Reduction of Lead Time Using Value Stream Mapping In Gear Manufacturing

Deepaa C Rathod

P.G. Student,
Department of Industrial Engineering and Management,
R. V College of Engineering, R. V. Vidyaniketan Post,
Bangalore, Karnataka, India

Vivekanand S Gogi

Associate Professor,
Department of Engineering and Management, R. V
College of Engineering, R. V. Vidyaniketan Post,
Bangalore, Karnataka, India

Abstract: This paper explores involvement of Value stream is for a production process. The concept of lean has been introduced and popularized by the Toyota by the name. "Toyota production system". Lean is a systematically approach to identify and eliminate waste through continuous improvement. The value stream initiates at the concept and ends when delivered to consumer. Value stream mapping is an important tool for implementing lean philosophy. VSM is a method to describe the flow of material and information through the production system. The ratio of value added to the total lead time is determined by documenting the current lead time, inventory levels, and cycle times. Value added activities make the product more closely to the customer requirement. Non value added activities do not create customers value, and anything that does not constitute to value is defined as waste. VSM helps to identify waste and eliminate waste by drawing; analysis current state VSM and eliminating waste in future state VSM. Lean principles are being more widely implemented. Analysis is carried out by applying lean tool value stream mapping in the gear production line to bring improvements. By Analysis the current production line the current state VSM is drawn and wastes are identified. And a future state VSM is drawn to carryout production by eliminating wastes identified. Eliminating waste the lead time is reduced and manufacturing cost could also be decreased. This results in delivering more value to the customer at lower cost. This ultimately results in gaining competitive advantage in the competitive market.

Keywords: Kaizen, Value stream mapping, Kanban, production line, Simulation.

I. INTRODUCTION

A Value Stream Map (VSM) is drawn, to visually show waste occurrences in the process. In existing manufacturing processes VSM is frequently used to assess, in addition to create ideal, future state processes. As the manufacturing field escalating and spreading more widely across the globe, it is important for companies to get used to the increasing business strategies. VSM is a collected works of the all activities, the non value-added actions as well as the add-value one, from the raw material to the consumer it is essential for a complete process of a product in the course of technological flow. Value Stream Map has a plan to recognize all the type of wastes from value flow and to remove all the wastes. A set of predefined harmonized icons are used by Value Stream Map. For creating the Value Stream Map the initial action is to choose a product or family products that we desire to develop. Second action is demonstration of present state map. The third action is to draw a future state map which will present the way that the system should look after removing all the wastes from a value flow. The base for decision-making concerning the essential changes in the system. The value stream map was drawn and improvements are brought in the production. A future state VSM is projected to decrease the lead time. Which results in removal of non value added actions and reduction in the cost of operation. **Er. Manoj Ade1 et.al [1]** explains about waste minimization while developing his mass assembly manufacturing system and work standardization. While standardizing the work, each activity is analyzed on the basis of desirable activity or undesirable activity. All the desirable activities are known as value added activity and undesirable activities are known as wastes. Lean thinking is a set of methodologies for maximizing value of an item or feature for which a customer is willing to pay. Thus work standardization has become the basis of Lean thinking. Lean thinking is an approach to achieving manufacturing excellence based upon the continued value addition and elimination of waste**. Simon Caulkin et.al [2]** explains about Lean principles and methods focus on creating a continual improvement culture that engages employees in reducing the intensity of time, materials, and capital necessary for meeting a customer's needs. Improving product quality, reducing production costs, and being "first to market" and quick to respond to customer needs are critical to competitiveness and success. Lean manufacturing is the systematic elimination of waste from all aspects of an organization's operations, where waste is viewed as any use or loss of resources that does not lead directly to creating the product or service a customer wants when they want it. While lean production's fundamental focus is on the systematic elimination of non-value added activity and waste from the production process, the implementation of lean principles and methods also results in improved environmental performance. **Frank C. Garcia et.al [3]** explains about a representative value stream map. value stream maps are the most useful tool developed by a cross-functional team as most of the actions in the value stream being evaluated.. Value stream maps are developed in many different industries including

electronics, food, metal fabrication, plastics, and chemicals. Different techniques used to plan the map. For developing and advancement understanding of the purpose of lean concepts a value stream map can also be part of the guidance used. A variety of methods used to enlarge the maps including operator teams, engineer teams, and management teams are compared and evaluated. value stream map is the road map that reveals the obstructions to constant flow and the opportunity for sinking waste through the use of other lean techniques. Value Stream Maps have developed by a cross functional team that has representatives from various company functions that are common with the product of family being mapped. The advantage of this approach is that the team members become skilled in implementing lean techniques and take possession of the improvements essential to achieve the Future State. **Michael Lobaugh et.al [4]** This paper provides a discussion of the value of teaching the lean manufacturing The technique is used to recognize possible improvement areas within the manufacturing plant. Once acknowledged, the appropriate Lean Manufacturing technique is used to meet specific development metrics. Value Stream Mapping is a technique that is used to view, on a broad level, a company's manufacturing of a part family. In a manufacturing environment the Engineering students in college typically do not have an extensive understanding, or the experience the topic of value stream mapping to present correctly and the students may not be able to properly use the technique in an actual theoretical condition. The technique is to reinforcing and One of the method to have the students working in teams to carry out an actual analysis of a manufacturing system and present proper with realistic opportunities for the improvement. Overview of Value Stream Mapping (VSM) technique will be discussed first. The incorporate active learning in the presentation of VSM to engineering students is being discussed in the primary section of the paper. Activities that does not add value to the product is measured as waste. Overproduction, waiting, transportation, poor processing, excess inventory, excess motion, and defective products these are the 7 commonly categories of wastes. **William M.Goriwondo et.al [5]** explains about Value Stream Mapping (VSM) is a World Class Manufacturing tool that can be used to reduce waste in manufacturing. Companies are experiencing strong competitive pressure due to globalisation hence they cannot afford to operate with waste in their processes. The details of use of the VSM tool in dropping waste in bread manufacturing for a company in Zimbabwe is being discussed in this paper. The VSM tool was used to recognize and decrease defects by 20% laid off inventory by 18% and motion by 37% in obtained in the case study. **Balkema et.al [6]** explains about a steel service centre current state map for a steel producer and first-tier component supplier. The current state map identify huge piled of inventory and long lead-time. In the future state map it target areas which are subjected to adifferent lean tools including kanban, supermarket, and continuous flow. **Ballard et.al [7]** explained that, the value stream mapping can provide a good starting point for any course of action that wants to be lean. It provides common causes for discussion about manufacturing development. It ties lean concepts and techniques together which will help to avoid "cherry picking". It forms the base for a performance plan by serving to design the whole flow. **Taiichi Ohno, Shingo et.al [8, 9]** explains about a Value stream map as a standard method for mapping the flows visually and it has became the standard basis for scheming improvements at Toyota. It is becoming one of the business planning tool. VSM is now being utilized through the world, in many businesses plan to deliberate and it is the starting point to any of the lean transformation and performance. The value stream mapping is extensive in the field of aircraft manufacturing. Abbett and Payne have also discussed about the application of value stream mapping in an aircraft manufacturing unit. They have developed the current and future state maps with the purpose of reducing lead time according to the customer's needs. It has discussed the strategy for the constructive implementation of Value Stream Mapping in a wood industry. They have also suggested the ways to eradicate non value added activity and proposed method to increase the Value added ratio.

II. METHODOLOGY

To identify the product or product family (the group of goods that pass through similar processes and use common equipment and resources) which we have selected to improve. The methodology begins with the collection of data of lead time between the process by collecting data's from dynamatics technology as project is carried out there. The through times of all processes involved in the gear manufacturing process with the help of manual Value stream map. With the help of data collected current state value stream map was constructed. Then to verify and validate the results of current state value stream map, model is developed. The process will be repeated to make ideal process, i.e. future state becomes the current state and that will be re evaluated, adding improvements to it and modified to become once future state. The result obtained was of production lead time of the gear manufacturing process.

A) Data collection: The required data is to be collected by observing production process in the Dynamatic technologies ltd. Data needed for the value stream mapping is collected.

B) Proposed Analysis: In lean manufacturing concept we analyze the manufacturing process in which we have Qualitative analysis: In this analysis theory amplification and concept are generated (emerged out) from data collection. In this progression of data collection and examination, qualitative method are used and data is in the outline of words, and pictures.Quantitative analysis: Quantitative analysis is used for testing the theory and concepts. The investigator use tools, such as questionnaire or equipment to gather numerical data and to examine the processes. The data are in the summarize of numbers.

C) Tools and techniques Value stream mapping: The Value Stream Mapping process is visualization and streamlines work processes by the means of tools and technique. The objective of the Value stream map is to identify, decrease and reveal wastes in the manufacturing firm. A industrialized organization operate with time of step-by-step activities. Value stream mapping is flow chart that uses symbols known as “language of Lean" to represent and get better inventory flow and information.

D) SMED Quick changeover: For tumbling wastes in manufacturing process it is one in the middle of the lot of lean production methods. It provides a quick and competent way of converting a manufacturing procedure beginning running the existing product running to the next product. The phrase "single minute" does not mean that all changeovers and start-ups have to take just one minute, they take less than 10 minutes (In other words, "single-digit minute"). Single Minute Exchange of Dies is changing process tooling in 9 minutes or less.

E) TPM Equipment Reliability: In today’s global economy, the continued existence of companies depends on their ability to rapidly innovate and get better. As a result, an increasing search is on for methods and process that drive improvements in quality, costs and productivity.

F) Failure mode and effect analysis: For failure analysis FMEA was one of the first systematic techniques. It involves review as a lot of components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are record in a specific FMEA worksheet. A FMEA is mostly a qualitative analysis.

G) Poka-Yoke: It is a Japanese term that means "fail-safing" or "mistake-proofing". A poka-yoke is any mechanism in a lean manufacturing process that helps an equipment operator avoid (yokeru) mistakes (poka). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur. The concept was formalized, and the term adopted, by shigeo shingo as a part of the Toyota Production System.

The current state VSM represents the flow process at Dynamatic technologies starting from the customer stage to final product dispatch stage based on the above collected data.

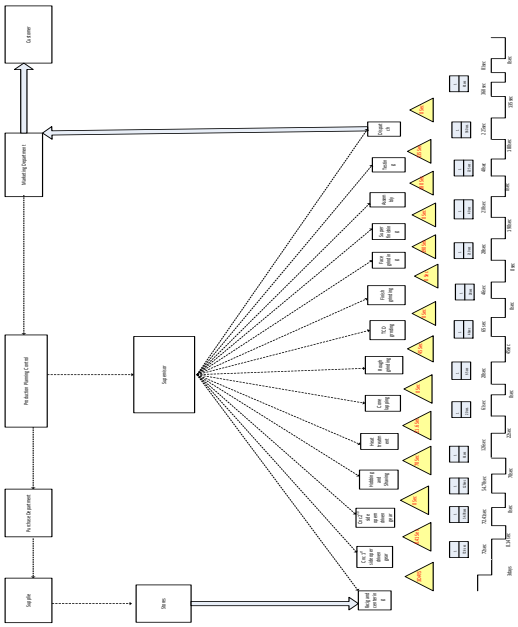


Figure 1: Modelling of current state VSM

Calculations of Current state VSM

Operation/ variables	Facing and centering	Cnc 1st operation	Cnc 2nd operation	Hobbing/ shaving	Heat treatment	Cone lapping	Finish grinding
Wip	0	0	0	489	0	0	0
Days Wip	1.08	1.09	0.86	1.80	0.81	0.33	0.74
Cycle time in min	1.37	1.37	1.08	2.27	1.02	0.42	0.93
Change over time in min	30.00	30.00	30.00	20.00	0.00	5.00	30.00
Material handling time(min)	5.00	0.17	0.17	1.20	1.33	0.92	0.50
Up time %	92.82	92.82	92.82	95.20	100.00	98.77	92.82
Batch process time in min	1464.11	1471.62	1157.14	2374.80	1020.00	421.12	1000.01
Delay in min	0.00	0.00	0.00	1180.86	0.00	0.00	0.00
Av.time/shift(min)	420.00	420.00	420.00	420.00	420.00	420.00	420.00

Operation/variables	Finish grinding	Tcd grinding	Face grinding	Super finishing	Assembly	Testing	Dispatch
Work in*/ process	0	0	821	0	772	375	0
Day's Work in process	0.74	0.50	2.91	0.66	2.98	4.76	1.07
Cycle time in min	0.93	0.63	3.67	0.83	3.75	6.00	1.35
Change over time in min	30.00	15.00	15.00	10.00	0.00	0.00	0.00
Material handling time(min)	0.50	0.50	0.50	0.50	5.00	3.00	2.00
Up time %	92.82	96.39	97.58	100.00	100.00	100.00	100.00
Batch process time in min	1000.01	655.86	835.16	3750.00	3750.00	6000.00	1350.00
Delay in min	0.00	0.00	0.00	2896.84	2896.84	2250.00	0.00
Av.time/shift(min)	420	420	420	420	420	420	420

H) Future state value stream mapping: Methodology for drawing the futurestate map is based on the constant improvement need to be made for the current state process. For defining the future state map, a number of target areas for improvements start to show up. Looking at the current state map it can recognize a large inventories between workstations, the big difference between the total production of lead-time which is (82.5 days) and the value added time (42.5 days) in the process, and each workstation is producing on its own schedule. The inventory and the lead-time can be viewed as two related issues since the more the inventory; the longer any part must wait for its turn to the workstation, and thus a longer lead-time.

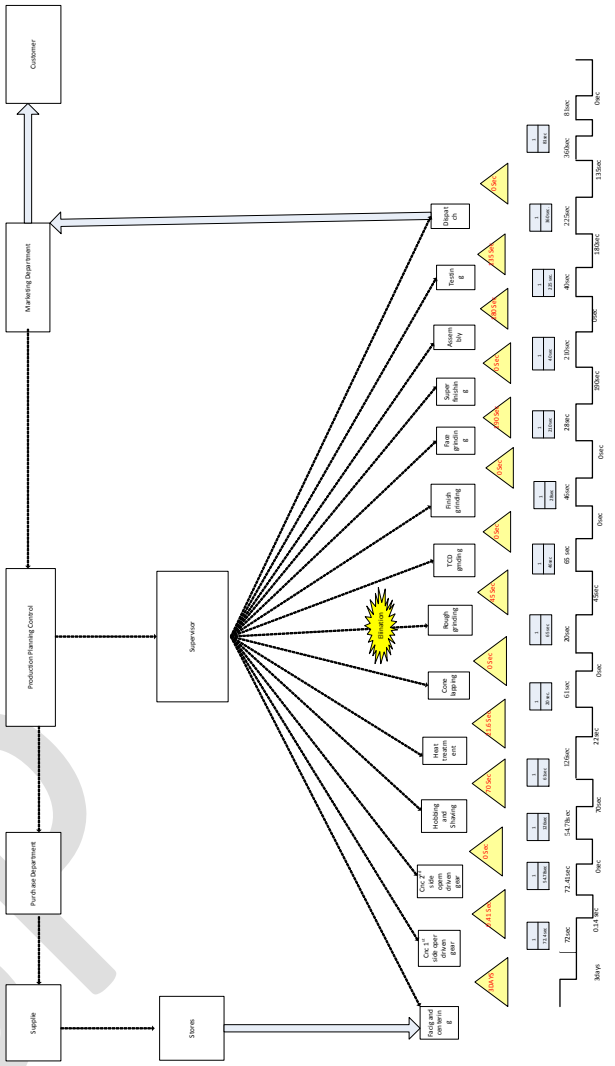


Fig 2:Future state VSM

I) Kaizen burst: It helps to know a problem in the manufacturing process, elimination of rough grinding which is the main factor causing to more lead time is being observed. Calculations obtained for future state VSM (after elimination of rough grinding)

Operation/ variables	Facing and centering	Cnc 1st operation	Cnc 2nd operation	Hobbing/ shaving	Heat treatment	Cone lapping	Finish grinding
Wip	0	0	0	489	0	0	0
Days Wip	1.08	1.09	0.86	1.80	0.81	0.33	0.74
Cycle time in min	1.37	1.37	1.08	2.27	1.02	0.42	0.93
Change over time	30.00	30.00	30.00	20.00	0.00	5.00	30.00

in min							
Material handling time(min)	5.00	0.17	0.17	1.20	1.33	0.92	0.50
Up time %	92.82	92.82	92.82	95.20	100.00	98.77	92.82
Batch process time in min	1464.11	1471.62	1157.14	2374.80	1020.00	421.12	1000.01
Delay in min	0.00	0.00	0.00	1180.86	0.00	0.00	0.00
Av.time/shift(min)	420.00	420.00	420.00	420.00	420.00	420.00	420.00

Operation/variables	Tcd grinding	Face grinding	Super finishing	Assembly	Testing	Dispatch	
Wip	0	642	0	772	375	0	3007
Days Wip	0.50	1.45	0.66	2.98	4.76	1.07	19.59
Cycle time in min	0.63	1.83	0.83	3.75	6.00	1.35	24.69
Change over time in min	15.00	0.50	10.00	0.00	0.00	0.00	20.78
Material handling time(min)	0.50	15.00	0.50	5.00	3.00	2.00	185.00
Up time %	96.39	96.39	97.58	100.00	100.00	100.00	
Batch process time in min	655.86	1899.19	853.16	3750.00	60000.00	1350.00	25316.21
Delay in min	0.00	1177.14	0.00	2896.84	22500.00	0.00	9777.72
Av.time/shift(min)	420	420	420.00	420	420.00	420.00	

J) Simulation Process: As Shannon states simulation is a continuous "process'' rather than a onetime create-and-use application. Especially computer simulation is an iterative method that includes several stages. A simulation study starts with efforts on understanding the system in addition with the identification of the goals of the study. The next step is creating the formulation of the model representation usually in terms of mathematical models or flowcharts. Subsequently, the created formulation needs to be transferred into modeling software using programming languages or with specific software tailored into the needs of a simulation study

K) Arena: The ARENA modeling system from systems modeling corporation is a flexible and powerful tool that allows analysts to create animated simulation models that accurately represent virtually any system. First released in 1993, ARENA employs an object oriented design for entirely graphical model development. Simulation analysts place graphical objects, called modules, on a layout in order to define system components such as machines, operators, and material handling devices. ARENA is built on the SIMAN simulation language. After creating a simulation model graphically, ARENA automatically generates the underlying SIMAN model used to perform simulation runs. This brief description provided by a senior software developer of the program owning company, emphasizes the graphical interface, and ease of programming that arises as a result. The ARENA product suite is designed for use throughout an enterprise, from strategic business decisions, such as locating capacity in a supply chain planning initiative, down to operational planning improvements, such as locating capacity in a supply chain planning initiative, down to operational planning improvements, such as establishing production line operating rates. To achieve enterprise wide to-down scalability and ease of use by all levels of an enterprise, ARENA has many unique properties, which are described in brief below. ARENA has a natural and consistent modeling methodology due to its flowchart style model building regardless of details or complexity. Even the flowchart of systems created by Microsoft visio can be imported and used directly. It is extendable and customizable, which results in a re-creatable, reusable and distributable templates tailored to specific applications. The scalable architecture of ARENA provides a modelling medium that is easy enough to suit the needs of the beginner, and powerful enough to satisfy the demands of the most advanced users. This makes it a perfect tool for continuously improving modeling studies as the modeller's capability and experience increase as the study progresses. One other advantages of ARENA is that it is open to interaction with many applications such as Microsoft Access and Excel with its built-in spreadsheet data interface.

III. ANALYSIS

A) Cause and effect diagram: A cause and effect diagram is a tool that helps to identify, sort and display possible causes of a specific problem it graphically illustrate the relationship between a given outcomes and all the factors

that influence the outcome. Here increase in lead time is the main cause and rough grinding is the factor leading to more lead time. In this project we have concentrated on reducing lead time using cause and effect diagram analysis.

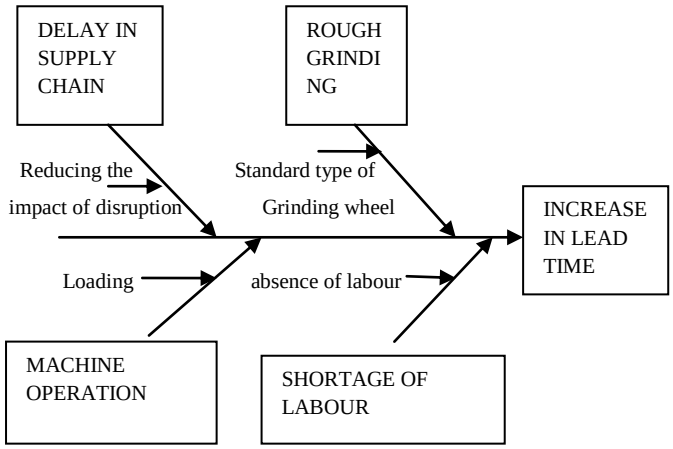


Figure 3: Cause and effect diagram of lead time analysis

B) Simulation of gear manufacturing process of current state: The purpose of simulation of current state VSM is to verify the results of value stream map developed. This study is conducted at the shop floor of a gear manufacturing unit. The focus is on cycle time, set up time, material handling time of the process. Original simulation model was developed for CVSM in the create module. The simulation models were developed using the create, process, decide and dispose modules of ARENA. Besides that, representative and accurate data must be entered into the right modules within the flowchart window to model the various times. As the sub module includes many steps involved in the process it can be given only as screen shots.

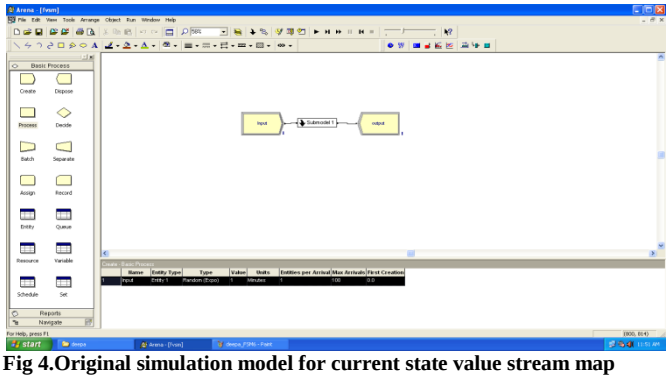


Fig 4.Original simulation model for current state value stream map

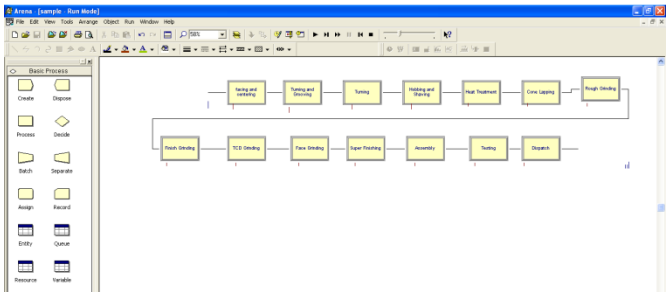


Fig 5.Sub module of original simulation model for CVSM

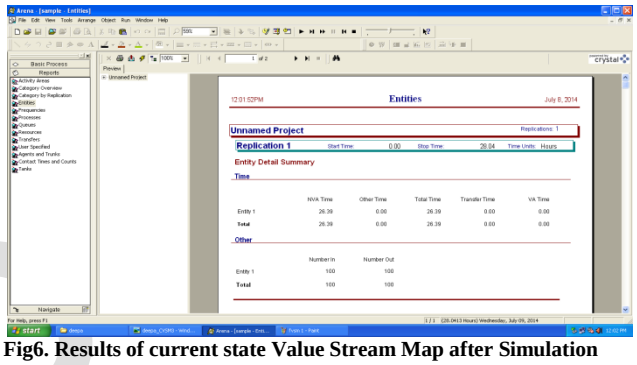


Fig6. Results of current state Value Stream Map after Simulation

Fig.4 verifies that the current state value stream map constructed based on the manually constructed Value Stream Maps. With the help of which, non value added time can be easily identified and removed.

C*) Simulation of Future State VSM:* The purpose of simulation of future state VSM is to verify the results obtained in current state Value Stream Map. The focus is on all the processes because the answer obtained by Value Stream Map is verified. Original simulation model is developed for FVSM in the create module.

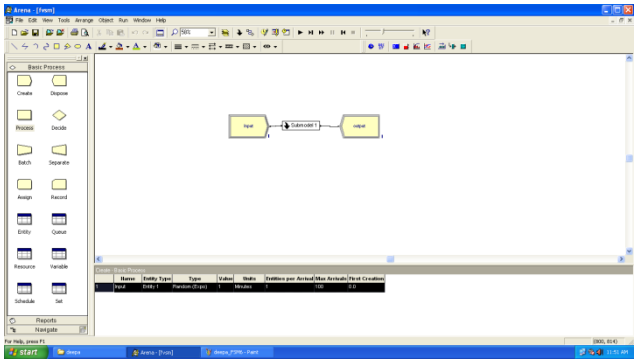


Fig 7 Simulation model for Future State Map

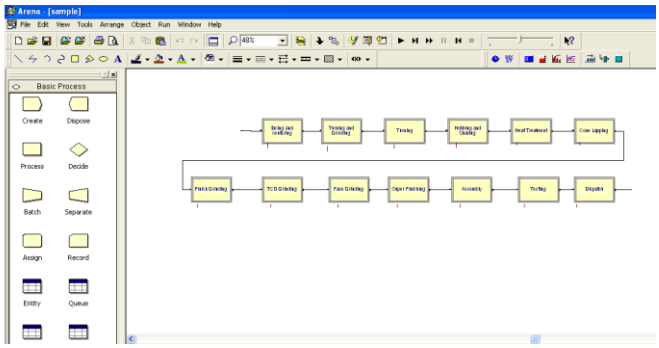


Fig 8. Sub model of Future State Map

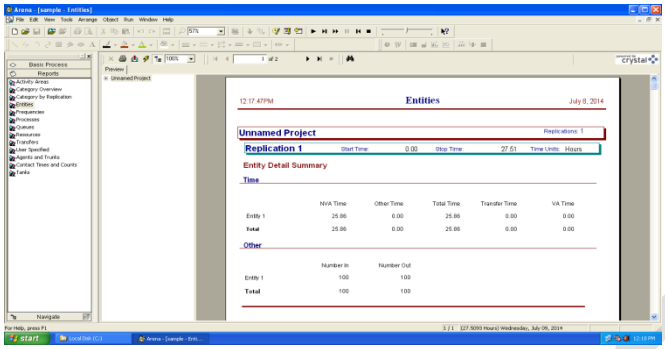


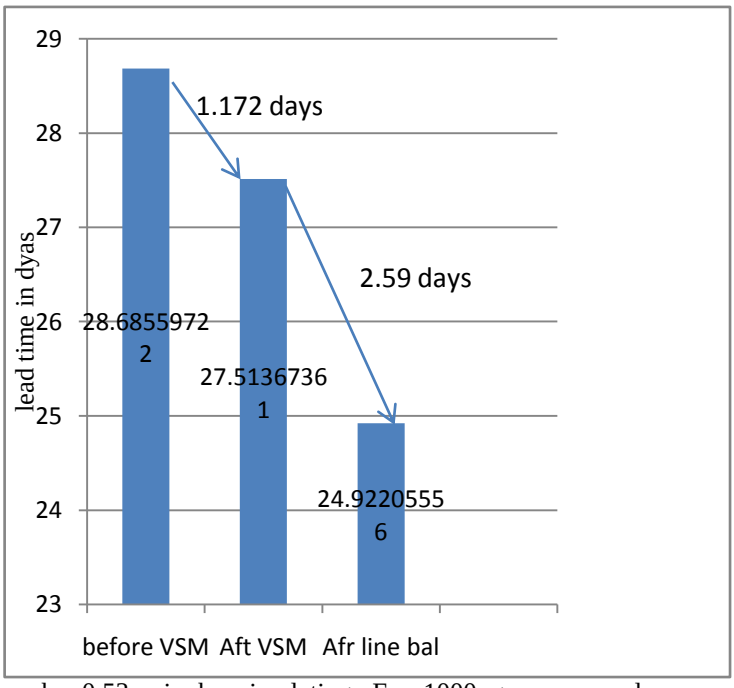
Fig.9. Results of future state simulation model

The non value added time is reduced by 0.53 min .

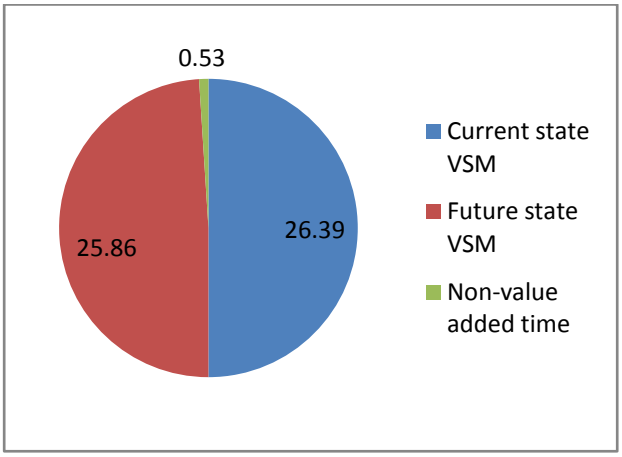
D) Lead time in days (per batch): Lead time results obtained is analyzed for the process using VSM before, after and after line balancing of.

Graph 1.Lead time in a day

E) Non-Value added time: Simulation is done using ARENA to analyze non-value added time result reduced



by 0.53 min by simulating. For 1000 gears non-value added time will reduce by 5.3min.s for current and future state VSM. We have taken for 100 gears and obtained 26.39 min for current state VSM and 25.86 min for future state VSM, non-value added time is reduced by 5.3 min.



Graph 2.Result of simulation

CONLUSION

The project carried out at Hydraulic manufacturing firm, has been forwarded to the higher management in the form of a report for consideration By analysing the current state VSM, the future state VSM is successfully drawn on the excel sheet. The proposed future state VSM is tested on the production of gears, whose task is to eliminate rough grinding in the production line. This results in following benefits.

1) Lead time is reduced.

2) Manufacturing cost is reduced.

3) If the rough grinding is allocated to face grinding, the cycle time can be reduced.

As the demand exceed, firm must plan for future improvements. Lean reduction refers to continuous improvement in the work process and a firm must keep on changing future state into current state and again find improvements, as it's a never ending process. VSM is proved to be a greatly useful tool to eliminate non value added activities and provide more value using less.

REFERENCES

[1] Aleksandar Rikalovicz "Manufacturing Lead Time Reduction of Gear Box Side Frame Using Lean Principles." Redesigning an Automotive Assembly Line through Lean Strategy. December 2011.

[2] Rajesh Kumar Mehta 'Applying the lessons learned from 27 lean manufacturing. The relevance of relationships management'.J.Production Economics. Vol 55, 1998.

[3] John S.W.Farghe , Womack JP, Jones D., 'The machines that changed the world'. New York, NY: Rawson Association., 1990.
[4] Bethany Denise Gregory, F. Frank Chen, 'Measuring the impact of Lean tools on the costtime investment of a product using cost–time profiles', Robotics and computer integrated manufacturing Vol. 23, 2007.
[5] Manoj Ade1and Goldberg J B., 'Design and Analysis of Lean Production System' John Wiley and Sons Inc., 2003.
[6] Simon Caulkin 'Applying the lessons learned from 27 lean manufacturing. The relevance of relationships management'.Int .J.Production Economics. Vol 55, 1998
[7] Diogo Manuel, Toni L. Doolen and Maria E. Hacker, 'A Review of Lean Assessment in Organizations: An Exploratory Study of Lean Practices by Electronics Manufacturers'. Journal of manufacturing systems Vol.24,2005.
[8] Ch Raviteja ,Askin R G and Goldberg J B., 'Design and Analysis of Lean Production System' John Wiley and Sons Inc., 2003.
[9] J. Blanco, Leonardo Riveraa, F. Frank Chen, 'Measuring the impact of Lean tools on the cost–time investment of a product using cost–time profiles', Robotics and computer integrated manufacturing Vol. 23, 2007.
[10] Wolfgang Apel ,Oliver.N. et al (1996), :lean production practices international comparisons in the auto component industry" british journal of management, vol.7 special issue,2006.
[11] S. P. Vendan, Shah,R and Ward, P.T., 2007 "defining of developing measure of lean production" Journal of operation management25, pp 785-805.
[12] A. S. Anand " Improving the Productivity using Value Stream Mapping and Kanban Approach" International Journal of Scientific & Engineering Research Volume 2, Issue 8, August-2011.
[13] William Faulkner **"**Application of Modern Management Concepts by Polish Companies" Academy of Business in Dąbrowa Górnicza, Department of of Management, Number 2, March-April 2012.
[14] Ravikumar Marudhamuthu "Implementation lean in aerospace challenging the assumption and understanding the challenges", Technovation, Vol. 23, 2003.
[15] Frank .c.Gargia, Rother, M., Shook, M. (1997). Learning to See – value stream mapping to creat value and to eliminate muda. Lean Enterprise Institute, Cambridge.