

Investigation and Analysis of Barriers for Implementation of Lean Manufacturing Practices in Ethiopian Basic Metal Industries

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Abstract: Lean manufacturing is the most widely used manufacturing philosophy for producing high-quality products quickly and efficiently. Lean concept implementation requires systematic procedure as it involves significant challenges, barriers. The lean idea also focuses on the elimination of various forms of waste by using different lean tools. The present study is planned to investigate and analyze the major challenges, barriers, and applications of lean tools in the lean implementation of manufacturing practices in Ethiopia's basic metal industries. The study is carried out through a questionnaire, descriptive statistics, and exploratory data analysis to check the internal consistency, validity, and reliability of the data using SPSS software. The survey has shown most respondents believe that the challenges of wastages are related to waiting, with a mean of 3.19, unutilized creativity 3.14, a poor work environment 3.08, and unnecessary motion, 3.0. Consequently, knowledge-related barriers have a mean of 3.71, organizational culture 3.57, strategy 3.56, people-related 3.4, and technical 3.17, respectively. The present study helps to sort out various levels of waste, challenges, and barriers to lean implementation, and different applications of lean-to raise the industry's economic growth.

Keywords: Lean manufacturing, Lean applications, Lean implementation, Waste reduction

1. Introduction

Ever-growing global trends focus to adapt to emerging manufacturing technologies to create the desired quality products with economical ranges to reach modern customers[1]. Customer thinking natures are changing in the modern world as they are demanding intelligent products in a very short period and price[2]. These global demands force manufacturing industries to respond rapidly and to make customer-based parts survive in the competitive

world[3]. Ethiopia is one of the fast-growing countries in the African continent by developing industrial sectors in major fields like leather and textiles, metalworking, service sector, etc. Basic metalworking organizations in the Nation are in the initial development stages as compared to other industrial revolutions, as it contributes only 0.4% of countries' gross domestic product (GDP)[4]. The availability of natural resources in the country makes local industrialists concentrate on metalworking organizations to increase revenues from it to contribute more for countries development to the next level. The Country is now focusing to adopt innovative manufacturing ideas like lean manufacturing to accelerate the manufacturing capability to produce high-quality parts to the consumers[4].

Lean manufacturing is an innovative concept that was proposed and used by the Toyota production system in Japan to enhance the efficiency of production processes by utilizing maximum capabilities of employees by boosting up their job satisfaction [5]. Lean manufacturing ideology proposes different concepts as compared to traditional manufacturing practices[6]. Conventional production systems give priority to inventory systems and this concept is not considered in lean manufacturing as it is treated as waste in the organization[7]. It is highly essential to understand the basic concept of lean manufacturing and how it is different from traditional manufacturing to make use of it to get maximized efficiencies to the organizations[8],

Lean manufacturing is an advanced lean tool to eliminate waste by reducing internal variability [9]. It entails producing the same result with fewer resources, such as time, space, human effort, machinery, materials, and money [10]. Lean is a concept demonstrated delivery, cost, and quality interlocking principles, techniques, and tools, philosophy [11], and it also includes softer elements such as leadership, teamwork, and human respect [12]. It is a promise made by a company's leaders to deal with the company's competitiveness. The strategic approaches in lean are helpful to resolving organizational problems that can save money [13]. Lean ideology is also triggering to implement some basic practices like training, education, and technical knowledge which makes lean system more powerful tool[14] [10]. In the context of lean practice activities, a "lean knowledge management ability" (LKMA) is an expansion and extension of a general knowledge management ability.

Yang and Zhuang stated that LKMA relates to the capability to acquire, integrate, and apply various knowledge and lean tools [15]. This fact would create barriers to the implementation

of lean practices. Employees with insufficient knowledge of lean are confused by its implementation and fail to recognize its full potential benefits. In addition, employee involvement in decisions is significantly influenced by a lack of proper training [16]. Therefore, the goal of lean manufacturing is a continuous improvement by providing effective training sessions to their employees to achieve advantages from lean concepts. Lean organizations prioritize customer demand while producing high-quality products and services most efficiently and cost-effectively possible by utilizing minimized material, fewer human resources, reduced production times, and less energy and space [17], [18].

Rahmanasari et al., (2021) [19] had been demonstrated the advantages of lean manufacturing to reduce waste in manufacturing organizations through a case study. They stated in their work that adopting systematic maintenance activities, providing efficient training and supervision, and offering better work facilities can improve production efficiency thereby reducing waste as well. Palange and Dhattrak (2020) [20] had carried out a research analysis to identify the importance of lean tools to increase productivity in manufacturing organizations. They mentioned from their work that customer satisfaction can be achieved through lean manufacturing as it focuses on the delivery of quality products at right time at a minimized cost. Rother and Shook (Mike Rother, John Shook) mentioned in their study that lean concepts are useful to enlighten and analyze the workflow, as well as to identify non-value-added and value-added activities that contribute to the final product. They also stated that lean mainly focus on waste reduction, lead time reduction, and improved material flow. Singh, et al 2010 [22] had been made a research to implement lean principles to enhance the production capacity by minimizing waiting, queuing, and moving time, and some other wastes. They found better results from lean implementation in the production-based organization.

Several key success factors were identified after a thorough review of the literature, including organizational culture, ownership and readiness, management commitment, and capability, adequate resources to support and change for effective communication, and commitment to attend a strategic approach to improve performance [[22][23], [17], [20], [24], [18]]. Mentioned success factors are categorized into four classes: strategy and goals, leadership and management, staff, and external factors. Most of the reported studies in the literature have been emphasized senior management's commitment to lean transformation [25]. Dombrowski & Mielke

(2013) had been stated from their extensive study that leadership is a vital factor for implementing the lean concept because it is the foundation for involving employees in continuous improvement efforts [26]. Singh et al (2010) had also been stated that effective management policies, various strategies, and attitudes towards enhancement of efficiency of organizations are crucial for the lean concept [27]. Puvanasvaran et al. (2009) mentioned that adopting some important activities like effective communication, training, and motivation culture is necessary to raise the level of understanding in the organization to attain the maximized benefits from lean ideology [28],

The present research work is focused to study and analyze the organizational structure followed by existing metal and other industries in Ethiopia and implementing lean ideology to gain better manufacturing excellence. The study is also aimed to identify the various forms of waste, lean implementation barriers, and the application of lean tools in basic metalworking for organizations in Ethiopia.

2. Scope of the work

In the present work, analysis is aimed to study the different forms of waste and implementation barriers for lean concept in basic metalworking industries in Ethiopia and to guide to support industries that are planning to initiate lean applications to create economical products by following maturity levels of lean manufacturing culture. To address stated concerns, the present study is divided into five sections: after the introduction with an extensive literature survey, section 2 provides the scope and objective of the present study, and the organization of the paper and section 3 summarizes the research methodology. Section 4 result, and data analysis. The last section discusses the implications of the proposed work and concludes the work objectives with a recommendation for future research.

3. Research Methodology

This study was conducted through interviews, visiting and distributing questionnaires, literature review of research articles, and company reports that are discussed with nine basic metal industries to investigate and analyze the challenges, barriers, and applications of lean tools for the implementation of lean manufacturing practices. More number of respondents were considered while gathering data and filtered after receiving data from them and finally data 36 respondents are considered to analyze the data. The questionnaire which is distributed to respondents is given in Appendix.

The quantitative data analysis was performed using statistical procedures. The information gathered and the responses obtained from the respondents were then analyzed to achieve the study's goal. Accordingly, descriptive statistics were used to describe the obtained results, and exploratory statistics were used to check the reliability and validity of the responses, with Cronbach's alpha being used to validate the internal consistency of the answers using SPSS Statistics tools. Figure 1, shows that the research methodology for investigating the barriers, challenges, and application for implementation of the lean manufacturing practice.

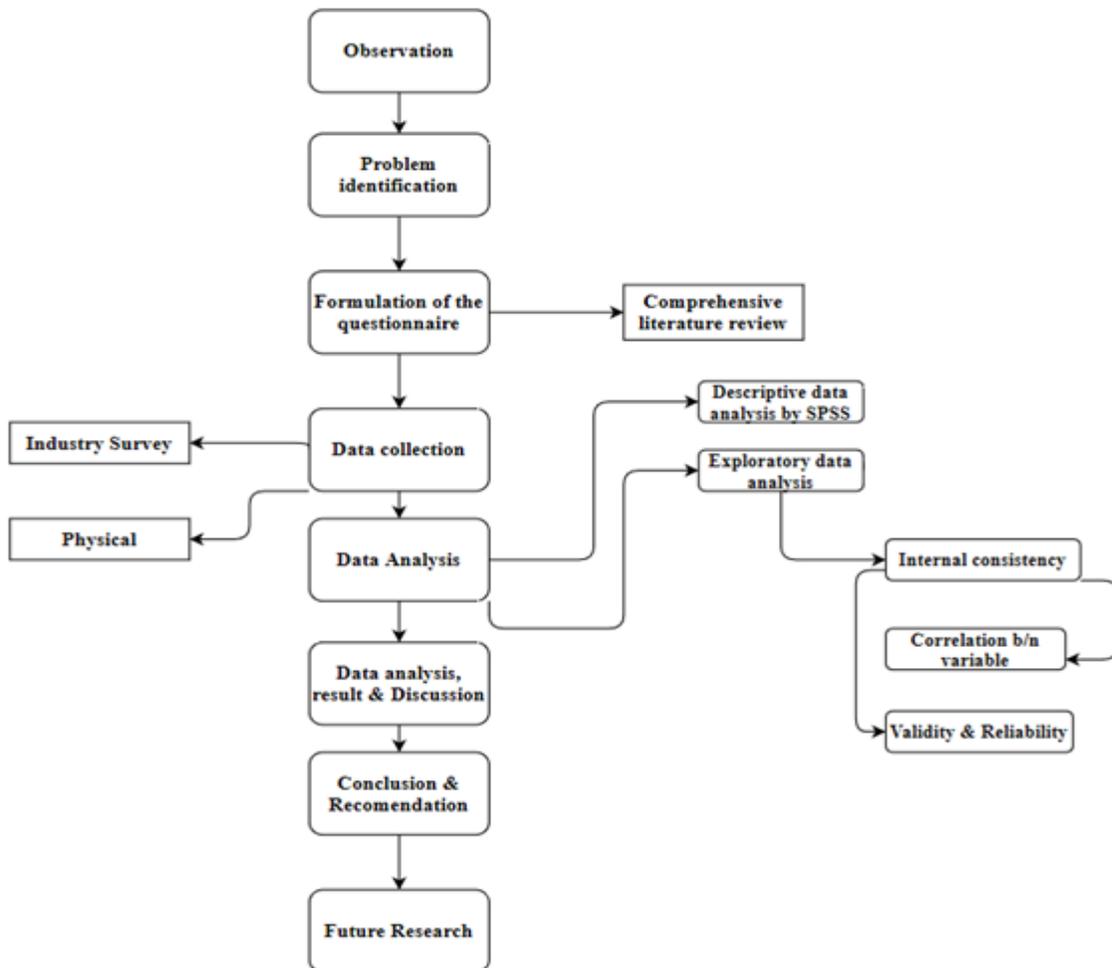


Fig.1 Research methodology flow diagram

4. Result and discussion

4.1 Validity and reliability

According to the classical Cronbach alpha quotation, Cronbach (1951) identified thousands of studies that must deal with accuracy or reliability based on measurement [29]. All constructs have a Cronbach's alpha coefficient greater than 0.7, indicating a virtuous level of reliability [30]. The present study uses the Cronbach analysis procedure to investigate the reliability analysis for wastes, implementation barriers, and applications of lean tools. Detailed analysis of Cronbach analysis relating to reliability aspects of collected data is discussed in the following sections.

4.1.1 Reliability Analysis for Challenges of wastes

The challenges of wastage during the application of lean in the basic metal industry were investigated using questionnaires distributed to 36 respondents. Based on the responses, the value of Cronbach's alpha was calculated for all ten questions to measure the internal consistency and validity of the data. Figure 2 shows that the value of Cronbach's Alpha is 0.820 which is greater than 0.7, indicating that the data is consistent. The collected data has a high level of reliability and it can be used for performing research analysis.

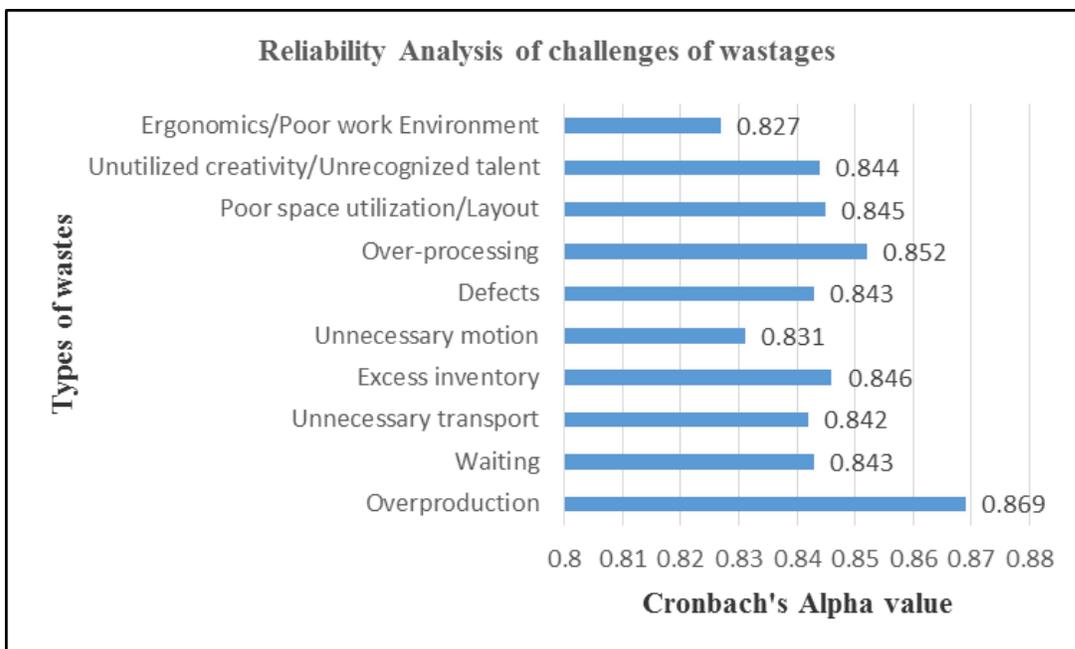


Fig.2 Reliability analysis of challenges of wastages

4.1.2 Reliability Analysis of Barriers

The barriers in industries during lean manufacturing implementation in basic metal industry questionnaires were distributed to 36 respondents based on the response, and Cronbach's alpha value was calculated for 12 barriers and 49 independent variables to measure the data's internal consistency and validity. The implementation barriers of lean manufacturing and the corresponding Cronbach coefficient are given in Table 1. The analysis is carried out as per Cronbach coefficient values of different implementation aspects shown in Table 1. From the Table 1, it is observed that the value of Cronbach's Alpha is 0.920 and which is more than 0.7, indicating that the data is internally consistent, and the results may expect to be reliably rich.

Table 1. Reliability Analysis of Barriers

Barriers	Independent variables	Cronbach's Alpha if Item
Strategy	Lack of management involvement	0.923
	Unclear objective	0.922
	Short term vision	0.923
	Poor decision-making process	0.922
Technical	Insufficient structure system	0.923
	Absence of time and financial resource	0.921
	Reduced service and layout configuration	0.921
	Lack of understanding of the method	0.920
Organization Culture	Lack of skilled human resource	0.922
	Fear and change resistance	0.922
	Deficiency of proper exercise for workers	0.923
	Shortage of empowerment of employees	0.921
Market-related	Instability in the manufacturing schedule	0.921
	Shortage of influence over suppliers	0.921
	Lack of external support from the Gov't, suppliers, customers, and consultant	0.920
Knowledge	Lack of adapted methodology	0.923
	The practice of wrong tools and methods	0.923
	Lack of understanding of lean	0.923
	Lack of guidance and information	0.922
	Lack of an improved measurement system	0.923

People related	Lack of perception and knowledge	0.921
	Negative staff attitudes	0.923
	Lack of top management support	0.923
	Backsliding to the old ways of working	0.922
Employee's skill & expertise	You completed lean practices training to a satisfactory level.	0.923
	Newly hired employees receive adequate training to familiarize them with lean practices.	0.921
	Your team members have enough experience in the use of lean practices	0.919
	lean practices significantly impact the lean implementation process	0.922
Economic	The management allocates sufficient resources to help implement and maintain lean practices.	0.924
	The company's executives want to fund lean practices.	0.923
	Shortage of financial support, lean projects, or practices is not abandoned.	0.922
	Financial capability significantly impact the lean implementation process	0.922
Top management support	Have you enough top management supports?	0.923
	Top management responds to employee suggestions and encourages them.	0.924
	Top management effectively involves and motivates employees in the lean implementation process to overcome lean barriers.	0.924
	The support of top management has a significant impact on the lean system's implementation.	0.923
Effective communication system	Employees are invited to regular meetings to discuss issues, barriers, and information sharing.	0.924
	Just on the shop floor, employees are given timely access to relevant information.	0.924
	Sharing of information and communication with stakeholders are lacking.	0.919
management Leadership and style	The group leader is rotated among the team members.	0.922
	Employees are given clear guidance on how to practice lean by their managers.	0.923
	The management creates short term wins to motivate employees in the lean practice	0.924
	Employees throughout the organization are motivated and inspired to work toward a common goal by management.	0.922
	The lean implementation process is strongly influenced by leadership and management style.	0.922

Linking lean to the business strategy barriers	Lean is an integral part of the company strategy in the industry.	0.921
	Engaged personnel provides a clear vision, resources, financial allocations, responsibilities, and authority for lean implementation.	0.922
	The main performance measure for staff members is linked to lean tools and activities	0.921
	The connection between the business strategy and the lean implementation significantly influences	0.920

4.1.3 Reliability analysis of the application of lean tools

The use of lean tools in Ethiopia's basic metal industries is depicted in Figure 3. Based on the responses, the questionnaire was distributed to 36 respondents, and Cronbach's alpha value is calculated for all of the questions to measure the internal consistency and validity of the data. Figure 3 shows that Cronbach's estimate is above 0.950, which is greater than 0.7, indicating that the data in the analysis has excellent reliability.

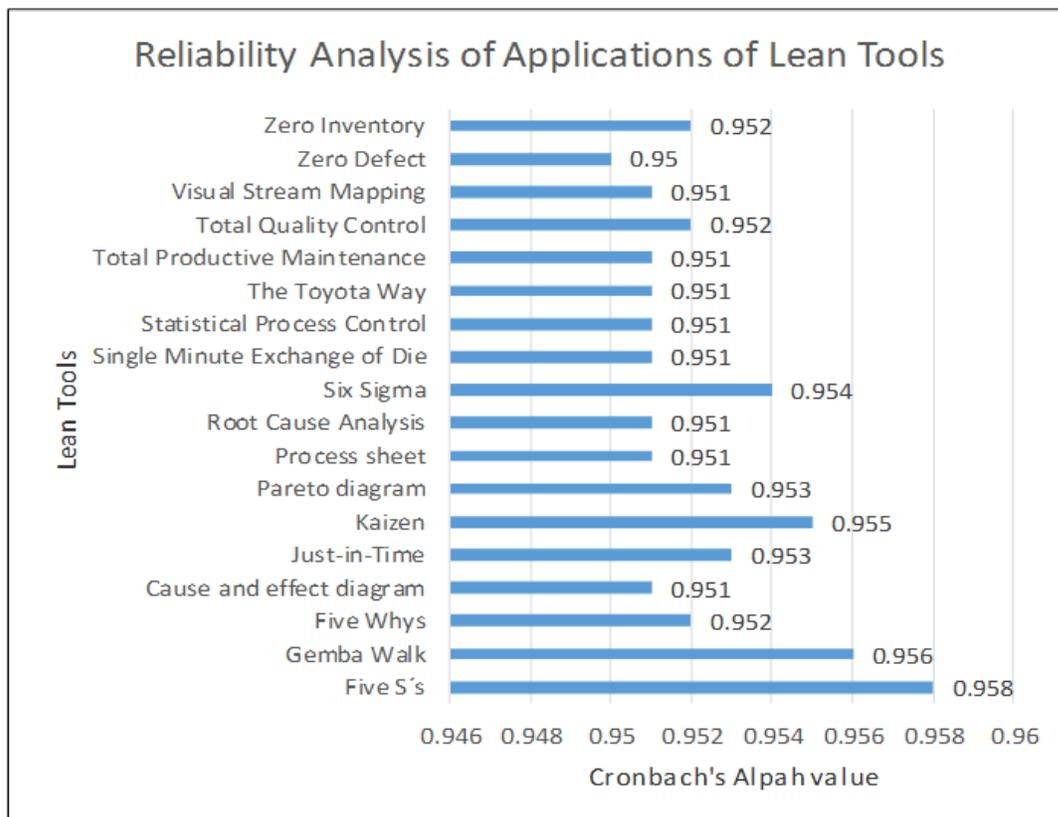


Fig. 3 shows Cronbach alpha value for use of lean tools in basic metal industries

4.2 Challenges of waste, barriers for implementation of the lean concept, and major applications of lean manufacturing

4.2.1 Challenges of waste

Although the concept of lean manufacturing appears simple, putting it into practice in Ethiopia's basic metal industries is a difficult task. The current priority challenges in the basic metal industries are depicted in Figure 4. Waiting has been identified as the first challenge in lean manufacturing implementation, with a mean of 3.19, unutilized creativity as the second challenge, with a mean of 3.14, ergonomic/poor work environment as the third challenge, and unnecessary motion as the fourth challenge, with a mean of 3.00.

When lean manufacturing is properly implemented, it can result in a variety of positive changes in the organization, including improvements in quality and safety. Production quality is improved using lean manufacturing techniques. It also improves everyone's working environment's safety. By employing lean tools, they can even avoid minor risks of errors in the processes and methodologies used in the workplace.

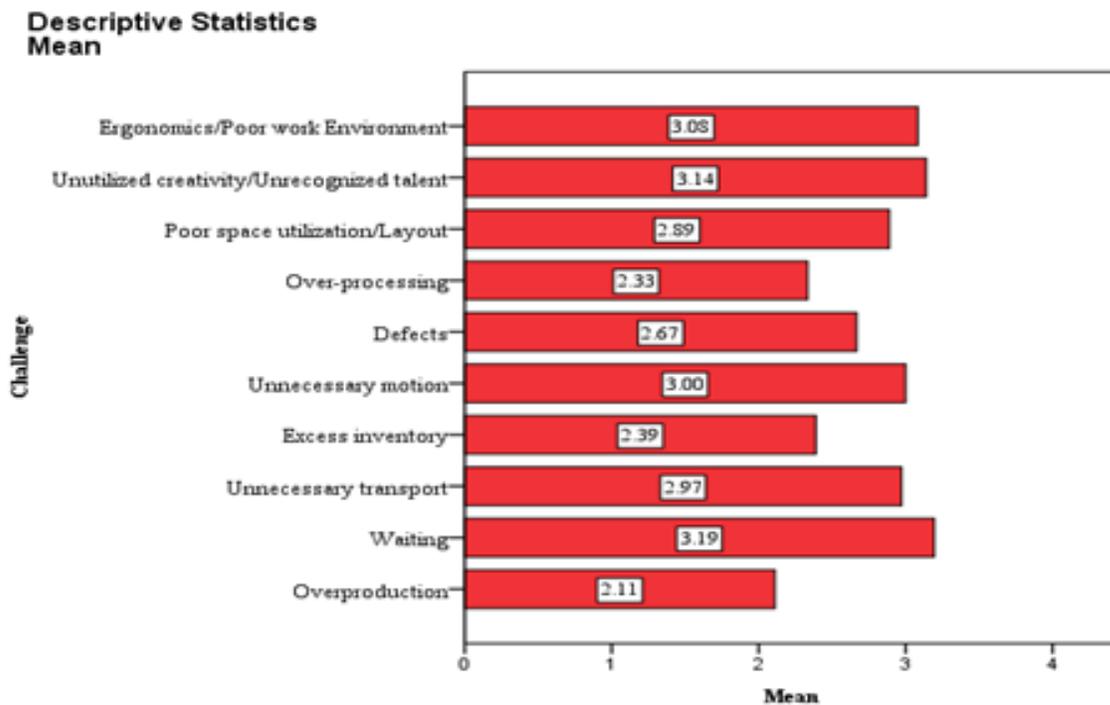


Fig.4 Challenge of wastage

4.2.2 Barriers of Lean manufacturing

The barriers to the implementation of lean manufacturing are drawn from the data collected from respondents and shown in Figure 5. Figure 5 shows the investigation and analysis of the barriers to lean implementation practices by ranking them based on the “mean method”. The outcomes of the respondents' responses are depicted by the bar chart in figure 5. The results observed with the present conducted survey set the first knowledge barrier (KB), with a mean of 3.71, the second organizational culture barrier (OCB) mean value 3.57, the third strategy barrier (SB) mean value 3.56, the fourth people-related problem (PR) mean value 3.4, the fifth market-related (MR) mean value 3.29, the six technical barriers (TB) mean value of 3.17, the seven effective communication (EC) mean value of 3.13, the eight links lean in business strategy (LLB) mean value of 3.13, the nine top management (TM) mean value of 3.06, the ten economic barriers (EB) mean value of 2.99, eleven employees skill barrier (ES) mean value of 2.99, twelve leadership style (LS) mean value of 2.76.

Lean implementation barriers in Ethiopian basic metal industries are identified using various testing techniques and ranked according to their problems in this study. From the Figure 5, it is noted that the knowledge barrier is the most influential task to implement the lean concept in basic metal organizations, next is the organizational culture barrier (OCB) and followed by others.

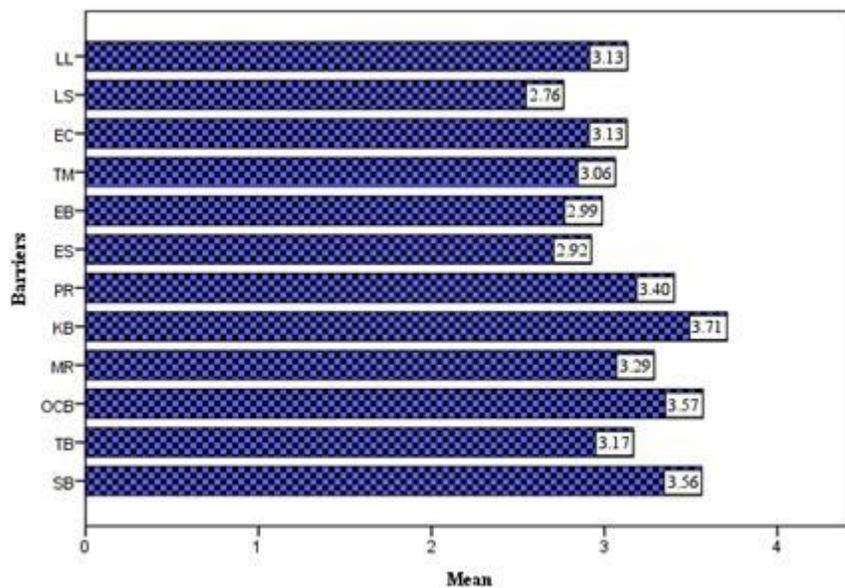


Fig.5 Barriers of lean manufacturing

4.2.3 Application of Lean tools

From the data of respondents for the adoption of applications of lean tools, the statistical chart is drawn and shown in Figure 5. From Figure 5, it is found that kaizen has the highest implementation of lean tools and methods with a mean value of 3.64, while total quality control has a mean value of 3.17, Five Whys a mean value of 3.17, and the lowest mean value is 2.5 with Zero defects. Hence, Figure 5 also shows that some lean tools, methods, and principles are very likely to be implemented in the Ethiopian basic metal industries as compared to others. Lack of employee training, clear instruction, changing employee mindset, and little awareness about lean concept and principles are the reasons for which low scoring lean tools like six sigma, root cause analysis, just in time (JIT), etc., and these are some problems faced by basic metal industries when implementing lean tools.

The benefits of implementing lean tools, such as eliminating waste, cost reduction, customer satisfaction, productivity improvement, and having a better and safer working environment, are agreed upon by the respondents. The survey revealed that the basic metal industries recognize the need for lean manufacturing techniques to remain competitive in today's global market. The survey is also confirming that most of the top management in the basic metal industries are very supportive of lean implementation initiatives to enhance productivity and consumer satisfaction levels.

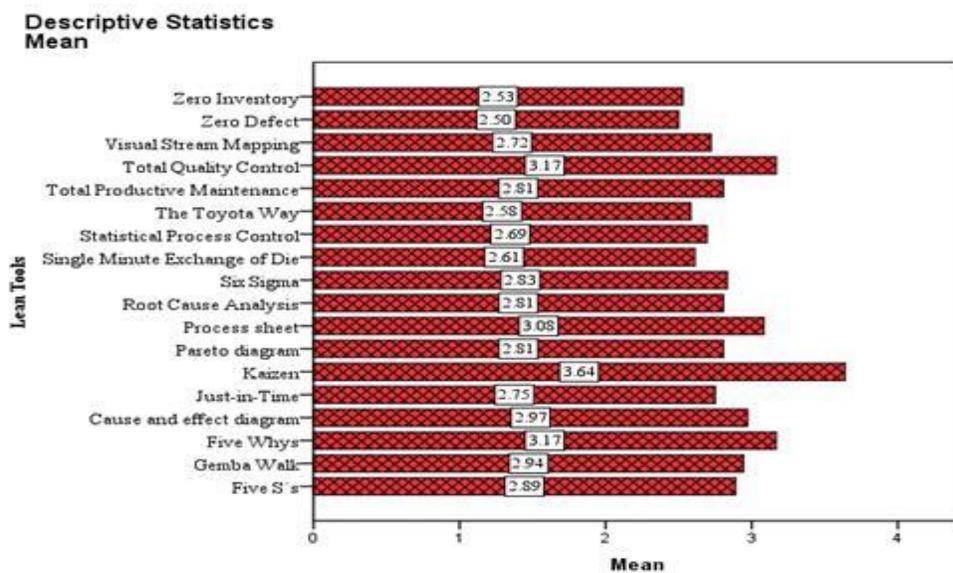


Fig. 6 Application of Lean tools

4.3 Discussion on critical issues relating to waste, implementation, and applications of lean manufacturing

The research finding described to waste, challenges, barriers for adoption of lean manufacturing, and applications of lean practices to improve organizational excellence in Ethiopian basic metal industries. Important discussions are given below about the stated research study.

The wastages in different forms like waiting, unnecessary transportation, unnecessary motion, and producing defective products required to be eliminated or minimized as much as possible to increase the overall efficiency of industry by the adoption of lean manufacturing to achieve better productivity levels and high-quality parts[3]. The higher management authorities are essential to be aware of the degree of their involvement in decision making, acquiring high skilled human resource people, providing sufficient training to the workers/employees. Production managers should focus on developing efficient organizational structure and effective facility and layout configurations by giving sufficient information and time for technical employees. Providing employees with lean training and cultivating an improvement culture can aid in the implementation of lean in a simple and long-term result-oriented manner.

The primary responsibility of management needs to initiate the implementation of lean ideology for seeking organizational change for reaching the next levels of manufacturing excellence. The positive attitude of employees is a key element for successful implementation of lean and that needs to habituate by management through providing proper training sessions. The support from Federal government agencies, suppliers, consumers, and other consultant groups are also playing important roles in the implementation of lean manufacturing by eliminating existing manufacturing procedures. Correct measuring tools and methods need to be incorporated in lean manufacturing with appropriate training for gaining better manufacturing excellence.

5. Conclusion

The followings are the summary points drawn from the present study and analysis:

- i. Lean manufacturing concept is discussed elaborately by seeking improvement to basic metalworking organizations in Ethiopia
- ii. Three important aspects of lean that identification and elimination of different forms of waste, implementation barriers of lean and finally applications of lean tool are discussed.

- iii. Innovative ideology of the lean manufacturing concept can help to enhance the quality of product with maximized productivity and minimized waste and production costs.
- iv. Lean is also enabled to establish continuous improvement of work that invites the timely review of processes which helps to the creation of high-quality products to the consumer with fewer expenses.
- v. Survey results revealed that the lean concept is well known in many metalworking industries
- vi. From the study, it is noted that kaizen and TQM are more likely to help to enhance industrial excellence in basic metalworking for organizations in Ethiopia as compared to other lean tools
- vii. The outcome of this study would help for effective lean manufacturing practices, challenges, barriers, and application of lean tools to improve productivity, wastage, and quality of products and customer satisfaction for Ethiopian basic metal industries.
- viii. Based on the study and analysis, it is understood that industries that are interested to initiate the awareness about the lean concept, seeking help from top management to start adopting lean manufacturing in the organization and develop effective communication strategies to transform traditional manufacturing policies to lean ideology.
- ix. Systematic implementation of lean manufacturing practice requires continuous improvement time, finance, and commitment from every employee.
- x. Present research contributes to closing the gap in existing Ethiopian basic metal industries by implementing lean manufacturing practices to eliminate waste, improve productivity, quality, and customer satisfaction for efficient and competent metal industries in the global market.

8. Recommendation

Primarily based on the results and conclusions researcher has recommended to:

- Understand the aim of lean manufacturing practice, principles, and techniques for the betterment of the organization.
- Industries need to change their attitudes and working culture from looking for individual benefits to the industry's benefits.

- Practice lean tools, principles, and techniques, by involving employees and customers. These efforts make all employees feel accountable and involved in implementing these practices.
- Implement an appropriate IT infrastructure to manage their information systems to fulfill the gap in communication between the management, employees, customers, and industries.
- Conduct regular induction/training programs about lean manufacturing concepts by collaborating with universities, industry experts, and consultants to provide reliable training resources to all industries.
- Allocate motivational awards, effective training, and work instructions to perform the task in Zero defect that makes best efforts to apply lean manufacturing practices.

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