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Use of value stream mapping from lean supply chain perspective: An Indian case study

[1] Mrunalini D Dodkey, [2] Dr. Abhijeet Shelke

[1] Faculty, Symbiosis Institute of Opertions Management, Nashik, Maharashtra, India

[2] Associate Professor, Department of Management Science, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India

Abstract

Purpose: The term Lean in lean supply chain management is a paradigm shift in today's business world. While supply chain management focuses on integrating all the stakeholders across the entire value chain right from raw material suppliers to the end users, lean supply chain management focuses on how to make this entire supply chain more effective and efficient. Lean philosophy, principles and objectives are playing a pivotal role in businesses to cater to the needs of competitive markets and demanding customer. The lean tools provide direction, framework in achieving lean supply chain objectives. This paper focuses on the use of Value Stream Mapping in an automobile industry and illustration of the same in one of the auto component industry in Maharashtra.

Design/Methodology/Approach: The study is based on literature review, substantiating the findings from it in the context of case study of manufacturing organization. It further aims to give the direction for use of lean tools along with value stream mapping.

Findings: The paper focuses on how value stream mapping can be used as an internal process improvement tool and can also be used to extend the same for integrating the processes outside the organizational boundaries.

Research Limitations/implications: This paper explores the availability of literature in the area of lean supply chain practices. As a conclusion it gives further direction where research in Indian context should be focused. It is not a research to prove any hypothesis.

Practical implications: Although lean supply chain management is getting prime importance in today's business world, penetration of best practices is far away from reality. Adopting lean tools to eliminate waste and improve the efficiency of the process is essential for every organization for its existence.

Keywords: OEM, VSM, SCM, Lean tools

1. Introduction

The evolution of Supply Chain Management from support function to strategic function of the organization is seen as a paradigm shift in today's changing business world. With cut throat competition amongst the various players and the maturity of the businesses in various domains, it is expected that every function of the organization remains profit center and contributes to the bottom-line of the organization.

With industries becoming more mature and building upon the competencies of each other, supply chain management gamut has changed drastically. Supply Chain is not seen as function within the boundaries of the organization but it is seen as one of the important function across the organization that covers upstream and downstream operation of the organization connecting customers to vendors. A special focus is given to this area in premier MBA School to understand the information flow, material flow and cash flow across the entire value chain. Any industry big or small in size, functional or matrix type in nature, Service or Manufacturing type will always have a goal of satisfying the end customer. Supply chain management roots lies in this end state. The 7 supply chain management principles i.e. Adapt supply chain based on customer segment, Customize logistics network of each segment, Align demand planning across supply chain, Differentiate product closer to customer, outsource strategically, Develop information technology that support multi-level decision making, Adopt both service and financial metrics revolves around the improving customer satisfaction that have been adopted by various companies enhanced the customer satisfaction and profitability says David L Anderson, Frank F Britt and Donavan J Favre. In this context it becomes very essential to understand how effective and efficient supply chain management can be practiced that will make the entire supply chain management more lean and flexible.

2. Literature Review

Derived from Toyota Production system that emerged from resource crunch, lean supply chain management is practiced in manufacturing as well as service sector. Automobile industry is the early beneficiary of this philosophy and has integrated downstream and upstream players of value chain no matter how small the player in the value chain is. Lean organization is the term coined newly in the industry referring to the businesses that follow lean manufacturing. Popular tools that are practiced as a part of Lean Manufacturing thereby assisting Lean Supply Chain Management include 5S, Single Minute Exchange of Die (SMED),Value Stream Mapping (VSM),Kanban (Pull System), Poka-Yoke, Total Productive Maintenance, Mixed Model Processing, Rank Order Clustering, Single Point Scheduling, Redesigning working cells, Multi Process Handling and Control Charts etc.

Secondary research through literature review, articles, papers mention that SME's of Indian auto industry are attempting to adopt different management practices. Humm (1990) mentions that there have been evidences of local players using techniques like TQM, JIT, BPR and lean SCM practices that enhances the performance of the companies. These local players believe that SCM adoption and implementation is bare minimum and newer ways of remaining competitive requires continuous improvement (Kaizen) and innovation. This is supported by study done by Souresh Bhattacharya and others (June 2014) where they mention that " Interestingly, the top two supply chain goals have shifted, from reducing operating costs and overall inventory levels, to concerns of how to improve customer service and speed of product delivery to markets". Contrast to this, is study done by Saad & Patel (2002) mentions that only one third of Indian Auto component manufacturing companies are ISO 9000 certified.

Value Stream Mapping (VSM) is a powerful tool that is practiced in an organization to improve the information as well as material flow thereby reducing the cycle time and waste in the process. It helps the team to identify the inefficiencies in the process and take corrective action (Womack, J.P and Jones 1996). As an approach to VSM, all the value added and non-value added activities that are required to make a finish product are identified (Rother and Shook 1999). Not just limited within the organization, this can be extended across the entire value chain to cover the processes that are outside the boundaries of organisation (Rother and Shook 1999). McDonald 2002, emphasizes the bigger scope of VSM which can cover end to end processes thereby identifying waste and process improvement across the entire value chain as opposed to other tools that concentrate just on single/individual process at a time. Typical steps followed in any VSM implementation are:

1. Define product family
2. Document current state
3. Design future state
4. Create Implementation plan
5. Implement

While current state flow of the process is known and is being practiced, the future state process needs inputs from the management as well as technical team since it involves elimination of certain activities and addition of new improved activities to bring out the noticeable changes in overall process in terms of cycle time reduction, waste elimination and efficiency improvement.

Some of the contribution in the area of VSM in the recent past is tabulated as under

Major contributors Area of work	Area of Work
Monden (1993)	Defined value from customers' viewpoint
Jessop and Jones (1995)	Developed tools to understand different value streams and their overlapping nature
Hines *et al*. (1998); Hines (1999); Grewal andSareen (2006); Grewal and Singh (2006)	Identification and elimination of muda
Peter Hines *et al*.(1998)	Value Stream Management
Mcmanus and Millard (2002)	Product development (PD)
Emiliani and Stec (2004)	Leadership development
Seth and Gupta (2005)	Productivity improvement at supplier end
Snyder *et al*. (2005)	Health care center
D Seth*, V Gupta (2005)	Application of value stream mapping for lean operations and cycle time reduction
T da CL Alves, ID Tommelein, G Ballard (2005)	Value strem mapping for Make to Order Products
RB Whitaker (2005)	Value stream mapping and earned value management: two perspectives on value in product development
Faisal *et al*. (2006)	Mapped supply chains on these two dimensions risk and customers satisfaction
M Braglia, G Carmignani, F Zammori (2006)	A new value stream mapping approach for complex production systems
RR Lummus, RJ Vokurka (2006)	Improving quality through value stream mapping: A case study of a physician's clinic
FA Abdulmalek, J Rajgopal (2007)	Analyzing the benefits of lean manufacturing and value stream mapping via simulation
Brunt (2000); Abdulmalek and Rajgopal (2007);Seth *et al*. (2008); McDonald *et al*. (2002)	Improved productivity of process industry
Klotz *et al*. (2008)	Explained impact of process mapping on transparency in an employee training session
Lasa *et al*. (2008)	VSM is a valuable tool for redesigning the productive systems
M Bevilacqua, FE Ciarapica (2008)	VSM in project management
Seth *et al*. (2008)	Address various wastes in the supply chain of the edible cottonseed oil industry
GQ Pan, DZ Feng, MX Jiang (2010)	Delivery time reduction using VSM
SS Abuthakeer, PV Mohanram (2010)	Activity Based costing using VSM
A Brown, J Amundson, F Badurdeen (2015)	Sustainable VSM

3. Method

This research paper aims to study the application of VSM in Indian automobile industry. The case study approach is followed to verify the theoretical aspects of VSM into organizational context (Eisenhardt, 1989, Boiral, 2007). Automobile sector is ever demanding and competitive. To that extent the supply chain of auto industry is tightly integrated with suppliers and supplier's supplier. This case study may set best practice example for other organizations to adopt the methodology and implement the same in their organization.

3.1 Overview of case organization

Case

A Global Manufacturer of Seating and Electrical Distribution systems for automotive and Air Craft industry with presence in 36 countries and 226 locations around the globe and India operations contributing to almost Rs. 500 Crores, is supplier to major OEMs in India. With state of art facilities in Maharashtra region and well defined Quality Processes like Six Sigma, TS16949 the company is early adopters of Lean Supply Chain Management principles and practices. As said by one of the directors of the company, India operations, "Lean is a Culture of our organization", so much so that our forward and backward integration follows lean practices irrespective of size of players that form our value chain. Company is Tier 1 supplier for major automotive companies in India with end to end solutions in design, engineering, just-in-time assembly and delivery of complete seat systems as well as manufactures all major seat components, including seat structures and mechanisms, seat covers, seat foam and headrests.

Lean Practices of the Organization

- Seat assembly facilities use lean manufacturing techniques, and finished products are delivered to the automotive manufacturers on a JIT basis, matching customers' exact build specifications for a particular day and shift, thereby reducing inventory levels.
- The facility is located adjacent to customers' manufacturing. The Seat components, including recliner mechanisms, seat tracks and seat trim covers, are manufactured in batches, typically utilizing facilities in low-cost regions to feed the OEM as per their production schedules. The batch production is bar coded and loaded in dedicated vehicles of the company that are lined up to carry the same to OEM.
- The principal raw materials used in seat systems, including steel, foam chemicals, leather hides and yarn are generally available and obtained from multiple suppliers located nearby under various types of supply agreements. The inspection of the raw material quality is done at the supplier facility as well as at the receiving bay to ensure that quality is not compromised. Checking quality at source is one of the lean building blocks of lean manufacturing.
- The company adopts a combination of short-term and long-term supply contracts to purchase key components. The suppliers are the parts of extended organization and their operations are monitored through the concept of CLUSTER. The company invests in cluster along with the government aid to ensure that the operations of entire supply chain are uninterrupted, cost effective, defect free, with minimum delivery delays.
- The cluster operations include Management Review Meetings on the monthly basis, aiding the Tier I, Tier II and Tier III companies to evangelize the Lean Supply Chain practices like 5S, Kaizen, TQM, Six Sigma, VSM, SMED, KanBan, Quality Circles, TQM etc. The process is ongoing and brings lot of innovative ideas among the small players, sharing the views and thus enhancing the healthy competition across the cluster.

3.2. Problems Faced

Customer focus is of utmost importance to organization and hence delivery commitment. The OEM and supplier organization systems are integrated to the extent that daily production plan is visible to the organization and accordingly production plan for the seat assembly is set. This supplier organization has made agreements with their suppliers of various parts and they provide ready sub-assemblies to supplier at their plant on daily basis. Schedule is sent a day prior to domestic vendors and no inventory is kept for these sub-assemblies. For vendors away from the plant minimum inventory is kept based on the lead time for fulfillment of order. Organization also keeps an inventory of finished goods, enough to meet demand of customers for 1 day. The final assemblies are transferred to OEM every two hours after final inspection and packing.

However to maintain the production plan and because of existing processes, there exists a high WIP inventory at different workstations, along with other problems such as high rework, unbalanced line activity, uneven labor distribution etc. The problem is more severe because same setup is used for manufacturing the other product type as well. There also exists an issue of high manufacturing lead time. This called for initiating improvement project with the use of Value Stream Mapping tool.

3.3. Data Collection Process

Data was collected by

- Reviewing earlier process maps and other documentation
- Observing the process over a period of 2 weeks
- Interviewing the supply chain expert, quality expert and General Manager (Operations)

Access was given to the facility for all the 4 weeks and one Point of Contact was given to interact on daily basis. Earlier interaction happened with the Management executives and real data was collected through observations. In order to create accurate and actionable value stream maps we typically follow 4 steps as mentioned above.

3.4. Use of Value Stream Mapping to reduce the manufacturing lead time

The Case primarily focuses on the following steps:

1. Study and analyze the current operations.
2. Time study to determine bottlenecks in the processes.
3. Identify process improvements, eliminate non-value added activities.
4. Collect relevant data to substantiate the recommendations.

3.4.1. Study and analyze the current operations – Co Driver Frame

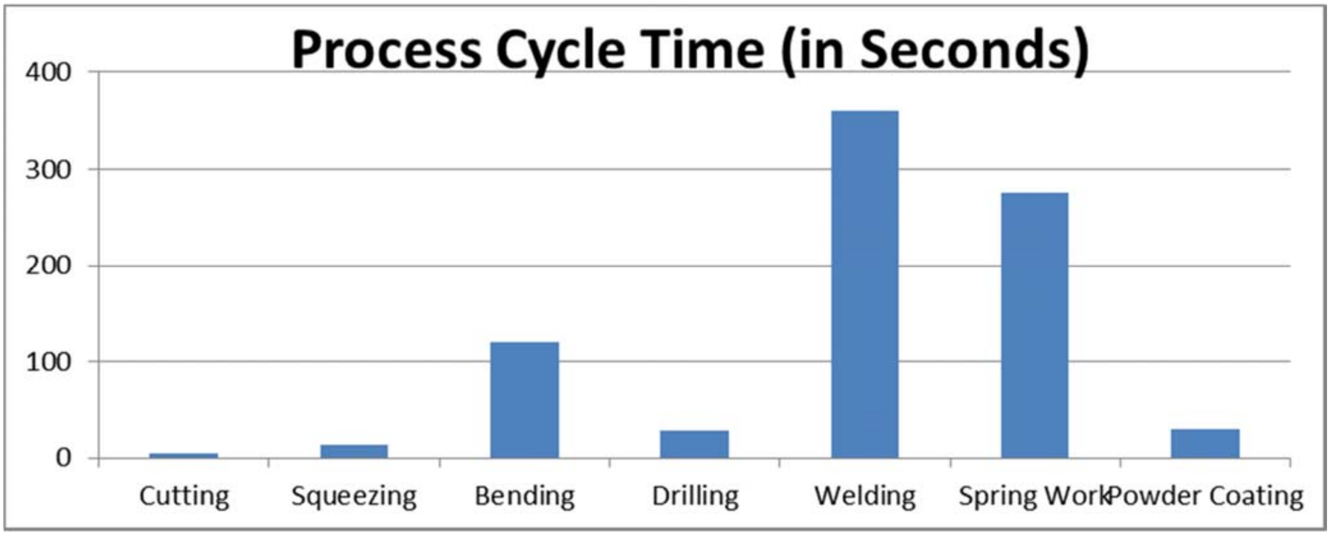
The manufacturing of co-driver frame involves operations like cutting, squeezing, bending, drilling, welding, spring work and powder coating. The manufacturing process is push based and batch driven. The manufacturing facility is not fully automated and manual intervention is seen at many work stations. The work load of the labor is not same all across and hence utilization of resources is also an issue. The current state

3.4.2. Time study to determine bottlenecks in the process

A) Cycle time study

The steps involved in manufacturing process included Cutting, Squeezing, Bending, Drilling, Spring Work, Welding and Powder Coating along with quality checks at regular intervals. The observations were made at each workstation to note the actual cycle time and following data is collected.

Process	Cutting	Squeezing	Bending	Drilling 1	Drilling 2	Welding	Spring Work	Powder Coating
Day	Total Cycle Time	Total Cycle Time	Total Cycle Time	Total Cycle Time	Total Cycle Time	Total Cycle Time	Total Cycle Time	Total Cycle Time
Day 1	4.26	12.35	62.82	23.03	7.47	309	294	30
Day 2	4.61	13.03	59.57	23.64	7.77	303	285	30
Day 3	3.81	15.71	58.89	20.38	6.71	278	278	30
Day 4	4.92	15.25	63.78	17.46	8.07	293	269	30
Day 5	4.78	13.28	61.45	19.01	6.57	343	269	30
Day 6	5.13	12.68	60.72	23.06	8.02	284	264	30
Day 7	4.9	13.2	60.99	13.65	8.04	302	305	30
Day 8	4.67	12.53	62.04	20.66	7.98	269	293	30
Day 8	4.98	16.34	60.21	21.77	8.26	308	282	30
Day 10	5.33	13.02	60.27	15.61	8.27	325	245	30
Day 11	5.35	13.21	59.23	19.9	7.88	292	266	30
Day 12	5.61	12.71	60.35	20.69	7.91	294	290	30
Day 13	5.68	13.44	60.5	18.28	7.38	308	261	30
Day 14	4.5	14.72	60.79	21.1	7.72	205	253	30
Day 15	4.87	14.1	59.73	20.49	8.43	298	275	30
Day 16	4.45	13.63	59.53	23.33	8.3	290	280	30
Day 17	4.73	13.27	59.68	23.51	7.59	278	286	30
Day 18	5.01	13.65	59.42	20.38	8.26	289	281	30
Day 19	4.97	13.6	58.93	22.45	7.74	323	254	30
Day 20	5.45	15.27	59.35	22.78	7.41	330	282	30
Average (in seconds)	4.9005	13.7495	60.4125	20.559	7.789	296.05	275.6	30



B) Lead Time study
i) Inventory Data Observed at Various Stations

Observation No	Day	Pipe Stock	Cutting	Squeezing	Bending	Drilling	Welding	Spring Work	Powder Coating
1.	Day 1	8000	45	1136	80	30	38	77	188
2.	Day 2	5400	80	618	598	64	74	79	103
3.	Day 3	4600	119	827	653	40	124	80	94
4.	Day 4	6400	50	594	550	55	115	102	42

5.	Day 5	5400	60	450	400	35	102	84	82
6.	Day 6	4200	79	600	225	55	128	92	88
7.	Day 7	4800	45	480	350	48	122	81	80
8.	Day 8	5000	130	530	400	29	118	72	120
9.	Day 8	5200	120	600	275	35	83	39	84
10.	Day 10	5400	30	580	450	38	68	49	128
11.	Day 11	6600	21	580	550	48	48	88	140
12.	Day 12	5800	120	650	450	44	78	29	122
13.	Day 13	6400	32	480	350	39	45	59	93
14.	Day 14	6600	29	680	350	38	84	99	88
15.	Day 15	7200	48	720	300	27	150	88	30
16.	Day 16	6200	16	680	400	39	120	94	40
17.	Day 17	7400	38	500	375	29	89	93	82
18.	Day 18	5800	24	520	450	40	28	94	102
19.	Day 19	6800	17	800	300	49	112	98	104
20.	Day 20	6400	39	680	425	27	80	88	130
	Average Inventory	5980	57	635	396	40	90	79	97

ii) Lead Time Table considering the available inventory at each work station

Process	**Pipe Stock (RM)**	**Cutting**	**Squeezing**	**Bending**	**Drilling**	**Welding**	**Spring Work**	**Powder Coating**	**Total Lead Time (Days)**
Input Load	5980	57	635	396.55	40	90	79	97	
Daily Production	---	385	385	385	385	385	385	385	
Lead time (Days)	4	0.148052	1.649351	1.03	0.1038961	0.233766	0.205195	0.251948	***7.62 days***

The input load differs at each workstation due to push system. The production plan did not ensure smooth flow of information and process owners were not aware of the requirements of the subsequent processes. Although it is expected to have 385 pieces as a part of production output per batch, due to unequal inventory, the number of pieces as actual output would turn out to be equivalent to lowest inventory available at the work station involved in the process. In this case, the number of finished co-driver frame output will be only 57. This number will change depending on the inventory availability at each work station on daily basis.

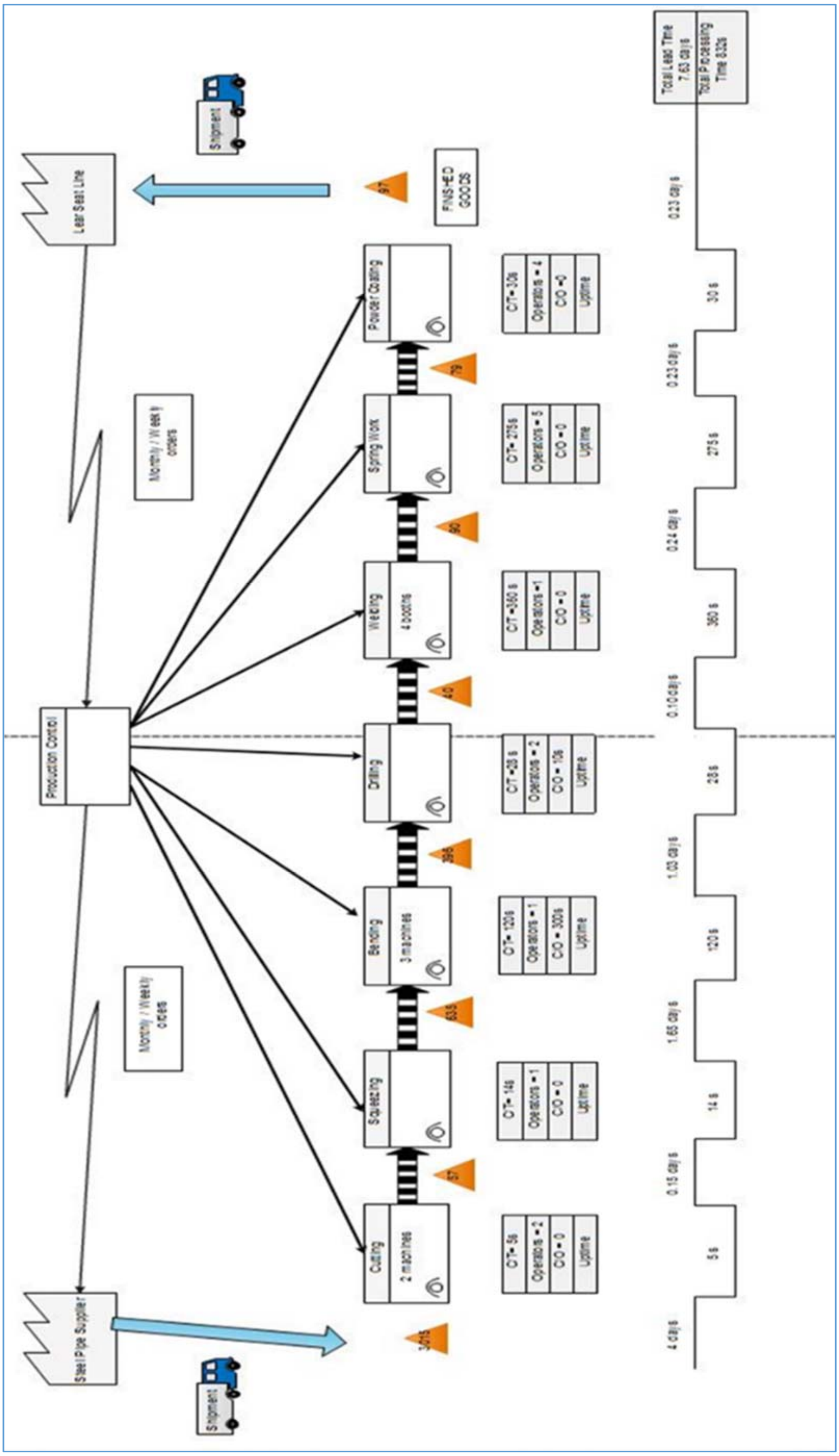
C) Takt Time

The Takt Time is calculated as the available time per day divided by the average daily demand for the product. In the context of lean manufacturing takt time describes the rate at which our customer is buying our product.

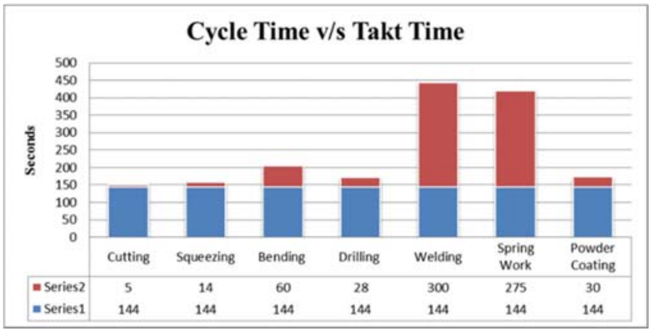
TAKT TIME = Available Time / Demand
= 920/385 =2.38 mins
= 2.38 x 60 secs
= 143.37 ~ 144 secs

Note: Available time = 460 * 2 shifts = 920 mins.

D) Current state map



E) Balancing Cycle Time with Takt Time



As seen in the graph, the cycle times of cutting, squeezing, bending drilling are powder coating are well below the the takt time of 144 sec. Hence these processes are not bottlenecks. The bottlenecks are Spring Work and Welding units. The Welding units have 4 booths dedicated to the above product hence the product is welded every 75- 100 secs which is below the takt time. The Spring Work assembly takes 275 seconds which is almost twice as the takt time. Kaizen should be done to reduce cycle time in the assembly process to bring it down as close to the takt time of 144 secs.

3.4.3. Identify Process Improvement

As the project was being conducted, few of the observations found are:

- ⇨ The push system of operations has created a large WIP inventories and hence the higher lead time. The information flow at the plant is made to all the processes without synchronizing all the process in producing the same product at the same time.
- ⇨ Plant Layout is process based and has its limitations as there are more than 130 different products manufactured. Shifting to a product based layout is nearly impossible.
- ⇨ The sequence of operations and the agreements with the labor union is not flexible to employ labors with frequent changes in production setups. Hence it has led to longer batches of same products.

(A) Recommendations from case study

- ⇨ Implementing a supermarket based pull system which is totally based on customer orders.
- ⇨ Lot size of 100 determined to reduce WIP inventory at large after discussing with Management
- ⇨ Introducing Andon system to ensure better information flow.
- ⇨ Layout changes from a process based to a product group based layout so as to reduce WIP inventory.
- ⇨ Kaizen at (Welding & Spring work Assembly) stations where the cycle times are higher than the TAKT time.

(B) Implementation of Lean Manufacturing Techniques after drawing value stream map

i) Introduction of Single Piece Flow

A production method whereby parts are produced one piece at a time while passing each piece to the next process without delay. The processes at the plant are nowhere following a single piece flow. The process at cutting and squeezing can be clubbed together as a cellular layout to reduce manpower, cost and cycle times. The bending and drilling processes also can be clubbed as the previous two processes to achieve similar results as above. The other process cannot include this flow as it is not possible to do the same. The main reason in implementing this is the fact that all of the processes are applicable to other products as well which makes it more feasible.

ii) Implementing Pull system when continuous flow is not possible

When pure flow is not possible the next best thing is to pull throughout the value stream based on customer demand. This is to say that no work begins until the customer, either external or internal, tells it to produce. One of the primary means of implementing a downstream pull system is by the use of kanban. In the context of production control, kanban refers to the visual production control system that signals replenishment. The supermarket based pull system involves creating a supermarket to keep WIP stocks between process with maximum and minimum stock predefined. When a WIP stock is consumed from the stock it is a signal from shipping to the supermarket that it needs product to meet a customer request. Once the product is removed from the supermarket a production, kanban will be sent to the previous process operators saying that the supermarket needs to be replenished. Withdrawals of finished goods by the customer triggers production of that product upstream through the use of kanban. This system will ensure that there are only enough inventories to meet the actual demand and excess inventory is drastically reduced.

iii) Production Leveling

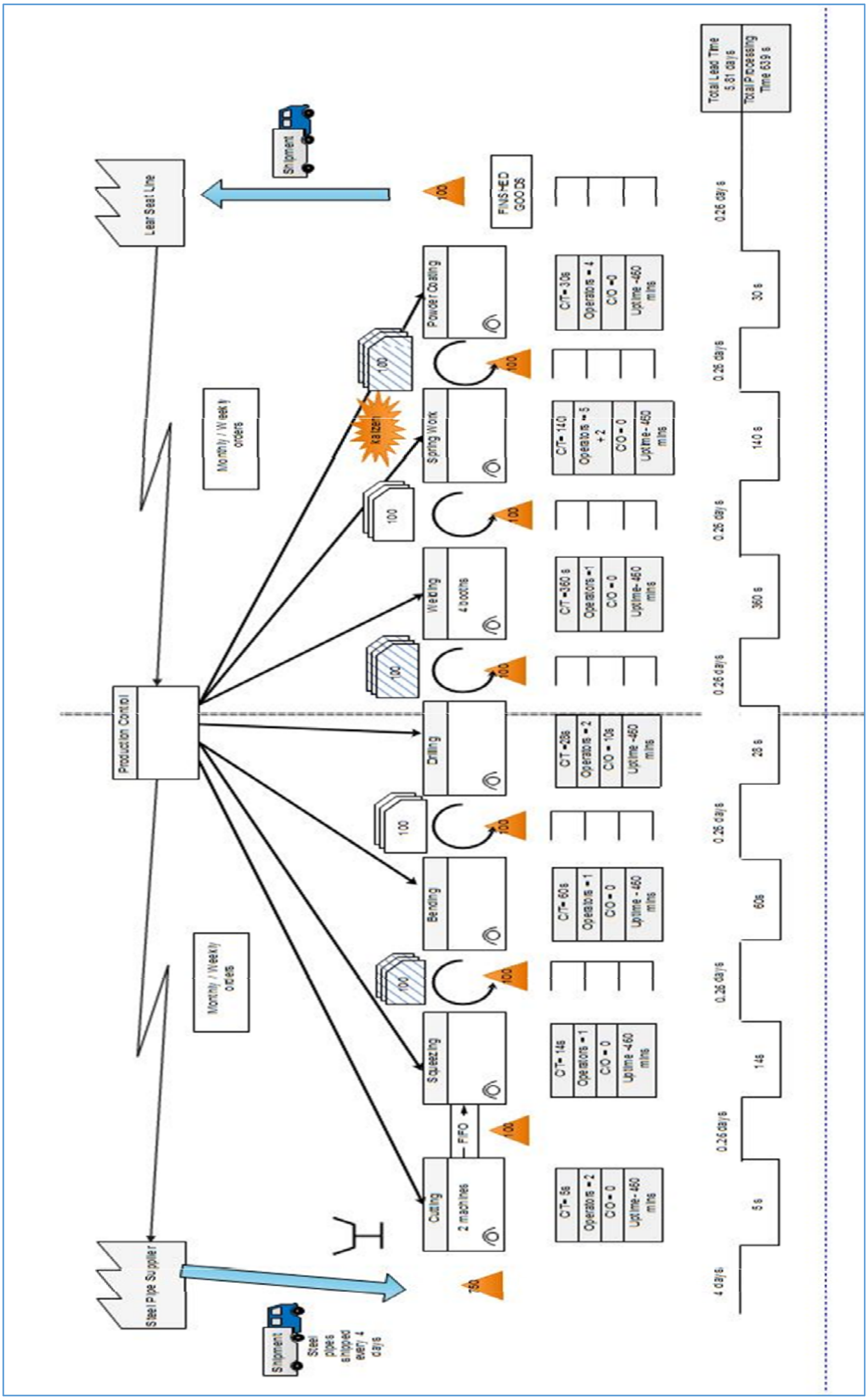
The Customers' demands are not constant and keep varying hence large batches of production make the plant operations difficult to meet varying demands at all times. Hence the key is to mix the production batches of all products in sizes of which are worth the changeover made. The ideal size is the lot size to be delivered to the end customers.

3.4.4. Collect relevant data to substantiate the recommendations

(A) New Lead Time with a lot size of 100 units

Process	Pipe Stock (RM)	Cutting	Squeezing	Bending	Drilling	Welding	Spring Work	Powder Coating	Total Lead Time (days)
Input Load	5980	100	100	100	100	100	100	100	
Daily Production Plan		385	385	385	385	385	385	385	
Lead Time (Days)	4	0.25974	0.25974	0.25974	0.25974	0.25974	0.25974	0.25974	***5.81 ays***

(B) Future State Value Stream Mapping



(C) Benefits Achieved

By implementing the above mentioned Lean techniques following benefits were realized

- The lead time was reduced to 5.81 days from the current state of 7.62 days which is equivalent to 23.75 % reduction.
- The total cycle times have also been reduced to 639 seconds from earlier 832 seconds which is equivalent to 23.19 %.
- There are additional changes made in the processes like introduction of a multipurpose CNC bending machine for bending which brings down the cycle time by 50% i.e.60 secs.
- In case of Spring Work it is seen that spring fixing and Spring Clip fixing takes a long time to complete the process compared to the other processes, adding 2 more operators will reduce the time lag between processes and also reduce total cycle through redistribution of work.
- Reduction of WIP inventory at workstation.

4. Conclusion

Value stream mapping tool identifies the flaws in the existing process. These flaws or improvements once identified can be tackled using different tools as suggested in the case study viz. use of andon cards, small improvement projects at workstation, resizing the lot size, implementing pull system, layout changes etc. As a part of lean tool it can be extended beyond the boundaries of the organization to make the supply chain more predictable by making it lean. With more and more sectors using the information technology tools, lot of automation can be brought into the process leading to considerable waste reduction, cycle time reduction and inventory reduction. Once the as-is process state is studied and future state is documented, simple tools like 5s, kaizan can very well be adopted without much cost. However strong support from the management and lean culture will help to see the impact of lean tools in more quantifiable and beneficial manner.

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