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**Enhancing productivity of Ethiopian Hand Tool Industry through Lean tool
(A Case of Negate Mechanical Engineering Sch.Co)**

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Enhancing productivity of Ethiopian Hand Tool Industry through Lean tool

(A Case of Negate Mechanical Engineering Sch.Co)

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This is to certify the Thesis prepared by Wondwossen Adem, entitled, Enhancing productivity of Ethiopian hand tool Industry through lean tool and submitted in partial fulfillment of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulation of the university and meets the accepted standard concerning originality and quality.

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Declaration

I hereby declare that the work which is being presented in this thesis entitled “Enhancing productivity of Ethiopian Hand tool industry through Lean tool.” is original work of my own and has not been presented for a degree of any other university and all the resources of references used for the thesis have been duly acknowledged.

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



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Abstract:

Introduction: Productivity Improvement in Ethiopian metal industries is a major area of economic activity that concerns, cost savings, measurable quality gains, improved consistency & rapid payback. Hand Tool industries in Ethiopia are not a skilled person to implement new technologies for improving productivity and flexibility. Lean manufacturing contributes significant improvement efforts to solve the productivity problem of the Ethiopian hand tool industry.

Research Purpose: This paper is aimed at improving the productivity of the Ethiopian hand tool industry using a lean management tool and develops a continuous productivity improvement model of the Ethiopian hand tool industry.

Methods: This paper has been implemented in Negate Mechanical Engineering Sch.co. This is located in Addis Ababa, Ethiopia. A well-designed questionnaire was distributed to 60 employees at the case company. Besides the questionnaire, semi-structured interview questions and workplace observation is conducted. The collected data was then entered and analyzed by using SPSS software version 20 and Visio professional.

Results /Findings: The study shows that waste has a significant impact on Productivity. Pearson Correlation is used to determine the relationship between waste, idle time, Customer requirements, Productivity improvement problem, and Continuous improvement variable. The result shows the lead time of the current VSM higher than the future VSM. The result indicates that there is the highest correlation between waiting waste vs. unnecessary motion waste and Defect vs. over production waste. Lean and Kaizen have the highest correlation in continuous improvement variables.

Conclusions: To minimize waste of the hand tool industries, Lean management has answered the research question and to improve the productivity of the company.

Keywords: Productivity, Waste, Lean, Productivity Improvement, Value stream mapping

Contents

CHAPTER ONE	1
Introduction.....	1
<u>1.1 Back ground of the study</u>	1
<u>1.2 Problem statement</u>	2
<u>1.3 Research Question</u>	4
<u>1.4 Objective of the study</u>	5
<u>1.4.1 General objective of the study</u>	5
<u>1.4.2 Specific Objective of the study</u>	5
<u>1.5 Significance of the Study</u>	5
<u>1.6 Scope and Limitation of the study</u>	5
<u>1.7 Research Organization</u>	6
CHAPTER TWO	7
<u>LITERATURE REVIEW</u>	7
<u>2.1 Introduction</u>	7
<u>2.2 Productivity</u>	7
<u>2.2.1 Productivity Measurement</u>	9
<u>2.2.2 Factors affecting productivity</u>	10
<u>2.3 Waste (Muda)</u>	11
<u>2.4 LEAN MANAGEMNT</u>	11
<u>2.4.1 Lean Management and its Technique</u>	12
<u>2.4.2 Lean tools:</u>	16
<u>2.4.3 Waste (Muda)</u>	22
<u>2.4.4 6S:</u>	23
<u>2.4.5 Lean principle</u>	24
<u>2.5 Literature Gap:</u>	25
CHAPTER THREE	27
<u>RESEARCH METHODOLOGY AND MATERIALS</u>	27
<u>3.1 Data Source</u>	27
<u>3.2 Sampling Strategy:</u>	29
<u>3.2.1 Target Population</u>	29
<u>3.2.2 Sample Size</u>	29

<u>3.2.3 Sampling Procedure</u>	30
<u>3.3 Tool and Method of Data Analysis</u>	31
<u>3.4 Validation of data/ reliability testing:</u>	32
<u>3.5. SPSS Software:</u>	32
CHAPTER FOUR	35
<u>OVER VIEW OF ETHIOPIAN METAL INDUSTRY AND THE CASE COMPANY HAND TOOL PRODUCTION PROCESS</u>	35
<u>4.1 Over view of Ethiopian metal Industry</u>	35
<u>4.2 SWOT Analysis of The case company NMESC.</u>	37
<u>4.3 Over view of Case Company NMESC</u>	38
<u>4.4 Forging Process</u>	39
<u>4.5 Selected Hand tool production process at NMESC.</u>	41
CHAPTER FIVE	47
<u>Data Analysis and Interpretation</u>	47
<u>5.1 Introduction</u>	47
<u>5.2 Descriptive Analysis</u>	51
<u>5.3 Correlation Analysis</u>	52
<u>5.4 Introduction to Quantitative data analysis</u>	57
<u>5.5 Production time of the selected product pick axe, shovel and sickle.</u>	68
<u>5.6 Summery of the Findings</u>	73
CHAPTER SIX	74
<u>SOLUTION PROPOSAL</u>	74
<u>6.1 Selection and proposal of Continuous Productivity Improvement Model</u>	75
<u>6.2 Proposal for the Future State Value Stream Mapping</u>	76
CHAPTER SEVEN	88
<u>Conclusion and Recommendation</u>	88
<u>7.1 Conclusion</u>	88
<u>7.2 Recommendation</u>	89
<u>7.3 Future Study area</u>	89
Refernce	90
Appendix	93

LIST OF FIGURE	Page
Figure 2.1 Conceptual model of lean	14
Figure 2.2 Sequence of lean tool	19
Figure 2.3 Step of VSM	20
Figure 3.1 Selection of article.....	27
Figure 3.2 Research Methodology flow	34
Figure 4.1 Metal industries vs. Ethiopian manufacturing industry.....	35
Figure 4.2 Major Ethiopian metal industry products.....	40
Figure 4.3 SWOT Analysis.....	40
Figure 4.4 Impression die forging	40
Figure 4.5 Process flow of pick axe	42
Figure 4.6 Process flow of shovel	44
Figure 4.7 Process flow of sickle	46
Figure 5.1 VSM of Pick axe.....	59
Figure 5.2 Cause & Effect diagram of Pick axe.....	61
Figure 5.3 VSM of shovel	62
Figure 5.4 Cause & Effect diagram of Shovel	64
Figure 5.5 VSM of sickle.....	65
Figure 5.6 Cause & Effect diagram of Sickle	67
Figure 5.7 Cause & Effect diagram of Low productivity.....	68
Figure 6.1 Model of VSM.....	78
Figure 6.2 FVSM of Pick axe	79
Figure 6.3 FVSM of shovel	81
Figure 6.4 FVSM of Sickle	83
Figure 6.5 Plant lay out.....	85

LIST OF TABLE	Page
Table 1.1 Summery of annual production	3
Table 2.1 Summery of main article	26
Table 3.1 Target respondent	30
Table 4.1 Metal industry vs. Ethiopian manufacturing industry.....	36
Table 4.2 Open die forging	36
Table 4.3 Closed die forging.....	38
Table 5.1 Existing production capacity.....	47
Table 5.2 Key performance Indicator	47
Table 5.3 Customer Requirement Respondent result	49
Table 5.4 Waste Respondent Result.....	49
Table 5.5 Idle Time respondent Result.....	50
Table 5.6 Productivity Improvement Respondent Result.....	50
Table 5.7 Continuous Improvement Respondent Result	51
Table 5.8 Cranbach’s alpha.....	51
Table 5.9 Descriptive analysis	52
Table 5.10 Analysis of waste	53
Table 5.11 Analysis of Idle time	54
Table 5.12 Analysis of Customer requirement.....	55
Table 5.13 Analysis of Productivity improvement	56
Table 5.14 Analysis of continuous improvement	57
Table 5.15 Pick axe waste	60
Table 5.16 Pick axe analysis	61
Table 5.17 Shovel waste	63
Table 5.18 Shovel analysis	64
Table 5.19 Sickle waste	66
Table 5.20 Sickle analysis	67
Table 5.21 Observed time	69
Table 6.1 FVSM of pick axe	77

Table 6.2	FVSM of shovel	80
Table 6.3	FVSM of Sickle	82
Table 6.4	Cost of plant lay out.....	87

LIST OF ACRONYMS

CI: Continuous improvement

VSM: Value stream mapping

FVSM: Future value stream mapping

CVSM: Current value stream mapping

SMED: Single minute exchange of dies

CM: Cellular manufacturing

TPM: Total productive maintenance

MIDI: Metal industry development institute

NMESC: Negate mechanical engineering sch.co

KMTF: Kotebe metal tool factory

SWOT: Strength, weakness, Opportunity, threats

1. Chapter One –Introduction

1.1 Back ground of the study

Productivity is the main factor in which a business firm's existence is based upon. The main objective of a business firm is to provide consumer's satisfaction while making a profit. Business firms always attempt to maximize profit. But to maximize profit, a business firm has to be efficient where efficiency is measured by the capacity of the business firm to raise the productivity of existing resources so that cost per unit production is reduced (Kendrick, 2016).

The efficiency with which manufacturing firms/organizations and industries convert inputs (labor, capital, and raw materials) into output. Productivity grows when output grows faster than inputs, which makes the existing inputs more productively efficient. The level of productivity in manufacturing firms increases, the overall output value increases, resources are used efficiently and their contribution to the whole economy will increase. [Grover. 2008]

The metal industry sector is provided a strategic focus by the Ethiopian government in the past five years as it is the main base for the development of other downstream industries and there has been a continuous increase in demand for metal products. According to the country's GTP II document, in the past decade, the manufacturing sector has shown an average 5% growth rate (MIDI, 2016). The metal and engineering sub-sector has been growing slow rate compared to other manufacturing sectors. Several studies have been conducted on the sector and yet the sector has not been appreciated regarding its national supply, import substitution & global competitiveness which is a direct result of poor productivity level and capacity utilization which is below 60 (MOI, 2016).

Productivity Improvement in Ethiopian metal industries is a major area of economic activity that concerns cost savings, measurable quality gains, improved consistency & rapid payback. The metal industry in the Ethiopian economy is important for reviewing

national policy to analyze the external competitiveness, assessing the platform for competitiveness, and identify the challenge and opportunity of the industry (MIDI, 2016). Hand Tool industries in Ethiopia are not the skilled person to implement new technologies for improving productivity and flexibility. The industry face different waste like the unnecessary movement of people, a worker is an idle and high rework and rejects on the production floor [NMESC Annual Report, 2018]. Industries have been running traditionally for years and are rigid to change. They don't have much confidence and will towards innovation over old processes; hence resulting in low productivity and dissatisfaction of customers. This limitation of existing techniques forces researchers to find a more comprehensive improvement technique to improve the productivity of a company. One approach of this is the use of a Lean approach to form a comprehensive and reliable set of manufacturing practices and contributes optimistically to continuous productivity improvement (Tesfaye, 2016).

Lean focuses on identifying ways to streamline processes and reduce waste (Rothenberg, 2016). Lean management contributes to significant improvement efforts to solve the productivity problem of the Ethiopian hand tool industry. Lean focuses on eliminating the sources of waste aiming for a continuous process flow. (Mohamood, 2015) . Lean has been more accepted in the Metal and other industries, which faces many of the same issues and challenges--how to reduce waiting time, how to increase capacity, how to be best organize resources, etc. (Khalil A, 2013).

Waste elimination is one of the most effective ways to increase the productivity of any business. The process gives either values or wastes as output during the production of goods or services. Hence, the elimination of waste as applied in lean management is used to bring about productivity improvement and also a method employed in this research work (MURUGESAN, 2016).

1.2 Problem statement

There are many problems manufacturing companies face today, such as unreliable production processes, financial losses, waste of resources and delays in product delivery (Jevgeni, 2015). Limited technological capabilities, lack of modern processing

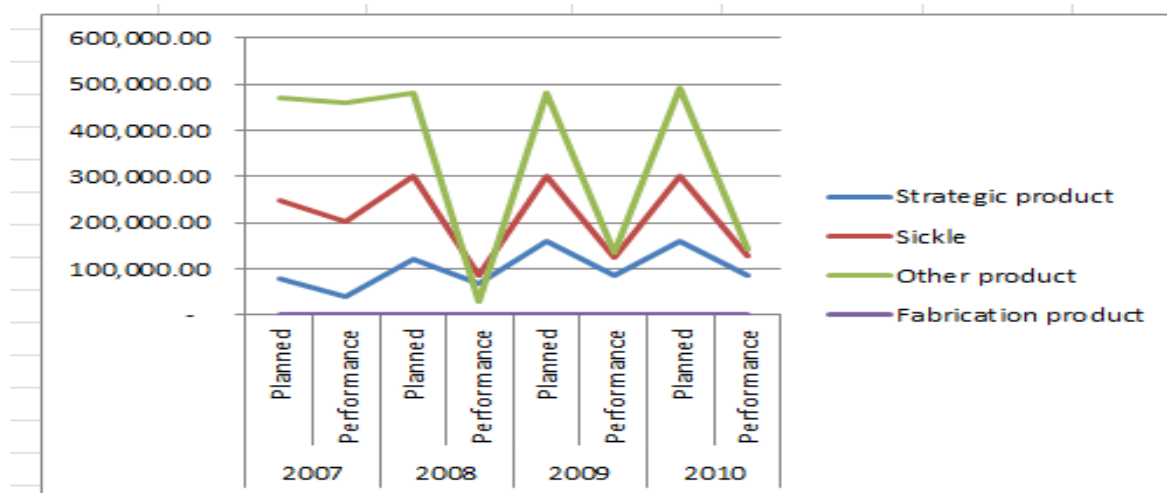
equipment, and poor market systems lead to poor productivity of the Metal industry (Mohamood, 2015).

Even though NMESC is still the only agricultural hand tool producing factory in Ethiopian aside from the local Blacksmith, the company lacks competitiveness in the locale market due to lack of quality and production volume of finished products required by the customer. NMESC implements Kaizen Philosophy, start improvement notation as a solution to their problem, but ignores continuous improvement effort. The top management of the company is not understanding and commitment of continuous productivity improvement.

Table 1.1 shows the annual production plan and performance report. Four-year performance shows strategic product 53.3%, sickle product 48.5%, other product 40.3%, and fabrication product 62.6%. The result shows the problem with the production process. Moreover, to achieve continuous productivity improvement and competitiveness in the market, it is better to have the company smart production system like a lean management tool for Negate mechanical engineering sch.co.

Table 1.1 Summary of annual production plan and performance report (4-year data report)

s/n	Description	Qty	2007 E.C		2008 E.c		2009 E.C		2010 E.C	
			Plane	Performance	Plan	Performance	Plan	Performance	Plan	Performance
1	Strategic product	Pcs	80,000	40,569	120,000	66,787	160,000	84,649	160,000	86,456
2	Sickle	Pcs	250,000	202,600	300,000	84,560	300,000	123,280	300,000	129,640
3	Other product	Pcs	470,000	461,337	480,000	30,595	480,000	136,658	492,631	142,768
4	Fabrication product	Pcs	2000	1800	1655	603	1655	920	1655	1040



Source: Negate Mechanical engineering sch.co. (Kotebe metal tool factory) 2011E.C annual report

Observing a four-year annual report generated by the case company, a pilot survey conducted on the case company and discussions with the stakeholder of the company has indicated the following as major problems.

1. No standard time exist for various production operation and target setting is based on experience
2. Poor resource utilization such as labor, space, machine, and time
3. Large work in progress in the production floor
4. Unnecessary movement during the operation time
5. High rework and high wastage of the product during the production process

1.3 Research Question

Following the problem above, this research is therefore expected to answer the following question

1. What are the major wastes observed in the case company?
2. How the major waste problem is resolved?
3. Which lean tool can effectively be applied in the case company?
4. How the productivity of the case company is improved through lean practice?

1.4 Objective of the study

1.4.1 General objective of the study

The main objective of this research is to improve productivity by minimizing wastes through lean practice for Ethiopian hand tool industries.

1.4.2 Specific Objective of the study

- To identify the major wastes & the root cause of waste observed in the case company.
- To determine the appropriate lean tool that can minimize wastes & improving productivity.
- To develop a model that can minimize wastes and improve Ethiopian hand tool industries.

1.5 Significance of the Study

The study outcome benefits for Negate mechanical engineering share company as well as other hand tool factory through the adoption of continuous productivity improvement technique that helps to improve the status of productivity factors available in the factory. Moreover, the improvement techniques bring tangible changes in the production process of hand tools and general working conditions in Ethiopia. This research can provide significant contributions to different users Especially the Hand tool industry and will be used as baseline information for contemporary researchers in similar areas.

1.6 Scope and Limitation of the study

Improving productivity is a very broad subject and can be approached from different angles such as company business strategy, application of the theory of constraints, total quality management, etc. This research is limited to the removal of wastes as a means of improving productivity by lean management. The study only investigates the processing step of three of the case company best-selling product like a shovel, Pick axe, and Sickle. The study concentrates model development for continuous productivity improvement by a lean management tool. This research not includes small-scale homemade industries.

1.7 Research Organization

The paper is organized into seven chapters. The first chapter covers an introductory part, which contains the problems, objectives, research question, and scope. Chapter two the literature review part regarding productivity improvement through lean management, lean tools, Value stream mapping, and wastes definition benefits highlights a review of studies on the production sector and gap of the literature. Chapter three: the methodology, sampling strategy, tool, and method of data analysis, data source discussion. Chapter four: deals with the overview of the Ethiopian metal industry and the case company hand tool production process. Chapter five: contains the data collection and analysis, results and discussion in detail. Chapter six: deals with the continuous productivity improvement model, model development criteria, and detail of the proposed model. Finally the conclusion, recommendation, and future study area.

2. Chapter Two –Literature Review

2.1 Introduction

Continuous improvement in the global market is credited as a key driving element in companies towards achieving cost reduction, improved company profit, and customer satisfaction. Hence, companies have to be more effective to survive and stay in business for long. Continuous improvement is a culture of sustained improvements that targeted the elimination of wastes. Productivity is any process or procedure developed to transfer a set of inputs into a specified set of outputs in proper quality and quantity thus achieving the objectives of industry (Moktadir, 2017). Lean describes a system that produces what the customer wants and when they want it with minimum waste.

2.2 Productivity

The definitions of productivity depend on the individual or organization perspective. According to Julian Buenos (2015) productivity is one of the most renowned concepts within the field of business administration. Because of that a lot of the management strategy is planned to attend the factors that affect it. Nevertheless, it could be difficult to identify them all because of the diversity of circumstances they come from. Productivity is the relationship between the quantity of output (goods and services produced) and the quantity of input (i.e., a resource such as labor, materials, machinery, and energy) that are used in production (Mohamood, 2015).

Productivity grows when output grows faster than inputs, which makes the existing inputs more productively efficient. Productivity does not reflect how much we value the outputs it only measures how efficiently we use our resources to produce them. (Hans, 2012). The organization for European economic cooperation (OEEC) has defined the concept of productivity as its widest sense it may be said that productivity; is the measurement of the economic soundness of the nations. (OECD, 2012).

"Productivity is an attitude of mind. It is a mentality of progress, of the constant improvement of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adaptation of economic and social

life to changing conditions”. [EPA].

From a manager’s perspective, productivity in all cases reflects success or failure in producing goods and services in quantity, quality, and good use of resources. In short, it is the ratio of output value to the input value. This concept is expressed in the productivity equation (R.schermerborn, 2015)

$$Pr oductivity = \frac{Output Value}{Input Value}$$

The equation shows the productivity rises, keeping other things constant, when the quantity of outputs increases, the quality of output increases, and/or the cost of resources (input) utilized decreases.

The performance of an organization cannot be judged by the increment of the quantity of the output alone. The output may be raised without an increase in productivity. That means the rate of the increment of input cost may be higher or the quality of the output may be decreased.

The concept of productivity is also increasingly linked with the quality of output, input, and process itself. Taking the definition of quality as conformance to requirements of the customer, productivity decreases as the quality of the output decrease. For example, in Hand tool products, quality means Hand tools without any defect on it.

Productivity is also linked with how the resources are utilized in the company. It is the function of achieving the maximum possible with the minimum resource. The resources are manpower, material, equipment, spares and building, capital, and time. The responsibility of achieving higher productivity rests on managing these resources efficiently. By definition, productivity doesn't come from working harder. This may increase output, but it also increases labor input. Similarly, using more capital or other production factors does not necessarily increase productivity. Productivity growth comes from working smarter. This means adopting new technologies or new techniques for production.

Productivity can also be defined as the relationship between result and the time it takes to accomplish them. Time is often a good demonstrator since it is a universal measure, and it is beyond human control. The less time is taken to achieve the desired result, the more productive the system is (R.schermerborn, 2015).

Generally, productivity should be considered as a comprehensive measure of how organizations satisfy the following criteria.

- Objective: the degree to which they are achieved.
- Efficiency: how efficient resources are used to generate useful output.
- Effectiveness: what is achieved compared with what is possible.
- Comparability: how productivity performance is recorded over time
(R.schermerborn, 2015)

2.2.1 Productivity Measurement

Productivity is a comparative tool for managers, industrial engineers, economists, and politicians. To be useful, measures must be as simple and as consistent as possible. Deciding to measure productivity, consider what a person does, how well, how much, and how often (hubert, 2015).

Similarly, a proper measure of inputs includes not only labor hours but also the quantity and quality of capital equipment used, materials and other resources consumed, worker training and education, even the amount of organizational capital required, such as supplier relationships cultivated and investments in new business processes (Joseph, 2016).

Productivity is one of the various measures that are used to evaluate the performance of an organization (Schweikhart, 2016). Productivity measurement has been practiced by almost all types of establishments regardless of their size and status. Productivity can be measured by **Total productivity**: the ratio of total output to the sum of all input factors. **Partial productivity**: the ratio of output to one class of input. For example, labor productivity (the ratio of output to labor input), capital productivity (the ratio of output to capital input), and material productivity (the ratio of output to materials input).

Surrogate Productivity: Surrogate productivity indicators are the measure of surrogate factors and they are not measured directly as the ratio of output to input (Ephrem, 2015).

2.2.2 Factors affecting productivity: There are different factors affecting productivity (Mohamood, 2015)

A. Controllable (internal) factors: They are inside the dynamic and the production process of the company. The major internal factors of the company are:

1. **Human factors:** Human skills such as work experience, training, and educational background.
2. **Technology:** New technology improves the productivity of the company.
3. **Product Factor:** Different product meets output requirement and judged by its customer demand.
4. **Plant and equipment:** The increased accessibility of the plant through proper preservation and reduction of idle time increases productivity.
5. **Management style:** Active and flexible management style is a better approach to increase productivity.
6. **Material and Energy:** Good quality material and low energy consumption materials will improve productivity.
7. **Work methods:** Proper work method improves productivity, work-study and industrial engineering techniques and training are the areas which improve the work methods.

B. Uncontrollable (External) factors: External factors affect the company production process.

1. **Natural resources:** Manpower, land, and raw materials are vital to productivity improvement.

2. **Government Policy and infrastructure:** fiscal policies (interest rates, taxes) influence productivity to a greater extent and Infrastructures like Transport, Communication, and power affect productivity.

3. **Structural Adjustment:** Structural adjustments include both economic and social changes that affect productivity. A Shift in employment from agriculture to the manufacturing industry, Import of technology and Industrial competitiveness are some of the structural adjustment that affects productivity.

2.3 Waste (Mud)

Waste is a process for which the customer does not pay the company. There are 7 types of wastes transportation, motion, inventory, waiting, overproduction, over-processing, and defect (Khalil A, 2013).

2.4 LEAN MANAGEMENT

The concept of Lean originated in Japan when manufacturing firms could not afford huge investments in rebuilding their industries (Baum & Sang wan 2014). Toyota was the first automobile company to adopt Lean manufacturing and produced a variety of cars at the lowest possible cost while keeping the smallest possible inventories. Lean aims at reducing costs by eliminating waste and wasteful steps within a process and producing at a faster rate (Bhamu & Sangwan 2014).

Lean management or lean production, often simply "lean", is a systemic method for the elimination of waste in a process. Lean differentiates of seven types of waste: defects, overproduction, transportation, waiting, inventory, motion, and processing. Lean related to developments of the product, technical preparation of production, logistics, and administration. Lean production influences financial performance by improving organizational processes and cost efficiencies. The various lean tools taken are 5S, OEE, 8 step Practical Problem Solving(PPS) Method, Pareto Analysis, Elimination of Waste, Kaizen, Setup Time Reduction, Process Mapping, Value Stream Mapping (VSM), Quick & Easy Kaizen, SPC / Control Charting, 5 Whys, Automation, Continuous Improvement, Continuous Flow, Visual Controls, Design for Six Sigma (DFSS), Cellular

Manufacturing, Production Leveling, KANBAN / Line Balancing, VOC (Voice Of The Customer), Judoka, ANOVA, Work Standardization, Work Simplification, Fishbone diagrams, Six Sigma, Tact Time, QFD and Poke Yoke / mistake-proofing (Arunagiria, 2017).

2.4.1 Lean Management and its Technique

The objective of lean is to create the most value for the customer while consuming the least amount of Resources to design-build and sustain the product. Improvements can be made by implementing lean tools and techniques appropriate to the particular situation (Sharon A. Schweikhart, 2016) Lean management describe a set of technique when combined and matured to result in the elimination of seven waste (Mud) is built on the strong foundation of process and product quality. Continuous evolvment is perpetuated by a strong and healthy culture (Willson.L, 2010).

(Kariuki, 2013) Stress the need to lower cost and at the same time provide as high customer value as possible. Lean Thinking is one of the new techniques that can help companies to meet with those needs. Hence the goal of lean management is to minimize waste in terms of non-value adding activity. Further, waste in lean can be defined as the redundant application of resources that doesn't add value to the product or activities for which the customer is not willing to pay.

According to (James P. Womack, 2003), Lean management techniques are based on the application of five principles to guide management action toward success. These five principles are the following:

- 1. Value:** Define value for a specific product from the customer perspective which meets customer needs.
- 2. The value stream:** Identify all the steps in a value stream across all parts of the organization involved jointly delivering a product to the customer. Identifying the value stream exposes as non-value adding process steps

3. **Flow:** Make the value-creating step flow in tight sequence so that the production flows smoothly towards delivering products to the customer without wastes such as waiting & interruptions.
4. **Pull:** Produce only what the customer wants when the customer wants it.
5. **Perfection:** Having value specified, value stream identifies, waste removed, flow and pull introduced the process should be in continuous improvement until the state of perfection is reached in which every action adds value for the end customer (Zero waste).

An initial conceptual model of lean tools and principles was developed as shown in Figure 2.1. A total of 20 tools were identified and these were grouped into six categories: Visual Management, Policy Deployment, Quality Methods, Standardized Work, Just-In-Time, and Improvement Methods. The focus of all these tools is meeting customer requirements which are the center of the model (Jeyaraman, 2015).

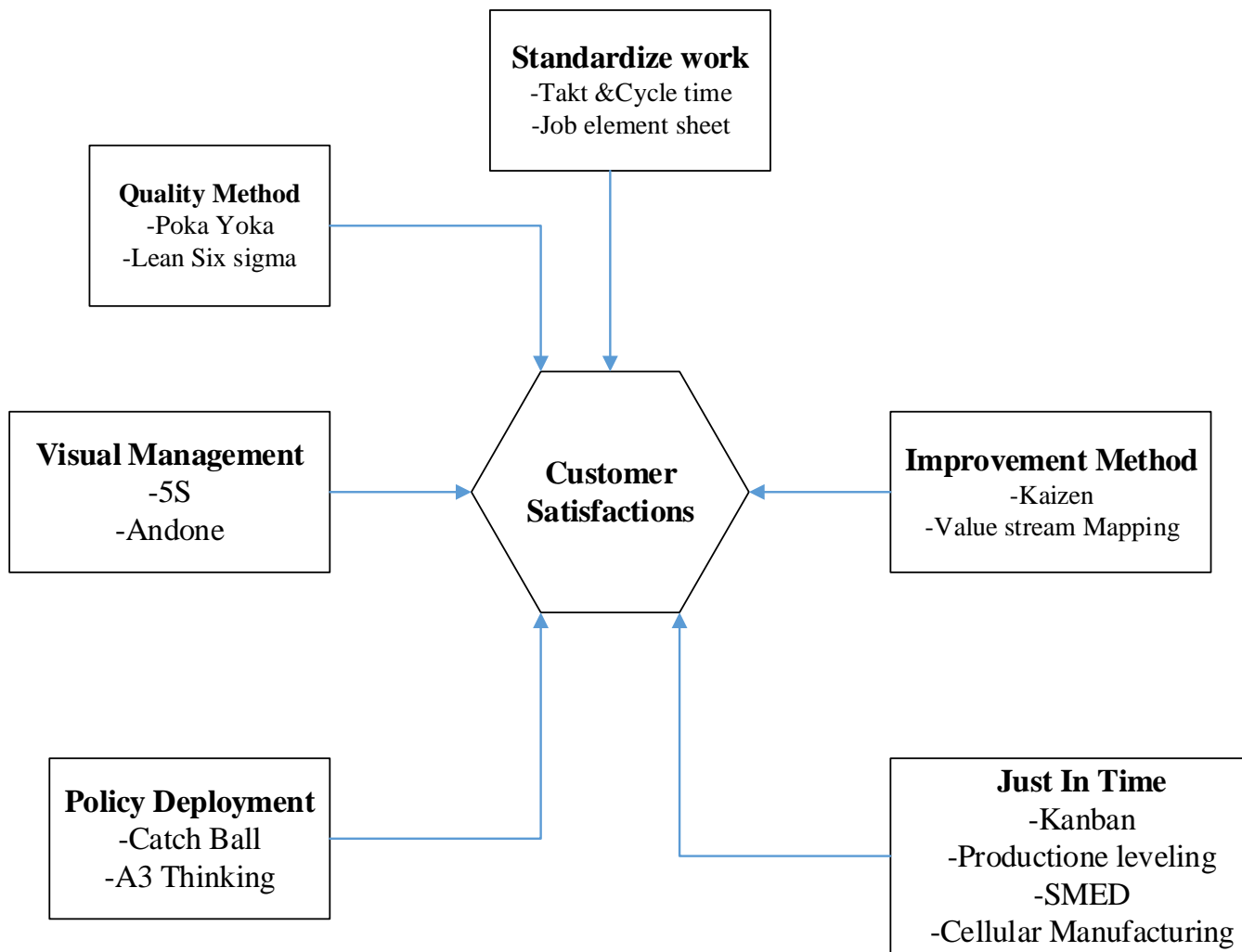


Fig 2.1 Conceptual model of Lean tools and Principle (Jeyaraman, 2015)

Standardized work is the safest, easiest, and most effective way of doing the job that we currently know, but the purpose of standardized work is to provide a basis for improvement on that job (G.Vijayakumar, 2016).

Quality methods include Judoka, Poke-Yoke, and Lean Six Sigma. Poke-yoke, as introduced by Shingo (1985a), is implementing simple low-cost mistake-proofing devices that detect abnormal situations before they occur or once they occur stop production to prevent defects (Prajapati Brijeshkumar, 2016).

Visual management is the 5s organization system. The 5s tool as Hirano (1996) teaches a structural system to organize any type of business or operation, and 5s represents five steps including sort, set in order or place, shine or scrub, standardize and sustain (Mohamood, 2015).

Just in time includes Kanban, production leveling, single minute exchange of dies (SMED), and cellular manufacturing. SMED is a series of techniques developed by Shingo for a reduction in production changeover time to less than 10 min. Shingo (1985) has compiled this methodology into his book entitled *A Revolution in Manufacturing: The SMED System* (G.Vijayakumar, 2016).

Improvement methods include Kaizen, Kaizen Blitz, and VSM. Ortiz (2006) identifies Kaizen as a team approach to quickly tear down and rebuild a process layout to function more efficiently. Russell and Taylor (2002) use the term Kaizen Blitz to describe when a process is quickly changed to eliminate activities that have no value. Womack and Jones (1996) found that for almost all companies, value stream redesigns are a critical step to becoming lean; the design of the end-to-end value stream must be considered instead of applying tools randomly, to address an apparent problem. VSM is used extensively in Six Sigma Methodology and Henderson and Larch (1999) recently added the procedure to the list of tools that can be used to apply the principles of lean. Seth and Gupta (2005) present a case study of VSM as applied to an Indian automotive manufacturer showing both current state and future-state maps (Rothenberg R. , 2016).

However, the concept of Lean Management is still relatively new for these Hand tool industries except for some Metal industries like (Yesu metal manufacturing, Akaki metal factory) which are introducing a kaizen system. Still, any studies or implementation related to lean Management systems for Ethiopian Metal industries are very little. Similarly, the case company follows the traditional production system.

2.4.2 Lean tools:

Lean tools are major tools for improving productivity. The removal of 100% of waste dictates the implementation of all these lean tools (Kumar, 2012), (R.sundar, 2014) describes the lean tool as follows;

- a. Value Stream mapping
- b. Worker Involvement
- c. Cellular manufacturing
- d. Line Balancing
- e. Flow manufacturing
- f. Production Leveling (Heijunka)
- g. Continuous Improvement (Kaizen)
- h. Total Productive maintenance
- i. Kanab
- j. Single Minute Exchange of dies
- k. Pull system with one-piece flow

a. Value stream mapping (VSM): Value stream mapping is a set of a machine to visually display the flow of material and information through the production process. The objective of VSM is to identify the value-adding step from the non-value-adding step so that the potential for improvement can be identified. VSM should depict what happens rather than what should happen. VSM demonstrate exactly how the process operates with detailed timing of step by step activities for consequent analysis and elimination of time spent in non- value-adding activities.

b. Worker Involvement: In lean management, workers are encouraged to take active parts in the identification and ultimate removal of non- value-adding activities. (Wulf, 2014) Stress that prior attempts to implement Lean in industries have shown that key ingredients to be the support of workers in a company and only through their support, understanding, and acceptance of the change needed can be lean implemented. Work method can strengthen worker identification and involvement .particularly commitment and that employee perception can be enhanced through training and awareness by defining road maps, metrics, and measurements.

- c. Cellular manufacturing (CM):** Cellular manufacturing is the grouping of the machine into cells for the manufacturing of family of parts. Cellular lay out helps to achieve many of the objectives of lean manufacturing due to its ability to help eliminate non-value-added activities from the production process such as waiting time, bottlenecks, transport, and work in progress. U-line manufacturing is a special case of cellular manufacturing that improves flexibility in the manufacturing system.
- d. Line Balancing:** Operator walking time and fluctuating on man, machine cycle time leads to line imbalance. Based on the demand the number of the machine in a work station is increased or decreased to overcome line imbalance.
- e. Flow manufacturing:** Flow manufacturing principle is based on producing an item at a rate equal to the Tact time. The successful implementation of flow manufacturing requires U line layout, Multi skill operator, Standardize cycle time, and well-designed operator movement in the work station.
- f. Production Leveling (Heijunka):** Production leveling work towards leveling of production volume and product mix to avoid picks and valleys in the workload. The fluctuation in the workload is caused by the fluctuation in customer demand which has to be leveled off. The balanced workload is achieved through. Every part Every Interval (EPEI) concept which is formed based on product families. According to EPEI, every product is produced within a periodic interval. The concept of Heijunka is to control the variability of the job arrival sequence to permit higher capacity utilization, also it avoids peaks and valleys in the production schedule.
- g. Continual improvement (Kaizen):** Lean manufacturing requires a commitment to continuous improvement where a systematic process is insured for the system to continuously search for non-value-adding steps and remove those. The successful implementation of continuous improvement depends on employee perception, adaptation, teamwork, leader engagement, motivation, initiative, and training.
- h. Total Productive Maintenance (TPM):** It is a revolutionary approach to the management of machinery. According to (Willson.L, 2010), it consists of activities designed to prevent breakdowns. Minimize equipment adjustment and cause lost

production, make the machine safer and easily operated, run the machine most cost-effectively.

- i. Kanab:** Kanab is a lean management tool created for the control of inventory levels. Once a product is removed from the finished good by the customer, to replenish, the moved quantity is replaced by colored paper or electronically which becomes a production order for the internal suppliers in the upstream value chain.
- j. Single Minute Exchange of dies:** Lean management works towards the reduction of set up time & change over time as they will consume critical working time. This can be achieved through structured and sequenced work instruction to perform the job. The operator following the instruction should be able to finish with minimum possible time. Designing of the work instructions follow time and motion study.
- k. Pull system with the one-piece flow:** The pull system is based on the idea that the customer/ downstream process takes the product/service they want and pulls it from the producer. A successful pull flow depends on the flow of small batches approaching one-piece flow pacing the process to Tact time, signaling replenishment through a Kanab replenishment signal, and leveling a product mix and quantity over time. In a one-piece pull production system, the producer begins production when the customer removes a product to initiate the Kanab card/ signal for the product.

The sequence of lean tools during the implementation period for the stage by stage as indicated below

(R.sundar, 2014).

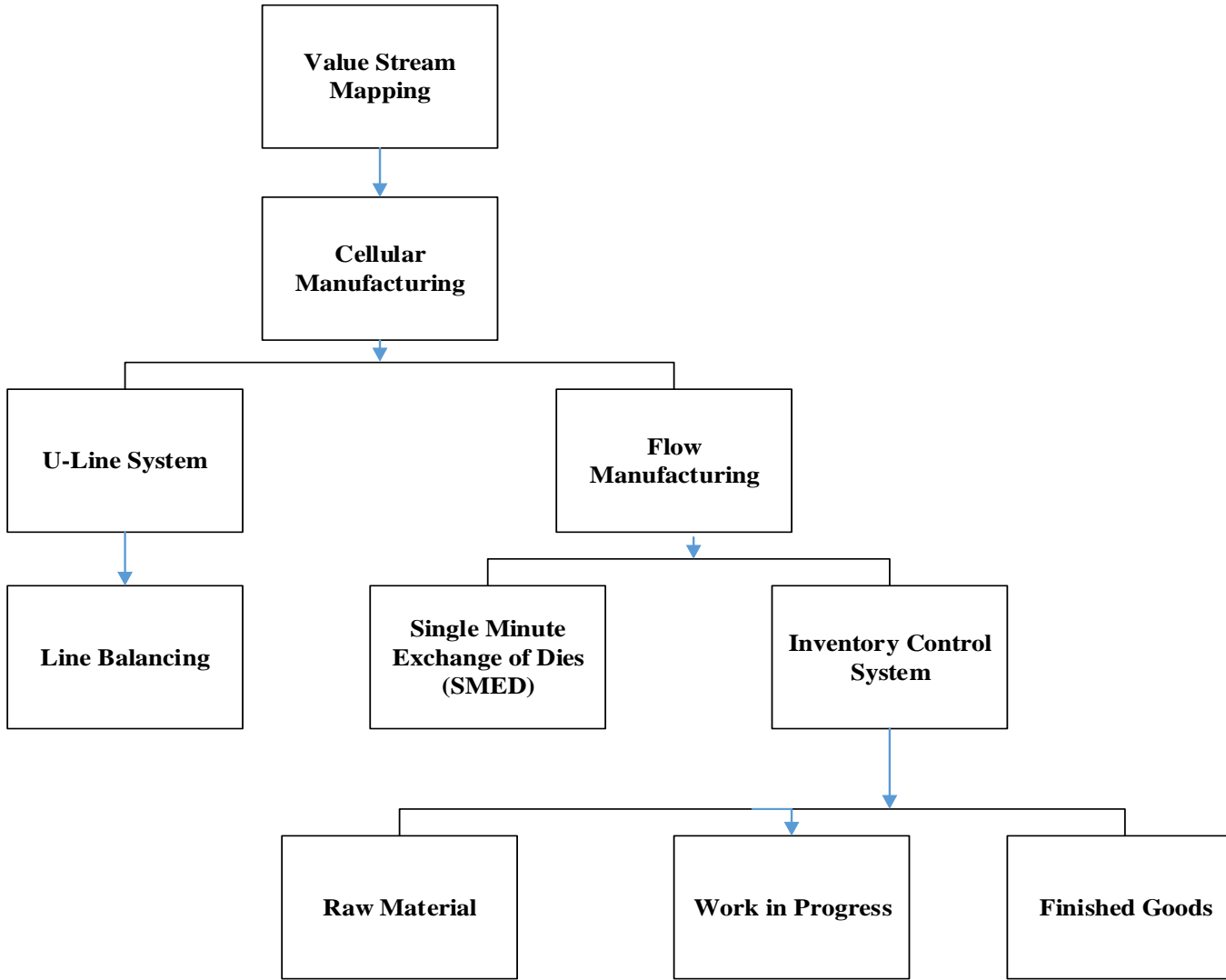


Fig 2.2 Sequence of Lean tools (R. sunder 2014)

According to (Lopes, 2015), the Initial Implementation of Lean typically involve Value stream mapping. Value stream mapping (VSM) is a standardized way of the mapping process, information, and material flow. VSM systematically analyze these processes for ultimate identification of various types of waste and target specific areas for improvement (Jeong, 2018). VSM gives a graphical overview of the flow of material and information in a production process which would be a very good foundation for understanding how

activities and operations are connected and form a basis for the analysis of the process (Langstrand, 2018). The following are a sequence of five steps to describe the VSM development Methodology (Langstrand, 2018).

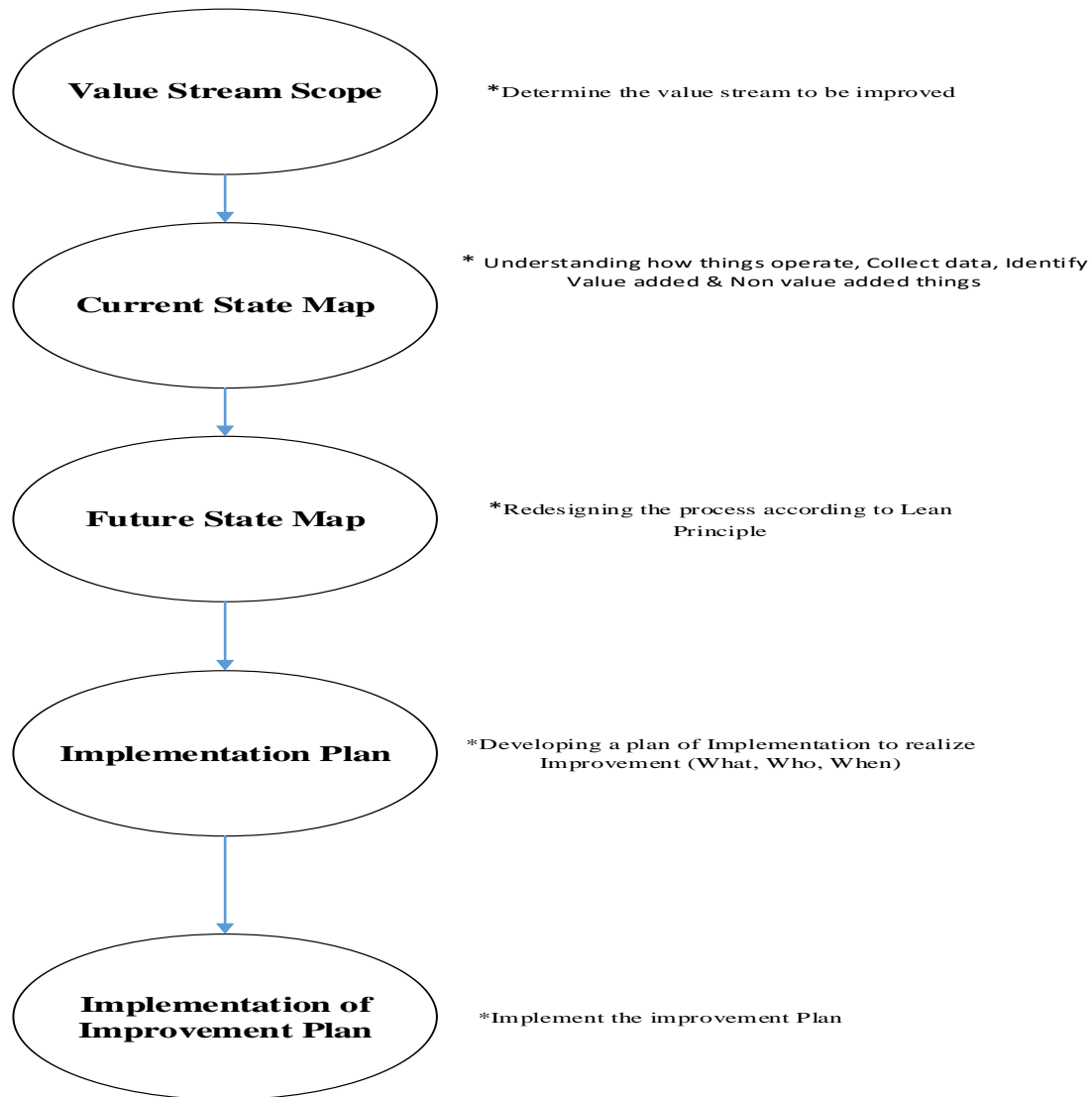


Figure 2.3 the main step of the value stream mapping methodology (Lang strand 2018)

(Wulf, 2014) Describe the process of mapping a value stream as starting from the customer delivery endpoint and working back through the entire process documenting the process graphically and collecting data along the way until reaching the suppliers. It results in a single page map that contains data such as cycle time, works in progress levels, equipment performance data, and information flow within the system. VSM

identifies the value added activities and non- value added activities adding up to the total lead time of production.

Analyzing the value stream map

According to (Wilson, 2015), there are five basic tools in Value stream map which are:

- i. The basic time study
 - ii. The Tact Time
 - iii. Balancing analysis
 - iv. A Spaghetti diagram
 - v. The present state value stream maps
- i. The basic time study:** The most fundamental tool to synchronize flow and analyze the work is the basic time study. (Wilson, 2015) States that while the study can be made in many ways, stress that several cycles should be observed. Ten cycle reading is given as common.
- ii. The Tact Time:** According to (Langstrand, 2018) , calculating the Tact time &Waiting time is the first step to analyze the current state map these results being used towards obtaining Total lead time, the processing time & Process efficiency. Tact time is the production pace that must be maintained to meet customer demand.

$$Tact\ time = \frac{Availabe\ time}{Customer\ demand}$$

Waiting Time: Waiting time is a time when a product or people are idle. Inventory lead time signifies the waiting time that the product stays in inventory or buffers (Langstrand, 2018).

Process efficiency: The processing time is taken as the cycle time which is also the value-adding time in the process. The summation of all cycle time will give the total value-added time in the process. The total lead time in the process is obtained by adding all the waiting time as a single product pass through the entire process from start to finish. The process efficiency which is the ratio of the total value-adding time to the total lead time is obtained.

$$\text{Process efficiency} = \frac{\text{Total Process time}}{\text{Total Lead time}}$$

iii. Balancing analysis: (Langstrand, 2018) Give the following consideration as necessary towards bringing about balance in the process.

- ❖ The vertical distance from the tact line to the station cycle time represents the waiting time which is time wasted for that work station.
- ❖ Compare the customer tact time to the cycle time of the operation.
- ❖ Compare the cycle time between operations. (Potential bottlenecks are identified. Also, the need for re- Balancing of the process is assessed). For these balance load charts are required.

iv. The Spaghetti Diagram: This is a simple yet powerful tool to visualize the movement and transportation of entities. When transportation paths are seen it is often easy to reduce these wastes.

V. Value stream Mapping: Value stream maps show the information flows necessary to plan and meet the customer normal demands. Process information shown in VSM includes cycle time, inventories held change over time, staffing, and mode of transportation.

The key benefit of VSM is that it focuses on the entire value stream to find system wastes and tries to avoid the pitfall of optimizing some local situations at the expense of overall de-optimization of the entire value stream. VSM highlights the two métiers namely value-added work given as total production time and non-value added time given as production lead time.

2.4.3 Waste (Mud)

(Wulf, 2014) State that the elimination of wastes categorized into seven basic types.

- ❖ **Overproduction:** This is the most deadly waste of all the waste since it is not only a waste but aggravates the other six types of wastes. Overproduction is making of product not required by the customer?

- ❖ **Transportation:** This is waste created by moving parts around. It is created between the processing Steps. Between the processing line and when the product is shipped to the customer.
- ❖ **Waiting:** The time that a worker or machine is idle waiting for the previous task to finish. It should be short term waiting as is observed in unbalanced lines or long term waiting such as stock-outs and machinery failure.
- ❖ **Inventory:** All inventories are it raw material, WIP, finished good is considered wastes unless the inventory directly translates in to sales.
- ❖ **Motion:** This is the unnecessary movement of people, the movement of people during the processing of products, has to be value-adding, work design & work station design is taken as a key factor here.
- ❖ **Over-processing:** This is a waste created by processing a product beyond what the customer wants. Over-processing consumes more resources than is strictly needed.
- ❖ **Defect:** This waste is due to, as put by Ohio, “Making of defective parts”. Not only is the part type than what was previously stated by Tahiti Ohio to be added as the 8th waste type.
- ❖ **Lost people potential:** This waste is due to the underutilization of people skills, Knowledge, and abilities; this should be used to the fullest.

All the lean tools work towards common goals of eliminating this waste to bring the most value to the customer (Bartholomew, 2015).

2.4.4 6S:

An established methodology procreating in Japan that, when implemented, mitigates the waste of resources and work area despite increment in manufacturing & operational proficiency (Derya Sevim Korkut, 2009). According to Derry (2009), the 5S elements are Sort, Set-in-Order, Shine, Standardize and Sustain and are applied in various industries to achieve lean Management & to ultimately improve productivity Idea of 5S can be explained by the following.

- ✓ **Sort:** Completely Sort out & classify that which item is required and/or not required in the work area (eliminate that which is not needed, separate the essential from non-essential).
- ✓ **Set in Order:** Arrange items in required order that are important so that they are ready to find & easy to use (organize remaining items, a place for everything its place).
- ✓ **Shine:** Clean the work area, tools, machine & equipment's continuously to identify defects& maintain standards.
- ✓ **Standardize:** Ensure standard & uniform procedures and methods throughout the operation to promote change over (write standards for above, ensures we don't do what we always did).
- ✓ **Sustain:** Stay to the regulations to maintain the standard & continue to improve every day (regularly apply the standards, make the other part of everything life to maintain improvement).
- ✓ **Safety:** The condition of being protected from or unlikely to cause danger, risk, or injury.

2.4.5 Lean principle

Lean is focused on eliminating waste. Perhaps every organization agrees that waste should be eliminated, but the question is how. Here Lean principles have an important task in providing guidance. To be successful in a Lean effort it is necessary for an organization that its values are aligned with the Lean principles (G.Vijayakumar, 2016).

Lean has five principles according to "Womack and Jones" and they are defined as:

- **Identify value from the customer point of view:** This principle is related to the knowledge of customers' needs. It needs to be applied in all organization's departments in order not to encounter waste during the production cycle.
- **Value stream mapping (process map):** This principle refers to the elimination of all non-value-added steps for each product family and service.

- **Create flow:** The flow becomes continuous and smooth in the remaining value-added steps for better communication among departments and for a safe movement of the information and the materials between the different stages.
- **Establish Pull:** The client will ask for the product or service when needed thus reducing inventory cost.
- **Seek perfection:** wastes are eliminated, inventory is reduced and work is faster thus reducing time lag and the amount of information needed (Prajapati Brijeshkumar, 2016).

The following steps which are required to implement the Lean Management are:

1. Identifying the fact that there are wastes to be removed.
2. Analyzing the wastes and finding the root causes of these wastes.
3. Finding the solution for these root causes.
4. Application of these solutions and achieving the objective.

The major purposes of the use of Lean Management are to increase productivity, improve product quality, and eliminate manufacturing waste, reduce inventory, and reduce the lead time of the company (Guillory, 2017).

2.5 Literature Gap:

To get enough information and best understand the subject matter and the field of study many kinds of literature are reviewed from different sources, journals, articles, reports, and thesis are the main one. Therefore in this research, even though so many researches are focused on the deployment to solve the problem of productivity. The lean approach in Metal Industries is not explored and not much has been found in the Ethiopian context and little literature is available focusing on metal industries. The research focuses on improving productivity by using Value stream mapping (VSM) lean tools.

Table 2.1 Summary of the main article

Author	Title	Technique used	Benefit derived	Limitation
T. Mezgebe (2015)	“Economic analysis of lean waste:	Lean	Reduce rework & Waste	Problem not clearly stated
Prajapati Brijeshkumar,(2016)	Lean manufacturing & six sigma	Lean, six sigma	Improve productivity	Mainly focus on the lean and six sigma approach
Rothenberg (2016)	“Lean six sigma application in the textile industry”	Lean	Reduce rework, compliance risk	The finding from this case study cannot be generalized.
Mahmood (2015)	Factors affecting productivity	Comparison	Show the factors affect production	Show general factors it is not clear
Murugesan (2016)	Manufacturing process improvement using lean tools	VSM	Reduce worker movement, Reduce inventory & lead time	Improvement Expect from future
Lopes (2015)	Application of lean manufacturing tools	5S	Reduced change over time, less movement from employees	Effect of machine design change not quantified
Wolf (2014)	Application of lean methodologies	VSM	Improvement in production lead time, saving in inventory cost	Simulation not used to supplement the result of VSM

3. Chapter Three – Research Methodology and Materials

This chapter discusses the methods that were used in the collection and analysis of data to answer the research question. Both qualitative and quantitative research methods were used in carrying out this research.

3.1 Data Source

The methodology applied in the research includes a literature review, primary and secondary data collection methods.

1. Literature Review: published journal articles and books were surveyed to understand the concept, principle, and benefit gained by implementing lean.

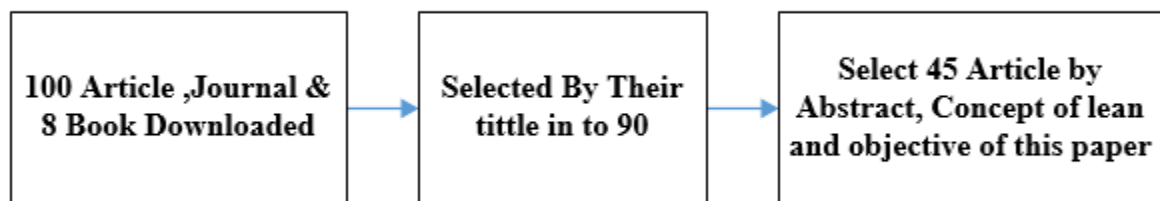


Figure 3.1 Selections of Articles

2. Primary Data: Primary data collected through questioner, interviews, and observation. Personal observation in Forging, cutting, bending, piercing, and other operation in the production sections and interviews with the production manager, section foramen, and selected worker in the forging and sickle factory.

I. Direct Observation (Descriptive observation): During visiting of the case company, necessary data gathered through careful observation of operator movement, material handling, work station design, machine set up and process flow of the production department.

II. Questionnaire: Prepared questioner based on productivity, lean waist, and a different area used for the hand tools industry. Structured questioners were used to getting complete information about the company. The questionnaire is translated from English to Amharic to make it suitable for the respondent. The questioner direct to the production department and Production area (Operator of the company).

Only full-time employees are used for data analysis. The collected data entered and analyzed using SPSS software version 20 and Visio 2013.

Most of the questioners are close-ended. Give rank

- ✓ Rank 5 = Very strong = Strongly agree
- ✓ Rank 4 = Strong = Agree
- ✓ Rank 3 = Moderate = Neutral
- ✓ Rank 2 = Modest = Dis agree
- ✓ Rank 1 = Weak = Strongly Disagree

The questioner designed and distributed for 60 employees of whom 6 of them were high-level managers, 15 of the middle-level managers and supervisors; 39 were operators, machinist & worker at the case company.

III. Interviews: Semi-structured interview conducted with Forman, Section head, and managers of NMESC to get the additional information and data validation.

IV. Stopwatch: Time study has been taken by stopwatch and using timesheet to determine the basic time for all operation sequences and the capacity of each workshop per day.

3. Secondary Data: Secondary data used in this research include previous documents, government institutions like MIDI, and the case company.

I. Document review: To show the existing problem of productivity in the case company documents are reviewed such as production sheet, Process planning sheet, quality records, attendance sheet, and other related reports on the company from external sources.

II. Statistical data: conducted using data from the metal industry development institute (MIDI) and Negate mechanical engineering sch.co (KMTF) Annual performance.

3.2 Sampling Strategy:

This section consists of a description of the target population, sample size, and the sampling procedure used to evaluate the current observed time of each element.

3.2.1 Target Population

Population refers to the complete set of individuals (subjects or events) having common characteristics in which the researcher is interested (Lagasse, 2016). The target population of this study includes Top managers, Middle managers, operators, maintenance, quality controls, and supervisors working on the shop floor. As of the Annual report 2019 of NMESC report, there are a total of 142 man powers. Of the total manpower, 110 are full-time workers, 32 are part-time workers, 92 employees are direct labors engaged in production and the remaining staff are working in the administrative area.

3.2.2 Sample Size

The sampling method applied in this study is the simple random sampling method. A simple random sample is a sampling method in which every member of the population has an equal and independent chance of being chosen. To get a representative and reasonable sample size that supports the research findings, the following equations were used. Equation (1) is applied to compute the initial sample size. Since the population is finite (less than 50,000), Equation (2) is used to compute the new sample size. These equations were developed by Johnson et.al, (2009) and Freedman et al., (2007) according to (Othman, 2014).

$$n_o = \frac{z^2 * p(1-p)}{c^2} \dots\dots\dots (1)$$

$$n_f = \frac{n_o}{n+n_o-1/N} \dots\dots\dots (2)$$

Where:

n_o = initial Sample Size

n_f = target sample size

Z = Z-values for confidence levels are (1.645 for 90% confidence level, 1.96 for 95% confidence

Level and 2.576 for 99% confidence level)

p = percentage picking a choice, expressed as decimal 0.5 used for sample size needed

c = confidence interval, expressed as decimal; $0.08 = \pm 8$

N = Population = 142 workers

$$n_o = \frac{2.706 * 0.5(1-0.5)}{0.0064} = 105.7$$

$$n_f = \frac{106}{1+0.74} = 60.9=61$$

$n_o = 106$

$n_f = 61$

3.2.3 Sampling Procedure

Stratified random sampling is used to get the desired representation from the various employees' subgroups in the population. The subject was selected in such a way that the existing subgroups in the population are more or less reproduced in the sample. After sampling at each subgroup, simple random sampling proportional to size based on the relative number of employees in each section was used. A sample should be optimum; fulfills the requirements of efficiency, representativeness, reliability, and flexibility (Kothari, 2004).

Table 3.1 Target respondents

Section	Responsibility	Total Staff	Sample Size
Forging	Manager	2	$2 * (61/142) = 1$
	Supervisor	2	$2 * (61/142) = 1$
	Forman	4	$4 * (61/142) = 2$
	Operator & Helper	50	$50 * (61/142) = 22$

	Quality Control	2	$2*(61/142)=1$
Shovel	Forman	2	$2*(61/142)=1$
	Operator & Helper	25	$25*(61/142)=10$
	Quality Control	4	$4*(61/142)=2$
Machine shop	Forman	2	$2*(61/142)=1$
	Machinist & Helper	9	$9*(61/142)=4$
	Quality Control	2	$2*(61/142)=1$
Administration	Administration worker	38	$2*(61/142)=16$
Total		142	61

3.3 Tool and Method of Data Analysis

Selecting tools or methods from a set of candidate tools, given data in the simplest cases, data is considered from referred articles to try to separate the majority of the tools used. The data will be analyzed by taking the information from primary and secondary sources. During the analysis of the data Microsoft Office 2010, Excel used to manipulate the raw data collected from the sources and the response rate of a questionnaire, interview, and statistical data. Present the result of data through a different chart like; Cause and effect diagram, bar graph, and SWOT analysis to know the strengths, weaknesses, opportunities, and treats of the case company. Using a stopwatch to measure (observe) the production time per minute that each element takes (evaluate the working time) and also using Lean tools. (Johnson, 2009)

- ❖ Productivity = Output/Input
- ❖ SMV= basic time + allowance
- ❖ Average observed time = Sum of the times recorded to perform each element/Number of observation

- ❖ Normal time= observed time * Rating
- ❖ Required sample size = $n = (z_s / h_x)^2$
- ❖ Standard time =(total normal time/1-allowance factor)
- ❖ Down time = (total down time/total working time)*100

3.4 Validation of data/ reliability testing:

Cronbach's alpha is a coefficient of reliability. It is considered to be a measure of scale reliability, a high value for alpha does not imply that the measure is one-dimensional. (Reliability coefficient of 0.7 or higher is considered acceptable) (Changiz, 2011).

$$\hat{\alpha} = \frac{kc}{v + (k-1)c}$$

Where:

K: is the number of test items

V: is the average variance, and

C: is the average of all covariance between the components across the current sample

Cronbach's alpha is a measure of internal consistency, how closely related a set of items are as a group. Below is the summarized Cronbach's Alpha's Coefficient, using George and Mallory (2003) rule of thumb any items with a value of less than 0.5 would be unacceptable, 0.8 "good" or 0.7 rather sufficiently reliable and 0.6 questionable. Based on the Cronbach's alpha coefficient in Table 5.8, it shows variables have exceeded the acceptable level and suggesting acceptable reliability.

3.5. SPSS Software:

The software name originally stood for statistical package for social science. It is the acronym of statistical package for social science and one of the most package popular

statistical packages that can perform highly complex instruction. It is used by researchers to perform statistical analysis (Mezgebe, 2015).

Table 3.2. Cronbach's alpha results for each productivity Measurement.

Productivity Improvement measurement	Reliability Statistics	
	Cronbach 's alpha	No of Items
Waste Minimization	0.933	7
Idle Time	0.873	5
Continuous Improvement Tool	0.781	5
Customer Requirement	0.813	5
Improvement Problem	0.877	7

3.6 Research Design

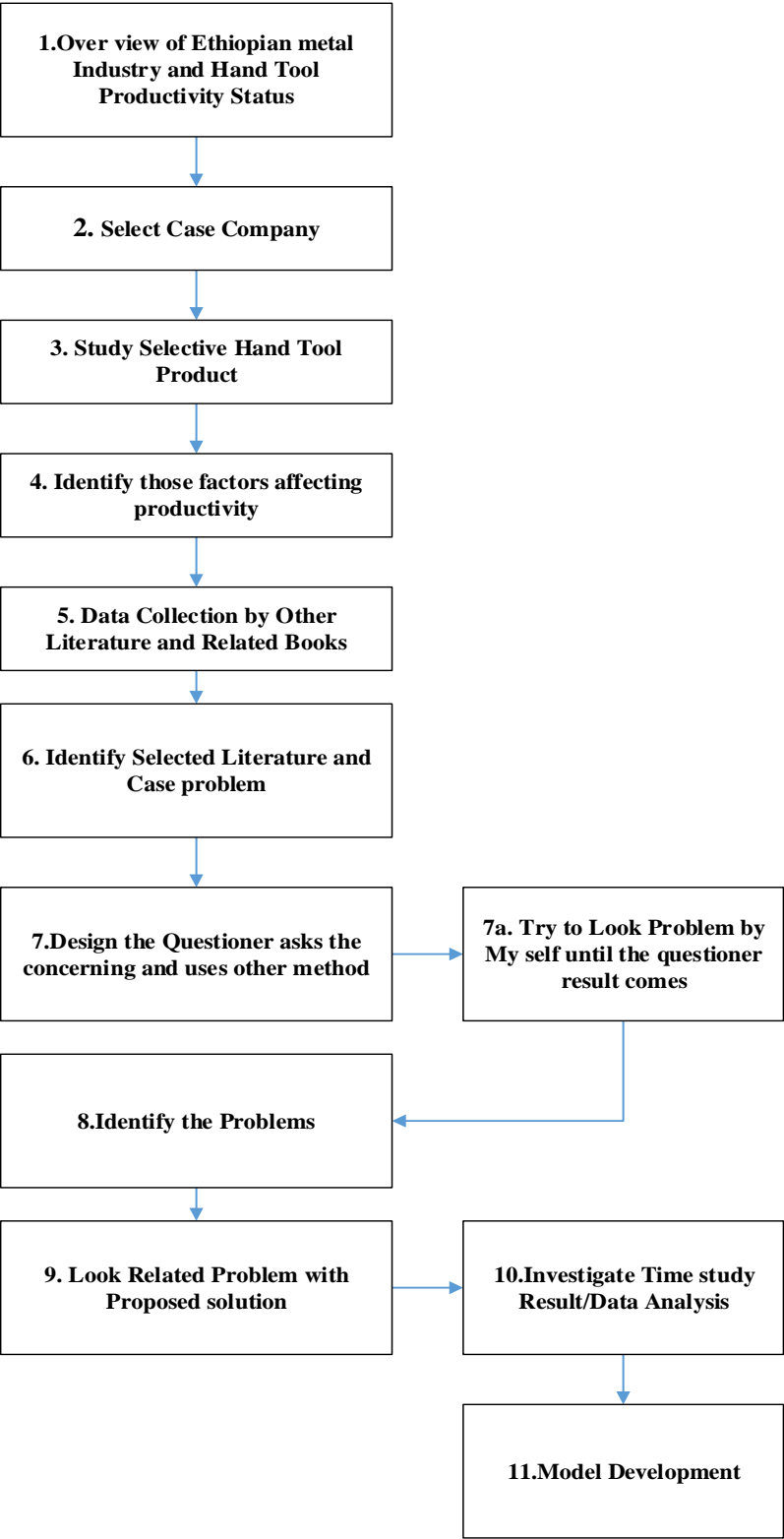


Figure 3.2 Research methodology flow

4. Chapter Four - Overview of the Ethiopian metal industry and the case company hand tool production process.

4.1 Overview of Ethiopian metal Industry

Metal industries are considered to be upstream technologies that are the base for the requirements of downstream technologies by providing the required raw material through acceptable quantity and quality (Singh, 2012). Ethiopian metal manufacturing industries could be considered as nonexistent as they lack the crucial component of producing basic metals from ore or other process routes. Table 4.1 the overview of the Ethiopian metal industry for the other industrial sectors; [MOI GTP II and MIDI annual report, CSA].

Table 4.1 overview of Ethiopian metal Industry

S/No	Industry Sector	Total Number of factory	Total Number of Employee	Worth of production (Billion Birr)
1	Metal and Related Product	243	13,431	6.62
2	Textile and Garment	77	19,214	1.84
3	Leather & Leather Product	141	14,101	3.5
4	Agro Processing	687	68,759	24
5	Chemical Product	183	10,926	4.67

Source: [MOI, CSA 2015]

[GTP II] demonstrates that by the end of the year 2015 the number of medium and higher manufacturing industries in Ethiopia reached 2,655 when compared to the year 2012 it shows a 22.2% increment.

Figure 4.1 shows the Ethiopian metal industry's status for several industries, employment opportunities and worth of production.

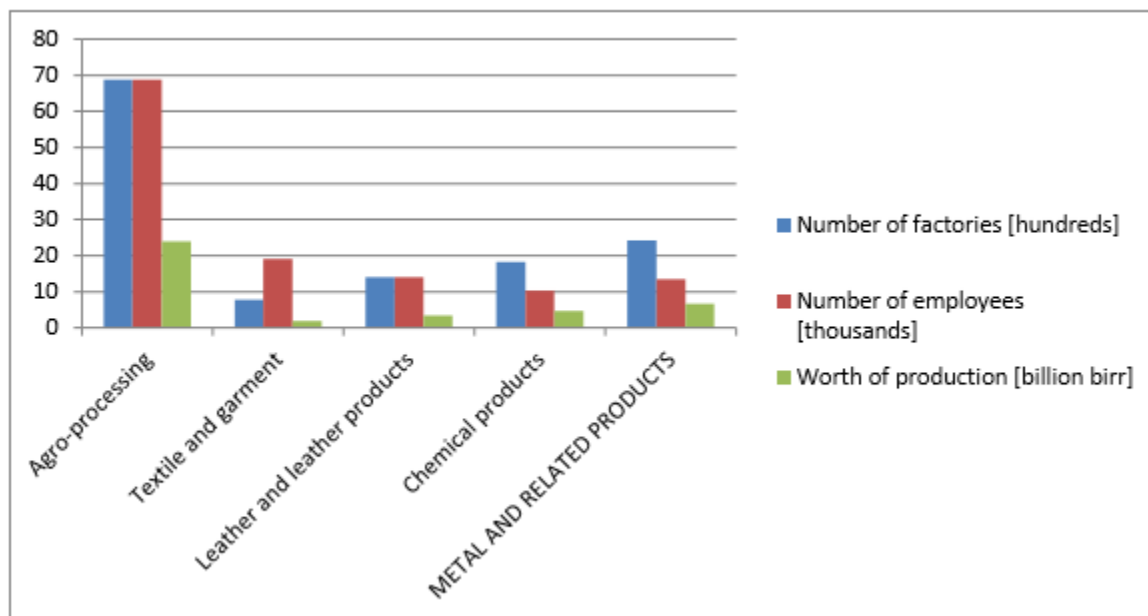


Figure 4.1: Metal industries Vs. the Ethiopian manufacturing industries status (MIDI 2015)

From the above figure the sector has the second-highest worth of production among the manufacturing sectors however, the number of industries is far fewer than the agro-processing and the upstream behavior of the sector and the second-lowest based on employment opportunity which shows that, even though it is increasing in the recent years, it still needs to work on that area.

Table 4.2 Major Ethiopian Metal industries products, production capacity, and utilization

No	Company Name	Installed Capacity (Tons)	Working Capacity (Tons)	Capacity Utilization (%)	Types of Products
1	Negate mechanical engineering sch.co	1788	677.5	38	Hand tool products like a shovel, Pick axe ,sickle and hammers
2	Ethiopian crown & can factory	6607.2	3833	55.5	Corks, can
3	Akaki metal	40,000	21,000	50	Galvanized iron sheet, Water

	products				pipe, and Steel structure
4	Adam steel	26.8	25.8	90	Galvanized and pre painted sheets and Nail 3mm-15mm
5	AMCE Automotive manufacturing	120	80	66.6	Trailer assemble, Cargo body and trailer and body manufacturing
6	Dan Lift Technology	782.5	216.03	27.6	Passenger lift 4p/320k.g,6p/480k.g,8p/640k.g,10p/800k.g
7	Ethiopian spring Profile	720	434.4	60.34	Different types of leaf springs
8	Walia Steel Industry	201,500	38,600	19.1	Hallow section, rebar, and sheet metal
9	East Steel	300,000	180,000	60	Reinforcement bars
10	Yesu Manufacturing	200,000	140,101	70	Rebar and galvanized sheet metal

Source: MIDI industries profile

Table 4.2 shows the maximum production capacity utilization among the metal industries (90%) and the minimum production capacity utilization (19.1%). As can be seen from the table, steel manufacturing plants have relatively higher capacity utilization rates whereas engineering and basic metal industries have the lowest capacity utilization rate.

4.2 SWOT Analysis of The case company NMESC.

SWOT (strengths, weaknesses, opportunities, and threats) analysis has been made for NMESC to identify which of these areas are dominating the status of the factory. The analysis so made is presented below. (NMESC Business plan 2016)

Table 4.3. SWOT Analysis of Negate Mechanical Engineering sch.co.

<p>Strength</p> <ul style="list-style-type: none"> • Skilled manpower in forging and related areas of production • The machines are flexible and there is a capacity to produce new products; • The products of the factory are well known all over the country 	<p>Weakness</p> <ul style="list-style-type: none"> • Low labour productivity; • Low financial capacity; • Low level of competitiveness in product quality and pricing; • Lack of sufficient capacity to respond to customer requests.
<p>Opportunities</p> <ul style="list-style-type: none"> • There is large local demand for sickles and NMESC is the only local producer; • Increase of construction works • Increase in irrigation schemes; • Availability of local manufacturers of some raw materials 	<p>Threats</p> <ul style="list-style-type: none"> • Increase steel price on the international market • There is import of low priced (and in some cases sub-standard) goods. • Commitment to continuous change.

4.3 Overview of Case Company NMESC

Negate Mechanical Engineering Sch.co. (KMTF) the former Ethiopian metal Tools Factory (EMTF) was established by Polish and Ethiopian owners as a private limited company in 1969 and is engaged in the manufacturing of various types of hand tools. The plant was nationalized in 1975G.C, by the military government and put under the ex-national metal works corporation (NMWC). The NMWC was dissolved in the current Ethiopian government. The supervision of the KMTF was hence finally given to the privatization and public enterprises supervising agency until it was sold and handed over to negate Mechanical Engineering S.C. as of March 1, 2006, G.C.

Negate mechanical engineering sch.co.is found in Addis Ababa city and is engaged in the manufacturing of various hand tools commonly used for agricultural & construction applications. Some of the products of the company are a shovel, pick axe, sickle, and a different size of Hammer which are manufactured using the open die and closed die forging technology. The major customers of the company are farmer association, government offices & non-government organization. The raw material inputs to the company are mainly imported from countries like China, India, and local steel melting and rolling plants. (KMTF Business plan 2016).

4.4 Forging Process

Forging denotes a family of bulk metal forming process by which plastic deformation of the work piece is carried out by the compressive forces applied by drop hammers, hydraulic mechanical friction press, and roll forging (Witt, 2011). Forging is one of mankind's oldest technologies but still preferred today in certain products especially automobile parts, because of the grain flow that results in giving good strength and toughness to the product.

The forging process can be put under the following classification (Mahendra, 2014).

1. Classification based on Temperature of the work piece

- a) Hot forging: Forging is carried out above the re-crystallization temperature of the metal. Recrystallization temperature is defined as the temperature at which new grains are formed in the metal.
- b) Cold forging: Forging is carried out at or room temperature (below a recrystallization temperature of the metal). Commonly applied to soft metal types.
- c) Warm forging: The forging temperature of the steels runs between room temperature and below the re-crystallization temperature of the metal.

2. Classification based on arrangements of dies

- a) Open die forging: Forging in which the flat dies of simple shape is used to allow material to flow in the lateral direction of the applied load. This forging type has less dimensional accuracy and is most suited for a simple shape that mainly depends on the skill of the operator.

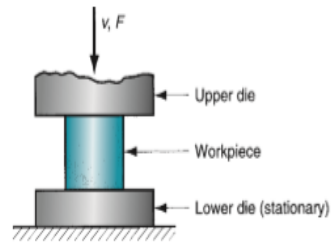


Fig 4.2 Open dies Forging

- b) Closed die forging: Forging in which the material is fully contained in cavities of the upper and lower die.

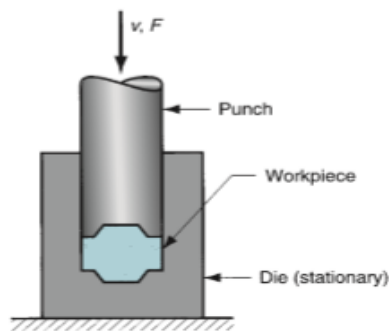


Fig 4.3 Closed die Forging

- c) Impressions die Forging: Forging in which the material is allowed to fill the cavity created by the upper and lower half of the dies. The dies are not fully closed and allow some material to escape as a flash.

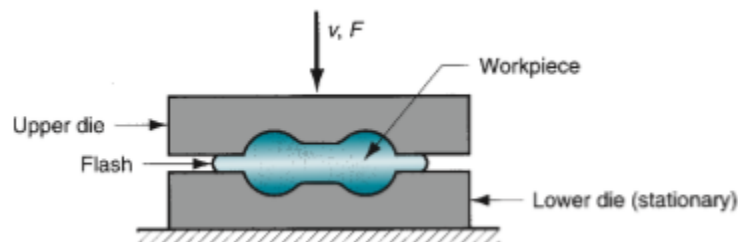


Fig 4.4 Impression dies forging

- d) Extrusion: Forging in which a punch is forced into a piece of hot steel to form a cavity.

4.5 Selected Hand tool production process at NMESC.

NMESC has identified and currently manufactures 9 strategy products in their hot forging factory and one product sickle in a sickle factory. Out of the selected strategy products two of the majority of the share, pick axe and shovel. Hence Pick axe, shovel, and sickle production process are further analyzed and improved in this research.

4.5.1 Pick axe Production process:

Pick axe production is conducted in the hot forging section of the company whereby rectangular billets of size (70x30) mm are cut to attain a mass of 2.5 K.G each. A group of these cut pieces is loaded into an oil furnace with a capacity to load 50-60 pcs. Commonly a batch of 50 pieces at a different stage of processing is loaded into the oil furnace and heated to attain the temperature in the range of 1100^oc to 1250^oc. Each piece is then taken out from the furnace one by one and is loaded into the crank press extrusion machine that punches the first hole, final hole, and flashes trimming successively in the three separate dies loaded on the machine. These extruded pieces are collected in a cage so that they cool down due to the hole extrusion step is trimmed. These pieces are sent once more to the oil furnace for heating and after heating sent to the hot forming machine that is a pneumatic assisted hydraulic hammer with the last stroke to form the flat part and pointed part of the pick axe by successive hammering. After the hot forming step, bending, tip trimming, and hole correction step are performed successively whereby each piece one piece at a time is hand transported between processes but are now passed without stopping for additional heating. After correcting the hole, heat-treating the pieces on the heat treatment furnace and they can pass to the grinding step to be done at both ends of a pick axe. The final step is dipping in paint, drying, and taken to the store. The process flow of pick axe production is given in the following flow chart.

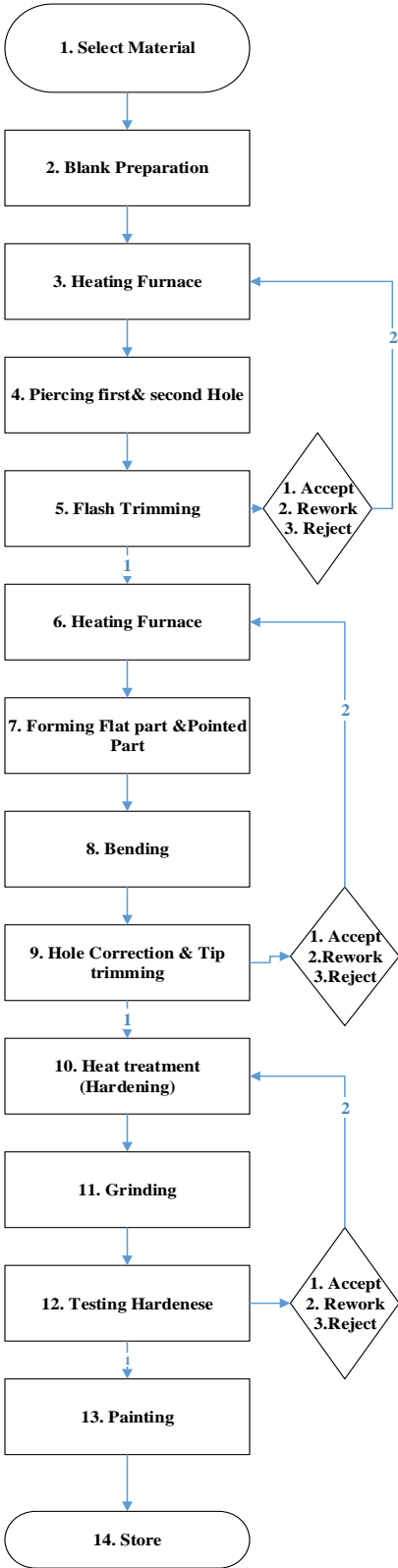


Fig 4.5 Process flow of Pick axe production (Own source)

4.5.2 Shovel Production Process

Shovel production is conducted in the hot forging section of the company whereby flat-rolled sheet thickness 1.1mm is cut. A group of these cut pieces is blank with a screw press machine. Commonly 450-500 piece blank per day. Each piece is loaded into another crank press machine that punches three holes of the shovel on the piercing punch and dies. Commonly 50 Pieces at different stages of processing are loaded into the oil furnace and heated to the shovel. Each piece is then taken out from the furnace one by one and is loaded into a screw press machine that forms the cavity of the shovel by forming punch and die. These formed pieces are collected in a cage and cool down by air. After forming, curling the handle part and rambling the shovel to clean the dust part of the shovel. The final step is dipping in paint in a batch 50-60 pieces at a time, drying, and taken to the store.

The process flow of shovel production is given in the following flow chart.

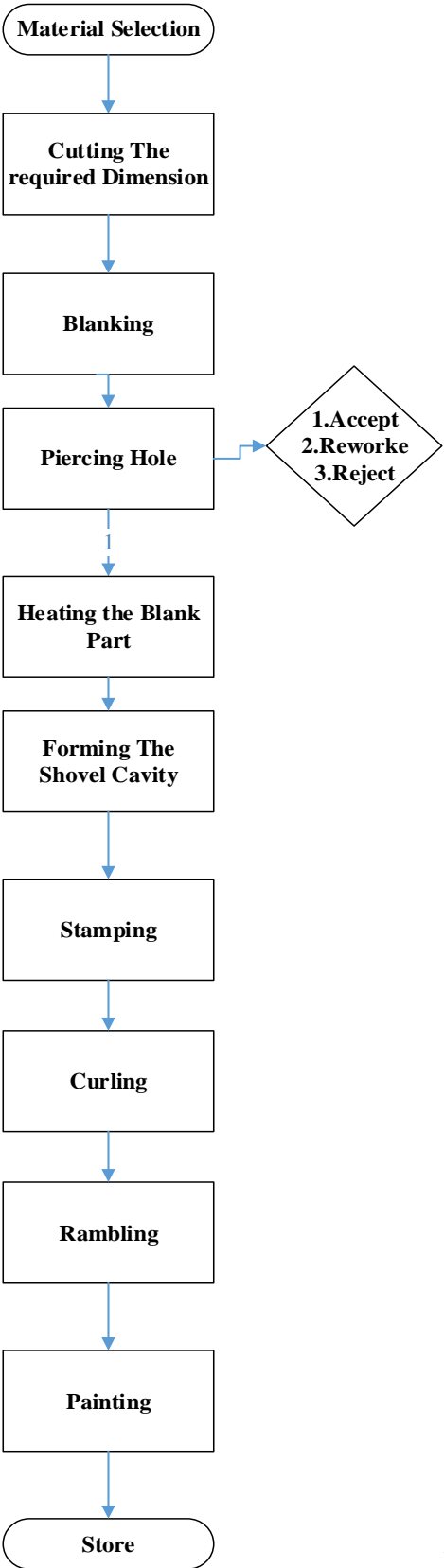


Fig 4.6 Process flow of Shovel production (Own source)

4.5.3. Sickle production process

Sickle production is conducted in the sickle factory of the company. Where by flat strip thickness 1.2mm is cut. A group of these cut pieces is edge cutting by screw press machine .commonly 450-500 piece cut per day. Each piece is then loaded to another press machine that forms the teeth of the sickle on the notching die. These formed pieces are bending by the screw press machine on the bending punch and die to form the shape of the sickle. After bending checking the flatness of sickle on the flat plate, treated the teeth part of the sickle on the induction furnace. The final step is grinding the teeth part of the sickle , dipping into the oil in a batch 50-60 pieces at a time, inserting the wooden handle on the sickle , packing 20 pieces on the cardboard, and take to the store.

The process flow of sickle production is given in the following flow chart.

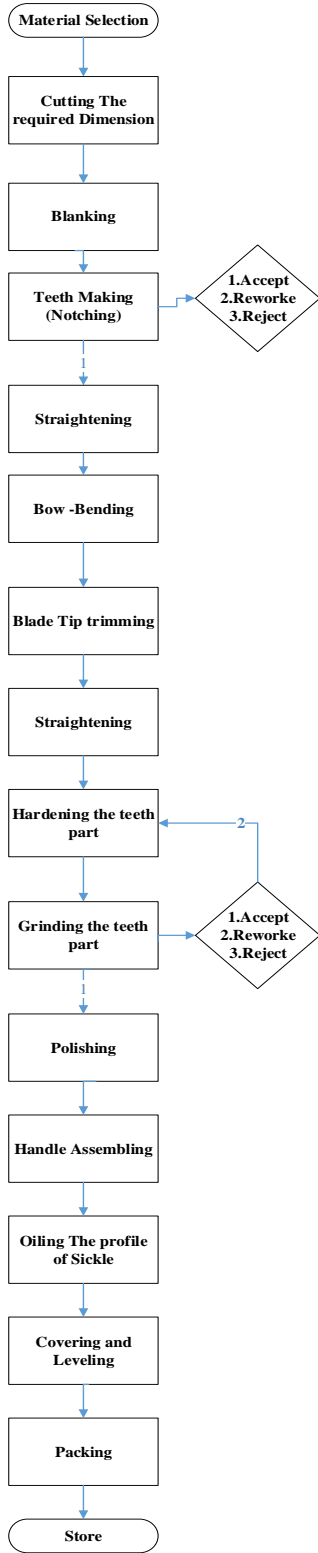


Fig 4.7 Process flow of sickle Production (Own Source)

5. Chapter Five - Data Analysis and Interpretation

5.1 Introduction

This chapter discusses and shows the empirical data collected from the observation, interview, and questionnaire survey. It's analyzed by Microsoft Excel and SPSS data processing results.

5.1.1 Introduction to Quantitative Data Analysis

The quantitative data were obtained from the case company statistical during the survey time.

The Existing Production of the case Company

The current production of Negate mechanical Engineering sch.co is determined by different data collection systems like questioner, observations, and interviews.

Table 5.1 Existing Production /day/pcs (NMESC 2019/20 Annual Report)

S/N	Type of Product	Quantity/day
1	Pick axe	91
2	Shovel	232
3	Sickle	496

Selection of Key Performance Indicators

Different researchers suggested that companies must keep these metrics very simple and that a reasonable number will about 5-6 metrics.

Table 5.2 Key performance indicators

Perspective	Code	Description
	W1	Overproduction
	W2	Transportation
	W3	Inappropriate processing

Waste	W4	Unnecessary Inventory
	W5	Un necessary motion
	W6	Waiting
	W7	Defect
Customer requirement	CRM1	On-time delivery
	CRM2	Price
	CRM3	Durability
	CRM4	Design
	CRM5	Aesthetics
Continuous Improvement	CI1	Kaizen
	CI2	Lean
	CI3	BPR
	CI4	Training
	CI5	TQM
Idle Time	IT1	Material shortage
	IT2	Power failure
	IT3	Machine set-up
	IT4	Machine failure
	IT5	Material searching
Productivity Improvement Problem	PI1	Input problem
	PI2	Capital Problem
	PI3	Machinery & Equipment problem
	PI4	Planning & Management problem
	PI5	Process Problem
	PI6	Skill & Labor problem

5.1.1 Questioner survey result

A. Customer requirement of NMESC

5= Very strong 4= Strong 3= Moderate 2= Modest 1= Weak

Table 5.3 Respondent result in percentage

No	Questioners	1	2	3	4	5
CRM1	On time delivery	20	20	16.7	28.3	15
CRM2	Price	15	20	23.3	26.7	15
CRM3	Durability	16.7	20	23.3	25	15
CRM4	Design	18.3	20	23.3	23.3	15
CRM5	Aesthetics	11.7	23.3	26.7	21.7	16.7

Table 5.3 show the analysis of the customer requirement results from the high result shows the on-time delivery the first one (28.3%), Price (26.7%), and the third one durability (25%).

B. The Questions about waste happens in the production section of NMESC.

5= Very strong 4= Strong 3= Moderate 2= Modest 1= Weak

Table 5.4 Respondent result in percentage

No	Questioners	1	2	3	4	5
W1	Over production	21.7	26.7	16.7	23.3	11.7
W2	Transportation	28.3	20	16.7	23.3	11.7
W3	Inappropriate processing	6.7	30	16.7	35	11.7
W4	Unnecessary Inventory	21.7	26.7	16.7	23.3	11.7
W5	Unnecessary Motion	28.3	20	11.7	23.3	16.7
W6	Waiting	10	26.7	16.7	35	11.7
W7	Defect	6.7	30	11.7	35	16.7

High waste happens on the companies because of Defect, Waiting, inappropriate processing, and unnecessary motion.

C. The Questions about idle time on the production section of NMESC

5= Very strong 4= Strong 3= Moderate 2= Modest 1= Weak

Table 5.5 Respondent result in percentage

No	Questioners	1	2	3	4	5
IT1	Material shortage	21.7	21.7	15	28.3	11.7
IT2	Power failure	16.7	23.3	15	33.3	11.7
IT3	Machine set up	21.7	21.7	15	28.3	13.3
IT4	Machine failure	10	20	15	33.3	21.7
IT5	Material searching	20	23.3	20	25	11.7

Table 5.5 show most of the company idle time happens because of machine failure, Power failure, and material shortage.

D. The Questions about Productivity Improvement Problem the production section of NMESC

5= strongly agree 4= Agree 3= Neutral 2= Disagree 1= Strongly Disagree

Table 5.6 Respondent result in percentage

No	Questioners	1	2	3	4	5
PI1	Input	15	23.3	20	21.7	20
PI2	Capital	13.3	18.3	20	25	23.3
PI3	Machinery & Equipment	16.7	23.3	20	21.7	18.3
PI4	Planning & Management	13.3	11.7	18.3	23.3	33.3
PI5	Production Process	10	13.3	16.7	20	40
PI6	Skill and Labor	13.3	20	21.7	25	20

Table 5.6 shows most of the company Productivity Improvement problem comes from the production process, Planning & Management problem.

E. The questions about continuous improvement

5= Very strong 4= Strong 3= Moderate 2= Modest 1= Weak

Table 5.7 Respondent result in percentage

No	Questioners	1	2	3	4	5
CI1	Kaizen	21.7	20	10	25	23.3
CI2	Lean	20	21.7	10	23.3	25
CI3	BPR	20	16.7	16.7	26.7	20
CI4	Training	21.7	15	18.3	28.3	16.7
CI5	TQM	21.7	20	16.7	26.7	15

Table 5.7 show lean has the highest factor in the continuous improvement of the production section.

5.2 Descriptive Analysis

Table 5.8 tabulates the mean and standard deviation of waste. The defect has the highest mean score 3.25 and followed by a mean score of 3.15 for Inappropriate processing waste as the second-highest mean and sequenced by Waiting waste, unnecessary motion, unnecessary inventory, overproduction waste, and transportation waste.

Table 5.8 Waste- Mean and standard deviation

Statistics							
	Over production waste	Transportation waste	Defect	Waiting	Unnecessary motion waste	Inventory waste	Inappropriate Processing
Valid	60	60	60	60	60	60	60
Missing	0	0	0	0	0	0	0
Mean	2.77	2.70	3.25	3.12	2.80	2.77	3.15
Std. Deviation	1.345	1.406	1.244	1.223	1.493	1.345	1.176
Minimum	1	1	1	1	1	1	1
Maximum	5	5	5	5	5	5	5

Table 5.8 tabulates the mean and standard deviation of the continuous improvement tool. Lean has the highest mean score of 3.12 and BPR 3.1 as the second-highest mean and sequenced by kaizen, training, and total quality management.

Table 5.9 Continuous improvement tool: mean & standard deviation

Statistics					
	kaizen	Lean	BPR	Training	TQM
N Valid	60	60	60	60	60
N Missing	0	0	0	0	0
Mean	3.08	3.12	3.10	3.03	2.93
Std. Deviation	1.510	1.508	1.434	1.414	1.401
Minimum	1	1	1	1	1
Maximum	5	5	5	5	5

The mean score below 3.39 was considered as low, the mean score from 3.40 up to 3.79 was considered as moderate, and a mean score above 3.8 was considered as high as illustrated by Comparison bases of the mean score of five-point Liker scale instrument (Bagheri, 2014).

5.3 Correlation Analysis

Correlation is a bivariate analysis that measures the strength of the association between two variables. The strength of the relationship, the value of the correlation coefficient varies between +1 and -1. + indicates a perfect degree of association between two variables, if its 0 the relationship is weaker - sign shows a negative relationship. In the SPSS data entry module the analysis is shown as Pearson Correlation (r) and significance (p) value of the two variables therefore, it will be vital to remind the properties and interpretation of r value (or Pearson Correlation).

- Pearson correlation (r) is between -1 and +1. That indicates the extent to which two variables are linearly related.

- If $r=1$ Perfectly positive correlation
- If $r=-1$ Negative correlation
- Correlation never higher than 1 & never lower than -1.
- $r<0.1$ weak, $r<0.3$ modest, $r<0.5$ Moderate $r<0.8$ strong and $r\geq 0.8$ Very strong.

Table 5.10 Production waste variable analysis

		Over production waste	Transportation waste	Defect	Waiting	Unnecessary motion waste	Inventory waste	Inappropriate Processing
Over production waste	Pearson Correlation	1	.760**	.775**	.769**	.795**	.644**	.537**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N	60	60	60	60	60	60	60
Transportation waste	Pearson Correlation	.760**	1	.703**	.681**	.689**	.626**	.407**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.001
	N	60	60	60	60	60	60	60
Defect	Pearson Correlation	.775**	.703**	1	.727**	.757**	.725**	.634**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
	N	60	60	60	60	60	60	60
Waiting	Pearson Correlation	.769**	.681**	.727**	1	.858**	.615**	.565**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
	N	60	60	60	60	60	60	60
Unnecessary motion waste	Pearson Correlation	.795**	.689**	.757**	.858**	1	.635**	.548**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
	N	60	60	60	60	60	60	60
Inventory waste	Pearson Correlation	.644**	.626**	.725**	.615**	.635**	1	.526**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
	N	60	60	60	60	60	60	60
Inappropriate Processing	Pearson Correlation	.537**	.407**	.634**	.565**	.548**	.526**	1
	Sig. (2-tailed)	.000	.001	.000	.000	.000	.000	
	N	60	60	60	60	60	60	60

** Correlation is significant at the 0.01 level (2-tailed)

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Highest Pearson correlation (r), waiting Vs. The unnecessary motion of their value is **0.858** it means a very strong relationship, waste in the production section comes from

waiting time. Defect Vs. The overproduction waste their value is **0.775** it means a strong relationship, waste comes from defect.

Table 5.11 Idle time variable analysis



		Correlations				
		Idle Time in Power failure	Idle Time in Material shortage	Idle Time in machine set up	Idle Time in machine failure	Idle Time in material searching
Idle Time in Power failure	Pearson Correlation	1	.707**	.484**	.485**	.564**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
Idle Time in Material shortage	Pearson Correlation	.707**	1	.647**	.490**	.730**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
Idle Time in machine set up	Pearson Correlation	.484**	.647**	1	.641**	.582**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
Idle Time in machine failure	Pearson Correlation	.485**	.490**	.641**	1	.455**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Idle Time in material searching	Pearson Correlation	.564**	.730**	.582**	.455**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

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Pearson Correlation of a variable of idle time on Material shortage Vs. Material searching their value is **0.730** which shows a strong relationship, it means idle time may come due to material Shortage. The highest Pearson correlation in customer Perspective is idle time happens by a Material shortage.

Table 5.12 Customer requirement variable analysis



		Correlations				
		Customer requirement on time delivery	Customer requirement on Price	Customer requirement on Durability	Customer requirement On Design	Customer Requirement on Aesthetics
Customer Requirement on time delivery	Pearson Correlation	1	.434*	.510*	.603*	.301*
	Sig. (2-tailed)		.001	.000	.000	.020
	N	60	60	60	60	60
Customer requirement on Price	Pearson Correlation	.434*	1	.256*	.634*	.511*
	Sig. (2-tailed)	.001		.048	.000	.000
	N	60	60	60	60	60
Customer requirement on Durability	Pearson Correlation	.510*	.256*	1	.584*	.182
	Sig. (2-tailed)	.000	.048		.000	.165
	N	60	60	60	60	60
Customer Requirement On Design	Pearson Correlation	.603*	.634*	.584*	1	.631*
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Customer Requirement on Aesthetics	Pearson Correlation	.301*	.511*	.182	.631*	1
	Sig. (2-tailed)	.020	.000	.165	.000	
	N	60	60	60	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).



When we see the above relationship of each variable in customer requirement they have a strong relationship with a significance level of 0.05 and the causal Pearson Correlation of a variable of customer requirement on Price vs. Design their value is **0.634** and Customer requirement on-time delivery Vs. Design their value is **0.603** which shows a strong relationship it means customer satisfaction may come due to on-time delivery and price.

Table 5.13 Productivity improvement variable analysis

		Input problem on productivity Improvement	Capital problem on Productivity Improvement	Machinery & Equipment problem on Productivity Improvement	Planning & Management problem on productivity Improvement	process problem on Productivity Improvement	skill Labor problem on Productivity Improvement	Technology & Innovation problem on Productivity Improvement
Input problem on productivity Improvement	Pearson Correlation	1	.533**	.433**	.355**	.336**	.548**	.533**
	Sig. (2-tailed)		.000	.001	.005	.009	.000	.000
	N	60	60	60	60	60	60	60
Capital problem on Productivity Improvement	Pearson Correlation	.533**	1	.387**	.801**	.738**	.299*	1.000**
	Sig. (2-tailed)	.000		.002	.000	.000	.020	.000
	N	60	60	60	60	60	60	60
Machinery & Equipment problem on Productivity Improvement	Pearson Correlation	.433**	.387**	1	.347**	.369**	.415**	.387**
	Sig. (2-tailed)	.001	.002		.007	.004	.001	.002
	N	60	60	60	60	60	60	60
Planning & Management problem on productivity Improvement	Pearson Correlation	.355**	.801**	.347**	1	.941**	.138	.801**
	Sig. (2-tailed)	.005	.000	.007		.000	.292	.000
	N	60	60	60	60	60	60	60
process problem on Productivity Improvement	Pearson Correlation	.336**	.738**	.369**	.941**	1	.162	.738**
	Sig. (2-tailed)	.009	.000	.004	.000		.216	.000
	N	60	60	60	60	60	60	60
skill Labor problem on Productivity Improvement	Pearson Correlation	.548**	.299*	.415**	.138	.162	1	.299*
	Sig. (2-tailed)	.000	.020	.001	.292	.216		.020
	N	60	60	60	60	60	60	60
Technology & Innovation problem on Productivity Improvement	Pearson Correlation	.533**	1.000**	.387**	.801**	.738**	.299*	1
	Sig. (2-tailed)	.000	.000	.002	.000	.000	.020	
	N	60	60	60	60	60	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

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When we see the above relationship of each variable in the Productivity improvement problem they have a very strong relationship with a significance level of 0.05 and the causal Pearson Correlation of a variable of Planning & Management problem VS Process problem their value is **0.941** and the Technology problem Vs. Planning & Management problem their value is **0.801**, which shows a very strong relationship it means Planning and management problem is a big factor on productivity problem on the case company.

Table 5.14 Continuous improvement variable analysis

		Correlations				
		kaizen	Lean	BPR	Training	TQM
kaizen	Pearson Correlation	1	.628**	.489**	.324*	.379**
	Sig. (2-tailed)		.000	.000	.012	.003
	N	60	60	60	60	60
Lean	Pearson Correlation	.628**	1	.496**	.268*	.429**
	Sig. (2-tailed)	.000		.000	.038	.001
	N	60	60	60	60	60
BPR	Pearson Correlation	.489**	.496**	1	.374**	.366**
	Sig. (2-tailed)	.000	.000		.003	.004
	N	60	60	60	60	60
Training	Pearson Correlation	.324*	.268*	.374**	1	.386**
	Sig. (2-tailed)	.012	.038	.003		.002
	N	60	60	60	60	60
TQM	Pearson Correlation	.379**	.429**	.366**	.386**	1
	Sig. (2-tailed)	.003	.001	.004	.002	
	N	60	60	60	60	60

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

On this relationship of each variable, they have a strong relationship with a significance level of 0.05 and the causal Pearson Correlation of variable continuous improvement **on lean Vs. Kaizen** their value is 0.628.

5.4 Introduction to Quantitative data analysis

The data obtained from observation, interview of the employee and manager to the factors that affect productivity.

5.4.1 Interview Questions Responses

The interview questions were prepared for the company Production Manager, Section Head, Production Engineer, and Forman based on lean, waste, and other factors focused on productivity and waste minimization. The response is different according to them

work sections more discussed with the Forging Section sickle factory Head and Forman on the production section.

A. Analysis of current state value stream mapping of pick axe

The value stream mapping of pick axe shows set up time, cycle time, inventory between each process step, and production lead time. Pick axe production flow, the most type of wastes are un-necessary inventory, waiting, Inappropriate processing, defect, and unnecessary motion. This waste cause large production lead time, the production lead time affects the production of pick axe.

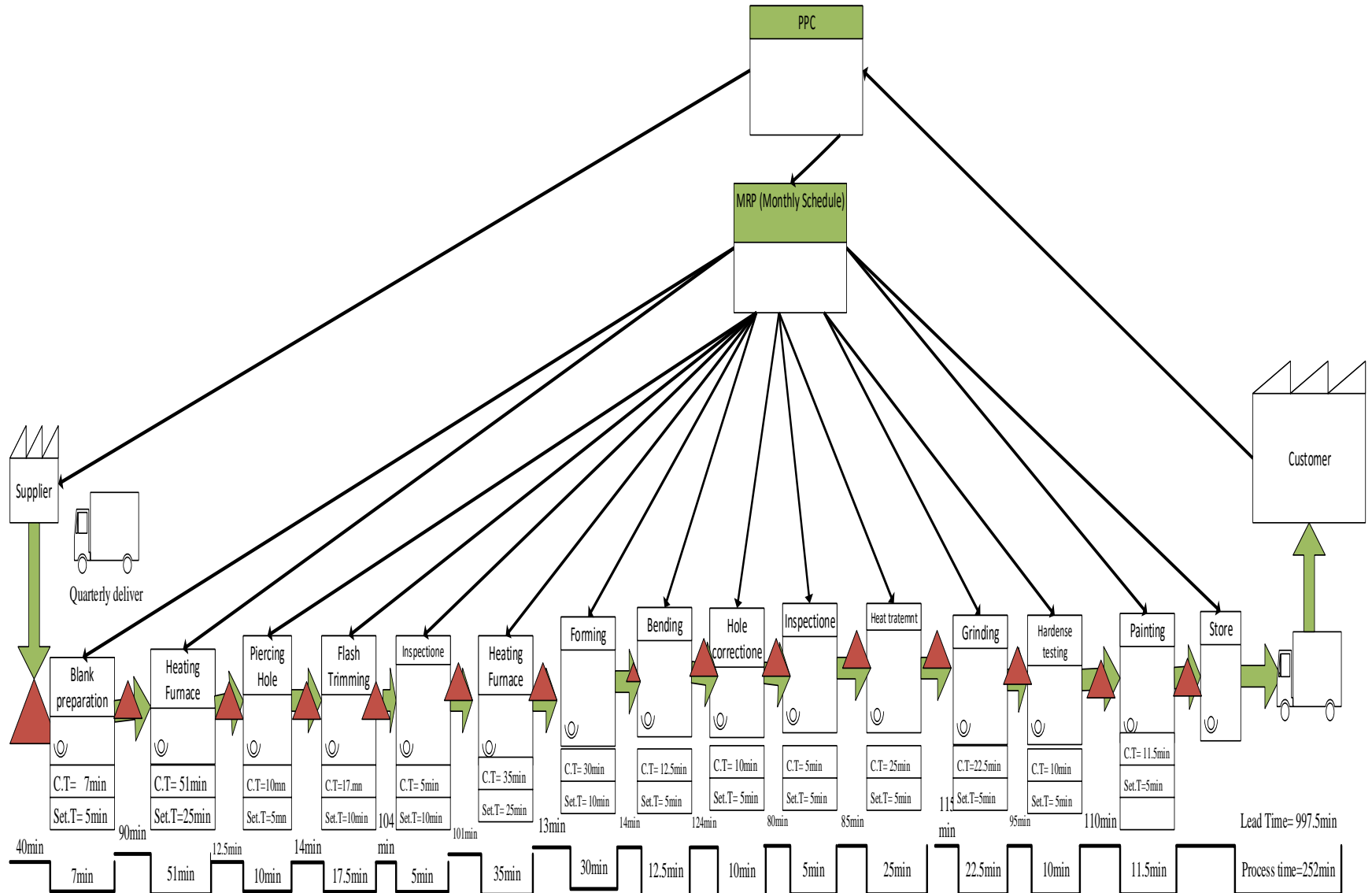


Fig 5.1 VSM OF PICK AXE

Table 5.15 Pick axe waste

Type of deadly waste	Current state map Observation	Lead time
Inappropriate processing	<ul style="list-style-type: none"> ➤ Repeated heating and cooling process ➤ Poor flow of production 	➤ 218 Minute
Un-necessary inventory	<ul style="list-style-type: none"> ➤ Waiting for the heating furnace ➤ Before and after the grinding operation 	➤ 554Minute
Defect	<ul style="list-style-type: none"> ➤ Piercing first & Second hole ➤ Flash trimming ➤ Hole correction and Tip trimming process 	➤ 39.5Minute
Waiting	<ul style="list-style-type: none"> ➤ Pieces being produced waiting for the next process to finish due to miss-match cycle time 	➤ 101Minute
unnecessary motion	<ul style="list-style-type: none"> ➤ Long-distance moved to the grinding department ➤ Long-distance moved to the painting department 	➤ 85Minute

Average batch size of pick axe 50pcs/batch

Root Cause analysis of pick axe

A fishbone diagram is a visual way to look at the cause and effect. The problem or effect is displayed at the head of the fish. Possible contributing causes are listed on the smaller “bones “under various cause categories. A fishbone diagram can help identify a possible cause for a problem that might not otherwise be considered by directing the brainstorming –team to look at the categories and think of the alternative cause. The fishbone diagram is prepared to carefully investigate the cause that leads to the problem of low production of pick axe.

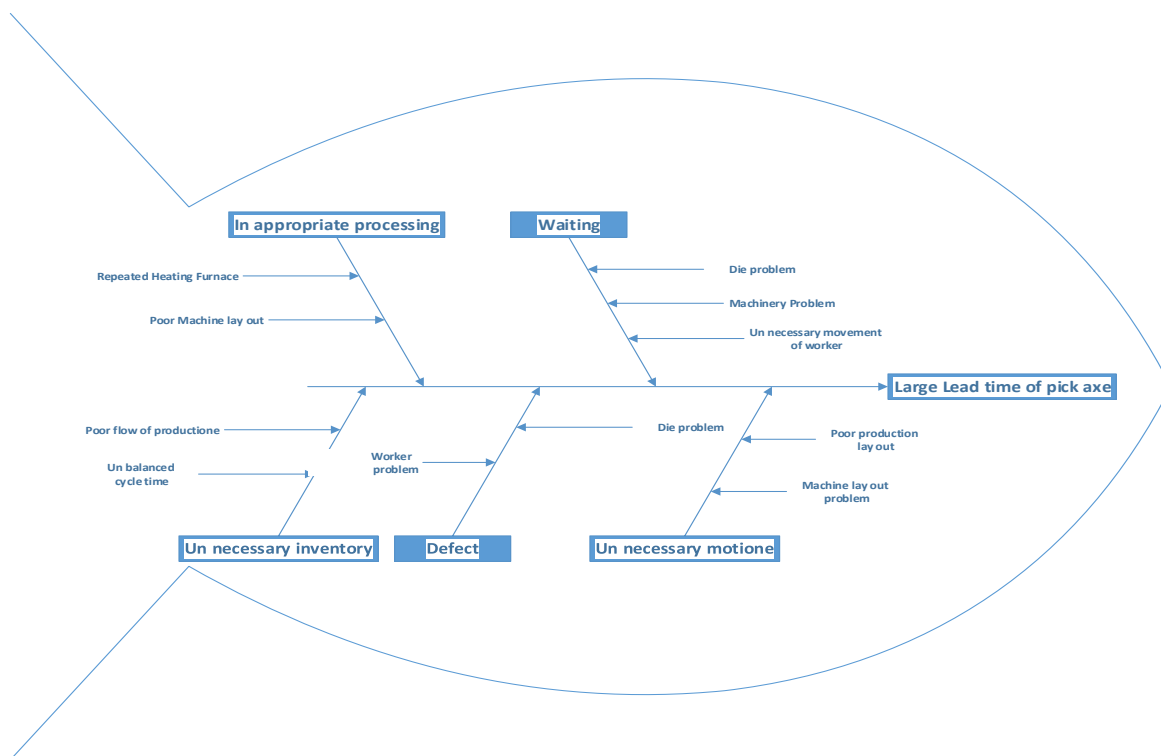


Fig 5.2 Cause and effect diagram of Pick axe production line

Table 5.16 Analysis summary table for pick axe production

Total Lead time	997.5 Minute
Takt time	2.16 Min/pcs
Process efficiency	25.6%
Bottleneck	Heating furnace and Crank press for making the hole
Identified waste	Waiting, unnecessary inventory, defect, inappropriate processing, and unnecessary motion.
A selected lean tool to apply	Value stream mapping, Kanab, and line balancing

A. Analysis of current state value stream mapping of Shovel

The value stream mapping of the shovel show set up time, cycle time, inventory between each process step, and production lead time. The most type of waste of shovel production is waiting, unnecessary inventory, Overproduction, and transportation.

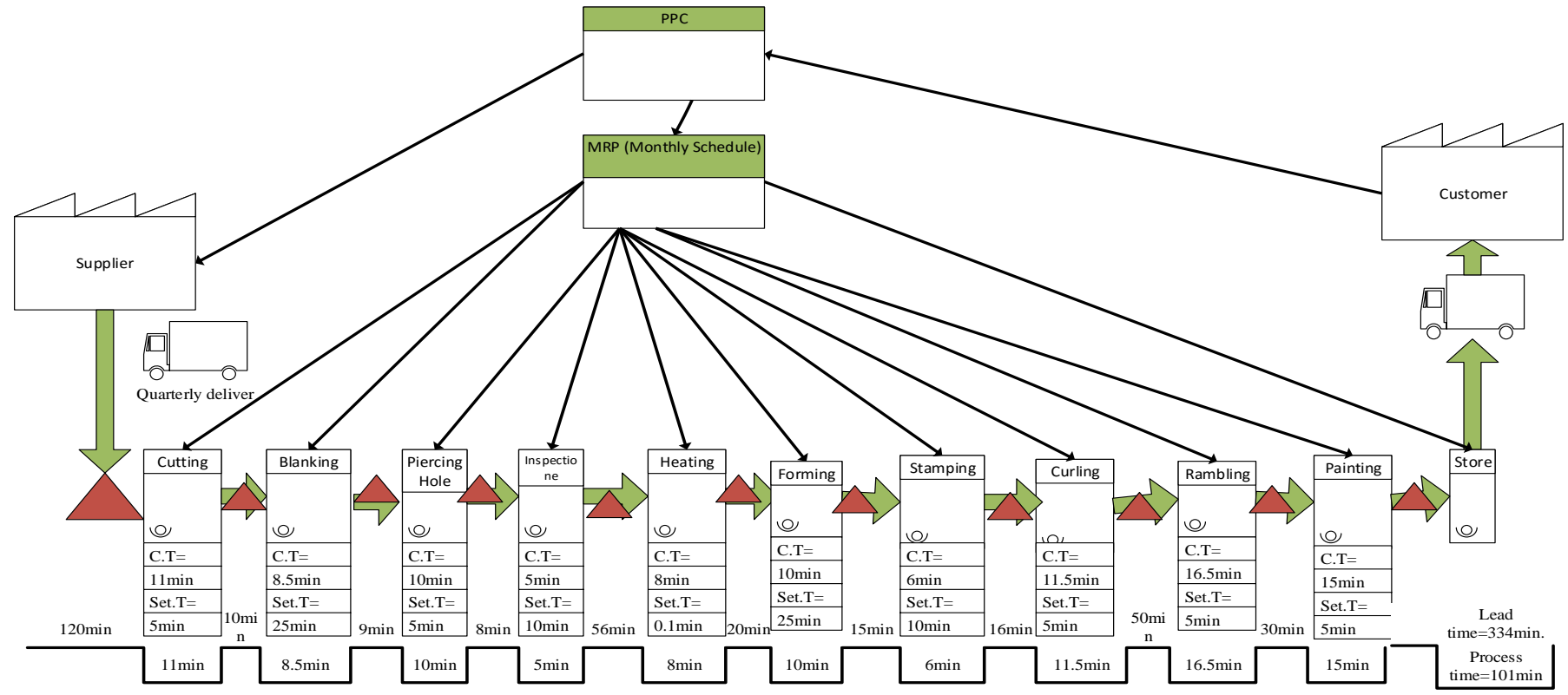


Fig 5.3 VSM OF SHOVEL

Table 5.17 Shovel products waste.

Type of waste	Current state map Observation	Lead Time
Waiting	<ul style="list-style-type: none"> ➤ One process waiting for the next process to finish due to miss-match between cycle time ➤ Waiting for painting 	➤ 56min
Un necessary Inventory	<ul style="list-style-type: none"> ➤ Movement in a process step is in batch of an average 50 pcs, waiting to start the next process. ➤ More WIP in the production floor. 	➤ 242min
Over transportation	<ul style="list-style-type: none"> ➤ Long distance moved from curling process to rambling process ➤ Long distance moved from rambling to painting process 	➤ 20min
Over production	<ul style="list-style-type: none"> ➤ Over production for cutting operation ➤ Overproduction for blanking operation. 	➤ 16min

The process of Shovel production is currently operating in the “Push” system which should be corrected towards a pull system whereby the customer pulls the products from the producer as dictated by lean.

Root cause analysis of shovel

The fishbone diagram is prepared for the shovel production to carefully investigate the cause that leads to the problem of the low production of a shovel.

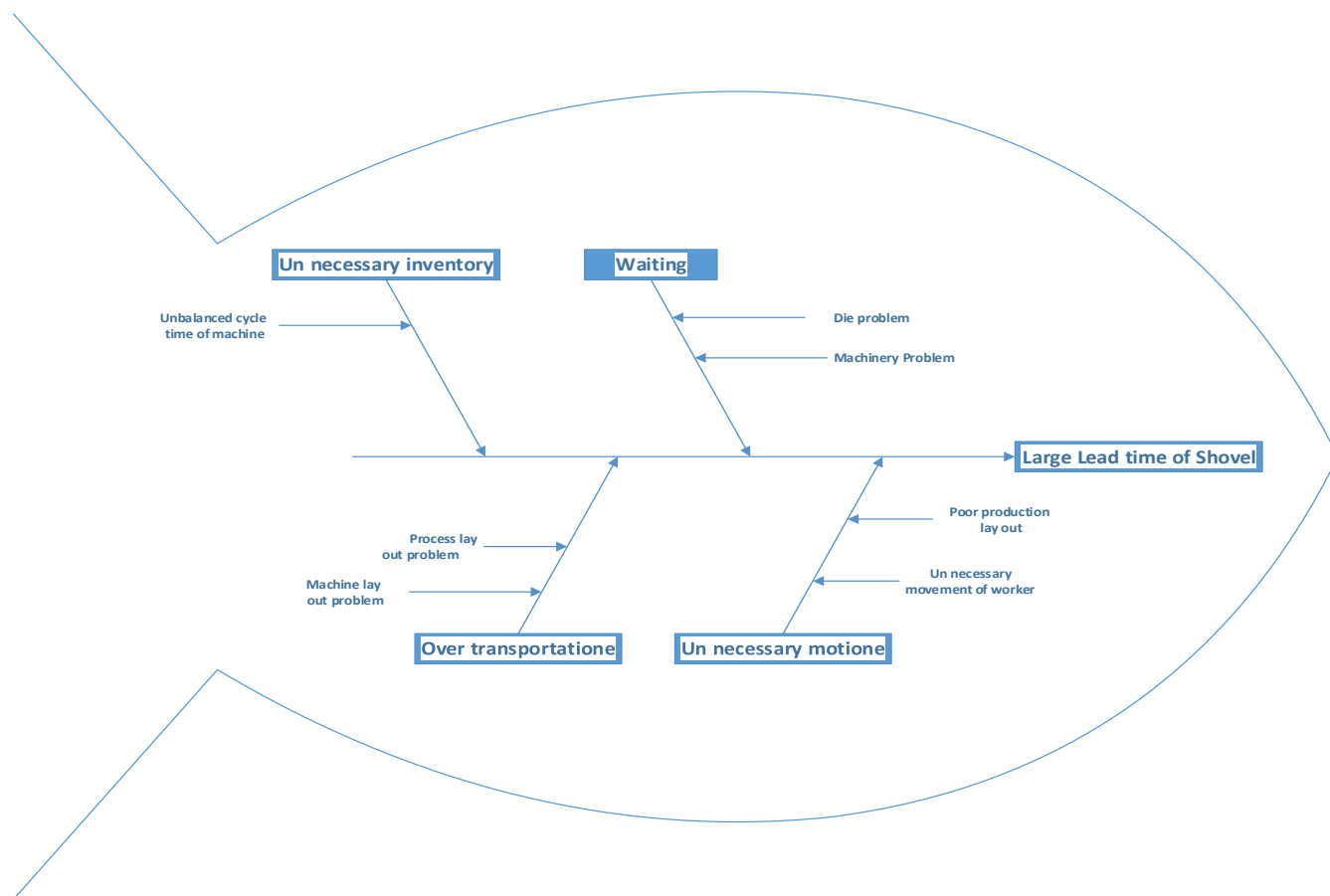


Fig 5.4 Cause and effect diagram of the Shovel production line

Table 5.18 Analysis summary table for Shovel production

Total Lead time	334 Minute
Tact time	0.84 Min/pcs
Process efficiency	22.7%
Bottleneck	Rambling Operation
Identified waste	Waiting, unnecessary inventory, Over transportation & production
A selected lean tool to apply	Cellular manufacturing and Kanab

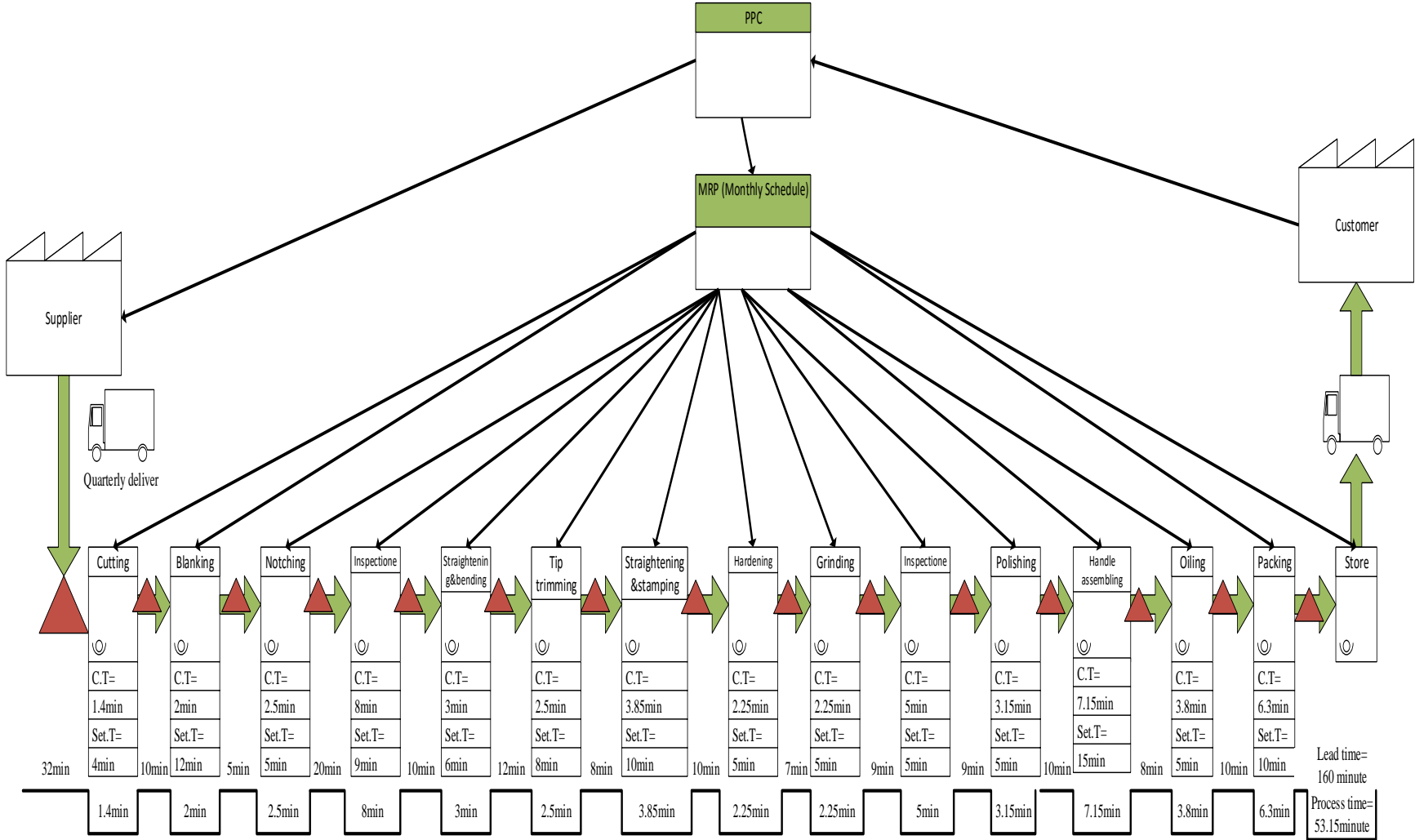


FIG 5.5 VSM OF Sickle

C. Analysis of current state value stream mapping of Sickle

The value stream mapping of sickle show set up time, cycle time, inventory between each process step, and production lead time. The Most type of waste sickle production is a defect, waiting, unnecessary Inventory, unnecessary motion, and transportation.

Table 5.19 Sickle waste

Type of waste	Observed process	Lead Time
Waiting	<ul style="list-style-type: none"> ➤ One process waiting for the next process to finish due to miss-match between cycle time ➤ Waiting for Handle assembly of sickle ➤ Waiting for Grinding of teeth profile 	➤ 30minute
Unnecessary Inventory	<ul style="list-style-type: none"> ➤ Movement in a process step is in a batch of an average 300 pcs, waiting to start the next process. ➤ More WIP in the production floor. 	➤ 110minute
Over transportation	<ul style="list-style-type: none"> ➤ Long-distance moved from Heat treatment to the grinding process ➤ Long-distance moved from grinding to handle assembly. 	➤ 7minute
Overproduction	<ul style="list-style-type: none"> ➤ Overproduction for cutting operation ➤ Overproduction for blanking operation. 	➤ 5minute
Defect	<ul style="list-style-type: none"> ➤ More defect for heat-treated the teeth profile ➤ More defect for grinding the teeth profile ➤ More defect for inserting the handle 	➤ 8minute

Root cause analysis of Sickle

The fishbone diagram is prepared for the Sickle production to carefully investigate the cause that leads to the problem of low production of Sickle.

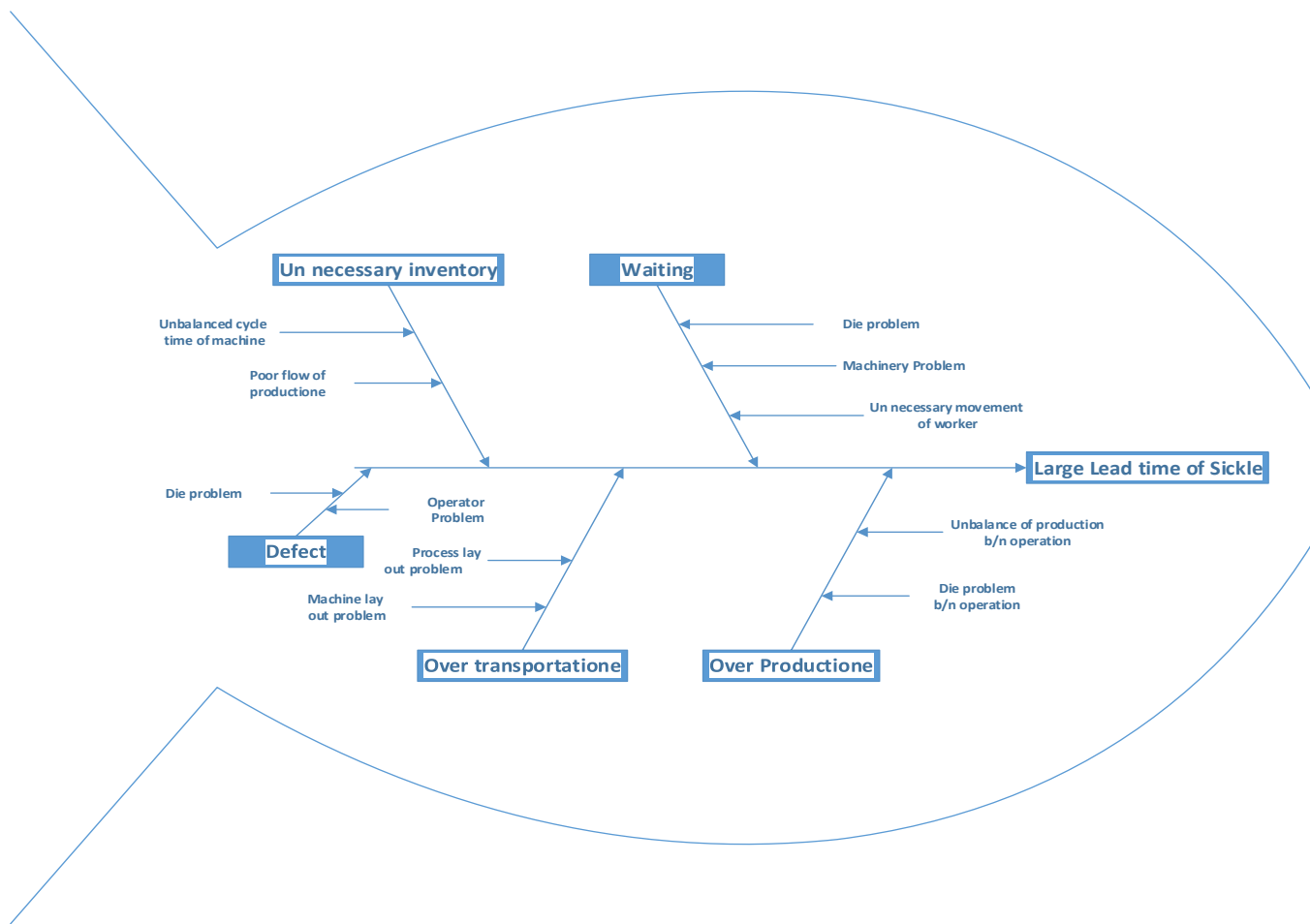


Fig 5.6 Cause and effect diagram of Sickle production line

Table 5.20 Analysis summary table for Sickle production

Tack time	0.48min/pcs
Total Lead time	160 Minute
Efficiency	30 %
Bottleneck	Grinding operation and assembling the handle to the metal sickle
Identified waste	Defect, Waiting, Overproduction, Over transportation & Unnecessary Inventory.
A selected lean tool to apply	Cellular manufacturing, Line balancing, and Kanab

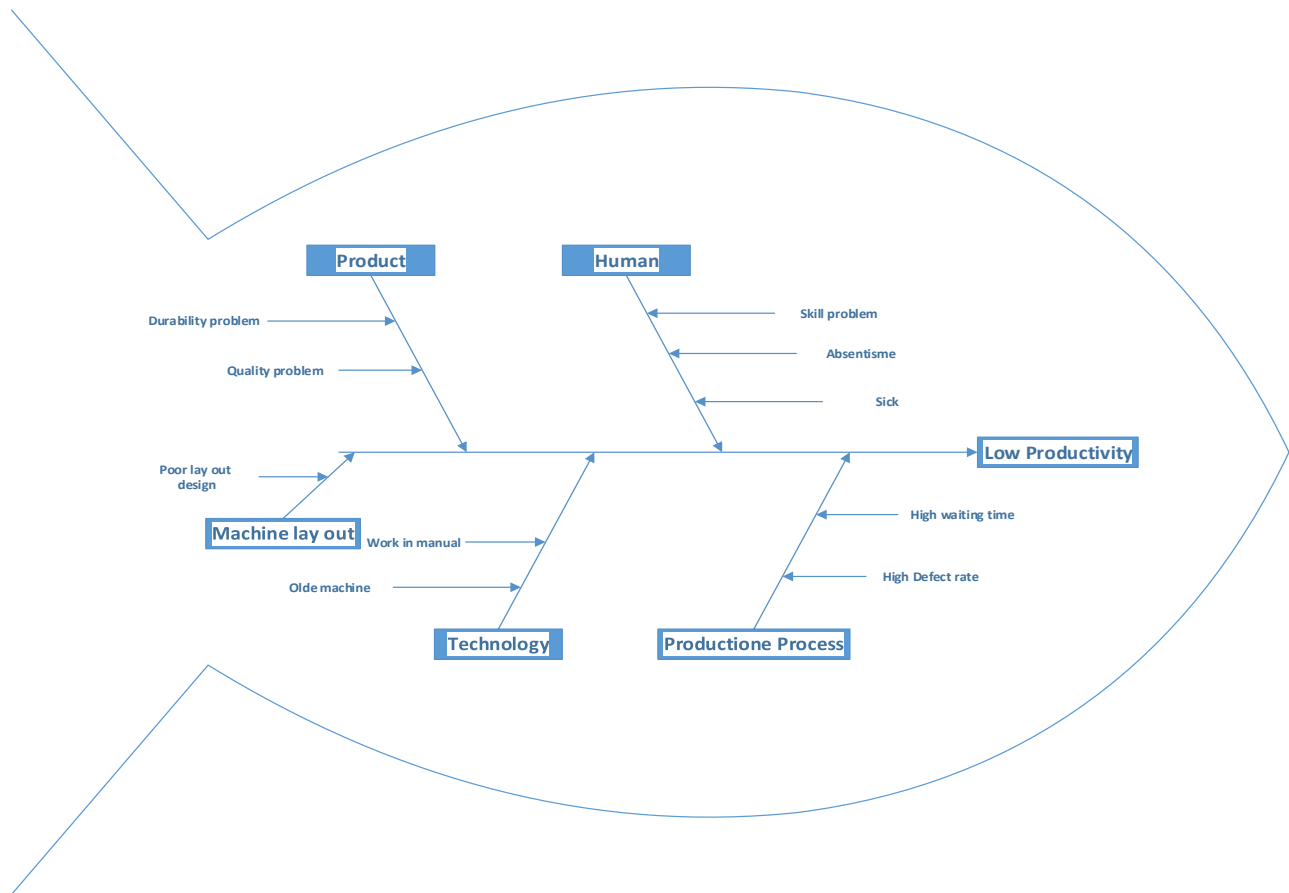


Fig 5.7 Cause and effect diagram of Low productivity

5.5 Production time of the selected product pick axe, shovel, and sickle.

1. Make ready the study format, stopwatch (digital) pencil, and got overall information about the operator & process of the selected product.
2. Select the three product to conduct our study (B/c the three product have a strategic product of the case company)
3. Inform the operator to measure the time for each operation.

5.5.1 Time capturing Analysis

The time taken for completing each operation cycle by the operator is measured in Minute. The element timing is performed for a consecutive 3 operation cycle. The

stopwatch and later the element timing are calculated. Any abnormal time didn't appear and will not record during the time study. Abnormal time may be occurred due to die problems, machine problems and power failure.

A. Analysis of Pick ax production process

Table 5.21 Observed time of each operation in Minute.

Operation	1	2	3	Total	Average
Cutting	0.1	0.15	0.18	0.43	0.14
Heating furnace per piece (50 batch at time)	1	0.9	1.2	3.1	1.03
Piercing hole	0.3	0.2	0.1	0.6	0.2
Flash trimming	0.3	0.35	0.4	1.05	0.35
Heating furnace	0.8	0.7	0.6	2.1	0.7
Forming flat part & Pointed part	0.7	0.78	0.6	2.08	0.693
Bending	0.3	0.25	0.2	0.75	0.25
Hole correction & Tip trimming	0.2	0.23	0.19	0.62	0.206
Hardening	0.6	0.56	0.5	1.66	0.55
Grinding	0.5	0.45	0.4	1.35	0.45
Testing hardness	0.3	0.28	0.3	0.88	0.293
Painting	0.2	0.23	0.28	0.71	0.236
Total	5.3	5.08	4.95	15.33	5.11

Tact Time calculation of Pick axe

A. Tact time = Available time /Customer demand

Available time /month= 22 working days/month= 176Hr/month

Customer Demand /month = 4800 Pick axe/Month

Tact time =176Hr/month/4800 = **0.036Hr/Piece = 2.16min/pcs**

B. Waiting time of Pick Axe = Inventory level at each stage* tact time

C. Process Efficiency= $\sum(\text{Process time}/\text{lead time})$

Total lead time of Pick axe = lead time (LT) incurred in un-necessary inventory+ LT
Over processing + LT Over transportation + LT waiting

LT Un-necessary Inventory (batch of 50 pcs) = 554Minute
 LT Over Processing (batch of 50 pcs) = 218 Minute
 LT Defect (batch of 50 pcs) = 39.5 Minute
 LT Waiting (batch of 50 pcs) = 101 Minute
 LT Motion (batch of 50 pcs) = 85Minute
 Total LT =997.5minute

Process Efficiency = (5.11*50/997.5) Minute

= 0.256 Minute

= 0.256*100% = 25.6%

B. Analysis of Shovel production process

Table 5.22 Observed time of each operation in Minute.

Operation	1	2	3	Total	Average
Cutting	0.2	0.21	0.23	0.64	0.213
Blanking	0.21	0.23	0.24	0.68	0.17
Piercing Hole	0.2	0.2	0.21	0.61	0.203
Heating	0.21	0.2	0.24	0.65	0.16
Forming the cavity	0.2	0.21	0.2	0.61	0.203
Stamping	0.11	0.16	0.18	0.45	0.112
Curling	0.23	0.25	0.22	0.7	0.233
Rambling	0.5	0.4	0.45	1.35	0.337
Painting	0.2	0.3	0.4	0.9	0.3
Total	2.06	2.16	2.37	6.59	2.19

Tact Time calculation of Shovel

A. Tact time = Available time /Customer demand

Available time /month= 22 working days/month= 176Hr/month

Customer Demand /month = 12,540 Shovel/Month

Tact time = 176Hr/month/12,540 = **0.014Hr/Piece = 0.84 min/pcs**

B. Waiting time of Pick Axe = Inventory level at each stage* tact time

C. Process Efficiency= $\sum(\text{Process time}/\text{lead time})$

Total lead time of Shovel = lead time (LT) incurred in un-necessary inventory+ LT over Production+ LT Over transportation + LT waiting

LT Un-necessary Inventory (a batch of 50pcs) = 242Minute

LT over Production (a batch of 50 Pcs) = 16 Minute

LT Over transportation (a batch of 50 Pcs) = 20 Minute

LT Waiting (a batch of 100 pcs) = 56 Minute

Total LT = 334 Minute

Process Efficiency = (2.19*50/334) Minute

= 0.327 Minute

= 0.327*100% = 22.7%

C. Analysis of Sickle production process

Table 5.23 Observed time of each operation in Minute.

Operation	1	2	3	Total	Average
Cutting	0.034	0.032	0.023	0.089	0.0296
Blanking	0.044	0.041	0.035	0.12	0.04
Teeth Making (Notching)	0.054	0.052	0.045	0.151	0.0503
Straightening	0.023	0.021	0.018	0.062	0.0206
Bow bending	0.047	0.043	0.042	0.132	0.044
Blade tip trimming	0.054	0.052	0.051	0.157	0.0523
Stamping	0.047	0.045	0.043	0.135	0.045
Straightening	0.033	0.032	0.031	0.096	0.032
Hardening	0.048	0.045	0.042	0.135	0.045
Finish Grinding	0.2	0.18	0.2	0.58	0.193
Polishing	0.06	0.07	0.06	0.19	0.063
Handle assembling	0.1	0.14	0.19	0.43	0.143

Oiling	0.076	0.078	0.075	0.229	0.076
Covering & Labeling	0.08	0.06	0.04	0.18	0.06
Packing	0.08	0.07	0.05	0.2	0.066
Total	0.98	0.961	0.945	2.886	0.962

Tact Time calculation of Sickle

A. Tact time = Available time /Customer demand

Available time /month= 22 working days/month= 176Hr/month

Customer Demand /month = 22,000 Sickle/Month

Tact time =176Hr/month/22,000 = **0.008Hr/Piece = 0.48 min/pcs**

B. Waiting time of Pick Axe = Inventory level at each stage* tact time

C. Process Efficiency= $\sum(\text{Process time}/\text{lead time})$

Total lead time of Sickle = lead time (LT) incurred in un-necessary inventory+ LT over Production+ LT Over transportation + LT waiting

LT Un-necessary Inventory (a batch of 50pcs) = 110Minute

LT over Production (a batch of 50 Pcs) = 5 Minute

LT Over transportation (a batch of 50 Pcs) = 7 Minute

LT Waiting (a batch of 50 pcs) = 30 Minute

LT Defect (a batch of 50 pcs) = 8 Minute

Total LT =160 Minute

Process Efficiency = (0.962*50/160) Minute

= 0.30 Minute

= 0.30*100% = 30%

5.6 Summery of the Findings

From the above analysis, it can be seen that the low productivity of the case company due to the problem of internal factors like different kinds of waste based on the survey result. Problems associated with low productivity of the hand tool industries are mainly skilled manpower, different kinds of waste, low-quality level of products, technology, machinery, and equipment.

However, based on the company analysis, the company has decreasing productivity during the past years due to several problems. The organization's low productivity-related problems arise from the behavior of the hand tool manufacturing process it constitutes a multi-stage process, operation, and modern technology, skill manpower in which the system requires an approach how activities/process should be linked to obtain the desired output and make the system efficient and productive. However, from the analysis, it can be summarized that the production environment consists of old method/systems, low level of employee skill & motivation, that create inconsistencies including a high level of scraps & reworks, high amount of machine break down and waste.

6. Chapter Six – Solution Proposal

6.1 Selection and proposal of Continuous Productivity Improvement Model

This chapter presents the basic means of productivity improvement and the development of a knowledge transfer framework and implementation guideline for the Ethiopian Hand tool industries. The development of this model/ framework is based on the literature review, observation, and survey questionnaire findings of the case company analysis.

Before selecting a particular productivity improvement or management tool/framework or approach, it needs to be clear in what, why, and how it is trying to achieve and this will involve raising several related questions, such as (Joseph, 2016).

- ❖ What is aiming to change, improve and what outcome to look for?
- ❖ What are the key driver for change; review, change of staff, system, and setup?
- ❖ What is the timescale for the change and what resources are required/ available?
- ❖ Does the improvement be holistic in organizational activities or designed for a specific task?
- ❖ What is the level of organizational staff involvement?

As it is conducted in the previous chapters, research is to be undertaken to decide on the approach or balance of approaches that would best suit situations, environment organizations, sub-sectors, and sectors. It is unlikely that a single approach would address all the associated problems and it does not aim at providing definite information on each approach however it is about to choose the best to address the strategic objectives and the vital/main problems that are responsible for low productivity in this context.

The following model is drawn mainly from the Hand tool industries gap, experiences, failures, and problems found from the questionnaire, critical observation, and interviews. The model can assist its users in evaluating the strengths and weaknesses of their

productivity system, targeting their improvement areas, setting up an action plan for improvements, and tailoring a special part to the needs of their firm. Productivity improvement is not just doing things better; it is doing the right thing better (Jeong, 2018).

6.1.1 Model Development criteria

To develop a model, it must fulfill some criteria's according to the literature and the case company problems, the developed model be easily understandable, addressing the main problems of the company, have continuity for the continuous improvement of the production, easily can to apply for all workers on the company and it must involve all the workers from the top-level up to the low-level workers.

6.1.2 Model parameter consider during implementation are:

1. **Problem Statement-** Identify the problems prevailing and to fill the gap to establish lean compliancy.
2. **Management Commitment-** This is an important step for the lean implementation initiative. The management has not only to be committed but also should be willing to implement change.
3. **Current State Data collection-** This is an important step in VSM analysis. The data is collected while walking along the actual pathways of material and information flow. Data has to be collected using the stopwatch and should personally collect the data of cycle time and change over time for the process of manufacture. The analysis of the current data collection is based on the bottlenecks observed in the process of manufacture.
4. **Lean Implementation teams** – The team should have top-level managers, middle-level managers and workers. This plays an important step in the lean tool implementation.

5. **Select the appropriate Lean Tool-** Once the data is collected, depending on the problems and the gaps prevailing in the case company, an appropriate lean tool needs to be applied.
6. **Establish the desired state** – the desired state is based on the objectives set by the management.
7. **Formulate the lean tool-** This is the most critical step for effective implementation in the case company.
8. **Validate with test runs** – The model has to be validated by test runs before launching on a full scale.
9. **Finalize for implementation** – use-value stream mapping, kaizen, and other lean tools to propose a future state value stream mapping.
10. **Train concerned member-** This is the most crucial step, as the workers should cultivate lean thinking. It is proposed to the management to carry out a training program for effective implementation.
11. **Monitor the lean model** –Monitor the model for implementation.
12. **Validation-** Check the validity of the new applicable model it reduces the defect rate, waiting, waste, and machine setup hours.

A model plan was arrived at after a detailed discussion with the management. As the NMESC was manufacturing many products, it was proposed to carry out a case study in the three selective products like sickle, shovel and pick axe. A model for carrying out Value stream mapping in this industry was devised. The model proposed for the implementation of VSM is shown in Fig 6.1. The model proposed is applicable for any hand tool industry. The plan starts with problem statement and discusses the issue relating to the commitment from the management. A detailed plan is discussed here with for the implementation in the phased manner.

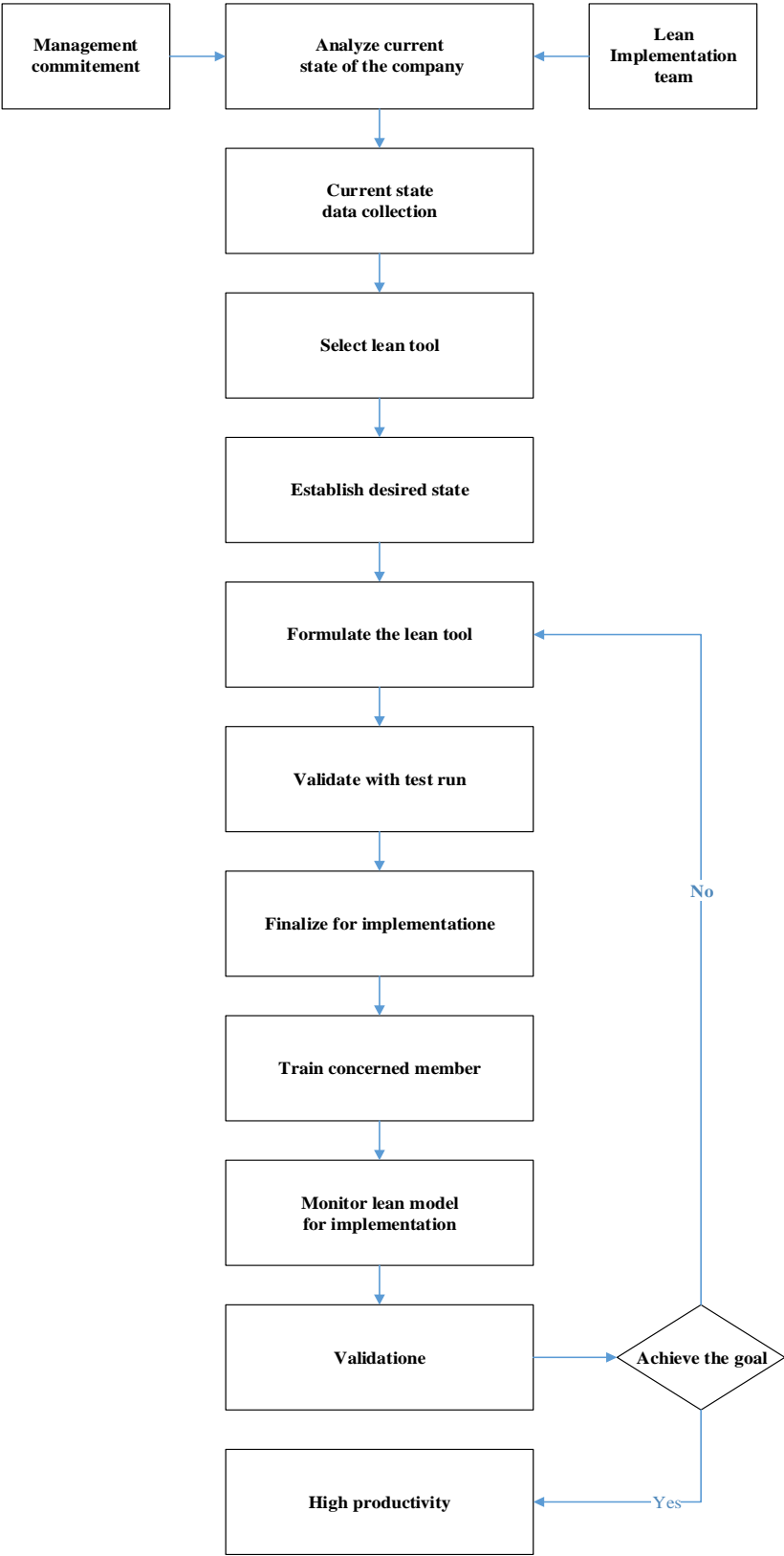


Fig 6.1 Model for VSM

6.2 Proposal for the Future State Value Stream Mapping

After analyzing wastes in both system and applying the respective Lean tool to bring about improvement, the FSVSM has been developed. The summary of non-value added activities that were corrected accordingly have been summarized in the following section.

Table 6.1 Future value stream mapping of pick axe

Type of waste	CVSM	Cause	Effect	FVSM
Inappropriate processing	-Repeated heating & cooling process	Manual system	Extra time on the process	Apply line balancing
Unnecessary inventory	-Waiting for heating furnace -Shop floor process inventory	Lead time	Space requirement	Apply Kanab
Unnecessary motion	Long-distance from heat treatment to grinding & painting room	Layout & location procedure issue	Leads to fatigue (muri & mura)	Proper shop layout
Defect	Process defect like piercing hole, flash trimming & hole correction	Die problem, set up a problem	Reject & Rework	Avoid die problem & use line balancing
Waiting	Between process & location	Layout, location & Balancing	More space required for material	Use line balancing

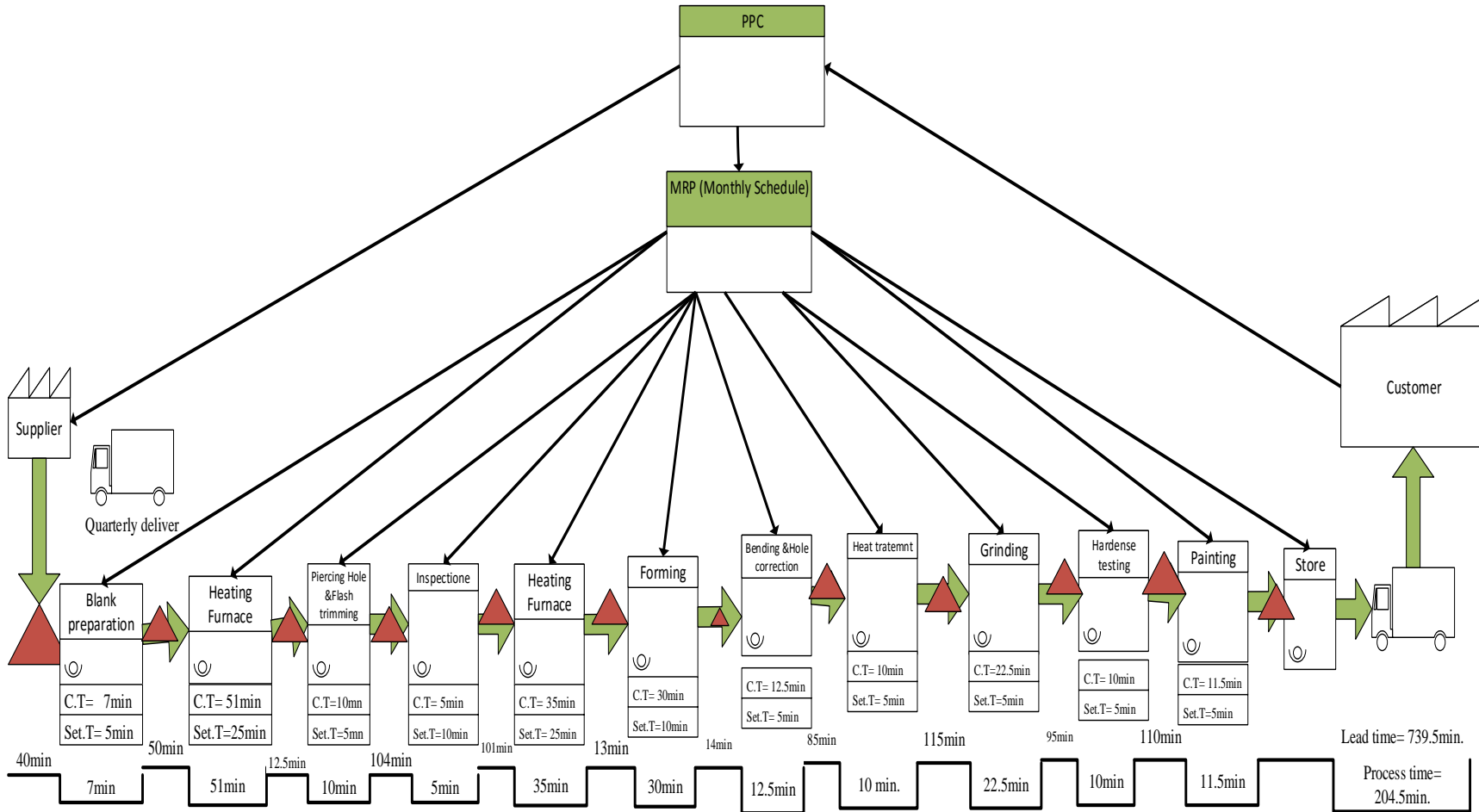


Fig 6.2 Future Value stream mapping of Pick Axe

Lead time reduced from 997.5 minute to 739.5 minute and Cycle time reduced from 252 minute to 204.5 minute.

Table 6.2 Future value stream mapping of a shovel

Type of waste	CVSM	Cause	Effect	FVSM
Waiting	- One process waits for the next process. -Waiting for painting.	Layout & balancing problem.	More space on the shop floor.	Cellular manufacturing
Unnecessary inventory	-More WIP on the production floor	Lead time	Space requirement	Apply Kanab
Over transportation	-Long-distance move from rambling to painting	Layout	Extra time	Proper shop layout
Overproduction	Overproduction for cutting &bending operation	Strategic, capacity balancing	More storage space	Balancing the flow of operation
Inappropriate processing	-Forming & stamping process	Layout	Extra time on the process	Apply line balancing

Future VSM total lead time reduced from 334 minutes to 265 minutes and Cycle time reduced from 101 minutes to 85 minutes.

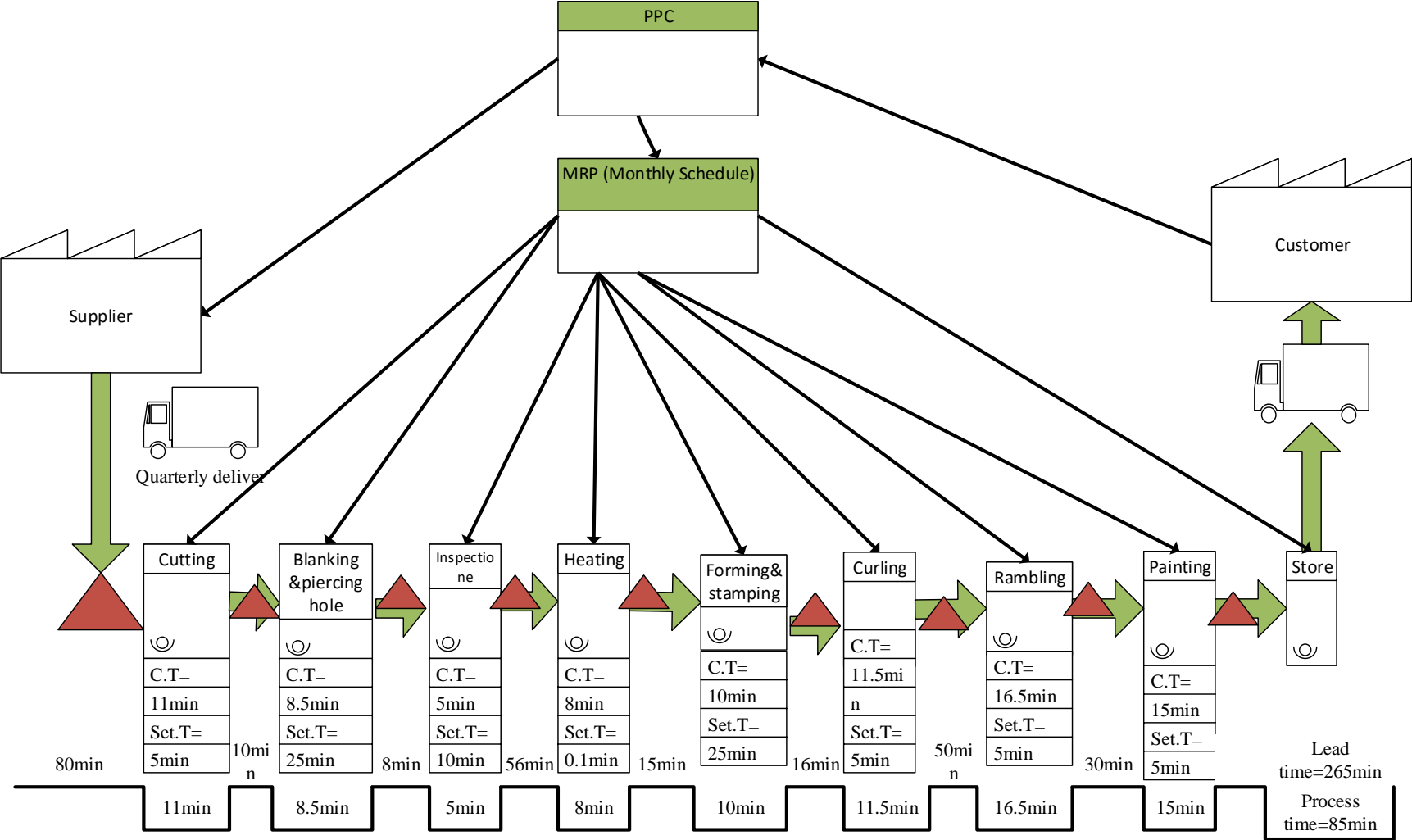


Fig 6.3 Future value stream mapping of a shovel

Table 6.3 Future value stream mapping of sickle

Type of waste	CVSM	Cause	Effect	FVSM
Waiting	-Waiting for the grinding of teeth -Waiting for the handle assembly	-Balancing, location & layout	-More space required	Apply line balancing
Unnecessary inventory	- More WIP on the production floor	Lead time	Space requirement	Apply Kanab
Over transportation	- Long-distance move from grinding, heat treatment to handle assembly	Layout	Extra time on the process	Proper shop layout
Overproduction	- Overproduction for cutting & bending operation	Strategic capacity balancing	More storage space	Balancing the flow of operation
Defect	-Heat treatment, grinding & handle assemble defect	Die problem & operator problem	Reject & Rework	Avoid die problem & training for operator
Inappropriate processing	-Grinding & Polishing	Layout	Extra time on the process	Apply line balancing

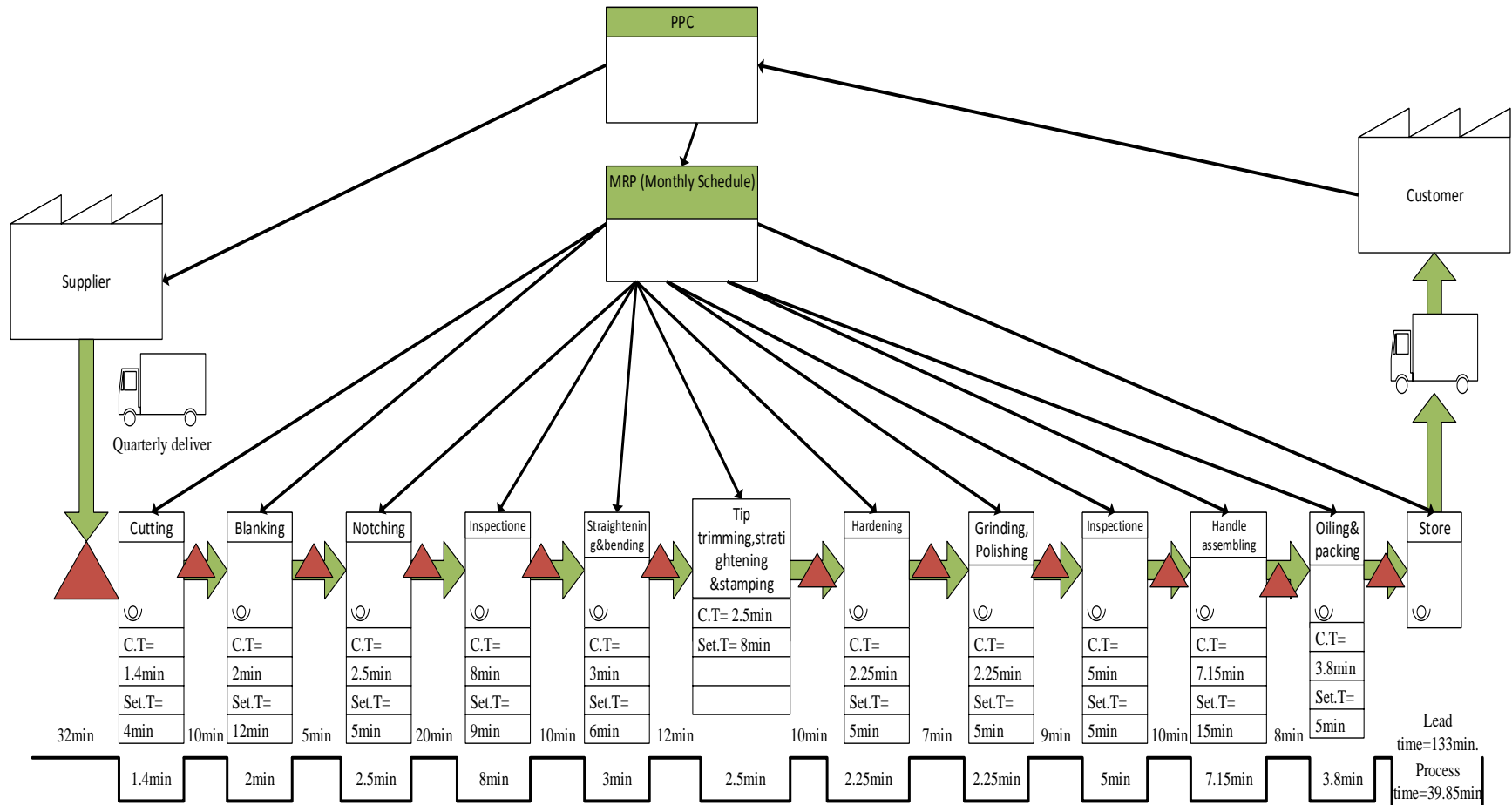


Fig 6.4 Future value stream mapping of Sickle

Total lead time reduced from 160 minutes to 133 minutes and Cycle time reduced from 53.15 minutes to 39.85 minutes.

6.3 Plant lay out

Plant layout means the disposition of the various facilities (equipment, materials, manpower, etc.) And service of the plant within the area of the site selected.

A properly designed plant layout provides an ideal synergy among raw materials, manufacturing processes, available space, and the output. It ensures the efficient utilization of all available space and flexibility of arrangements and manufacturing operations, streamline the movement of inventory in the entire manufacturing plant without hitches or unnecessary delays, maintains adequate turnover of materials, reduces lead time and cost of material handling, and also ensure the workers safety, comfort and convenience (Thinking, 2017).

Factors that determine the Designing of new plant lay out in negate mechanical engineering sch. company are:

- Efficient utilization of space: this entails the provision of sufficient space around the machines and the traffic lanes, as well as ensuring that adequate spaces are made available for storage points within the facility.
- Ease of communication: plant layouts should be designed to enhance communication and easy flow of information among the various departments/units, as well as the customers.
- Maximum accessibility: the repairs and maintenance sections should be made readily accessible. This implies that equipment and machines must not be placed against the walls in order to ensure that maintenance and servicing operations are easily undertaken.
- Promotional Value: a well-designed layout enhances the image and reputation of a company, thereby serving as a good promotional factor.
- Safety: As the importance of safety in all human endeavors should not be overemphasized, a good plant layout should be designed to function efficiently and ensure that accidents and its causes are reduced to the barest minimum.
- Maximum Flexibility: good plant layout should be easily modified in order to meet up with the ever-changing demands of the customer and market.

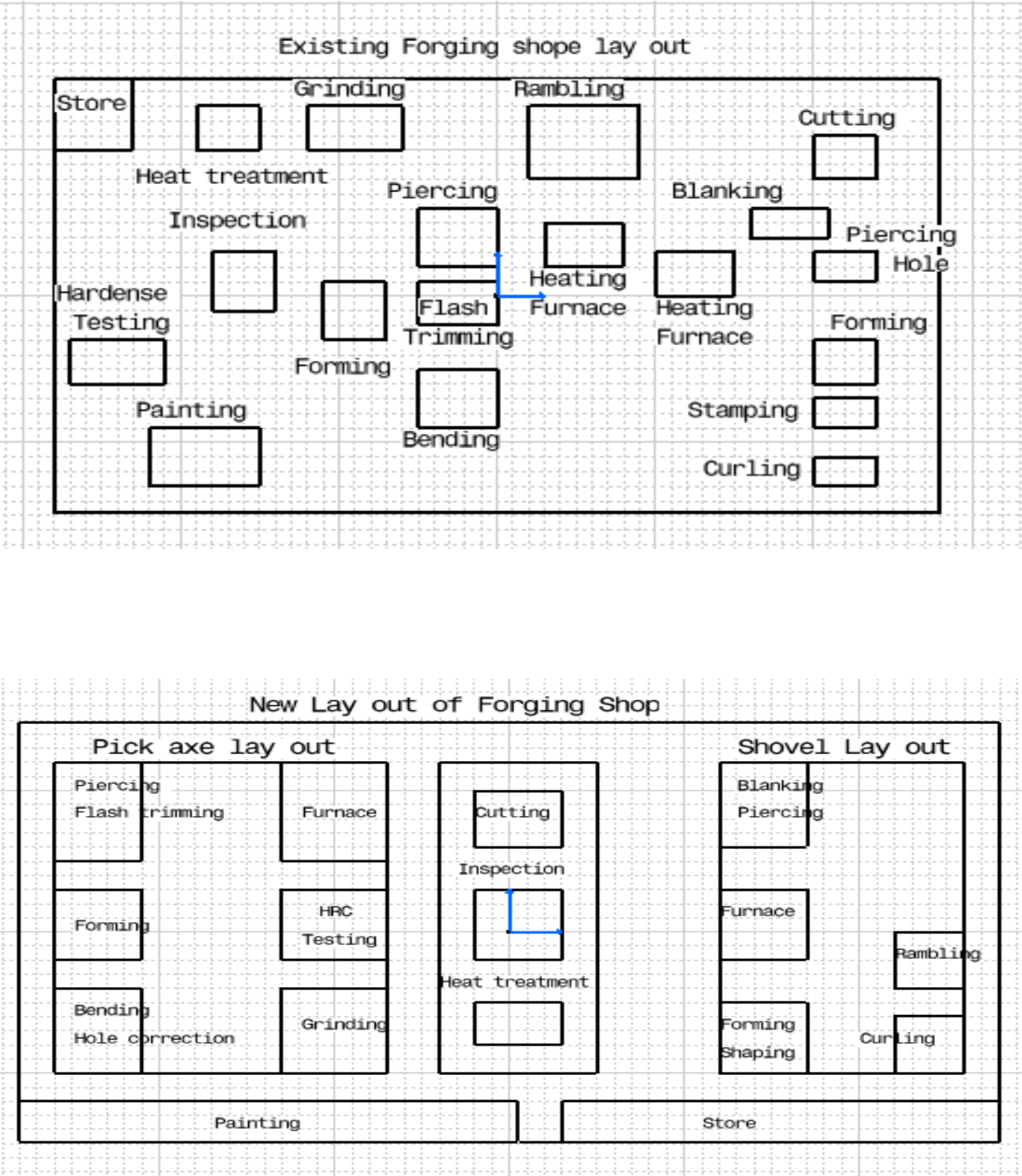
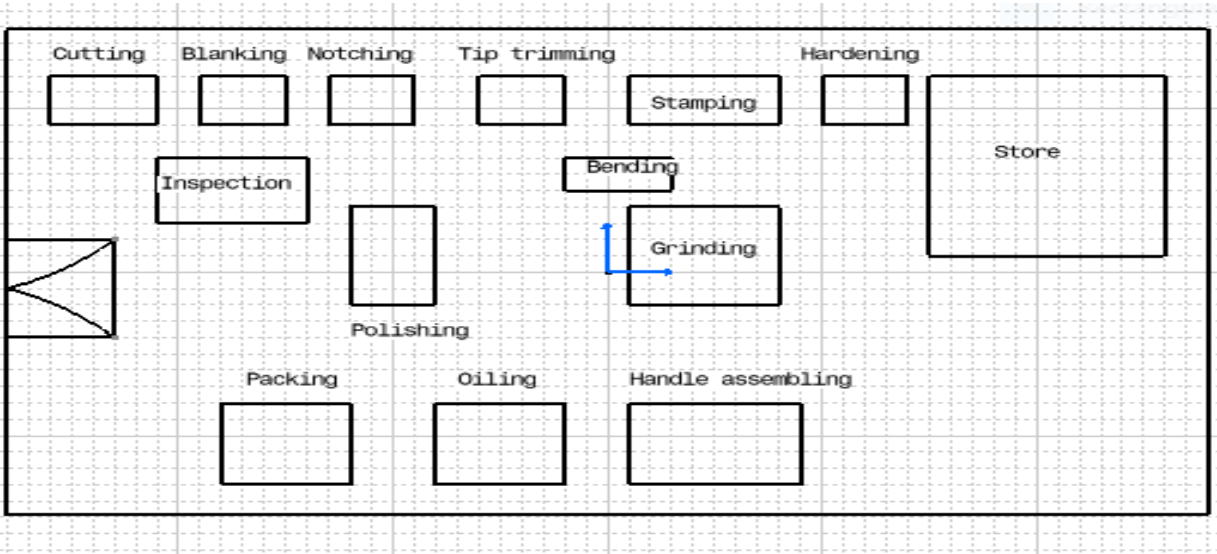


Fig 6.5 Existing and Proposed forging shop lay out

Existing Sickle layout



Proposed sickle lay out

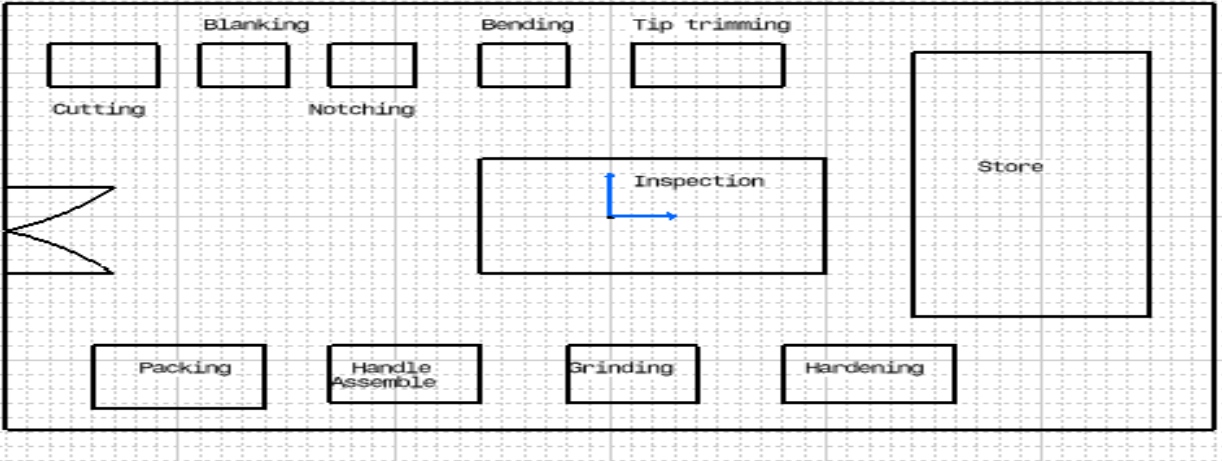


Fig 6.6 Existing and proposed sickle lay out

6.4 Cost of New plan lay out

Table 6.4 Cost of Forging plant lay out (own source)

S/N	Description	Unit	Quantity	Unit cost (Birr)	Total cost (Birr)
1	Foundation	M ³	50	380	19,000
2	Electric cable (ID=10mm, OD= 60mm)	meter	200	1100	220,000
3	Machine repair	pcs	7	5700	39,900
4	Painting	Gallon	40	250	10,000
5	Accessory of Electrical equipment	set	5	863	4315
Total cost					293,215

Table 6.5 Cost of Sickle plant lay out (own source)

S/N	Description	Unit	Quantity	Unit cost (Birr)	Total cost (Birr)
1	Foundation	M ³	60	380	22,800
2	Electric cable (ID=10mm, OD= 60mm)	meter	220	1100	242,000
3	Machine repair	pcs	8	5700	45,600
4	Painting	Gallon	46	250	11,500
5	Accessory of Electrical equipment	set	7	863	6041
Total cost					327,941

7. Chapter Seven - Conclusion and Recommendation

7.1 Conclusion

Productivity improvement is an important issue in the Ethiopian Hand tool industry. Although productivity and productivity measurement are the common practice for firms, the research asserted that implementation of measurement and analysis of productivity system calls for companies is carried out employing a process approach where a process has got input and output values and productivity is the ratio of output to input considering the manufacturing firms perspectives of a composite of interrelated are value-adding sub-processes.

In this research, the application of lean management in the production process of three of the company best-selling product namely Sickle, shovel, and pick axe. Any investigation has been conducted on the Ethiopian hand tool industries and it can be concluded that firms have a misconception about what productivity is and how it is measured. This study shows the way of finding a gap in the production process and operations. The objective of this paper is to assess the current manufacturing conditions of the Negate mechanical engineering sch.co, to improve productivity by minimizing waste, and to develop a model for the continuous productivity improvement by the lean tool. The questionnaire was designed to collect data from the case company by five performance perspectives were identified to assess the measurement system of the organization and 29 key performance indicators were selected based on the correlation having strong 'r' value.

The new model preparation giving awareness for the top and middle-level management, select in which area of the case company have high wastage and delay happens, by the data the selected product Defect 38.3%, Waiting for 33.3 %, inappropriate processing

23.3 %, unnecessary motion 21.7%, then after record & examine the data here apply lean tools to be more preferable reducing waste and increasing productivity.

Finally, concluded by the analysis part the performance indicators couldn't applicable practically, how related to productivity and waste reduction, because of limited time and the corona virus. I will at other times of research or another researcher continue.

7.2 Recommendation

Based on the above conclusion some recommendations are proposed for consideration by Negate Mechanical Engineering sch.co.

- ❖ Productivity is the basis for the firm's survival and competitiveness capability at the local & global stage, therefore, companies should be able to manage and utilize efficiently their resources to have a productive manufacturing system and ensure that to keep its sustainability growth.
- ❖ Negate mechanical Engineering sch. company has problems with productivity. Therefore, The Company will be beneficiary by implementing this model because it touches all the company problems and tries to show some corrective ideas.
- ❖ Since the production system in the company comprises different sub-processes, the company should integrate these activities to have a better output.
- ❖ Since there is a high level of scarp & rework level in the production process that consumes the capital resource inputs, the company should practice Lean management.

7.3 Future Study area

This paper focuses on NMESC, but it is an advantage to see other small scale industries. The paper has been targeted at future state improvement models that can provide improved productivity for the case company. But searching for future state model leads to an optimum improvement in productivity is recommended through the application of the principle of optimization.

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Appendix I

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT)

School Of Mechanical and Industrial Engineering

Graduate Program in Industrial Engineering



Survey Questionnaire on Negate Mechanical Engineering Sch. Company

Prepared by: Wondwossen Adem E-mail: wondwossen43@gmail.com

Advisor: Dr. Sisay Addis Co-advisor: Mr. Yichalewal Goshime

This questionnaire is prepared to gather data for research entitled “**productivity improvement of Ethiopian Hand tool Industry through Lean tool**”. The objective of the questionnaire is to improve productivity by identifying production problems that influence the case company performance. Also to test their understanding of different production wastes those affect both the worker and the process. I would be very grateful if you could spend a small amount of time to answer the attached questionnaire. All the questions are designed for quick and easy response. If you need further clarification, please contact me at the above address.

Company Information

1. Name of your company _____

2. Year of establishment _____

4=Strong or agree 5 =Very Strong or strongly agree and please tick '√' mark in the corresponding cell

General Information: Indicate your responsibility in your company

I. Operator Mechanic Supervisor Quality control Machinist

other: please specify it-----

II. Sex Male Female

III. Age below 20 20-29 30-40 41-54 54 and

above

IV. Your educational background

Primary school Secondary school Certificate

Diploma Degree and above

V. Your work experience in this company

Below 1yr 1-2 yr. 2-5 yr. 5-10 yr. More than 10
years

VI. Employment Level

Low-Level Middle Management Top Management

1. Waste

S/n	Waste Happen on production Time of NMESC	Score				
		1	2	3	4	5
1	Overproduction					
2	Transportation					
3	Inappropriate processing					
4	Unnecessary Inventory					
5	Unnecessary Motion					
6	Waiting					
7	Defect					

2. Idle Time

S/n	Idle Time happen on production Time of NMESC	Score				
		1	2	3	4	5
1	Power failure					
2	Material shortage					
3	Machine set-up					
5	Machine failure					
6	Material searching					

3. Continuous Improvement strategies

S/n	Proper Improvement strategy for NMESC	Score				
		1	2	3	4	5
1	Kaizen					
2	Lean					
3	BPR (Business process reengineering)					
4	Training					
5	TQM (Total Quality Management)					

4. Customer Requirement

S/n	Best customer requirement of NMESC	Score				
		1	2	3	4	5
1	On-time delivery					
2	Price					
3	Durability					
4	Design					
5	Aesthetics					

5. Productivity Improvement Problem

S/n	Reason does not work at high productivity	Score				
		1	2	3	4	5

1	Input related problems					
2	Capital related problems					
3	Machinery and equipment related problems					
4	Planning and management problems					
5	Process related problems					
6	Skill and labor-related problems					
7	Technology and innovation-related problems					

Thank you for your cooperation

አዲስ አበባ ቴክኖሎጂ ኢንስቲትዩት

አዲስ አበባ ዩንቨርሲቲ

ለንጋት ሜካኒካል ኢንጅነሪንግ አ.ማ የተዘጋጀ የጥናት መጠይቅ

አዘጋጅ: ወንድወሰን አደም

አማካሪ: ዶ/ር ሲሳይ አዲስ

ተባባሪ አማካሪ : ይቻለዋል ጎሽሜ

ጥናታዊ መጠይቁ የተዘጋጀው ለ መመሪያ ፀሁፍ ሲሆን ጥናቱ የሚያተኩረው በኢትዮጵያ የሚገኙ የእጅ መሳሪያ ማምረቻ ድርጅቶች Lean Tool ተጠቅመው ምርታማ የሚሆኑበትን መንገድ ማሳየት ነው። የጥናታዊ ፀሁፉ አላማ በንጋት ሜካኒካል ምህንድስና አክሲዮን ማህበር (ኮተቤ ብረታ ብረት ፋብሪካ) በምርት ዙሪያ ያሉትን ችግሮች በማሳየትና መፍትሄ በመፈለግ የድርጅቱን ምርታማነት ማሳደግ ሲሆን በተጨማሪም በምርት ዙሪያ ያሉትን የብክነት አይነቶች በዝርዝር መለየትና ማወጣት ነው። ጥናታዊ መጠይቁን ለመሙላት ላደረጉልን ትብብር ምስጋና እያቀረብን በመጠይቁ ዙሪያ ግልፅ ያልሆኑ ፤ መብራራት ያለባቸው ነገሮች ካሉ ከላይ በተቀመጠው አድራሻ መጠየቅ የሚቻል መሆኑን እያሳወኩ ለሚደረግልኝ ትብብር ከወዲሁ አመሰግናለሁ።

ከ ሰላምታ ጋር

የድርጅቱ መረጃ

1. የድርጅቱ ስም፤.....
2. የተቋቋመበት አ.ም (E.C) :
3. ባለቤትነቱ የግል የመንግስት አክሲዮን ማህበር
4. የንግድ ስራ ባለቤትነት አገር ወስጥ የወጭ የሽርክና ንግድ
5. የድርጅቱ ዋና ዋና ምርቶች
6. ካፒታል (በብር)
7. በስራ ላይ ያለው የሰው ሀይል ብዛት ቋሚ..... ግዛዊ.....

ለድርጅቱ የምርት ስራ አስኪያጅ፤ የክፍል ሀላፊና ፎርማን የተዘጋጀ ቃለ መጠይቅ

1. የድርጅቱን ምርታማነት እንዴት የለካሉ?
2. የድርጅቱን የምርት ሂደት እንዴት ይቆጣጠራሉ?
3. የድርጅቱን ምርታማነት ለማሻሻል ምን ሙከራ ያደርጋሉ?
4. በምርት ሂደት ወስጥ የትኞቹ ማሽኖች፤ የመስሪያ እቃዎችና የምርት ፕሮሰሶች ምርትን ይገድባሉ?
5. ከዚህ በፊት ድርጅቱ ለምርት ስራተኞች ስልጠና ይሰጥ ነበር? ካላ የስልጠናው አይነት ቢገለፅ
6. በምርት የስራ ሂደት ወስጥ ብክነት አለ ? አዎ ከሆነ መልሰዎ የብክነት አይነቶችን ከነምክኒያታቸው ቢጠቅሱቸው?
7. ድርጅቱ ብክነትን ለመቀነስ ምን አይነት ዘዴ ይጠቀማል?
8. ድርጅቱ ብክነትን ለመቀነስ Lean tool የተባሉትን የብክነት መቀነሻ መንገዶች ተጠቅሞ ያቃል? ከተጠቀሙ አይነቶችን ቢገልጹቸው ?
9. ድርጅቱ በቀን ምን ያህል ምርት ያመርታል ? በተለይ እንደ አካፋ፤ ዶማና መጥረቢያ ያሉ የድርጅቱ ስልታዊ ምርቶች
10. አፕሬተሮች በቀን ወስጥ ማምረት ያለባቸውን የምርት አይነቶችና ብዛት የሚያመርቱት በምን መስፈርት ነው ?

ለኦፕሬተር፣ ማሽኒስትና መካኒክ የተዘጋጀ መጠይቅ

የዚህ መጠይቅ አላማ በድርጅቱ ውስጥ ያለውን የምርት ብክነት መነሻ በማድረግ መረጃ ለመሰብሰብ ሲሆን መጠይቆቹ በተለየ ሁኔታ ለሰራተኛ ተዘጋጅተዋል። በትክክልና በሀቀኝነት መልስ እንዲሰጡ እየጠየኩ ከዚህ በታች በተጠቀሰው መለኪያ መሰረት ደረጃ ይሰጡ።

1. ደካማ 2. መጠነኛ 3. መካከለኛ 4. ሀይለኛ 5. በጣም ሀይለኛ

አጠቃላይ መረጃ፣ በድርጅቱ ውስጥ ያለዎትን ሀላፊነት ይግለጹ

I. ኦፕሬተር 2. ማሽኒስት 3. ጥራት ተቆጣጣሪ

4. መካኒክ

II. ያታ ወንድ ሴት

III. እድሜ ከ 20 አመት በታች ከ 20-29 ከ 30- 40

 ከ 41-54 54 እና ከዛ በላይ

IV. የትምህርት ደረጃ የመጀመሪያ ደረጃ ሁለተኛ ደረጃ

ሰርትፍኬት

ዲፕሎማ ዲግሪና ከዛ በላይ

V. በድርጅቱ ውስጥ ያለዎት የስራ ልምድ

አንድ አመትና ከዛ በታች ከ1-2 አመት ከ2-5 አመት

ከ 5-10 አመት ከ 10 አመት በላይ

VI. የስራ ደረጃ

ዝቅተኛ ደረጃ መካከለኛ አስተዳደር ከፍተኛ አስተዳደር

1. ብክነት

በድርጅቱ ላይ የደረሰው የብክነት አይነት	ደረጃ				
	1	2	3	4	5
1. ብዛት በማምረት					
2. በመገኘት					
3. ተገቢ ያልሆነ የምርት ሂደት በመጠቀም					
4. አላስፈላጊ የምርት ክምችት በመኖሩ					
5. አላስፈላጊ እንቅስቃሴ በማረጋገጥ					
6. ምርት በመጠበቅ					
7. በምርት ብልሽት					

2. ስራ የተፈታበት ሰአት

በድርጅቱ ብዛት ስራ ያልተሰራበት ሰአት	ደረጃ				
	1	2	3	4	5
1. በመብራት ችግር					
2. በጥሬ እቃ እጥረት					
3. ማሽን በማስተካከል					
4. በማሽን ብልሽት					
5. ጥሬ እቃ በመፈለግ					

3. ቀጣይነት ያለው የማሻሻያ ስልት

በድርጅቱ ትክክለኛው የማሻሻያ ዘዴ	ደረጃ				
	1	2	3	4	5
1. ካይዘን					
2. ሊን					
3. BPR					
4. ስልጠና					

5. ጠቅላላ የጥራት አያያዝ					
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4. የደንበኛ መስፈርት

የድርጅቱ ደንበኞች ዋነኛ መስፈርት	ደረጃ				
	1	2	3	4	5
1. ደንበኛው በሚፈልግበት ጊዜ ማድረስ					
2. ዋጋ					
3. ዘላቂነት ያለው ምርት					
4. የአሰራር ቅርፅ					
5. ወጠት					

5. ምርታማነትን ለማሻሻል የሚታዩ ችግሮች

በአጭር ሁኔታ ምርታማ ላለመሆን እንደ ምክንያት የሚቀመጡ	ደረጃ				
	1	2	3	4	5
1. የግብአት ችግር					
2. የካፒታል እጥረት					
3. ማሸነፊያ ተያያዥ የመስሪያ እቃዎች ችግር					
4. የመምራትና የማቀድ ችግር					
5. በምርት ሂደት የሚታዩ ችግሮች					
6. የሰራተኛ አቅም (ችሎታ) ማነስ					
7. ቴክኖሎጂና አዳዲስ ነገሮች ያለመጠቀም					

ለትብብረት እናመሰግናለን

Appendix II

Response rate and demographic analysis of the questioners

A total of 60 questionnaires were distributed to employees, all employees gave response and The rate of response is 100 %. The respondents' demography includes gender, age, work experience, educational back ground and Employment level. So, they exhibited the following report in table below.

Table 1 . Demographic of respondents

Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Men	50	83.3	83.3	83.3
Valid Female	10	16.7	16.7	100.0
Total	60	100.0	100.0	

Age

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Below 20 Years	3	5.0	5.0	5.0
Valid From 20-29	24	40.0	40.0	45.0
Valid From 30-40	20	33.3	33.3	78.3
Valid From 41-54	9	15.0	15.0	93.3
Valid Above 54	4	6.7	6.7	100.0
Total	60	100.0	100.0	

Work Experience

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Below 1 year	3	5.0	5.0	5.0
Valid From 1-2 Year	10	16.7	16.7	21.7
Valid From 2-5 Year	20	33.3	33.3	55.0
Valid From 5-10 year	20	33.3	33.3	88.3
Valid More than 10 year	7	11.7	11.7	100.0

Total	60	100.0	100.0
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Educational Background

	Frequency	Percent	Valid Percent	Cumulative Percent
Primary school	2	3.3	3.3	3.3
Secondary school	4	6.7	6.7	10.0
Certificate	33	55.0	55.0	65.0
Diploma	11	18.3	18.3	83.3
degree and master	10	16.7	16.7	100.0
Total	60	100.0	100.0	

Employment Level

	Frequency	Percent	Valid Percent	Cumulative Percent
Low level	39	65.0	65.0	65.0
Middle Management	15	25.0	25.0	90.0
Top Management	6	10.0	10.0	100.0
Total	60	100.0	100.0	

Table 1. Presents the profile of the respondents: the total respondents, 50 (83.3%) were males, and 10 (16.7%) females. This shows that the male employees mainly dominated in number. Regarding their work experience at NMESC, most of the respondents who represent 3 (5%) respondents have less than one years of work experience, 10(16.7%) have 1-2 years of experience, 40 (33.3%) have 2-10 years of experience, 7(11.7%) have above 10 years. As for their age, 3 (5%) of the respondents were below 20 years, 24 (40%) were between 20-29 age groups, 20 (33.3%) were between 30-40 age group, 9 (15%) were between 41-54 age group and 4 (6.7%) were above 54 years this implies that most of the respondents are young and productive. With regards to educational qualifications 2 (3.3%) reported to be a primary school, 4 (6.7%) were secondary school, 33 (55%) were certificate, 11(18.3%) were diploma and 10(16.7%) were degree and above.

Appendix III

Organizational structure

