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A study on decisive tool "value stream mapping "to excel the potentiality of manufacturing industries

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Abstract

During the second half of the twentieth century, several business sectors have experienced far-reaching changes, due to global investment, innovation in technology and deregulation imposed on the businesses. All these factors compounding together – has caused severe impact on the businesses of this 21st century, which has forced most of the leaders in several sectors to implement more competitive manufacturing system. The best answer as seen in many manufacturing engineering arena is Value Stream Mapping (VSM) - a Lean technique. It is a fundamental tool which identifies waste, reduce process cycle times, and implement process improvement. This study is concerned with four product families at a manufacturing engineering firm which are produced in many configurations and once the order is placed for a particular product it takes nearly 60 days to pass through the production process. This long lead time and backlogs of order has driven this firm to quote a 70 days lead time to customers.

In the process of working on this paper through VSM, we have ascertained that the productivity improvement can be increased by curbing out non-value added activities. Also this paper has revealed that production lead time could be reduced drastically.

Keywords: Value Stream Mapping (VSM), Toyota Production System (TPS), Value Added (VA), Change over Time (C/O), Cycle Time (C/T)

1. Introduction

The compounding of number of factors seen in the macro business environment like the global investment, deregulation imposed on the businesses, shorter product life cycles, innovation in technology and gloomy markets has converged to create a perfect storm in any business whether it is a production/manufacturing sector or service sector. This storm has forced most of the leaders in several sectors to implement more competitive manufacturing system. And the businesses which are not going to adapt to world class business practices by cutting down its costs and upgrading its-self are going to diminish. The best answer as seen in many manufacturing engineering journals to this is Value Stream Mapping (VSM) - a Lean technique which puts the operations into value stream by diminishing the non-value added activities thus giving an edge in competition by reducing the costs and passing the benefits to the customers. Initially it started at Toyota plant, Japan, which is known Toyota Production System (TPS). Thereafter substantial research and literature indicates that many industries are actively implementing Value Stream Mapping as a key strategy for eliminating non-value added activities and passing the benefits to customers in order to remain competitive in today's manufacturing environment. According to Womack 'A lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste. Further, this Lean emerged as a concept at Toyota Production System and it put forth the core ideology of continuous improvement efforts to reduce the costs in serving customers. It moved one step further in going beyond its manufacturing facility and taking in its stride, the suppliers, distributors and the production system as a whole that supported the manufacturing function. These changes brought in improvements and harmony in the whole system leading to curb the MUDA (Japanese word) which is the 'waste' associated with all activities performed to deliver an order to a customer.

VSM is one of those concepts of lean which identifies the non-value added activities in the value stream. Value is anything a customer is willing to pay for it and Waste is anything that adds cost and the customer would not pay for. Formally value adding activities are those activities that transform or improve the product for the customers. On the other hand non-value added activities can be defined as those activities that consume resources yet do not directly contribute to the product or service. This can be over production, Work-in-process, Excess transportation, Scrap and rework, Wasted-time, People or goods waiting. The important thing that James Womack says here is: 'We need to understand and work to drive out this waste and flow our products through the value stream so that our operations become less costly and more response to our customer demand'.

Unlike the traditional mapping tools used by Industrial Engineers' to map the processes, Value Stream Mapping is a graphical tool created using predefined set of icons that maps not only the material flow but also the information flow that signal and control the flow of material. This improved visual representation alleviates the identification of value-adding activities and the non-value adding activities, or wastes (muda). Jones and Womack (2002) has defined Value stream mapping as *'the simple process of directly observing the flows of information and materials as they occur, summarizing them visually, and then envisioning a future state with much better performance'* that is VSM analyzes the current material and information flow in order to arrive at the future state of material and information flow wherein the non-value added activities are curbed out – so that we could make the product at faster pace and passing on the benefits to the customer by serving them better.

In order to implement VSM – many Original Equipment Manufacturers and their top-tier suppliers have refurbished their existing facility layouts, as well as existing systems for material handling, inventory control, purchasing and scheduling, to reduce the total throughput times of orders and current levels of work-in-process (WIP) inventories – to match with the Value Stream Mapped in order to reap the rewards of VSM.

Value stream mapping helps to understand the entirety of the transformation of a component / product in study. 'Learning to See', the first publication in the field of Value Stream Mapping written by Rother and Shook (1998) provides a step-by-step guideline for applying VSM in manufacturing environment. They proposed four steps for VSM: *'1. Getting started 2. Current-state map 3. Future state map 4. Achieving the future state'*

1.1 Objective of the Study

This paper looks at the production flow at a manufacturing engineering firm right from customer order, to the procurement of raw-materials and the process there after - till the final product reaches to the customer. In doing so – we identified the non-value added activities in the process by using VSM and then reshuffled the process – by removing the non-value added activities completely or at least minimising it so that the lead time could be reduced. This implementation of VSM technique at a manufacturing engineering firm has given tremendous result which is further discussed. Following are the basic objectives of the paper:

- To improve the productivity by reducing the total production lead time and the non-value adding time (wasted time) in the assembly
- To understand the bottleneck situations in the production process which are the causes for the non-value added activities
- To make the process able to deliver the right amount of products to its customers at the right time
- To focus on why companies are shifting to Lean practice

2. Literature Review

This review is of existing discussion, which aims to understand Value Stream Mapping. This study is taken up in order to refine ideas as reflected in introduction.

Success in this 21st century whether for a manufacturing sector or service sector directly correlates to how a company takes into its stride the global competition, world class business practices, Cost effective solutions that are paramount and essential to stay in competition in this current business environment. With respect to this - now a day's many manufacturing facilities have undergone changes and refurbishing their process in *'physical and cultural transformation to adopt the concept of lean thinking'*. Lean has been originally created and defined as the process of eliminating waste (Womack et al. 1990)

According to Rineheart *et al* (1997) lean manufacturing will be the standard manufacturing mode of the 21st century. Further, in one of the articles of Michael Porter reveals that *'internationally competitive companies are not those with the cheapest inputs or the largest scale, but those with the capacity to innovate and improve continually.'* Further to this with the change in business scenarios due to macro factors and in order to survive in this sluggish markets – 'need is the mother of all inventions' therefore emerging new business are taking every step in defining a value for every activity and passing on the benefits to the customers. Traditional multinational companies are now revolving around these ideas to break their traditional barriers and implement innovative ideas – wherein Value Stream Mapping a Lean technique has become one of the powerful tools as one of their key strategies in their business.

Many Researchers have defined VSM as the process of visually mapping the material flow and information of the process under study. It helps to visualize the cycle time of the work station, inventories at each station, manpower needed and information flow across the whole supply chain (Womack and Jones, 1996). It provides a blueprint for implementing Lean manufacturing concepts by illustrating how the flow of information and materials should be in future state mapping of operation.

According to Rother & Shook (1999), earlier quality initiatives like the kaizen came up with disappointing results, and the program became abandoned. Even six sigma initiative which aimed at most visible quality problems – failed to improve as a whole as it was very specific. According to Chakravorty S (2010), many companies have embraced Six Sigma, a quality-control system designed to tackle problems such as production defects which aims to remove all processes that don't add value to the final product. But many of those companies have come out with not significant results. He further reveals that nearly 60% of all corporate with Six Sigma initiatives fail to yield the desired results. According to (Tapping & Shuker, 2002), six sigma was introduced in General Electric and its impact in great savings was seen but the question arose whether the reported savings were really making an impact on a company's bottom line. But, when this was analyzed, the impacts weren't as great that potentially could be.

Furthermore, the ideas of great authors Taiichi Ohno (1988), Womack et al (1990), Womack and Jones (1998), Daniel. T. Jones (2006), Rother and Shook (1999), and Peter Hines and Nick Rich (1997) have studied the implementation of Value Stream Mapping effectively. Initially when the process was undertaken by Taiichi Ohno (1988), he could not see waste at a glance (especially across a geographical area at Toyota). He then developed material and information flow mapping which is known as Value Stream Mapping (VSM). He started the

process by jotting down the information and drawing the flow of the operation under study and identified the value added and non-value added activities. This process later became, not only the standard for designing improvements at Toyota but also one of the best business planning tools of the operations in the firm. VSM is now explored throughout the world, in many businesses to strategically plan and it is the starting point to any lean transformation and implementation.

In one of the case study conducted by Joshi and Naik (2012), for a small scale industry reveal that *'Lean Production starts from the argument that adding value and reducing waste are the key goals of any business.'* But for many it is still a pain to accept change and to climb up this steep ladder. They further argue that Organization may contain number of weak points within them - which makes it hard to accomplish the desired gains for the hard work they put in it. But what they infer is out of several approaches value stream mapping (VSM) a lean manufacturing technique has emerged as the preferred way to understand the flow of operations and processes, mapping them, and discarding non-value added activities by applying Lean techniques. They further highlight VSM is quite different than other conventional recording techniques, as it captures the information about activities at individual work stations about their station cycle time, manpower required, setup time, resources consumed, work-in-process inventory, and the information flow from raw material stage to finish goods. Their research paper 'a case study on Die manufacturing' reveals the use of the value stream mapping in reducing waste. In this Die manufacturing industry, the production process path was followed and the current state value stream map was drawn. This map was studied thoroughly tracking the entirety of the process - which revealed the wastage which affected the cycle time. Further, the causes for the wastage were identified and analyzed and a future state value stream map was developed and improvement ideas were recommended. With the recommended ideas, the cycle time was which was 14400 minutes expected to be shortened to 9600 minutes, almost 30% reduction. Thus Value Stream mapping proved to be a useful technique in minimizing the cycle time and further increase in the Production run.

In one of the article written by Jared Lovelle an industrial engineer for Textron Automotive Co reveal that value stream mapping (VSM) will help industrial engineers and enlighten those managers who still support heavy manufacturing techniques. His study reflects that VSM is a mapping tool that summarizes the current and future state of a production process system, allowing the participants to recognize where they are and which wasteful acts need to be curbed and then applying lean manufacturing principles to switch over into the future state. This article further reveals that *'VSM is an outline of a product's manufacturing life cycle that identifies each step throughout the production process. The overall goal is to move from batch and push to one-piece flow and pull through the entire value stream.'* Further, designing a Lean value stream flow that optimizes the whole system - from the information flow, to material flow, till the finished goods arrive at the customer's door.

Ballard and Howell (1994) suggest that, in order to transform any enterprise into Lean, VSM is a good start as it is simple

and easy. VSM provides a common language for all manufacturing process.

In another case study of VSM done by Rajenthirakumar, Gowtham (2011), adapted for 'A consumer durables manufacturing company', reveals that: the company was experiencing severe pressures internally to improve its operations for one of its product 'wet grinder' in the assembly line. The company had tried many alternatives with huge capital investments, however, the results achieved were not that significant. In the pursuit of getting consistency, the management decided to implement lean tools. VSM was the main tool applied - to identify the opportunities where lean techniques could be a proper fit. The benefit what could be achieved from this was reduced lead-time and improve Lean rate.

Furthermore in another case study by Muhammad Samad, SaifulAlam, and NishatTusnim (2013), 'Value stream mapping to reduce manufacturing lead time in a semi-automated factory' revealed - that the work-in-process was reduced by changing the push system to pull system when VSM tool was applied.

According to Lummus, Vokurka & Rodeghiero at Iowa State University, - the case study done by them in 'Improving Quality through Value Stream Mapping' at a Physician's Clinic reveal that *'As organizations look to improve overall systems to reduce costs and improve throughput, lean principles are being more widely implemented'*. Their implementation of VSM in a small medical clinic resulted in recommendations that significantly lowered patient waiting time and increased patient throughput. They further suggested that this new system can increase the capacity of the office without adding people or equipment - it also lowered waiting time for people with scheduled appointments and further increased the opportunity for patients without appointments where they can be seen at the last minute, this eventually lowered the stress levels of the clinic's staff.

Thus in this literature review some of the objectives as mentioned why organizations are shifting to Lean Manufacturing, and how VSM is used to decrease the production lead time by cutting non-value added activities is been answered. With these objectives achieved and testing it on the reality basis at the manufacturing engineering firm, have guided us in getting closer to our Aim.

2.1 Importance of This Study

Lean manufacturing is a paradigm shift in manufacturing. It is proven and tested system of providing the simple solution for the complex problems. No doubt it is a need of many organizations today as lots of benefits are seen - but it is yet to penetrate as a concept / system / process / in the manufacturing arena and service sectors. When completely matured we can see great rewards in manufacturing as well as in service sectors. Lean's core ideology is to attack waste and utilize the resources to its maximum and thereby providing perfect value to the customers. Implementing lean thinking includes value stream mapping, a process for linking together lean and quality improvement initiatives in order to give the greatest overall benefit to an organization.

3. Methodology

To start with- some information about the company and its processes and activities was collected from supervisors of the

Company. They were then briefed about Value Stream Mapping, its steps and its benefits in order to take them in confidence.

The firm under study manufactures several components for pumps and D.C. Motors. The study was conducted for four product families of Gear Pump – Gears, Bush, Cover and Brackets – which were produced in many configurations. Because of these varieties of the product configurations and the fact that customer configuration requirements vary from order to order, the above said four components are ‘Made – to – order’. Furthermore, once an order was put across by a customer it took nearly 60 days to pass through the production process. This long lead time and many order backlogs have driven this firm to quote a 70 days lead time to customers.

3.1 Problem Definition

- The main objective was to come up with the ideas to reduce the total production lead time and curb out non-value adding time in the assembly line.
- To understand the bottleneck situations in the production process which are the causes for the non-value added activities
- The resultant of the above two objectives eventually blossoms the third objective that is to make the process able to deliver the right amount of products to its customers at the right time and capture the market.

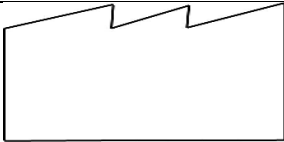

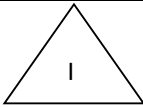





3.2 How Mapping Tool is used


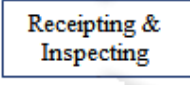




The drawing of the current state map starts with gathering of information from various experienced persons verbally on the shop floor and then developing a future state begins with an analysis of the current production situation.

- Mapping begins as we walk through the process from door to door flow in the plant. We draw ‘process categories’ like ‘Cutting’ or ‘CNC’ instead of recording every processing step.
- We use a set of symbols or icons to represent the process and flows.
- We start collecting information as we walk through the actual material flow along the entire door to door value stream, to get the sense of flow and sequence of processes. After this quick walk we start gathering information at each process.
- At times we use a stopwatch to obtain correct time for some operations – where we could not find the standard times.
- Observation of the current situation and recording of an event exactly as it occurs is a direct data collection method that provides very specific understanding and perspectives which are not attainable using other methods.

3.3 Value Stream Mapping Icons used

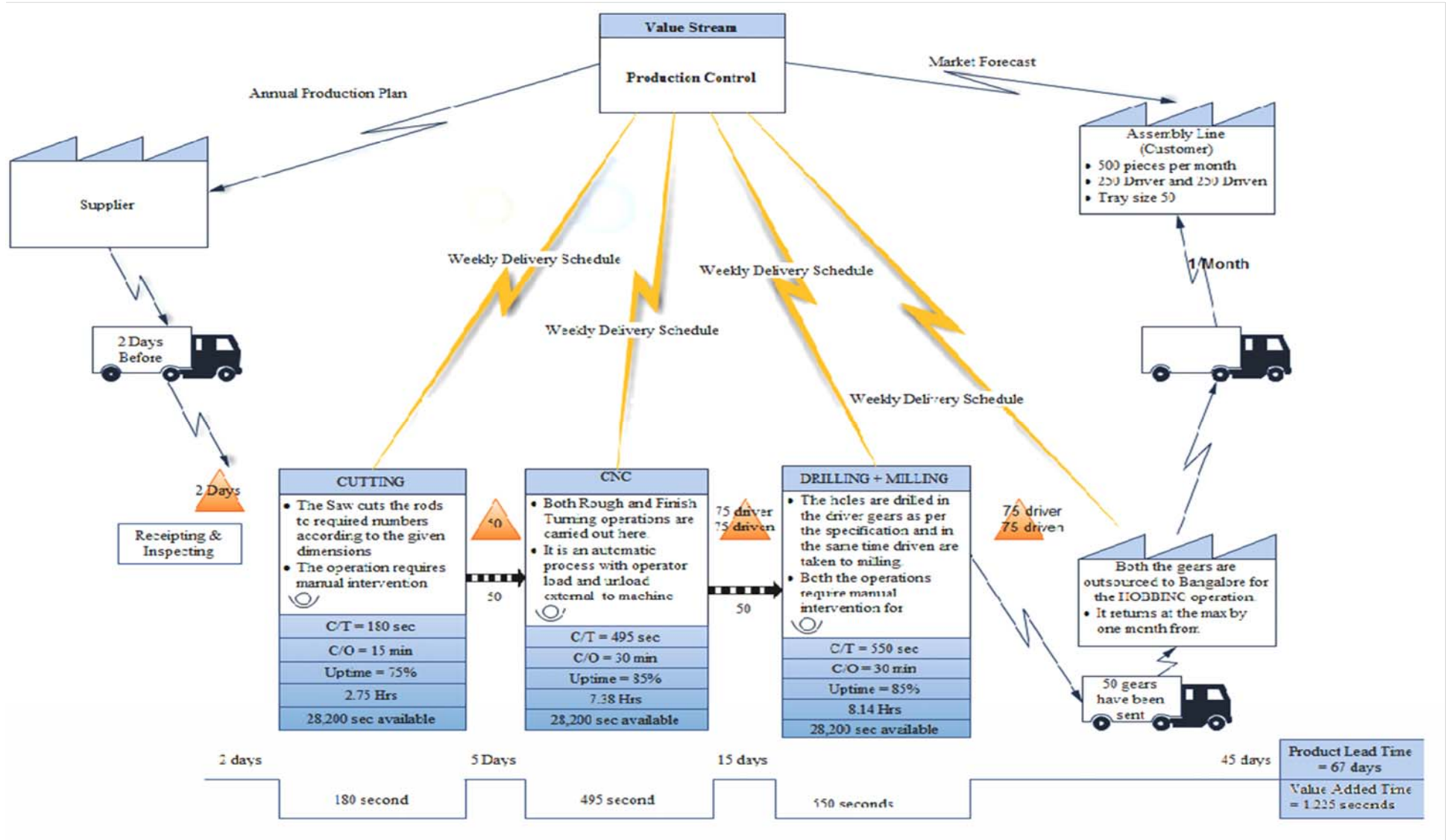
Reference: Rother, M., and Shook J. (1999) in ‘*Learning to see*’ a *Lean Tool Kit*

	<p>This Icon represents ‘Out Side Sources’ to show customers, suppliers, and outside manufacturing process, Department, customer, etc.</p>
	<p>This Icon represents ‘Truck Shipment’</p>
	<p>This Icon represents ‘Inventory’</p>
<div style="border: 1px solid black; padding: 5px;"> <p>ASSEMBLY</p> <ul style="list-style-type: none"> • Cross Drilling operation and tapping operation takes place here. • Operation requires manual intervention for operation.  </div>	<p>This Icon represents ‘Manufacturing Process’, also used for Departments such as control</p> <p> → this icon represents Manual Intervention</p>
<div style="border: 1px solid black; padding: 5px; background-color: #e0e0e0;"> <p>C/T = 90 sec</p> <p>Uptime = 85%</p> <p>37.5 min</p> <p>28,200 sec available</p> </div>	<p>This Icon represents ‘Data Box’, used to record Information concerning a manufacturing process, department, customer, etc.</p>
	<p>This Icon represents ‘Load Leveling’</p>
	<p>This Icon represents ‘Manual Information Flow’</p>
	<p>This icon represents ‘Signal Kanban’ – This ‘signal kanban’ is one per batch. When a reorder point is reached another batch is produced.</p>

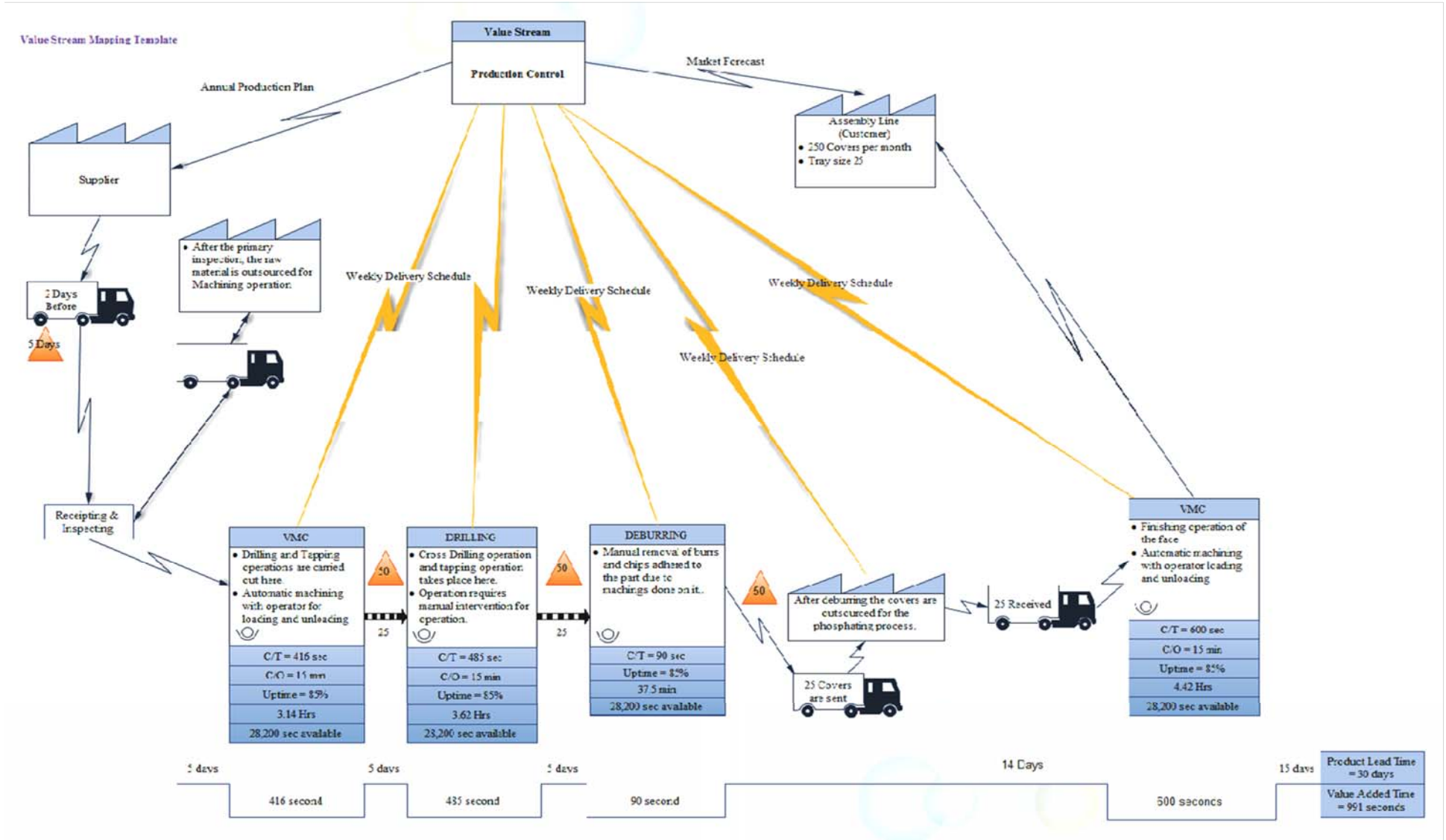
	<p>This icon represents 'Buffer or Safety stock'</p>
	<p>This icon represents 'Operator' – A person viewed from above 'Top View'</p>
	<p>This icon represents 'Receipt and Inspection'</p>
	<p>This icon represents 'Production flow'</p>
	<p>This Icon represents 'Movement of Production material by Push', Material that is produced and moved forward before next process needs it</p>
	<p>This Icon specifies 'Electronic Information flow'</p>
	<p>This Icon specifies 'Time Line'</p>

3.4 Current State Mappings Data for Pump Components

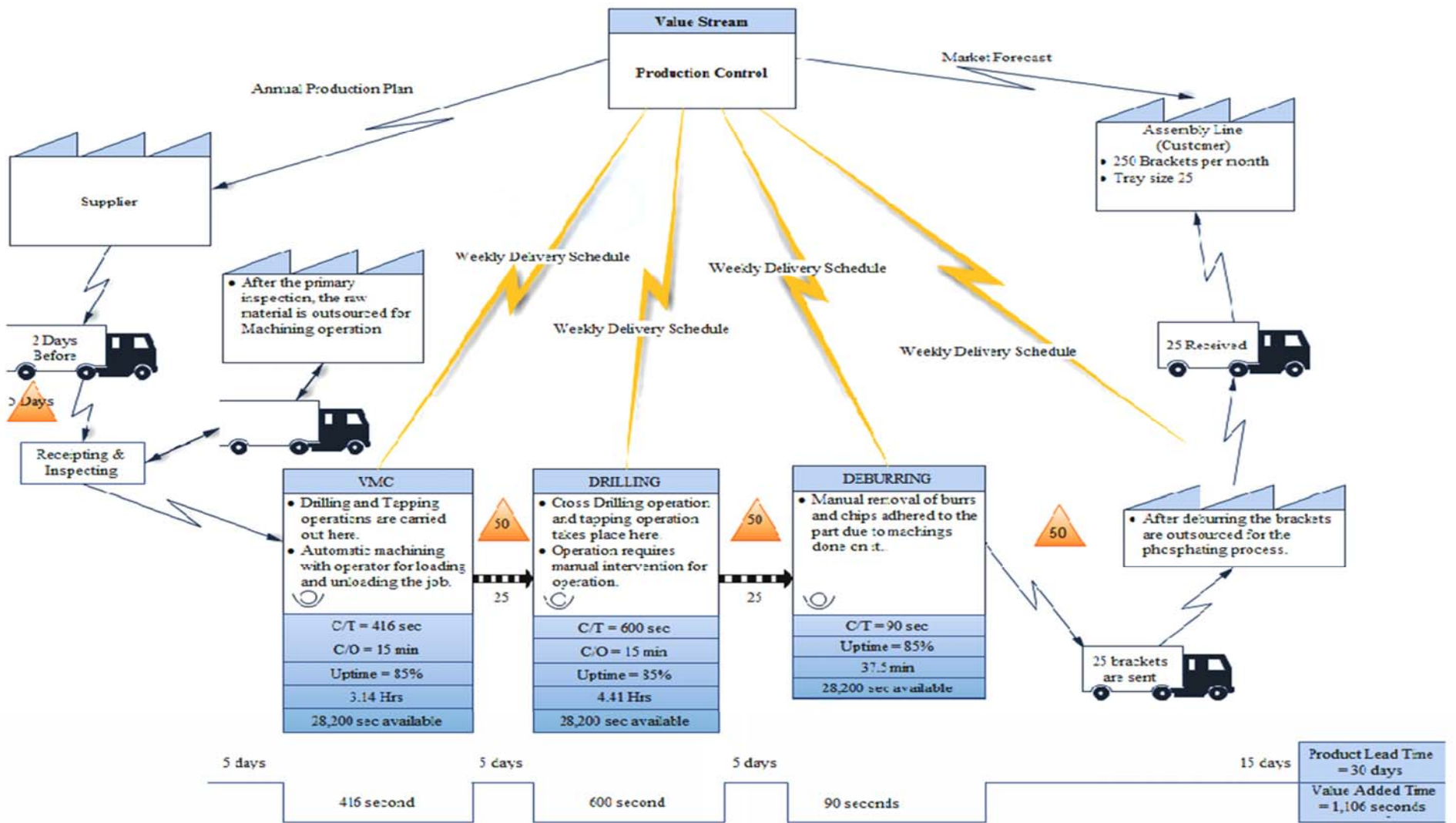
The current state mapping was drawn for gears, covers, brackets and bushes as per the method. The flow of the material from the receiving of raw material till the complete operation of each component in study was recorded with the assistance of supervisor of the firm.



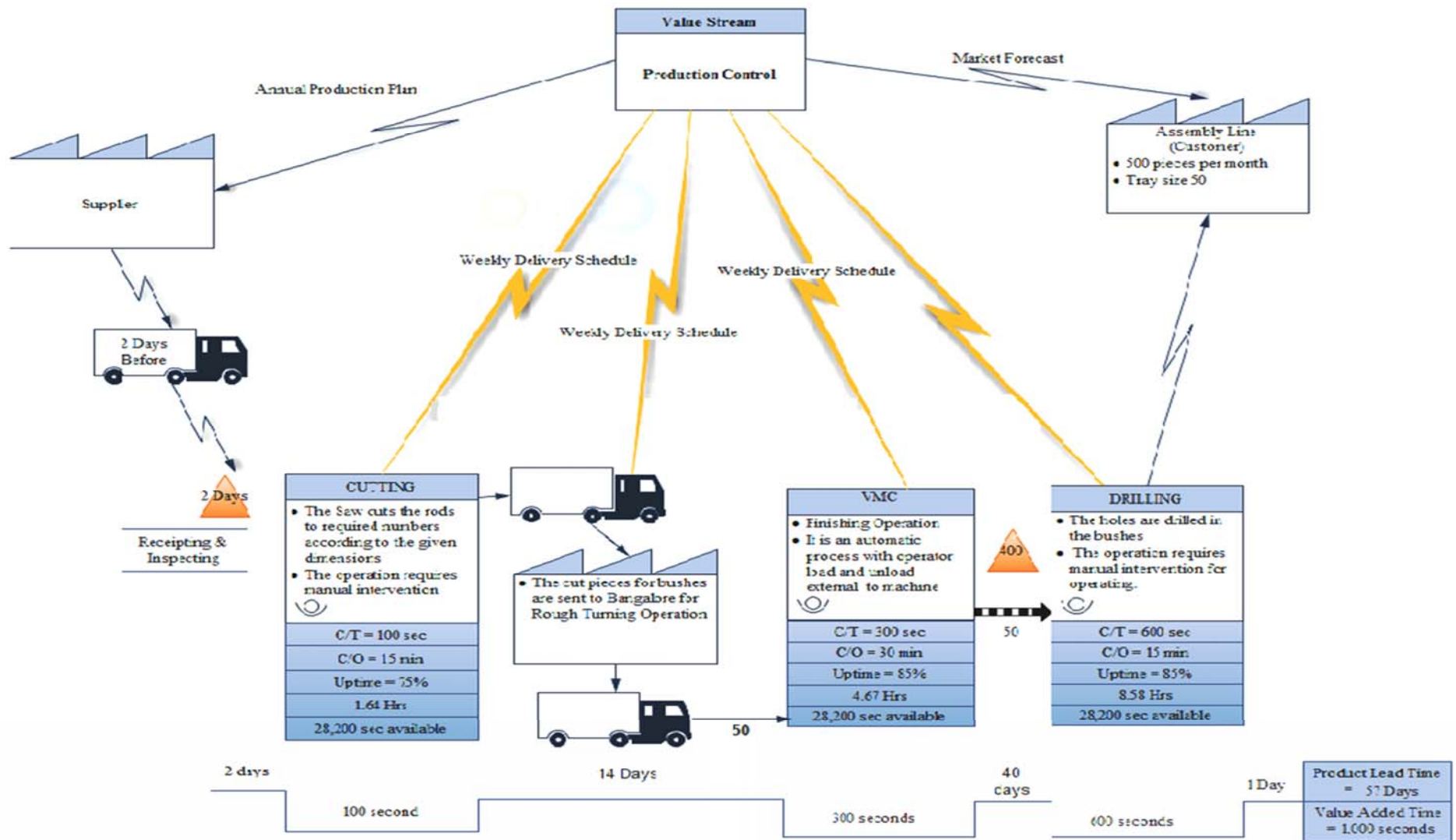
Current State Mapping for Gear



Current State Mapping for covers



Current State Mapping for Bracket



Current State Mapping for Bush

4. Results and Discussion

After a critical examination of the current state map of each part:

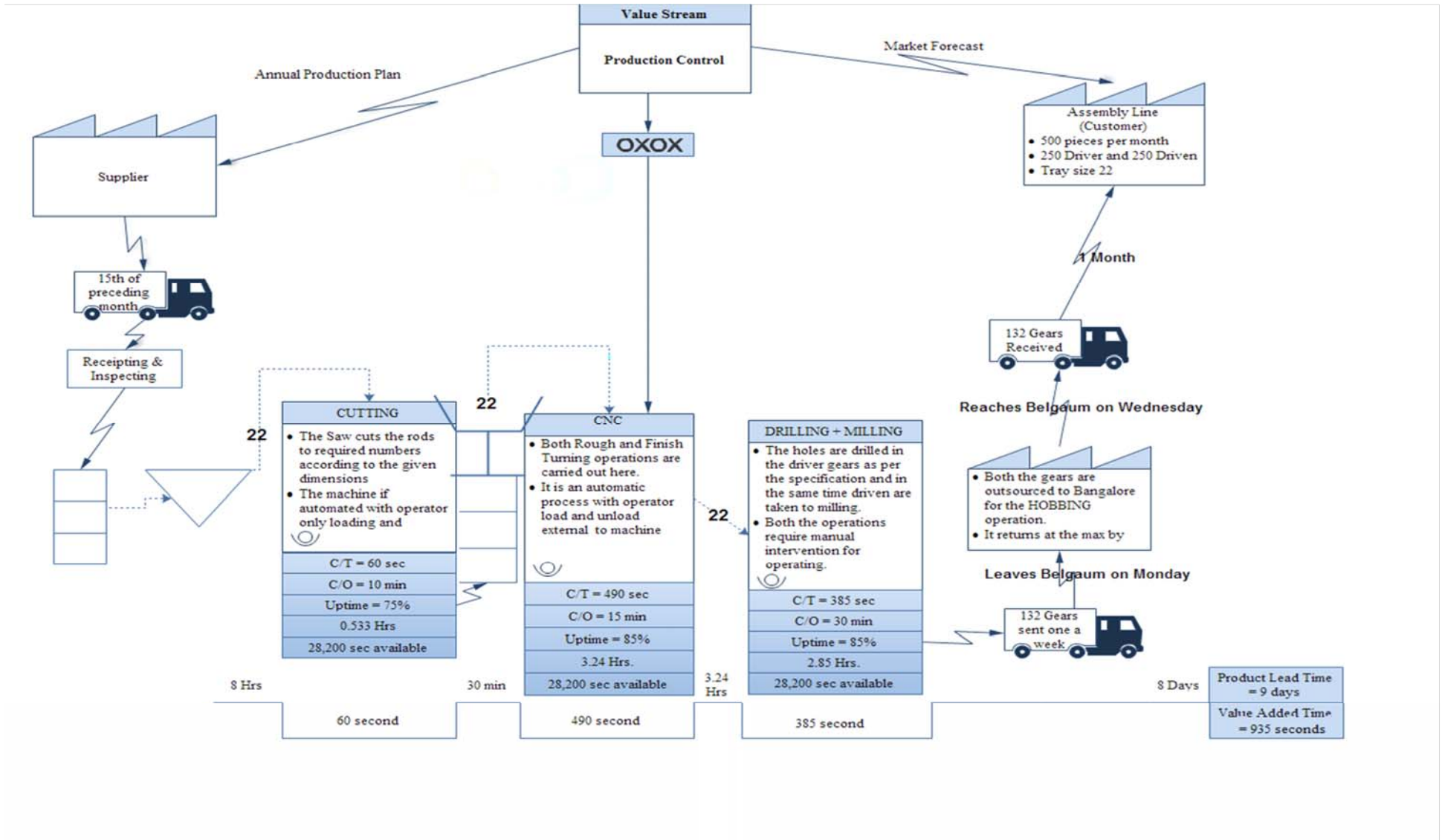
- The first thing which was exposed is the components were never manufactured in a continuous (flow) that is after one operation was over – the components were lying idle for number of days and the inventories were accumulating.
- Further, each process in the value stream was operating as an isolated island that is workers were separated (isolated) from one another and as such they couldn't help each other - leading to difficulties in line balancing. Therefore whatever orders received from Production Control department were pushed forward and manufactured which lead to unnecessary inventory - instead of the actual needs of the downstream process i.e., 'customer'. As a result, the total time that product spend getting through the plant was very long.

Depending upon these critical observations following suggestion where made to improve the process:

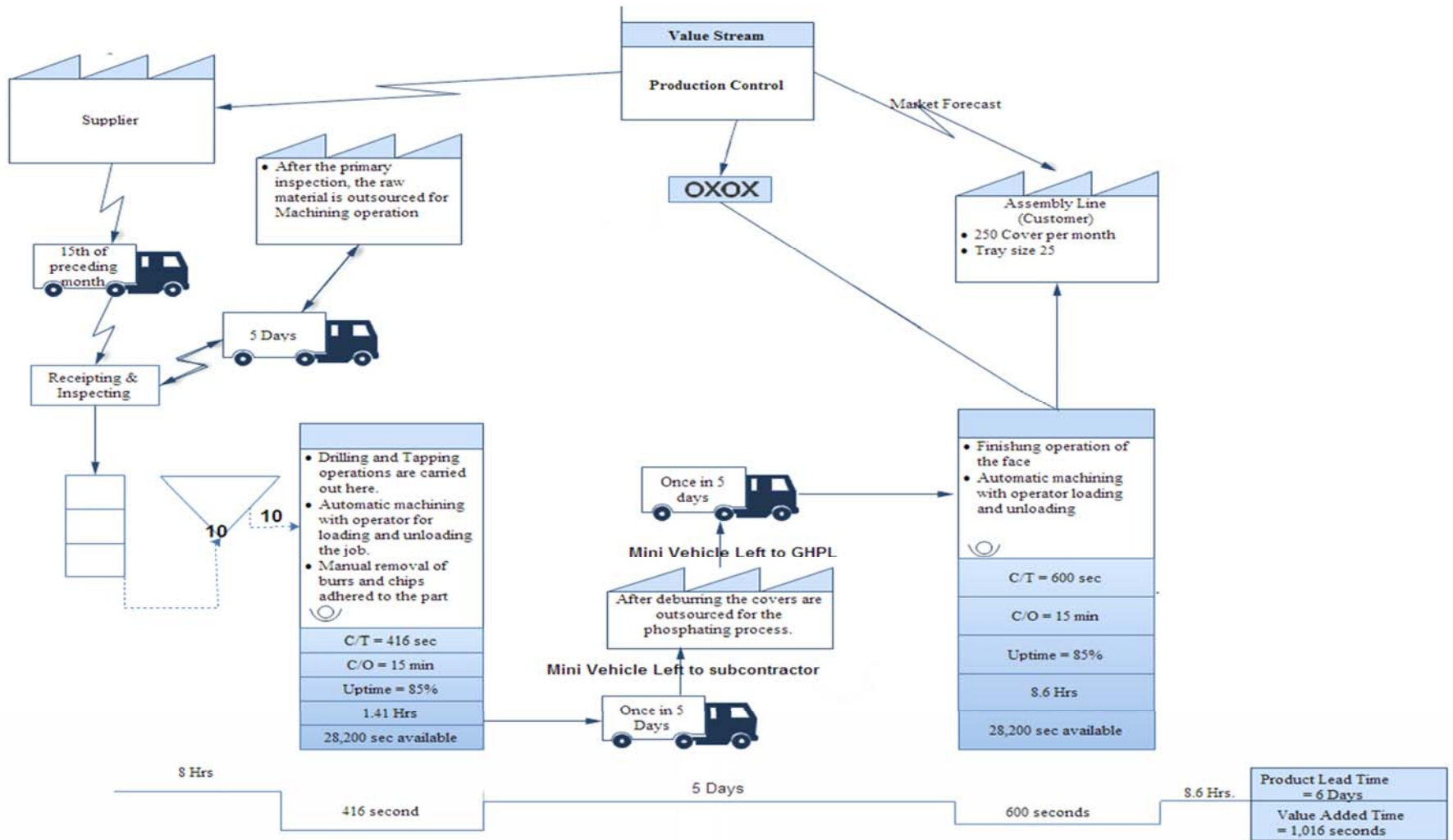
- First to decrease the production lead time and at the same time maintain quality and continuous flow.
- Second Effective Economic Batch Order Quantity Implementation.
- Practice the elimination of 3-M's:
 - Muri (Unreasonableness) Overburdening of equipments, facilities, people beyond its natural limits.
 - Muda (All the 7 Wastes like Over-production, Over-time, etc)
 - Mura (Unevenness) This exists when workflow is imbalanced and workload is inconsistent.
- Use standard containers that is use of Withdrawal Kanban (WK) and Production Order Kanban (POK) must be made mandatory between the workstations.

5.0 Future State Mapping & Discussion

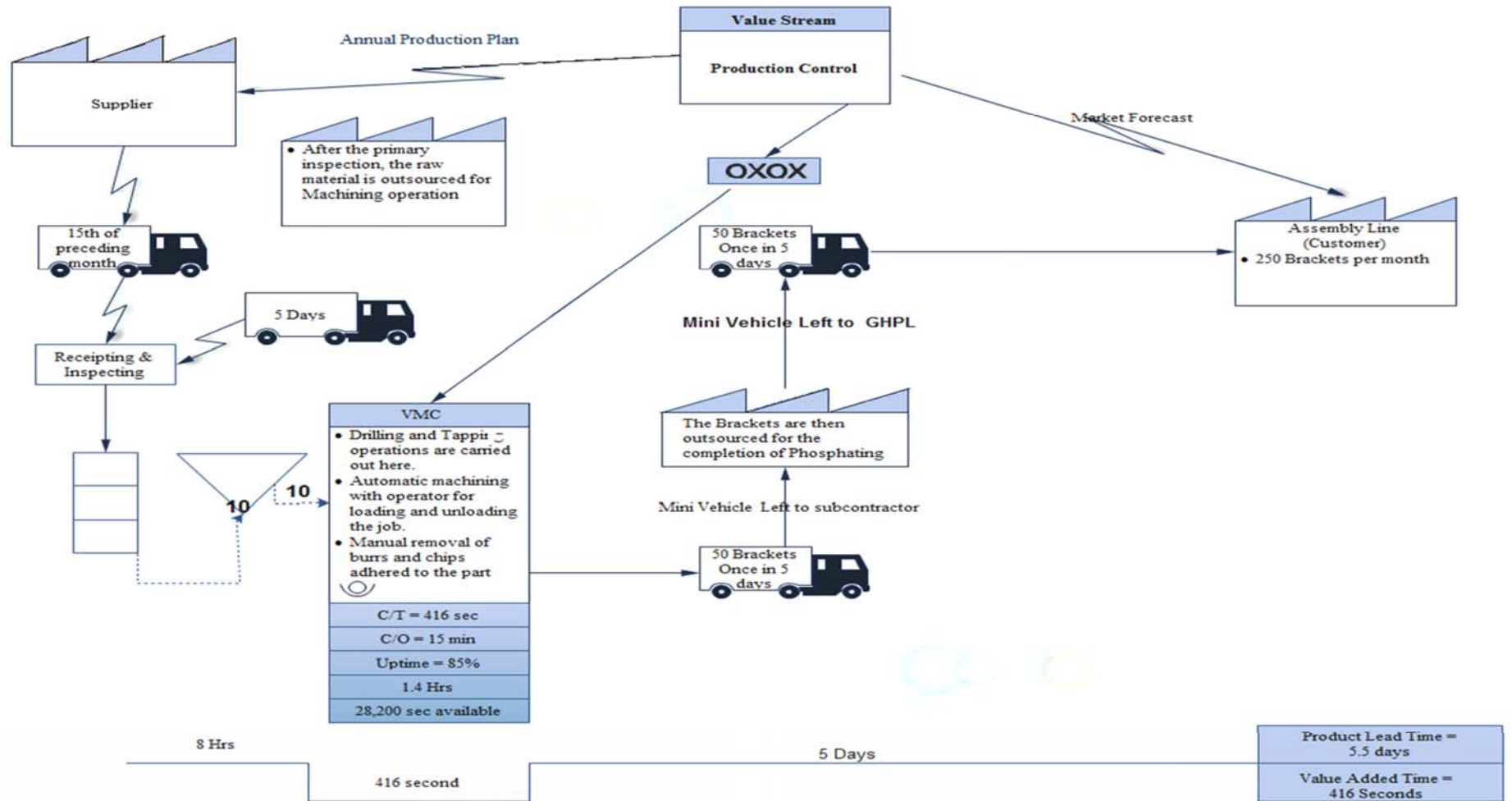
- **Guidelines Followed**
- The TAKT time was produced for all the four products being observed.
- Takt time is calculated by dividing the customer demand rate per day (in units), into available working time per day (in seconds).
- Continuous flow was put in practice where-ever it was achievable.
- Store was converted to supermarket (fill-up) to control production where continuous flow could not extend upstream.
- Replacement of Push by Pull also was put in practice.
- On the basis of these guidelines and prior mentioned suggestion, the future state map was drawn.



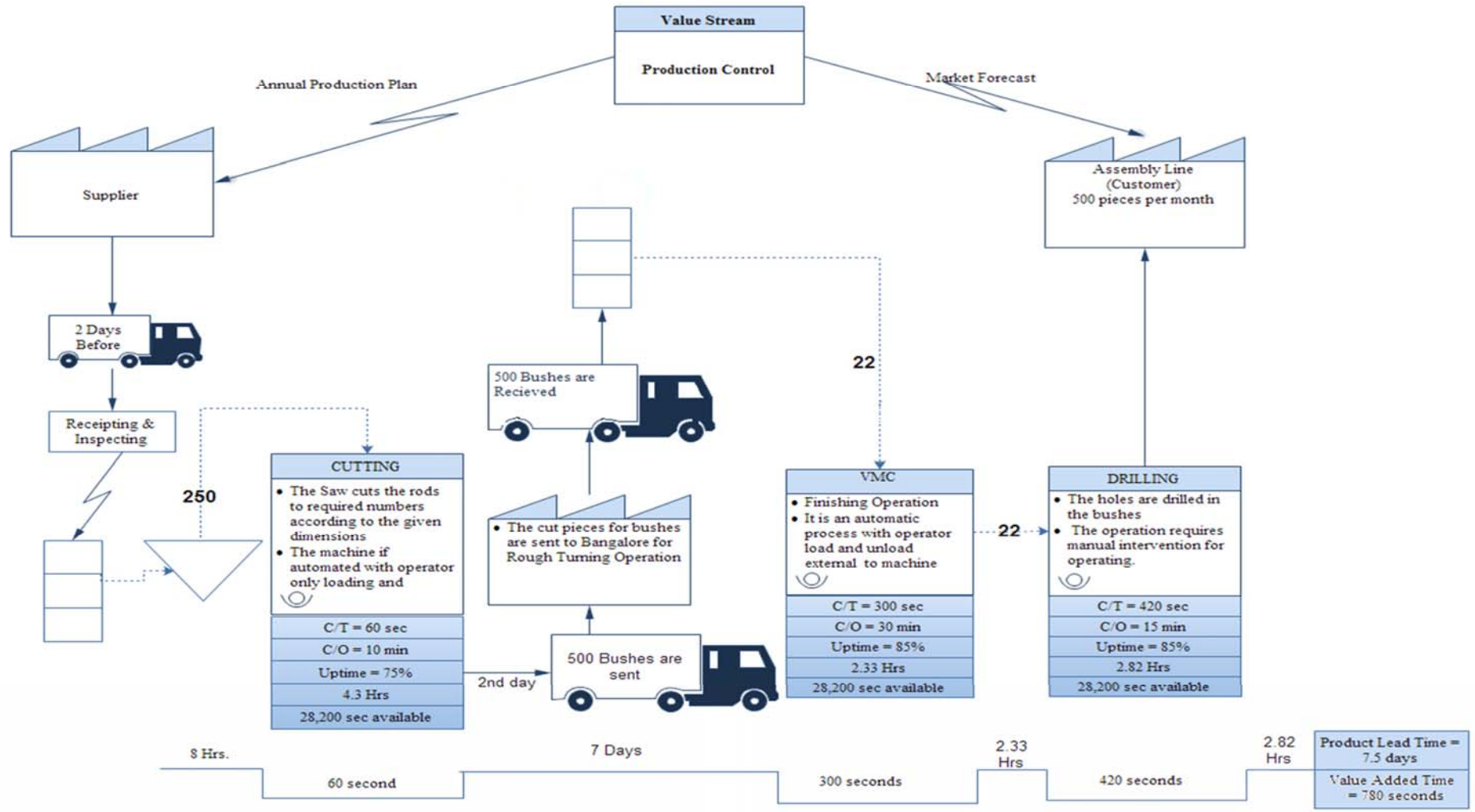
Future State Mapping for Gears



Future State Mapping for Cover



Future State Mapping for Brackets



Future State Mapping for Bushes

6.0 Results

The future maps produced yielded tremendous results: with the application of continuous flow process, changes in tray sizes (lot sizes) – implementation of EOQ batch size, change in the cycle times applicable with automation. The cycle time could be reduced compared to current mapping - with the recommendation of automated machines further smoothing out the production schedule by using Super Market pull system for upstream operations.

The Current State Mapping for ‘Gear’ – when drawn the lead time was 67 days, but with VSM of Future State Mapping for ‘Gear’ reduced considerably to 9 days which was excellent result obtained using VSM.

The Current State Mapping for ‘Cover’ – when drawn the lead time was 30 days, but with VSM of Future State Mapping for ‘Cover’ reduced considerably to 6 days which was again great result obtained.

The Current State Mapping for ‘Brackets’ – when drawn the lead time was 30 days, but with VSM of Future State Mapping for ‘Brackets’ reduced considerably to 5.5 days which was again great result obtained.

The Current State Mapping for ‘Bushes’ – when drawn the lead time was 57 days, but with VSM of Future State Mapping for ‘Bushes’ reduced considerably to 7.5 days which was again great result obtained.

7.0 Conclusion and Future Scope

The aim of this paper was to determine improvement in the productivity by using Value Stream Mapping – a lean approach at a manufacturing engineering firm. This aim together with more specific objectives described earlier has been met. First, the fundamental problem with mass, batch and push system was exposed with regards to the components in study. As a result, the total time that product spend getting through the plant was very long.

The ultimate conclusion could be drawn from this is: the study undertaken for the product family is in good demand. If the firm could decrease the lead time and prioritize its operations and use proper production planning as per the future mapping, it could - not only serve present customers better but also may attract new customers. And at the same time it may go for faster introduction of its products in the market.

The study clearly shows that the VSM brings out the positive impact on process time, process inventory level, line speed, total lead time.

Furthermore, the literature review also throws a light on VSM a Lean approach is a paradigm shift in manufacturing. It is proven and tested system of providing the simple solution for the complex problems. It is a need of many organizations today, as lots of benefits seen but it is yet to penetrate as a concept / process in the manufacturing arena and service sectors. When completely matured we can see great rewards in manufacturing as well as in service sectors.

7.1 Future Scope

Phase wise, if this firm can start applying Value Stream Mapping to its other product families – the company can streamline its whole operations and may be a world class manufacturing company. Further, it can bring its products at a faster pace into the market, leading to a competitive advantage over its rival companies.

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