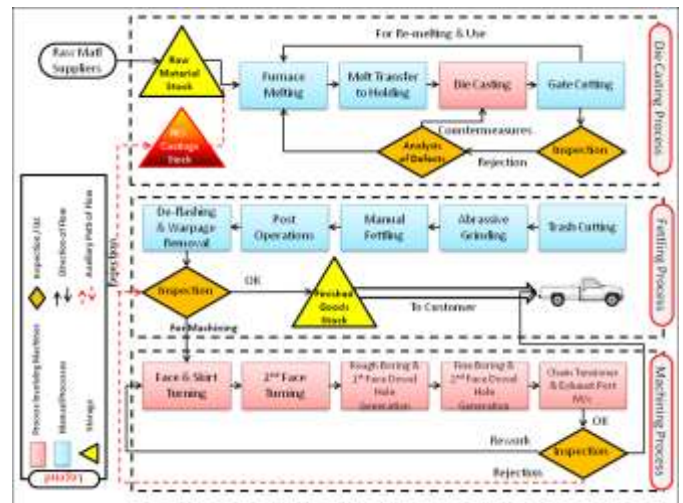


Figure : 5- 2 Process Flow at M/s XYZ Ltd.

The manufacturing facilities (Infrastructure) at M/s XYZ Ltd. available are :

- Raw Material Stores.
- Melting Section.
- Tool & Die Maintenance & Crib.
- Die Casting Section.
- Fettleing Section.
- Machining Section.
- Quality Control & Inspection Section.
- Packing & Delivery

### 1) Die Casting Section :

The Die casting Section is Equipped with Horizontal Cold Chamber High Pressure Horizontal Die Casting Machines in various capacities. These machines are well supported by

Electric Holding Furnaces which maintains the Molten Metal at a Temperature of 665°C to ensure fluidity in the closed Die to reach up to intricate shapes/corners. This ensure the Die casted parts to be free from Short Molding, Cold Shuts, Welds (Joining lines visibility at the merging area of two melt streams of melt) etc. The Machines are using Nitrogen Gas as Secondary Pressure System to ensure Melt flows and compacted in the closed cavities of Die. The Die Castings Machines available at M/s XYZ Ltd are listed below in Table : 5-1:

Table : 5- 1 PDC Machines Availability

Sr	Types of Machine	Availability
1	Type : H, 800 D (800 T Capacity Die Casting Machine) with Auto Ladler, Auto Extractor, Auto Die Coat Spray .	01 No.
2	Type : H, 660 D (660 T capacity Die Casting Machine) 01 Machine with Auto Ladler.	02 Nos.
3	Type : H, 420 D (420 T Capacity Die Casting Machine) with Auto Ladler, Auto Extractor, Auto Die Coat Spray .	01 No.
4	Type : H, 400 D (400 T Capacity Die Casting Machine)	01 No.
5	Type : H ,250 D (250 T Capacity Die Casting Machine)	01 No.
6	Type : H, 120 D (120 T Capacity Die Casting Machine)	01 No.

2) *The background of KANBAN implementation in M/s XYZ Ltd:*

The first version of KANBAN was implemented during the second half of 2012 in M/s XYZ Ltd. as an initiative of its one of the Major customer for pulling the supplies i.e. only Deliveries are driven by KANBAN Triggers.

Since Dec 2013 an upgraded version of the KANBAN philosophy was started up to be implemented to extend KANBAN to Production System, When this thesis project was introduced into this KANBAN project, Combined Engineering is still on its second step which is expected to be finished during 2014.

During the first step, the bottleneck has been defined, electronic KANBAN signals (Email base Triggers) have been applied in the Dispatch system; Stock & WIP has been followed up on daily basis and Die Loading on Machines as well as on a weekly basis as a KPI (key performance indicator). [4]

In the second step, the KANBAN implementation would continue what has been done in the first step and pull the KANBAN project going further. The following subprojects as described [4]:

- Working out plan for WIP & Takt.
- Output monitoring from each stage of operation.
- Redefining KANBAN Size from a Lot size to few

50003000Hours of Production i.e. Challenging Safety Stock (Excess is also one of the Muda-Waste).

- Study & Improvement of Through put Time (TPT).
- Constrained Process Identification & Evaluation.
- Standardization i.e. Development of SOPs.

3) *Study of Business Performance of M/s XYZ Ltd. :*

The Broad Classifications are based on following Assumptions of Nos. of Parts supplied in the month, which directly correlates to the Business Volume of the month and also to the Production of parts (Capacity Utilization) as given below in Table : 5-2 Business Class Assumptions:

Table : 5- 2 Business Class Assumptions

Sr	Business Volume / Month	Category Assumed
1	≤ 3000 Nos.	Visitor / Stranger
2	≤ 5000 Nos.	Repeater
3	≥ 5000 Nos.	Runner

The average Monthly Business Volumes were examined to primarily classify parts based on the above assumptions as shown below in Table : 5-3 Monthly Average Business Volume Category Wise :

Table : 5- 3 Monthly Average Business Volumes Category Wise

Sr.	Business Model	Average Buying /Month (Nos.)
1	Runner	45954
2	Repeater	22205
3	Stranger	6975
Grand Total		75134

This is further classified to establish Machines Involvement and Category wise Utilization to be more Focused and Meticulous in developing Production Plan, as shown below in Table : 5-4 Business Model Classification

Table : 5- 4 Business Model Classification

Average Buying /Month	Classification of Business Model			Grand Total
	Runner	Repeater	Stranger	
-	1			1
250T		1	9	10
400T		1	1	2
660T	2	2	2	6
800T		2		2
Grand Total	3	6	12	21

The Average Monthly Business Volumes are expressed in terms of Revenue generation to establish a relationship

between the Capacity Utilized for vis-à-vis Revenue Generated, which is shown in Table : 5-5 Monthly Sales (Average) Business Model Wise :-

Table : 5- 5 Monthly Sales (Average) Business Model Wise

Sr.	Business Model	Buying Value / Month (Rs.)
1	Runner	14954864
2	Repeater	6687807
4	Visitor / Stranger	1676716
Grand Total		23319387

The Capacity utilization with respect to Business Volumes i.e. in terms of Capacity Occupancies and Value Realization for different business proportions is as shown Below for Capacity Acquisition (which is as shown below in Figure : 5-3 Capacity Acquisition Business Model Wise) & Value Proportions respectively (which is as shown below in Figure : 5-4 Value Proportions Business Model Wise) :-

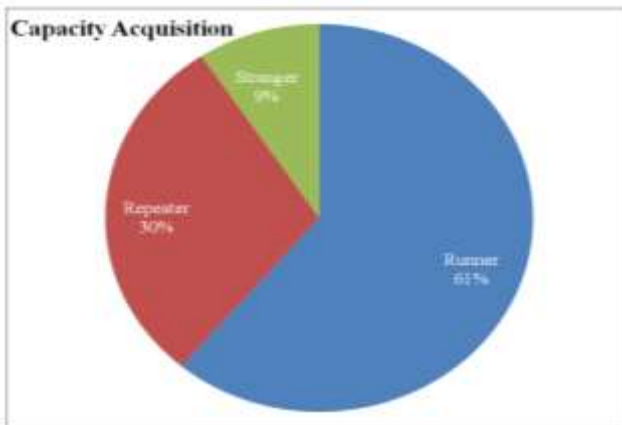


Figure : 5- 3 Capacity Acquisition (Business Model)

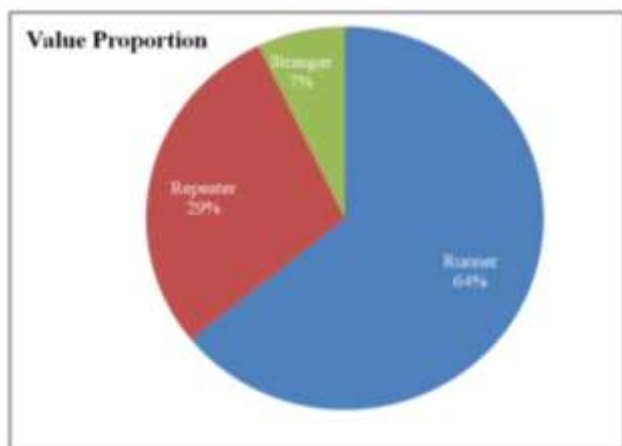


Figure : 5- 4 Value Proportion (Business Model)

Which further reveals that the annulated Capacity Acquisition for following Business Model are as under:-

- Runner = 61% Utilization of Total Capacity.
- Repeater = 30% Utilization of Total Capacity.
- Stranger = 09% Utilization of Total Capacity.

Which is further interpreted in terms of Value Realization against each Business Model :-

- Runner = 64% Generation of Total Revenue.
- Repeater = 29% Generation of Total Revenue.
- Stranger = 07% Generation of Total Revenue.

This gives a preliminary insight of the Business at M/s Combined Engineering, though the Major generation of Revenue comes from Runners but, Repeaters Product is having significant contribution in terms of Capacity Utilization and Revenue Generation. Therefore cannot be ignored, the distribution is as shown in Table : 5-6 Repeater's Business Contribution & Value Distribution in Figure : 5-5 Repeater's Value Distribution Part Wise :

Table : 5- 6 Repeater's Average Sales Volume

Business Model Classification	Part Description (Castings)	Buying Value / Month (Rs.)
Repeater	L. Crankcase	2567538.00
Repeater	L. Crankcase cover	955290.24
Repeater	R. Crankcase	896218.68
Repeater	R. Crankcase cover	752236.23
Repeater	Mission case comp	680598.23
Grand Total		5851881.38

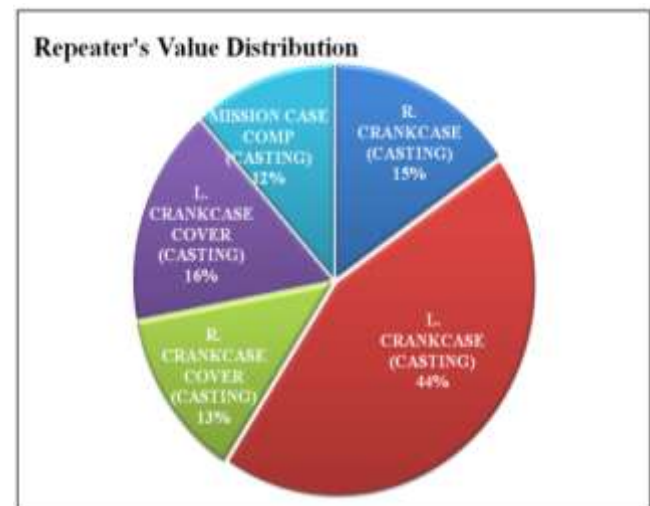


Figure : 5- 5 Repeater's Value Distribution

4) Value Stream Map (Current State) :

The Business Model (Repeater) is identified as the Scope of Improvement, which resembles with our Problem

Definition of Rolling out Kanban in a Fluctuating Demand Cycle. Further investigating the problem the Cycle Times of following products have been studied :-

- L Crankcase Castings.
- R Crankcase Castings.
- R Crankcase Cover Castings.
- L Crankcase Cover Castings.
- Mission Case Castings.

The Cycle Time of each process element is as recorded in Table : 6-10 (Shown Below) and Throughput Time (TPT) and Processing Time (PT) is calculated as:-

Table : 5- 7 Cycle Time of Repeater Class Parts

Parts Description (Castings)	Casting (Seconds)	Trash Cutting (Seconds)	Abrasive Grinding (Seconds)	Manual Fettleing (Seconds)	Post Operations (Seconds)
L. Crankcase	125	60	60	155	72
R. Crankcase Cover	82	60	45	135	50
R. Crankcase	85	65	60	125	30
Mission Case Comp	82	30	30	60	22
L. Crankcase Cover	82	60	20	120	45

The Effective Cycle Timing is worked out for each Repeater Category Part validating with Quality Reliability of Output of the Operation and Machine’s Up-Time Trends to establish a realistic timeline :-

5) Value Stream Map of L Crank Case (Casting) :

The Value Stream Map for L Crankcase Casting is drawn with Effective Processing Time of each element of Process and accounting the various Lead Time Elements, in getting the Customer Order, Production Planning for Takt Decision, Planning for Raw Material & Resources, which is as shown in Table : 6-11 below :-

Table : 5- 8 Cycle Time (Minutes) of L. Crankcase

L. Crankcase Casting ( Cycle Time in Minutes)					
Sr	Operations	Cycle Time (A)	Reliability (B)	Up Time (C)	Effective Cycle Time = (A) / (B*C)
1	Melting Furnace	60.00	99%	95%	63.80
2	Holding Furnace	30.00	99%	99%	30.61
3	Casting	2.08	95%	90%	2.44
4	Trash Cutting	1.00	100%	100%	1.00

5	Abrasive Grinding	1.00	100%	98%	1.03
6	Manual Fettleing	2.58	100%	100%	2.60
7	Post Operations	1.20	100%	95%	1.27
TOTAL		97.87	-	-	102.7

With the above data (Table : 5-8) have drawn the Value Stream Mapping (VSM) of Current State of L Crankcase Casting is (as shown in Figure : 5-7) :-

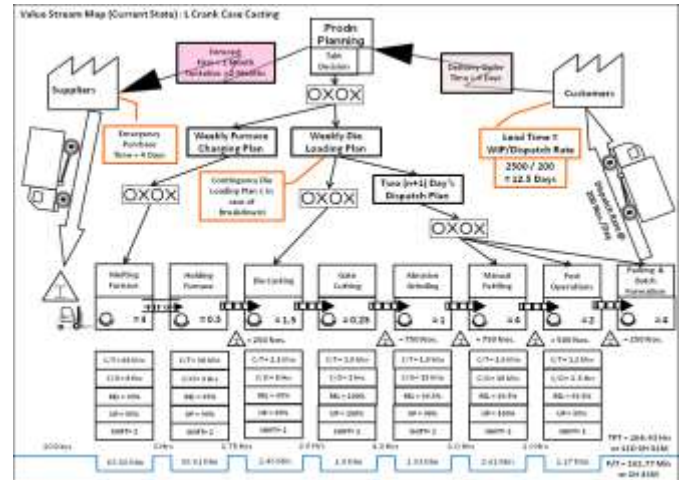


Figure : 5- 6 VSM of Current State (M/s XYZ Ltd.)

6) Value Chain Overview

On the Value Stream Map (VSM) [5] , there are three main processes which enable information and physical flows going through the manufacturing system and realizing the daily production.

The value chain starts with order taking process which begins when Combined Engineering receive Purchase Orders from customer by marketing department and ends when the orders are passed to production planning.

For Regular supplies to Original Equipment Manufacturer (OEM) M/s XYZ Ltd. receive Open order and that is to be executed against Monthly Delivery Schedules. It excludes the quoting and order confirming process M/s XYZ Ltd. also does the Job-work for variety of Customers for varied Requirements to ensure 100% Capacity Utilization on Die Casting Machines.

In most of the cases Pressure Die casting Dies are provided by the customers that has reduces the Die Development Time thus helps in reducing start time once order is received, this process takes normally 6days to finish.

For different orders, M/s XYZ Limited follows different Production Planning Techniques:-

- Build-to-Order (BTO).
- Make n Shift.
- Long Term Planning
- Short Term planning.



7) Value-Stream-Mapping based Description :

The Value Stream Map for Die Casting Repeater Category part (L Crankcase (Casting) reveals following information as Tabulated & shown below in Table : 5-9 :

Table : 5- 9 VSM Observations L. Crankcase (Casting)

L CRANKCASE (CASTING)		
Sr.	Items	Results from VSM
1	Process Time (PT) (Value Addition)	102.73 Minutes or 1Hrs & 43Min
2	Through Put Time (TPT)	266.43 Hrs. or 11Days 0Hrs & 42 Min
3	Lead Time	18 Days { 11 Days (TPT) + 6 Days (Order Processing) + 1 Day (Transport) }

8) Lead Time :

The Lead Time is from order taking to delivery. According to the historical experience, what Combined Engineering can assure for customer is normally 12.5 Days which includes one weekly off. As the TPT [6] for L Crankcase Casting is higher than the other products, the lead time could be set less than 12.5 Days.

There are some of the processes to consist of these days especially Order taking time (excluding quoting), Production planning (include Takt decision and furnace planning), Purchasing, Producing and Delivering.

9) Through-Put-Time (TPT)

According to the above table, the TPT [30] is 11 days, including 01 Hrs 43 Minutes value adding time. Thus the non-valuing adding time is 10days 22Hrs (including 8 Hrs of preparation time for Furnace Charging). The calculation result from VSM could almost reflect the realistic daily working condition. The data from production data for this year shows that the average Through-Put-Time of L Crankcase Casting is 12.5 days.

The Non-Value Addition (NVA) time means that the TPT could be shortened by 7 days, which would be a huge achievement for M/s XYZ Limited.

10) Process Bottleneck

The bottleneck has been detected by Combined Engineering as Die Casting & Manual Fettling, However when different product mix goes through the production line, the other Process Elements possibly will turn into be a bottleneck, e.g. Machining > Setup-1 on VMC, Fine Boring on VMC or 6-ø8.2x120L Holes Drilling on VMC.

There are three tables drawn based on the VSM. They could give a comprehensive understanding of the bottleneck.

The first figure shows the working capacity for each process unit. In the Figure : 6-, the working capacity is presented by the volume of L Crankcase Casting & each Process Element could produce based on the current shifts setting. It is infer that the Post Operations could also be a bottleneck.

However when considering the next two figures, Casting & Post operations processes are more possible to be the bottlenecks. Their extra available working time is fewer than the other processes. The Manual Fettling process has the least flexibility to increase deployment due to Skill, Space and shifts, hence it is the most often bottleneck of the production line

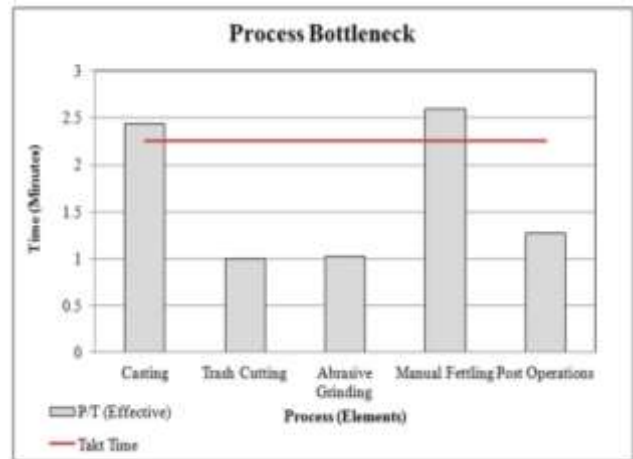


Figure : 5- 7 Bottlenecks in Process

The characteristic of the customer order is inconsistent and few types of parts are exhibiting fluctuations like high tide and some are having the order volume is on such a low level even the Die Loading & Preparation time costs more than the total Business Volumes in terms revenue generated out of.

The reasons associated with are mostly Customer’s Product performance and Off-take as these products are having direct adoption to a Model Specific or its Variants. The sales are directly linked with the Production. In this case, the order follows the Business Trend and acceptance in the market; the low volume is just reflecting the customers’ production condition. Low quantity of a Product Family or a Moderate Requirements makes the Business at Combined Engineering to be more Adaptive & Planned to combat with the situations thus arises.

After the above analysis, it could sum up that M/s XYZ Limited is operating in a Business Scenario which faces a market which needs Timely Supply of a Large Variety of Parts at Competitive Pricing with High Demand Fluctuation.

This Demand Fluctuations makes M/s XYZ Limited a Potential playground for meeting the unique market requirement and challenge the production system to do Quick & Timely Response.....and that is the condition is what KANBAN is designed for.



11) Value Stream Mapping with KANBAN :

Here we will use Value Stream Mapping (VSM) to give an overall picture to visualize where and how KANBAN will improve the process flow of L Crankcase casting. The value stream mapping is still based upon the data of the L Crankcase casting (Current State).

The Takt decision states at the top level of production control, which levels customer orders directly and send the production schedule together with weekly Takt goal downward to Melting Furnace and Die Casting Shop. Then the Die Casting Shop does casting re-planning based on the Die Loading & Business Volume, which cost normally 1 week. The Die Casting shop uses planning KANBAN Board to plan the Daily Work for Die Casting Processes, excluding Gate Cutting. As the Value Addition Time to Non Value Addition Time is very Low therefore bottleneck is shifted from Die Casting to Manual Activities which is affecting Takt Time. The daily production plan in Combined Engineering is always adjusted according to the KANBAN Board schedules, addressing to Daily Customer's Requirements..The Kanban cards go through each process unit working with local Kanban board.

The TPT here is obtained from the calculation: WIP is divided by Takt. The time sum up method is not used here, because when the mix products go through production line, the TPT cannot be got from simply time sum up calculation.

Kanban Board adopted for Repeater category of Parts is as given below in Figure : 6-15 :-

PART	KANBAN TYPES	GATE CUTTING							SUPPLY STOCK
		1	2	3	4	5	6	7	
L CRANKCASE CASTING	A	Red	Green	Green	Green	Green	Green	Green	
R CRANKCASE CASTING	A	Green	Green	Green	Green	Green	Green	Green	
R CRANKCASE COVER CASTING	A	Green	Green	Green	Green	Green	Green	Green	
L CRANKCASE COVER CASTING	A	Green	Green	Green	Green	Green	Green	Green	
MEDIUM GAST CASTING	A	Green	Green	Green	Green	Green	Green	Green	

Figure : 5- 8 KANBAN Board for Repeater Category Parts

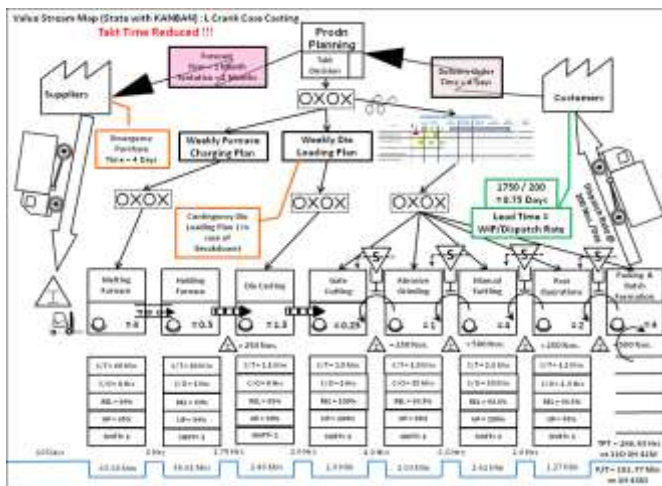


Figure : 5- 9 VSM with KANBAN for L Crankcase

VI. RESULTS & DISCUSSIONS

1) Strength of the holistic Kanban system

The respective components are expected to work as a whole system. When having an overview of the whole system, it could get the some functions which the respective Kanban components cannot delivery by itself.

2) Synchronize the production pace

The Kanban synchronizes the production pace from input pace setting to implementing. The bottleneck limits the production pace. The non-bottleneck processes are scheduled to coordinate with it.

3) Set products flow sequence :

The Kanban set the producing sequence rule-FIFO. The machine shop uses planning Kanban board to realize the FIFO rule.

4) Standardize work and operation procedure :

Every staff involve in the production unit follows the Kanban rules and routines to process their daily work. These rules and routines have standardized work time, work sequence and work in process. These series standardized works clarify the daily work for operators as well production managers.

5) Visualize the production process :

The physical Kanbans are all have function to visualize and clarify the daily works for each stakeholder. The visual daily work could easily inform stakeholder what to do, when to do and what is going wrong as well. The visual stuff could release some remember thing from each stakeholder, eliminate wrong operation and bring problem out of water.

6) Reduce TPT And Guarantee Delivery Date :

As the WIP is reduced, the TPT would be automatically reduced to some extent. The following table shows the change of TPT before and after Kanban implementation. Some product families have longer TPT, but the TPT for the Roll-up product L Crankcase Casting has been reduced over 25%. Because of Shorter Through-Put-Time more Accurately Forecast for the output can be done. The shorter and more consistent TPT enables M/s XYZ Limited to guarantee the delivery date to its customers.

7) Integrate Thinking And Doing :

The Kanban requires the production planning staff to think the production system in an integrated way. The planning Kanban board provides a good plate for the floor staff to work

together, sharing, discussing and cooperating. The Kanban reveals and illustrates the daily work of each operator, and informs the operators how important their work is. This positive feedback has possibility to enable the operators to think their job in a more open way. In this way, any extra thinking and discussion would improve the production.

8) *Accelerate Cash Flow :*

After the above analysis, it is easy to tell that the reduced WIP lower the inventory carrying cost, which, together with the decreased TPT, accelerate the cash flow rate.

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