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# *Lean in industrial projects: A Case Study on Sintec Ethiopia Industrial Projects*

**BY: SERKALEM ASFAW**

**June, 2019**

**Addis Ababa, Ethiopia**

# *Lean in industrial projects: A Case Study on Sintec Ethiopia Industrial Projects*

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**A Thesis Submitted to**

**The School of Mechanical and Industrial Engineering**

**Presented in Partial Fulfillment of the Requirements for the Degree of Master of**

**Science in Mechanical Engineering (Industrial Engineering Stream)**

**Addis Ababa University**

**Addis Ababa, Ethiopia**

**June, 2019**

**Addis Ababa University**

**Addis Ababa Institute of Technology**

**School of Mechanical and Industrial Engineering**

This is to certify that the thesis prepared by Serkalem Asfaw, entitled: Lean in industrial projects in a case of SINTEC Ethiopia Industrial Projects and submitted in partial fulfillments of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by Examining Committee

Internal Examiner **Dr. Ameha Mulugeta** Signature _____Date_____

External Examiner **Dr. Yitagesu Yilma** Signature _____Date_____

Advisor **Dr. Ermias Tesfaye** Signature _____ Date_____

_____

School or Center of Chair Person

**DECLARATION**

I hereby declare that the work which is being presented in this thesis entitled **"Lean in industrial projects in SINTEC Ethiopia Plc. Industrial projects"** is my original work, has not been presented for a degree in this or any other university, in any projects by any means, and all the resource materials used for this thesis had been accordingly acknowledged.

Serkalem Asfaw _____ _____
(Candidate) Signature Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

Dr. Ermias Tesfaye _____ _____
(Thesis Advisor) Signature Date

# ABSTRACT

*The main purpose of this research is to identify the means of delay in industrial projects. In today's global and highly competitive environment, to be stable in a global market, it is critical to preserve and grow for any firm need to be price competitive, time and quality, proactive and reactive and has to deliver a world rank new/better product to fulfill customer requirements. Nowadays to compute global market SINTEC Ethiopia Plc. has been struggling and suffering from a lot of challenges including delay of industrial projects. The major problems contributing for the delay of industrial projects are waiting for the missing parts and procurement of consumables & Argon gas. The main objectives of this study is to identify means of reducing the delay of projects in SINTEC Ethiopia industrial projects by value stream mapping*

*Lean production reveals to meet the needs of the market demand by implementing Lean tools of value stream mapping to stable in the global market by eliminating wastes.*

*In order to show where the focus area of the delay of industrial projects for SINTEC Ethiopia is used a value stream mapping tool. This study adopted a case study approach. For this study, the research methodology requires gathering relevant primary and secondary data. Primary data was conducted using interviews and observation to provide qualitative insights and company visits. Secondary data collected from recent literature and company records in order to examine the waste level.*

*The collected data have been summarized using descriptive analysis method and analyzed by a statistical tool called bar chart. Moreover, value stream mapping was used to determine the strong point of incorporation of time, cost, quality and flexibility with the involvement of supplier and customer for the reduction of delay of projects. Based on the identified main aspects and the collected data, the level of wastes in SINTEC Ethiopia Plc. was assessed and problems were identified. Finally the study came up with the following findings: the incorporation of time, cost, quality and flexibility with the involvement of supplier and customer are strongly related with the means of reducing delay of projects. Furthermore, at the end of the study a constructive model is developed which gives a solution regarding to the problem mentioned for SINTEC Ethiopia industrial projects.*

***Keywords:*** *VSM, Delay, SINTEC Ethiopia Industrial projects*

# ACKNOWLEDGEMENTS

I am grateful to all of those with whom I have had the pleasure to work during this research. Each of the members of my thesis committee has provided me extensive personal and professional guidance and taught me a great deal about research and life in general. I would like to express my sincere gratitude to my Advisor Dr. Ermias Tesfaye and co- Advisor Mr. Shimelis Tilahun for the continuous support of my research. As my Advisor and Co-Advisor, both of them taught me more than I could ever give those credits.

Those people such as postgraduate students at Addis Ababa University which helping and supporting to complete the work all the difficult way that provided a much-needed form of escape from my studies, also deserve thanks for helping me keeping things in perspective.

And most especially to God, for giving me the guidance and knowledge as well as good health in making this research work. Last but not the least; I would like to thank my family for giving birth to me in the first place and supporting me spiritually throughout my life.

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# NOMENCLATURE

| | |
|---|---|
| APRN | Asia Pacific Research Network |
| BOQ | Bill of Material |
| CM | Cellular Manufacturing |
| ERP | Enterprise Resource Planning |
| IACSIT | International Association of Computer Science and Information Technology |
| IEEE | Institute of Electrical & Electronics Engineers |
| IOSR | International Organization of Scientific Research |
| IJEIT | International Journal of Engineering & Information Technology |
| ISERT | International & Scientific Engineering Research & Technology |
| ISO | International organization for Standardization |
| JIT | Just In Time |
| MIG | Metal Inert Gas |
| MMA-Welding | Manual Metal Arc Welding |
| PDCA | Plan Do Check Act |
| PI | Piping and Instrumentation |
| SMED | Single Minute Exchange of Die |
| SPRU | Science Policy Research Unit |
| SPSS | Statistical package for the social sciences |
| SSRG | Software Systems Research Group |
| TQM | Total Quality Management |
| TIG | Tungsten Inert Gas |
| TPM | Total Productive Maintenance |
| VSM | Value Stream Mapping |
| WIP | Work In Process |

# CHAPTER ONE

# 1. BACKGROUND AND JUSTIFICATION OF THE RESEARCH

## 1.1 Introduction

In today's global and highly competitive environment to be stable in a global market, it is critical to preserve and grows for any firm to be price competitive, proactive and reactive and has to deliver *world rank a new/better* product to full fill customer requirements (K.Eswaramurthi & P.V.Mohanram, 2013). Manufacturing industries with obsolete production system because of excessive production cost and undecided delivery time are losing business (Haider & Mirza, 2015). Firms which produce a wide multiplicity of products in the market place based on customer order which are delivered within minimum time and good quality that means production activates based on customer needs efficient production system to compete in global market and cost saving. In this research one of the electromechanical industries in Ethiopia which is SINTEC ETHIOPIA PLC is taken to analyze means of delay industrial projects.

*"The presence of our competitors is making us take another look at the way we do things. Our challenge is to meet our clients' quality, delivery, support and price needs. The project we conducted with Fujitsu let us achieve our objectives. The challenge was tackled brilliantly."*(Spurr, 2011)

SINTEC ETHIOPIA (plc) is one of the first Companies established in 1989 among a consortium of seven sister companies. These group of companies includes SINTEC ETHIOPIA (plc), Metaferia Consulting Engineers (MCE), African Business & Development Consultants (ABD - Consult), ESSET P.L.C. and SINTEC ENERGY, SINTEC MOTORS and ESSET Constructions. The Companies were formed with the primary purpose of providing specialized and focused service by undertaking need assessments for their clients, develops engineering design and technical specifications.

Nowadays to compete global market SINTEC Ethiopia PLC has been suffering from a lot of challenges. Some of the challenges are a long processing time, unnecessary wastes, non-flexibility of the workforce, considerable rework, on time delivery. Lean production reveals

to meet the needs of the market demand by implementing various Lean tools to stable in the global market by eliminating wastes.

Normally business companies need have more flexible, more responsive to market demands, well scheduling, increase throughput, reduce lead time and produce goods to the right time at the right place is a very important issue to compute other companies and even though to improve production capacity.

Lean is a philosophy and set of management techniques focused on continuous "eliminating waste" so that every process, task or work action is made "value adding" (the real output customer pays for!!) as viewed from the customer perspective. Lean "waste elimination" targets the "Nine Wastes" namely: inventory, lead time, Transportation of material, Movement or motion of human, Overproduction, Over-processing, Defective items, space utilization, and non-value add activities through the entire process And this study focuses on applying lean tools particularly Value stream mapping, or material and information flow, should play a very productive role in the entire Lean process by eliminating waste and adding value to SINTEC Ethiopia Plc.

Lean underlines the members of a process improvement crew are those most closely associated with adding value to the product. The whole process is based on defining customer value, focusing on the value stream, making value flow, and letting customers determine the product or service they want, with a relentless pursuit of perfection in a timely manner at an appropriate price (III, 2007).

## 1.2 Problem Statement

In today's world, any business sectors had a competition to its areas so in order to survive the market improving productivity is the better way, by accomplish minimum production cost, response time and flexibility in manufacturing be subject to the above. All over the world manufacturing industries face this competition. In this study the nominated case manufacturing plant SINTEC Ethiopia Plc. Have a challenge to compete other competitors. The major problems are high production cost, high concentration of waste, the inflexibility of the process and workforce, higher production time, and reworks. According to the result of six year performance report the company loss on an average of 274,882.44 birr per year because of delay of projects. Thus to compete with other related companies on price, quality, on-time delivery, the flexibility it needs to try some new solution like lean philosophy's in order to have better productivity plus to be competitive in the global market. Lean is a best & effective concept which reduces the time between customer order and products.

## 1.3 Research Questions

The research question of this research paper are:

1. What are the existing problems of project delays facing in SINTEC Ethiopia Industrial projects?
2. How can a lean practice solve the exsiting problems in SINTEC Ethiopia industrial projects?

## 1.4 Research Objective

**The general objective of this thesis is** to study the problem regarding to delay of projects and to prupose lean implementation frame work in SINTEC Ethiopia industrial projects.

**The Specific objectives** are described as follows

- To assess the existing problems of delay of projects facing in SINTEC Ethiopia industrial projects

- To study how lean practice solves the existing problems in SINTEC Ethiopia industrial projects
- To propose lean implmentation framework for reduction of delay in industrial projects.

## 1.5 Scope of the Research

This research is limited to SINTEC Ethiopia Plc. manufacturing firm and it does not fully encompass all field services of the enterprise because the other departments seems to be organized. It focuses only on the industrial projects and it does not consider other product related core processes.

## 1.6 Significance of this Research paper

This research benefits the enterprise by applying the lean philosophy to improve productivity; it will get a great benefit by reducing wastes and to give very quick responsiveness for its customers, and also relevance to the need source of information for other research works that may be conducted in this field and give knowledge to the industry as well.

## 1.7 Limitation of the study

The study limited to lean in industrial projects. Regarding workshop (job shop) products there are many issues or problems that should be avoided but in this study only cover industrial project delay problems are considered due to lack of adequate time and data. And also a limitation or obstacles while conducting this work. Among the many, major obstacles which are lack of time, shortage of secondary data, lack of recorded document on planning department and shortage of research in this area.

## 1.8 Organization of the thesis

This work is organized in eight chapters. The first chapter is devoted to introducing all about the research work, problem statement, research questions, general and specific objectives, scope of the research, significance of the research and limitations. The second chapter presents literature review on the introduction of lean, lean in the manufacturing system and industrial projects, principles of lean in industrial projects, measurement of customer

satisfaction through lean manufacturing , tools of lean implementation, value stream mapping and at last the gap of the literature. The third chapter is about methodology of the research which includes data collection, company survey and observation and data analysis and model development. The fourth chapter is all about the background and company profile. The fifth chapter is focus on the data analysis and result which includes the preparation of current value stream map; cost based current state of VSM, future value stream map, cost of future state VSM and cause and effect analysis. The sixth chapter deals with the discussion part the research. The seventh chapters hold the proposed framework of the study. The last chapter devoted to draw conclusions, recommendations and future works.

# CHAPTER TWO

# 2. LITERATURE REVIEW

## 2.1 Introduction to Lean

To compete with today global market companies must plot and offer better products and services to improve their production operations, So to improve operational performance lean production is a better idea (Morosan, 2011). Lean production or Toyota production system have grown and been successfully implemented in 1950 by Toyota motor company led by Ohno. Taiichi Ohno, the father of the Toyota production system has found a way to convert waste to value. The term "lean" was invented by the research team working on international auto production at Massachusetts Institute of technology to reflect both the waste reduction nature and to contrast it with craft and mass forms of production (Aziz & Hafez, 2013; Sarhan & Fox, 2013). Lean techniques are developed to reduce waste and increase productivity. Lean techniques encourage business to change orders, minimize rework, reduce cost overruns and minimize delays and also improve projects by giving new knowledge to accomplish projects (Haresh S. Palve & Kamat, 2017).

In today's competitive market lean manufacturing is essential in every industry. The concept of lean manufacturing was develop for reducing the time between customers, maximizing resource utilization and reduce the flow of non-value added time. Lean manufacturing is a flexible, excellent and efficient manufacturing technique is by reducing the seven wastes: overproduction, waiting time, defects, non-valve added processing activities, excess of motion, high inventory and transportation (A. N. M. Rose, B. Md. Deros, & Rahman, 2013; Mehul Mayatra, Mr. N.D. Chauhan, & Trivedi; Sundar, Balaji, & Kumar, 2014). Now day's many organizations have realized the need for adopting lean manufacturing to stay in the recent situation by reduce their cycle time, cost, customer lead time and increase quality and productivity. Lean manufacturing is one of the top and wide ranging concepts in all over the world to compute in the market (Čiarnienė & Vienažindienė, 2015; Joshi Chirag D. & Puranik, 2015).

## 2.2 Lean in the Manufacturing system

Lean is the best approach for elimination of the seven wastes in a manufacturing firm for all manufacturing and service industries. Wahab, Mukhtar, and Sulaiman (2013) develop an input -output conceptual model of the manufacturing system to measure leanness in the manufacturing industry. The conceptual model which develops by the above researcher have consists of seven elements of lean dimension in manufacturing which are in input system supplier relationship and workforce management; in transformation, system manufacturing process & equipment, manufacturing planning & scheduling, visual information system and product development & technology; in output system which is customer relationship. The design conceptual model shows the factors or determents contribute to the measurement of lean practices.

According to Mostafa, Dumrak, and Soltan (2013) the lean manufacturing system is treated in four phases the first one is a conceptual phase which selects widens scope and trans for the personnel; the second phase is the implementation design phase which designs the lean plan and prepares the lean team to the practice; the third phase is implementation and evaluation phase which delivers and evaluates the lean plan and the fourth phase is complete lean transformation phase which is the final phase documented the new lessons. Also Belhadi, Touriki, and El fezazi (2016) proposed lean implementation framework is shown in pre-implementation (preparation) phase which requires all necessary foundations are taken place ; Implementation (execution) phase which focuses on performance improvement and post-implementation (generalization) phase which plays a critical role in completing lean implementation project and to enable a successful and sustainable lean implementation.

## 2.3 Lean in Industrial projects

In Industrial projects of developing countries have various problems to complete the projects. Nguyen Duy Long, Stephen Ogunlana, Truong Quang, and Lam (2004), have studies problems in developing countries of large construction projects. The research focuses on the common and general problems of construction projects like incompetent designers/contractors, poor estimation and change management, social and technological issues, site related issues and improper techniques and tools. And the researcher articulates that similar problems occur in developing countries. Managing construction projects by

applying lean principles advantages for contractors to deliver projects ahead of schedule (Helena O'Connor & Khalid Siddiqi, 2014). Lean construction tool guide from performing a situation analysis, to find the reason behind waste and prioritizing and estimation of potential consequences of waste reduction (Dr.A.V.Suresh & Nagaraj.N, 2013).

Abhiram and Asadi (2016), have examines the implementation of lean methodology in Indian construction. The main objective of this paper investigates factors of wastes in construction industry suggest suitable measure. The study finds that the wastes generated have a great impact on the construction of cost, quality and time. The researchers recommended that give proper training for labors, use lean methodology, use buffers, equalize work resources, reduces variation, quality policy and all work packages for the resources for reduction of wastes. Bubshait (2001), has studied the effect of incentive and disinvite contracts on industrial projects. The reasons for studying this research are due to delays in project and cost overruns in industrial projects. Delay of projects and cost overruns are a nightmare in industrial projects because of poor planning, low productivity, inadequate resources, and inaccurate estimates due to not use incentives simply because they think that incentives will add to their costs.

Nowadays projects are facing many problems due to resource constraint and utilization of lean management. Effectively implemented lean techniques by giving orientation programs, adequate training, weekly meeting, considering of use of maximum available materials and good relationship between manufacturers and management is used to reduce the waste and increase profit (A.Chandrasekar & Kumar, 2014; Yan & Peng, 2014). On time and defect free product delivery is essential for projects. Yadav (2014) has studied the improvement of products using lean six sigma. The reason behind the study of this research takes much time for generating a bill of materials. Develop a route to move every order through six activates of screening of incoming orders, spec entry into the ERP (enterprise resource planning) system, check the price, plan the job check inventory and schedule the manufacturing. This research gives a clue of high returns of invested time of team for lean six sigma methodology. The researcher said for delivering speed and defect-free quality focuses on lean six sigma methodologies

Lean practice has influenced in industries. (Ravindaran, Anandakumar, & Krishnamoorthy, 2016), have studied the influence of lean management practices on quality in construction industries. The aim of this study is to determine the ways of quality affecting problems in

construction industries through the application of lean management practices. There are nine important factors for the elimination of wastes such as top management involvement, team empowerment, timely delivery, increase learning, planning of materials, and capability of employees, lean awareness and material quality.

In industrial projects especially in plant installation faces many problems such as Lack of realistic time schedule to do quality work because the site manager is always under pressure finish the work, Accesses to the work area of lifting machinery, Unplanned installation because of the change in installation plan, Missing parts during installation and wetting for that part, Electrical controls during commissioning get a misplaced connection, Wetting for consumables and argon procurement and The project doesn't start on time

Researchers worldwide have attempted to solve the improper understanding of Lean Management by both the management and employees of an organization by proposing various framework (Anand & Kodali, 2010). Frameworks are developed in order to provide guidelines for the application of lean manufacture (U. V. KUMAR & RAMASAMY, 2016). Frameworks can be used to determine the completeness of project improvement and Lean manufacturing is the outcome of improvement project improvement. The basic purpose of developing framework is to help projects crews convert their project delivery processes for productivity improvements (Kornfeld & Kara, 2013; Liao, Teo, & Low, 2017). The result of lean production projects implementation is the overview of lean manufacturing tools at the industrial firms (A Suetina, Y Odinokov, & M Safina, 2014).

(Ramphal, 2017; T. M. Shahada, 2012) was developed a lean six sigma framework to permits the company performance with respect to customer's requirement. The proposed framework is illustrated based on five phases of six sigma methodologies such as Define, Measure, Analyze, Improve and control and each phase contains several steps. According to Al-Aomar (2012) by the integration of lean techniques and six sigma develop a framework. To implement the lean techniques use a cyclical look ahead planning and execution approach and lean six sigma being used to measure the performance. The framework is weighted on reducing the defects, errors; variability of the project schedule, performance measures and cost estimates use Six Sigma to compliment the lean practices.

Erick C.Jones, Parast, and Adams (2010) link the implementation of six sigma with quality management and the PDCA cycle develop a conceptual framework for six sigma implementation. Also, Joshua Chan Ren Jie (2014) develops a lean six sigma framework in a

small-medium enterprise by the integration of lean manufacturing and six sigma to increase the scope and size of improvement. The lean six sigma approach gives a dual effort on reducing waste and increasing value to companies. The generic framework contains five phases which are created perfection, specify a value, align value stream, create flow and pull on demand and each phase consists define, measure, analysis, improve and control six sigma methodologies (J. Hill, 2017).

## 2.4 Principles of Lean in Industrial Projects; Lean in Construction & Production process

A new production philosophy which is approaching to changes in the construction industry is lean construction. When applying lean thinking in the construction industry is used improvement in customer satisfaction, safety, design, quality, waste reduction, productivity, and reliability will be accomplished (Oyedolapo Ekundayo Ogunbiyi, 2013). (RAMASAMY, 2016) says it is a critical feature of lean construction such as application of project control from design to delivery and also set clear objectives for delivery makes the project easier to manage. (Mohamed Saad Bajjou, 2017) Most construction industries are characterized by a low level of performance which pointers to poor security condition, cost overruns, delay, and low performance.

Lean manufacturing generates more value to achieve high performance by minimalizing resources, reducing human participation, eliminating waste, less floor area & minimum lead time in the manufacturing process by applying lean techniques in the manufacturing process. (Madushan S.T.K, 2016).

The end aim of lean in industrial projects, construction and production process is to design and ensure the quality of product with a minimum resource with less delivery time.(Mohamed Saad Bajjou, 2017) says that improve productivity and waste minimization by applying lean philosophies in projects. The major difference from industrial projects to construction projects is In industrial projects three types of participant contribute for manufacturing processes which are material supplier side (only supply machinery and raw materials), contractor side (supply manpower and hand tools) and customer side. So in industrial projects some difficulties happen because of delivery of machinery and raw material, construction building, lack of realistic time schedule, the project dalliance, waiting for consumables and argon gas procurement, missing arts during packaging, unplanned

installation due to change in installation plan, site road and work area access for lifting machineries. Therefore, applying lean principle on the industrial project will minimize the above-mentioned problems.

## 2.5 Measurement of Customer Satisfaction through, lean manufacturing

Nowadays companies all over the world have been facing challenges with increasing pressure due to higher customer expectations. Customers are trying to choose goods at a lower and competitive cost with fast delivery; so the industries are now concerned about customer satisfaction. Lean manufacturing has given a chance to change management practices to enhance customer satisfaction. Without the need of high investment organizations satisfy customer expectation and rationalize of waste to remove affecting companies financially result in the manufacturing area using implementation of lean manufacturing (A. N. M. Rose et al., 2013; Ahmad, 2017; Campos, Cotrim, Galdamez, & Leal, 2016; Čiarnienė & Vienažindienė, 2015). In present the global market is full of crisis because of customer expectation; so organizations are more focused on achieving full customer satisfaction (Rajender Kumar, Kumar, & Singh, 2017; Pereira, Anholon, & Batocchio, 2017). Customer satisfaction is a critical factor to achieve company long term success. Lean manufacturing is a method fulfilled to shorten the time between the customer order and delivery time and also customer satisfaction measurements can be the result of the product or service feature in a comparison with a cost like product quality, service quality and competitive price (Ameer, 2014; Found & Harrison, 2012).

Quality values reflect the voice of the customer because customer satisfaction enables companies to communicate directly with customers about their needs so evaluating effective customer service drivers and their relevance to customers are very important in achieving business service (Pokalsky, 2010; Yeboah, Gyawu, & Bampoe-Addy, 2015). According to BARUTÇU, AKGÜN, and AYDIN (2015), the main drivers of customer satisfaction is suitability, usability, entertainment, appearance (look), availability, customization, interaction, confidentiality, trust, material quality, flexibility, and price. The most important customer satisfaction drivers are reliability, information about the product and commercial features; if the customer is satisfied they will be interested to purchase from the firm and remain trusty for it (M. Arefi, A.M. Amini, & Fallahi, 2010). Farzad Sattari Ardabili,

Manouchehr Molaie, and Kheiravar (2012) found three factors affecting customer satisfaction such as performance, relation and announcing.

Companies adapt lean processes for various reasons whether it's to update cost or to gain entry into new markets. The critical factors that implementing lean manufacturing process is time, money, resources, & centralized management (Jackson, 2013). According to (B. S. Kumar & Sampath, 2012) the lean manufacturing initiative factors are minimizing WIP, pitch time, cost of manufacturing and manufacturing lead time. Lead time, work routines, teamwork, empowerment, quality and cost is lean initiatives in both the private and public sector (Beata Kollberg, J., Dahlgaard, & Brehmer, 2007). The understanding of lean initiative is necessary for identifying anyshortcomings in lean implementation.

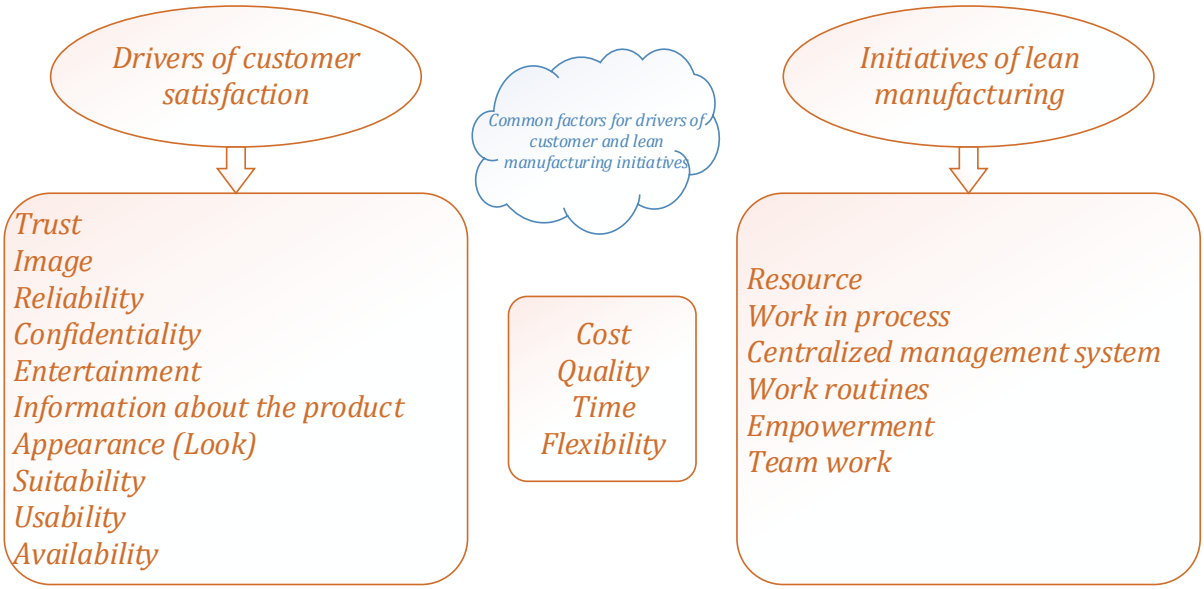



Figure 1. Drivers of customer Satisfaction with initiatives of lean manufacturing

The purpose of lean is to maximizing value while minimizing waste that means creating more value for the customer with less resource. Some of Lean application benefits are facilitate to accomplish a number of objectives plus completing the project on time and reducing the time to competition, finalizing the project on budget and meeting project performance requirements, improving the quality of the final products, eliminating waste, reducing costs and adding value. The extents of a customer are agreeable to play for a product or service is directly related to how much they value it. In the project based workings customers give

value more for quality, time, cost and flexibility; therefore time, quality, cost and flexibility are the common factors for drivers of customer satisfaction and lean manufacturing initiatives so to build the conceptual framework add this common factors towards the effectiveness of lean application and satisfaction of customers. Because several firms in the international have applied lean organization and achieved great improvement and fulfill customers expectation (Konstantinos Salonitisa & Tsinopoulos, 2016).

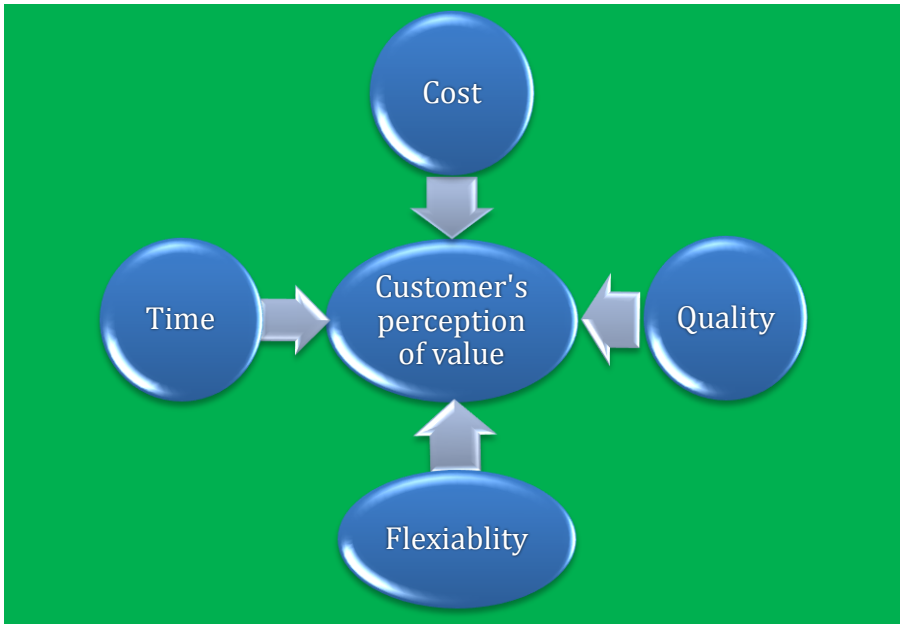



Figure 2. Customer perception of value

Lean is one of the most common tools used for elimination of waste in order to enhance quality and productivity in many firms: although the quality of services is a key driver of customer satisfaction since customer satisfaction is important for lasting survival. Customer satisfaction and high quality is a competitive advantage for both levels (Farzad Sattari Ardabili et al., 2012; M. Arefi et al., 2010; Wahab et al., 2013).

Lean philosophy is preferred in manufacturing organizations due to its ability to produce the products at competitive prices. Implemented lean philosophy is used to improve servicing environment at lower cost and preserve excellent production quality. Production activities are focused on customer, if an efficient production will provide an advantage for cost savings. Companies realize that one of the ways for costs reduction lies in improving production process using a lean philosophy (Antosz & Stadnicka, 2017; Görener, Başer, & Türkyılmaz, 2013; Haider & Mirza, 2015; S.Kolanjiappan & K.Maran, 2011).

Flexibility of products is important for customers by decreasing deliver time because flexibility reduces cycle times & simplifies the production system. Lean tools and techniques have enabled companies to be more flexible and more profitable (Idrissi, Mesfioui, Aftais, & Benazzouz, 2015; Manzouri, Ab-Rahman, Zain, & Jamsari, 2014; Sacks, 2009).

Lean manufacturing is a philosophy to reduce the time between customer order and products. Lean is a best and effective concept which is about designing and operating the right process at the right time (Mehul Mayatra et al.; Radhika R, 2017)

According to (Olhager, 1993), there are four contributing factors of flexibility on the impact of sales(cost) such as setup time reduction, capacity, multifunctional workforce, and modular product design.

## 2.6 Tools of Lean Implementation

Lean is an integrated system of principles, practices, tools and important techniques to stay competitive and succeed in challenging market place for all types of resources and for any purpose. There are various types of lean tools are used like value stream mapping, one-piece flow, 5S, Kanban, cellular manufacturing, JIT, continuous improvement, production smoothing, total productive maintenance, standardization of work, SMED etc..(Čiarnienė & Vienažindienė, 2015; Haider & Mirza, 2015; Mehul Mayatra et al.)

Table 1. Summary of Lean tools

| No | Lean tools | Description |
|---|---|---|
| 1 | 5s | Eliminate wastes that results from poorly organized work area |
| 2 | Andon | Acts as a real time communication tool for the plant floor that brings immediate attention to problems as they occur |
| 3 | Bottleneck Analysis | Improves throughput by strengthening the weakest link in the manufacturing process |
| 4 | Continuous flow | Eliminates many forms of waste such as inventory, waiting time etc.. |
| 5 | Cellular Manufacturing | Supports continous flow by calling on teams to arrange workstations based on the parts they produce in order to minimize travel time |
| 6 | Gemba (The Real Place) | Promotes a deep and through understanding of real world manufacturing issues |
| 7 | Heijunka (Level Scheduling) | Reduces lead time (since each product or variant is manufacturing more frequently) and inventory (since batches are smaller) |
| 8 | Hoshin Kanri (Policy Deployment) | Eliminating the waste that comes from poor communication and inconsistent direction |
| 9 | Jidoka (Automation) | Workers can frequently monitor multiple station (reducing labor cost) and improving quality |
| 10 | Just in time (JIT) | Highly effective in reducing inventory levels and improves cash flow and reduce space requirement |
| 11 | Kaizen (Continuous improvement) | Combines the collective talents of a company to create an engine for continually eliminating waste from manufacturing process |
| 12 | Kanban (pull system) | Eliminates wastes from inventory and overproduction |
| 13 | KPI (key performance indicators) | Important and powerful derivers of behavior |
| 14 | Muda (waste) | Anything in the manufacturing process that does not add value from the customer perspective |
| 15 | OEE (Overall Equipment Effectiveness) | Provides a benchmark/baseline and a means to track progress in eliminating waste from the manufacturing process |
| 16 | PDCA (Plan, Do, Check, Act) | Applies a scientific approach to making improvements |
| 17 | Poka-Yoke (Error proofing) | Design error detection and prevention into production process with the goal of achieving zero defects |
| 18 | Root cause analysis | Helps to ensure that a problem is truly eliminated by applying corrective action to the root cause of the problem |
| 19 | SMED (Single Minute Exchange of Dies | Enables manufacturing in smaller lots, reduces inventory and improves customer responsiveness |
| 20 | Six Big Losses | Provides a framework for attacking the most common causes of wastes in manufacturing |

| No | Lean tools | Description |
|---|---|---|
| 21 | SMART Goals | Helps to ensure that goals are effective |
| 22 | Standardized work | Eliminates wastes by consistently applying best practices and forms a baseline for future improvement activities |
| 23 | Takt time | Provides a simple, consistent and intuitive method of pacing production |
| 24 | TPM (Total Productive Maintenance) | Creates a shared responsibility for equipment that encourages greater involvement by plant floor workers and improve productivity by increasing up time, reducing cycle time and eliminating defects |
| 25 | VSM(Value Stream Mapping) | Exposes wastes in the current process and provides a roadmap for improvement through the future state |
| 26 | Visual factory | Makes the state and condition of manufacturing process easily accessible and very clear to everyone |

Lean production principles and techniques are important strategic tools for maximization of productive resource, inputs procurement and improve the suitability of products and value-added services. Lean establishes guiding principles of works such as process flow creating and analyzing the use of pulled production system, and the examination for the disposal of waste (Antoniolli, 2014). According to S.Kolanjiappan and K.Maran (2011), lean is important for the contribution of operational performance. And lean is benefited various sectors According to Leite and Vieira (2015), implementation of lean philosophy in the service sector use a mixture of lean tools and follows standards because of the condition of the work.

According to Joshi Chirag D. and Puranik (2015), articulates that the main factor of not achieving the result of lean implementation is misconception of lean philosophy but not limitation of lean. The article examines the implementation of lean manufacturing in the cement industry. The problem for studying this article is intensive energy and raw materials, high breakdowns, large work in progress inventories and increase productivity. This article develops a simulation model and identifies the relationship between variables with Taguchi orthogonal array. These studies get a reduction of WIP is the main problem of the reduction of efficiency of productivity.

Table 2. Literature reviews

| Ye | Author | Titile | Problem | Tools | Result |
|---|---|---|---|---|---|
| 2007 | Sahoo, A. K., Singh, N. K., Shankar, R., & Tiwari, M. K. | Lean philosophy: implementation in a forging company. | increased customer expectations & fierce global competition | VSM & Taguchi's method | reduction in non-value-added activities |
| 2009 | Sezen, B., & Erdogan, S. | lean-philosophy-in-strategic-supply-chain-management-&-value-creating | High waste & high non value add activities | VSM | reduced non conformity & improve organizational quality |
| 2009 | Adan Valles, Jaime Sanchez, Salvador Noriega, and Berenice Gómez Nuñez | Implementation of Six Sigma in a Manufacturing Process: A Case Study | failures accounted | Six Sigma | reducing the nonconforming units or improving the organization quality and personal development |
| 2011 | Mohamed Marzouk, Bakry, I., & El-said, M. | Application of lean principles to design process in construction consultancy | High process duration & high resource utlization | Simulation & process modelling | improve process efficiency & increased resource utilisation |
| 2011 | S.Kolanjiappan, & K.Maran, D. | Lean philosophy in aircraft maintenance | low quality | VSM | increased quality, servicing expected by the customer and fierce global competition |
| 2011 | Ravikumar Marudhamuthu, Marimuthu krishnaswamy, Damodaran Moorthy Pillaic | The Development and Implementation of Lean Manufacturing Techniques in Indian garment Industry | high setup times & high waste | VSM & SMED | improve the production process by identifying waste and its causes, set up time is also reduced considerably |
| 2012 | Deshpande, Filson, Salem, & Miller | Lean Techniques in the Management of the Design of an Industrial Project | high cost estimation & low performance | 5S | Improving efficency & Eliminating waste |
| 2012 | Rahani AR, Muhammad al-Ashraf | Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study | High production lead time & high WIP | VSM | Reduced production lead-time & lower WIP |
| 2013 | Harsha N. & Nagaraj.N., | Implementation Of Lean Concepts In The Construction Engineering Project | labor redundancies, delayed projects and zero margin contract bids. | VSM | lean can be successfully applied and adopted to the construction industry. |
| 2013 | Ali Görene, Hümeyra Başer, Ali Türkyılmaz | Lean Production Application in a Manufacturing company | high utilization of space | Kaizen | Space utilization, save costs |

| Ye | Author | Titile | Problem | Tools | Result |
|---|---|---|---|---|---|
| 2014 | Keitany, P., Riwo-Abudho, M. | Effects of lean production on organizational performance: A Case study of Flour producing company in Kenya | increasing demand for quality output | TQM, JIT, Inventory Management System. | improved performance |
| 2014 | Malihe Manzouri , Mohd Nizam Ab-Rahman , Che Rosmawati Che Mohd Zain & Ezad Azraai Jamsari | Increasing Production &Eliminating Waste through Lean Tools and Techniques for Halal Food Companies | higher total cost & wastes | continuous improvement, & inventory management | improvement of company performance |
| 2015 | Haider, A., Mirza, J | An implementation of lean schedulingin a job shop environment | suffering delays & costly production | One piece flow | reducing the manufacturing-led time, WIP & space utilization |
| 2015 | I. Idrissi, A. Mesfioui, I. Aftais & B. Benazzouz | Implementatio of lean manufacturing in Fish canning company: A Case study of a canned sardines production company in Morocco | high waste, high motion & low productivity | 5S & SMED | reducing cost, improving productivity, teamwork, & consistency of product quality. |
| 2015 | Sri Indrawati, Muhammad Ridwansyah | Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application | low quality performance & presence of non value added activity | Lean Six Sigma | Improve performance |
| 2015 | Parthipan. R, Anto Jenith.J, Nirmalkannan. V | Reliability of Lean Tools | Decrease of the system reliablity | cellular manufacturing | improve system reliability |
| 2016 | Shrivastava, A. | A Study on Application of Lean Techniques in Indian IT Industry | rising customer's expectation & fluctuating demand | VSM | minimize waste & improve efficiency |
| 2016 | Ravindaran, Anandakumar, & Krishnamoorthy | Influence of Lean Management Practices on Quality in Construction Industries | low quality performance | lean concept | quality of materials |
| 2016 | Leopoldo Gutierrez-Gutierrez Sander de Leeuw Ruud Dubbers | Logistics services and Lean Six Sigma implementation: a case study | supporting continuous improvement in logistics services | Lean Six Sigma | improving the performance in a logistics services environment |
| 2016 | Campos, V. M. K., Cotrim, S. L., Galdamez, E. V. C., & Leal, G. C. L. | Introduction of Lean Manufacturing Philosophy by Kaizen Event: Case Study on a Metalmechanical Industry | high setup time, high delivery lead time & high inventory | Kaizen | reduce setup time, reduce delivery lead time & reduced inventory |
| 2017 | C. Roriza, E. Nunesb, S. Sousab | Application of Lean Production Principles & Tools for Quality Improvement of Production Processes in a Carton Company | high setup times, low availability of machines, lack of organization in the working area | 5S & visual management | reduction setup time & improve performance |

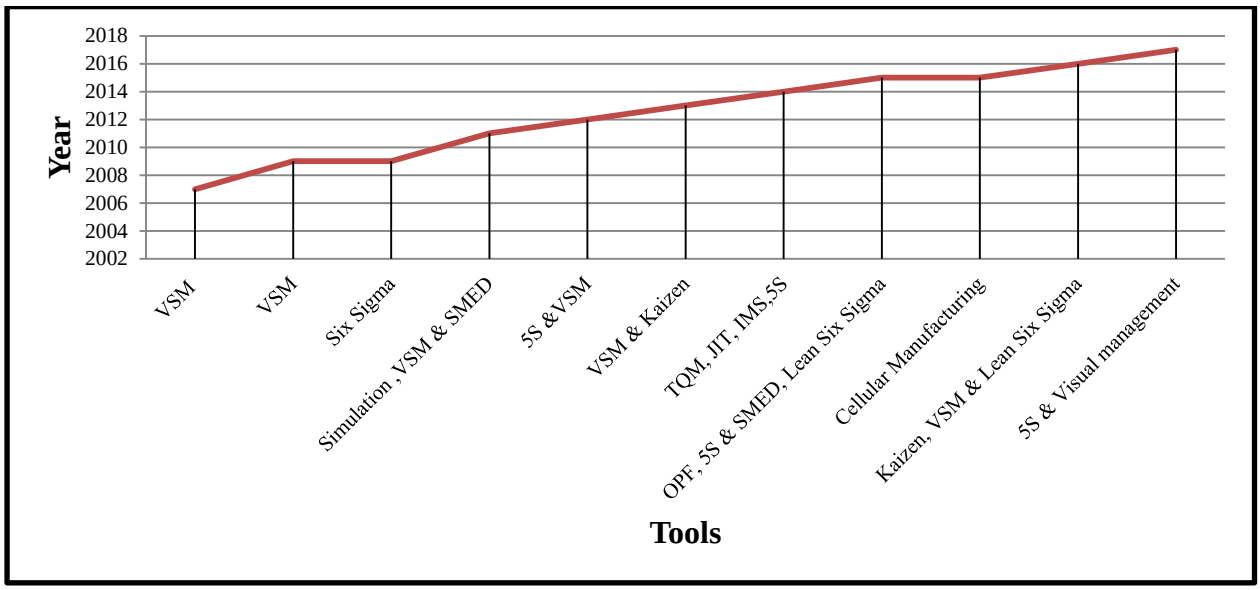



Figure 3. Summary of Lean tools in different years

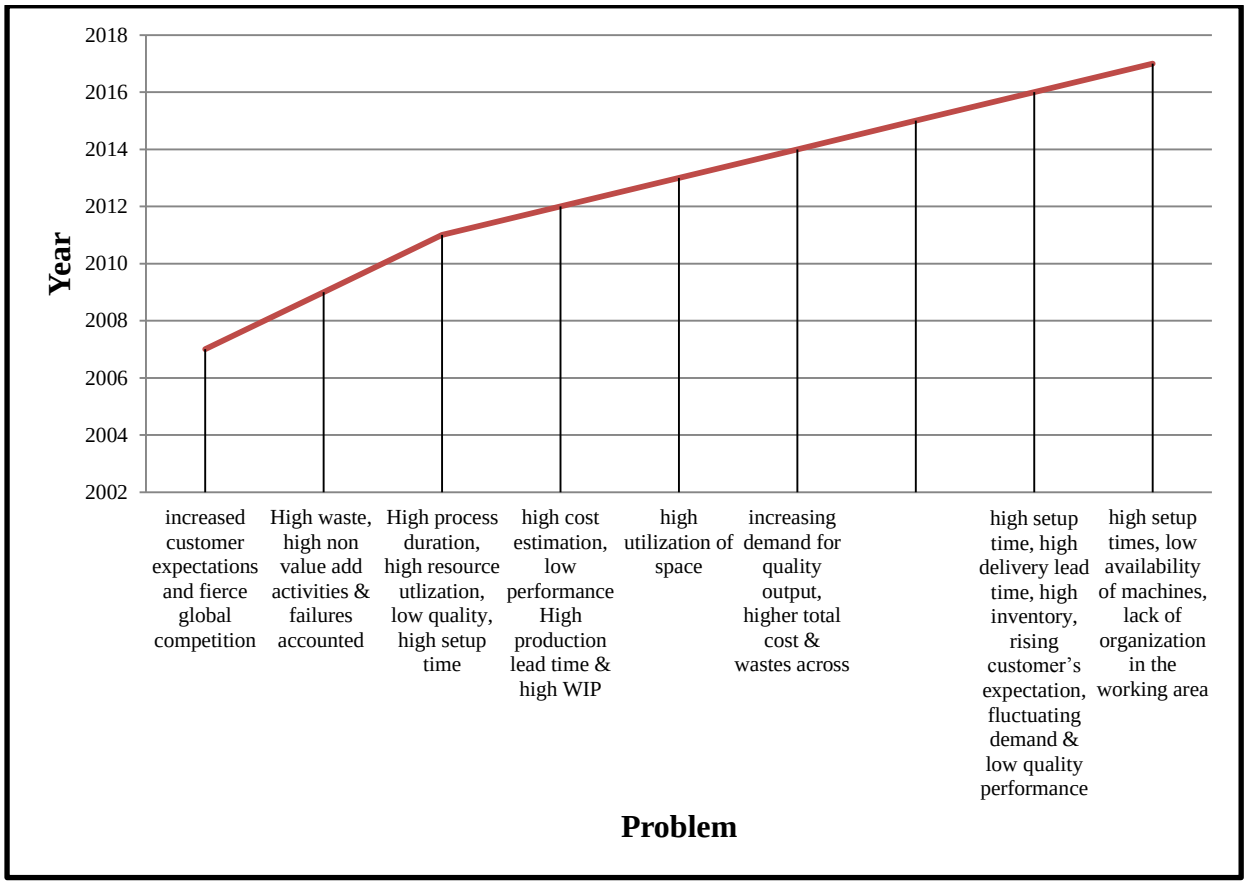



Figure 4. Summary of Problems which raised in different years

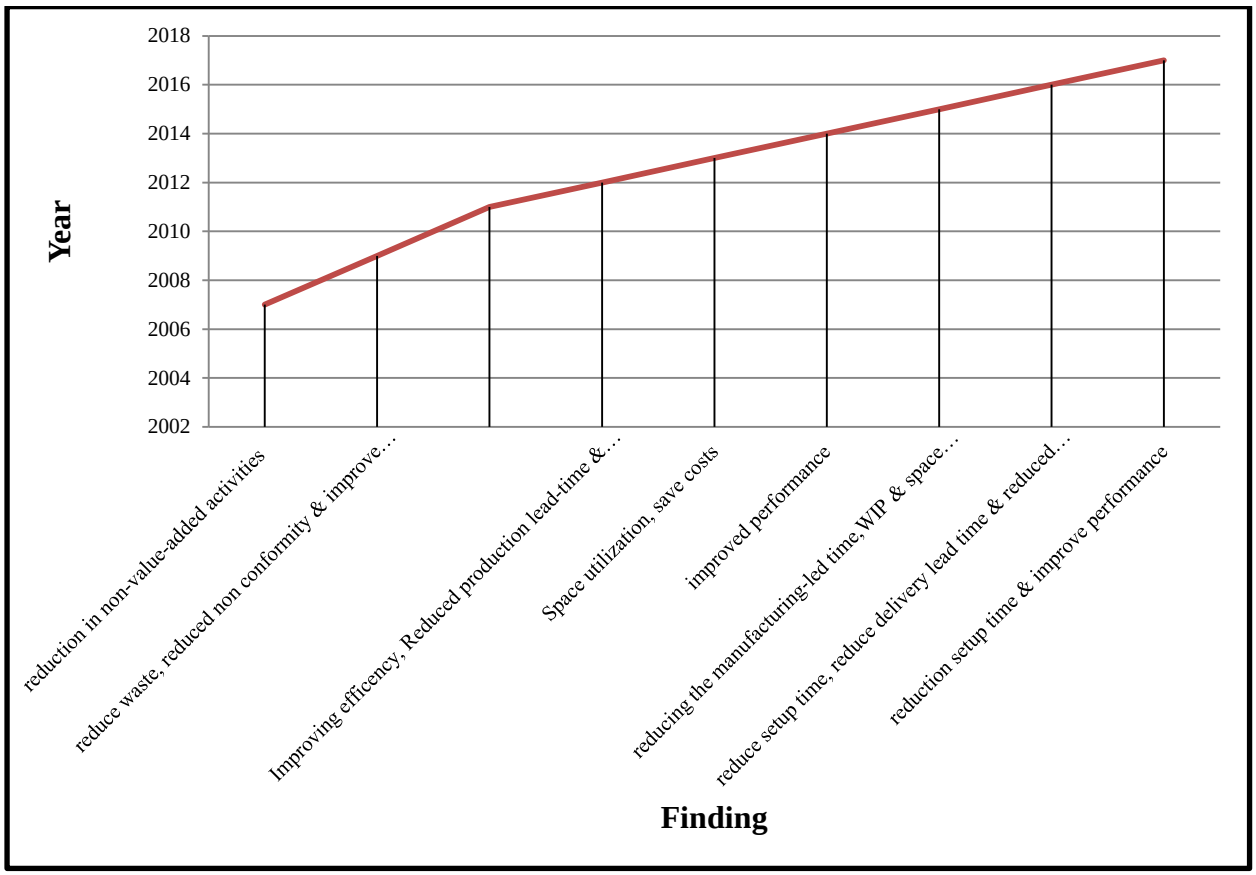



Figure 5. Summary of research Findings in different years

From various types of lean tools value stream mapping and 5s are effective (Mehul Mayatra et al.), have conducted a bibliographical study the impact of lean manufacturing on various types of industries like automobile, cotton seed oil, health care hospitals and pharmaceutical company. The survey result concludes that from various types of lean tools value stream mapping and 5s tool are effective and use for the detection of waste.

VSM is a lean tool to realize the entire construction process, material flow and representing information in order to increase the construction process by detecting waste and its sources; required to produce a specific product service or combination of products and services to a customer including those in the overall supply chain (Sahoo, Singh, Shankar, & Tiwari, 2007). VSM is an effective tool for the practice of lean manufacturing which applied to assess the probable impact of the variation in the production process resulting in lower rejection rates (Rahani & al-Ashraf, 2012). (Chen & Cox, 2012), argues that the most powerful tools available is a VSM. VSM is an easier technique to visualize and recognize the

entire products or services which comprise similar customers and inputs put together as a target product family.

Lean manufacturing as a VSM is a great ability to increase the traditional manufacture system through waste reduction by encouraging people involvement to ensure the continuous improvement of production. A value stream map is a communication tool and sharing techniques and outcomes of the larger lean community because VSM serve as a blue print for lean manufacturing (A.Ramachandran, 2014). In industrial projects to satisfied customer and coordinated the material and information flow VSM is the effective tool to solve the problems regarding to information management and physical transformation. Generally VSM is clearly indicate the process time, lead time , weighting time, inventory and process flow which helps to demonstrate the possible profits of the company.

## 2.7 Value Stream Mapping

VSM is one of the most powerful tools in the lean toolbox. By using a VSM communicate effectively in a short time where the focus point is continuous improvement. In industrial projects the key important success of lean implementation working together with customer, supplier and contractor so VSM is used when plans a lean implementation to display the current state map of the process including information flows, material flows and other important information. When working with a big project found many complexity can cause people to check out but VSM facilitate focus on the cycle time in each process step by reducing non value added steps from the project. VSM assists to see at a scan where the delays are in the working process.

VSM is a group workout and should comprise representatives from all of the areas within the process being mapped; this practice should be facilitated and controlled by an expert with knowledge in generating value stream maps. Its need to include how the customer's order products and how we interpret that back to our supplier and also include how we then communicate requirements to the working process to ensure that produce what the customers wants because VSM is different from most of mapping tools by inclusion of the information flows into the map. The value stream map data boxes contain much information about the process and easily see the problem areas within the process. The main value of lean is to realize the product or service from the viewpoint of the customer; so VSM are drawn to

reduce waste and improve the rate of flow and it can be beneficial to consider competitive burdens and advantages overcome by the value stream. Lean thinking relies on recognized the seven wastes such as inventory, over processing, over production, waiting, motion, transportation and scrap so the aim of the targeted maps tell which of these wastes can be eliminated. VSM is essential in the assembly process because the process industry is so capital intensive therefore attention must be taken to clearly manage the difference between the VSM and process map.

A six sigma is a lean implementation tool but a value stream is an analyzing tool. A value stream map is a tool which gives a graphical overview of flow information and material that helps individuals visually see and understand a given process. Value stream means working on the big image and improving the whole process which follows a process from start to finish measuring and monitoring what happens within each process step. It is a pencil and paper tool that helps you to see and understand the flow. It provides a common language for talking about manufacturing processes. according to Eleftherios Andreadis (2017); (Muhammad & Yadrifil, 2017); Rahani and al-Ashraf (2012); (William M. Goriwondo, 2011) value stream mapping is considered to be one of the most significant and the most important lean tools used to identify the probabilities for the various lean techniques aimed at preparing better methods and performance in a proposed future state map and also which lean philosophers will need to make sustainable progress in the war beside waste. Value stream mapping is a tool used to reduce lead times, improve quality, on time delivery and utilization of resources.

## 2.8 Literature Gap

From the review of different kinds of literatures, most of the researchers grasped cost, quality, time and flexibility individually related to the influence of lean but did not focus on the combination of each other's parameter to the lean. And from the review of the existing frameworks of lean philosophies in industrial projects above underlined there are some limitations on the parameters of the frame works; Most of the frame works are built with lean with six sigma and also their implementation of lean tools. But none of the studies have been mixed supplier involvement and customer involvement in one in the framework. As could be observed, the new framework developed; has combined cost, quality, time and flexibility with adding supplier involvement and customer involvement in the best practices and the finding of the reviewed of the existing framework is to overcome the limitations of the

integration of key lean parameters and frameworks. Hence, this framework was constructed on the basis of important considerations and preferred through the review of the existing frameworks in the literatures and the review of key lean parameters.

**Supplier involvement:** better supplier relationships and presence in the planning process decreases material lead time, promotes on the on-time delivery of information and establishing trust and lasting relationships with suppliers introduces more reliability in the process. Suppliers are an important factor contributing to the success of going on and for a current competitive market to ensure reliability and frequent delivers (Al-Abdallah, Abdallah, & Hamdan, 2014; SHARMA, GUPTA, KUMAR, & SINGH, 2011; Siti Norhafizan Hibadullah & Zamri, 2013).

**Customer involvement:** Customer relationship in the early stage is used to focus on the real customers' needs. Customer's contribution permits the reduction of reworking, identifying problems and solutions introduce changes in the project processes and create a system that leads to a continuous improvement. The value of the customers must be recognized in the chain of the assessment process (Brege & Semnani, 2013; Manzouri et al., 2014).

# CHAPTER THREE

# 3. RESEARCH METHODOLOGY

This research adopted a case study approach. For this study, the research methodology required gathering relevant primary and secondary data. Primary data was conducted using interviews to provide qualitative insights and company visits. Secondary data were collected from recent literatures and company records in order to examine the waste level in SINTEC Ethiopia. The detail working methodologies to achieve the objectives are:

## 3.1 Data Collection

This research used both quantitative and quantitative data. Through case study methods the researcher recognizes the behavioral circumstances through the performer's perspective beyond the quantitative statistical results. Case study research benefits on both the process and outcome of the occurrence through complete observation, rebuilding and analysis of the cases under investigation by containing both Quantitative and qualitative data. In addition, the case study method permits a researcher to closely observe the data within a specific condition. Use both primary and secondary data. Collect primary data by a survey of the case company and secondary data from the past ten selected projects documented data regarding the above key lean parameters. After primary and secondary data are collected, they are analyzed in accordance with the objective of the research and engineering application. Primary data is the information that was gathered clearly for the study and the main source was interviews, observations, and information obtained during completing of the study.

## 3.2 Company Survey and Observation

While conducting a research getting, a core findings are the main goals but searching answer by means of interviewing or written document limits on the source. Therefore, in this research, the researcher used physical observation as a tool for collecting information and data. (Harsha N. & Nagaraj.N., 2013) said observation is a source of relatively objective information. By surveying of the case company to understand the existent to which lean projects tools and techniques have important for the industry. In service and wellbeing situation to examine services and physical surroundings, customer and work connections are used to by observation method. Using direct observation to study typical environment are

used to demonstrate the way in which observation can be used to enhance understanding of the environment.

Data collection tools using observation is preferring rather than using questionnaires and interviews because the researchers or others who need to learn and raise an understanding of the world around them helps from definite observation. In observation data collection method, the observer has an opportunity to listen to and watch others and may help to identify restrictions and yield an understanding of both customer response and accessibility of basic facilities.

The observational data collection method is used for direct contact to research occurrences and high levels of flexibility in terms of application. Therefore projects in Guberia, Modjo, Gonder and Addis Ababa were observed on site to understand the problem faces on industrial projects which were problems on site road and work area access for lifting machinery, construction material (steel structure or civil construction).

Observational research technique has many positive aspects which is observations are usually flexible and do not necessarily need to be structured around a hypothesis. Observational research results are considered solid invalidity because the researcher is able to collect depth of information about a specific behavior. In this research used observation as a tool for collecting information and data.

Direct observation is used as a means to assess the techniques used in documentation and system of the process as well as the existing services of the case company. Important documents such as annual reports, documented planning data, company profile have been used to accomplish quantitative analysis. Furthermore, the infrastructure of the project site has been observed.

Visit the project site of each project and observe each plant management, and work site area supervisors were informally interviewed. The plant was visited to develop an overall affecting of time, quality, cost, and productivity potential problem areas. During these visits, specific target jobs suggestions of work area problems, the structure of the building, the weighting of some construction materials project delay are the main issues are raised as a hot spot.

Having a particular model selection, a serious of visit and observation were conducted to identify the problems or the hot spot areas, and then collect data's and informations from various types of staff in selected areas throughout the case company.

In order to prioritize problems top management persons were interviewed, then important factors for improvement were determined, verified and evaluated which seemed to be risky and reason for the efficiency of improvement which management considered as critical. The prioritizing problems were carried out using Pareto diagram, then detail investigation were conducted using the selected problems inorder to analysis its cause and effect.

## 3.3 Secondary Data Collection

Secondary data were collected from recorded data (Archive), journals, different websites, and other published sources. Different 197 articles were Collected regarding lean from the most easily accessible popular sites and selected 85 relevant international and national publications concerning lean in industrial projects. The most widely published and relevant articles were reviewed in this paper because reviewing all lean benefits was not reasonable (Mostafa et al., 2013).

Reviewing the selected published journals specially focused on the presentation of lean which is essential to the research topic was chosen to be reviewed. According to (Mostafa et al., 2013) electronic database is the most operational way of searching for different articles. Among those of different databases available for searching it is essential to search the right files that attend the objectives and the subject matter of the paper.

In this research search relevant databases which is appropriate source of lean philosophy in industrial projects and select the relevant publications such as Taylor and Francis group, Emerald Insight, Elsevier, springer, IEEE, IOSR journal, Scientific and engineering, Alexandria engineering, science and technology policy research (SPRU), engineering research and technology (ISERT), engineering and innovative technology (IJEIT), International journal of research in business management (IMPACT), international journal of civil engineering (SSRG), European scientific journal, ARPN journal of engineering and applied science, international journal of engineering and technology (IACSIT), Asian social science, international journal of project management, international journal of industrial

engineering, African journal of business excellence, South African journal of industrial engineering, journal of manufacturing technology management.

The purifying process of the selected articles established combinations of keywords to search for journals titles. Key words which is used for search the publications built-in 'lean in industrial projects', 'lean philosophy', 'implementation of lean', lean implementation framework', 'lean thinking'. Studying the keywords and abstracts of the selected articles that revealed the concepts of lean implementation in industrial projects varied in the range of study; such as A.N.M. Rose, B.Md.Deros and M.N.Ab. Rahman (2013) focused on the study on lean manufacturing; Ghaith M, Ayman B. & Khaled.B (2014) focused on the impact of supplier relationship management; Antosz & Stadnicka (2017) focused on implementation of lean philosophy, Almani, Salonitis & Xu (2017) focused on lean implementation framework; Anand & Kodali (2010) focused on lean manufacturing framework analysis; Aziz & Hafez (2013) focused on the application of lean thinking; Belhadi, Touiki & El fezazi (2016) focused on effective implementation of lean production framework; Cianine & Vienazindiene (2015) focused on the empirical study of lean concepts; B.Dineshkumar & Dhivyamenaga (2016) focused on the study of lean principle application; Found & Harrsion (2012) focused on understanding the lean voice of customer; Rakesh & Dr.Vikas (2014) studied on barriers of lean implementation. As a result, 85 different articles were finally select. An in-depth study into each selected articles was conducted and focus on the critical factors of application of lean philosophy in industrial projects. Finally, propose a lean implementation framework in an industrial project based structure.

In lean implementation, a case study research is the most widely used method followed by the conceptual and survey approach (Paschal Ugochukwu & Langstrand, 2012). And analysis using the value stream mapping tool. The objective of this research is to explore the status of lean concepts in the industrial projects by surveying the existing problem on plant installation and commissioning works of the selected ten main projects.

The available data of the factories were collected and examined for relevance with the proposed measurement. Secondary data are collected for the primary research purposes which provide basic research principles. The major secondary source for quantitative data used in the study was collected from the last 5 years documented data of large industrial projects only. These data used to measure the effectiveness of the case company. At present, a total number of 243 works are done out of which 228 are workshop works and the remaining 15

are contractual works on site (project based). The data collection was focused on project-based works by random sampling technique due to time constraint and repetitiveness of the work only 10 mainly large projects were randomly selected.

### 3.4 Data Analysis and Model Development

In data analysis part, following the method that used in data collection analysis has been shown clear image of the existing system for the easy of finding an appropriate solution. Both data from company survey or observation and from data collected from company recording data which are secondary data were analyzed by means of computer software i.e. Microsoft excel 2010 & pareto diagram. Finally the data were compared with written approach in literature survey for finding new or possible reeducation of delay of industrial projects system approach. This research were used the case studies from Sintec Ethiopia where by primary and secondary data are collected and analyzed. The general flow plan of the methodology is visualized in figure, which gives an understanding on how the method suits the stated objectives of the research and engineering application, the process started with theory building and ends with conclusions and recommendations.

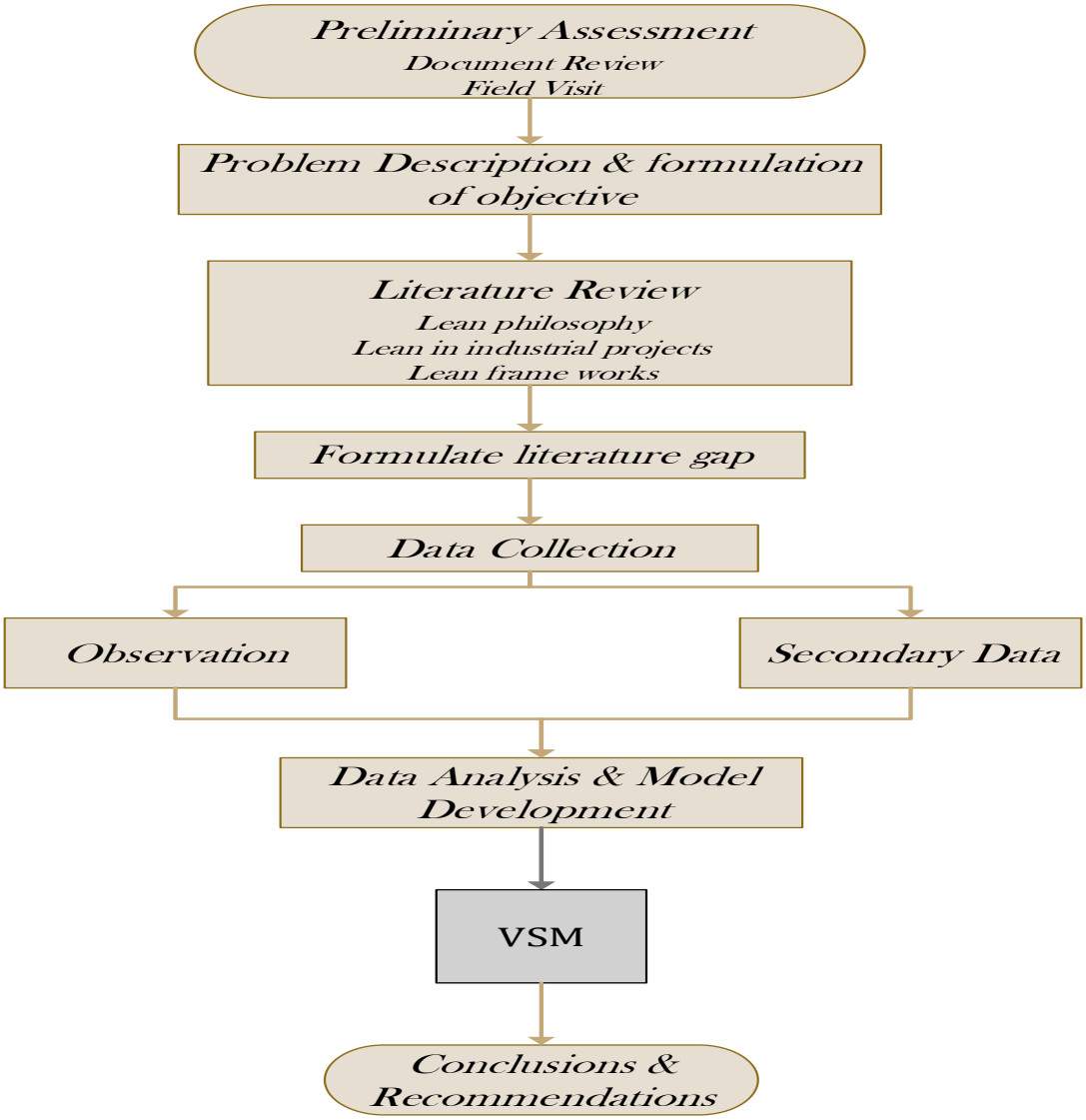



Figure 6. Research methodology framework

# CHAPTER FOUR

## 4. BACKGROUND AND COMPANY PROFILE

The case company is one of the first companies in Ethiopia established in 1989 among a consortium of seven sister companies.

Its primary objective is to engage in providing full-fledged technical services to the Mechanical / Electrical engineering sectors such as engineering, Supply of Technologies, Fabrication of Local Components, Erection / Installation, Commissioning, Maintenance / Rehabilitation, Advisory services. The company have over 105 full-time staff, 67 contractual employees and 57 casual labors in addition to a number of part-time professionals contracted for specific projects. The staffs consist of Mechanical Engineers, Electrical Engineers, and Electricians, Mechanics, Fitters, Welders, Plumbers, Riggers, Administrative and Marketing Personnel.

This company was established with the ultimate purpose of promoting science and Technology in Africa. The broad mission of the company is to contribute to the process of Industrialization, transfer of technology and know-how that takes into consideration not only local resource endowment but conditions of application for the achievement of national and regional development goals and technological self-reliance.

Facilities of this company include offices, two workshops, equipment's/tools. The company has different machineries like metal bending, rolling, shearing, cutting, punching, forming, forming,joining, guillotine shears, cross cut saw hydraulic and electric motor driven, power hack saws, eccentric presses, iron worker, brake press, radial drill and milling machines just to name a few.The facilities are fitted with a machine to cut sheets of up 16 mm in lengths of 6, meters, rolling of up to30 mm thick in three meters and press brake of seven meters length and 400tons capacity. There are also welding machines for steel, cast iron, aluminum, and stainless steel. This consists of manual metal arc welders ac/dc transformers and rectifiers), spot welders, MIG welders, TIG welders, Pulse TIG welders, Oxy-Acetylene gas welders, powder spray equipment and solders. In addition, it has cutting, bending forming and bending, rolling, cutting, trimming, punching, and seaming and threading equipment's. The case company owns a wide range of tools consisting of personalized toolboxes for all specialties. For field service (projects), the company has mobile equipment's such as crane trucks, vehicles.

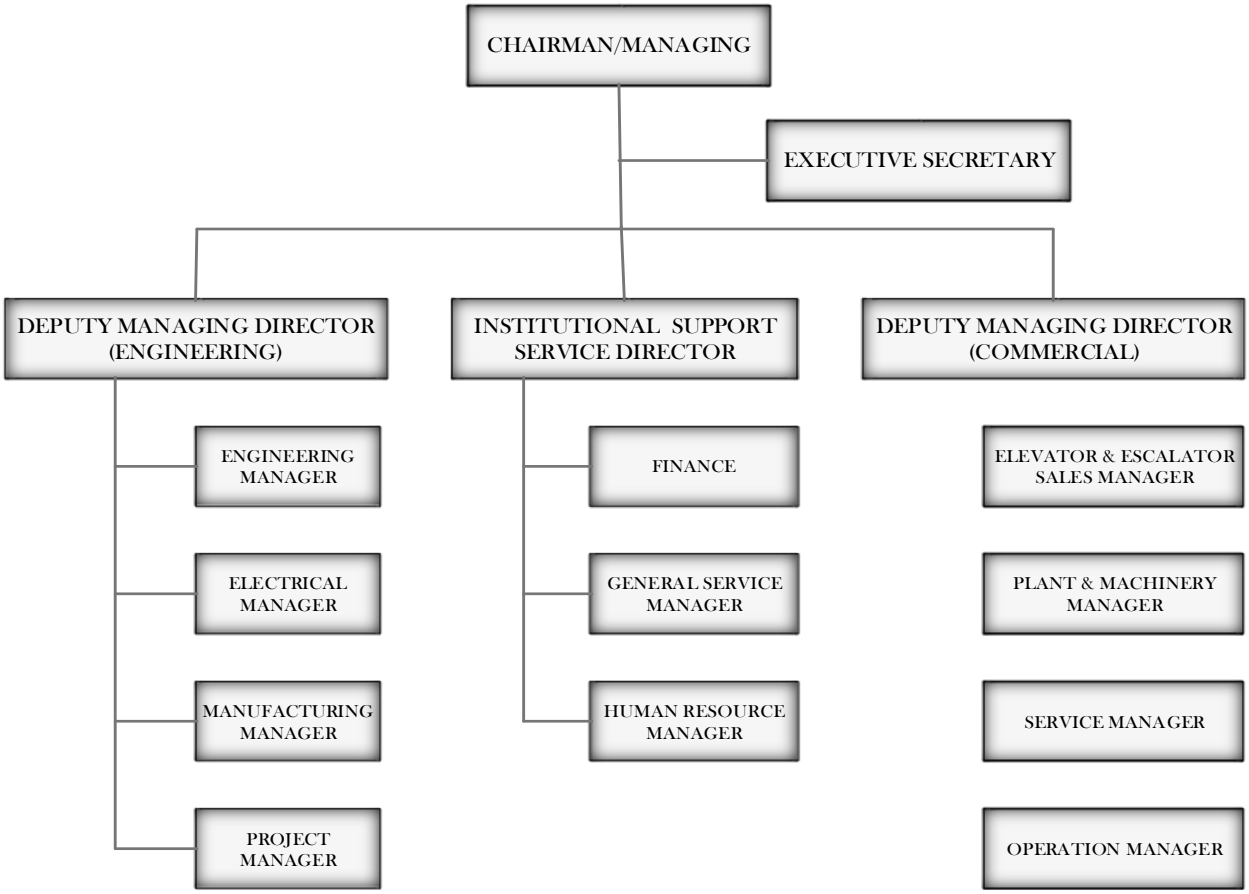



**Figure 7. Organizational structure**

The case company mainly works on different projects like sugar factory, brewery factory and steel structural work and such projects require Plant equipment and machineries, and/or parts to be installed/ erect so in order to perform the task Installation drawing layout of each machineries and plant equipment shall be prepared by site engineer with the intention of ensuring the expected result, as well as the economic utilization of construction materials, are met. The first step for erection/installation is receiving BOQ, design and technical drawing from the engineering department (After discussion of specification terms design section for clarity and confirmation), fabrication process will follow in the production department if there is any part required.

In this research, a general assessment of the case company and its problems were carried out. Mostly the assessment focused on main wastes in industrial projects. Problems at the case company were identified and lessen to the problems. This study proves how lean Application increases the competitive advantages from varies industries of the same work line.

Essential features of lean application in industrial projects are a clear objective for the delivery process, designed at maximizing performance for the customer at the project level. Implementation of lean techniques in any simple or complex projects shapes the projects safer, easier to manage, completed earlier and cost effective with a better quality. The proposed framework helps many significant contributions by resolving the limitations of the existing framework (Belhadi et al., 2016).

## 4.1. Request Managing and Order Processing

Project works come to the organization by direct customer order or through bid document. The process of receiving the order through bid document procedures include but not limited to tender review, participation, negotiations, contract agreement, etc. After the order is secured either through the bid or through direct customer order, working methodology preparation follows. Once the schedule is made and communicated to the production department especially planning department which contains information pertaining to the type of works, time and relevant information for the erection or installation of industries.

## 4.2. Overview of Plant Installation

In case of Installation/erection of plant equipment and machines work the same producer are followed such as installation drawing shall be prepared by supplier experienced design engineers with the intention of ensuring the estimated productivity. The installation or erection procedures ensure all engineering techniques required for erection and maintaining all safety parameters. Step by step detail instruction information getting from the contractor side and supplier side then the site manager helps the installation or erection process to be smoother & faster.

The first step for erection and installation works is receiving BOQ, design and technical drawing from the supplier. After discussion of the specification terms design section for clarity and confirmation. All plant machinery shall be erected on site in accordance to process line diagram. Accordingly, the following procedure shall follow.

- The contractor shall read and understand the manufactures installation requirements prior to beginning the installation of the equipment.
- Equipment shall only be lifted and handled in accordance with the manufactures instructions and at points and locations designated for such handling
- Before installation, all parts shall be thoroughly cleaned of all rust, grit and foreign matter.
- During the installation of equipment, all small access openings shall be covered with temporary covers made of tape, plywood or sheet metal whenever work is not actually in progress.
- Clearance around all equipments shall be checked prior to installing the equipment. Any interference or lack of access for installation, machine transportation and also for maintenance purpose.
- Based on the equipment line diagram, identify the type of equipment per the respective foundations
- Sort the machines in accordance with the line sequence and bring all parts of each equipment on the foundation or near the foundation
- All foundation elevations and bolt locations shall be verified prior to the start of installation of equipment.
- Assemble equipment parts and place the equipment on the foundation.
- Levelling and alignments of all equipment shall be within the tolerance specified in the manufactures instructions. Where equipment is received as a shop –assembled unit, alignments shall be checked and adjusted where necessary.
- Carry out alignments of machinery on the respective foundations taking due care of the center line of the overall process.
- Upon confirmation of alignment of the equipment, secure the machines tightly to respective foundations with anchor bolts
- Where necessary the process equipment's shall be interconnected with pipelines, conveyors, etc.
- Safety guards around the rotating equipment shall be installed in accordance with equipment manufactures instructions.
- After the basic system and equipment is installed, the following shall be performed and recorded to assure constriction completeness.
- ✓ Check installation for conformance with the design and specifications using available

- ✓ Confirm suitability of mechanical equipment's
- ✓ Perform and record required tests such as visual inspection, pressure and hydrostatic
- ✓ Check that all moving parts have safety guards and if not, the contractor shall provide acceptable field guards.
- ✓ Check cleanliness of equipment and systems
- ➢ When installation completeness is confirmed, preoperational tests require. The first operation of the equipment shall be without material which must be run with water or oil. And run-in tests shall consist of continuous operation until all bearing temperatures and equipment vibrations reach a steady state condition
- ➢ All equipment is to be certified complete and ready for start-up. All parties involved in all disciplines are to sign off each system prior to commissioning

## 4.3 Delivery Performance

In this research, the researcher observed that the case company has a problem regarding to the planning and cost preparation process. During the preparation of planning of work schedule, the project manager is challenged to make an educated guess about the staff, equipment needed to complete the project, and resource planning. Project planning is the heart of the project because the planning phase refines the project objective. In this phase, the project deliverables and requirements are defined and the project schedule is created. Interpretation of a project balance sheet is usually not straightforward until a project is completed so the time at which major cost savings can be done is during planning and design for the project. Good managers should focus on future costs and technical problems.

Table 3. Delivery performance of different industrial projects in number & cost variation

| Delay of projects | # of projects | Cost variation |
|---|---|---|
| Year of 2011/2012 | 13 | 328,426.42 |
| Year of 2012/2013 | 12 | 74,262.49 |
| Year of 2013/2014 | 16 | 91,726.56 |
| Year of 2014/2015 | 12 | 316,279.18 |
| Year of 2015/2016 | 10 | 410,750.98 |
| Year of 2016/2017 | 14 | 427,849.03 |

The above table shows there is no a significant amount of difference in the number of delay of projects that means there is no a significant improvement in the company. And also shows the cost loss due to delay of projects. So needs more attention need on the working project schedule and review the critical path. A best project plan delivers the objective of the project to know what needs to be performed and in which time frames the project needs to be completed. In the past 6 years an average amount 274,882.44 birr lost due to a wrong estimation of project duration. Whether a big or small project, the person in charge need to forecast the time required appropriately estimate. So, it's really serious to come up with a detailed estimation for the costs of the project.

## 4.4 Delivery Performance of Selected Industrial projects

Once completed the installation process, the production departments authorizes for the plant/ factory to produce the next section. Mainly the case company works both job shop or workshop products and industrial projects. Among 77 delayed projects which are mentioned in the above section (table 3) only 10 projects are industrial projects. Therefore in these research the ten industrial projects among the others which are also the case company working on is selected as a sample.

Table 4. Delivery performance of slected projects

| No | Project Price | Planning Time | Project starting Date | Project estimated Date | Actual Project finishing Date |
|---|---|---|---|---|---|
| 1 | 22,695,148.57 | 20 weeks | 16-Apr-12 | 16-Sep-12 | 16-Dec-12 |
| 2 | 3,200,000.00 | 16 weeks | 25-Feb-14 | 25-Jun-14 | 25-Jul-15 |
| 3 | 3,356,720.00 | 12 weeks | 21-Apr-14 | 11-Jul-14 | 30-Apr-15 |
| 4 | 2,540,431.57 | 18 weeks | 18-Nov-14 | 3-Apr-14 | 24-Oct-15 |
| 5 | 2,163,000.00 | 08 weeks | 2-Feb-15 | 2-Apr-15 | 9-Jul-15 |
| 6 | 17,632,506.76 | 20 weeks | 10-Mar-16 | 10-Aug-18 | 7-Sep-18 |
| 7 | 21,740,384.99 | 16 weeks | 20-Jan-17 | 20-May-18 | 15-Mar-19 |
| 8 | 3,185,603.18 | 16 weeks | 7-Mar-17 | 11-Jul-18 | 5-Sep-18 |
| 9 | 3,045,217.46 | 12 weeks | 11-Jul-18 | 11-Nov-18 | 15-Jan-19 |
| 10 | 3,521,361.85 | 20 weeks | 25-May-18 | 25-Nov-18 | 1-Feb-19 |

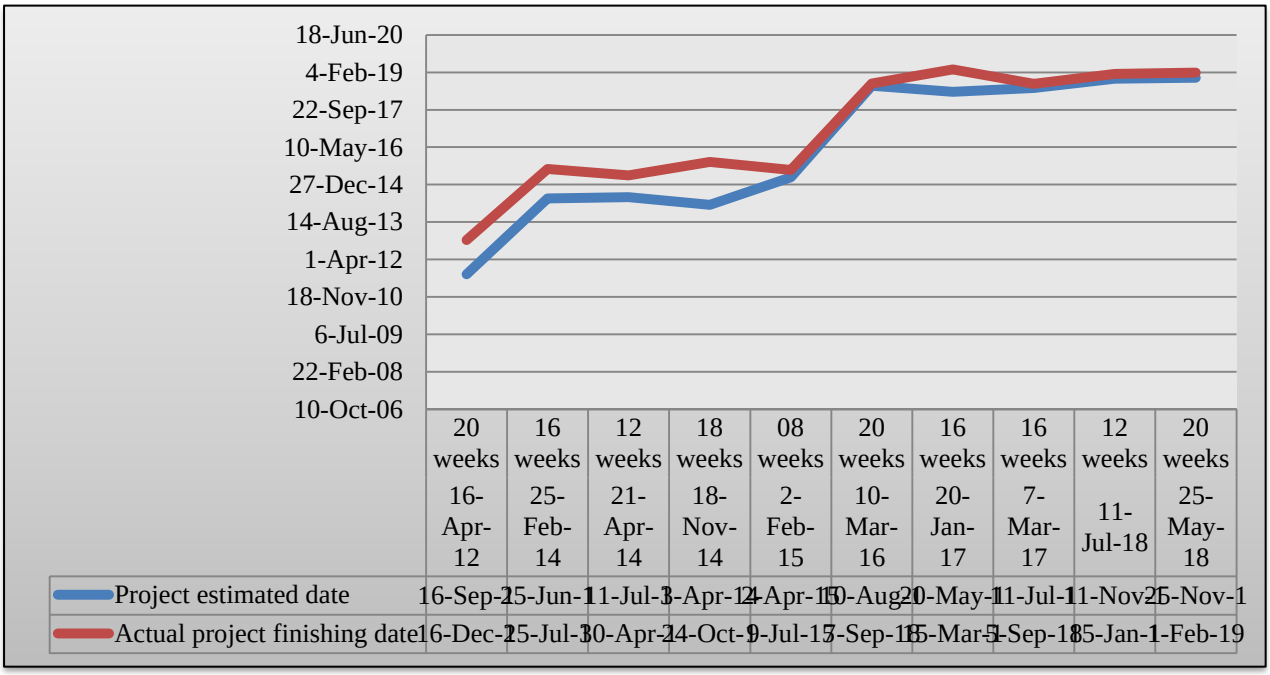



Figure 8. Delivery performance of selected projects

The above table shows on-time deliveries for the company for selected industrial projects. Thus there is a delay of timely deliveries of projects to customers unto a maximum of ten months and a minimum of two months. It implies that many customers did not receive the products within the set delivery target time for the company.

The best project schedule is that connects what work needs to performed, which resources of the organization will perform the work and the timeframes in which that work needs to be performed. The project schedule should reflect all of the work associated with delivering the project on time. Therefore, inorder to minimize unnecessary wastes scheduling appropriate plan to deliver earlier or within the time plan is needed.

## 4.5 Procurement of consumables and Argon gas

Best procurement consumable method is important to minimize the risks of delay in the project completion resulting from late deliveries because without consumables erection is impossible. Procurement of consumables starts with design estimation and purchased by the marketing department. Late delivery of consumables and argon gas is one of the main causes of delay in major industrial projects. In the case company, the purchasing procedures typically involve a paper based communication process between the project manager,

engineering department and purchaser. Consumable procurement needs to be accurately planned and executed to avoid the negative impacts of material shortage or excessive material inventory on site.(Ar. S. Kamalaeaswari & Vedhajanani, 2015) lack of planning before starting the project and late deliveries are the major problems elaborate in the material (consumable) procurement. The times required for varies activates in the procurement of consumables might be estimated to be as follows.

The research was based on data from the actual documented data and observations at the case company. It looked at the current Working system and its merits under the existing conditions. Awareness of employees on lean philosophy and implementation status of lean is assessed in this paper. Effort was made to investigate how lean can be applicable in industrial projects. This was done by looking at how the existing system implements lean philosophy; planning time, site road and work area accesses, procurement of consumables and Argon gas which are strategic goals in the application of lean philosophy in industrial projects. Information on suppliers' delivery lead times and production lead times was gathered in this study. Most repeatedly a type of installation projects, ten plant installation projects were selected for this case study.

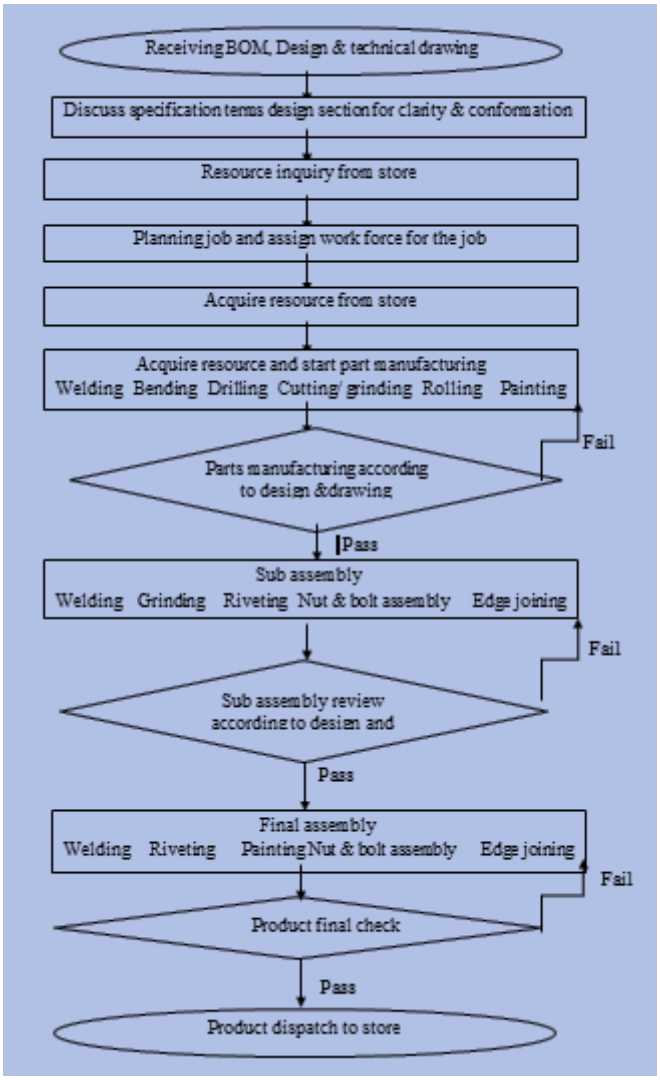



Figure 9. Process flow of projects

Table 5. Duration of procurment of consumable

| Item | Description | Duration (days) |
|---|---|---|
| 1 | Requisition ready by designer | 0 |
| 2 | Receiving approved purchase requisition | 1 |
| 3 | Gather Performa invoice from supplier | 4 |
| 4 | Prepare comparison & propose winner | 1 |
| 5 | Request necessary amount | 1 |
| 6 | Receive money & perform purchase | 5 |
| 7 | Deliver to project site | 1 |

As a result this type of consumable procurement will typically 13 days. The consumable and argon deliveries and completion of contracted work dates are placed on the project schedule and any procurement activities that create a project delay or fall on the project critical path may require special attention and lean application solve this kind of problem.

## 4.6. Design consideration related to work area access for installation

The building of the project site has certain aspects that must be considered during construction. The designer must consider free space to access easy to movements of machinery. These design considerations can create estimating problems in work area access. During the erection of machinery defalcate a lot of time because of construction building which not considers free space to move machineries place to place and easy installation process. Therefore for the opportunity for cost savings, consider free space on the construction of the building is important. By designing space easy to move machinery to ensure, projects won't have to suffer from overruns due to corrective work in construction of building because additional works or requirements will generally result in a higher cost.

# CHAPTER FIVE

# 5. DATA ANALYSIS & RESULTS

This chapter contains a summary of data findings and their interpretation. The analysis was done by the collected data in detail and gives an indication to concern with research objectives.

## 5.1 Preparation of current value stream map

The main processes that are handled in the projects are unpacking, sorting, rigging, fitting, tack welding, cleaning, final welding, cleaning & grinding and commissioning. In order to check and assess the consequence of lean thinking concepts on reducing production process wastes with the interaction of the industry and customer requirement is obtained.

The entire data was collected according to the method of value steam mapping lean tool because it is related and easy for this research; the data is collected by the support of production planning and quality control department, and also by asking the workers and operators at project site. Having conducted the data the company has a delaying problem. To overcome these problems there is a need to recognize the key areas which are the causes for the producing wastes, and to identify bottleneck processes.

The data is forecasted on yearly bases and the orders are received from the customers on monthly bases. The following information is related to the projects producing/assembly line:

- Working shift per day = 1
- Working hours per shift = 10 hours
- Available time per shift = 10hrs*60 min.= 600 minutes
- Lunch break per shift = 60 minutes
- Total installation service per year = 3 projects
- No of working days in a year = 312 days
- No of working hours in a year = 2808 hours
- Installation service per a project = 936 hours per installation

In the process of developing project plans, the planning person must consider resource optimization, time and workflow it will take to complete the entire project. So the cycle time of each process is recorded and on the basis of the collected data.

For the sake of showing clearly the delay of the project one sample project out of the ten is randomly selected because of the process of analyzing have the same producer. The data for the sample project is gathered from the case company recorded file.

Table 6. Processing time of Assembling line

| Process | Processing time (Hr) |
|---|---|
| Unpacking | 60 |
| Sorting | 60 |
| Rigging | 60 |
| Fitting | 240 |
| Tack welding | 170 |
| Cleaning | 120 |
| Final Welding | 280 |
| Cleaning & Grinding | 100 |
| Commissioning | 220 |
| **Total processing time** | 1,310 |

Takt time demonstrate the rate at which you need to complete the production process in order to meet customer demand. By calculating the correct takt time the company has benefited from the following points: to maintain a constant production flow, to estimate service delivery process and set realistic time targets. To calculate the takt time, the following formula is used

$$Takt\ time = \frac{Available\ working\ time\ per\ project}{customer\ demand\ per\ project} = \frac{2808}{3} = 936\ Hours$$

The analysis of cycle time of the process is shown in the figure below

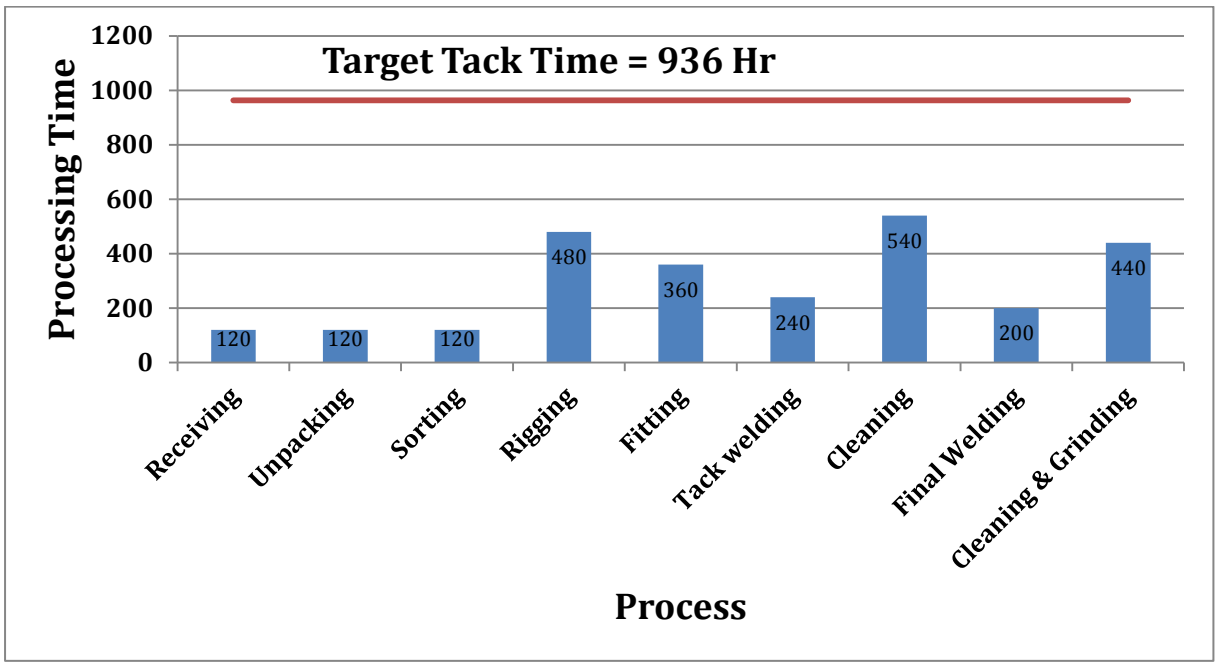



Figure 10. Existing Cycle time of process

The above graph shows the target takt time is 936 hours, which means below the maximum acceptable time to meet the demands of the customer. So the above result shows most of the time workers not doing their works and there was a lot of free time in the project.

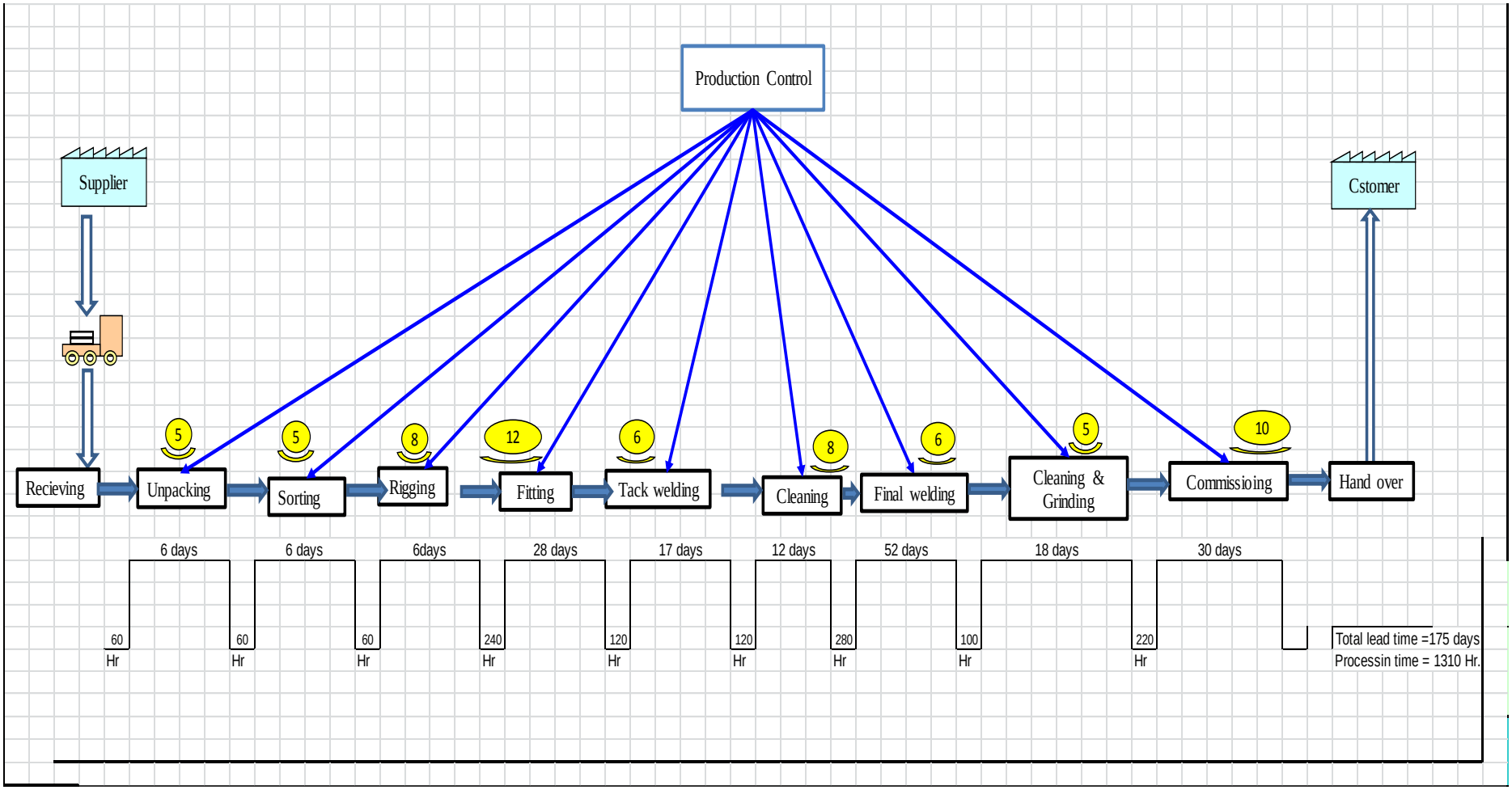



Figure 11. Current state of VSM of Erection/ installation of machinery

The current VSM demonstrates that, the total cycle time for assembly line is 1146 hours whereas the lead time is 1575 hours. The project is being delivered to the customers on monthly basis. While studing the recorded data regarding to handling of work there are many wastes and non-value added activities in the process like waiting for missing parts, procurement of consumable or argon gas and modification work of construction building. This problem causes the increasing of lead time and customer dissatisfaction . The Other point to notice is very low line balancing efficiency, which is 52% for the present condition. Inorder to satissfay the need of customer the working time have to approch the targeted takt time which is 936 hours.

## 5.2 Cost Based Current State of VSM

The cost based on current state is mainly calculated daily project cost and takes into account of all costs in the VSM. As mentioned previously all costs related to VSM is considered as a direct cost. Any cost outside the Value Stream Mapping is not included in the costing of Value Stream Mapping. Per day cost of VSM is listed in the table below. The total cost is 107,573 Birr which will be compared with a cost of future state Value Stream Mapping later to investigate and evaluate the difference between these two costs.

Table 7. Existing production costs of the sample project

| Current state of VSM | Employee **cost(Birr)** | **Production support cost (Birr)** | **Machine / Equipment cost (Birr)** | **Consumable cost (Birr)** | **Other cost (Birr)** | **Total Cost (Birr)** |
|---|---|---|---|---|---|---|
| Unpacking | 2580 | 530 | 1250 | …….. | 1860 | 6220 |
| Sorting | 2075 | 280 | 520 | …….. | 1550 | 4425 |
| Rigging | 1680 | 395 | 2760 | ……. | 1240 | 6075 |
| Fitting | 9750 | 3760 | 115 | 6760 | 2480 | 22865 |
| Tack Welding | 7320 | 2675 | 213 | 4712 | 1860 | 16780 |
| Cleaning | 900 | 1100 | 124 | 567 | …… | 2691 |
| Final welding | 9900 | 5215 | 318 | 8216 | 3720 | 27369 |
| Cleaning and grinding | 1800 | 1312 | 132 | 792 | ……. | 4036 |
| Commissioning | 8450 | 2320 | 195 | 3047 | 3100 | 17112 |
| | | | | | | **107,573** |

The delay of time due to rework or poor quality is mainly calculated daily project hours and takes into account of all times in the VSM.. Any time outside the Value Stream Mapping is not included in the calculating of houres of Value Stream Mapping. The delay of time due to

rework or poor quality of the project is about 127 hour Per day . This rework due to poor quality will lead to delay of time for the project because when making the sechdgule/plan for the project reworking time is not considered.

Table 8. Existing delay of time due to Rework or poor quality for the sample project

| Current state of VSM | Total Man houres (Min) |
|---|---|
| Unpacking sorting | |
| Rigging | |
| Fitting | 1950 |
| Tack Welding | 1464 |
| Cleaning | 180 |
| Final welding | 1980 |
| Cleaning and grinding | 360 |
| Commissioning | 1690 |
| | **7,624** |

The delay of time because of flexiablity is mainly calculated daily project time and takes into account of all hours in the VSM.. Any times outside the Value Stream Mapping is not included in the estimating of Value Stream Mapping. The delay of time because of flxiablity of the project is about 9,530 Min Per day. The flexiablity of project will comes from site condition, absence of workers, shortage of electric power and lack of raw of material will totally lead to delay of the project.

Table 9. Existing delay of projects due to flexiablity for the sample project

| Current state of VSM | Total Man hour (Min) |
|---|---|
| Unpacking sorting | |
| Rigging | |
| Fitting | 2437.5 |
| Tack Welding | 1830 |
| Cleaning | 225 |
| Final welding | 2475 |
| Cleaning and grinding | 450 |
| Commissioning | 2112.5 |
| | **9,530.00** |

## 5.3 The proposed future value stream map

After assigning and carefully examining of the existing installation/erection process of an industrial project, it has found a lot of waiting time problems. When comparing the cycle time with the Takt time it's found that all the cycle time have less than Takt time in the assembling area. So it can improved by combining the cycle time less than the Takt time by applying lean thinking methodology in the entire system. And also remove the bottleneck to take more time to doing work. In addition apply Kaizen burst was implementing in the system to eliminate wastes that result from waiting for missing products and procurement of consumables and argon gas. Most of the process lead time is tied up in waiting for materials. So to reduce this waste a number of proposed improvements were suggested and implemented in the installation/erection process of the industrial projects to improve the productivity and fulfillment of customers requirement.

- To reduce the delay of projects first take attention on planning stage and working together with suppliers and customers.
- To save time for waiting of missing parts first arrange the existing material and check which parts is missing and immediately communicate with suppliers before the time of the work.
- To reduce the waiting time of modification of construction building or rework suggest the customers build the site with steel structure works rather than construction or civil to easily movements of crane and machineries in the project.
- To save extra time to wait procurement of consumables and argon as first work on check the detailed information for connection methods and in cost preparation working together with project manager and supervisors of the project.
- Unpacking, Sorting and Rigging operation are done the same time by 10 workers
- Tack welding and cleaning operation are done the same time by 8 workers
- Cleaning & Grinding and Commissioning operation are done the same time by 10 workers

After considering of the above points the future value stream map for installation/ erection works of industrial projects are as show the figure below.

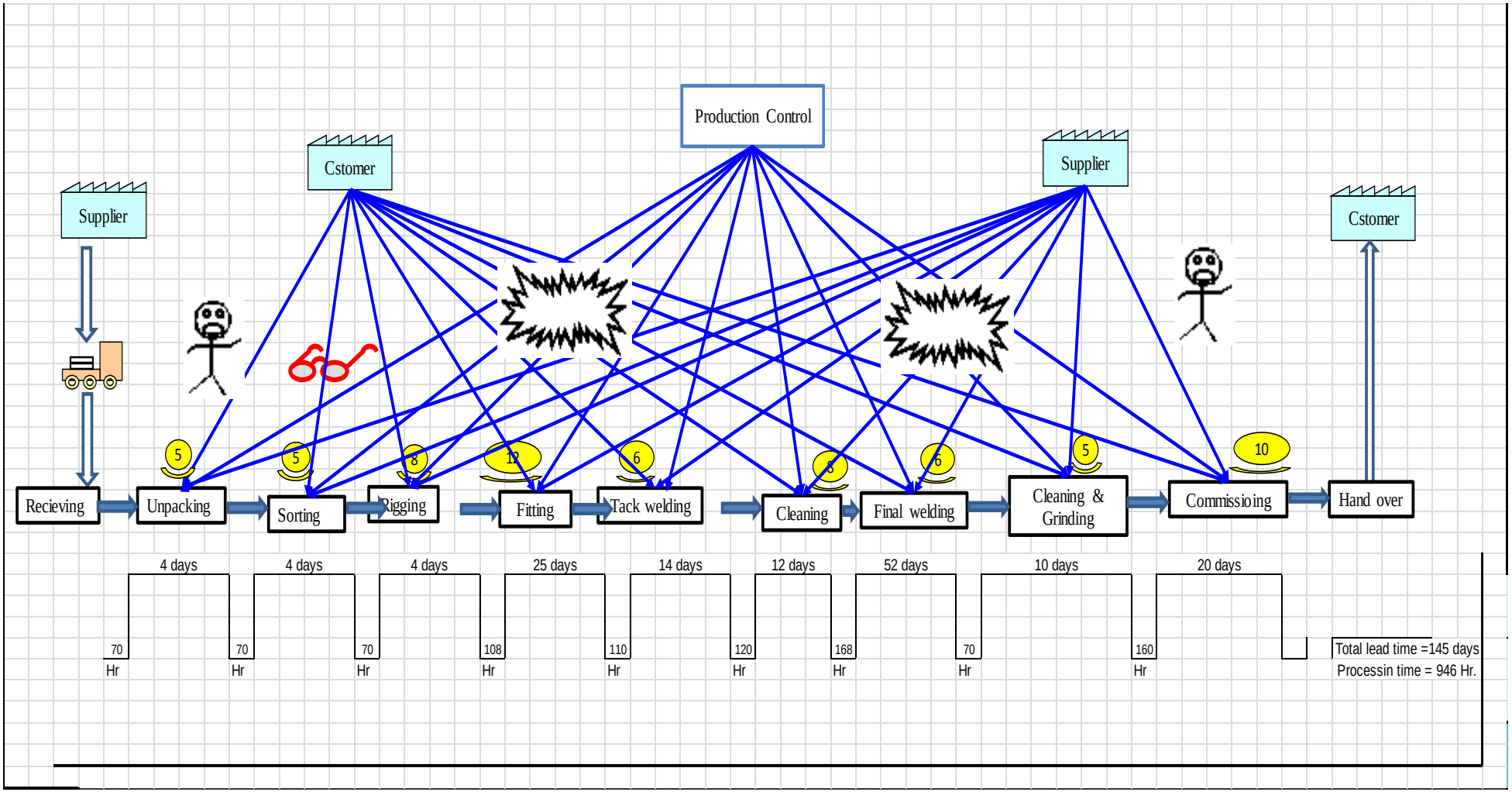



Figure 12. Future state of VSM of Erection/ installation of machinery

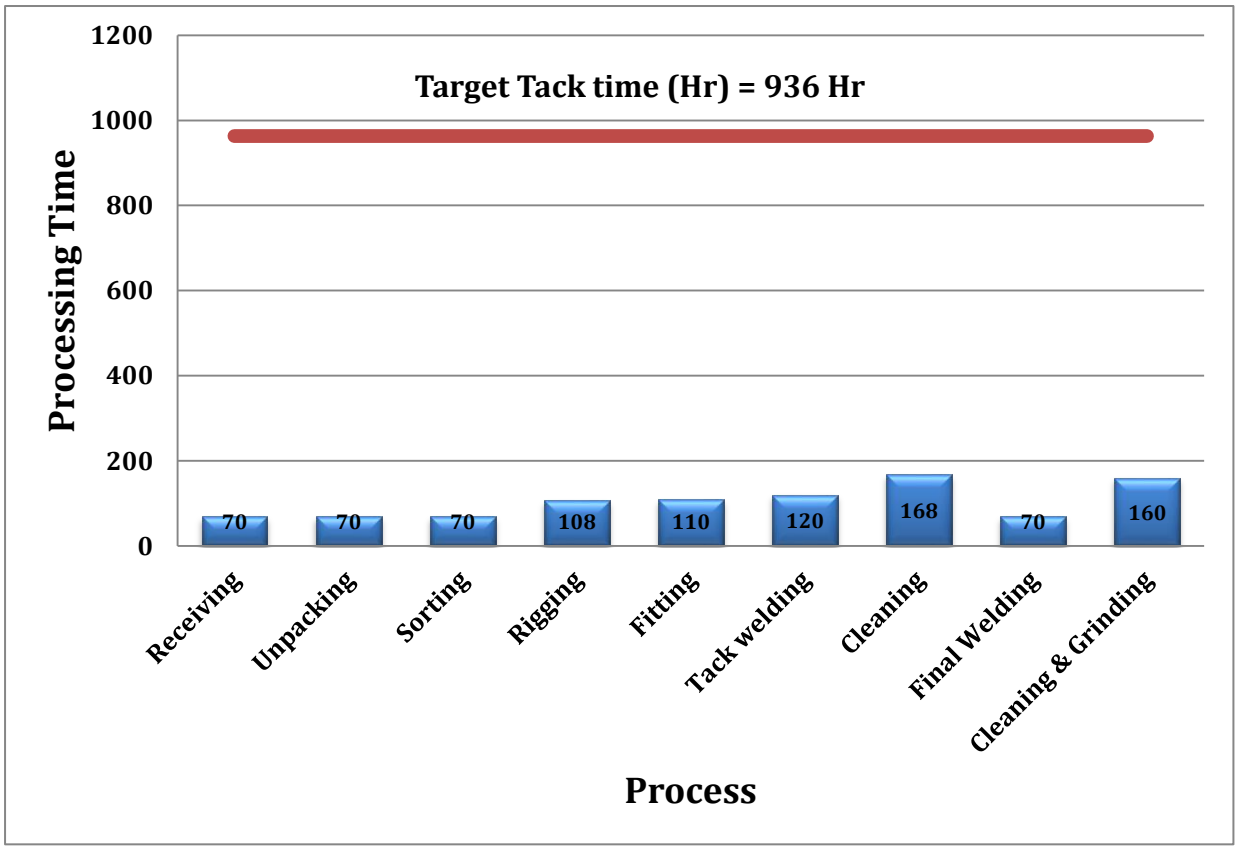



Figure 13. Future cycle time of the projects

## 5.4 Cost of future state VSM

By identifying the wastes of time delay using value stream mapping and take assumption which is listed in 5.3 section to minimaize the cost of future state. After suggestion improvements and the formulation of future state of Value Stream Mapping, the cost has been calculated and summarized in Table below of the daily time as previously implemented in the current state.

Table 10. Cost of future state of VSM of the sample project

| Future state of VSM | Employee cost(Birr) | Production support cost (Birr) | Machine / Equipment cost (Birr) | Consumable cost (Birr) | Other cost (Birr) | Total Cost (Birr) |
|---|---|---|---|---|---|---|
| Unpacking | 2193 | 377 | 950 | …….. | 1636 | 5156 |
| sorting | 1867 | 252 | 520 | …….. | 805 | 3444 |
| Rigging | 1344 | 335 | 1760 | ……. | 1054 | 4493 |
| Fitting | 9750 | 3760 | 115 | 6760 | 2480 | 22865 |
| Tack Welding | 7320 | 2675 | 213 | 4712 | 1860 | 16780 |
| Cleaning | 720 | 1154 | 124 | 567 | ….. | 2565 |
| Final welding | 9900 | 5215 | 318 | 8216 | 3720 | 27369 |
| Cleaning and grinding | 1030 | 1115 | 132 | 792 | …… | 3069 |
| Commissioning | 4815 | 2034 | 195 | 3047 | 2769 | 12860 |
| | | | | | | **98,601** |

In comparison between the delay of time based for current and future states of Value Stream Mapping, the reduction in time is 4950.25 Min per day. It shows the importance of using the Value Stream Mapping in industrial projects using the assumption taken on the 5.3 section. Moreover, this technique provides an accurate time calculation method that can be used for tendering purposes.

Table 11. Future reduction of time due to rework or poor quality for the sample project.

| Future state of VSM | Employe cost(Birr) | Total Cost (Birr) |
|---|---|---|
| Unpacking | | |
| sorting | | |
| Rigging | | |
| Fitting | 975 | 975 |
| Tack Welding | 1098 | 1098 |
| Cleaning | 72 | 72 |
| Final welding | 1980 | 1980 |
| Cleaning and grinding | 103 | 103 |
| Commissioning | 722.25 | 722.25 |
| | | **4,950.25** |

In comparison between the less flexiablity of the project delay time based for current and future states of Value Stream Mapping, the reduction in time is 3,485.50 minutes per day. It

shows the importance of using the Value Stream Mapping in industrial projects using the assumption taken on the 5.3 section.

Table 12. Future reduction of time due to flexiablity of manpowers

| Future state of VSM | Man houres | Total Man houres (Min) |
|---|---|---|
| Unpacking sorting | | |
| Rigging | | |
| Fitting | 1462.5 | 1462.5 |
| Tack Welding | 1098 | 1098 |
| Cleaning | 79.2 | 79.2 |
| Final welding | 2277 | 2277 |
| Cleaning and grinding | 164.8 | 164.8 |
| Commissioning | 963 | 963 |
| | | **6044.50** |

### 5.5 Supplier and Customer involvement

**Analysis of Supplier and Customer involvement**

This section will provide the interview results from the six cases, which are three suppliers (Krones AG, Buhler GMBH and Voestalpine Böhler Welding) and three Customer lists such as Habesha brewery, Meta Abo brewery and National Alcohol and Liquor factory. For privacy reasons the name of the interviewers will not be mentioned.

**1. Krones AG**

Krones AG is a German packaging and bottling machine manufacturer that designs and implements complete lines for beverages, food and related companies. This company cover each individual production process step starting from product and container production, filling and packaging all the way up to material flow and container recycling. Therefore, they supply the raw materials or brew machineries for the sake of the fulfillment of erection/ installation of brew factory. In this case, the supplier was involved in the first stage because it is mandatory to have the input (machineries and raw material) to proceed the erection/installation work. The reason for early involvement of the supplier is that the supplier already delivered the raw materials and thus had further information for the functionality of the product and know how to attain this in the best way possible. Krones is a

known supplier of Sintec Ethiopia PLc. And asked about the possible effects of supplier involvement on the process of industrial projects, the project manager believed that two aspects to be of high importance enhanced information and expertise of the supplier, and the ability of the supplier to identify opportunities to reduce delay of projects. Moreover, the importance aspects were sharing the right information at the right time with the supplier and get better communication. When having better communication, products could be produced and deliver faster thus reducing delay of projects.

**2. Buhler GMBH**

Buhler is a global expert in the field of plant design related services for processing foods and manufacturing advanced materials. Bühler Germany is the competent partner or supplier when it comes to machines, plants and services for the grain and food processing as well as for producing high quality materials. This supplier holds leading market places worldwide in the fields of technology as well as processes for transforming grain into flour and animal feeds, producing pasta and chocolate, and manufacturing die cast components. We collaborate closely with our customers throughout the life cycles of their production plants by developing new additional values for their products. In this case also the supplier involved in the early stage of erection/ installation service. When asking about the effects of supplier involvement in the early stage with one of the supervisor says early involvement of supplier is good for many cases like to ensure the alignments and accountability, understand all assumptions and minimizing risk by working together closely, the supply chain becomes more effective in erection/ installation processes. Better supply chain with supplier is important to deliver projects within the planned time.

**3. Voestalpine Böhler Welding**

Voestalpine Böhler Welding is a manufacturer of welding consumables for joint welding, maintenance, repair and overlay welding and brazing, with headquarters in Düsseldorf. The company owns over 40 subsidiaries in more than 25 countries, 2,300 employees, customers in approximately 150 countries and more than 1,000 distribution partners. Sintec Ethiopia is one of the partners of bohler electrode among 1,000 distribution partners. The company offers extensive technical consultation and individual solutions for industrial welding and soldering applications. It has three specialized and dedicated brands for joint welding, maintenance and cladding, and brazing and soldering. This company is one of electrode supplier for

installation/ erection service. In this case, because of early supplier involvement and communication problem the projects wait until the procurement of consumables, without consumable it is impossible to perform the installation/ erection work at all. By asking, one of the sales representative of the company responds that supplier involvement in the early /planning stage is important to reduce the period of the procurement of consumables. The sales representative believes that in the preparation of planning all raw materials suppliers as well as consumable suppliers are working together in early stage of planning. And having a better communication with suppliers to share information's and delivers enough amounts of consumables to finish the projects on time.

**4. Habesha brewery**

Habesha brewery is one of the latest beer companies to join the Ethiopian market. The company has started projects in Debrebrihan town with the engaged more than 8,000 shareholders in the brew industry. Habesha brewery is one of the customers of Sintec Ethiopia from the brew sector. Few among contracts handled by Sintec Ethiopia from Habesha brewery is the supply and fabrication of fuel tanks, fabrication and installation of hot water line and fire hydrant line. The main reason for involving customers in the early stage is because the project will not realized without the customers since projects are done for customers. One of the project supervisor said that early discussion with customer is important because customer may express the needs in terms of scopes to be achieved and clarify requirements to complete scope of the projects is addressed duration and intended benefits of the project can be achieved. In addition, to know the project site condition form the beginning of the projects with timely manner, customer needs to give suggestions while the plan is processed. Along the way of the project plan, the customer might discover potential risks which need to be addressed because regular reviews of the project is must for achieving the goals of the project. The project supervisor believed that an early involvement of customer in the projects is important for the benefit of both the contractors and customers to finish the projects within the planned time. As a project supervisor, if deliver results with in the planned time that only satisfy contractors but also customers with unrivalled credibility, then you've successfully secured future business for the company.

**5. Meta Abo brewery s.c (Diageo)**

Meta Abo brewery Share Company is a leading beer company in Ethiopia. Diageo plc, the world's leading premium drinks business, has completed the acquisition of the Meta Abo brewery share company. The purpose of the enterprise is to manufacture, can, bottle all kinds of beer, and other beverages weather alcoholic or non-alcoholic; to prepare and manufacture malt, hops, yeast, carbonic acid, gas and other ingredients of the products; to sell its products both locally and abroad and to engage generally in any other business conductive to the attachments of the purpose. SINTEC has handled several major contracts; few among the many are pipelines, pipe racks, insulation work, different platforms, installation of pumps and works on electrical parts. So this customer (client) works with SINTEC for both the sake of the fulfillment of erection/ installation of brew factory. In this case, the customer was involved in the first stage because the first of erection/installation work is getting the interests of customers for the input. The main reason for early involvement of the customer was in any project is the customer and their involvement throughout the process is crucial because customer has a representative on site with our development team and available at all times to offer inputs into the development process. Meta Abo Brewery (Diageo) is a known customer of SINTEC Ethiopia PLc. When asking about the possible effects of customer involvement on the process or installation/erection of industrial projects to the project manager, he suggested that it is important to enhance information about the project and the interest of customers from the very beginning. Customers can help to give information to prioritize which issue is sensitive or need to be handle first. The project manager also says customer involvement in the early stage is important to produce the best and successful results, when the customers engaged during analysis, development and testing of the project, it will lead to a better solution and meets the customer requirement. When having a better communication to know the interests of customer to identify the better opportunities to reduce delay of projects.

**6. National Alcohol and Liquor factory**

National Alcohol & Liquor factory is a state owned business organization and pioneer factory in manufacturing and distributing extra neutral alcohol, denatured alcohol and different brands of liquor in the country. The factory have four branch, two of them are operational and

two of them are service giving. The major projects' working with national alcohol is factory expansion project at Addis Ababa around Mekanisa. This contract covers the assembling, erection and commissioning works of stainless steel and mild steel tanks of various capacity, piping installation works, ladders, frames, decks and instrumentation are a few among the other works. Asking one of the operation manager about early involvements of customers in the installation/erection of industrial projects, he says it is very important to clear the objectives of projects in order to illuminate the problem that can cause from misunderstanding after all the aim of any project has the goal of delivering solutions to customers problem and deriving value. Therefore, it is important to know the better way of ensuring these goals to meet customer requirement by asking customers to communicate their problems. Also working with customers in early stage is important to deliver the projects with in the planned time by solving the problems of customers.

## 5.6 Cause and Effect analysis

Cause and effect analysis is an effective tool to see the relationship between factors common for lean manufacturing and customer satisfaction used in improvement of productivity by reducing delay time in the industrial projects. Therefore; the figure 16 shows how cost estimation, planning and rework are accountable for delay issues or liable for productivity issues or respective low productivity problem.

The construction of cause and effect digram is based on mind maps which represents the core idea. The idea of mind maps was first familiarized by the author of over 100 books and leading expert on the thinking and brain Tony Buzan. Mind map is a tool that the researcher builds their own mind maps of what they want to learn, read or present. It has been suggested as a technique to brainstom and summarize information (Taqi, 2017).

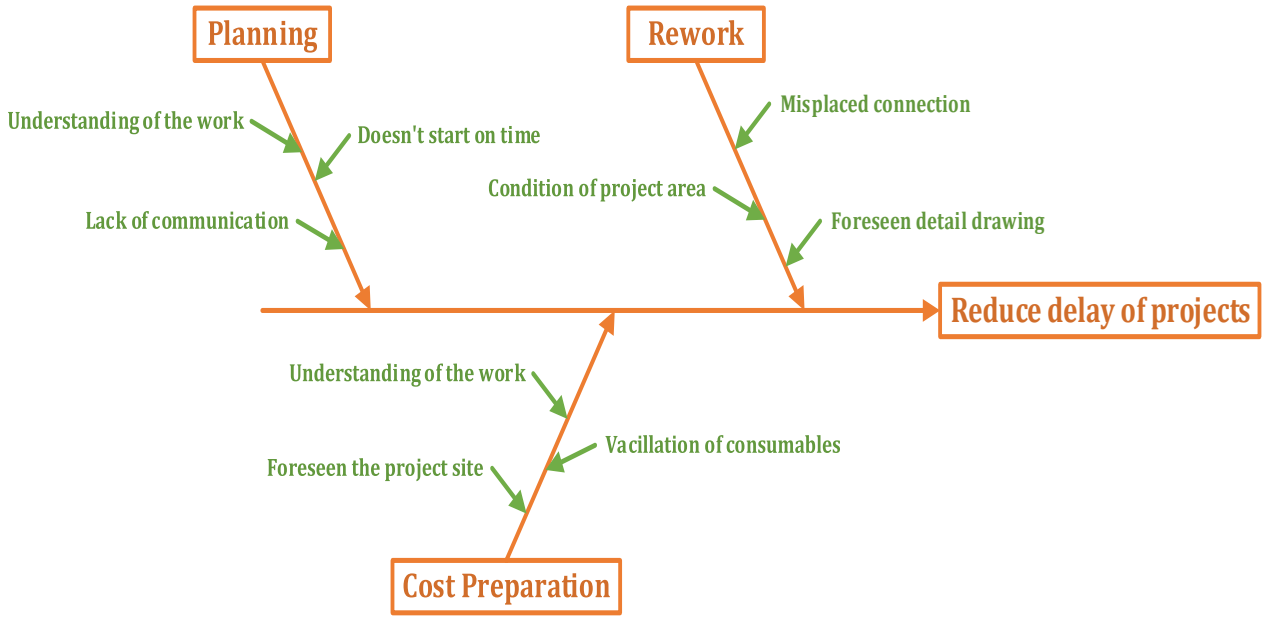



Figure 14. Cause and effect analysis of delay of projects

The above graph shows the comparsion of the future and current state of vale stream map of the assembling process of the inductrial projects. The result shows in current state map results in inefficiencies and wastage of resources were as in the proposed future state of value stream map reduction in lead time and improves the overall productivity. But from all the above listed cause and effects planning is the actual delaying reason for the selected sample project.


Figure 15. Improvment of production

The goal of this research is reducing the delay time of the industrial projects and satisfy the customers requirement. In installation/erection work of the project in the case company waiting time is the prominent wastes and to tackle the delay of industrial projected value streaming lean tool is recommended.

## 5.6 Simulation model formation

The simulation model was built using arena version 14.0 simulation software. The construction period of the model is based on the industrial projects assembly line process flow fabrication drawing which highlighted during observation. The objective model formation or development is to determine which components of the system should be included in the model and how the model should flow to imitate the system. In this simulation model the assembly parameters and performance indicators are going to be discussed. The model development was started with the declaration of the entity, the location of the workstations, generating path network and resources, declaration of the arrival and processing programming. This software is used to build line simulation model and conduct simulation experiments to achieve the objectives of the study. The arena simulation software performs the simulation the simulation of processes allowing doing analysis without interfere the system. The simulation model which design to the real process and input data can be combined to visualize the real background of the problems.

### ❖ Input, output data, performance indicators and assumptions

The input data used for the model are:

- ✓ Cycle/ processing time of each erection/ installation process of the project
- ✓ Manpower average assembling speed
- ✓ Assembly length
- ✓ Average number of manpower in the assembly line

### ❖ Output data/ performance indicators

To measure output data we use the following performance indicators are:

- ✓ Average waiting time in assembly line
- ✓ Maximum waiting time in the line
- ✓ Average and maximum total time in a system

- ✓ Utilization

### ❖ Assumptions

The aim of the simulation model is to mimic the real world system being delivered, including real world conditions and assumptions. So the starting point for generating a simulation model is the development of assumptions to estimate the simulation model with the real life situation. Building a reliable and valid simulation model requires specific steps to be followed.

- ✓ Required amount of line input
- ✓ The model is flexible
- ✓ No construction plan change have to be done
- ✓ No lack of manpower during assembly process
- ✓ No down time of machineries
- ✓ Line operators are always available in the line
- ✓ All human factors are not considered

### 5.7 Line simulation model

Once completing the data collection and analysis, a line simulation model has been built to represent the real construction line using arena simulation software. The simulation model built is not to represent the real line processes only, to analyze and understand the effect of change of line parameters under different operating conditions could be investigated for improved productivity and reduce delay of project delays. The simulation model of existing assembly system with associated line improvement area are presented as shown

### 5.8 Simulation of Installation/Erection works of CVSM in industrial projects

In order to avoid repetition all the datas and resources given for the simulation is taken from the above sections.

The reason for simulation of CVSM is to confirm the outcomes of value stream map settled. This study is conducted at the assembly line of industrial projects. Basically the focus area is cycle time of the process because the main problem of the company is delay of projects. The simulation models were established using creates process and dispose modules of Arena.

Further that, expressive and exact data must be entered into the correct modules within the flowchart window to model the processing time.

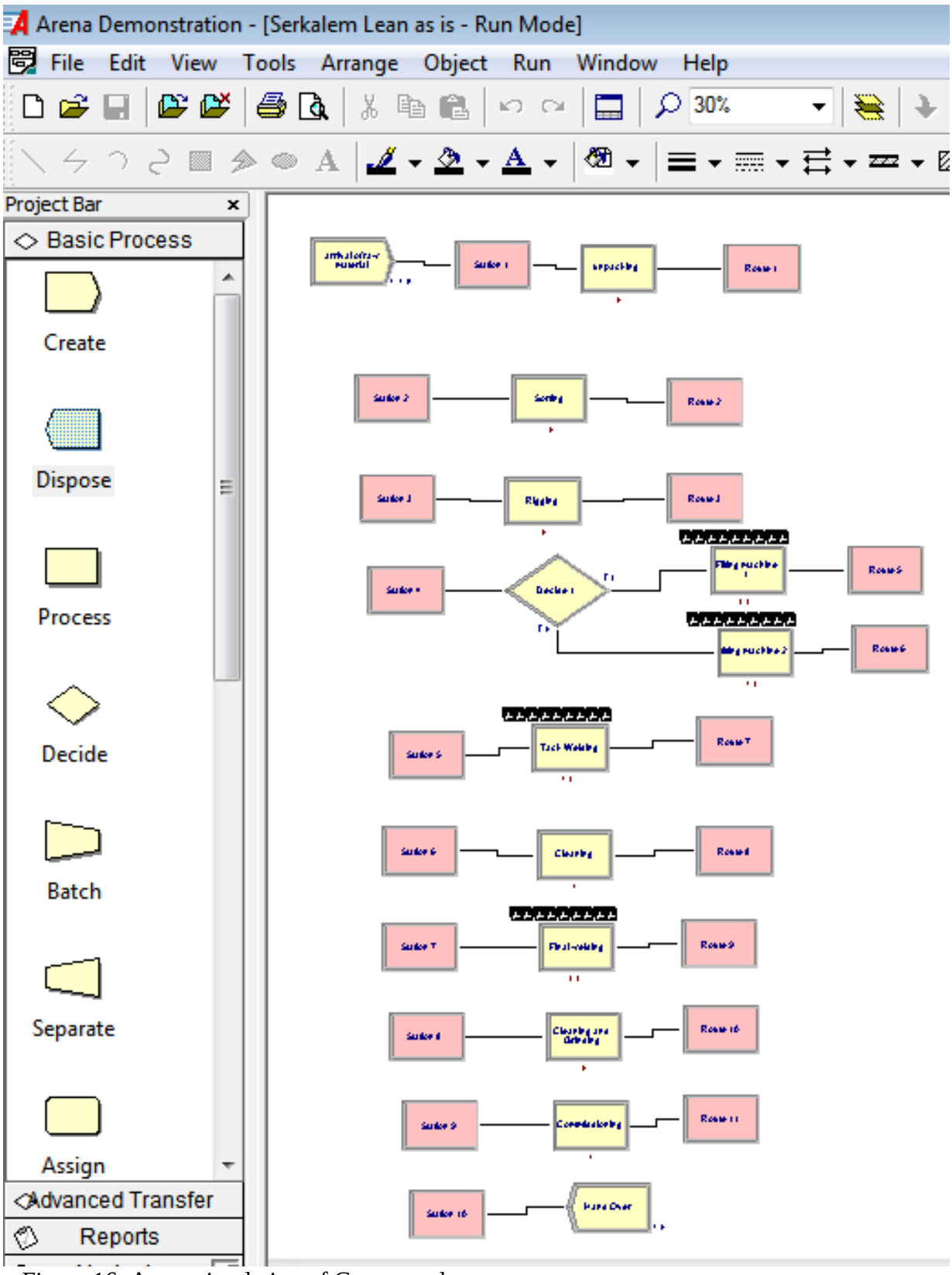



Figure 16. Arena simulation of Current value stream map

The current state value stream map verifies that the built actually with the help of which, the non-value added time can be easily identified and easily show the exact cause of delay of projects and removed or reduced from the system.

## 5.9 Simulation of Installation/Erection works of FVSM in industrial projects

The purpose of the future state of vale stream map is that the identification of improvements to the current state of value stream map that will lead to a shorter lead time. And also verify the results obtained in current state value stream map. The focus area is on all process for the response found by value stream map is verified.

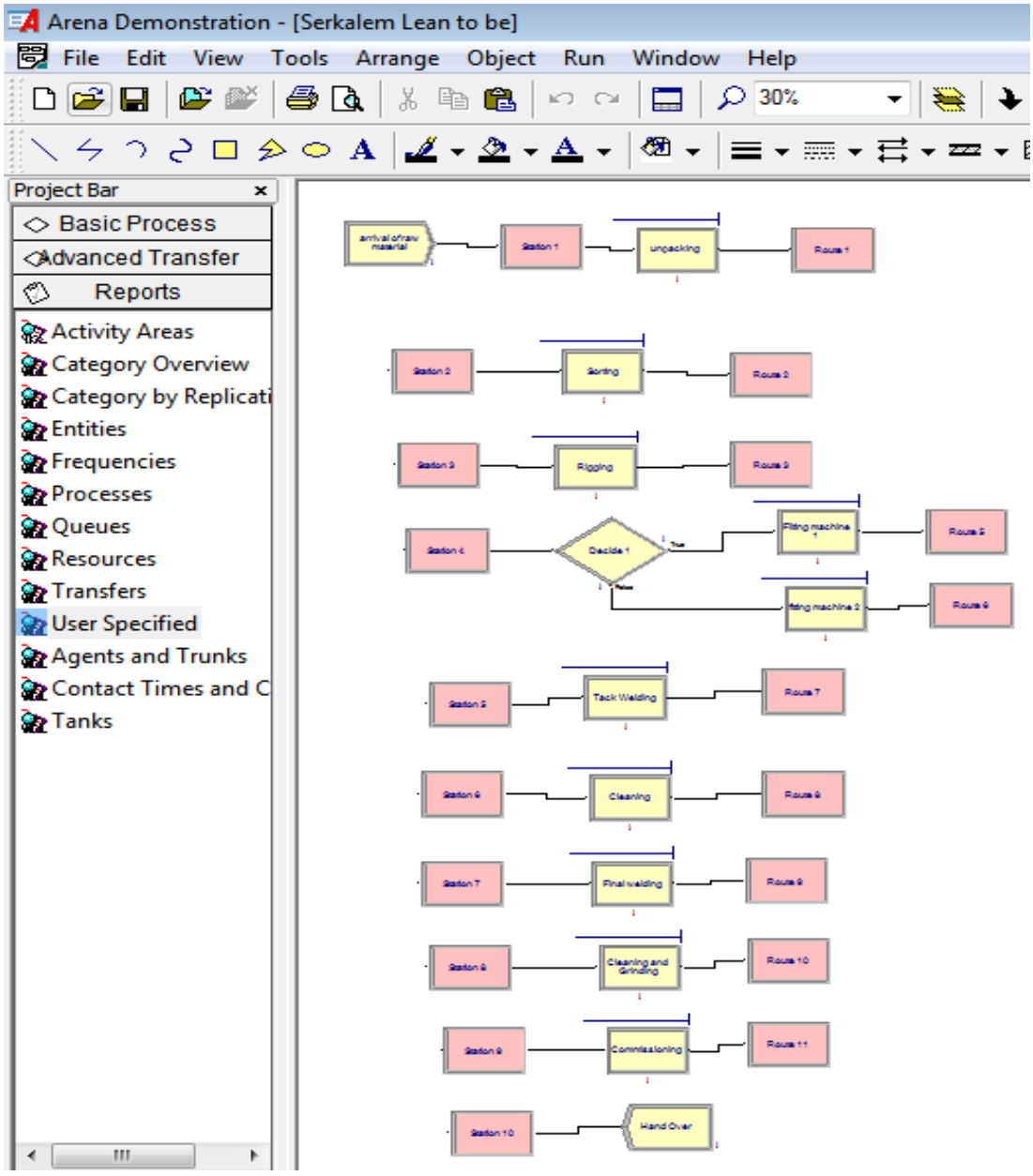
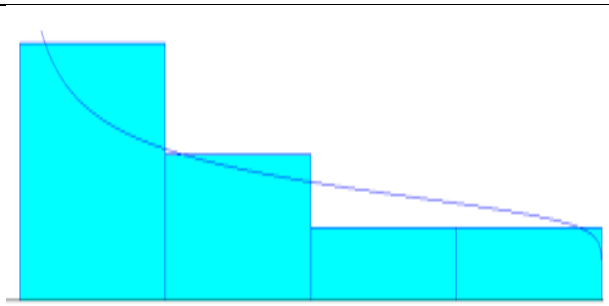
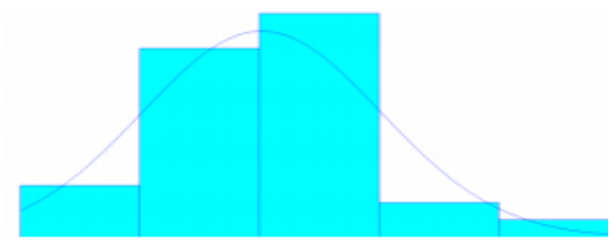
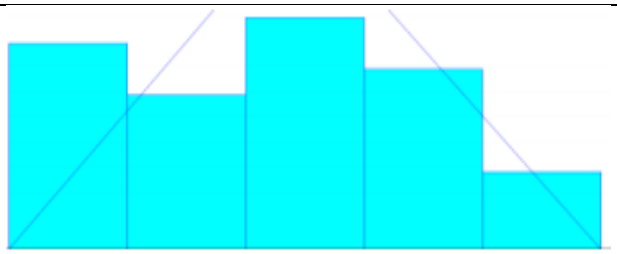
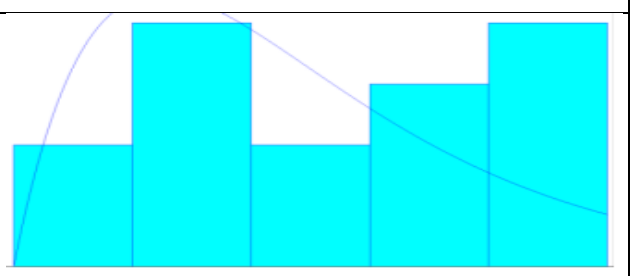


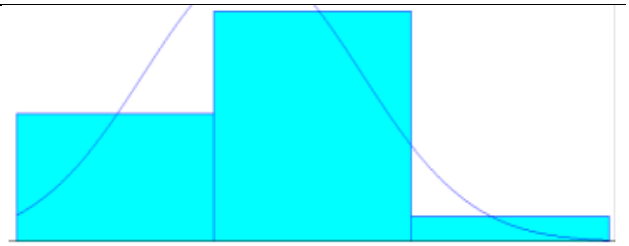
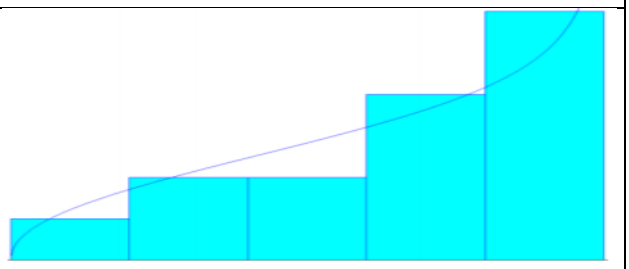
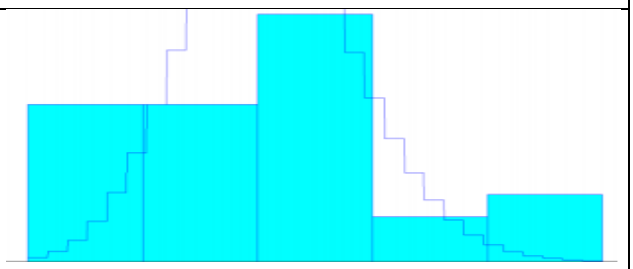
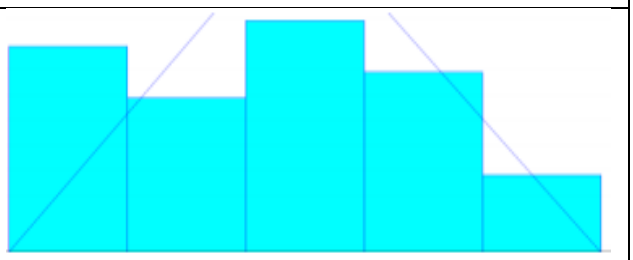
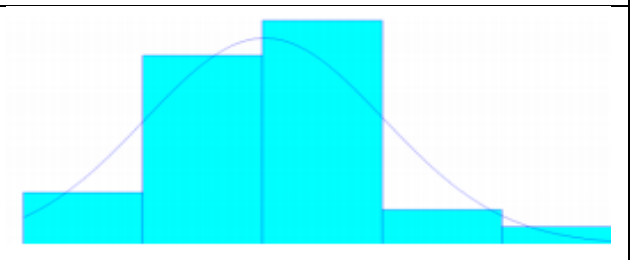

Figure 17. Arena simulation of future value stream map

**Data analysis**

Data collection is done for estimating model input parameters. The sequence of processes, the assembling time, and the failure damaged rate of materials and the required resources are collected during the manufacturing process such as (unpacking, sorting, rigging, fitting, tack welding, cleaning, final welding, cleaning and grinding and commissioning process). The inputs of the collected data are analyzed with input analyzer of arena to determine the distribution of these parameters. The fitness of these data is determined by taking the smallest squared error of the distribution.

Table 13:Distribution fitness data and graph

| Operation | Graphical representation |
|---|---|
| **Unpacking process**<br>Distribution summary<br>Distribution Beta<br>Expression BETA(0.715,1.12)<br>Square error 0.007082 |  |
| **Sorting process**<br>Distribution summary<br>Distribution Normal<br>Expression NORM(781,251)<br>Square error 0.015246 |  |
| **Rigging process**<br>Distribution summary<br>Distribution Triangular<br>Expression TRIA(2.4,31,49.5)<br>Square error 0.027348 |  |
| **Fitting process**<br>Distribution summary<br>Distribution Erlang<br>Expression 8.5+ERLA(4.2,2)<br>Square error 0.027792 |  |

| | |
|---|---|
| **Tack welding process**<br>Distribution summary<br>Distribution Normal<br>Expression NORM(24.5,8.12)<br>Square error 0.003146 |  |
| **Cleaning process**<br>Distribution summary<br>Distribution Beta<br>Expression 9.2+10*BETA(2.45,0.81)<br>Square error 0.004604 |  |
| **Final welding process**<br>Distribution summary<br>Distribution Poisson<br>Expression POIS(17.2)<br>Square error 0.146712 |  |
| **Cleaning & Grinding process**<br>Distribution summary<br>Distribution Triangular<br>Expression TRIA(3.1,25,36.4)<br>Square error 0.035246 |  |
| **Cleaning & Grinding process**<br>Distribution summary<br>Distribution Normal<br>Expression NORM(671,315)<br>Square error 0.011235 |  |

**Simulation result**

After having run the simulation model, the following data is found about the number of erection/ installation construction process that leave the system to deliver customers; And according to the simulation of assembly line.

**Key performance indicators of the simulation**

After giving the necessary inputs to the system model and ordered to run the system it gives the arithmetical analysis of the simulation result under some of the following groups according to our design model. Those are entities, resources, queues, processors, etc. in this thesis; the statistical analysis of the simulation result is given under entities, queues, resources and process. The category overview has a predefined KPI as the number out. This gives the number of entities which sucessufuly left the system. For the process of industrial project model, which was run for a replication length of 1 hour, the number out value was 17, for 10 replications.

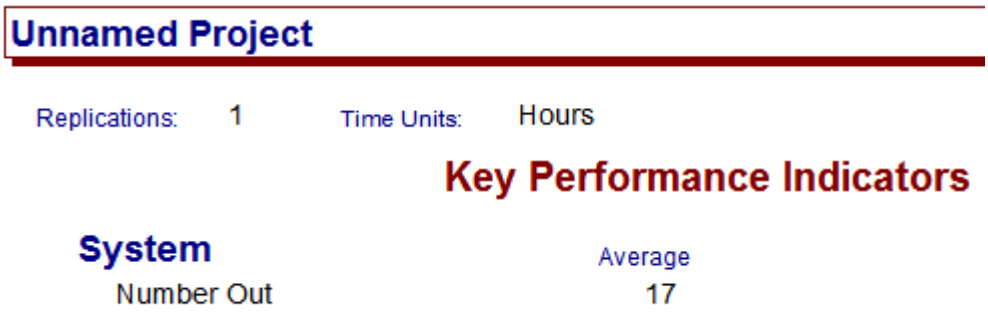
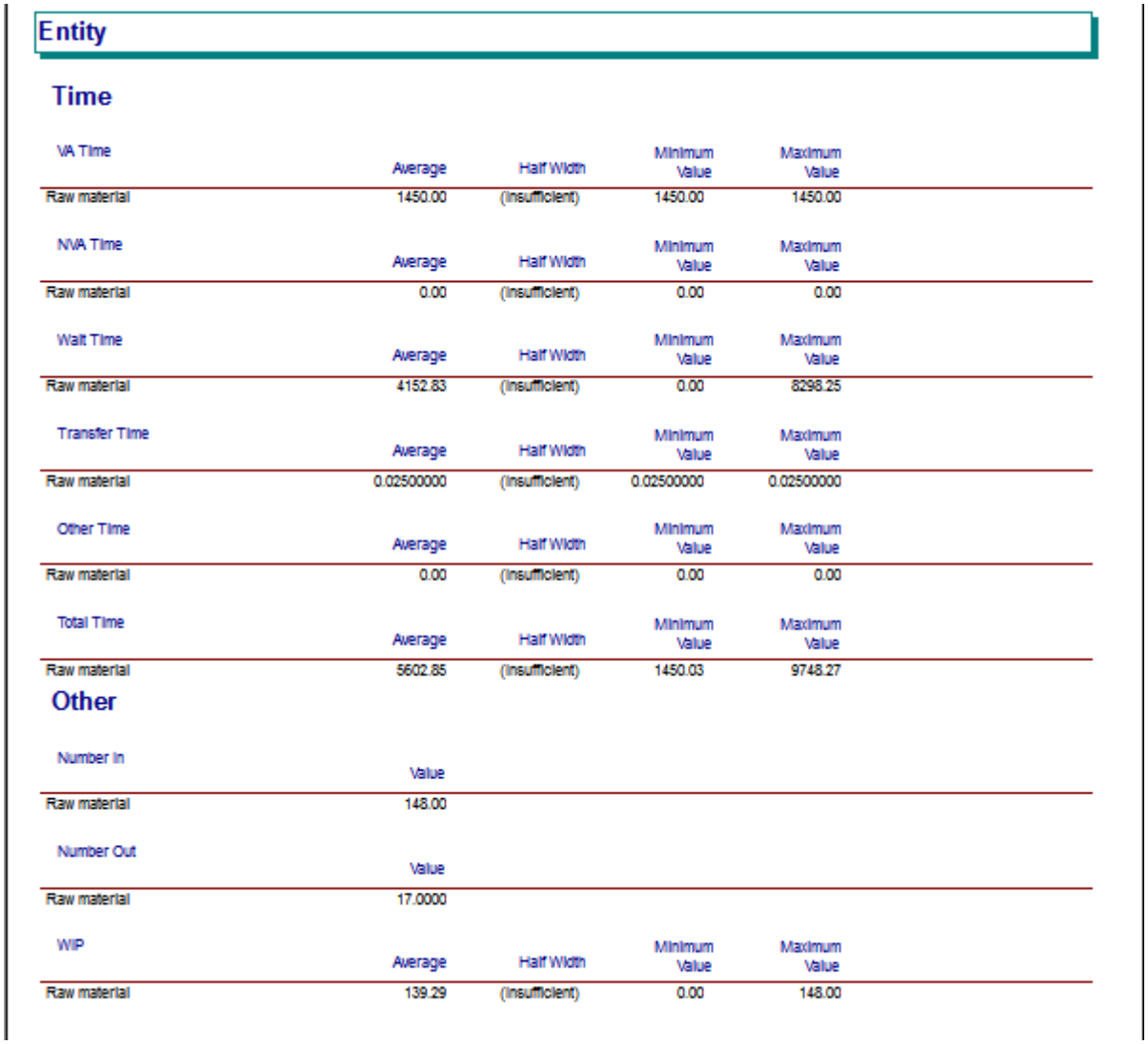



Figure 18. pre-defined KPI as the number out

**Entity**

The most important attribute attached with the entity is ‘time’. The simulation result gives the details of the time spending on each assembly line activates from the unpacking process to the commissioning work. The main output is the total time in system, the wait time and the processing time. Based on the simulation result the different time spends during the installation/erection process are listed.



**Entity**

**Time**

| VA Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 1450.00 | (Insufficient) | 1450.00 | 1450.00 |

| NVA Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 0.00 | (Insufficient) | 0.00 | 0.00 |

| Wait Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 4152.83 | (Insufficient) | 0.00 | 8298.25 |

| Transfer Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 0.02500000 | (Insufficient) | 0.02500000 | 0.02500000 |

| Other Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 0.00 | (Insufficient) | 0.00 | 0.00 |

| Total Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 5602.85 | (Insufficient) | 1450.03 | 9748.27 |

**Other**

| Number In | Value |
|---|---|
| Raw material | 148.00 |

| Number Out | Value |
|---|---|
| Raw material | 17.0000 |

| WIP | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Raw material | 139.29 | (Insufficient) | 0.00 | 148.00 |

Figure 19: Simulation results showing time of Erection/installation process

The average waititng time for a raw material is 4,152.83 hours and the average processing time for the raw material is 1,450 hours. This makes the average total time spent by a raw material in the system to be 5,602.85 hours. We want to reduce this quanitity in order to increase the effeciency of the system.

**Queue**

The simulation system gives the waiting time and number of entities waiting for each queue in the model. By observing the results for the maximum waiting time and this need to bring some changes to reduce the waiting time of the particular queue. Here is the output

## Queue

### Time

| Waiting Time | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Cleaning and Grinding.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Cleaning.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Commissioning.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Fiiting machine 1.Queue | 3527.00 | (Insufficient) | 0.00 | 6830.00 |
| Final welding.Queue | 3420.00 | (Insufficient) | 0.00 | 6840.00 |
| fitting machine 2.Queue | 3175.00 | (Insufficient) | 0.00 | 6430.00 |
| Rigging.Queue | 0.00000000 | (Insufficient) | 0.00 | 0.00000000 |
| Sorting.Queue | 0.00000000 | (Insufficient) | 0.00 | 0.00000000 |
| Tack Welding.Queue | 512.46 | (Insufficient) | 0.00 | 1020.00 |
| unpacking.Queue | 2875.19 | (Insufficient) | 0.00 | 5750.87 |

### Other

| Number Waiting | Average | Half Width | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Cleaning and Grinding.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Cleaning.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Commissioning.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Fiiting machine 1.Queue | 31.9760 | (Insufficient) | 0.00 | 48.0000 |
| Final welding.Queue | 22.9139 | (Insufficient) | 0.00 | 49.0000 |
| fitting machine 2.Queue | 31.5720 | (Insufficient) | 0.00 | 53.0000 |
| Rigging.Queue | 0.00000000 | (Insufficient) | 0.00 | 1.0000 |
| Sorting.Queue | 0.00000000 | (Insufficient) | 0.00 | 1.0000 |
| Tack Welding.Queue | 3.9930 | (Insufficient) | 0.00 | 9.0000 |
| unpacking.Queue | 42.8403 | (Insufficient) | 0.00 | 144.00 |

Figure 20: Simulation results showing queue of Erection/installation process

It can be seen that the waiting time is maxiumum, 3,527 hours for the fitting process queue followed by the queue for final welding. We went to reduce tis quantity in order to increase the efficiency of the system.

**Resource**

The resource gives the usage indicators of the resource used in the model. Regarding resource allocation the study uses the lump sum instead of quantifying each resource. Here the writer considers one house as it is fully equipped with all required resources. The numerical value of the resource is in the range between zero and one. If the given percentage of the resource is close to one it indicates as it is highly used resource and if it is close to zero, it indicates as it is almost unused resource. The resource utilization of all the resources in the model is

| Scheduled Utilization | Value |
|---|---|
| fitting machine 1 | 0.9760 |
| fitting machine2 | 0.9880 |
| Grinding | 0.8150 |
| grinding 9 | 0.3400 |
| Grinding Machine 2 | 0.1710 |
| human | 0.5960 |
| human power | 0.5960 |
| operator 3 | 0.5960 |
| operator 4 | 0.9760 |
| operator 4 2 | 0.9880 |
| operator 5 | 0.9630 |
| operator 6 | 0.8150 |
| operator 7 | 0.9370 |
| operator 8 | 0.1710 |
| Rigging machine | 0.5960 |
| Testing | 0.3400 |
| Welding 9 | 0.3400 |
| Welding machine | 0.9630 |
| Welding machine 2 | 0.9370 |

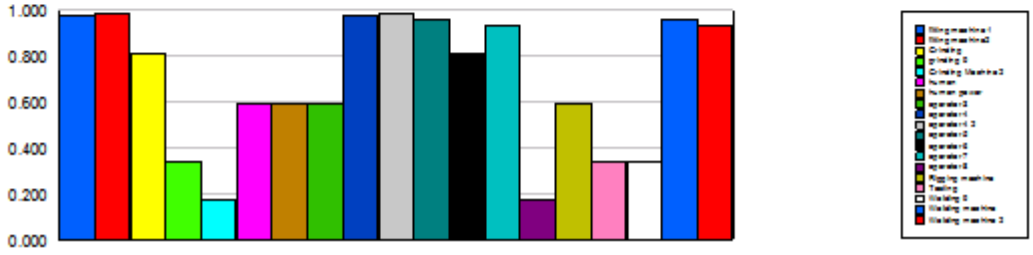



Figure 21: Simulation results of the resource usage

It can be observed that the fitting operation and final welding operation is used up for a maximum time while the utilization of grinding and tesing operation is very less comparatively. Finally it observed that in fitting and final welding operation resource have high utilization and high waiting time in queues. Also, the material spend more than twice the time waiting in the queue as compared to the time when they are being served.

**Model verification and validation**

One of the most important steps of simulation modeling is validation and verification. Verification and validation of a model is required for readers to gain confidence on the results of simulation. If the model does not reflect the real system, outputs of the model has a bad effect on the reliability and quality of the decision that will made. To get the expected result, throughout the process of this study, and the collection of data, component of the model is transparent with the intent of providing all the necessary information to show the models purpose, sources of information, structure, and results to the best of the writer knowledge.

Therefore, in order for this model to correctly reflect the assembly line behavior, it is verified and validated.

**Model verification**

Model verification is concerned with building the model right. During the model translation, it is guaranteed that the simulation model has all the necessary components and that the model actually runs and checked the model operates as intended. The animation of the process observed; the path was correct. It can be said this model verified and represent the real system. In the case production line, model verification dand validation steps were implemented. The verification process on the simulation model is done by test with various combinations of input parameter values and step by step execution techniques. Moreover, formulation of input parameters was checked to build the model correctly. To verify the model the following points are carefully seen by the writer. And also the model is adjusted and the experiments are repeatedly run without any problem.

- ✓ Checks the flow diagram which includes each logically possible action a system can take an event occurs, and follow the model logical for each action for each event type.
- ✓ Examine the model output and it is reasonable when it compared with the input parameters
- ✓ Checks whether the flow of the process is according to every flow and steps mentioned above.

**Model validation**

To validate the model consistency by matching the output of the real system and the model output of the present systems, a test run with 10 replications was done and the output value checked. According to Kelton et al. (2007), higher number of replications of the system run will lead to more precise results for the simulation model and hence is preferred in practice. In this simulation run, after analyzing all the data in required format and specifying the appropriate replication number and with a duration of 10 industrial projects assembly process.

Table 14. Comparison between existing and modified system

| Differentiation based on | Existing system | Proposed system | Remarks |
|---|---|---|---|
| Number in | 148 | 148 | Same |
| Number out | 16 | 17 | 6% increased |
| Average Total waiting time per entity in system | 4,152.83 (hour) | 3,893.04 (hour) | 94% Reduced |
| Average Total Transfer time | 0.025 (hour) | 0.025 (hour) | Same |
| WIP | 139.29 | 139.77 | Increased |

From the above comparison table of performance measures of the current system and the modified system, the modified system with the model developed has shown a significant decrease in average total transfer time, on average it is 94% reduction which will greatly improve the overall production quantity and there has been a consequences of productivity improvement from 16 pieces to 17 pieces of raw materials per hour. Eventually the production of raw material has been increased to 94 pieces per month which is 6% increase in total production output.

# CHAPTER SIX

# 6. DISCUSSION

This study focused only the case of one industrial company works on industrial projects. It is therefore not possible to generalize the outcomes to all industrial companies. In this section compare the findings with another study from the previous studies. Previous studies have typically examined or discussed philosophies of lean in manufacturing process from the perspective of waste reduction and value adding activates.

There are different articles discussed on lean and selected those papers from all to discuss mainly lean in industrial projects and lean in manufacturing industries. Different researchers concluded from those studies lean tool which apply in different industry as per necessity or types of problems are much effective for the finding of waste and improvement of the process. Application of lean philosophy techniques and their findings in various industries such as in year 2007 Sahoo, A.K., Singh, N.K,Shanker, R., & Tiwari, M.K find by their research to the problems of increased customer expectation & fierce global competition by implementing lean philosophy in a forging company. The major intention of this paper is to change and investigate several approaches to eliminate waste only in shop floor and it's describe the application of value stream mapping and taguchi method to improve defects.

The evaluation of articles has yielded a total number of 88 articles, which dealt with mainly lean concepts in product development, food processing, aircraft, construction, manufacturing process, job shop environment, healthcare, supply chain etc. however an application of lean in industrial projects is not widely researched and very little was found in the literature. The reason for lack of research can be projects are different from manufacturing and production process therefore direct application of lean concepts in manufacturing or production process was not possible and transformation of ideas was required in industrial projects.

More than 30 benefits were identified in the 88 Journals, the most frequently stated benefits of lean were reduction in non-value added activates, reduced non conformity, improve quality, improve process efficiency, increased resource utilization, reduce setup time, reduce

lead time, eliminating waste, space utilization, improved performance are most companies achieved the level of improvement due to the successful implementation of lean philosophies in their organization. The researcher observed that most of the journals stated lean benefits in the manufacturing or production part, but no studies were not discussed application of lean philosophies in industrial projects. It can be argued that publishing lean in industrial project stories can absolutely guide future research work. Other study and work is needed.

The concept of lean is adding value of process activates by eliminating the non-value added activities which all the remaining activities will be purely value added to the organization and also for the customers. Finally this research gets an improvement in the reduction of delay of projects working with or considering the common parametrs of customer satisfaction drivers and lean manufacturing intiatives of time, cost, quality and flexablity together and proposes framework which deals with the application of lean methodology in industrial projects to accelerate the performance of projects by reducing delay of projects. Then the proposed framework evaluated by the top managements, supervisors and directors of the organization lead to acceptable arguments.The framework is established with the intention of reducing the identified pain arguments which delay of projects and the proposed framework is validated through the result of the comparsion with the previous frame works.

# CHAPTER SEVEN

# 7. PROPOSED FRAMEWORK

The main focus of this paper is to propose the effective VSM framework for SINTEC Ethiopia industrial projects. The proposed model modified from the study of productivity improvement using lean six sigma methodology (Yadav, 2014) consists of serious steps which can be stated as follows.

Most of the researcher about delay of industrial projects is focused only on the time perspective only. However, it is important to study from the perspective of the integreation of time, cost, quality and flexiablity view. This frameork is important which has an impact on solving the identified problem of delay of projects.

From the prvious value stream mapping result time, cost, quality and flexiablity all together the the involvement of supplier and customer is show a significant improvement on the reduction of delay of proects as well as improve production capacity of SINTEC Ethiopia industrial projects. And with the reason that all the four drivers of customer satisfaction and lean manufacturing intiatives together with the involvement of supplier and customer has an impact on the reduction of delay of the industrial projects. Based on this result the focus of this proposed framework will be on the four drivers of customer satisfaction and intiatives of lean manufacturing parameters. A solution is also given for the problem areas of these parameters in the framework.

The idea of this frmaework is that if the problem of the delay of industrial projects is solved and satisfied the customers and also improve productivity. This model solves the problem of SINTEC Ethiopia industrial projects mentioned in this paper. How this cost, time, quality and flexability with the invlovment of customer and supplier solves the dealy of projects.

## 7.1 Time on the delay of projects

Time mangament on projects is a key factor to success and fast response to customers. Effective Estimation of the production time in early phases of the project is the baisis for the decision whether to commence with planning or not. Because the project success depends on

reliability of the estimation plan. When the project is delayed, the project will call for an increase in labour and more productive equipment and then the cost will increase

## 7.2 Cost on the delay of projects

Project delay is always has costs associated with it, but all project delay is a waste of time and public money. When the project delays cause cost overruns. Delay is a later completion date than planned or exected but in stage of cost preparation consider only when the project is finished on time so that additional time is cause on overruns of cost of the project. Most reserchers accepted that many project practitioners that cost overruns are directly related to schedule delays.

## 7.3 Quality on the delay of projects

A good quality of product is important to satsfiy customer and reduce additional manufacturing costs and increase productivity. Quality affects the projects directily and indirectly the delivery of projects and cost of the project. The end aim of lean in industrial projects, construction and production process is to design and ensure the quality of product with a minimum resource with less delivery time. The level of success of erection/installation projects depends on the quality performance. Quality of product is the ability of ensure complete customer satisfaction so on time delivery is the key requirement of customers. The most influential factor for time is quality error or omission in construction work.

## 7.4 Flexablity on the dealy of projects

Flexibility of products is important for customers by decreasing deliver time because flexibility reduces cycle times and simplifies the production system. Lean tools and techniques have enabled companies to be more flexible and more profitable

## 7.5 Supplier involvement on the delay of projects

Good communication with suppliers on the installation/ erection process of industrial projects is important for planning of production schedule and sharing information about the detail parts or lists of bill of material. Better supplier relationships and presence in the planning process decreases material lead time, promotes on the on-time delivery of information and

establishing trust and lasting relationships with suppliers introduces more reliability in the process. Suppliers are an important factor contributing to the success of going on and for a current competitive market to ensure reliability and frequent delivers

### 7.6 Customer involvement on the delay of projects

A good communication with customer is important to share current market information and project site condition to delivery their projects on time. Having active communication with customers about construction plan and condition of project site, to have quick installation/ erection system. Customer relationship in the early stage is used to focus on the real customers' needs. Customer's contribution permits the reduction of reworking, identifying problems and solutions introduce changes in the project processes and create a system that leads to a continuous improvement.

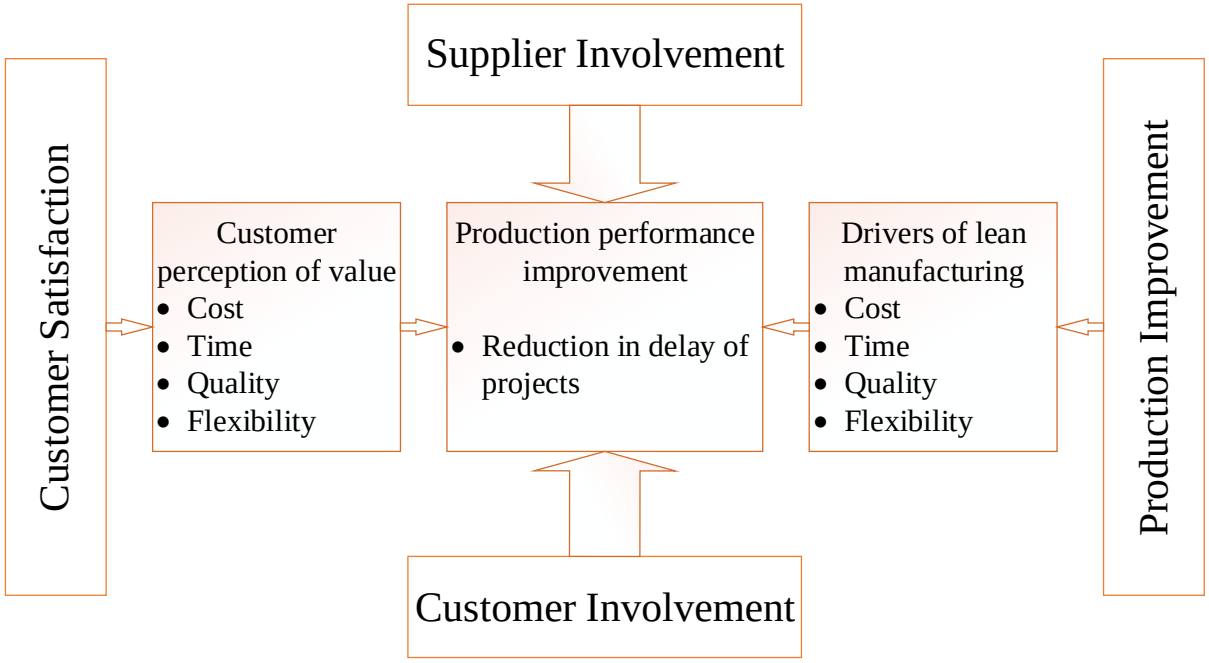



Figure 22. proposed framework for reduction of industrial projects delay

## 7.7 Implementaion procedure of the proposed model

A certain step needs to be followed during implementation of the proposed framework

- Give awareness for all employess strat from the top management to shop floor worker should be commited to implement the framework
- Before implementation training will be given by the team for those who are going to apply the framework concering the procedure, route they follow and other issue that helps to the successful implementation of the method.

## 7.8 Feasibility of the proposed model

Validation is the task of representing that the model is a realistic demonstration of the actual system. The proposed model was checked its feasiablity by collecting a comment from the SINTEC Ethiopia Plc. Managing directors, department managers, project supervisor, planning department and Ethiopian basic metal industry one of team leader.

To validate the proposed framework some interview questions are prepared to evaluate the importance of the organization related to industrial projects. The objective of the feedback is to point out the proposed framework importance in industrial projects cause of exsiting delivery of projects. List of questions to evaluate the framework is as follows below:

- Is the proposed framework is usefuel to the organization
- Do you belive this proposed framework is applicable to the case of the organization
- Do you think the organization change through this structure
- Is the framework clear and understandable to do working on it
- How interested would you be working on the proposed framework to improve the performance of the company

As per the comments for the evaluation of the proposed model, most of the respondants gave that it better to practice and it can solve the existing problem of delay of industrial projects. Also both supplier and customers communicate and works altogether with contractor in the planning activity; according to the responseces the proposed model is appropriate for all industrial projects.

# CHAPTER EIGHT

# 8. CONCLUSION, RECOMMENDATION AND FUTURE WORK

## 8.1 Conclusion

This paper has described both the drivers of customer satisfaction and lean manufacturing intiatives together with supplier and customr involvement in the factor of delay of projects to determining a successful implementation of lean in industrial projects. The identified critical success factors which are time, cost, quality and flexiablity have provided a useful insight for the development of lean manufacturing by reducing delay of projects.

Analysis from the research, together with the evidence from literature, indicates that SINTEC Ethiopia PLc. has a poor performance on time delay of projects. The main reason behind delay of projects is lack of communication with customer and supplier, rework, spend a lot of time on waithing of missed parts and building site condition. Since the four drivers of customer satisfaction and lean manufacturing intiatives together with supplier and customer involvement have a positive significant on the reduction of industrial projects and improve the competitiveness of the sector.

Furthermore, the root cause for the on time delivery of the inductrial projects in SINTEC Ethiopia PLc. is lack of communication with customers and supplier, waiting on the missed parts, waiting for procurement of consumable and argon gas and building site condtion and absence of adequate knowledge on lean. The study revaled the problem on delay of industrial projects. Therefore, the study recommends the following specific points in order to solve the problems.

## 8.2 Recommendation

Based on literature reviews and research findings, the study recommends the following for consideration of SINTEC Ethiopia industrial projects.

- ✓ SINTEC Ethiopia PLc. has problems on project delays. Therefore, the company will be beneficiary by implementing this framework because it touches the company's problem and try to show some corrective ideas and the proposed framework is mainly focus on delay of industrial projects.
- ✓ It is better for the company to take more time in cost preparation and document review because in cost preparation for tender/enquiry phase different parameters will be taken in to considerations like the project site, purpose of the product and time frame. Preparing accurate cost estimation for the bid/ offer is really importance due to deliver the projects within the planed cost.
- ✓ Planning is the key to successful projects. The appropriate data gathering methodologies must be determined and an action plan developed as to project activities and loads. In this stage working with both supplier and customers are important to know the way of performing the work and also the project site condition.
- ✓ It is important careffuly Check installation for conformance with the design and specifications using available data and assemble equipment parts. In this stage care must be taken in to consideration because it takes time to adjusting when misplacing the connection point.

## 8.3 Future Work

- ➢ Identifying other causes of project delays which are not considered in the study due to time constraint.
- ➢ The study focus only SINTEC Ethiopia PLc. industrial projects due to time constraints, so that it is necessary to see the impact of the framework other related to the case company.

# REFERENCE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