# “PRODUCTIVITY IMPROVEMENT OF EXHAUST GAS RECIRCULATING (EGR) ELBOW BY USING VALUE STREAM MAPPING OF LEAN MANUFACTURING”

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# CERTIFICATE

It is certified that the work contained in the dissertation thesis entitled "**PRODUCTIVITY IMPROVEMENT OF EXHAUST GAS RECIRCULATING (EGR) ELBOW BY USING VALUE STREAM MAPPING OF LEAN MANUFACTURING"** submitted by **DABHI DEVENDRA MAHESHBHAI** ENROLLMENT NO. **200044002**, studying at Mechanical Engineering Department, Faculty of Engineering & Technology, for the award of M.Tech. (Production Engineering) is absolutely based on his/her own work carried out under my/our supervision and this work/thesis has not been submitted elsewhere for any degree.

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Seal of Institute

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At last, I express my thanks to those all who were source of inspiration to me and directly or indirectly involved in the project.

# ABSTRACT

The manufacturing industry is adopting lean manufacturing practices. Many manufacturers struggle to produce a product, produce the right products or services in the right place and timely delivery meeting. To survive in today's competitive world, manufacturers need to come up with innovative ways reducing production lead times to improve productivity and performance goal. Today, it is aimed at improving production performance by reducing production lead time and dissipation of existing production the most important goals for almost every manufacturing company. Each industry's shop floor contains multiple stations that work together to complete specific activities according to a timetable in order to fulfill the production rate. Machine breakdowns, inventory shortages, and tool shortages all cause delays in meeting demand. The only lean tool recommended in the literature to eliminate Muda, or bottlenecks, across the manufacturing line is value stream mapping. Before implementing techniques, value stream mapping uses a current state map to record the current status of the production line. The main purpose of this study is to design Effective Value Stream Mapping (VSM) to improve productivity in automobile part manufacturer company in to reduce lead time and establish a future state for the action plan's process improvement to sum up, the proposed Future Value Stream Map (FVSM) aids in the effective identification of inefficient activities and industrial processes, according to this research. By lowering the manufacturing lead time, VSM serves as an input for improvement. In current state value stream mapping lead time is 7 Days. Applying lean concept in production area and calculate the lead time for Future state is 3.02 days. So reduce lead time by 3.97 days.

# TABLE OF CONTENTS

## LIST OF FIGURE

# LIST OF TABLE

# CHAPTER: - 1
# INTRODUCTION

## 1.1 INTRODUCTION

Japanese car company, Toyota, has launched Lean Production (LM) or Toyota Production System (TPS), and has now been approved. many countries in every name because of its proven benefits of quality improvement, cost reduction, flexibility and speed. answer. Reduced production can best be described as waste disposal in a production-related production system effort, time inventory at various stages of production. Depending on production is an effective and popular tool in many manufacturing industries and resources to deal with non-essential tasks as well waste. Any kind of waste, in the literal sense that work does not add any value to the final product, it must be reduced or possibly, eliminated by low production costs. The main theme of the transformation process is transformation existing production methods and processes in mitigation waste to be effective in reducing costs, increasing quality, increasing profit and increase customer value.

## 1.2 VARIOUS LEAN MANUFACTURING TOOLS

Lean production tools work wherever there is a selection of the right tool, integrity of collected data, involvement of nearby people with good sense, express and acceptance a change in the way of work or culture that will lead to improvement workplace.

**Kaizen**

Kaizen is a Japanese philosophy that encourages continuity better due to continuous effort and staff' to join. Appreciate even the smallest progress and encourage continuity in the future.

**5's**

There is a place for everything and everything has to be in it the place, kept in a proper place, is in good condition and available whenever needed. Remove unwanted (Filter), sort the rest (Organize), Keep it clean and check workspace (Shine), write above standards (Standardize), always use standards (Sustain).

**KANBAN**

Display card method to provide parts only if required. The KANBAN program is based on partial customer which draws a part from the supplier of that part. This is a customer part can be a real buyer of the finished product (external) or production workers at the next station in the (internal) production area. This concept of pull type helps to reduce goods and higher costs.

**Single Minute Exchange Dies (SMED)**

The strategy of reducing the transition time to one minute is SMED. Its value lies in the production of different or mass production, during product change the change over time can be minimized by changing the internal set function to the external one and to facilitate internal work faster.

**Time and Motion Study**

Recording time for various reading and recording activities all movements during the activity movement study are performed.

**Value stream mapping (VSM)**

This process initially begins with current state mapping depict- ing the flow of material, activities performed during manufacturing and if required between manufacturers, suppliers, and distributors to deliver products to customers. Followed by proposed future state map with its benefit.

## 1.3 OBJECTIVES OF LEAN MANUFACTURING

Lean Manufacturing, also called Lean Production, is a position of utensils and methodologies that aims for the continuous elimination of all waste in the construct process. The main profits of this are minor production costs; increased output and shorter manufacture lead times. More specially, some of the goal includes:

**Defects and wastage** - Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, and costs associated with reprocessing defective items and unnecessary product characteristics which are not required by customers.

**Cycle Times** - Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times.

**Inventory levels** - Minimize inventory levels at all stages of manufacture, mainly work-in- progress between manufacture stages. Lower inventory also means lower Working capital requirements.

**Labor productivity** - Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or unnecessary motions).

**Utilization of equipment and space** - Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though presented equipment, while minimizing machine downtime

**Flexibility** - Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time.

**Output** - Insofar as reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can, generally increase output from their existing facilities.

## 1.4 KEY PRINCIPLES OF LEAN MANUFACTURING

Key values behind Lean Production can be summarized as follows:

**a) Recognition of waste** - The first step is to recognize what does and does not create value from the customer's point of view. Any material, course or attribute, which isn't

required for creating value from the customer's point of view, is abuse and should Be eliminated. For example, transporting materials between workstations is waste because it can strongly be eliminated.

**b) Standard processes** - Lean require the implementation of very detailed production guidelines, called Standard Work, which clearly states the satisfied, chain timing and outcome of all actions by employees. This eliminates disparity in the way that workers perform their tasks.

**c) Continuous flow** - Lean usually aims for the implementation of a continuous production flow free of bottleneck, disruption, detour, reverse flows or waiting. When this is fruitfully implementing the production cycle time can be minimized by as much as 90%.

**d) Pull-production** - Also called Just-in-Time (JIT), Pull-production aim to produce only what is desirable, when it is desirable. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

**e) Quality at the Source** - Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

**f) Continuous improvement** - Lean requires striving for perfection by continually removing layer of waste, as they are exposed. This in turn requires a high level of worker involvement in the continuous improvement process.

## 1.5 LEAN MANUFACTURING CONCEPTS

### 1.5.1Value Creation and Waste

In Lean Manufacturing, the value of a product is defined solely based on what The Customer actually requires and is ready to pay for. Production operations can be group into following three types of actions. Value-added activities are those activities, which transform the materials into the correct product that the customer wants. No value-added actions are actions, which aren't required for transforming the materials into the product that the customer wants. Everything, which is non-value-added, may be known as waste. Something that Increase unnecessary time, effort or cost is measured non-value-added. Another way of looking at waste is that it is any material or activity for which the customer is not willing to pay. Checking or inspecting materials is also considered waste since this can be eliminated insofar as the production process can be improved to eliminate defects from occurring.

Research at the Lean Enterprise Research Center (LERC) in the United Kingdom indicated that for a typical manufacturing company the ratio of activities could be broken down as follows.

Table: 1.1 ratio of activities

| | **ratio of activities** | **In (%)** |
|---|---|---|
| | Value –added activity | 5% |
| | Non value –added activity | 60% |
| | Necessary non value –added activity | 35% |
| | **Total activity** | 100% |

### 1.5.2 Main Types of Wastages

Originally seven main types of waste were identified as part of the Toyota Production System .

**a) Over production** - Producing too soon, resulting in poor flow of information or goods and excess inventory.

**b) Defects -** Frequent errors in paperwork or material/ product quality problems resulting in scrap and / or rework, as well as poor delivery performance.

**c) Unnecessary inventory** - Excessive storage and delay of information or products, resulting in excess inventory and cost, leading to poor customer service.

**d) Inappropriate processing** - Going about work processes using the wrong set of utensils processes or systems, often when a simpler approach may be more effective.

**e) Excessive transportation** - Excessive progress of people, products or goods, ensuing in wasted time and cost.

**f) Waiting** - Long periods of indolence for people, information or goods, resulting in poor flow and long lead times.

**g) Unnecessary motion** - Poor workplace institute resulting in poor ergonomics, e.g., unnecessary bending or stretch and normally lost items.

## 1.6 STRATEGIES OF IMPLEMENTATION OF LEANMANUFACTURING

**a) Senior Management Involvement** -As for any significant process improvement project, the total promise and support of the most senior management is essential for implementation of lean manufacturing. Problems will almost certainly arise during the implementation of lean production systems and those problems will likely only be solved if the senior management is fully committed to the successful implementation of lean.

**b) Start with a Partial Implementation of Lean** - Some companies may initially implement only some of lean manufacturing and gradually shift towards a more complete implementation. In a 2004, a survey of manufacturing industries in the U.S. by Industry Week Magazine, among companies which had commenced lean manufacturing programs, 39.1%reported implementing some aspects of lean, 55.0% reported implementing most aspects of lean and only 5.9% reported complete implementation of lean. Some steps of lean include,

- Measuring and monitoring machine capacity and output
- Creating more clearly defined production procedures.
- Implementing the 5S system for shop floor housekeeping.
- Streamlining the production layout.

**c) Start Small -** It is recommended that companies try to implement lean as a test case at a small part of their operations before applying it through their entire operations, especially for the shift from a push-based to a pull-based system since this can potentially be disruptive. For example, the test case may be a single production line or a small series of processes. This will help to minimize the risk of disruption; help educate the staff on the principles of lean while also serving to convince others of the benefits of lean.

**d) Use an Expert** - It is recommended that for most private companies, it would be the best to use the services of a lean manufacturing expert to help them implement lean manufacturing systems. In particular, the shift from a push-based to a pull-based production system can potentially be quite disruptive so it is best to be guided by someone who has significant experience in this.

**e) Develop a Plan** - The Company should develop a detailed and clear implementation plan before proceeding with the conversion to lean manufacturing. A list of issues to cover in the implementation plan can be downloaded from the article Building the Lean Machine from the September 2000 issue of Advanced Manufacturing Magazine.

# CHAPTER: - 2
# LITERATURE REVIEW

## 2.1 INTRODUCTION

It covers a detailed review of literature on various aspects of lean manufacturing. The literature review includes the status of lean manufacturing implementation in India and abroad, the studies carried out and the benefits accrued. It also includes the status of various techniques of lean manufacturing. Various approaches are adopted for lean manufacturing have also been studied and presented in the Chapter.

## 2.2 CATEGORISATION OF LITERATURE

The literature has been categorized as under:

- Lean manufacturing principles.
- Position of lean manufacturing implementation in various classes of industry and benefits accrued.
- Approaches adopted for implementation of lean manufacturing.
- Status of different tools and techniques of lean manufacturing early.
- Since inventory is reduced, the waste of storage space will be reduced.
- Preventing excess production can uncover hidden problems.

## 2.3 LITERATURE SURVEY

**Atul Palange, Pankaj Dhatrak (2020)** [1] identifying the non-valued things in any processing industry and trying to reduce or eliminate for increasing the productivity or profit. It accelerates the company makes it more alert and dynamic to meet future expectations and encourage a culture of continuous improvement in activities at various sections routinely and amongst all the employees. The success of Lean Manufacturing depends on authenticity of data collected, total integration of various manufacturing department sand deployment of synchronized lean elements in proper sequence.

**Valeria Belvedere, Francesco Cuttaia (2019)** [2] Lean Product Development (LPD) is suggested as an approach that can reduce waste in projects aimed at developing technically complex items, which typically present substantial uncertainty about their output, as well as higher costs and longer development times. However, how can LPD be implemented in complex projects, where some redundancies in the development process are considered necessary in order to guarantee the quality of the final outcome.

**Gopi S, Abhinav Suresh , Asher John Sathya (2019)** [3] The objective of this paper is to identify and eliminate waste, reduce process lead time, establish continuous flow to improve manufacturing velocity and to reduce work in process inventory (WIP) for component known as 'Element' which consists of 'Barrel' and 'Plunger', Data collected for two months in a well-known auto ancillary unit on various processes was analysed and current state value stream mapping was drawn. The future state value stream was designed to determine the ideal state design for eliminating waste in the process. The velocity ratio for current state and future state value stream were also identified. Velocity ratio will be improved from the present 6.66% to 10.48% in 3 years and the target is set for First Pass Yield to be > 95%.

**Jafri Mohd Rohani ,Seyed Mojib Zahraee (2015)** [4] Lean Manufacturing

(LM) is a business strategy that was developed in Japan. The main role of lean manufacturing is to determine as well as to eliminate the waste. Companies implement LM to keep their competitiveness over their co meteors by improving the manufacturing system's productivity and quality enhancement of the product. The goal of this paper is to apply one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the production line of a color industry as a case of study. To achieve this goal, lean fundamental principles was implemented to construct VSM for identification and elimination of wastes by using team formation, product selection, conceptual design, and time-frame formulation through takt time calculation. Based on the future VSM, final results showed that by implementing some lean thinking techniques, Production Le ad-time (PLT) decreased from 8.5 days to 6 days, and the value-added time decreased from 68 minutes to 37 minutes.

**Dario Antonelli , Dorota Stadnicka (2018)** [5] Value Stream Mapping (VSM) is employed for the analysis of manufacturing processes. The VSM analysis leads to improve the process through the reduction of non-value added steps. The optimization is often verified by computer simulation (CS) before actual implementation in the factory. The two approaches imply a different underlying conceptual model of production: a deterministic flow of material against a stochastic queuing network. The authors discuss the critical issues, but show, with the help of an automotive case study, that they could produce positive outcomes if the goals are carefully chosen and if some rules of use are respected.

**Amir Azizi, thulasi a/p Manoharan (2015)** [6] This study has shown the implementation of VSM in PCB assembly line to reveal obvious and hidden waste that affected the productivity of smart tag production. This hidden waste was related to the high changeover time at the insertion process of PCB assembly line and induced high WIP. Improvement process is designed to reduce the WIP and lead time using SMED and Kaizen techniques. The SMED technique was implemented at the insertion process that was bottleneck. SMED technique was successfully implemented because the machine setup time in the insertion process was reduced from 145 seconds to 54 seconds.

**Ana Julia Dal Forno& Fernando Augusto Pereira(2014)** [7] Value stream mapping (VSM) is an important tool of the lean approach and is used to identify value-adding activities and those considered wasteful of materials and the flow of information and people. However, when not applied correctly, VSM can complicate the identification of waste, lead to misinterpretations and assessment mistakes, and undermine the implementation of future improvements. The purpose of this paper is to investigate the main difficulties and limitations encountered during the construction of current state maps, analysis of the associated causes, and pointing out of guidelines to facilitate the use of VSM to map processes.

**Peggy zwolinski (2021)** [8] Considering the concept of waste described in the state of the art, it is observed that through the circular VSM several types of waste are put in evidence, which are listed below and linked to the mapping element to which they are associated. Under this approach it can be seen that the description of wastes is more extensive than for a conventional VSM, since more elements are considered as waste generators.

**Maja Berings ,Daniel nafors (2018)** [9] Discrete Event Simulation (DES) has been applied to analyze and understand production systems for many decades, however the models created may not accurately represent the spatial data of the system. 3D laser scanning can be utilized to capture and digitalize the spatial data of production systems, giving proper references for the simulation model. This paper evaluates the benefits and drawbacks of using a DES model supported with Value Stream Mapping (VSM) and 3D laser scanning to analyze a low volume production system.

**Niels L. Martin, Antal Der (2020)** [10] Value Stream Mapping (VSM) is employed for the analysis of manufacturing processes. The VSM analysis leads to improve the process through the reduction of non-value added steps. The optimization is often verified by computer simulation (CS) before actual implementation in the factory. The two approaches imply a different underlying conceptual model of production: a deterministic flow of material against a stochastic queuing network. The authors discuss the critical issues, but show, with the help of an automotive case study, that they could produce positive outcomes if the goals are carefully chosen and if some rules of use are respected.

**Rodrigo Salvador, Murillo vetroni barros (2021)** [11] Integrating environmental commitment to manufacturing concerns seems unavoidable towards a more sustainable conduct. In the contemporary scenario, Value Stream Mapping (VSM) has been bringing new perspectives into companies' economics, improving production performance, whereas Life Cycle Assessment (LCA) has been the most complete tool for environmental assessment. Therefore, the present study aims to propose a model based on the integration of LCA and VSM to improve environmental and manufacturing aspects of organizations, the LCA-VSM model.

**Rachna Shah , Peter T. Ward (2003)** [12] Management literature has suggested that contextual factors may present strong inertial forces within organizations that inhibit implementations that appear technically rational. This paper examines the effects of three contextual factors, plant size, plant age and unionization status, on the likelihood of implementing 22 manufacturing practices that are key facets of lean production systems. Further, we postulate four "bundles" of inter-related and internally consistent practices; these are just-in-time (JIT), total quality management (TQM), total preventive maintenance (TPM), and human resource management (HRM). We empirically validate our bundles and investigate their effects on operational performance.

**E.J. Lourenço ,J.P. Pereira , R. Barbosa (2016)** [13] Multi-layer Stream Mapping (MSM) comprehends a new framework for the performance assessment of complex systems. The MSM was developed for multi-domain analysis in an original manner to assess if resources, process and other domains are used to their full potential. The costs related with misuses/inefficiency situations are also quantified and integrated in a simplified manner. A real case study applying the MSM method is validated through application to a Medium Density Fiberboard (MDF) finishing line. For this study all the resources and materials consumed in each unit process where considered. The overall efficiency was assessed and improvements actions were evaluated.

**Nithia Kumar Kasava, Noordin Mohd Yus(2015)** [14] Lean and sustainable manufacturing are two independent theories in industrial engineering. A conceptual hybrid framework integrating lean manufacturing with sustainable manufacturing theories, known as sustainable domain value stream mapping (SdVSM) has been proposed previously. An aircraft maintenance process undertaken at a local airline was chosen as a case study to demonstrate the partial application of Sd VSM where the first 3 steps of the SMMIAI methodology. Select, Map and Measure were illustrated. The selected process was analyzed and four main activities were identified. These were broken down into smaller sub activities and subsequently categorized into value adding and non-value adding activities

**P.M. Masuti ,U.A. Dabade (2019)** [15] The shop floor of each industry has several stations, working interdependent to carried out specified tasks, as per the schedule define to meet the production rate. The breakdown of machine, shortage of inventory, unavailability of tools causes delay to meet the demand. The excess inventory at workstation catches rust requires regrinding, fatigue to operator due to unnecessary movement, improper design of pallet, incorrect location of clamps are some of example consumes time at workstation and slower production rate. The fabrication line of global boom has considered for improvement and to increase production rate to satisfy the customer demand. This fabrication line is able to produce 12 global booms per day. This rate of production is inadequate to satisfy actual customer demand of 15 global booms per day. The efficiency of fabrication line has proposed to increases to meet actual demand. Value stream mapping is the only lean tool suggested in literatures, to eliminate Muda, bottlenecks across production line.

**Seyed Mojib Zahraee, Ali tolooie (2021)** [16] Manufacturing companies implement lean manufacturing (LM) tools to keep their competitiveness over their competitors by improving the manufacturing system's productivity. Value Stream Mapping (VSM) is a critical tool for implementing the lean approach, and it can be used to many sectors in industry. The paper aims to implement the VSM approach along with computer simulation for identification and elimination of wastes in a small-scale Heater industry by using lean principles and time-frame formulation through takt time calculation. Based on the future VSM improvements, results showed that production lead time (PLT) reduced from 17.5 days to 11 days, and the value-added time decreased from 3412 seconds to 2415 seconds.

**Adwait Deshkar ,Saily Kamle(2018)** [17] The paper principally aims to implement the emerging trend of making an organization 'lean', in a small scale industry. A Lean manufacturing framework is developed using value stream mapping for a plastic bags manufacturing unit. It consists of mapping the current process of the industry and evaluating the same to identify wastes and bottleneck processes. Based on the 7 wastes of lean manufacturing, solutions are suggested to remove the wastes identified. A future state map based on suggested solutions is created. Both current and future state map are simulated and analyzed for different attributes such as TAKT times, production lead times, processing time to evaluate the overall gain achieved by using value stream mapping. Simulation results predicted a reduction in TAKT time from 46 minutes to 26.6 minutes.

**Karen Y. Ferreira Garc-a, Jorge de la Riva Rodriguez (2019)** [18] To verify the tolerance resulting from the methodology proposed in this article, the AT were determined using the ILO tables (1977) under the following premises: all operators work standing up and operators A, B, and C are women, for whom allowances consist of 7% for personal needs + 4% for fatigue + 4% for working standing giving a total of 15%. Worker D is male and his activities involve the use of force (packaging), so his tolerance turns out to be 5% personal needs + 4% for fatigue + 2% for working standing + 3% for lifting or use of force giving a total of 14%. Following the same arguments mentioned above, a single value is used for the four operators,which is 15%; this percentage exceeds by 8.7% the current value used in the company.

**Nor Azian Abdul Rahmana, Sariwati Mohd Sharif (2013)** [19] KANBAN system is one of the tools under lean manufacturing system that can achieve minimum inventory at any one time. KANBAN system provides many advantages in managing operations and business in the organization. Using KANBAN system is a strategic operational decision to be used in the production lines. It helps to improve the company's productivity and at the same time minimize waste in production. The KANBAN system requires production only when the demand of products is available. Manufacturing companies especially in Japan have implemented KANBAN system successfully as this system originates from this country. However, it was found that not all companies in Malaysia, particularly, among the small and medium enterprises (SME) in manufacturing sector, are deploying the KANBAN system.

**Satish Tyagi, Alok Choudhary(2014)** [20] This research discusses the objective and associated problems with product development process for a case study unit of a Gas Turbine manufacturer. Drawing from the experiences and best practices of reviewed case study, the practical strategies are described to improve product development performance achieving lean goals such as improved quality, reduced waste and shortened PD lead-time. Specifically, Value Stream Mapping based method is used to develop the current state map in order to find the wastes in the process and action plan to eliminate all the wastes to reach the future (better) state. In order to develop the current state, a Gemba walk is done in order to find the most complex and lengthy lead-time process targeted for improvement.

**Vikram M. Patil, S. G. Bhatwadekar(2015)** [21] By controlling WIP inventory fewer than 66% and reducing production lead time by 3 days 4.2 hr in time span of quarter year, we can say VSM is effective way to control the inventory and reduce lead time by implementing modifications in the existing manufacturing conditions. VSM deals with overall, integrated optimization of enterprise processes at every level.

**Praveen Saraswat , Deepak Kumar(2015)** [22] This research study describes how the value mapping can be used to visualize graphically the flow of material and flow of information from customer order to finish product. With this approach (VSM) wastes in the company can be reduced. The measure of success of value stream mapping in this research was address on how one could reduce the wastes identified through the value stream mapping. The results indicate that TEI should be incorporate production KANBAN, pull system and supermarket wherever possible according to the customer satisfaction.

**Muhammad Abdus Samad, MD. SaifulAlam(2013)** [23] Value Stream Mapping (VSM) is a visualization tool oriented to the Toyota version of Lean manufacturing (Toyota Production System). It helps people to understand and streamline work processes and then apply certain specifictools and techniques of the Toyota Production System.The value stream mapping process will likely reveal that a significant amount of non-value-added activities are present in your current processes. These activities consume financial and human resources and make longer lead-time without adding value. However, some of these activities are really necessary in the process; therefore the idea is to minimize their impact.

**Christos Chatzopoulos, Alexander Tsigkas(2009)** [24] The Lean Flow product generator will be a tool that customizes the lean-flow for a large variety of industries. This paper presents basic concepts of such a configurator or product generator based on a Lean-Flow flexible system. A correlation approach of the conventional costing and the lead-time and the degree of customization is illustrated below. The Y axis presents the inventory cost and the X axis presents the lead-time. When the lead-time of a product is short for the internal supply chain, the inventory cost of the components of this product is high and the opposite.

**Ahmad Naufal, Ahmed Jaffar (2012)** [25] To ensure that manufacturing process is able to meet demand, KANBAN calculation was carried out. It was started with Production Instruction KANBAN (PIK) calculation and then followed by Production Withdrawal KANBAN (PWK) calculation. All parameter like cycle time, change over time, available time, number of working days, part variant and container capacity were taken into account to determine optimum numbers of KANBAN, refer table 2 for optimum numbers of KANBAN in the system.

**Nirali Pandya, Pratik Kikani, G.D. Acharya (2012)** [26] From the literature reviewed it concluded that lean manufacturing techniques promise to enhance the productivity by reducing the parameters like lead time, inventory level, production cost and material usage and delivery to a noticeable extent and also it resulted in increased Quality. It also depicts that amongst the various mapping techniques analyzed, VSM is an approach which proves to be more suitable in complex working environments, which not only helps in identifying the wastes hindering the productivity but also helps one to identify the right lean tools to be used for the given situation.

**Mr. Chaitanya Kale, Mrs. Swati Vijay** [27] KANBAN card is a carrier of information between the customer and the supplier. It contains code number, part name, quality, supplier and customer. It is a method used to control the production and material flow to support the pull system. Manufacturing/Assembly is carried out only if the KANBAN card is present. The number of KANBAN cards is an indicator of Inventory levels. Through this KANBAN system researchers were able to provide control methods for achieving optimization of material flow. This has ensured the optimised delivery performance and material availability at right time, right place and in a right quantity. It is possible to divide work into small value adding increments that can be independently scheduled. The rate of delivery of customer valued work into production. And for this two major variables which regulates the Throughput those are; WIP (Work In Progress) and

Cycle Time.

**Sharif, S. M., & Esa, M. M. (2013)** [28] In conclusion, the Kanban system implemented in this manufacturing company was found to be adequate due to the many benefits such as the operational costs, wastes, scraps and losses were minimized, over production stocks were controlled with flexible work stations. The factors that hinder SME companies from implementing the Kanban system are identified as ineffective inventory management, lack of supplier participation, lack of quality improvements and quality control and lack of employee participation and top management commitment.

**Yusoff, N. B., & Halim, N. H. B. A. (2013)** [29] the result after kanban system implementation is discussed. The case study results have been evaluated using lean metric parameter. Three lean metrics has been identified which are manufacturing lead time, inventory level and space of inventory. A comparison between two conditions was carried out to validate if the manufacturing performance had improved or deteriorated.

**Chaple, A. P., Narkhede, B. E., & Akarte, M. M. (2014)** [30] The main focus of lean manufacturing is to eliminate waste, doing things better in half of the resources as mass production requires, providing higher quality with lesser cost. More and more facets of lean manufacturing will come forth as researchers are keenly bringing through continual research. The good understanding of lean principles and practices is required for successful implementation of lean as lean practices without knowing lean principles can give short term success but may fail as long term strategy. The paper tried to present best way for lean implementation available in literature along with discussion that lean is applied successfully in different sectors than automobile sector such as service sector, discrete manufacturing, etc.

**Kouri, I. A., Salmimaa, T. J., & Vilpola, I. H. (2008)** [31] The study suggest that the most of the original kanban ideas should be followed while planning an electronic kanban system. However an electronic kanban system gives possibilities to solve some of the limitations of kanban system, like the model mix change management and failure recovery. The support for continuous improvement should be build into system to achieve the effectiveness of original kanban and JIT-ideas.

**Bhat, R. R., & Shetty, R. R. (2013)** [32] the various mapping techniques analyzed, VSM is an approach proves to be more suitable in complex working environments, which not only helps in identifying the wastes hindering the productivity but also helps one to identify the right lean tools to be used for the given situation.

**Lei, H., Ganjeizadeh, F., Jayachandran, P. K., & Ozcan, P. (2017)** [33] order to compare the effectiveness of Kanban versus Scrum on software projects, a survey was designed to include various questions about the company, software projects, project management methodology, implementation, and project feedback. Mean, standard deviation, and correlation results were computed to compare the effects that Scrum and Kanban have on the factors.

**Tregubov, A., & Lane, J. A. (2015)** [34] the team Kanban board is an abstract concept that aggregates a list of resources and a list of related WIs.

The purpose of Kanban boards is to provide visibility of work in progress. The network in the model has all three major levels: Executive-Stakeholder Management level, Systems Engineering level and Product/Domain Engineering level.

**Urnauer, C., Kaiser, J., Gunkel, M., & Metternich, J. (2019)** [35] The value stream method (VSM) is a well-accepted method for analyzing and designing value streams in order to reduce waste. The goal of value stream analysis (VSA) is in mapping an existing value stream (current state) in the most transparent way to identify potentials for an improved flow of production. VSD describes the design process towards a new ideal state.

**Lugert, A., Völker, K., & Winkler, H. (2018) [**36] Manufacturing enterprises are currently being faced with wide-ranging changes. So far, VSM has been successfully used to increase productivity and flexibility. However, a few weaknesses of the method becoming more apparent due to the influence of current trends require VSM to be developed further. Several approaches are to be found in the literature which all tackle only individual aspects but none of which provide an overall solution.

**Mudgal, D., Pagone, E., & Salonitis, K. (2020) [**37] This paper presents a systematic approach to develop a Value Stream Map in a Make-To-Order environment. The approach presented in the paper has added one more step to the traditional methodology to develop future value stream which helps in better analysis of data. The commonality analysis uses preliminary data from the commonality analysis.

**Adnan, A. N. B., Jaffar, A. B., Yusoff, N. B., & Halim, N. H. B. A. (2013) [**38] This paper presented a real industrial case study of kanban system implementation in manufacturing site. The research findings show that kanban system is essential in ensuring the success of Just In Time production and create smooth flow of part throughout manufacturing system. Systematic and full commitment in implementing kanban system is crucial in ensuring its effectiveness; ultimately meeting customer satisfaction. The implementation shows that lead time, in-process and finished goods inventory and also finished good area will certainly improve. Subsequently manufacturing pace will be controlled and synchronized with market demand. Therefore, it can be concluded that implementation of kanban system has improved manufacturing system and this should be part of the core task of JIT practitioner.

**Tardif, V., & Maaseidvaag, L. (2001) [**39] production control is to ensure that the right inventory and work in process(WIP) is present in order to meet customer demand. A common approach to simplify the flow of material in a manufacturing system is to aggregate process operations into a number of stages.

**Sugimori, Y., Kusunoki, K., Cho, F., & UCHIKAWA, S. (1977)** [40] In the Kanban System, a form of order card called Kanban is used. These come in two kinds, one of which is called' conveyance Kanban ' that is carried when going from one process to the preceding process. The other is called 'production Kanban' and is used to order production of the portion withdrawn by the subsequent process.

## 2.4 LITERATURE SUMMARY

- VSM is the main Lean Manufacturing tool.
- VSM can be described as the set of Value Adding (VA) and Non-Value Adding (NVA) activities needed to take products through all of the essential flows, from raw materials to customers.
- VSM is a valuable tool to identify waste and opportunities for value improvement.

## 2.5 BRIEF DESCRIPTION OF INDUSTRIAL UNIT

Founded by Mr. Gorecha Brothers on the bases of passion for innovative engineering designing with strong experience in the casting and manufacturing industry, Gorecha Metal tech is a professionally managed firm catering its services in CAD/CAM with VMC, Investment Casting Molds & Dies, Shell Molding Equipment, and Finished Precision Casting for last one and a half decade from the industrious city of Rajkot-Gujarat.

Their strength lies in their capacity to handle complex jobs for diverse applications from scratch. Due to years of experience in the casting industry combined with CAD/CAM today we are in the position to provide superior precision at relatively reasonable cost. Manned with a team of qualified as well as experienced design engineers, developers and skilled workers, we are a pioneer leader in our industry with in-house facility for all the above operations to handle local, national as well as international customers.

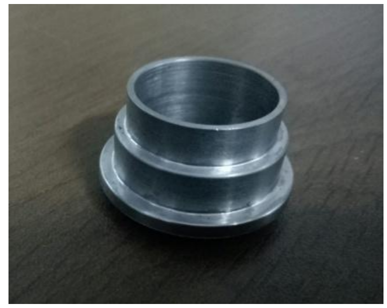
Company have well-built industrial infrastructure of 2800 sq. feet on Gondal Road in Rajkot City housing Design and Development Department as well as Tool Room in the same place.

The light machine shop has been divided into a few major sections as given below

- VMC machining: In this section VMC (milling) machines have been installed.
- CNC machining: In this section CNC machines, which are used, for various machining processes have been installed.
- Benching section: In this section light jobs like grinding / deburring of jobs by baby grinder are undertaken.
- Inspection and gauge room: In this section various gauging and inspection equipment's are there for measurement and inspection of various components being manufactured in the LMS.

Fig: 2.1 original photo of company

**Slotted Flange**



Bush

**Union Elbow**

EGR Elbow

Fig: 2.2 Types of Products

## 2.6 PROBLEM DEFINITION AND OBJECTIVE OF WORK

### Problem Definition

Gorecha metal tech pvt. Ltd manufactures various types of automotive parts. In this particular category Exhaust Gas Recirculating (EGR) Elbow is in high demand. Therefore, the challenge is to meet the demand of customers with the available machine and men's power. Other problems identified at the outset of the company should be addressed to meet customer needs. Problems such as inventory, slow production, waiting, high lead time.

**Objective of Work**

- To study current state process Time study and value stream map.
- To identify Work station, where wastes is generated.
- To apply FIFO and KANBAN in process to reduce waste.
- To create future state process value stream map with improvement.

## 2.7 PROJECT BOUNDARY

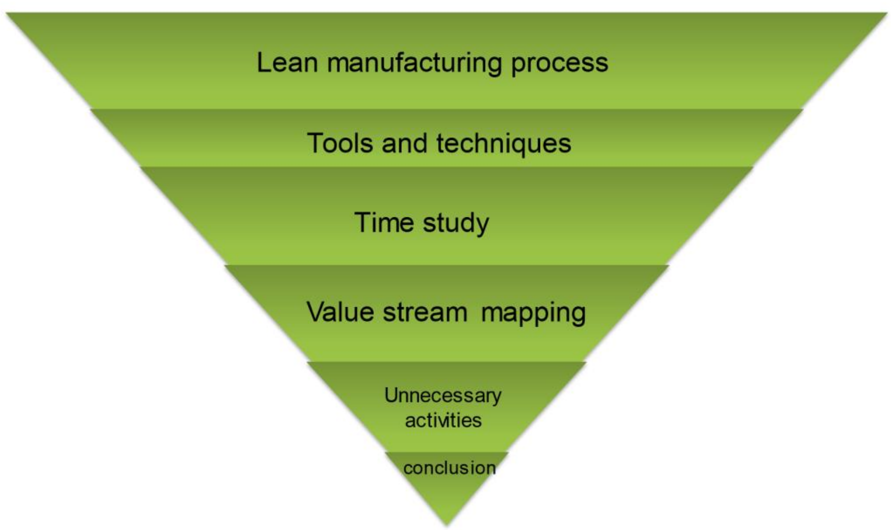



Fig: 2.3 project boundary

# CHAPTER: - 3
# METHODOLGY

This methodology is used for lean implementation with the help of value stream mapping.

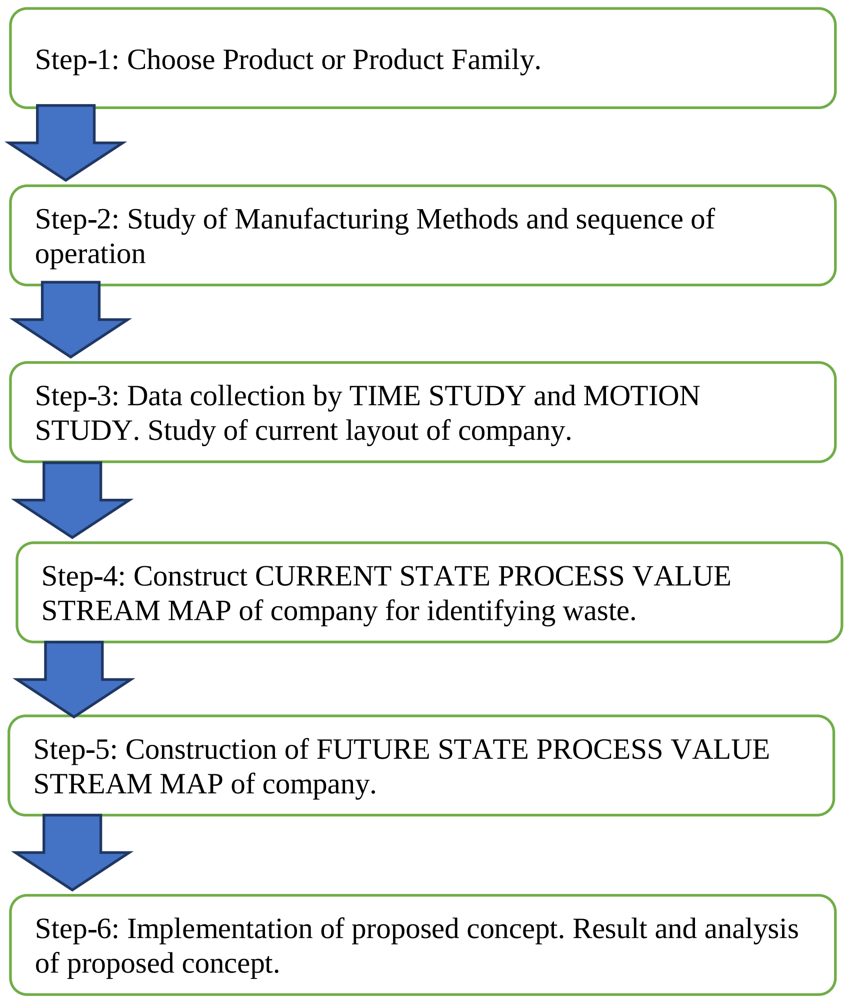



Fig-3.1 Methodology

## 3.1 CHOOSE THE PRODUCT OR PRODUCT FAMILY

In **Gorecha Metal Tech** the bases of passion for innovative engineering designing with strong experience in the casting and manufacturing industry, Gorecha Metal tech is a professionally managed firm catering its services in CAD/CAM with VMC, Investment Casting Molds & Dies, Shell Molding Equipment, and Finished Precision Casting for last one and a half decade from the industrious city of Rajkot-Gujarat.

Fig 3.2 EGR Elbow

## 3.2STUDY OF MANUFACTURING METHOD AND SEQUENCE OF OPERATION

**Gorecha Metal Tech** receive readymade casting from supplier. The casting of EGR elbow made in Gorecha metal unit-2. This EGR elbow is complex part. These EGR elbow used in jeep compass vehicle and volvo commercial vehicle. They supply these EGR elbow to martor supplier. In **Gorecha Metal Tech** various machining processes are done on EGR elbow. EGR elbow is complex part so there are no of machining operation done on EGR elbow.

### 3.2.1 Sequence of operation for EGR elbow

- Debarring
- Face Turning
- Outside Diameter(OD) & Inner Diameter(ID) Turning
- Drilling
- VMC Boring
- Threading
- Slotting
- PCD Hole Drilling
- Washing
- Oil dipping

After these all-machining processes, EGR elbow is ready to deliver to the customer.

## 3.3 DATA COLLECTION BY TIME AND MOTION STUDY

A time and motion study is a business efficiency technique combining the Time Study work of Frederick Winslow Taylor with the Motion Study work of Frank and Lillian Gilbreth (not to be confused with their son, best known through the biographical 1950 film and book Cheaper by the Dozen). It is a major part of scientific management. After its first introduction, time study developed in the direction of establishing standard times, while motion study evolved into a technique for improving work methods.

Time Study is a direct and continuous observation of a task, using a timekeeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera) to record the time taken to accomplish a task and it is often used when:

- there are repetitive work cycles of short to long duration,
- wide variety of dissimilar work is performed, or
- Process control elements constitute a part of the cycle.


Fig 3.3 Digital Stop Watch

This is a digital stop watch which is use for time study and motion study. There is various equipment like mechanical stop watch, electronic stop watch, computer assisted stop watch etc used in these days.

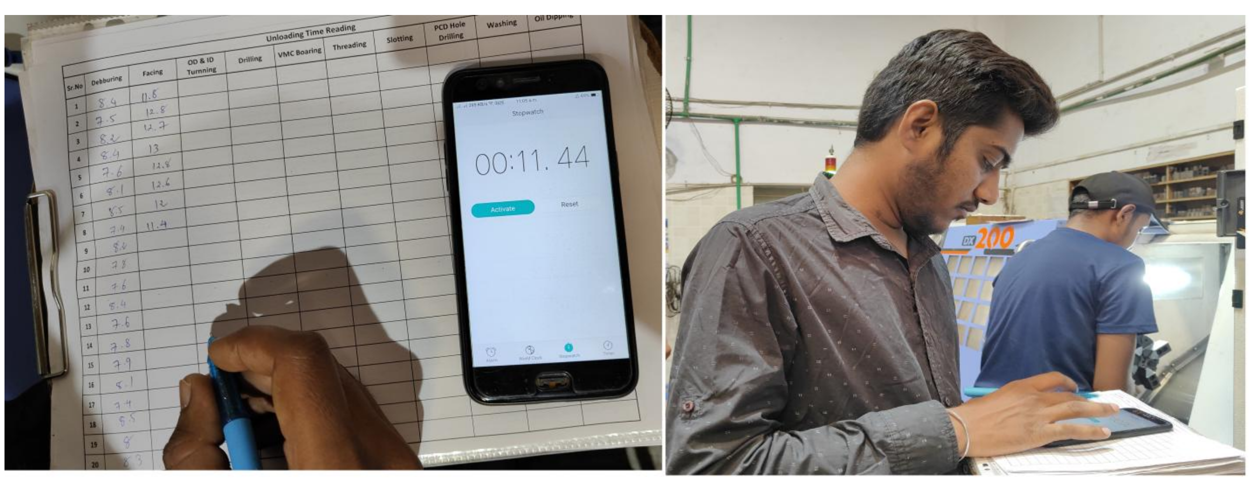



Fig 3.4 Stop Watch Reading

Table 3.1 observe time of loading

| Observe Time of loading | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sr. no | Types of operation | | | | | | | | | |
| | Debarring (S) | Facing (S) | OD & ID Turning (s) | Drilling (s) | VMC Boring (s) | Threading (s) | Slotting (s) | PCD Hole Drilling (s) | Washing (s) | Oil Dipping (s) |
| 1 | 6.8 | 10 | 14 | 18 | 15.2 | 9.9 | 12.5 | 17.5 | 12.7 | 5.5 |
| 2 | 7.1 | 11 | 13.5 | 17.8 | 14.8 | 10.2 | 12.8 | 18.8 | 13.2 | 4.8 |
| 3 | 8 | 9.8 | 14.8 | 18.2 | 15.2 | 9.5 | 13 | 16.9 | 12.6 | 5.2 |
| 4 | 6.5 | 10.5 | 13.8 | 17.6 | 14 | 10.5 | 13.4 | 18.4 | 13.4 | 4.7 |
| 5 | 7 | 11.5 | 14 | 18.4 | 14.6 | 9.8 | 12.9 | 17 | 12.8 | 5.1 |
| 6 | 5.8 | 9.9 | 14.2 | 17.5 | 15.35 | 10.2 | 13.1 | 18.2 | 13.1 | 4.6 |
| 7 | 6 | 10.2 | 13.8 | 17.9 | 15.1 | 11 | 12.6 | 17.9 | 12.8 | 5.6 |
| 8 | 6.2 | 10 | 14.6 | 16.8 | 16.3 | 10 | 13 | 18.4 | 12.4 | 4.5 |
| 9 | 6.4 | 10.2 | 14 | 17.6 | 14.7 | 9 | 12.9 | 17.5 | 12.9 | 5.8 |
| 10 | 5.9 | 9.6 | 14.1 | 17.5 | 15.5 | 9.8 | 13.2 | 17.8 | 13.5 | 4.9 |
| 11 | 6.9 | 9 | 14.8 | 18.5 | 15 | 10.1 | 13.4 | 18.4 | 12.5 | 4.78 |
| 12 | 8 | 10.55 | 13.9 | 18.2 | 15.3 | 9.86 | 12.8 | 17.9 | 12.4 | 5.3 |
| 13 | 6.7 | 10.4 | 13.4 | 17 | 14.8 | 10 | 13.2 | 18.4 | 1.7 | 4.8 |
| 14 | 6.6 | 11 | 14 | 17.9 | 15.9 | 11 | 12.4 | 18 | 12.7 | 5 |
| 15 | 7 | 11.2 | 14.2 | 18.5 | 14.88 | 10.5 | 13.4 | 18.1 | 12 | 5.6 |
| 16 | 6.1 | 9 | 14.1 | 18.4 | 15.68 | 10.2 | 13 | 17.9 | 12.6 | 4.9 |
| 17 | 7.4 | 8.5 | 14.05 | 18 | 15.42 | 9.7 | 13.6 | 18.2 | 12 | 5.4 |
| 18 | 7.4 | 10.8 | 13.85 | 17.9 | 15 | 9.68 | 12.5 | 17.84 | 12.7 | 4.6 |
| 19 | 6 | 10.56 | 13.7 | 17 | 14.85 | 9.8 | 13 | 18.3 | 12.5 | 5.4 |
| 20 | 6.7 | 9.54 | 13.9 | 18.4 | 15.4 | 10.1 | 13.4 | 18 | 13.4 | 4.87 |
| | | | | | | | | | | |
| **Average** | 6.7 | 10.2 | 14 | 17.9 | 15.1 | 10 | 13 | 18 | 12.2 | 5.1 |
| **round off** | 7 | 10 | 14 | 18 | 15 | 10 | 13 | 18 | 12 | 5 |

The upper table shows a observe time of loading by using stop watch. A collected data of 20 times loading in all operation and this all reading observe on a all operations.

Table 3.2 observe time of unloading

| Observe Time of Unloading | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Types of operation | | | | | | | | | |
| Sr. no | Debarring (S) | Facing (S) | OD & ID Turning (s) | Drilling (s) | VMC Boring (s) | Threading (s) | Slotting (s) | PCD Hole Drilling (s) | Washing (s) | Oil Dipping (s) |
| 1 | 8.4 | 11.8 | 15.4 | 23.8 | 21.8 | 14.5 | 9.7 | 13.8 | 12.8 | 5.3 |
| 2 | 7.5 | 12.8 | 16.5 | 24.6 | 22.4 | 13.8 | 10.2 | 14.2 | 13.1 | 4.9 |
| 3 | 8.2 | 12.7 | 15.8 | 23.8 | 20 | 13.6 | 9 | 13.7 | 12.9 | 5.4 |
| 4 | 8.4 | 13 | 16.3 | 24.6 | 22.9 | 14.2 | 10.4 | 14.3 | 12.7 | 4.9 |
| 5 | 7.6 | 12.8 | 15.9 | 24.6 | 20.4 | 13.9 | 9.5 | 14 | 13.4 | 5.1 |
| 6 | 8.1 | 12.6 | 15.1 | 23.5 | 21.6 | 14.4 | 10.3 | 14.7 | 12.7 | 4.6 |
| 7 | 8.5 | 12 | 16.1 | 24.3 | 22 | 13.8 | 10.5 | 13.5 | 13.2 | 5.3 |
| 8 | 7.4 | 11.4 | 16 | 24.1 | 21.4 | 13.4 | 10.1 | 14.3 | 12.8 | 4.8 |
| 9 | 8.2 | 11 | 16.2 | 24 | 22.3 | 14.6 | 10 | 13.8 | 13.1 | 5.4 |
| 10 | 7.8 | 11.8 | 16.4 | 23.9 | 20.8 | 14 | 9.7 | 14.1 | 12.9 | 4.95 |
| 11 | 7.6 | 11.6 | 15.8 | 24.3 | 21.9 | 14.2 | 9.88 | 13.9 | 13 | 5.2 |
| 12 | 8.4 | 11.8 | 16.9 | 23.7 | 22.5 | 13.8 | 10.4 | 14.2 | 12.1 | 4.86 |
| 13 | 7.6 | 11.8 | 15.7 | 24.6 | 22.4 | 14.5 | 10.3 | 13.8 | 12.9 | 5 |
| 14 | 7.8 | 11.7 | 16.8 | 23.8 | 22.8 | 13.6 | 9.6 | 14.1 | 13 | 4.7 |
| 15 | 7.9 | 11.2 | 15.8 | 24.7 | 22.5 | 13.9 | 10.2 | 13.9 | 13.5 | 5.9 |
| 16 | 8.1 | 11.9 | 15.2 | 23.7 | 22 | 14 | 9.8 | 14.3 | 12.9 | 4.9 |
| 17 | 7.4 | 12 | 16.3 | 24.9 | 22.6 | 13.8 | 11 | 13.8 | 13.4 | 5.2 |
| 18 | 8.5 | 12.3 | 16.7 | 22 | 22.4 | 13.76 | 10.6 | 14.3 | 12.8 | 5.1 |
| 19 | 8 | 12.1 | 15.2 | 23.8 | 22.5 | 14.1 | 9.9 | 13.8 | 13.8 | 4..8 |
| 20 | 8.3 | 11.9 | 15.9 | 24.7 | 21.9 | 13.9 | 10.2 | 14.3 | 12.7 | 5.3 |
| | | | | | | | | | | |
| **Average** | 7.99 | 12.01 | 16 | 24.07 | 21.96 | 13.99 | 10.06 | 14.04 | 12.99 | 5.1 |
| **Round off** | 8 | 12 | 16 | 24 | 22 | 14 | 10 | 14 | 13 | 5 |

The upper table shows a observe time of unloading . A collected data of 20 times loading in all operation and this all reading observe on a all operations.

Table 3.3 observe time study sheet

| Time Study Top Sheet | |
|---|---|
| **Department:** Mechanical Production |  |
| **Plant/Machine:** Gorecha Metal Tech | |
| **Customer :** Martor Industry | |
| **Product/Part :** EGR Elbow | |
| **DWG No.:** 352316/rev.no 03 | |
| **Material:** Mild steel | |

| Sr. no | Element Description | W.R | | | |
|---|---|---|---|---|---|
| | | L.T | O.T | U.T | T.W.R |
| 1 | Debarring | 7 | 25.3 | 8 | 40.3 |
| 2 | Facing | 10 | 33 | 12 | 55 |
| 3 | Outer & inner Diameter Turning | 14 | 54 | 16 | 84 |
| 4 | Drilling | 18 | 60 | 24 | 102 |
| 5 | VMC Boring | 15 | 32.4 | 22 | 69.4 |
| 6 | Threading | 10 | 35 | 14 | 59 |
| 7 | Slotting | 13 | 29.6 | 10 | 52.6 |
| 8 | PCD Hole Drilling | 18 | 51 | 14 | 83 |
| 9 | Washing | 12 | 40 | 13 | 65 |
| 10 | Oil Dipping | 5 | 15 | 5 | 25 |

**Note**: L.T = Loading Time O.P = Operation time Total Time Taken: 10.57 minutes

U.T = Unloading time T.W.R = Total watch reading Unit: All Time Digit are in Second

### 3.3.1. Standard Time

Standard time is the time allowed to an operator to carry out the specified task under the specified condition and defined level of performance.This is a standard definition for standard time.Some additional time is added to the basic time to arrive standard time of a task.In practice, none can work throughout the day without taking rest. Operators need time for relaxation from work.

Standard Time = Basic Time + Allowances

The basic constituents of standard time are shown in the following figure.

This figure shows how standard time is made up of the observed time and basic time of a job.

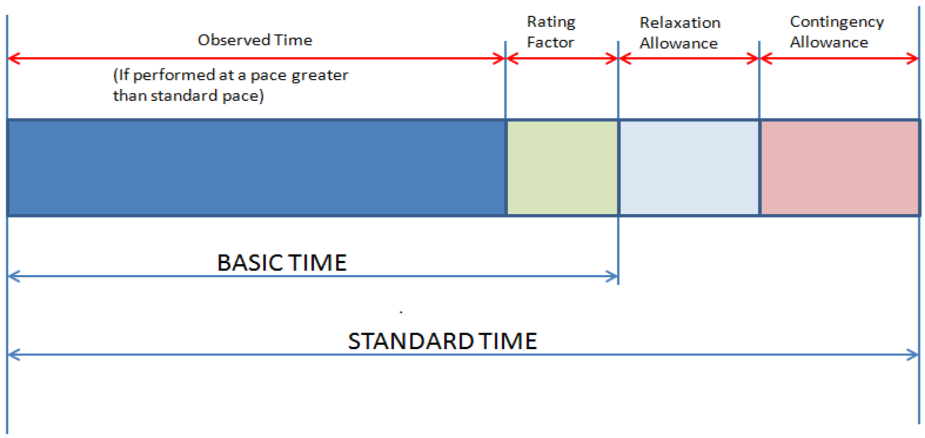



Fig: 3.5 formula of standard time **[I]**

Table 3.4 speed rating calculation

| speed rating calculation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| process | cycle time(s) | production per hour (Nos) | actual production per hour (Nos) | | | | average production | change in % | speed rating |
| Debarring | 40.3 | 89 | 95 | 90 | 94 | 88 | 91.75 | 2.71% | 102.71% |
| Facing | 55 | 65 | 60 | 58 | 62 | 64 | 61.00 | -6.81% | 93.19% |
| Outer & inner Diameter Turning | 84 | 42 | 44 | 47 | 41 | 40 | 43.00 | 0.33% | 100.33% |
| Drilling | 102 | 35 | 32 | 31 | 32 | 30 | 31.25 | -11.46% | 88.54% |
| VMC Boring | 69.4 | 51 | 48 | 45 | 43 | 47 | 45.75 | -11.80% | 88.20% |
| Threading | 59 | 61 | 57 | 60 | 54 | 58 | 57.25 | -6.17% | 93.83% |
| Slotting | 52.6 | 68 | 71 | 74 | 72 | 75 | 73 | 6.66% | 106.66% |
| PCD Hole Drilling | 83 | 43 | 40 | 39 | 40 | 40 | 39.75 | -8.35% | 91.65% |
| Washing | 65 | 55 | 60 | 61 | 61 | 60 | 60.5 | 9.24% | 109.24% |
| Oil Dipping | 25 | 144 | 130 | 132 | 135 | 131 | 132 | -8.33% | 91.67% |

This table is show that a speed rating of a operator at a different operations and its come from 4 hours data calculation from the production department and than after calculate the speed rating of operators.

Table 3.5 standard time calculation

| standard time calculation | | | | | | |
|---|---|---|---|---|---|---|
| sr no | process | observe time (s) | speed rating | basic time (s) | Allowance | standard time (s) |
| 1 | Debarring | 40.3 | 102.71% | 41.39 | 19% | 41.58 |
| 2 | Facing | 55 | 93.19% | 51.26 | 19% | 51.45 |
| 3 | Outer & inner Diameter Turning | 84 | 100.33% | 84.28 | 19% | 84.47 |
| 4 | Drilling | 102 | 88.54% | 90.31 | 19% | 90.50 |
| 5 | VMC Boring | 69.4 | 88.20% | 61.21 | 19% | 61.40 |
| 6 | Threading | 59 | 93.83% | 55.36 | 19% | 55.55 |
| 7 | Slotting | 52.6 | 106.66% | 56.10 | 19% | 56.29 |
| 8 | PCD Hole Drilling | 83 | 91.65% | 76.07 | 19% | 76.26 |
| 9 | Washing | 65 | 109.24% | 71.00 | 19% | 71.19 |
| 10 | Oil Dipping | 25 | 91.67% | 22.92 | 19% | 23.11 |
| allowance=international labour office recommended allowance | | | | | | |
| Basic time =o.t*speed rating | | | | | | |
| standard time = basic Time+ total Allowance | | | | | | |
| All Time in second | | | | | | |

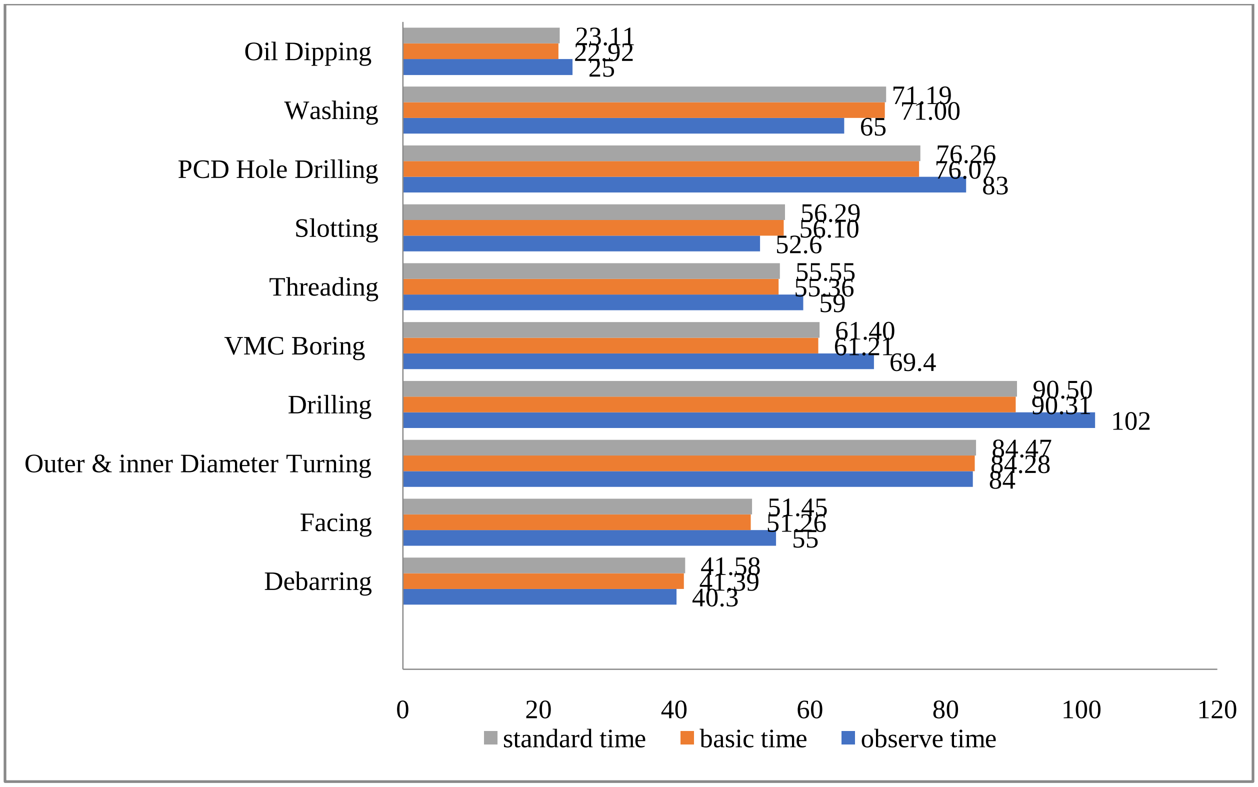



Fig: 3.6 time chart

following conclusion can be drawn from the chart.

Observed Time may be greater or lower than Basic Time. Basic Time is always lower than Standard Time. To set Standard Time of a job you must add allowances to Basic Time (normal time).

## 3.4. PROCEDURE FOR FLOW PROCESS CHART

1.Identify the process to be charted and the objective for charting it.

2. Identify the symbol set to be used.

3. Record the step of the process as it happens, starting at the top of the page, with symbols on the left overlaying a vertical line with appropriate notes about what is happening to the right. Try to record significant activities

which are generally of approximately equal size (unless the problem is at the detail level, do not try to capture too much detail).You can also make the diagram more useful by such tricks as numbering the different action types in sequence (for example so you can see how many times the item under examination was moved) and changing the direction of movement arrows to show input or output activity.

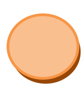
You can also put the time taken in each activity to the left of the symbol.

4. If you are watching the process as it happens, you may want to repeat the analysis several times to ensure you have captured the normal chain of events.

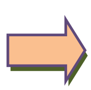
5. Analysis the final chart, for example total times taken in non-value-adding activities such as storage, movement and inspection.

## 3.5. PROCESS CHART SYMBOL

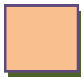
The American Society of Mechanical Engineers (ASME) has established the five standard symbols are described As follows:

**Operation** 

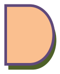
An operation occurs when an object is intentionally changed in one or more of its Characteristics. An operation represents a major step in the process and usually occurs at a machine or work station.

**Transportation** 

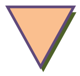
A transportation occurs when an object is moved from one place to another, except when the movement is an integral part of an operation or an inspection.

**Inspection** 

An inspection occurs when an object is examined for identification or is compare with a standard as to quantity or quality.

**Delay** 

A delay occurs when the immediate performance of the next planned action does not take place.

**Storage** 

Storage occurs when an object is kept under control such that its withdrawal requires authorization.

Table 3.6 Current state Flow process chart of Original Plant Layout

| Sr. No. | Description | Qty. | Distance In (m) | Time in Min. | ○ | ⇨ | D | □ | ▽ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Casting from Supplier | 1 | | | | | | | • |
| 2 | Move to machine Shop | 1 | 5 | 1.00 | | • | | | |
| 3 | Debarring | 1 | | | • | | | | |
| 4 | Move to facing | 1 | 3 | 0.63 | | • | | | |
| 5 | Inspection | 1 | | | | | | • | |
| 6 | Facing | 1 | | | • | | | | |
| 7 | Move to OD & ID | 1 | 1.5 | 0.46 | | • | | | |
| 8 | OD & ID Turning | 1 | | | • | | | | |
| 9 | Inspection | 1 | | | | | | • | |
| 10 | Move to Drilling | 1 | 7 | 1.81 | | • | | | |
| 11 | Drilling | 1 | | | • | | | | |
| 12 | Move to VMC Boring | 1 | 5 | 1.3 | | • | | | |
| 13 | VMC Boring | 1 | | | • | | | | |
| 14 | Move to Threading | 1 | 5.4 | 1 | | • | | | |
| 15 | Threading | 1 | | | • | | | | |
| 16 | Move to Slotting | 1 | 7 | 1.66 | | • | | | |
| 17 | Slotting | 1 | | | • | | | | |
| 18 | Move to PCD Hole Drilling | 1 | 1 | 0.53 | | • | | | |
| 19 | PCD Hole Drilling | 1 | | | • | | | | |
| 20 | Inspection | 1 | | | | | | • | |
| 21 | Move To Washing | 1 | 2.5 | 0.96 | | • | | | |
| 22 | Washing | 1 | | | • | | | | |
| 23 | Move to Oil Dipping | 1 | 2 | 0.78 | | • | | | |
| 24 | Oil Dipping | 1 | | | • | | | | |
| Total | | | 39.4 | 10.13 | 10 | 10 | 0 | 3 | 1 |

## 3.6. INTRODUCTION TO VALUE STREAM MAPPING

Lean manufacturing program is being followed by various industries in the recent year which mainly focuses on improving the efficiency of operations by reducing wastes. Value stream mapping is one of the tools of lean manufacturing. By value stream mapping we identify wastes occur in present production line. Industries which are wants to become lean for those types of industries value stream mapping is best way to implement lean manufacturing. Value stream mapping is powerful tool which highlights process inefficiencies as well as improvement guidance. Value stream mapping is combination of all actions value added as well as non value added. Value stream mapping shows material flow, information flow etc.

Value stream mapping is very helpful to lean implementation. Value stream mapping create road map for improvements in some areas. Value stream mapping is become bridge gap between existing state and future state. At present time every industry want to redesign and redefined production system to face demand and challenges of customer.

The value stream is the whole creation process for a product. The value stream starts at concept and ends at delivery to the customer. Every stage the product goes through should add value to the product, but often this is not the case. Mapping of the value stream aids the identification of value adding and non-value adding (i.e. waste) activities.

A value stream is all the actions (both value added and non-value added) presently required to bring a Product through the main flows necessary to every product: (a)the production flow from raw material into the hands of the customer, and (b) the design flow from concept to launch. Standard terminology, symbols, and improvement methods allows VSM to be used as a communication tool for both internal communication and sharing techniques and results with the larger lean community.

VSM is the process of visually mapping the flow of information and material as they are preparing a future state map with better methods and performance. It helps to visualize the station cycle times, inventory at each stage, manpower and information flow across the supply chain.

**Value adding activities:-**Machining, Processing, Painting, Assembling

**Non value adding activities:-**Scrapping, Sorting, Storing, Counting, Moving, Documentation etc.

Value stream mapping visually mapping material flow and information flow of current state. Then prepare future state with improvement and modification. Value stream mapping is help to map station cycle time, inventory, manpower requirement, distance to travelled etc.

Value stream mapping analyses and map the process in order to reduce waste. Purpose of Value stream mapping is used to identify wastes and highlight source of wastes. The aim of value stream mapping is eliminate these wastes and prepare future state value stream map which is more realistic view of company. In value stream mapping many different terminologies are used.

### 3.6.1. Terminologies used for value stream mapping

**Takt Time: -** Takt time is calculated by available working time per day (minutes or seconds) to customer demand per day (in relevant units)

$$\text{Takt time} = \frac{Avilable\ \ working\ \ time\ \ per\ \ day}{Customer\ \ demand\ \ per\ \ day}$$

**Production Lead Time: -** Lead time it means total time requires from raw material arrivals to finish goods deliver to customer.

**Value Adding Time: -** It is a time to require to perform some value adding activity like machining, Processing, assembling, painting.

**Current State Mapping: -** It shows the current position of production activity.

**Future State Mapping: -** It shows future position of production activity with improvement and modification.

**Kaizen: -** Kaizen is tool of lean manufacturing. Kaizen is used for continuous improvement in every process and every stage of industry.

### 3.6.2. value stream software:

To draw a value stream map or design there are many software like,

**-Smart Draw**

-MS-VISIO

-lean pilot

-flow breeze

Among which my work is on Smart Draw.

Using this software we can draw the any type of organization chart or business chart. Using various symbols we can draw the layouts. Value stream symbols are also in this software so using this symbol we can draw the current state map or future state map.

### 3.6.3. Symbols used in value stream mapping(vsm)

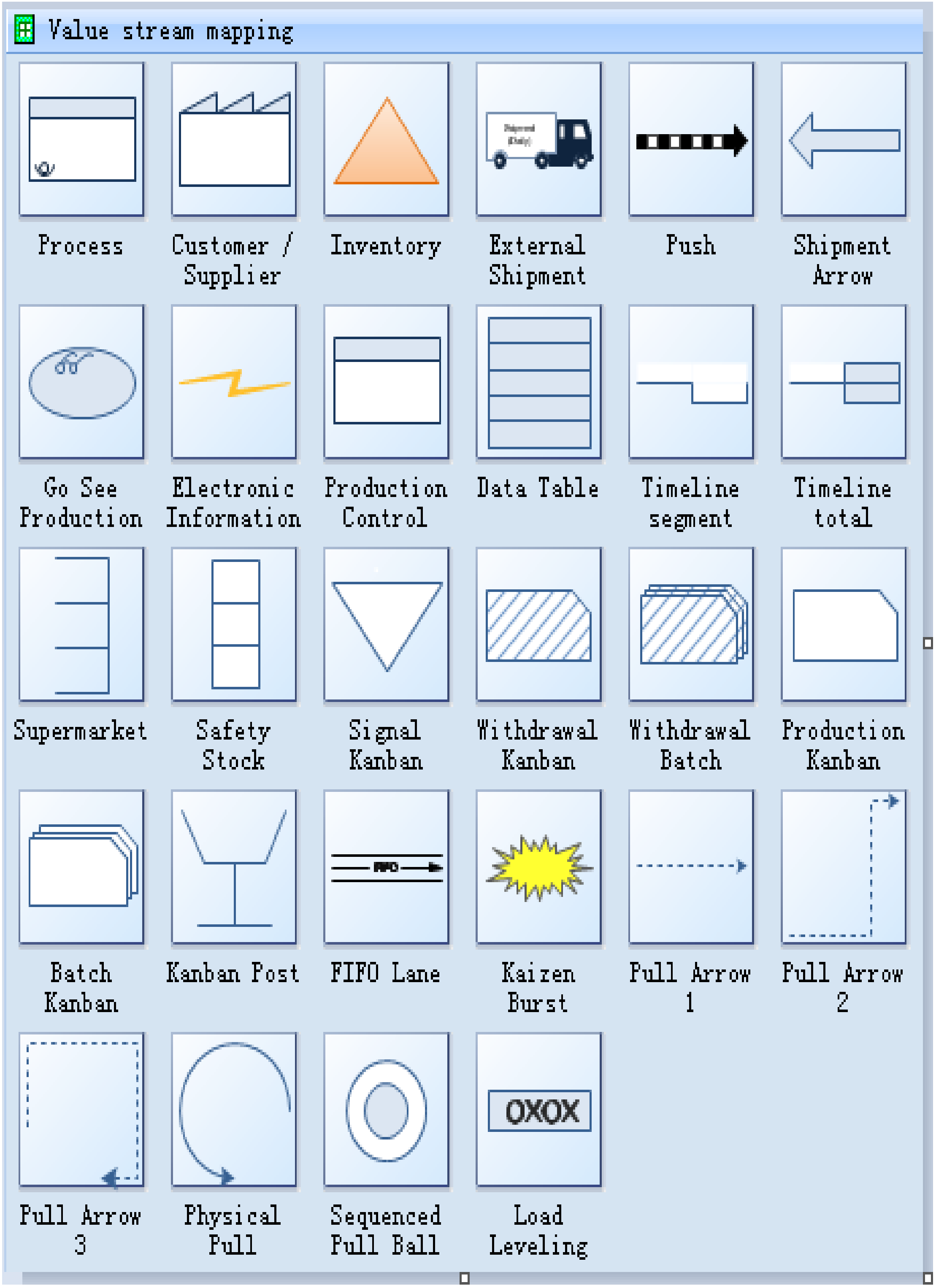



Fig:3.7 VSM Symbols

### 3.6.4. Methodology used for Value Stream Mapping

**Step1: -** Calculate the Takt time

**Step2: -** Under customer demand

In step2 we understand customer demand. Customer demand is 3500 pieces per month. Demand  is also in weekly or daily.

**Step3**: - Map the process flow

This **step** involves various processes to complete the product. In addition, measure relevant data to put in a value stream mapping box. Moreover, see the WIP between two processes.

**Step4** - Map the material flow

The flow of material from raw material to finished goods is given by supplier to customer.

**Step5**: - Map the information flow

The information flow provided demand information. Information are given by electronic or manually.

**Step6: -** Draw the time line

Calculate production lead times for inventory triangles by dividing quantity of inventory by the customer daily requirement.

### 3.6.5 Process steps

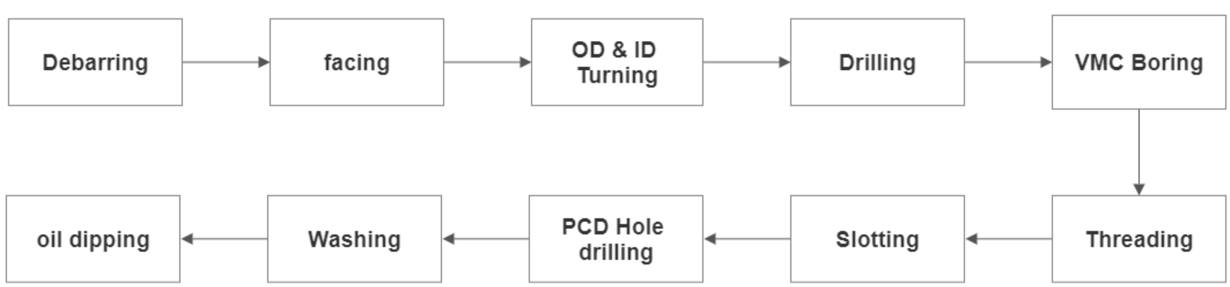



Fig:3.8-Process steps

### 3.6.6 Terminology and symbols and what they mean

With so much information packed into a VSM, it's no surprise that there are terms and features that may need some explanation. However, while we will provide an explanation of some of the standardized VSM features, keep in mind that they may be modified to help achieve specific objectives. As such, each value stream map may have some elements that are unique.

To start, each value stream map typically has three key sections. For example, Figure 1 above shows a simplified VSM for a software development lifecycle. Notice the three main colored sections. The colors were added to highlight the different sections of a VSM. These sections show Information Flow, Product Flow, and a Time Ladder or Lead Time Ladder.

**Information Flow**

This section shows the communication of process-related information and the transmission of data. In this simplified example, the release manager takes in all customer requests and submits only the approved requests into the development queue (Supplier). Depending on the objective or goal of the mapping exercise, information collection and distribution points shown here as SharePoint and Excel can include many levels of detail and many other integrated systems.

**Product Flow**

This section maps the steps of the development lifecycle from concept to delivery. However, depending on your objectives, this can be refocused on specific sections of the process, making it as granular, or as high level, as needed. It typically shows both the task being performed (blue boxes) and the person or team performing the task in the box immediately below it.

Below those boxes, you will notice smaller fields that show key process data. For the sake of simplification in this example, we've chosen to show only a couple of data figures. C/T represents "Cycle Time" and S/T represents "Set Up Time." In practical use, however, VSMs can include any number of data points in this section, highlighting pertinent information. The yellow triangles show the queue of features waiting at each stage of the process. The dotted arrows from one stage to the next are called "Push Arrows". They show where the product is being pushed from one stage to the next vs. being pulled.

**Time Ladder**

The Time Ladder provides a somewhat simplistic visual representation of the value stream timeline. The upper portion of the time ladder represents the average amount of time that a feature spends in the queue or waiting at each stage or gate in the process. The lower portion of the time ladder shows the average amount of time that each feature was actively being worked on, or more specifically when value is actually being added to the feature/product during that specific stage.

**Cycle time (C/T)**

Is the frequency of units/features produced or the average time between the completed production of one unit/feature to the completed production of the next. Using our scenario of feature development for an enterprise software solution, the cycle time is the average amount of time it takes from the completion/deployment of one feature request to the completion/deployment of the next.

**Setup Time (S/T)**

Is the amount of time needed to prepare for a given step. For application to software development, depending on the step, this can indicate the amount of time needed to understand what specifically is being requested or the time needed to configure, spin up, or allocate a test environment.

**Uptime (%)**

Gives you an idea of the percentage of the total time that the processes or systems are actually active. For our scenario, this can show system uptime or employee availability time.

**Lead Time**

Is the measurement of the average amount of time needed for one feature request to make it through the entire development cycle concept to delivery, or from the beginning to ending fence post.

**Takt Time**

Is a term that is commonly used with value stream mapping. It refers to the rate at which you need to produce your products in order to meet customer demand.

### 3.6.7 Planned operating time

Table 3.7-Planned operating time

| Total available time | | | | planned operating time | | | |
|---|---|---|---|---|---|---|---|
| **no. of shift(a)** | **hours/shift (b)** | **min/hours (c )** | **total time (min)** | **break time (min)** | **maintenance time (min))** | **rework time (min)** | **planned time in minute** |
| 2 | 12 | 60 | 1440 | 120 | 30 | 30 | 1260 |

### 3.6.8 calculation of customer TAKT time

For EGR valve,

Customer demand = 6000/month

No. of working Day =26

Planned time per day =1260 minutes

So,

Customer TAKT time = $\frac{\text{planned time* No. working Days}}{\text{Customer demand}}$

$= \frac{1260*26}{6000}$

Customer TAKT time=5.46 min

### 3.6.9 Input Data for current value stream mapping

Table 3.8 Input Data for current value stream mapping

| Process | No. of piece after process (Nos) | TAKT Time (min) | Time for process(min) | Cycle time (min) |
|---|---|---|---|---|
| Debarring | 818 | 5.46 | 630 | 0.69 |
| Facing | 623 | 5.46 | 630 | 0.86 |
| Outer & inner Diameter Turning | 379 | 5.46 | 630 | 1.41 |
| Drilling | 352 | 5.46 | 1260 | 1.51 |
| VMC Boring | 520 | 5.46 | 630 | 1.02 |
| Threading | 576 | 5.46 | 630 | 0.93 |
| Slotting | 570 | 5.46 | 630 | 0.94 |
| PCD Hole Drilling | 420 | 5.46 | 630 | 1.27 |
| Washing | 475 | 5.46 | 1260 | 1.19 |
| Oil Dipping | 1470 | 5.46 | 630 | 0.39 |

## 3.7. CURRENT STATE VALUE STREAM MAPPING

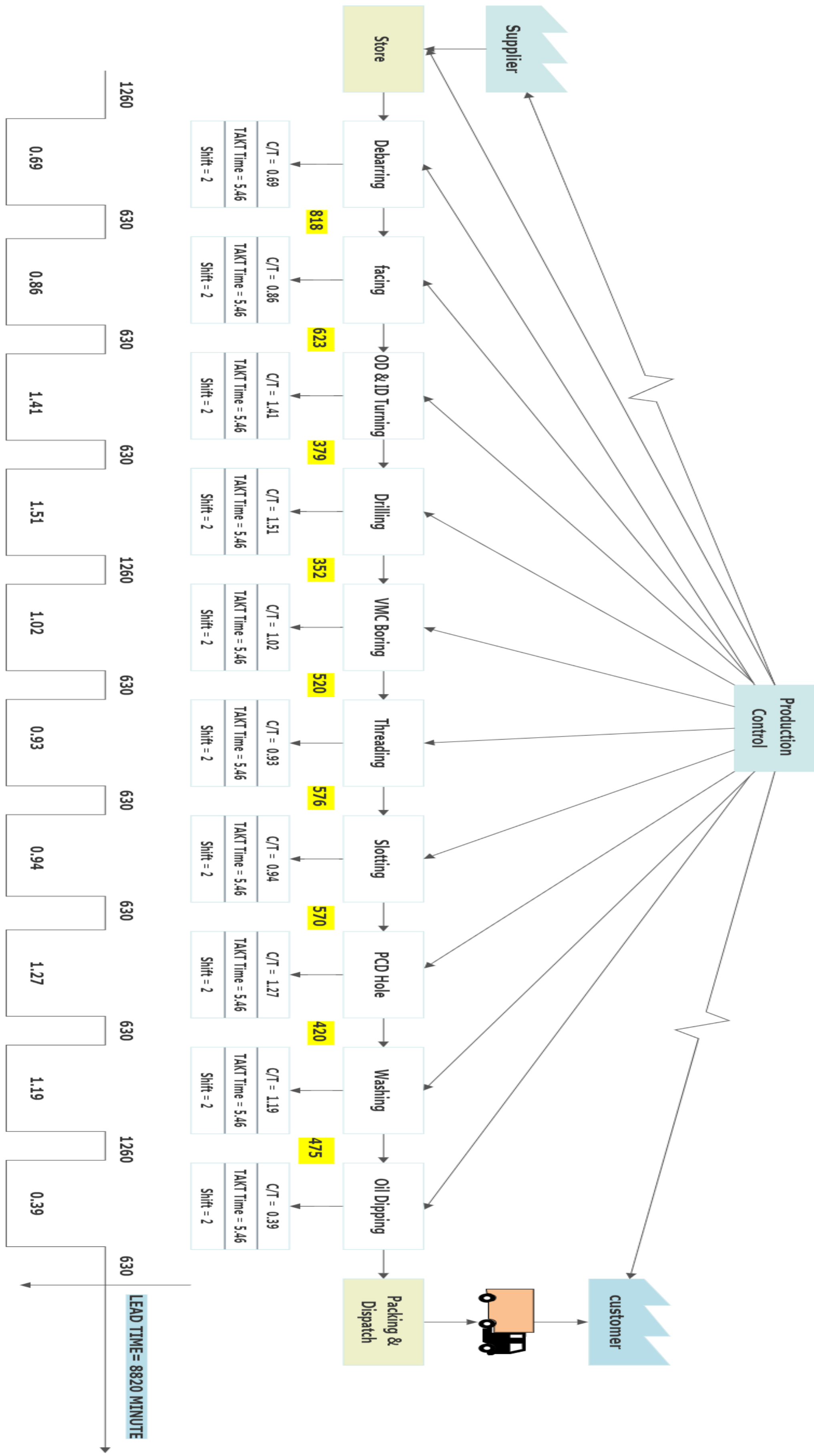



Fig:3.9-Current State Value stream mapping

Value stream map for EGR Elbow, shows the material and information flow, process data and also a time calculation. Based on this data calculate the Lead time for the current VSM.

**LEAD TIME** = 8820 minute

= 7 Days

So, lead time for current VSM is 7 Days.

# CHAPTER: -4
# Waste Identification & recommendation plan

## 4.1. INTRODUCTION

Value Stream Mapping is Lean tool which is used for identified the manufacturing waste from the production line. After the mapping of the current state of EGR Elbow production line find the type of manufacturing waste in the value stream which are discuss below.

## 4.2. IDENTIFICATION OF WASTES

There are basic seven types of waste which are generated in any organization i.e. transportation, waiting time, over production, over processing, defects. Out of some are also identified in EGR Elbow value stream map which are not adding value in the process and because of that lead time is increase. Below table shows the identified wastes.

Table 4.1- waste identification

| Types of waste | Value stream mapping | cause | Effect | Value stream design |
|---|---|---|---|---|
| Inventory | Identify WIP inventory between work station | Follow the push principle and not define the WIP stoke capacity | Much material handling is required | Introduce FIFO between each work station implement a KANBAN |
| Waiting Time | On a boring operation | Lake of stoke of parts | Lead time is increase because of waiting | Define a super market at a station which control by KANBAN |

From the above table get the non value adding activity because of Work in Process Inventory (WIP) and Waiting time.

### 4.2.1 Recommendation for Inventory

Because of the PUSH principle WIP is increased and it is required more handling time. The recommendation for eliminate the WIP is to material flow follow the PULL principle which work on the KANBAN.

Pareto analysis of WIP Inventory is shown below:

Table 4.2-WIP Percentage.

| PROCESS | WIP | percentage | Cumulative % |
|---|---|---|---|
| Debarring | 818 | 13% | 13% |
| Facing | 623 | 10% | 23% |
| Outer & inner Diameter Turning | 379 | 6% | 29% |
| Drilling | 352 | 6% | 35% |
| VMC Boring | 520 | 8% | 43% |
| Threading | 576 | 9% | 53% |
| Slotting | 570 | 9% | 62% |
| PCD Hole Drilling | 420 | 7% | 69% |
| Washing | 475 | 8% | 76% |
| Oil Dipping | 1470 | 24% | 100% |

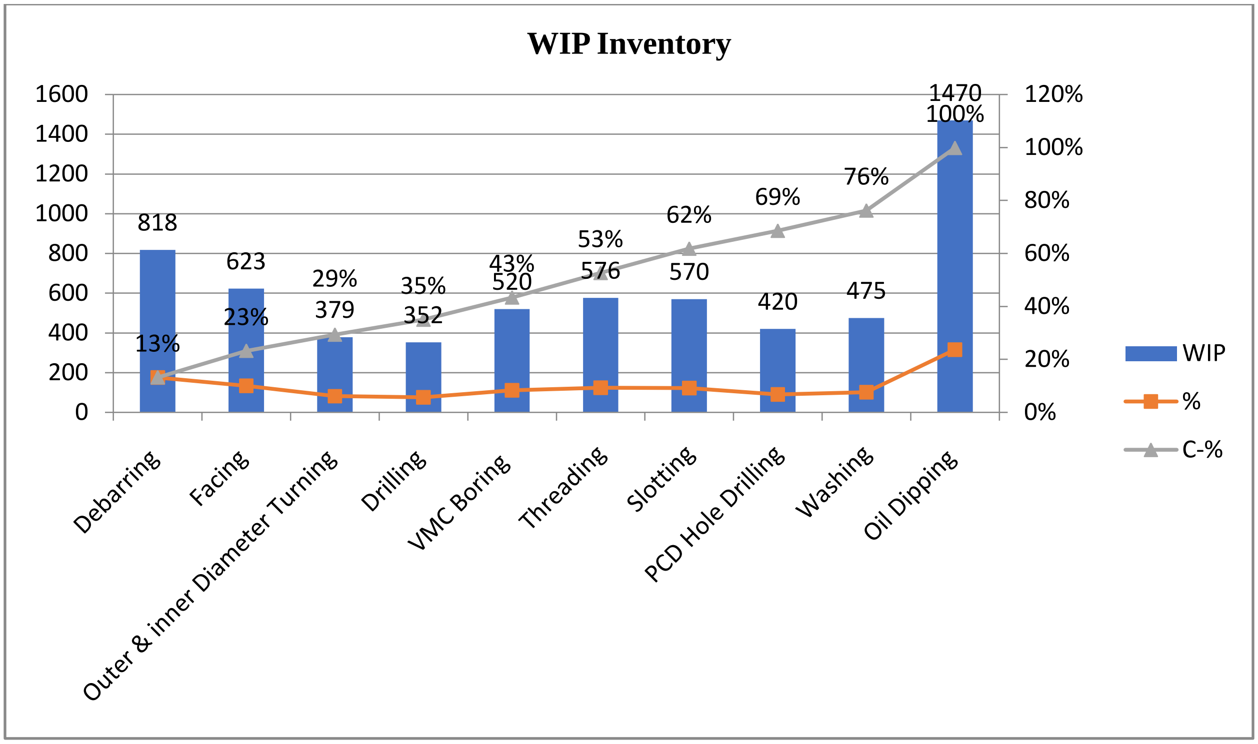



Fig:4.1-WIP Pareto Analysis

### 4.2.2 Recommendation for waiting time

Wait for parts on boring operation increase a lead time of products. This waste is visualized on boring operation. After a implement a supermarket of all required parts which control by KANBAN. Which define the stock of quantity of all required parts.

## 4.3. DESIGN OF VALUE STREAM

Future state design or value stream design is reducing the wastes which are identified from the current state map and Non value added activity. Using the different lean tool various gap area in current state were bridge in order to prepare future state map.

The above discussion in recommendation section and after implementation it can be possible to reduce the lead time. Lead time reduction in this project is mainly focus on WIP inventory and waiting time. It can be reduce for lead time reduction using lean tools such as;

-customer TAKT time.

-introduction of continuous flow

-introduction to supermarket pull system.

-KANBAN

The proposed recommendation will provide according to the current situation and their current resource, which is available to use immediately. The execution of desired future state value stream mapping will give positive result as soon as the organization starts to apply new action plan.

## Proposed value stream design

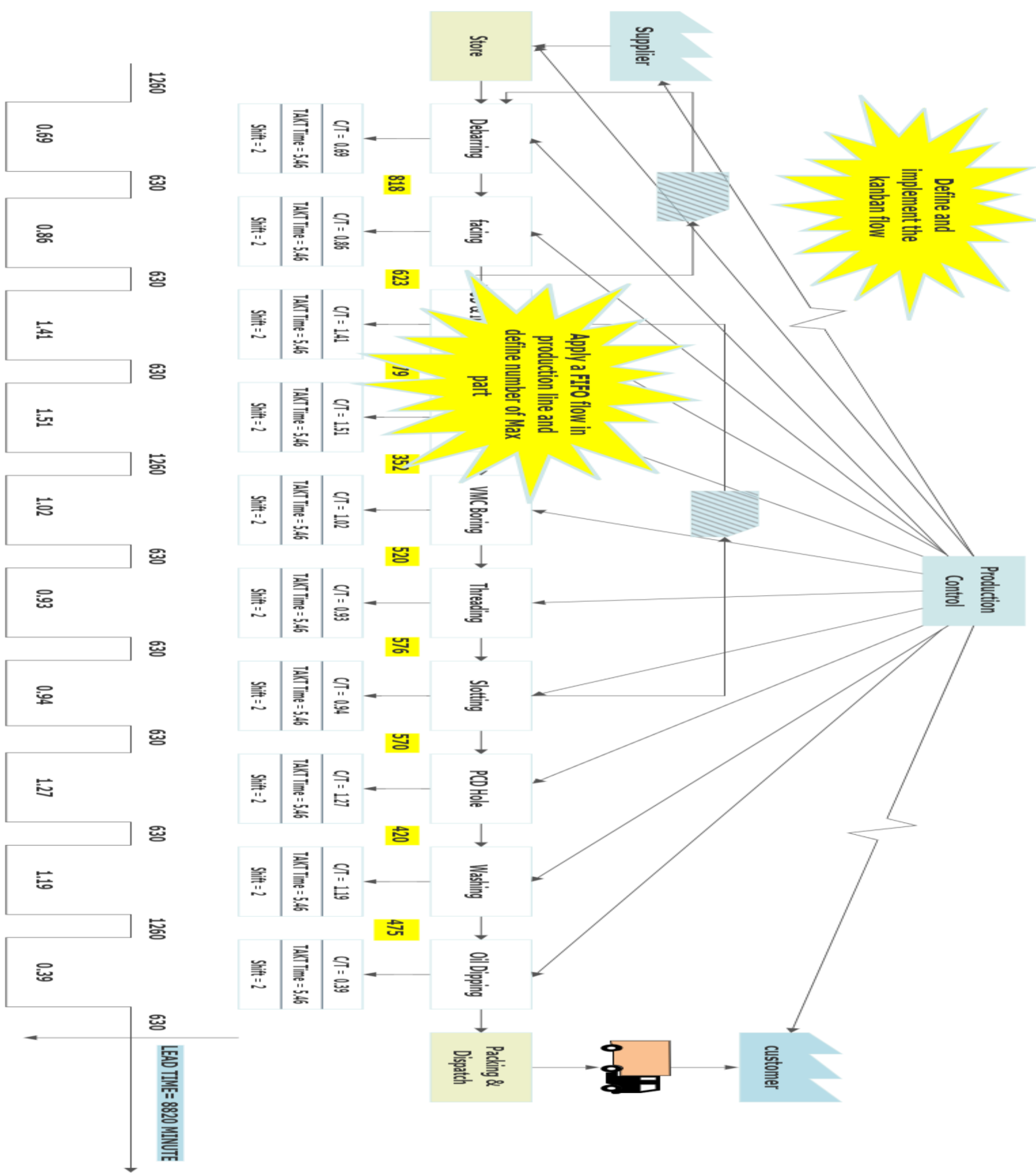



Fig:4.2-proposed value stream design

## 4.4. ANALYSIS OF RECOMMENDATION PLAN

### 4.4.1 Develop continuous flow

Eliminating the congestion of parts within a process or between processes and achieving sequential flow production is called “continuous flow processing”. Achieving sequential flow of production, ideally one piece at a time, with each item passed immediately from one process step to the next without stagnation in between. Continuous flow is the most efficient way to produce and to use lot of creativity in trying to achieve it.

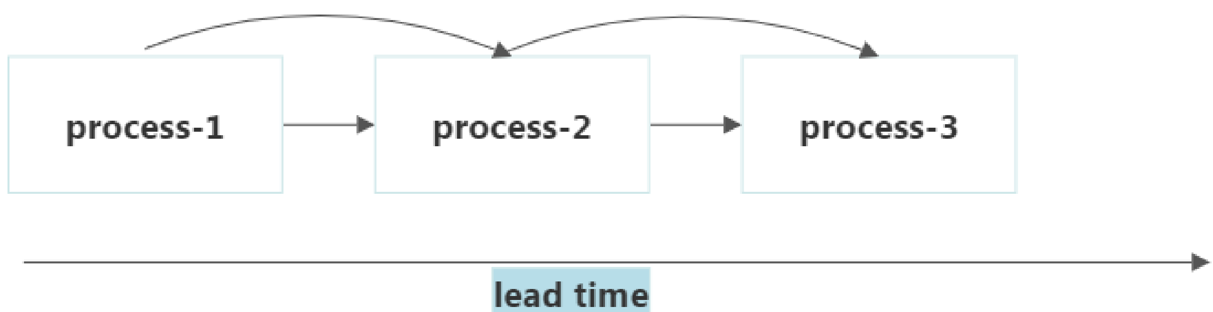



Fig:4.3-continuous flow

Single piece flow is not possible for EGR elbow value stream because all the process have a different operation part lot size. So the process time is different for all the processes. For smooth production flow there is required min amount of inventory between the processes. Develop a FIFO (first in first out) lane between all the processes and define max no of part in FIFO lane.

#### 4.4.1 .1 FIFO (first in first out)

Pull system are nice way to control production between processes that cannot be tied together in a continuous flow, but sometimes it is not practical to keep an inventory of all possible part variations in a pull system supermarket. so some of the cases, we can use a FIFO lane between two decoupled processes to substitute for a supermarket and maintain flow between them. Think of a FIFO lane like chute that can hold only a certain amount of inventory, with the supplying process at the chute entrance and the customer process at the exit. If the FIFO lane gets full, the supplying process must stop producing until the customer has used up some of the inventory.

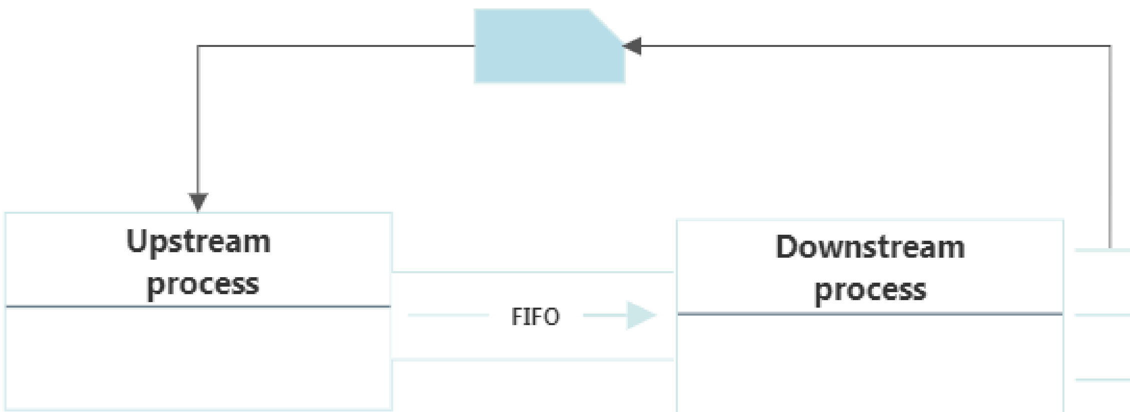



Fig:4.4-FIFO

In EGR Elbow, value stream Max no of pieces in FIFO is calculated as on its container (KLT) and trolley size. 25 no of pieces are fit in to the 1 KLT and such 10 KLT In one trolley. So 250 no of housing are transfer through 1 trolley.

FIFO = 25 (Pcs./KLT) x 10 (KLT/trolley)

=250 Pcs. / Trolley

Fig:4.5-KLT

Fig:4.6-Trolley

So for the future state we define the fix max no of quantity of part between the processes is 250 pcs.

## 4.5 SUPERMARKET PULLS SYSTEM

A supermarket is an area to store parts between supplying and consuming production steps. task supermarket is to guarantee deliver to the customer even if there are problems in production. There are often spots in the value stream, where continuous flow is not possible and batching is necessary.

There can be several reasons for this including.

- Some processes are design to operate at very fast or slow cycle times. Ex. Drilling have a higher cycle time 1.51 min as oil dipping has 0.39 min cycle time.
- Some processes have too much lead time or are too unreliable to couple directly to other process in a continuous flow.

In these cases we go for supermarket pull systems

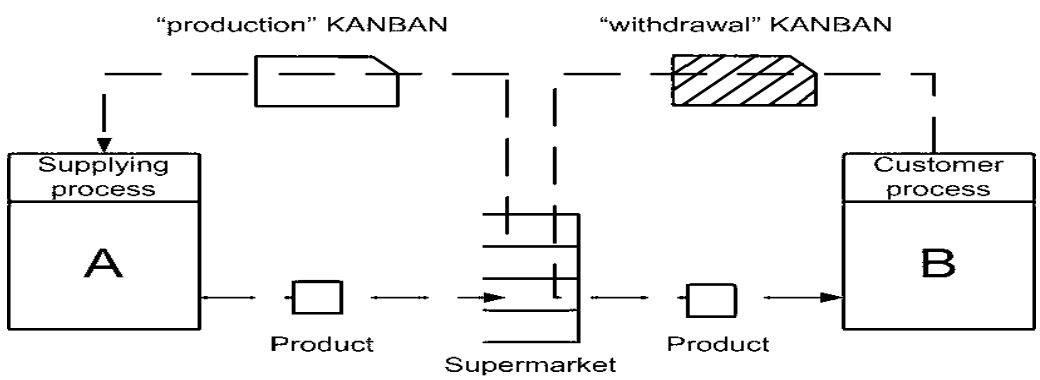



Fig: 4.7-Supermarket with KANBAN [23]

Customer process goes to the super market and withdraws what it needs it and supplier process produces to replenish what was withdrawn.

On the factory floor, super market should ordinarily be located near the supplying process to help that process maintain a visual sense of customer usage and requirements.

### 4.5.1 KANBAN

A KANBAN is a system of inventory and production control (pull system inventory) which use KANBAN as the principle information transmission device. KANBAN is a Japanese word meaning signal. KANBAN is card or tag usually attaches to the work in process parts and it is used to proper movement of this part.

**KANBAN shows**

**"When to start manufacturing"**

**"How much to manufacturing"**

**"What part to manufacturing?"**

KANBAN system is manages the material flow in production line.

Principle of KANBAN system:

Taiichi ohno apply the principle in his production.

- Product is store at a central and defines location.
- Customer withdraws the required amount and types.
- Filling the supermarket only when the customer withdraws.

There are basically two types of production system.

- Push production system
- Pull production system

The principle of 'pull' is that control is transferred from the beginning of the line to the end. It follows the produce a part only based on customer demand at the same time. Upstream process producing only the amount of goods, which are requested by the subsequent process. Actual customer demand drives the process. The rate of production for each product is equal to the rate of customer consumption.

The main objectives of KANBAN calculation are:

- Identify the material and information transformation.
- Identify factors which are defining the number of KANBAN.
- Define and analyze the calculation of KANBAN for EGR Elbow.

#### 4.5.1.1 factors influencing the calculation

Overall, there are five factors that determine the number of KANBAN in a system.

1. **Regular time of customer**: How many parts does the customer need in a certain period?
2. **Regular time of replenishment system**: How long does it take to replenish a product in your production or supply system?
3. **Fluctuations of replenishment system**: if there are problems in the replenishment system, what problems do we want to cover?
4. **Fluctuations of customer**: if the customer order more quantity, or the same overall quantity but less frequently, which fluctuations do we want to cover?
5. **Safety margin**: do we want to additional KANBAN so personal feel more comfortable with the system?

If your system is too slow, no amount of KANBAN will increase your delivery performance. A second assumption is that raw material for the KANBAN system is always available.

#### 4.5.1.2 KANBAN formula:

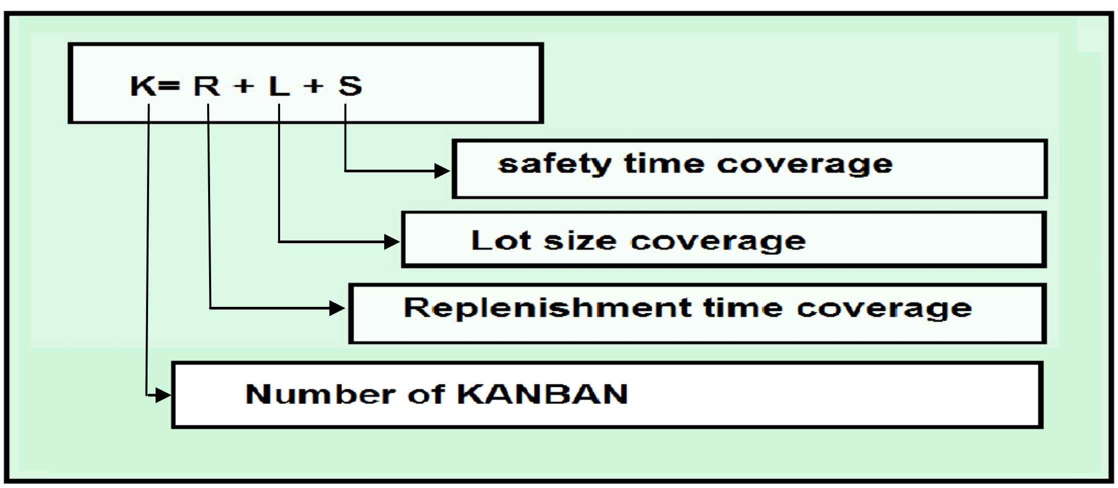



Fig: 4.8- KANBAN equation [a]

- **Some important Definitions:**

Table 4.3-Definations

| | |
|---|---|
| SN(Standard Number Of Parts) | Number of parts per KANBAN. |
| EPEI(Every part Every interval) | Internal in which the part is produced |
| WIP(work in process) | Number of parts that are between two work station. |
| Lot Size | Minimum amount of parts per number that can be produced at one time before another part number can be produced. |

**4.5.1.3 R: Replenishment time:**

The time between the KANBAN leaving the supermarket and KANBAN coming back to the super market attached to a part is hence known as the replenishment time. For our KANBAN calculation, this replenishment time is needed to estimate the number of KANBAN to supply the customer while the supermarket is restocked.

Consider four replenishment time for calculating R sequence.

R1=Operating Time

R2=Material Transportation

R3=Change Over Time

R4=Production Time

**4.5.1.4. Safety margin:**

The Last thing to add would be the safety margin. Technically, this is usually not needed. The KANBAN calculation above - for all their uncertainty – are usually quite conservative, and you may get away with even fewer no of KANBAN. However, in many plants, shop floor personal or lower management have negative experiences with upper management cutting margins too thin, hurting plant performance and therefore creating problems, especially for the people on the shop floor. Plus, your problems may be bigger than you think they are.

- **Calculation**

Table 4.4-Formula [a]

| |
|---|
| $R = \frac{PR \times R\ Sequence}{POT \times SN}$ |
| $L = \left(\frac{LS}{SN}\right) - 1$ |
| $S = 1$ |

Table 4.5-KANBAN: input parameter

| **process** | **Debarring** | **Facing** | **OD& ID Dia Turn.** | **Drilling** |
|---|---|---|---|---|
| cycle time (Min) | 0.69 | 0.86 | 1.41 | 1.51 |
| FIFO After Process (Nos). | 250 | 0 | 250 | 250 |
| Change over Time (C/O Time) (Min) | 0 | 0 | 0 | 0 |
| **VMC Boring** | **Threading** | **Slotting** | **PCD Hole Drilling** | **Washing** |
| 1.02 | 0.93 | 0.94 | 1.27 | 1.19 |
| 250 | 250 | 0 | 250 | 250 |
| 0 | 0 | 0 | 0 | 0 |

| **PARAMETER** | **LOOP-1** | **LOOP-2** |
|---|---|---|
| Planned Day/Month | 26 Days | 26 Days |
| Planned operating time (POT) | 1260 Min | 1260 Min |
| Customer demand for part/month | 6000 Nos. | 6000 Nos. |
| Customer TAKT time | 5.46 Min | 5.46 Min |
| Part Requirement per Day (PR) | =Demand/Working Days =6000/26 =230.76 ≈231 | =Demand/Working Days =6000/26 =230.76 ≈231 |
| KANBAN Card (SN) | 25 Nos. | 25 Nos. |
| Lot Size (LS) | 250 Nos. | 250 Nos. |

Table 4.6-KANBAN calculation

| | | |
|---|---|---|
| R1=Operating Time | =1260 Min | =1260 Min |
| R2=Material Transportation Time | =0.63 Min | =5.77 Min |
| R3=Change Over Time | =0 | =0 |
| R4=Production Time =(WIP in Whole Process)*CT Max+(SN-1)*CT Max | =(250+0)*0.86+(25-1)*0.86 =235.64 Min | =(250+250+250+250+0) *1.51+(25-1)*1.51 =1546.24 Min |
| R Sequence =R1+R2+R3+R4 | =1260+0.63+0+235.6 =1496 Min | =1260+5.77+0+1546.24 =2812 Min |
| $R= \frac{PR* R\ Sequence}{POT * SN}$ | $= \frac{231*1496}{1260*25}$ =10.97 ≈11 Nos | $= \frac{231*2812}{1260*25}$ =20.62 ≈21 Nos |
| L=(LS/SN)-1 | =(250/25)-1 = 9 Nos. | =(250/25)-1 = 9 Nos. |
| Safety factor (S) | =1 No | =1 No |
| K=R+L+S | =11+9+1 =21 Nos | =21+9+1 =31 Nos |
| Total Quantity = K*SN | =21*25 =525 | =31*25 =775 |

The KANBAN calculation drive the super market which is divided in two loop for this selected EGR elbow. so there are Maximum 21 Nos. of KANBAN are in loop 1 and 31 Nos. of KANBAN in loop 2.

# CHAPTER: - 5
# FUTURE VALUE STREAM DESIGN

## 5.1. INTRODUCTION

A future state map will be created according to the implementation instruction, the future value stream of EGR elbow is design as below. compare the current state map and state design of EGR elbow. With the shorter production lead time through the right KANBAN information. WIP (Work in process) inventory is also reduced. Develop the capacity to make First in First out(FIFO), Develop continuous flow and use supermarket make sure the work flow.

## 5.2. FUTURE STATE DESIGN

A future state design will be created to suggest solution to the inefficiency, which have been identified in current state map. Flash point in proposed value stream design is the area on which work has to be done. Those area generates the greatest waste and might provide significant higher productivity if they improved. The future state design discuss in the following section. It is far from the ideal map which doesn't exist as future improvements that can always be made. If the system works flawlessly, then there is always an opportunity of reducing the inventory and lead time. The future state map design utilizes several lean manufacturing techniques, which was earlier discussed in previous chapter. It appears very differently from the current state map; instead of individual processes and product is transferred between the process by the use of First in First out (FIFO) lanes and supermarket.

**5.2.1. Time line calculation;**

For calculating the value added and lead time count the number of pieces during or after the each process. For calculating the value added consider the no of piece which are perform the operation and no of pieces after the process are used to calculate lead time.

Consider the no of pieces average of collected data.

Table 5.1- Input data for future state map

| Process | Cycle time | no of piece on the process | no of piece after the process | lead time |
|---|---|---|---|---|
| Debarring | 0.69 | 1 | 250 | 173 |
| Facing | 0.86 | 1 | 250 | 215 |
| OD & ID Turning | 1.41 | 1 | 250 | 353 |
| Drilling | 1.51 | 1 | 250 | 378 |
| VMC Boring | 1.02 | 1 | 250 | 255 |
| Threading | 0.93 | 1 | 250 | 233 |
| Slotting | 0.94 | 1 | 250 | 235 |
| PCD Hole Drilling | 1.27 | 1 | 250 | 318 |
| Washing | 1.19 | 1 | 250 | 298 |
| Oil Dipping | 0.39 | 1 | 250 | 98 |

A tool used to visually map the flow of production. It shows the future state of processes in a way that highlighted opportunities for improvement to be implementing. Here shows the value stream design for EGR Elbow, shows the material and information flow, process data, and also time calculation. Based on this all data calculate the lead time for future state.

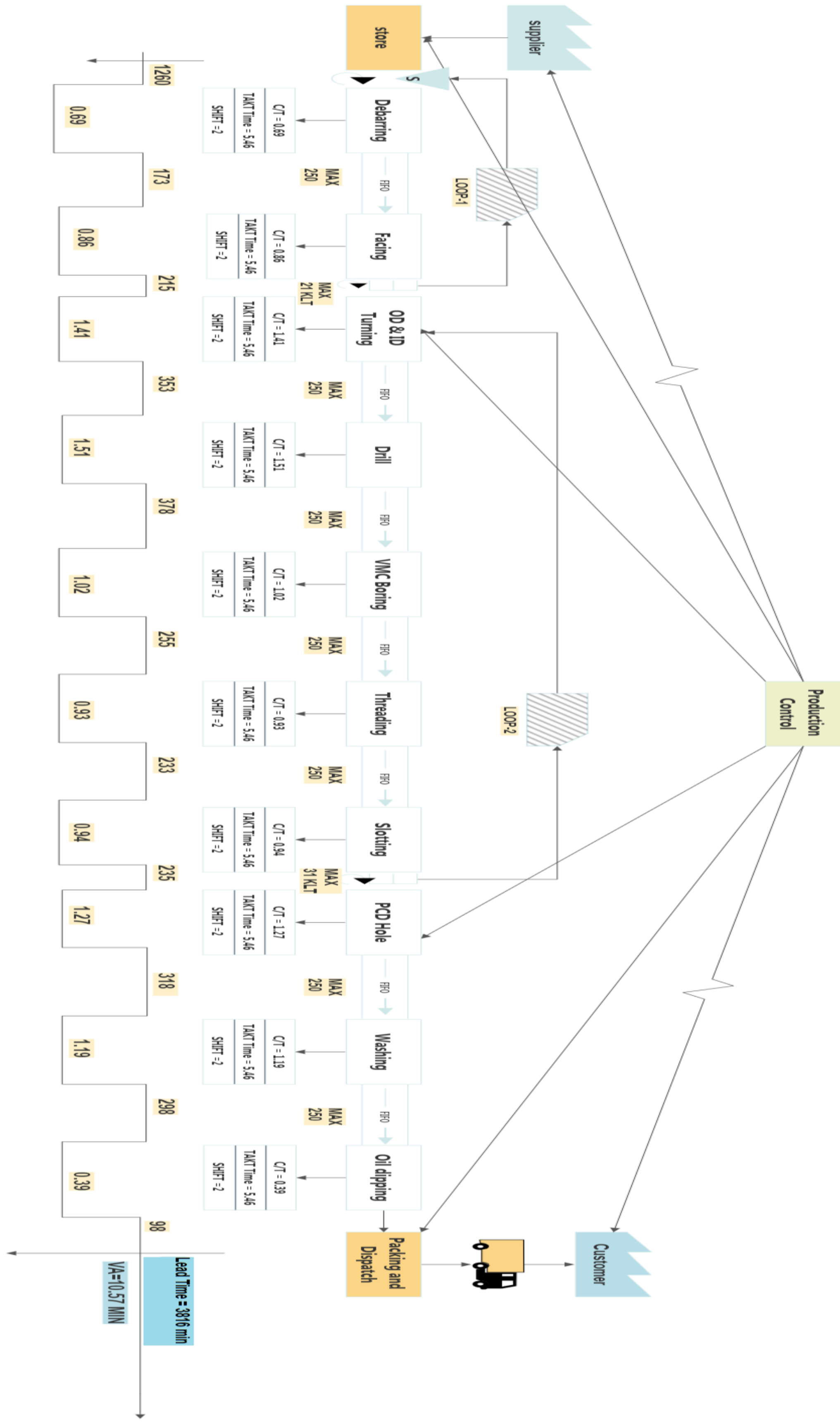



Fig: 5.1-Future state value stream mapping after applying FIFO and KANBAN concept in the production line and calculate the Lead time for EGR Valve,

**LEAD TIME** =3816 minute

= 3.02 Days

So, in future state VSM lead time is 3.02 Days.

## 5.3. DISCUSSION OF METHOD

### 5.3.1. Validity

Williamson describe validity as “the capacity of a measuring instrument to measure what it purports to measure, or to predict what it was design to predict; or, the accuracy of observation”. This is related to whether or not the result is showing what it is supposed show, and if the right parameters have been analyzed.

The validity of this thesis work can be seen as moderate. Due to the complexity of the value stream and difficulties in gathering and analyzing information, it cannot be said that the value stream mapping completely shows what it was supposed to show; there is some information lacking. However, from overall result from the analysis of these complex streams can be seen as satisfactory.

Related to internal validity, it is inevitable that the result has been affected by other factor. For example, the cycle time has been measured at the actual location where task are performed and is therefore to a great extent influenced by outer circumstances.

# CHAPTER: - 6
# CONCLUSION

## 6.1. INTRODUCTION

This section ties the thesis work and research work together. A target concept should be grafted on the basis of the principles and methods of lean production that simplifies control of the process by finding and analysis. It also discusses the chosen methodology with the results and concludes work.

## 6.2. CONCLUSION

The purpose of this study is mapping of the current state, an analysis of current state, a future state design and an action plan stating what needs to be improved. Value stream mapping identifies the opportunities for continuous improvement to eliminate waste. Value stream was very useful for company in being able to visually see how the entire process worked.

The work mapping is shown in above charts which describe the flow and its result. As on value stream mapping combine the information and material flow on one map, this allowed us to see where the big issues were in regards to lead time and inventory levels during the production. In current state lead time for the EGR Elbow is 7 days. Based on this mapping identified the types of waste, it's causes and effect on value stream i.e. product follow the push principle it creates the work in process inventory in production line, and identifying the waiting time. Now to reduce this type of wastes, recommendations some of lean techniques like, introduce to continuous flow and super market pull system, introduce FIFO and its quantity is 250 Pcs.

Implement a KANBAN in production line which is in two loop, and the max 21 Nos. of  KANBAN in loop 1 and 31 Nos. of  KANBAN In loop 2.

Applying all this lean concept in production area and calculate the lead time for EGR Elbow is 3.02 days. So reduce lead time by 3.97 days.

# CHAPTER-7
# REFERENCES


1. Palange, A., &Dhatrak, P. (2021). Lean manufacturing a vital tool to enhance productivity in manufacturing. *Materials Today: Proceedings*, *46*, 729-736.
2. Belvedere, V., Cuttaia, F., Rossi, M., &Stringhetti, L. (2019). Mapping wastes in complex projects for Lean Product Development. *International Journal of Project Management*, *37*(3), 410-424.
3. Gopi, S., Suresh, A., & Sathya, A. J. (2020). Value stream mapping & Manufacturing process design for elements in an auto-ancillary unit–A case study. *Materials Today: Proceedings*, *22*, 2839-2848.
4. Rohani, J. M., &Zahraee, S. M. (2015). Production line analysis via value stream mapping: a lean manufacturing process of color industry. *Procedia Manufacturing*, *2*, 6-10.
5. Antonelli, D., &Stadnicka, D. (2018). Combining factory simulation with value stream mapping: a critical discussion. *Procedia CIRP*, *67*, 30-35.
6. Azizi, A. (2015). Designing a future value stream mapping to reduce lead time
7. Forno, A. J. D., Pereira, F. A., Forcellini, F. A., & Kipper, L. M. (2014). Value Stream Mapping: a study about the problems and challenges found in the literature from the past 15 years about application of Lean tools. The International Journal of Advanced Manufacturing Technology, 72(5), 779-790.
8. Marquina, M. V. H., Zwolinski, P., & Mangione, F. (2021). Application of Value Stream Mapping tool to improve circular systems. Cleaner Engineering and Technology, 5, 100270.

9. Nåfors, D., Bärring, M., Estienne, M., Johansson, B., & Wahlström, M. (2018). Supporting discrete event simulation with 3D laser scanning and value stream mapping: Benefits and drawbacks. Procedia CIRP, 72, 1536-1541.
10. Martin, N. L., Dér, A., Herrmann, C., & Thiede, S. (2020). Assessment of smart manufacturing solutions based on extended value stream mapping. Procedia CIRP, 93, 371-376.
11. Salvador, R., Barros, M. V., dos Santos, G. E. T., van Mierlo, K. G., Piekarski, C. M., & de Francisco, A. C. (2021). Towards a green and fast production system: Integrating life cycle assessment and value stream mapping for decision making. Environmental Impact Assessment Review, 87, 106519.
12. Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. Journal of operations management, 21(2), 129-149.
13. Lourenço, E. J., Pereira, J. P., Barbosa, R., & Baptista, A. J. (2016). Using multi-layer stream mapping to assess the overall efficiency and waste of a production system: a case study from the plywood industry. Procedia CIRP, 48, 128-133.
14. Kasava, N. K., Yusof, N. M., Khademi, A., & Saman, M. Z. M. (2015). Sustainable domain value stream mapping (SdVSM) framework application in aircraft maintenance: A case study. Procedia CIRP, 26, 418-423.
15. Masuti, P. M., & Dabade, U. A. (2019). Lean manufacturing implementation using value stream mapping at excavator manufacturing company. Materials Today: Proceedings, 19, 606-610.
16. Zahraee, S. M., Tolooie, A., Abrishami, S. J., Shiwakoti, N., & Stasinopoulos, P. (2020). Lean manufacturing analysis of a Heater industry based on value stream mapping and computer simulation. Procedia Manufacturing, 51, 1379-1386.
17. Deshkar, A., Kamle, S., Giri, J., & Korde, V. (2018). Design and evaluation of

a Lean Manufacturing framework using Value Stream Mapping (VSM) for a plastic bag manufacturing unit. Materials Today: Proceedings, 5(2), 7668-7677.

18. Ferreira García, K. Y., de la Riva Rodriguez, J., Sánchez Leal, J., Reyes-Martínez, R. M., & Prieto, A. W. (2019). Determination of Allowance Time by Work Sampling and Heart Rate in Manufacturing Plant in Juárez México. Journal of Engineering, 2019.
19. Rahman, N. A. A., Sharif, S. M., & Esa, M. M. (2013). Lean manufacturing case study with KANBAN system implementation. Procedia Economics and Finance, 7, 174-180.
20. Tyagi, S., Choudhary, A., Cai, X., & Yang, K. (2015). Value stream mapping to reduce the lead-time of a product development process. International journal of production economics, 160, 202-212.
21. Patil, V. M., & Bhatwadekar, S. G. (2015). Application of Value Stream Mapping for Lead Time Reduction and Inventory Control. International Journal of Engineering, Business and Enterprise Applications, February-May, 1-4.
22. Saraswat, P., Kumar, D., & Sain, M. K. (2015). Reduction of work in process inventory and production lead time in a bearing industry using value stream mapping tool. International Journal of Managing Value and Supply Chains (IJMVSC), 6(2), 27-35.
23. Samad, M. A., SaifulAlam, M. D., & Tusnim, N. (2013). Value stream mapping to reduce manufacturing lead time in a semi-automated factory. Asian Transactions on Engineering, 2(06), 22-28.
24. Chatzopoulos, C., Tsigkas, A., & Papantoniou, A. (2009). An approach of a flexible manufacturing thinking system for Lean-Flow implementation for mass customization industries. In 5th World Conference on Mass Customization and Personalization MCPC.
25. Naufal, A., Jaffar, A., Yusoff, N., & Hayati, N. (2012). Development of

KANBAN system at local manufacturing company in Malaysia–case study. Procedia Engineering, 41, 1721-1726.

26. Pandya, N., Kikani, P., & Acharya, G. D. (2017). Analyze the value stream mapping for lead time reduction by lean: A review.
27. Vijay, M. S., & Kale, M. C. Lean Implementation by Executing Self Running Loop in MFN-1 Shop Floor at Bosch Ltd. Nashik. CHRONICLE OF THE NEVILLE WADIA INSTITUTE OF MANAGEMENT STUDIES AND RESEARCH, 39.
28. Rahman, N. A. A., Sharif, S. M., & Esa, M. M. (2013). Lean manufacturing case study with KANBAN system implementation. Procedia Economics and Finance, 7, 174-180.
29. Adnan, A. N. B., Jaffar, A. B., Yusoff, N. B., & Halim, N. H. B. A. (2013). Implementation of just in time production through KANBAN system. *system*, *3*(6).
30. Chaple, A. P., Narkhede, B. E., & Akarte, M. M. (2014, December). Status of implementation of lean manufacturing principles in the context of Indian industry: A literature review. In 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) (pp. 12-14).
31. Kouri, I. A., Salmimaa, T. J., & Vilpola, I. H. (2008). The principles and planning process of an electronic KANBAN system. In Novel algorithms and techniques in telecommunications, automation and industrial electronics (pp. 99-104). Springer, Dordrecht.
32. Bhat, R. R., & Shetty, R. R. (2013). Investigation of lean tools to enhance productivity in manufacturing sector. Int J Adv Eng Sci, 3, 116-120.
33. Lei, H., Ganjeizadeh, F., Jayachandran, P. K., & Ozcan, P. (2017). A statistical analysis of the effects of Scrum and KANBAN on software development

projects. *Robotics and Computer-Integrated Manufacturing*, *43*, 59-67.

34. Tregubov, A., & Lane, J. A. (2015). Simulation of KANBAN-based scheduling for systems of systems: initial results. Procedia Computer Science, 44, 224-233.
35. Urnauer, C., Kaiser, J., Gunkel, M., & Metternich, J. (2019). Multidimensional assessment of value stream design alternatives. Procedia CIRP, 86, 264-269.
36. Lugert, A., Völker, K., & Winkler, H. (2018). Dynamization of Value Stream Management by technical and managerial approach. Procedia CIRP, 72, 701-706.
37. Mudgal, D., Pagone, E., & Salonitis, K. (2020). Approach to value stream mapping for make-to-order manufacturing. Procedia CIRP, 93, 826-831.
38. Adnan, A. N. B., Jaffar, A. B., Yusoff, N. B., & Halim, N. H. B. A. (2013). Implementation of just in time production through KANBAN system. *system*, *3*(6).
39. Tardif, V., & Maaseidvaag, L. (2001). An adaptive approach to controlling KANBAN systems. European Journal of Operational Research, 132(2), 411-424.
40. Sugimori, Y., Kusunoki, K., Cho, F., & UCHIKAWA, S. (1977). Toyota production system and KANBAN system materialization of just-in-time and respect-for-human system. The international journal of production research, 15(6), 553-564.

**- project Report:**

a) Pandya, N. and , Kikani, P., " Analyze the value stream mapping for lead time reduction by lean" (2017)

**- web site**:

I. https://www.onlineclothingstudy.com/2014/08/difference-between-basic-time-and.html

**- Book:**


- M. Mahajan , Dhanpat Rai., “Industrial Engineering and Production Management”

## Appendix A: Compliance Report

Comments given during Dissertation Phase-1 Review are given below with required actions taken for their fulfillment.

- **Comments for Dissertation Phase – 1:**

| Sr. No. | Comments Given | Actions |
|---|---|---|
| 1. | Exhaustive study related to value stream mapping is required | Studied more in value stream mapping |
| 2. | Add more research paper in LR | Related literature paper has been added |
| 3. | Start preparing a review paper and publish it. | Published |
| 4. | Include the validation method in methodology. | Validation method has been added. |
| 5. | Identify the project boundary condition for research work. | Project boundary conditions has been added |

# Appendix – B Certificate of Publication

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*We acknowledge the manuscript*

"Productivity Improvement of Exhaust Gas Recirculating (EGR) Elbow by Using Value Stream Mapping of Lean Manufacturing – A Technical Review"

*Submitted by*

Devendra Dabhi

*Published in* Trends in Mechanical Engineering & Technology

*ISSN* 2231-1793 *Year* 2022 *Volume* 12 *Issue* 01

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# Appendix – C Industry Certificate

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**<u>INDUSTRY CERTIFICATE</u>**

This is to certify that **Mr.Devendra Dabhi** from Faculty of Engineering & Technology, Atmiya University, Rajkot has satisfactorily completed his project work on the title **"Productivity Improvement of Exhaust Gas Recirculating (EGR) Elbow By using Value Stream Mapping of lean Manufacturing"** in time duration from [June 2021 to April 2022].

During the span of his project we found him law abiding, honest and hard working in his work. The research work carried out by him useful for our Industry.

Thank You

**With Best Regards.**

**For Gorecha Metal Tech Pvt. Ltd.**

21/04/22

**COO**
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