Implementation of Lean Tools and Techniques in Footwear Industry– A Case Study

By

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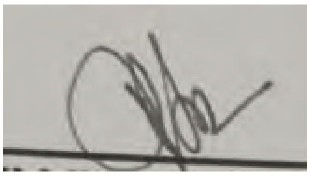

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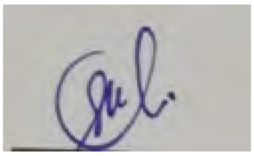

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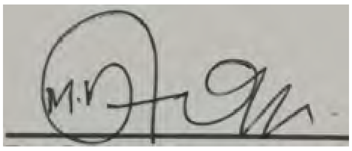

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DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Kaowsar Ahmed

This work is dedicated
To my beloved

Father
&
Mother

Table of Contents

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

The principle of Lean is to eliminate the waste from the system. The purpose of this study is to explore Lean implementation in manufacturing sector, especially in footwear manufacturing sector, by focusing on Lean tools and techniques, as well as critical success factors and challenges of Lean implementation.The work presented here is done in a large scale industry which engaged in making of shoes. The company produces variety of shoes according to the customer requirement. As the customer's demand is high quality with shorter delivery time, the firm has to increase productivity. This work takes initiative to implement lean tools and techniques to improve the work process in order to meet the customer demand. The study examined the problems associated in the shoe production in the perspective of work study which can reduce the production time, operation time and eliminate different types of wastage in the production process.

Improvement in the production procees, reduction of the production cost, and controllable production lead times are the expected result. Thus, the focus question was; "how could lean tools and techniques be applied to solve the manufacturing process problems of the footwear indstries ?"Relevent data were collected via observations and interviews. Production processes and process mapping were identified. Detailed production activities were analyzed and categorized into three groups: value added, non-value added, and non-value added but necessery activities. The non-value added activities were removed from the production process through a proposed a new production layout, with consequent lower production cost and controllable production lead times. The results indicate that lean manufacfuting concept could be efficient and efficiently solve the production problems of the footwear industries.

Chapter-1

Introduction

1.1 Introduction

Lean Manufacturing has become a subject of the attention for many manufacturing organizations. Manufacturing organizations are facing global competition by means of changing customer requirements, smaller order size with model mix, shorter product life cycles and fast delivery requirements put forward by global customers **[Womack et al. 2004]**. Lean Manufacturing is an important management subject, which emphasis on reducing waste in the process, working with lower inventories, avoiding unnecessary investment and strengthening the overall business by reducing of non-value adding activities **[Nordin et al. 2010]**. Lean Manufacturing has the ability to reduce the manufacturing lead time, trim down manufacturing costs, reduce material handling and get better quality. It also creates a region of reduced wastage, and shortened delivery time with lower product costs with enhanced customer satisfaction and supports other improvements, which can help companies meet competitive goals **[Taj and Morosan 2011].** The intention of Lean Manufacturing is to help organization provide the highest values to customers **[Shah and Ward 2007].**

Lean Manufacturing is well accepted approach, which has gained the admired position among industry based on measurable benefits accomplished and published by practicing manufacturing organizations. Lean Manufacturing can be effectively implemented across several disciplines. Lean manufacturing may be defined as a manufacturing philosophy, which focuses on delivering the highest quality product to customer on-time and at the lowest cost. The essential transformation in manufacturing can be achieved and sustained with the retention and utilization of people's knowledge within the organizations. Positive changes with LeanManufacturing Systems can be continued with a de-centralized knowledge and role-specific approach. This approach can be useful in identifying suitable procedure of knowledge management. Researchers presented management of knowledge as a matter of prime significance in Lean Manufacturing environment **[Liker and Meier 2006].**

Lean Manufacturing has been into practice for more than three decades but, still there is no established definition agreed by everybody. Lean manufacturing is directly associated with the elimination of wastes from manufacturing system to get better results in supplies, process time reduction and quality improvement. Plant not implementing lean manufacturing is likely to face performance issues in contrast with plants who have adopted Lean manufacturing in spite of age and size of the plant **[Shah and Ward 2003].**

Maintaining a customer focus is one of the most important elements in today's business market. Other elements such as money, resources and labor etc. are clearly important but in spite of the combination of all these factors, the wheels of an organization cannot moveif the customers are not satisfied **[Karim 2009]**. Customer requirements should get first priority. Traditionally, only getting orders and shipments were major concerns for firms. The evolution of marketing starts with only order taking and production and ends with customer orientation **[Skinner and Ivancevich 2002].** Firms are now more concerned about customer satisfaction because they have now more options than before. Customers are now demanding a wide variety of products at a lower cost but with fast delivery. They also expect more innovative products at a competitive price **[SAP AG2005]** as customers have more opportunities to choose from a variety of options.

Organizations have realized that survival is only possible through customer satisfaction, and satisfaction will come through quality goods and services with the lowest possible price. In today's competitive and changing business world, lean production philosophy has brought changes in management practices to improve customer satisfaction as well as organizational effectiveness and efficiency [**Karim 2009]**. The automotive and aerospace industries as well as a growing number of other industry sectors (Aberdeen Group, 2006) are responding to increased pressure by incorporating lean production strategies into their production processes, allowing them to compete in global markets. This manufacturing approach is opposite to the traditional approach which is characterized by economic order quantities, high capacity utilization and high inventory. Lean would replace mass and craft production in all industrial sectors, and will become the global standard for the production systems of the twenty-first century**[Womack et al. 1990]**.

However, companies cannot just implement lean and achieve success overnight because it requires a structured change program to reap the full benefits from this effort. Organizations introducing lean manufacturing methods have both cost and quality advantages compared to traditional organizations **[Fleicher and Liker 1997]**. The goal of lean is to satisfy the customer by delivering the highest quality at the lowest cost in the shortest time **[Manufactured Housing Research Alliance 2005]**. "Lean production is the end point of the process leading out of the Fordist Tailorist paradigm"**[Bartezzaghi 1999]**. Lean production places emphasis on the elimination of non-value added activity as well as waste from the production process. Evidence indicates that in the industrially advanced countries, non-value added activity could comprise more than 90 percent of a company's total activity **[Caulkin 2002]**. Taiichi Ohno, the co-developer of the Toyota Production System suggests that the non-value added activities account for up to 95 % of all costs in non-lean manufacturing environments **[Kilpatrick 2003]**. "Today lean may no longer be fashionable but its core principles (flow, value, pull, minimizing waste etc.) have become the paradigm for many manufacturing and (service) operations " **[Lewis 2000].**

The customized products such as footwear industry where customer's taste and choices change rapidly according to fashion dictates are known as labor-intensive products. Shoe making is neither an easy production system nor a simple business. It requires high skill and a lot of diverse knowledge in many aspects that may affect the quality, the appearance and the functions of a shoe. The significant thing is that it requires a lot of work which makes shoe making as a typical labor-intensive process.

The footwear manufacturing industry has a complicated production process and uses skilled workers. A common problem is inefficient of the production process that leads to a long lead time to deliver the product to the customers. Lead time is a very important aspect in managing the supply chain; especially in the downstream side since most customers do not want to wait a long for the product. Reducing the lead time gains competitive advantage, through sales and marketing share.

1.2 Objectives

The objectives of the present work are as follows:

i) To understand the application of Lean in footwear industry and to comprehend details of the approach taken for its deployment in any footwear industry.

ii) To examine the current production practices in footwear industry.

iii) To propose a Lean solution for footwear industries that would help them to overcome obstacles in delivering within shorter lead time by increasing productivity.

iv) Identify the total benefits derived from lean practices in footwear industry and evaluate the manufacturing performance of footwear industries in Bangladesh.

1.3 Methodology

The methodology would be as follows:

i) This study focused on work process and procedure involved in every department to identify the different types of wastage.

ii) Wastage calculation of various products /styles in different section of footwear industry (cutting, sewing and assembling / lasting)

iii) The causes of lower productivity and higher cost will be identified by lean tools and techniques.

iv) Considering existing bottlenecks, production line will be balanced and new manpower setup will be proposed after line balancing and final capacity of eachworker will also be reallocated. Finally, a new production layout will be initiated with smooth productivity.

The data required to be collected in this study are plant layout, process flow chart, details for each process and number of shoes produced in the specific period.

Chapter-2

Literature Review

2.1 Introduction

Lean concept was introduced firstly by Krafjick [**1988**] in the article "Triumph of the Lean Production System" in order to raise the idea of using less of everything to increase the efficiency and productivity in organizations. This means using less human resources, inventory, space, investment in tools and time spend to develop products **[Womack et al. 1990]**. Lean production is focused on identifying and eliminating non value activities in products and services in order to create value to customers. Lean is considered a set of management principles for production with the aim of reducing waste**[Lewis 2000]**. Lean involves different techniques of design, such as leadership to direct the process that involves multi-skilled employees; teamwork to assign workers from different functions in groups; communication to resolve critical design trade-offs and prioritize resources; and simultaneous development that involves a process with less tools, inventory and human resources **[Womack et al. 1990].**

Lean manufacturing is an important tool usedacross the industries in the recent scenario. At present the industries are facing a higher level of competition because of the globalization. In this context, to remain and compete in the market, companies need to deploy certain tools and techniques which are useful to the uplift their performance and to respond rapidly to the customer's needs. The fundamental concept of lean manufacturing is to provide a quality product while also ensuring that the product does not cost too much to the customer. In this paper an attempt has been made to present a review of the literature to identify the important and useful contributions to this Lean concept. Lean manufacturing utilizes a wide range of tools and techniques,the choice of tools is based on the requirement. Many parameters contribute success of lean. Organizations which implemented lean manufacturing have higher level of flexibility and competitiveness.

However, lean manufacturing provides an environment that is highly conducive to waste minimization.

The research papers related to Lean manufacturing from various reputed journals have been considered for the review. After doing thorough study of the Lean implementation, the results of the research papers considered for the review. The considered review papers have been grouped based on awareness about the lean, lean implementation, barrier and benefits of lean and performance. There are quite a good number of studies available in the body of literature focusing on the awareness and potential for implementation of lean tools in different sector. The one important such study is discussed below.

Roba Salem et al [2015]studied on the level of recognition of lean concepts, principles, tools, and techniques in different industrial sectors in Qatar, to assess lean awareness and to know the perception about lean benefits and lean challenges. Data were collected from 333 organizations from various sectors like oil and gas, academic institutions and service sectors through an on-line survey. Results showed that industries in Qatar need to give more credit to lean thinking in order to strategically advance current efficiencies as well as cope with competition at global level. Research also reveals that there is a difference on the levels of awareness, recognition and appreciation of lean concepts in different industrial sectors.

Chaple [2014] investigate the enablers and barriers in implementing the Lean principles and lean diffusion in Indian manufacturing industries. Result shows that the trend in lean manufacturing for research now is focused on lean assessment. Leanness attracts focus to answer specific questions of different levels of managers responsible for lean implementation to assess the lean implementation level and to justify spending over lean implementation. He worked on multiple criterion decision-making (MCDM) for lean assessment to assess lean performance holistically & popularity of lean in India; but when it comes to success, its only start of journey. Other than automobile andelectronics industry, others are having medium to low diffusion of lean in India.

Chikhalikar and Sharma[2015]study focused on theimplementation of the lean in the engine manufacturing unit in India. Research identified the important lean tools and time horizon to implementthe same. Study revealed that following factorseffects on lean implementation they are 7 Types of waste, Lack of information transmission, Improper inventory management, Bottleneck operation, Material flow and transportation problem, JIT, Kanban, Kaizen, TPM, 6 sigma, 5S, Single Minute Exchange of Die.

Kumar and Kumar [2015]conducted a study to establish the significance of Lean Manufacturing elements related to Indian manufacturing industry, study also list the benefits gained, major obstacles faced- and identifies the adverse impact such as over cost cutting, exceptionally low inventories, over dependence of Lean guideline, physical and mental health, society, product quality.

Chowdhury et al[2015]conducted a study to improve the productivity of the furniture manufacturing industry in India. Various lean strategies such as Single Minute Exchange of Dies (SMED), Gemba (The real place) and Short Interval Control were implemented. Result revealed that significant improvement in both monetary terms and also in reduction of processing time of different lots. Study also reveals that Overall Equipment effectiveness increased in a higher multifactor productivity of 2.26. It was realized through this study that lean strategies can successfully be implemented in furniture manufacturing industry.

Larteb Youssef et al [2015]study identified that success parameters of lean implementation are top management engagement, commitment, allocation of time and resources for improvement projects, strong management's leadership, and employee‘s development program. Study used a structure questionnaires, it includes seven parameters of lean implementation they are-

- Personalized demarche
- Top management commitment
- Allocation of resources
- Strong communication
- Structural methodology
- Multifunctional teams
- Continuous performance measurement.

Verma and Sharma[2015]conducted a study to identify waste related problems like cause of equipment failure, bottleneck problems and rectify them in lean manufacturing implementation in small scale industries. Process was analyzed in concern with rejection control, inventory control, waiting time, set time and eliminating non value added time / activities. In this study no new machines were purchased nor were operators expected to work faster or harder, only procedures and layouts were changed to allow the product to flow more smoothly through the manufacturing process.

Nordin et al [2012] research identified themain reason for failure of implementation of Lean manufacturing is due to the letdown in managing the change process during a lean manufacturing transformation, organizational change management.Serve as the basis for further empirical research and validation. Provide practitioners with a better understanding of lean transition and unambiguous guidance, and/or tools to minimize the resistance and conflicts of implementing a lean manufacturing system. In the present research 11 critical factors were studied, and proposed framework oforganizational change is intended to provide practitioners with a better understanding of the lean transition and a clear guidance to minimize the resistance and conflicts for the implementation of lean and thus improves its chance of success.

Karim and Arif-Uz-Zaman [2013]conducted a research to develop an effective methodology for implementing lean manufacturing strategies and a leanness, the methodology are adopted for the present study they are Production and process details, Lean team study, Performance variables. VSM and MTM (Method Time Measurement) together and offered a new approach to reduce lead time and to measure productivity based on Lean principle and standardized processes.

Hodge et al[2011] conducted a researchto identify lean tool for textile industries to eliminate waste and non-value added activities in US to enhance the customer satisfaction, Author identified the following barriers for implementing lean manufacturing they are resistance to change both shop floor employees and management; shop floor employees are reluctant to offer suggestions for improvements; disconnect among marketing, sales, product and development; shop floor personnel are not native English speakers; so training needs to be multilingual.

Storch et al [1999] paper deals withlean production of ship requires continuous and uniform process flows, build strategies must be established and followed which reflect the proper work breakdown, especially block breakdown, even at the expense of design convenience (design for manufacturing) .It involves integration and balance between hull, outfit, and painting work; facilitation of continuous and uniform work flows within manufacturing levels; maximum use of grouptechnology advantages. Three metrics are proposed to monitor lean process flows in ship production are –

- Work-in-process (WIP) inventory level
- Levelingfactor index
- Throughput

Marodin et al [2015]Study reveals, there are seven factors that affect the use of Lean Production (LP) practices in Manufacturing Cell (MC), and they are-

- The reason for adopting LP
- The experience of the company with LP
- The need for involvement of the supporting areas in some LP practices
- The interdependence of some practices
- The variety ofproduct models produced bin the MC
- The synergy between LP and MC attributes
- The size of the equipment used in the MC

Qualifying attributes for LP in MC are -

- Team work and leadership (TWL)
- CI-continuous improvement
- MCT- Multi functionality and cross training
- WAU-Worker's autonomy
- STW-Standardized work
- WHK- Work place housekeeping
- PULL- Pullproduction
- SPR-Smoothed production
- QST-Quick setups
- TPM
- LME-Lean Performance Metrics
- VPC-Visual management of production control
- VQC-Visual management of production control
- EQA- Equipment automation
- ONE-One piece flow

- VISVisibility and information exchange
- LSS-Layout size and shape
- ODF-Organization by the dominant flow

Dorota Rymaszewska[2013]the drive of this research is to identify the lean manufacturing implementation challenges in small and medium enterprises (SMEs). By comparing the different manufacturing environments as well as organizational characteristics, the potential challenges of lean adoption are outlined. Doing more with less. Compares between the two industries of boat and furniture. Also considers internal operations/ like Standardization, Material replenishment, Work load leveling, QA, Visual control, Reliable Technology. Research identifies Influencing factors as philosophy, know how, Employee relations, communication, financing, value creation, organizational learning, Hijunka and JIT, and Internal implementation facilitating/ reinforcing factors are communication, partner/suppliers andquality. He adds-

- The challenge of long term orientation
- The challenge of becoming a learning organization
- The challenge of leveling out workflow
- Supplier buyer relations and JIT
- Employee empowerment and standardization of the work procedures. The validity of the findings can be improved by adding more empirical evidence.

Vinodh et al [2011]the purpose of this research is to analyze lean manufacturing practices in different industries and to identify the critical factors for its success implementation. A Structural EquationModelling technique is used to build themeasurement and structural models. Later, statisticalestimates are used to validate the model that has been built. For data collection a questionnaire was prepared based on four enablers, namely management responsibility leanness, manufacturing management leanness, manufacturing strategy leanness, and technology and workforce leanness. The current study also calculated the R2 value, which also indicates a good deal of influence yielded by management responsibility leanness, manufacturing leanness, manufacturing strategy leanness, and technology and workforce leanness on organizational performance. Finally totally committed management, highly trained, motivated and empowered employees working in a team. Internal integration of operations with suppliers and customers. Promotion of creativity and innovative culture. Streamlining of processes and waste elimination are the important parameter for lean implementation.

Dave et al [2015]study deals with Lean Construction along with information and communication systems. Study reveals that by adopting techniques such as process modeling, lean principles and process analysis techniques, the manufacturing industry maintains a well performing process. Process standardization across the industry will highly effective and efficient.

Kumar and Kumar [2014] Study identified that though the implementation of lean manufacturing can improve the organizational performance, but still most of the Indian industries currently use as improvement tool instead of adopting this concept as a culture. If focus on full scale as organizational culture it can produce significant improvement overall performance. The principal implications are, Batch production method is replaced with one piece or single piece flow method, Scheduling is done at one point from where material is pulled throughout the value stream and rate of flow depends on demand from customer, There is lesser material in waiting for processing between work stations; hence work in process (WIP) inventory is reduced, Inspection becomes an integral part of production activities hence product is not waiting for quality approval from line inspector, Reference for manufacturing is changed from production and Supply to customer demand. Mainly Top management issues for lean implementation is also very important and top management policies and attitude towards lean implementation need some improvement in Indian industries. Research suggeststhe seven major attributed barriers of LPI are Management, Resource, Knowledge, Conflicts, Employee moraleand Financial and Past experience. Out ofthis Top management is rated 3.9/5 and others areless. Also suggests supposed to initiate theawareness and participation of senior leadership teamto create learning culture within the organization and develop effective communication to organize transformation in the industry with the help of effective implementation of Lean Manufacturing.

Marodin et al [2014]conducted a research to classify the risks that affect the lean production implementation process and to demonstrate how that classification can help to identify the relationships between the risks. Researcher used multiple sources of evidence for the present study such as interviews, observations and documents analysis. In this study risks that affect LPI were grouped into three categories: management of the process of LPI, top and middle management support and shop floor involvement. Mainly classification and relationship between risks were given major importance. 14 risks were identified; the collected data was analyzed using an exploratory factor analysis (EFA). The limitations of this study should also be emphasized. First, it did not include external risks in LPI, but only internal ones. Second, it does not deal with two risk management stages: response and monitoring.

Sindhwani and Malhotra [2015]study reveals that, LI will improve the manufacturer and consumer relation by meeting the latest demand of consumers. Typical seven parameters like Overproduction, Processing Waste/over processing, Transportation, Waiting/delays, Inventory waste, Motion waste, defects are used. The tools and technique for eliminating wastes were- Pull system/KANBAN, VSM and 5S. By applying the lean and agile principles of one piece flow, pull system and value streaming the production rate of the lower frame was increased. The pull system utilized to understand that there is need to increase the production rate. VSM was done to identify the constraints and one piece flow to achieve the required cycle time.

Ciarniene and Vienazindiene[2014]research reveals the challenges and barriers to be faced and overcome while implementing lean concept. Lean enterprise or simply "Lean" is a practice, which regards the use of resources for any work other than the creation of value for the end customer, as waste, and thus a target for elimination. Research depicts the following three types of barriers they are the people issue, theprocess issue, the sustainability issue. Study suggested that first use the tools and techniques instead of sufficient consideration to personally related issues. Trust issue, human motivation and commitment are the real constraints. Secondly clearlyunderstood by top management maintained properly,thirdly, LI have to be incorporated into the company's strategy. Concluded remarks- specific value to the customer, VSM waste elimination, CI, continuous flow and pull driven system.

Roslin et al [2014]Studies suggests, LM approach does not allow these organizations to fully explore and exploit the system's effectiveness; neither do they experience any massive improvements when measured against LM success standards. Up to so many days pick and choose concept were used, The Obstacles of LMI Grouped into 3 levels, attitude of shop floor employees and middle management, Inability of quantify benefitsand Lack of top management/Senior management commitment. Conceptual model of full blown Implementation of LMS-Influence factors, Lean Manufacturing and Organizational performance. Here implementation difficulties, perceived barriers, work culture, monetary restraints, knowledge and its understanding at every level.

Patel et al [2015]LM can be considered as a business strategy and it has been proved to be an effective management philosophy for improving business by eliminating non value added waste and improving in process operations. VSM can be an extremely powerful tool, combining material processing steps with information flow as well as other important related data. Parameters used were Cost Rate, Material Cost, Duration (min), and Predecessors, its inter relationship between them with the money and time. Application of tools were-

- Process activity mapping
- Demand amplification mapping
- Quality filter
- Production variety funnel
- Value adding time profile and related parameters.

VSM works in any of the sector such as hospitability, manufacturing, service industry, automobile, machining and casting, transportation etc.

Rahman et al [2010]purpose of this research is to examine the extent to which LM practices are adopted by manufacturing organizations in Thailand and their impact on firm's operational performance. The operational performance is measured by four parameters such as quick delivery compared to competitors, unit cost of products relative to competitors, overall productivity and customer satisfaction. Results indicate that three constructs play a vital role- JIT, Waste elimination and Flow management. It identified 13 out of 21 practices as the lean practices such as:

(i) Reducing production lot size
(ii) Reducing setup time
(iii) Focusing on single supplier
(iv) Implementing preventive maintenanceactivities

(v) Cycle time reduction

(vi) Reducinginventory to expose manufacturing, distribution and scheduling problems

(vii) Using new process equipment or technologies

(viii) Using quickchangeover techniques

(ix) Continuous/one pieceflow

(x) Using pull-based production system/Kanban

(xi) Removing bottlenecks

(xii) Using error proofing techniques/Pokayoke

(xiii) Eliminate waste

Using multiple regression models the effect of LP on operational performance were investigated for both categories of firms – size and ownership. Companies appear to be maintaining a higher level of supply of materials and a higher level of finished products to satisfy both internal and external customers and are not totally becoming lean in their operations.

Mahmood[2014] research aims to provide a better understanding of LP approach in order to enhance productivity, reduce cost and maximize customer value while minimizing waste during the production processes. Productivity is a relationship (usually a ratio or an index) between output (goods and/or services) produced by a given organizational system and quantities of input (resources) utilized by the system to produce that output. The inputs areusually classified as:

- labor
- Capital
- Material (inventory)
- Energy.

Successful lean efforts are –

- Quality
- Cost
- Flexibility
- Delivery reliability
- Delivery time.

Other factors that makes lean more effective and related to strengthening the workforce's welfare, driving force, motivation and influence. Examples-Reduced stress, increased competence, improved cooperation, Reduced Frustration, Improved customer communication, Broader and more developing tasks, improved safety at the workplace, Job Security. People must be ready to change the whole organization, not only production lines, Sales, Logistics, Marketing, Product development departments will be affected by this change and if one of them does not follow, Lean will not sustain.

Herzog and Tonchia[2014] the results shows that the developed variables can be important both for understanding lean and measuring the degree of lean implementation within existing manufacturing systems. Research divided in to three phase

- An analysis of existing literature was made to determine the major dimensions of lean manufacturing
- Aquestionnaire was designed, pre-tested on experts and pilot- The questionnaire contained 59 items, designed according to the **Likert scales**, ranging from 'strongly disagree' to 'strongly agree'
- The resulting data were examined through reliability and validity analyses, and then analyze.

Three different types of validity are typically measured: content validity,criterion related validity, and construct validity. JITascribed to lean by four variables: the existence of ontime deliveries, cooperation of the suppliers, a reduced number of parts and cleanliness inside the plant. The other two variables are employee cooperation and team.

Chauhan and Singh [2012] research depicts about Elimination of waste, JIT, and CI. Driving parameters towards LM are vertical information system, integration of functions, decentralization, multifunctional teams, Pull, JIT deliveries, Zero defects, CI and Elimination of waste. JIT is top priority then CI. He follows SPSS (Statistical Package for Social Sciences) correlation method to find the importance of implementation.

Vamsi and Kodali [2014] research identifies the existing lean product development frame work that is useful in implement LMS. Researchers aredone validity and reliability analysis using questionnaire survey. Respondents are from Top and middle level management determined through Cronbach's alpha value. The LPD framework can be categorized under two broad areas are-

1. Researcher/academic-based
2. Consultants/experts-based.

The study has identified 40 elements from eight frameworks, which reflects these are playing an important role in the implementation of LPD frameworks.

Obeidat et al [2014] research identifies five types of waste are identified and analyzed in the sewing line with the aid of VSM: defects, inventory, overproduction, transportation, and waiting time. Applied lean manufacturing techniques include line balancing, layout redesign, and quality at the source. Impacts of implemented lean techniques on production are analyzed, and an improved future-state value stream map is developed. Results show approximately 96% reduction in production wastes in addition to 43% reduction in lead time. Here process measures must be defined and the cost of processing must be quantified. Line productivity is based on the number of line workers and product cycle time. To increase worker's productivity, calculates Line target, work station target and work efficiency will be done separately. Using this cost per hour calculates. Line balancing concept is test for each line, redesign of the layout will be done. LP without high investment in machining,technology and human training.

Ciemnoczolowski and Bozer [2013] research suggests, In LM, milk run (MR) systems represent route-based, cyclic material handling systems that are used widely to enable frequent and consistent deliveries of containerized parts on an as needed basis from a central storage area to multiple line sided deposit points on the factory floor a central storage area (the supermarket) to multiple line-side deposit points on the factory floor. Here Kanban with simulation method followed to work on bottleneck stages. If a single tagger does not meet the demand on a particular route, an alternative solution that is also found in practice is to add more taggers to the same route, which leads to the chase method. Thedynamic interaction between the taggers serving the same route, and their impact on WS starvation, would also be a promising avenue for future research.

Achanga et al [2005] research identified the critical factors that constitute a successfulimplementation of LM within manufacturing SMEs.Leadership, management, finance organizational culture and skills and expertise, amongst other factors; strong leadership and management permeatea vision and strategy for generating, while permitting a flexible organizational structure. Good leadership ultimately fosters effective skills and knowledge enhancement amongst its workforce. Form the available literature it is clearly concluded that some of the lean tool like Standardizing Work/ cycle reduction, Kanban, continuous smooth flow/ cell design, Value stream mapping, TPM/TPS,JIT, Kaizen, SMED-Single Minute Exchange Die, Poke yoke, Visual Management/Control are most commonly used lean tools across the various sectors. Table 2.1 depicts the frequency of different lean tools used by the organization.

Table 2.1 Lean tools studied by Researchers **[Achanga et al 2005]**

Tools	Number of Research papers	Tools	Number of Research papers
Standardizing Work/ cycle reduction	23	Cellular Manufacturing	7
Kanban	22	Cycle reduction	7
Continuous smooth flow/Cell design	19	Heijunka-Lead scheduling/ Reengineering Production Process	7
Value stream mapping	17	One Piece flow	6
TPM/TPS	16	FMS/PDCA	6
JIT	16	Batch size/Volume Reduction	5
5 S	16	Empowerment	4
Kaizen	16	Safety improvement program	4
SMED-Single Minute Exchange Die	14	Layout Improvement	4
Poke yoke	12	Takt time	3
Visual Management/Control	12	Cross training	2
TQM/ SQC/ Gemba/ QMS	12		--

Form the available literature it is clearly concluded that main benefits of lean implementation are Reduction ofwaste, Inventory reduction, Productivity, cost related parameters, Effectiveness etc. across the various sectors.Table 2.2 depicts the frequency of benefits of lean implementation identified by the different researchers.

Form the available literature it is identified that some for the barriers for the implementation of lean tools areManagement Involvement, Employee involvement, communication, Lack of training, culture issues etc. Table 2.3 depicts the frequency of different barriers for lean implementation identified by the researchers

Table 2.2 Lean Implementation Benefits **[Achanga et al 2005]**

Benefits	Number of Research papers	Benefits	Number of Research papers
Reduction of waste	24	Improve flexibility	5
Inventory reduction	19	Travel distance (Material movement)	3
Productivity	13	Lead time	3
Cost reduction parameter	11	Profit maximize	3
Effectiveness	11	Setup time reduction	2
Improve quality	10	Improved cash flow	2
Cycle time	9	Safety of working conditions	1
WIP	6	Internal promotion	1
Floor space	5	Efficiency	1

Table 2.3 Barriers for Lean implementation **[Achanga et al 2005]**

Barriers	Number of Research papers	Benefits	Number of Research papers
Management involvement	22	Past experience	7
Employee involvement	20	Resource utility	4
Communication	14	Knowledge	4
Lack of training	12	Budget	4
Culture issues	10	Scared of failure	4
Lack of know how	10	Conflicts	2
Financial	7	Improper utilization of potential capacity of worker	2

Lean is applicable for all the type of theorganization irrespective of their size, lot of work has been carried out in manufacturing sector that to in different functional areas, the level of implementation varies across the sectors and their size. It is evident from the research paper studied that Kanban, continuous flow and TPS are the most commonly used lean tools in the organization. The Reduction of waste, Inventory reduction and Productivity improvement are commonly cited benefits across the lean implemented firms. Apart from thismanagement of employee involvement are the most commonly cited barriers across the implementedorganization. These parameters are also componentof the quality of work life, so it can be concluded that QWL needs to be studied across the lean implemented firms in order to get higher light on the issue also to reveal the linkage between QWL dimensions with the lean implementation.

2.2 Challenges of lean implementation

Even though Lean has shown great success in manufacturing, there are challenges they face during implementation. It is hard to persuade workers in the organization to change their thinking in order to focus oncustomer value and waste identification, because they might be resistant to new tools, such as Lean**[Worley and Doolen 2006]**. Moreover, delivering smaller amount of parts will be difficult for suppliers to apply JIT concept. Also, customer order forecast might not be the amount of products they want, which cause an excess of inventory for organizations **[Womack and Jones 1994]**. The main challenge is the lack of standardized process within the service industry. It is more difficult to identify processes within the service, because they are not as evident as in manufacturing**[Sarkar 2009].** Also, due to the size and complexity, it is difficult for organizations to deal with processes to minimize the waste. Therefore, processes should be documented in order to keep track of the performance continuously. **[George 2003]** also emphasizes the importance of following a procedure to keep track of process for services. For example, in Bank of America, there is no documentation of the process, and when employees need something, they have to contact the person who has highest experience. Furthermore, **[Grove et al. 2010]** discuss the challenge of process variability in the health visiting service. It was hard to find fixed processes, which made it difficult to apply the value stream mapping and there were various stakeholders, who were not all supporting Lean principle. Beside these, there are other Lean challenges related to people, which lead to complexity of processes. **[Sarkar 2009]** emphasize that Lean should engage all people from organization. This involves strategic changes because of the hierarchy's barriers. It requires low level of organization to be more empowered as they are the ones working in the operation, who can identify the waste easier. Even **[Aherne 2007]** agrees that in the healthcare while implementing Lean practices, the main challenge is empowering and providing the relevant training to the staff. Another challenge is that employees cannot keep track of process since they are not able to measure the time needed for different work items as there is uncertainty in task completion **[George 2003].**This happens because employees have control over their structure of tasks, which is the reason why processes are hard to define in service industry. However, employees should be aware that working by standardizing processes will give them more freedom and empowerment, as well as they will receive information about change management **[George 2003].**Sarkar**[2009]** mentions the importance of managing employees' behavior and actions because Lean applicability depends on their mood in every day work; therefore, there isneed to avoid their mistakes in processes. Employees of NHS UK faced challenge because of lack of effective communication and leadership. There was no proper collaboration between middle managers and low level of organization, because they did not develop strategic planning on how to implement Lean **[Grove et al. 2010]**. Aherne**[2007]** also highlighted that in NHS UK, the challenge was to get the support from the government and support for the program from the management. Beside these, in service processes, the interaction of people has more significance, so they should not be treated as machines. For example, it is less complicated to reduce setup time in machine than reduce the time of call for sales employees **[George 2003].**

2.3 Footwear industry: An overview

Footwear is a traditional export item of Bangladesh. Footwear produced from high quality leather in the country enjoys a good reputation worldwide for their quality. The country, however, has a growing success in this sector. The business experts believe that export earnings from the sector could be substantially increased if we use advanced technology to produce high quality footwear. This, however, depends on adoption of appropriate policies on the part of the government and business community to develop the sector. The products must be improved to satisfy the quality requirements demanded by the consumers of the international market especially of the developed world. The low wage rate and poor enforcement of environmental laws and rules have given the country's footwear sector a comparative advantage in the world market. Moreover, the country enjoys duty exemption under the GSP (Generalized System of Preference) from the most of the importing countries of the developed world. Bangladesh also enjoys a reduction of Tariff and other non-Tariff barriers from WTO (World Trade Organization).While this provide an opportunity for a country like Bangladesh to boost up its export.

Defining Footwear

Footwear refers to garments worn on the feet, which originally serves to purpose of protection against adversities of the environment, usually regarding ground textures and temperature. Footwear in the manner of shoes therefore primarily serves the purpose to ease the locomotion and prevent injuries. Secondly footwear can also be used for fashion and adornment as well as to indicate the status or rank of the person within a social structure.

The upper

The upper is the part of a shoe, boot, slipper or other item of footwear that's above the sole. The upper doesn't include the tongue or any padding around the collar. If the upper is made of more than one material then you have to decide which material covers the greatest external area. You should ignore any accessories and reinforcements like Ankle patches, Edging and Ornamentation Buckles, tabs, eyelet stays and similar attachments.

The outer sole

The outer sole is the part of a shoe, boot, slipper or other item of footwear that comes into contact with the ground during use. The outer sole doesn't include any separate attached heel. To establish what the outer sole is made of, we have to identify the material that has the greatest surface area in contact with the ground. We should ignore any accessories and add-ons such as Spikes, Bars, Nails and Protectors and similar attachments.

Reinforcements

Reinforcements are parts such as leather or plastic patches that are attached to the outside of the upper to give it extra strength. They may or may not be attached to the sole. To be treated as reinforcement, an attached part must cover material that's suitable for use as an upper, not just lining material. If an attached part covers just a small area of lining material it's treated as part of the upper and not as reinforcement. So that we can be sure of classifying footwear correctly, it might be necessary for you to cut the external material to see what's underneath it and find out which parts are reinforcements and which parts make up the real upper.

Types of footwear

When we classify footwear it's important to identify what type of footwear it is and any particular purpose it might have. For classification purposes the upper is the part of the shoe that covers the sides and top of the foot. Some of the more common types of footwear are listed below:

- **Clogs** - usually the uppers are made in one piece and are fixed to the soles by rivets. Sometimes clogs are made in a single piece and don't have - or need - a separate, applied outer sole, in which case they're classified according to the material they're made from and not covered in this chapter.
- **Espadrilles** - these are also called beach shoes and have plaited fiber soles that are no thicker than 2.5 centimeters. They don't have heels.
- **Flip-flops** - these are also referred to as thongs. The thongs - or straps - are fixed by plugs that lock into holes in the sole.
- **Hiking or walking boots** - note that these aren't classified as sports footwear.
- **Indian sandals** - these have leather outer soles and leather uppers. The upper consists of straps that cross the instep and go around the big toe.
- **Moccasins (American Indian type)** - these use a single piece of material - traditionally soft leather - to form both the sole and the upper (or part of the upper). This makes it difficult to identify where the outer sole finishes and the upper begins.
- **Safety footwear** - footwear in which the toe caps are made of metal.
- **Sandals -** the front part of the upper (the vamp) consists either of straps or of material with one or more pieces cut out of it.
- **Shoes** - this term covers footwear, including trainers, that aren't described elsewhere in this guide.
- **Slippers -** these include mules as well as other indoor footwear such as ballet slippers and ballroom dancing shoes.

Parts of Footwear

There are some main parts of footwear what is depicted in Fig.2.1

Fig. 2.1 Parts of Footwear

Footwear manufacturing

Shoe manufacturing is most likely labor intensive process and it cannot be fully automated. It requires craftsmanship in each phase of the production. More than a hundred operations are required for making a pair of shoes. With the development of the footwear machines, the production time has been reduced and processes are performed separately.Depending on the type of shoes and material usage, the manufacturing process can vary. The footwear company has mainly five departments in which a progressive route is followed in order to produce the final product. These are; Technical Design, Cutting Department, Closing Department, Lasting & Making Department, and Finishing Department.

Footwear Industry in Bangladesh

The Footwear Industry in Bangladesh is at its early stage of development. There was no mechanized Footwear Industry in the country until early 1900's and the footwear manufacturing was limited to cottage and family level small factories. The first mechanized industry, Bata Shoe Co. (Bangladesh) Ltd., a multinational enterprise. Followed by Eastern Progressive Shoe industries and Bengal Leather which used to produce mainly for domestic supply. Indeed, the shoe industry started featuring in Bangladesh in 1990 with the introduction of encouraging government policy measures of granting fiscal and financial incentives for production of leather footwear in the country for export. There has been a rapid growth in footwear production capacity. Both complete leather shoes and sports shoes manufacturing for export during last decade. There are now about 150 Mechanized and over 2500 non-mechanized small and cottage level units in Bangladesh producing various types of footwear for both domestic market and export. Most of the mechanized units are export oriented **[Howlader 2016].**

Footwear Sector, as a sub sector of Leather Sector gets also priority from Government but this sector as well was ignored by the Government for many years. Now in the era of globalization, nobody can find an alternative of product diversification (export diversification). For this reason, government is now started looking after Footwear Sector rather than Jute and Tea.

Growth in exports is due to the low production cost in Bangladesh compared to its neighboring countries: China, India and Vietnam, who also have a very well entrenched leather and footwear export industry. Orders which earlier used to be given to China or India are now being handed out to footwear manufacturers in Bangladesh because they can produce low-priced but quality shoes, which have now found its way in to key markets in EU and Japan **[EPB 2016].**

2.4 Fishbone Diagram

A fishbone diagram, also called a cause and effect diagram or Ishikawa diagram, is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes. Typically used for root cause analysis, a fishbone diagram combines the practice of brainstorming with a type of mind map template.A fishbone diagram is useful in product development& manufacturing and then troubleshooting processes to focus conversation. After the group has brainstormed all the possible causes for a problem, the facilitator helps the group to rate the potential causes according to their level of importance and diagram a hierarchy. The design of the diagram looks much like a skeleton of a fish. Fishbone diagrams are typically worked right to left, with each large "bone" of the fish branching out to include smaller bones containing more detail.

Dr. Kaoru Ishikawa, a Japanese quality control expert, is credited with inventing the fishbone diagram to help employees avoid solutions that merely address the symptoms of a much larger problem. Fishbone diagrams are considered one of the seven basic quality tools and are used in the "analyze" phase of Six Sigma's DMAIC (define, measure, analyze, improve, control) approach to problem solving.

Chapter-3

Data collection and analysis

3.1 Process Mapping

The current process mapping starts from the beginning of the process when the customer places an order, to the end when the order is delivered. The production process is sequential, step by step: next step can be started only when previous step is completed. The process mapping for a footwear industry is shown in Fig. 3.1.

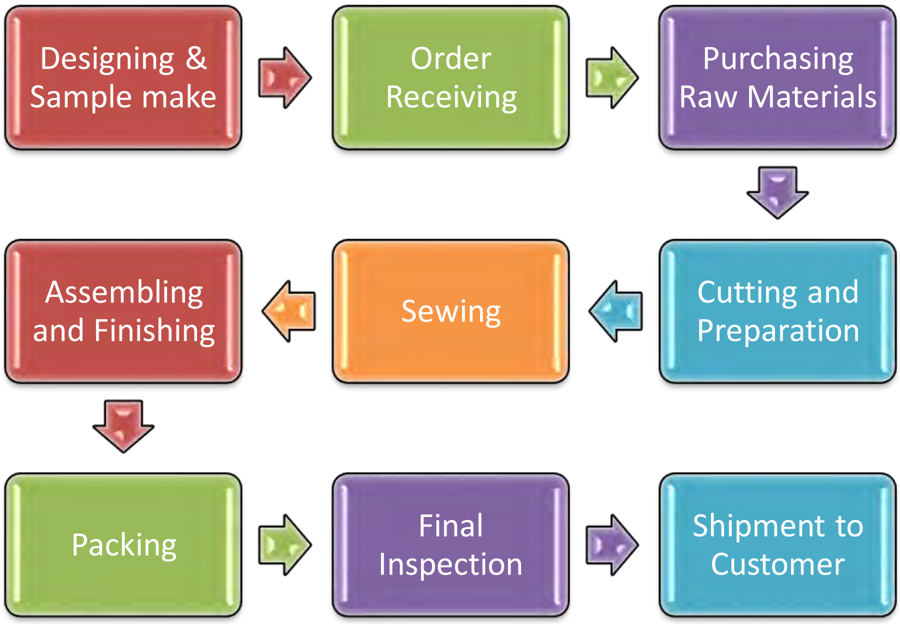


Fig. 3.1 Process mapping of a footwear manufacturing plant

Observation in the production process of under studiedfootwear company reveals that unnecessary activities are causing the problems, and therefore lean manufacturing strategies are applied, as it focuses on reducing and removing all waste.To get manufacturing efficiency, a company must have an appropriate production process layout, planning and control. The wastes are identified in cutting and preparation department by analyzing the existing process mapping of cutting and preparation department as shown in Fig.3.2.

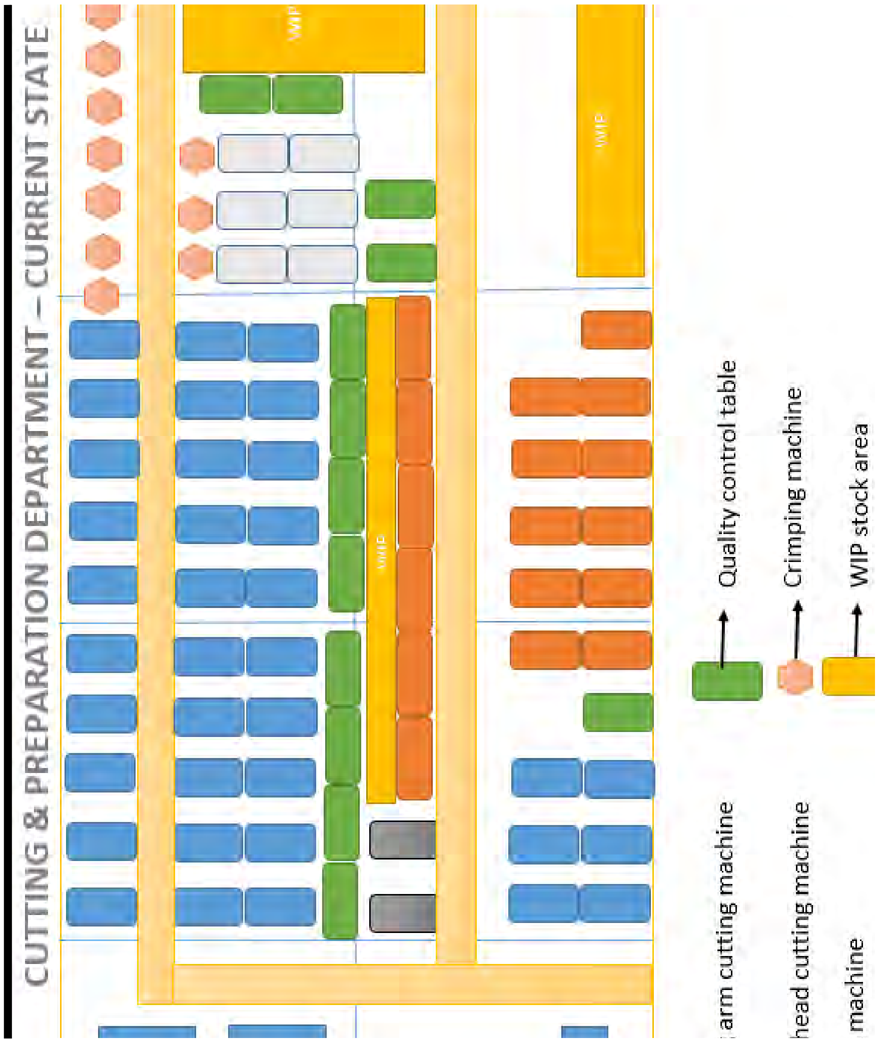


Fig. 3.2 Existing process mapping of cutting and preparation department.

Wastage analysis in cutting and preparation

The machines and work stations are not setup properly. There are a lot of motion wastage in this department. Cutting components are carried one work station to another station through basket. Sometimes workers become confused if this basket is prepared from previous process or not. BelowFig 3.3 shows the components movements from one work station to another work stations.Fig 3.3 shows new process mapping.

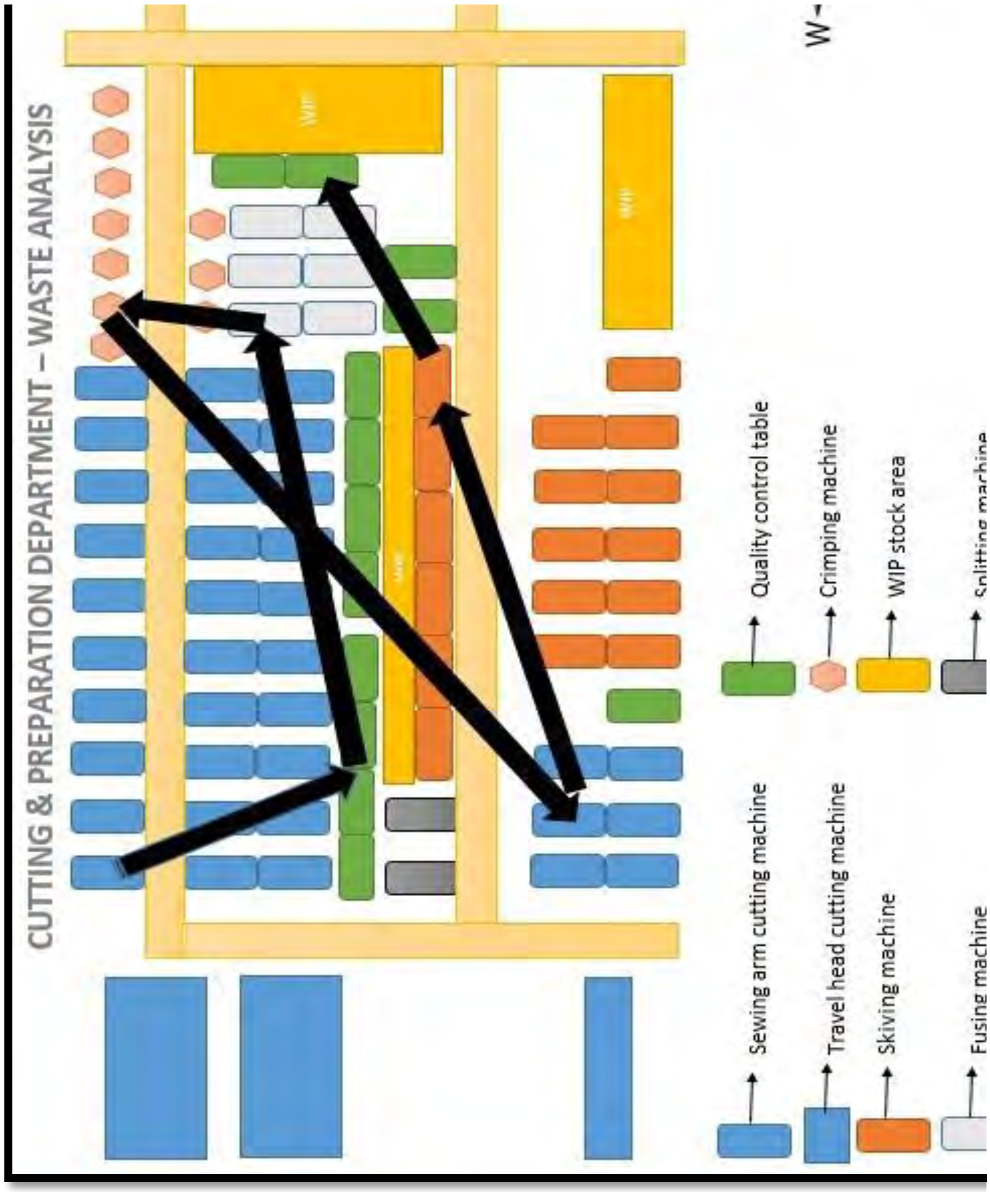


Fig.3.3 Waste analysis of current process mapping of cutting department

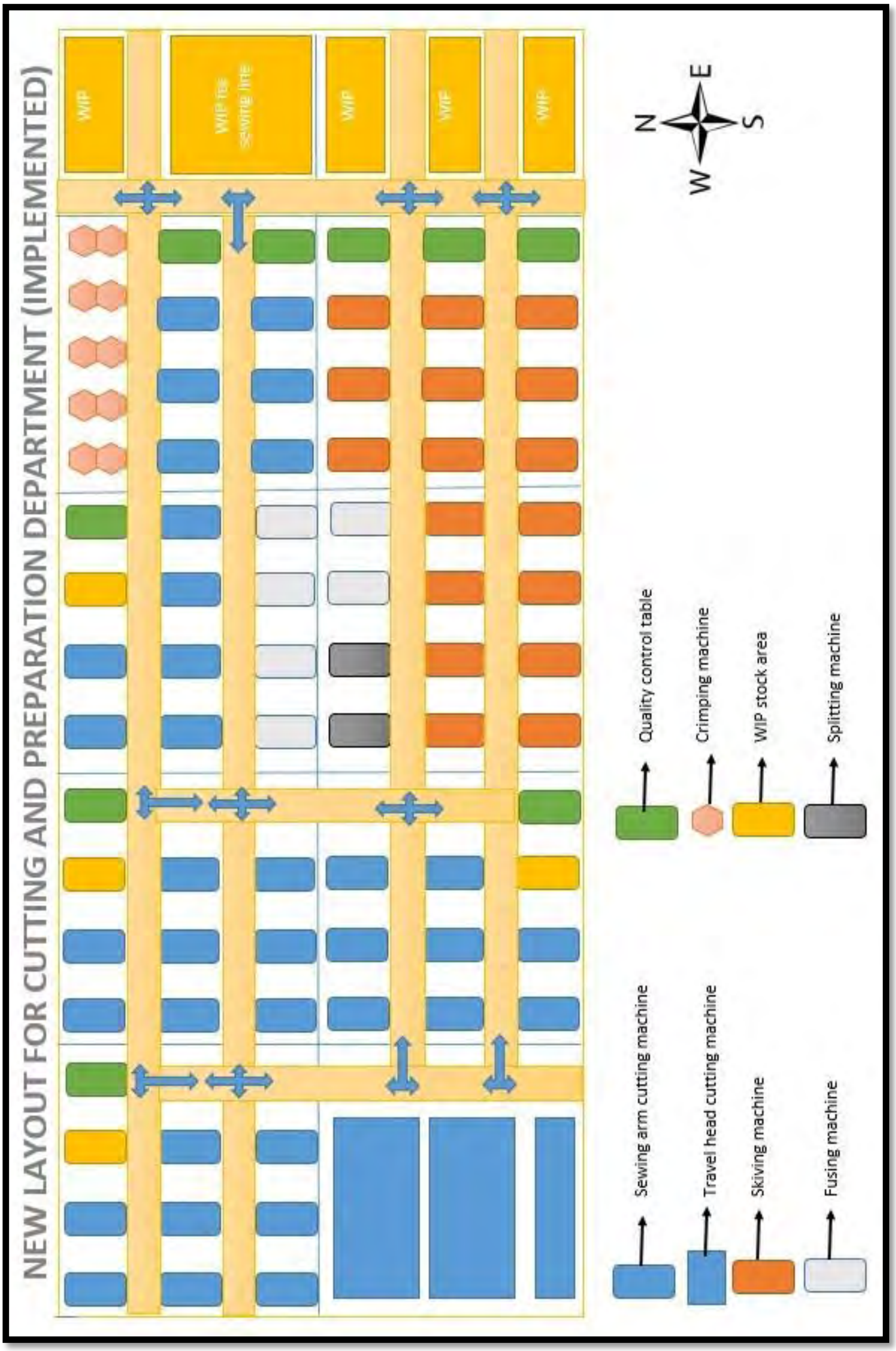


Fig.3.4 New process mapping of cutting and preparation department

Production planning method for individual workforce.

The method of production planning is developed as per below Table 3.1 by work measurement.

Table3.1 The work measurement and production planning method.

Dept.	Article's Image	Article	36608	
		Operation time	Plan	
		SMV	1 hour	8 hours
Cutting	**UPPERS**			
	Cutting leather	5.03	12	**95**
	Cutting reinforcement for vamp	0.38	158	**1263**
	Cutting reinforcement for counter	0.54	111	**889**
	Cutting QC	1.35	44	**356**
	LININGS			
	Cutting collar synthetic lining	0.08	750	**6000**
	Cutting added synthetic lining	0.59	102	**814**
	Cutting zip lining	0.23	261	**2087**
	Cutting warm lining	0.15	400	**3200**
	Cutting counter lining	0.23	261	**2087**
Preparation	Apply reinforcement thermod	2.91	21	**165**
	Skiving upper	3.38	18	**142**
	Re-cutting	0.35	171	**1371**
	Splitting loop	0.36	167	**1333**
	Skiving Warm lining	0.46	130	**1043**

3.2 Application of Kanban

The company under studied is using basket to move the goods from one individual process to another process. Majority time supervisor/ line leader became confused to identify if one process done or not. Author is suggested the below Kanban system to overcome this problem.

Kanban card for cutting department

After passing the goods from cutting QC, below Kanban card can be used to easy understand for the next department that this basket is passed from previous process and it is ready for the next process. Table 3.2 shows the Kanban card for cutting department.

Table 3.2 Cutting Department Kanban card blue color code

XYZ Footwear Company – Cutting			
Date		PO No.	
Article No.		Lot No	
Color		Combo	
Size		Quantity	
Total Quantity			
Line		QC ID	

Kanban card for preparation department

After passing the goods from preparations QC, below Kanban card can be used to easy understand for the next department that this basket is passed from previous process and it is ready for the next process.Table 3.3 shows the Kanban card for preparation department.

Table 3.3 Preparation Department Kanban card Orange color code

XYZ Footwear Company – Preparation			
Date		PO No.	
Article No.		Lot No	
Color		Combo	
Size		Quantity	
Total Quantity			
Line		QC ID	

Kanban card for sewing department.

After passing the goods from sewing department QC, below Kanban card can be used to easy understand for the next department that this basket is passed from previous process and it is ready for the next process.Table 3.4 shows the Kanban card for sewing department.

Table 3.4 Sewing Department Kanban card white color code

XYZ Footwear Company – Sewing			
Date		PO No.	
Article No.		Lot No	
Color		Combo	
Size		Quantity	
Total Quantity			
Line		QC ID	

Process Mannping for a Sewing / Assembling conveyor line

The company under study is using U shaped chain conveyor in sewing and lasting department. The shape of conveyor is depicted Fig.3.5as below –

Fig.3.5 U Shaped conveyor for sewing and assembling line

3.3 Work measurement

Time study is very much essential tool for work measurement and it can be done by the calculation of standard minute value (SMV). In this work, SMV was calculated based on individual task by time studies on several production lines and in case of variety products. For the calculation of SMV, allowance (for machine, personal & bundle) factor was added with the basic time whereas basic time was determined by multiplying worker's performance rating with the cycle time. Cycle time means total time taken to do all tasks to complete one operation, i.e. time from pick up part of first piece to next pick up of the next piece. Average cycle time was counted after measuring time for five repetitive operations with a stop watch by standing side of every worker during different periods of a day. The measurement was avoided if found any abnormal time in the process. The procedure was repeated for all operations in a production line and cycle time was measured accordingly.

In work measurement, it is very important to measure the performance rating of the worker, whose job is measured. According to International labor organization (ILO), rating is the measurement of the worker's rate of working relative to the observer's concept of the rate corresponding to the standard pace. The performance rating scale of the worker ranges from 0-100 (whereas 0 for no activity and 100 for standard performance) based on British Standard Institute (BSI) and ILO. Besides, allowance factor was considered from 15%-20% based on machine, personal and bundle allowance according to paper presented **[Shumon et al. 2010].** Table 2.1 shows the average workers' performance rating and allowance factor which are assumed in this work. Equation (1.1) and (1.2) are used to calculate the SMV and basic time for the five products.

SMV forindividualprocess=Basictime(1+Allowancefactor) [1.1]

Basictime = CycletimeX Performance Rating [1.2]

Processcapacityandworker'sefficiencywerealsodeterminedbyusingSMV.Capacity ofeveryprocessandproductivity ofalloperatorsandhelpersinalinewerecalculatedbyusingEquation(1.3)and(1.4).Equation(1.5), (1.6)and(1.7)wereusedforthecalculationofproductionlineproductivity.

$$\text{Capacity / hour (Pairs)} = \frac{\text{Total workforce X Total minutes attended}}{\text{SMV}} \quad [1.3]$$

$$\text{Workers productivity} = \frac{\text{Total minutes Produced}}{\text{Total minutes attended}} \text{X } 100 \quad [1.4]$$

Total output (minutes) = Total output (pairs) per day X SMV [1.5]

Total input (minutes) = Total workforce/day X Total minutes attended [1.6]

$$\text{Conveyor Speed} = \text{Production plan per hour} \quad [1.7]$$

$$\text{Balanced Work load per workforce} = \frac{60\ (\text{Minutes})}{\text{Conveyor speed}} \quad [1.8]$$

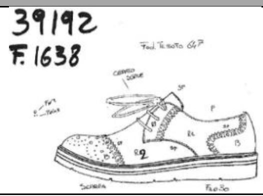
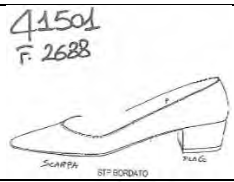
$$\text{Waiting time calculation} = \frac{60\ (\text{Minutes})}{\text{Conveyor speed}} - \text{Distributed process SMV} \quad [1.9]$$

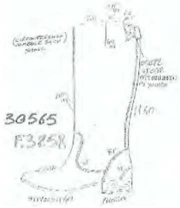
$$\text{Bottleneck Calculation} = \text{Distribute process SMV} - \frac{60\ (\text{Minutes})}{\text{Conveyor speed}} \quad [1.10]$$

$$\text{Workforce of balanced line} = \frac{\text{480 minutes X Production plan of 8 hours}}{\text{Total SMV of sewing or assembling}} \quad [1.11]$$

The data for existing production (pairs per hour) and cycle time (min) of different products have been collected from a footwear company under this study (as shown in Appendix-A and B)

Table 3.5 Productcategorywithworkers'performanceratingandallowancefactor

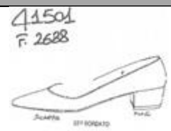
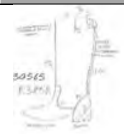
Product	Product Image	Average worker Performance Rating	Allowance Factor
Product 1		90%	15%
Product 2		90%	15%
Product 3		90%	15%
Product 4		90%	15%

Product 5		90%	15%

3.4 To eliminate different types of waste in sewing line

Balancing of Line is essential to make the operational flow of sequences smoother as compared to the previous layout. Line balancing is an effective technique to distribute balanced workload among the workers in a production line and to maintain uniform production flow. By line balancing selected production lines were balanced considering identified bottlenecks and waiting time in where the balancing process has shared the excess time in the bottleneck process after achieving its benchmarked target production. For line balancing work-sharing distance, type of machine and worker’s efficiency have been taken into consideration. According to **[Shumon et al. 2010],** the benchmarked production target is assumed to be 80% for RMG. We can consider this percentage also for footwear industry as it is one kind of apparel industry. After line balancing new manpower setup is proposed and final capacity of each process is also reallocated. Finally, a new production layout is modeled with the balanced capacity.

Table 3.6 Required data for sewing line balancing of different types of products (SMV are collected from Appendix: A and B)

Parameter	Product 1	Product 2	Product 3	Product 4	Product 5
Image					
Daily Production Plan per 8 hours*	350	350	750	300	350
Total workforce before line balancing	31	36	24	44	42
Total SMV for Sewing	39.67	54.75	13.24	62.89	48.45
Total Workforce in balanced line**	29	40	21	39	35
Target at 100% productivity	350	350	750	300	350
Target at 80% productivity	280	280	600	240	280
Target Hourly at 80% productivity	35	35	75	30	35
Balanced workload for each workforce***	1.71	1.71	0.80	2.00	1.71
Balanced workload at 80% productivity	1.37	1.37	0.64	1.60	1.37

Exiting sewing line layout for Product 1

The existing sewing line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.

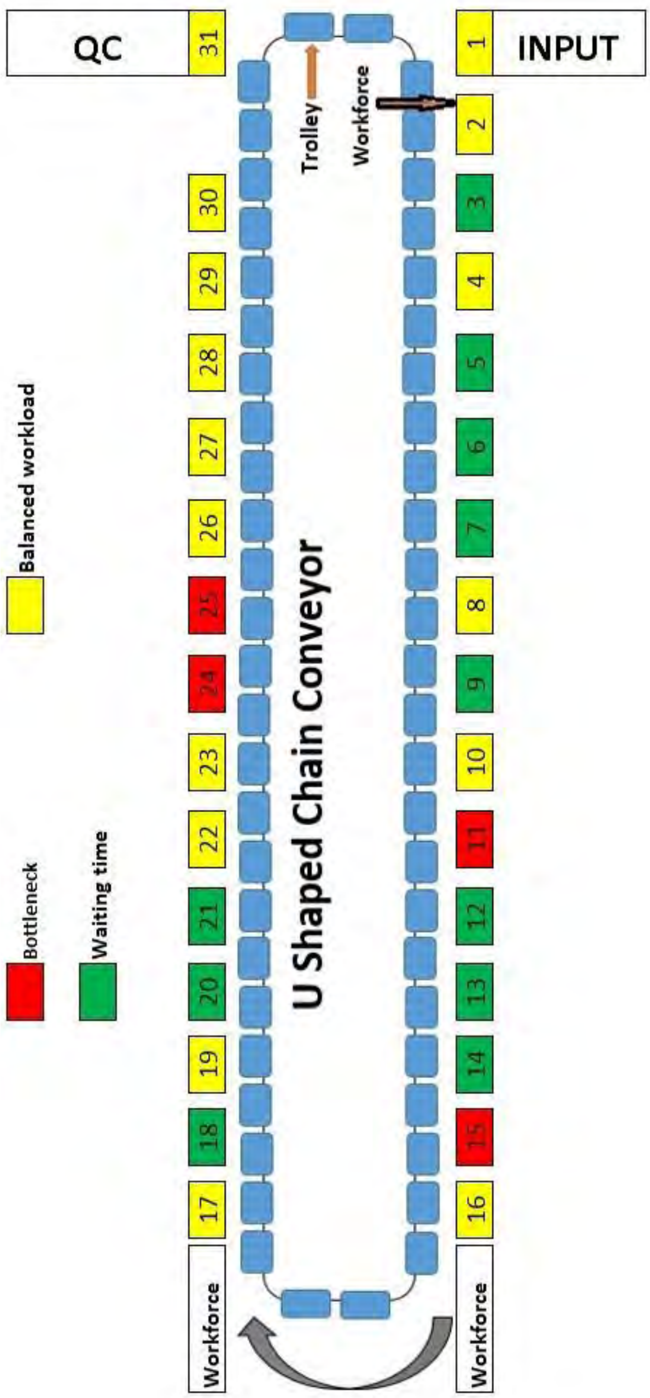


Fig.3.6 Existing sewing line layout for Product 1.

Developed sewing line layout for Product 1.

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

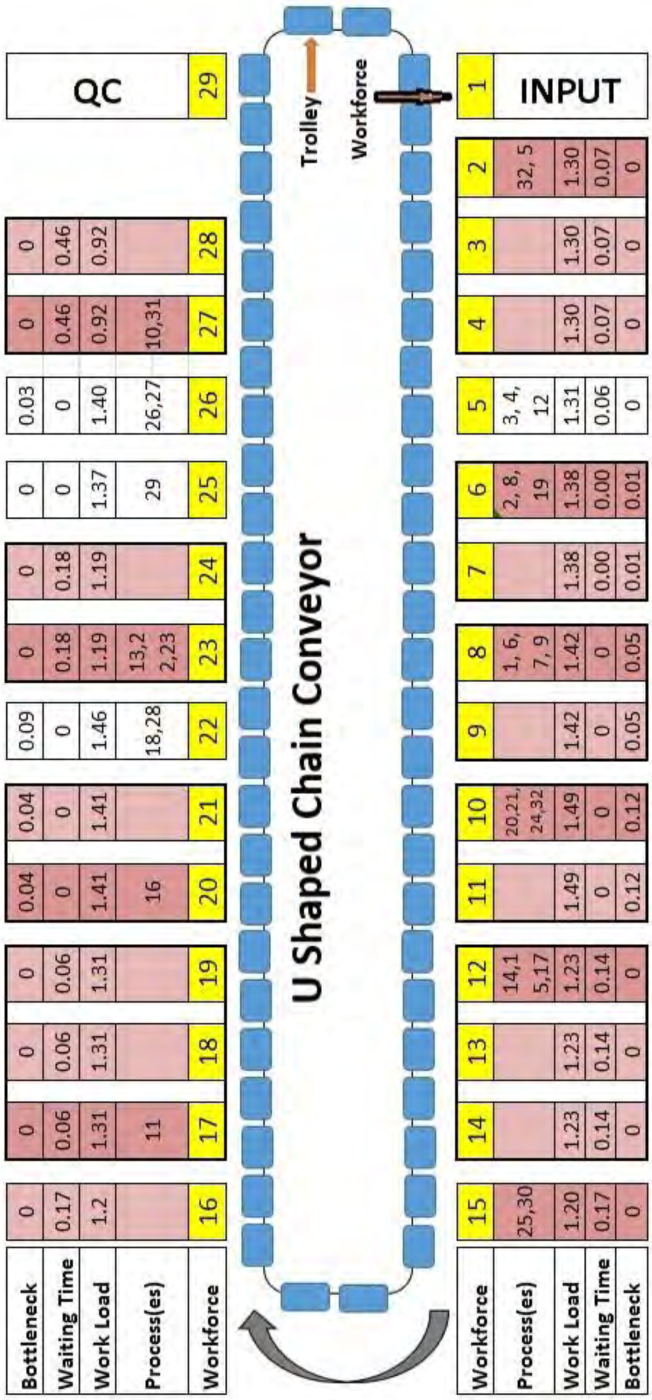


Fig.3.7 Developed sewing line layout for Product 1.

Exiting sewing line layout for Product 2

The existing sewing line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.

Fig.3.8 Existing sewing line layout for Product 2.

Developed sewing line layout for Product 2

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

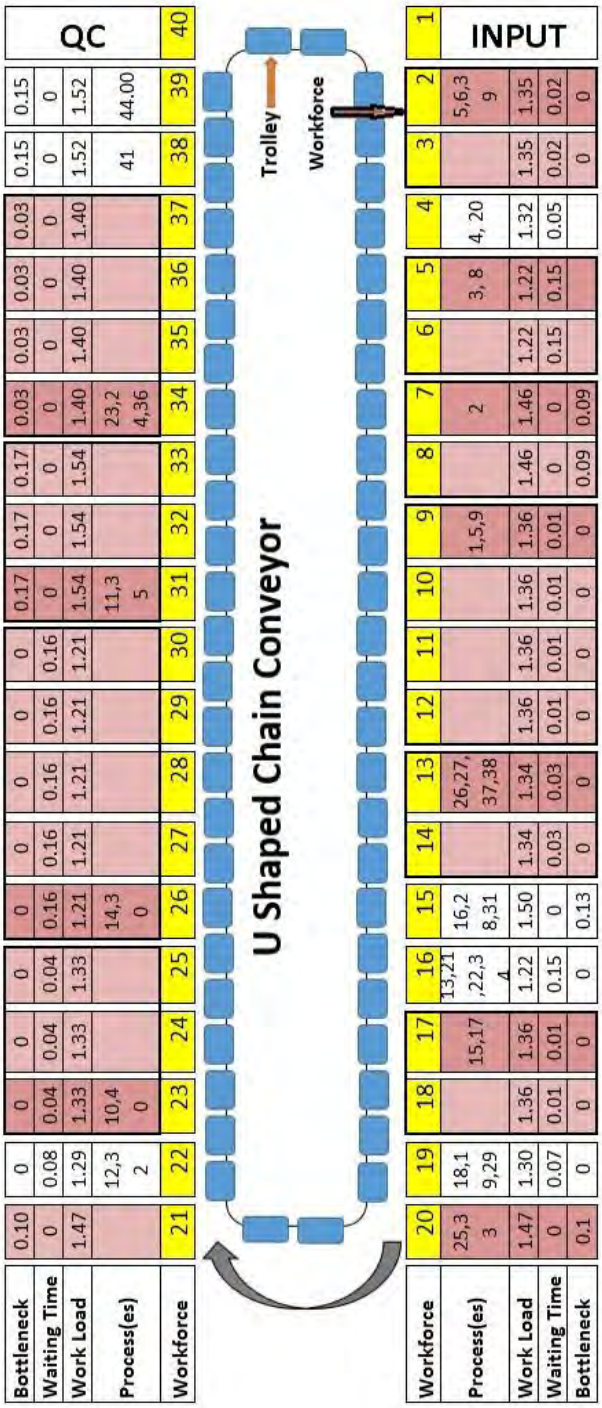


Fig.3.9 Developed sewing line layout for Product 2.

Exiting sewing line layout for Product 3

The existing sewing line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.

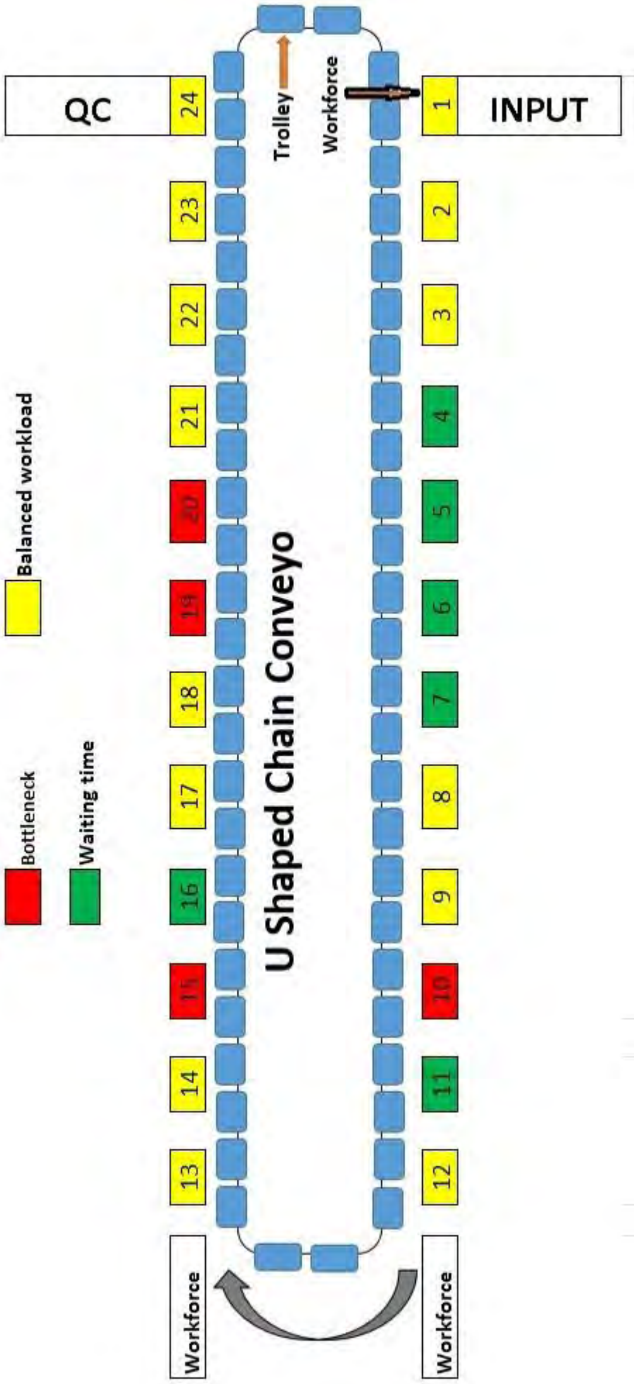


Fig.3.10 Existing line layout for Product 3.

Developed sewing line layout for Product 3

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

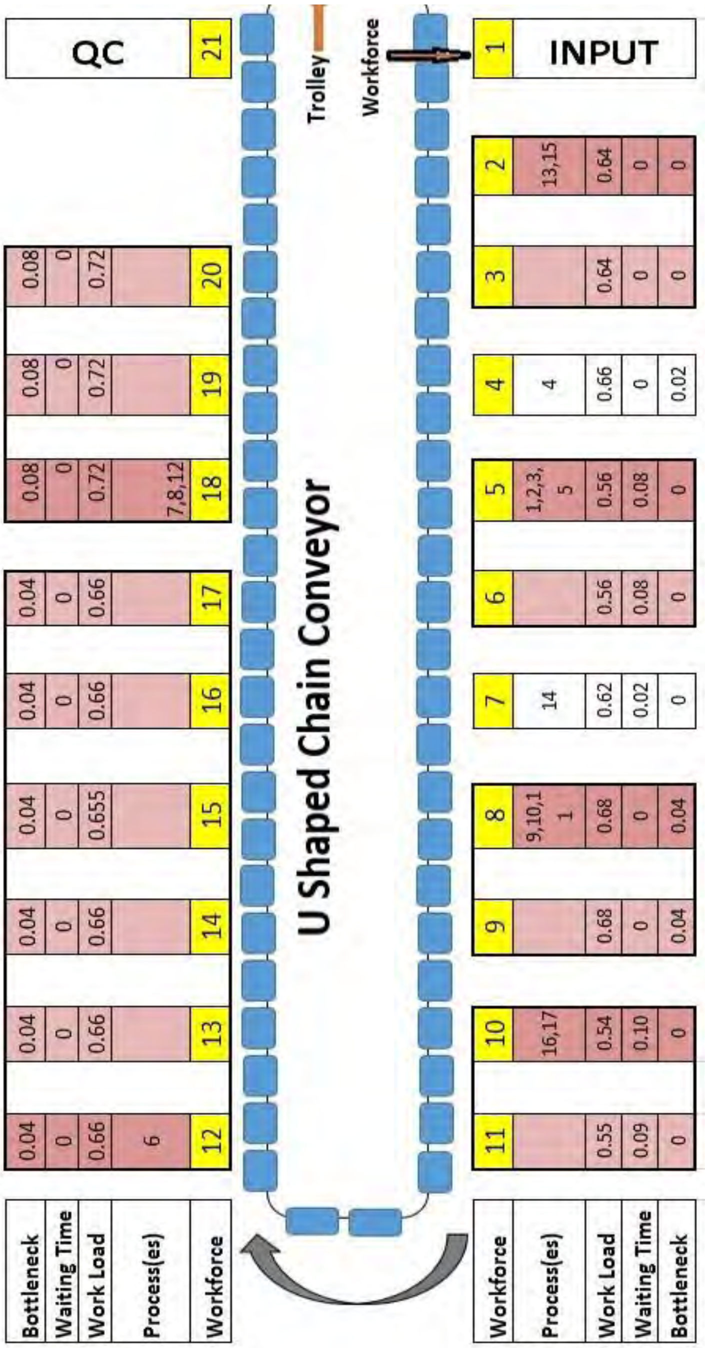


Fig.3.11 Developed sewing line layout for Product 3.

Exiting sewing line layout for Product 4

The existing lasting line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.

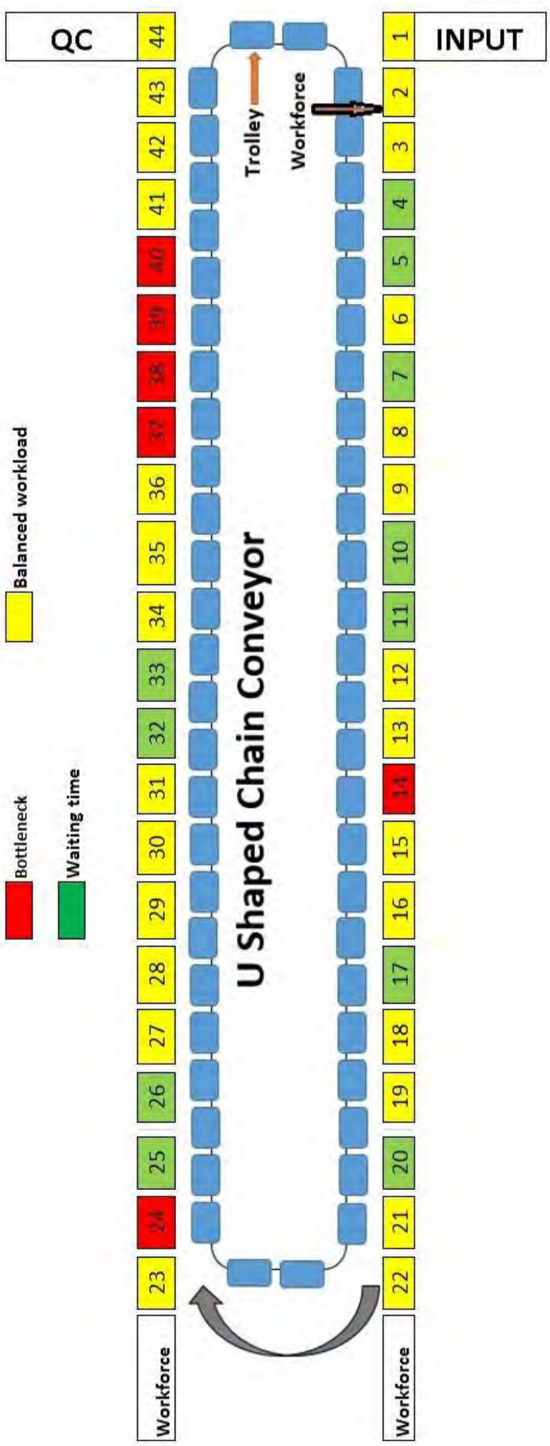


Fig.3.12 Existing sewing line layout for Product 4.

Developed sewing line layout for Product 4

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

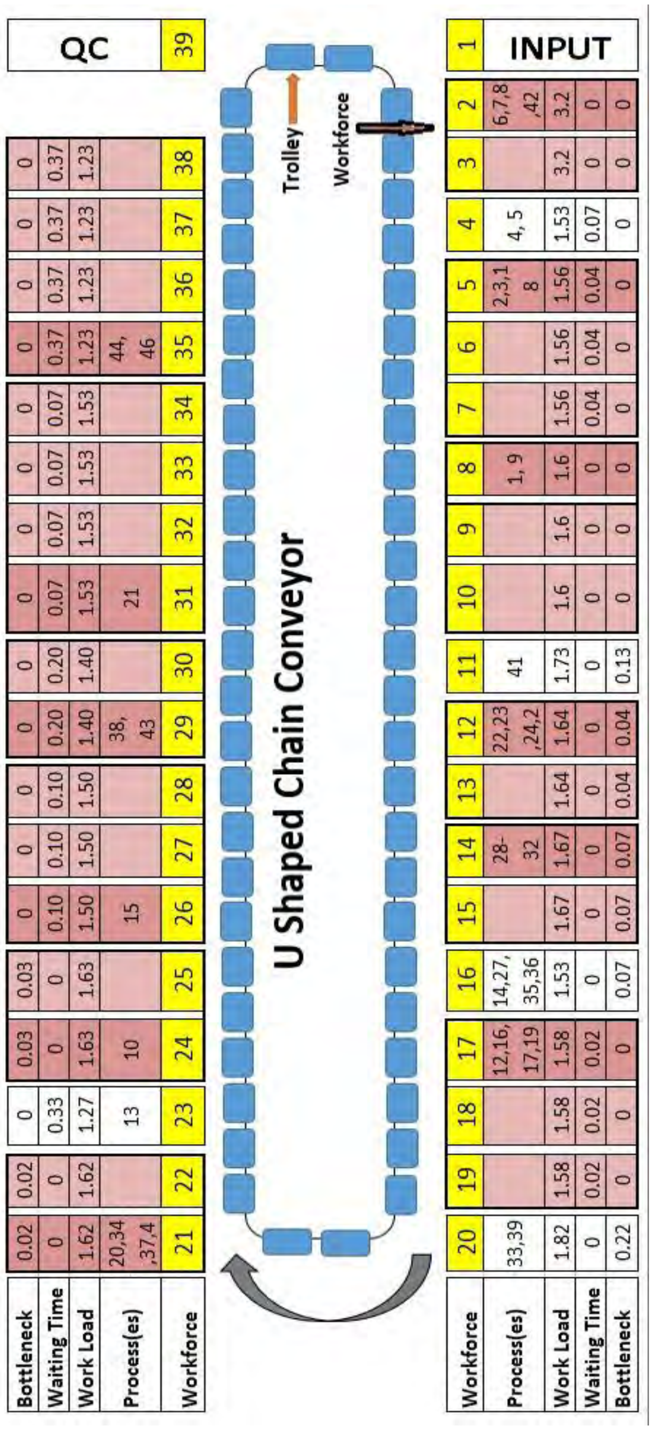


Fig.3.13 Developed sewing line layout for Product 4.

Exiting sewing line layout for Product 5

The existing sewing line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.

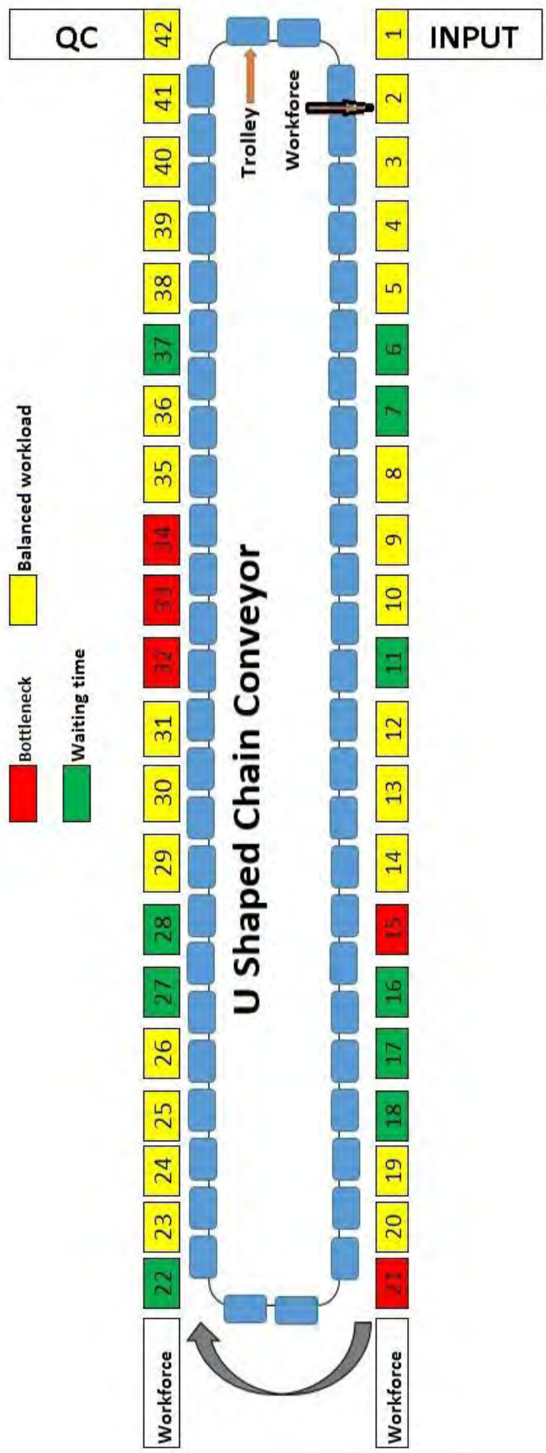


Fig.3.14 Existing sewing line layout for Product 5.

Developed sewing line layout for Product 5

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

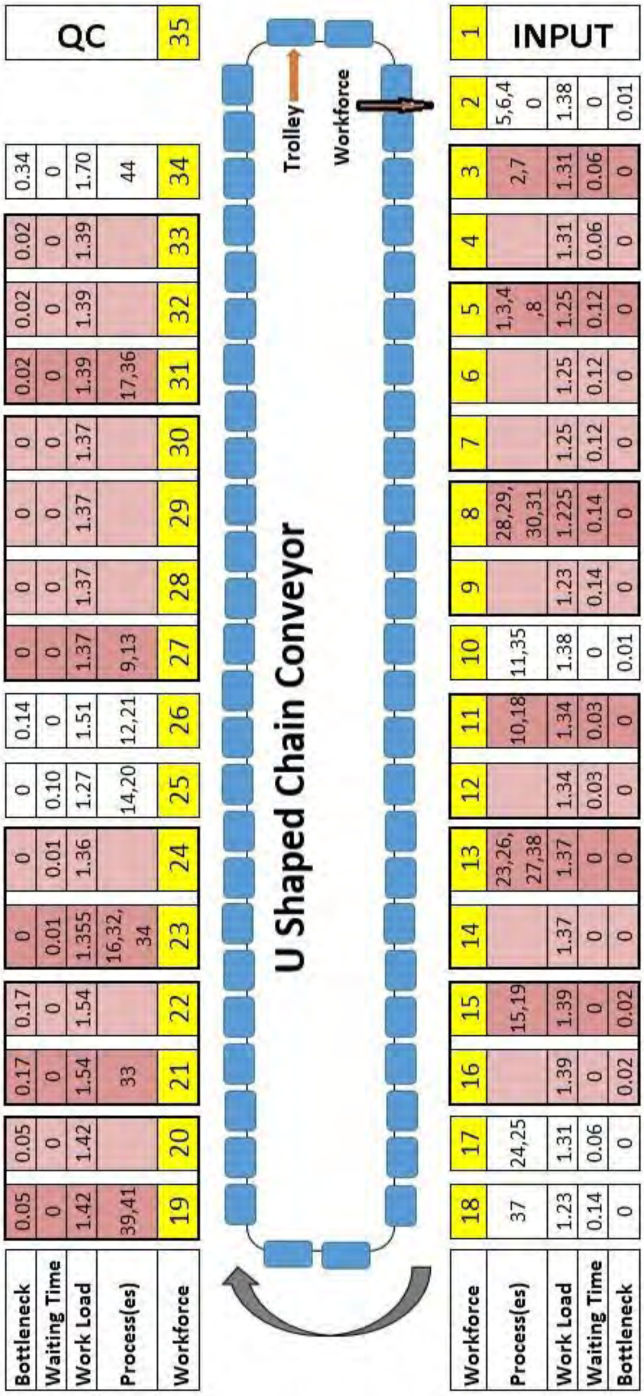


Fig.3.15 Developed sewing line layout for Product 5.

3.5 To eliminate waste from assembling line

The company under this study is produced the shoes by using cemented construction.The existing assembling line was not balanced properly. They couldn't distribute the balanced workload to each workforce. As a result there are some bottlenecks and waiting time remains on the line what are indicated with red and green colour respectively.Fig 3.16shows the existing line layout of assembling line.

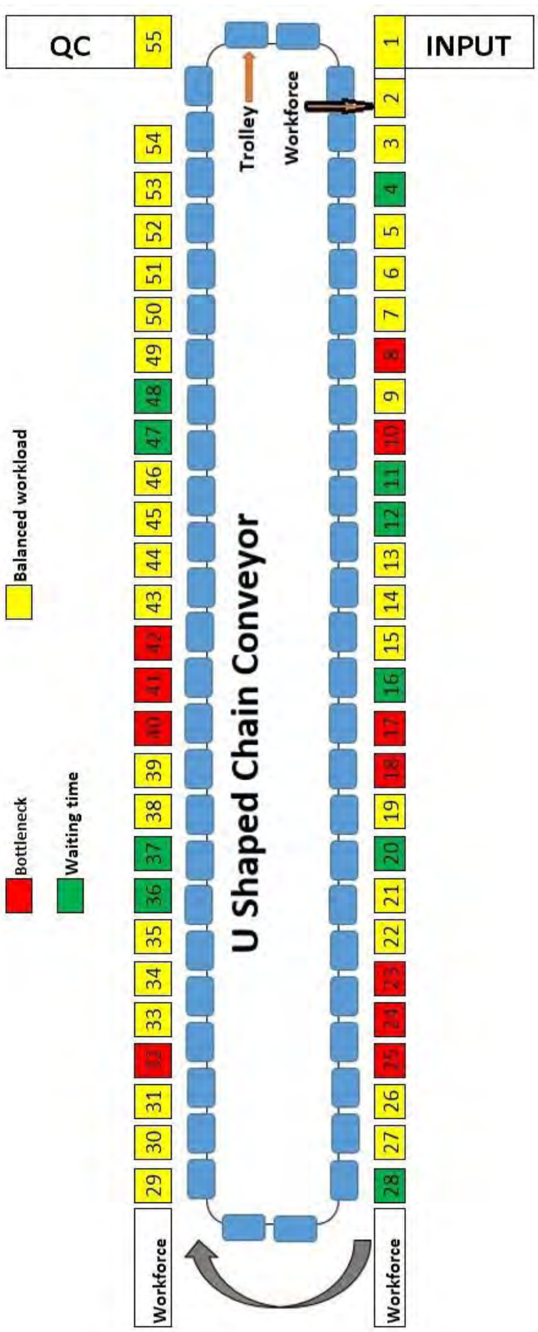


Fig.3.16 Existing assembling line layout for cemented construction.

Developed assembling line layout for cemented construction

Line is balanced by considering conveyor speed, sequence of operations and worker efficiency. As a result bottleneck time and waiting time are reduced. Pink highlighted work stations indicated the similar process(s) work in the next work station(s). White highlighted work stations indicated unique process(s) in individual work station.

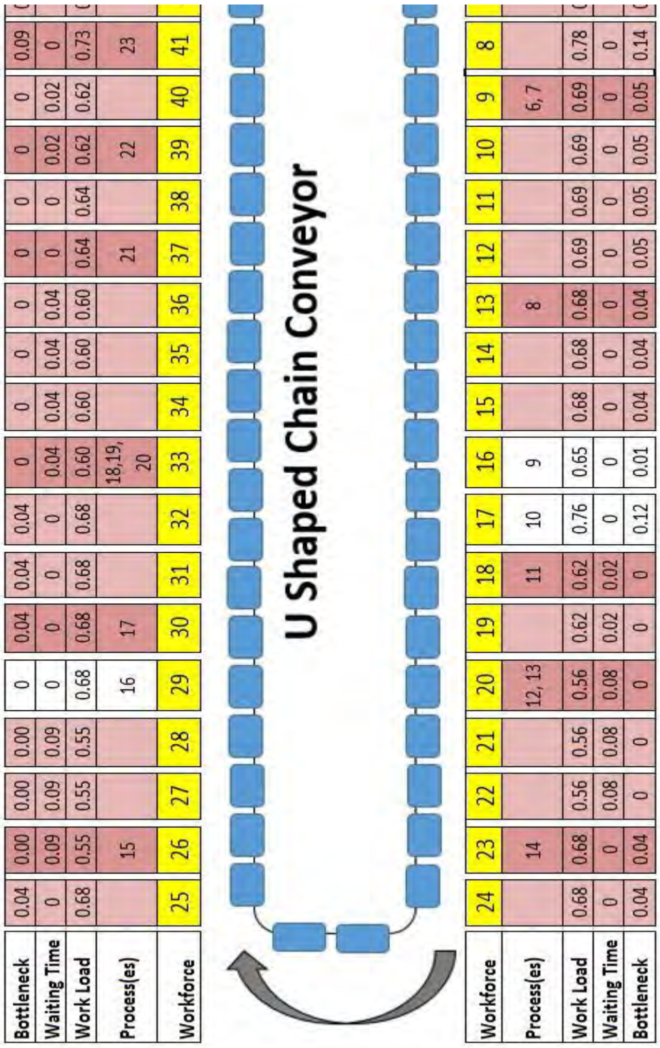


Fig. 3.17 Developed assembling line layout for cemented construction

3.6 Fishbone Diagram Analysis

Fish bone diagram is also known as cause-effect diagram which identifies actual causes for any result. The problem areas in RMG industries were closely noticed and identified during working time in the production floors and after discussion with the supervisors, operators and helpers in the industries. In this work, different problem areas for less productivity, more wastage and more production time are found in Footwear industries as shown in **Fig.3.18**.

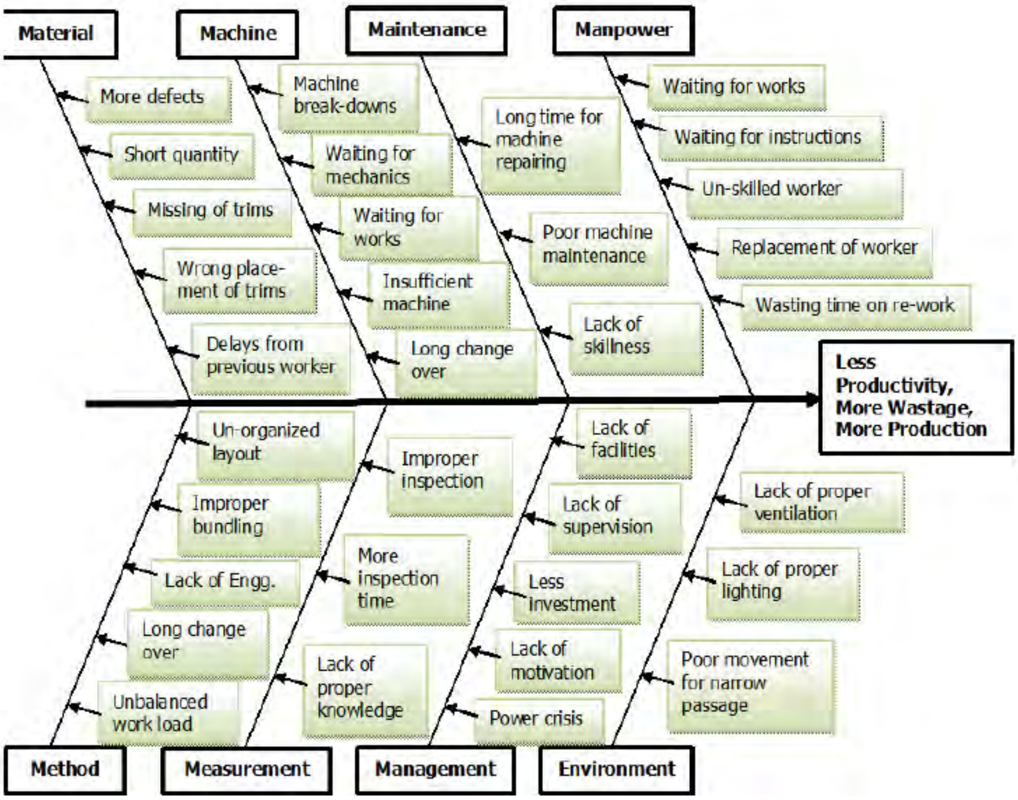


Fig. 3.18 Fishbone diagram for less productivity, more wastage and more production time in Footwear industry

Chapter-4

Discussion on Results

4.1 Application of lean tools and technique in a footwear industry

Fig. 3.1represents the common sequences of departments in a footwear industry. After purchasing the raw materials, the first manufacturing step is cutting. There are a lot of processes in the cutting department. The sequence of process and placement of the work station is very important and have to consider to remove waste and bottleneck. The main problems are the related people cannot setup the processes of different articles in an optimum way. As a result they are unable to get the optimum output from this factory.

The workload balancing between the departments and inside the departments are the main considering factor in a footwear factory. Factory must to do work measurement for every process to balance the workload between the departments and inside the departments.

Fig. 3.2 shows that the layout of cutting and preparation department. In cutting department all process are sequential and individual. The main production processes are –

i) Cutting upper and lining leather
ii) Quality Control
iii) Cutting reinforcement
iv) Reinforcement attaching
v) Crimping
vi) Re - cutting
vii) Skiving
viii) Splitting
ix) Embossing/ Stamping
x) Screen Printing
xi) Quality Control

Up to process 6, must have to respect the sequence of operations. To reduce the motion wastage, machine layout should be placed in an efficient way. But there is a lot of time waste due to unnecessary movement of materials.

Fig. 3.3 shows the movement of materials from one process to another process in cutting and preparations department. Due to poor machine layout and process mapping, the materials need to move inside the departments from back area to front area and again front area to back area and again back area to front area. As a result there is a lot of motion wastage and need also extra manpower to move the goods.

Fig. 3.4 shows the developed process mapping and line balancing of the departments. After that the materials, man and machine movements are reduced significantly. Bottleneck, waiting time are reduced and productivity is improved. **Fig 3.5** shows a work measurement and production planning method. With this method this factory can calculated the individual worker productivity and department productivity.

In this factory the materials are moved from one process to another process through basket. In average there are twenty pairs materials can be storage in one basket. For Example, after cutting of 20 pair's upper leather will be moved to QC through one basket. After quality control of this 20 pairs will be passed to next operation-reinforcement attaching. But sometimes worker become confused if it is processed/passed or not from previous operations. Normally they need to check physically by checking inside of the basket. To solve this problem, Kanban tools are applied. **Table 3.2, 3.3 and 3.4** are showing different color Kanban card which is attached in the materials basket and by this way it is very easy to understand which basket is waiting for the next operations. The comparison of tangible benefits before and after applying Kanban tools and Techniques is shown in the below **Table 4.1**

Table 4.1 The comparison of tangible benefits before and after applying the lean tools and Techniques

S. N	Parameter	Target	Current	Previous	% Change
1	Manpower	120*	125*	138*	-9%
2	Rework in line (Pairs/Day)	<5	<25	>40	-15%
3	Daily Production (8 Hours)	2500*	2320*	1950*	19%

*Depends on Article

The comparison of intangible benefits before and after applying the above lean tools and Techniques is shown in the below **Table 4.2.**

Table 4.2 Thecomparison of intangible benefits before and after applying the above lean tools and Techniques.

S. N	Parameter	Current	Previous
1	Traceability of Work/ Defects	Easier	Difficult
2	Materials Handling/ Movement	Less, Easy & Smooth	Done by operator as a result less production.
3	Supply to Sewing Line	Matching in colour/ pairs/ component	Less matching in colour/pairs/ component
4	Supervision	Very good	Normal
5	Supervisor Effort	Reduced	High

4.2 Process mapping for sewing department

Fig. 3.5 shows the chain conveyor line for sewing and assembling department. Basically there are two types of conveyor – chain and table conveyor. In both types conveyor need to balance the workload for each workforce to minimize waiting time and bottleneck in the line. In footwear manufacturing there is 50-60% process related to sewing department. Remaining 40-50% process related to cutting and assembling department. So among three departments – cutting, sewing and assembling, the sewing department is the bottle neck department. Actually the main challenge in every footwear factory is to balance the sewing department to get an optimum output of finished product. To get the optimum output through process balancing, it must be calculated the work measurement of this product.

4.3 To eliminate different types of waste to get balanced sewing line

Table 3.8 shows the basic data of 5 articles of this factory. There are five types of different articles are considering such as derby shoes , ankle boot,court shoes, knee boot and long boot which are depicted as products 1, 2, 3, 4, and 5 respectively. Daily production target and manpower of sewing lines are calculated based on experienced of planning department. But after time study, it is very easy to calculate the manpoweragainst the daily production target. Also it is very easy to calculate the hourly production target and balanced workload per workforce by equation [1.11] and [1.8].

To eliminate different types waste to get balanced sewing line for product 1

Fig. 3.6 shows the existing process mapping of sewing line for product 1. From **Table 3.8** we get the balanced workload for this article is 1.37minutes against 29 workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig 3.7** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table 4.3 The comparison of benefits of product 1 before and after applying the lean tools and Techniques

S.N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	31	29	-6.45%
2	Work station	31	29	-6.45%
3	Machine	16	14	-12.50%
4	Total waiting time (min)	13.34	2.48	-81.41%
5	Total bottleneck time(min)	15.54	0.55	-96.46%
6	Output/8 hours	210	255	21.43%
7	Line productivity	55.99%	72.67%	29.80%

Here total workforce is 29, total bottle neck time is 0.55 minutes and total waiting time is 2.48 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performance is more than an average. So line supervisor should be coordinated the line with higherperformance worker to minimize this bottle neck issues.

To eliminate different types waste to get balanced sewing line for product 2

Fig.3.8 shows the existing process mapping of sewing line for product 2. From **Table 3.8** we get the balanced workload for this article is 1.37minutes against 40workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig 3.9** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table 4.4 The comparison of benefits of product 2 before and after applying the lean tools and Techniques

S. N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	36	40	11.11%
2	Work station	36	40	11.11%
3	Machine	19	22	15.79%
4	Total waiting time (min)	12.36	2	-83.82%
5	Total bottleneck time(min)	11.35	1.44	-87.31%
6	Output/8 hours	185	250	35.14%
7	Line productivity	58.62%	71.29%	21.62%

Here total workforce is 40, total bottle neck time is 1.44 minutes and total waiting time is 2 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performance is more than an average. So line supervisor should be coordinated the line with higherperformance worker to minimize this bottle neck issues.

To eliminate different types waste to get balanced sewing line for product 3

Fig. 3.10 shows the existing process mapping of sewing line for product 3. From **Table 3.8** we get the balanced workload for this article is 0.80 minutes against 21workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig 3.11** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table 4.5 The comparison of benefits of product 3 before and after applying the lean tools and Techniques

S. N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	24	21	-12.50%
2	Work station	24	21	-12.50%
3	Machine	11	10	-9.09%
4	Total waiting time (min)	11.36	0.37	-96.74%
5	Total bottleneck time(min)	9.35	0.58	-93.80%
6	Output/8 hours	510	540	5.88%
7	Line productivity	58.61%	70.93%	21.01%

Here, total workforce is 21, total bottle neck time is 0.58 minutes and total waiting time is 0.37 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performance is more than an average. So line supervisor should be coordinated the line with higherperformance worker to minimize this bottle neck issues.

To eliminate different types waste to get balanced sewing line for product 4

Fig. 3.12 shows the existing process mapping of sewing line for product 4. From **Table 3.8** we get the balanced workload for this article is 2.00 minutes against 44workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig. 3.13** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table 4.6 The comparison of benefits of product 4 before and after applying the lean tools and Techniques

S. N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	44	39	-11.36%
2	Work station	44	39	-11.36%
3	Machine	18	21	16.67%
4	Total waiting time (min)	15.68	3	-80.87%
5	Total bottleneck time(min)	13.36	0.74	-94.46%
6	Output/8 hours	180	225	25.00%
7	Line productivity	53.60%	75.59%	41.03%

Here total workforce is 39, total bottle neck time is 0.74 minutes and total waiting time is 3.00 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performanceare more than an average. So line supervisor should be coordinated the line with higher performance worker to minimize this bottle neck issues.

To eliminate different types waste to get balanced sewing line for product 5

Fig. 3.14 shows the existing process mapping of sewing line for product 5. From **Table 3.8** we get the balanced workload for this article is 1.37minutes against 35 workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig 3.15** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table 4.7 The comparison of benefits of product 5 before and after applying the lean tools and Techniques

S. N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	42	35	-16.67%
2	Work station	42	35	-16.67%
3	Machine	20	17	-15.00%
4	Total waiting time (min)	15.85	1.14	-92.81%
5	Total bottleneck time(min)	18.12	1.04	-94.26%
6	Output/8 hours	220	245	11.36%
7	Line productivity	52.87%	70.66%	33.64%

Here total workforce is 29, total bottle neck time is 1.04 minutes and total waiting time is 1.14 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performanceare more than an average. So line supervisor should be coordinated the line with higher performance worker to minimize this bottle neck issues.

4.4 To eliminate different types waste for cemented construction.

Fig. 3.16 shows the existing process mapping of sewing line for product 1. From **Table 3.8** we get the balanced workload for this article is 0.80 minutes against 47 workforces. There we can observe the green highlighted workforce in which a lot of waiting time and red highlighted workforce involved with bottle neck. To distribute the workload in a balanced way, the new line layout is developed according to **Fig 3.17** where workforce, processes, total workload, bottle neck time and waiting times are depicted in details.

Table **4.8**The comparison of benefits of assembling line before and after applying the lean tools and Techniques

S. N	Parameters	Apply Lean tools		% of Variation
		Before	After	
1	Manpower	55	48	-12.73%
2	Work station	55	48	-12.73%
3	Machine	17	17	0.00%
4	Total waiting time (min)	9.35	1.16	-87.59%
5	Total bottleneck time(min)	12.23	1.48	-87.90%
6	Output/8 hours	510	560	9.80%
7	Line efficiency	57.57%	72.43%	25.82%

Here total workforce is 48, total bottle neck time is 1.48 minutes and total waiting time is 1.16 minutes. Due to respect the sequence of operations and operations times, it is not possible to neutral the bottle neck and waiting time. As we are considering the average performance of every worker, but practically some workers performance is more than an average. So line supervisor should be coordinated the line with higher performance worker to minimize this bottle neck issues.

4.5 Fishbone Diagram Analysis

Different problem areas in Footwear industry coupled with eight variables such asmanpower, machine, material, method, maintenance, measurement, management and environment are identified and accounted for more wastage, more production time, less productivity and higher production cost. Very common problems highlighted in this footwear industry for less productivity are:

- Lack of engineering and unorganized production layout impeded well distribution of work load among the workers.
- Production time is enlarged due to more waiting time for work, machine, mechanic, maintenance and machine setting. Besides waiting time, more defects (cutting and sewing) and re-works were also responsible lower productivity in this industry.
- Lack of motivation, supervision, overall co-ordination and power crisis in the footwear industry are some obstacles for productivity improvement.
- Productivity is decreased due to absence of skilled supervisor, operator, helper and inspector in the production lines.

Chapter-5

Conclusions and Recommendations

5.1 Conclusions

i. By work measurement, SMV and capacity of processes were calculated separately for five different articles.

ii. After applying lean tools and techniques in cutting and preparations department, the production is increased 19% and workforces is decreased 9%.

iii. After applying lean tools and techniques in sewing department, the line productivity is increased 21% - 41%, bottle beck is reduced 87% - 96% and waiting time is reduced 81% - 97% for all 5 articles.

iv. After applying lean tools and techniques in assembling department, the line productivity is increased 26%, bottle beck is reduced 88% and waiting time is reduced 87% for cemented construction.

v. The process mapping, machines and workforces are coordinated and synchronized properly and as a resultproduction is increased without increasing extra machinery and manpower.

vi. Different problem areas associated to man, machine, maintenance, material, method, measurement, management and environment were recognized during observation and are obviously indicated by fishbone or cause-effect diagram. These problem areas (causes) are also accountable to enlarge the production time as well as hamper overall productivity (effect). As a result, footwear industry require more lead time for order completion and also causes for poor product quality which are very alarming for any footwear industry in terms of growth and sustainable development of business.

5.2 Future Recommendation

- Factory should setup a well-equipped training center to develop the new worker's skill ness.
- Various lean tools and techniques such as VSM and Fishbone diagram can be applied to get more productivity in footwear industry.
- In assembling department, here just analyzed only one construction i.e. cemented construction. Lean tools and techniques can be applied in case of other construction such as Ideal, Strobel, Goodyear welted and so on.

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Appendix A: Profile of the Footwear Industry

Golden Moon Bangladesh Limited		
	Location	: SFB #1, EPZ, Cumilla.
	Nature	: Complete shoe. Stitched upper
	IE activities	: None
	Certification	: None
	Clients	: Clarks, Pierre Cardin, Aldo, Dune, Andre etc
	Production Lines Sewing	: 12
	Production lines Assembling	: 2
	Production Capacity/day (Upper)	: 2000 - 3000 pairs
	Production Capacity (Finished)	: 1200 -1500 pairs
	Workforce	: 750
	Type of products	: Leather Ankle, Knee boot and Ballerina.

Appendix B: Standard Minutes Value (SMV) data

Product 1				
Department	**S. N**		**Process Wise SMV**	**Total SMV**
Cutting	1	Cutting upper leather	3.19	**8.27**
	2	Cutting reinforcement	0.46	
	3	Cutting reinforcement for Vamp	0.38	
	4	Cutting QC	0.84	
	5	Apply thermo reinforcement	1.99	
	6	Skiving vamp decoration	0.14	
	7	Cutting warm lining	0.47	
	8	Cutting counter lining	0.80	
Sewing	1	Stitching collar lining	1.84	**39.67**
	2	Compose collar with glue	1.77	
	3	setting vamp lining	0.50	
	4	Setup toe on quarter lining	0.61	
	5	Marking for counter lining	0.64	
	6	Stitching counter lining	0.32	
	7	Zigzag stitching	0.27	
	8	setup counter lining	0.61	
	9	Stitching counter lining	0.40	
	10	Stitching Vamp on Quarter lining	0.82	
	11	Insert lining	3.93	
	12	Upper marking	0.20	

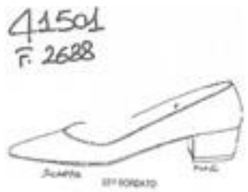
	13	Punching	0.38	
	14	Stitch counter on quarter	2.27	
	15	Stitch toe part	0.64	
	16	Stitch upper with lining	2.82	
	17	Stitching quarter	0.78	
	18	Trimming machine	0.85	
	19	Apply under collar	0.38	
	20	setup quarter	0.62	
	21	Setup toe	0.66	
	22	Setup toe on quarter	0.91	
	23	Setup vamp on quarter	1.09	
	24	Setup counter on quarter	0.97	
	25	Stitch back seam	0.30	
	26	Back lock stitch	1.25	
	27	Rubbing with 14mm tape side	0.15	
	28	Trimming manual	0.61	
	29	Stitching Vamp on Quarter	1.37	
	30	Apply reinforcement nylon	2.09	
	31	Lacing	1.01	
	32	Apply 3mm cotton tape	3.27	
	33	Toe puff attaching	0.72	
	34	Line QC	1.54	
	35	Line loading	1.54	
	36	Line cleaner	1.54	
Assembling	1	Outsole priming	0.56	**29.79**
	2	Insole attaching	0.45	
	3	Back Part molding	1.20	
	4	Conditioning	1.38	
	5	Toe lasting	0.95	
	6	Side lasting	1.89	
	7	Seat lasting	0.85	
	8	Pounding	0.65	
	9	Outsole marking	1.24	
	10	Buffing	0.76	
	11	Glue apply first coat	0.96	
	12	Glue apply second coat	0.72	
	13	Heat reactivation	3.05	
	14	Outsole laying	1.65	
	15	Outsole pressing	0.68	

	16	Celling / Cooling	2.54	
	17	Unlasting	0.23	
	18	Insocks attaching	1.32	
	19	Cleaning	0.86	
	20	Finishing	2.65	
	21	Quality control	1.23	
	22	UV tunnel passing	0.65	
	23	Nail detection	0.65	
	24	Final QC	1.25	
	25	Packing	1.42	

Product 2				
Department	**S. N**		**Process Wise SMV**	**Total SMV**
Cutting	1	Cutting upper leather	3.99	**14.37**
	2	Cutting reinforcement	0.08	
	3	Cutting reinforcement for Vamp	0.54	
	4	Cutting QC	1.04	
	5	Crimping	1.73	
	6	Recutting	2.07	
	7	Cutting paper board	0.25	
	8	Apply reinforcement	1.38	
	9	Apply reinforcement for crimping	0.54	
	10	Skiving upper	1.57	
	11	Splitting loop	0.28	
	12	Cutting Zipper lining	0.08	
	13	Cutting warm lining	0.59	
	14	Cutting counter lining	0.23	
Sewing	1	Stitching collar lining	3.83	**54.75**
	2	Compose collar with glue	2.91	
	3	Setup lining with 14mm cotton tape	1.57	
	4	Zigzag stitching on warm lining	0.91	
	5	Stitch back lining	0.62	
	6	Marking for counter lining	0.14	
	7	Marking for collar lining	0.14	
	8	Set up counter lining	0.87	

	9	Stitching counter lining	0.97	
	10	Insert lining	3.26	
	11	Hand punch	1.15	
	12	Stitching Zipper side	0.98	
	13	Rubbing with 14mm tape	0.17	
	14	Stitching upper with lining	5.11	
	15	Quarter decoration stitch	1.8	
	16	Stitch tongue	0.33	
	17	Stitch counter	0.92	
	18	Loop turn out	0.14	
	19	Attach leather with leather	0.22	
	20	Apply round deco	0.41	
	21	Apply ritza thread	0.14	
	22	Apply 15mm nylon tape	0.73	
	23	Apply ganci	1.04	
	24	Apply eyelet	2.38	
	25	Setup toe on quarter	0.79	
	26	setup tongue	0.39	
	27	Setup counter	0.59	
	28	Seam back side upper	0.46	
	29	Setup eyelet pieces	0.94	
	30	Testina seam stitch	0.95	
	31	Stitch tongue end	0.71	
	32	Box stitching	0.31	
	33	Insert Zipper and zipper lining	2.15	
	34	Rubbing with 14mm tape front	0.18	
	35	Trimming manual	3.47	
	36	Stitching Vamp on Quarter	2.17	
	37	Glue in Zipper	0.31	
	38	Apply reinforcement nylon	1.38	
	39	Apply 3mm cotton tape	2.41	
	40	Toe puff attaching	0.72	
	41	lacing	1.52	
	42	Line QC	1.52	
	43	Line loading	1.52	
	44	Line cleaner	1.52	
Assembling	1	Outsole priming	0.56	**29.79**
	2	Insole attaching	0.45	
	3	Back Part molding	1.2	

	4	Conditioning	1.38	
	5	Toe lasting	0.95	
	6	Side lasting	1.89	
	7	Seat lasting	0.85	
	8	Pounding	0.65	
	9	Outsole marking	1.24	
	10	Buffing	0.76	
	11	Glue apply first coat	0.96	
	12	Glue apply second coat	0.72	
	13	Heat reactivation	3.05	
	14	Outsole laying	1.65	
	15	Outsole pressing	0.68	
	16	Celling / Cooling	2.54	
	17	Unlasting	0.23	
	18	Insocks attaching	1.32	
	19	Cleaning	0.86	
	20	Finishing	2.65	
	21	Quality control	1.23	
	22	UV tunnel passing	0.65	
	23	Nail detection	0.65	
	24	Final QC	1.25	
	25	Packing	1.42	

Product 3				
Department	**S. N**		**Process Wise SMV**	**Total SMV**
Cutting	**1**	Cutting upper leather	1.19	**4.86**
	2	Cutting reinforcement	0.08	
	3	Cutting reinforcement for Vamp	0.15	
	4	Cutting QC	0.27	
	5	Apply thermo reinforcement	0.92	
	6	Skiving heel part	0.17	
	7	Skiving upper	0.48	
	8	Cutting leather lining	0.97	
	9	Skiving leather lining	0.63	
Sewing	**1**	Stitching counter lining	0.18	**13.24**
	2	Setup quarter with glue	0.23	

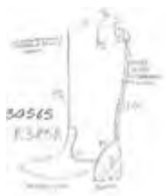
	3	Stitch back lining	0.3	
	4	Setup counter lining	0.66	
	5	Stitching counter lining	0.41	
	6	Insert lining	3.93	
	7	Stitching upper with lining	1.08	
	8	Trimming machine	0.46	
	9	Stitch back seam	0.32	
	10	Back seam stitch	0.72	
	11	Rubbing with 14mm tape side	0.32	
	12	Trimming manual	0.61	
	13	Apply reinforcement 15 mm tape	0.2	
	14	Apply 6mm tape	0.62	
	15	Apply 3mm cotton tape	1.08	
	16	Apply cotton reinforcement	0.35	
	17	Toe puff attaching	0.72	
	18	Line QC	0.35	
	19	Line loading	0.35	
	20	Line cleaner	0.35	
Assembling	**1**	Outsole priming	0.56	**30.13**
	2	Insole attaching	0.45	
	3	Back Part molding	1.2	
	4	Conditioning	1.38	
	5	Toe lasting	0.95	
	6	Side lasting	1.89	
	7	Seat lasting	0.85	
	8	Pounding	0.65	
	9	Outsole marking	1.24	
	10	Buffing	0.76	
	11	Glue apply first coat	0.96	
	12	Glue apply second coat	0.72	
	13	Heat reactivation	3.05	
	14	Outsole laying	1.65	
	15	Heel attaching	0.68	
	16	Outsole pressing	0.34	
	17	Celling / Cooling	2.54	
	18	Unlasting	0.23	
	19	Insocks attaching	1.32	
	20	Cleaning	0.86	
	21	Finishing	2.65	

	22	Quality control	1.23	
	23	UV tunnel passing	0.65	
	24	Nail detection	0.65	
	25	Final QC	1.25	
	26	Packing	1.42	

Product 4				
Department	**S. N**		**Process wise SMV**	**Total SMV**
Cutting	1	Cutting upper leather	5.03	**16.04**
	2	Cutting reinforcement	0.38	
	3	Cutting reinforcement for Vamp	0.54	
	4	Cutting QC	1.35	
	5	Recutting	0.35	
	6	Apply reinforcement	2.91	
	7	Skiving upper	3.38	
	8	Splitting loop	0.36	
	9	Cutting Zipper lining	0.08	
	10	Cutting warm lining	0.59	
	11	Cutting synthetic lining	0.23	
	12	Cutting counter lining	0.15	
	13	Cutting synthetic collar lining	0.23	
	14	Skiving lining	0.46	
Sewing	1	Stitching collar lining	3.83	**62.89**
	2	Compose collar with glue	2.91	
	3	Setup lining with 14mm cotton tape	1.57	
	4	Zigzag stitching on warm lining	0.91	
	5	Stitch back lining	0.62	
	6	Marking for counter lining	0.14	
	7	Marking on conveyor	0.14	
	8	Set up counter lining	0.87	
	9	Stitching counter lining	0.97	
	10	Insert lining	3.26	
	11	Hand punch	1.15	
	12	Stitching counter on Quarter	0.9	
	13	Stitching Zipper side	1.27	
	14	Rubbing with 14mm tape	0.17	

	15	Stitching upper with lining	4.51	
	16	Stitching tongue	1.44	
	17	Stitching talloncino	1.18	
	18	Loop form with glue	0.2	
	19	Stitching testina in Quarter	1.21	
	20	Apply 10mm cotton tape	0.22	
	21	Apply hook	6.11	
	22	Setup tongue	0.44	
	23	Setup loop	1.07	
	24	Setup toe on quarter	0.99	
	25	Setup telloncino	0.7	
	26	Setup counter on quarter	1.07	
	27	Setup testina on Quarter	0.9	
	28	Seam vamp with counter	0.65	
	29	Seam back side upper	0.41	
	30	Counter seam stitch	0.31	
	31	Loop seam stitch	1.25	
	32	Stitch tongue end	0.71	
	33	Stitch Quarter end	1.22	
	34	Insert Zipper and zipper lining	2.15	
	35	Rubbing with 14mm tape front	0.15	
	36	Rubbing with 14mm tape side	0.31	
	37	Trimming machine	0.61	
	38	Trimming manual	2.08	
	39	Stitching Vamp on Quarter	0.6	
	40	Glue the Zipper	0.26	
	41	Apply reinforcement nylon	1.73	
	42	Apply 3mm cotton tape	2.05	
	43	Toe puff attaching	0.72	
	44	lacing	2.9	
	45	Line QC	2.01	
	46	Line loading	2.01	
	47	Line cleaner	2.01	
Assembling	1	Outsole priming	0.56	**29.79**
	2	Insole attaching	0.45	
	3	Back Part molding	1.2	
	4	Conditioning	1.38	
	5	Toe lasting	0.95	
	6	Side lasting	1.89	

	7	Seat lasting	0.85	
	8	Pounding	0.65	
	9	Outsole marking	1.24	
	10	Buffing	0.76	
	11	Glue apply first coat	0.96	
	12	Glue apply second coat	0.72	
	13	Heat reactivation	3.05	
	14	Outsole laying	1.65	
	15	Outsole pressing	0.68	
	16	Celling / Cooling	2.54	
	17	Unlasting	0.23	
	18	Insocks attaching	1.32	
	19	Cleaning	0.86	
	20	Finishing	2.65	
	21	Quality control	1.23	
	22	UV tunnel passing	0.65	
	23	Nail detection	0.65	
	24	Final QC	1.25	
	25	Packing	1.42	

Product 5				
Department	**S. N**		**Process Wise SMV**	**Total SMV**
Cutting	1	Cutting upper leather	4.64	**17.29**
	2	Cutting reinforcement	0.16	
	3	Cutting reinforcement for Vamp	0.54	
	4	Cutting QC	1.35	
	5	Recutting	1.61	
	6	Cutting elastic by knife	0.16	
	7	Apply thermo reinforcement	1.12	
	8	Crimping	1.73	
	9	Skiving upper	2.68	
	10	Splitting loop	0.36	
	11	Cutting Zipper lining	0.08	
	12	Cutting warm lining	0.35	
	13	Cutting synthetic lining	0.15	
	14	Cutting counter lining	0.15	
	15	Cutting synthetic collar lining	0.23	

	16	Cutting leather collar lining	0.7	
	17	Skiving lining	0.33	
	18	Skiving collar lining	0.95	
Sewing	1	Stitching collar lining	1.11	48.45
	2	Compose collar with glue	1.74	
	3	Zigzag stitching on warm lining	0.76	
	4	Stitch back lining	0.99	
	5	Marking for counter lining	0.14	
	6	Marking on conveyor	0.14	
	7	Set up counter lining	0.87	
	8	Stitching counter lining	0.54	
	9	Pounding machine	0.6	
	10	Stitching strap	0.54	
	11	Manual folding	0.43	
	12	Machine folding	1.15	
	13	Insert lining	4.89	
	14	Stitching for collar turn out	1.01	
	15	Stitching counter on Quarter	2.18	
	16	Stitching zipper side	1.73	
	17	Stitching upper and lining	2.4	
	18	Stitch decoration on Quarter	2.14	
	19	Stitching counter	0.59	
	20	Trimming machine	0.26	
	21	Apply stud	0.36	
	22	Apply 15mm nylon tape	0.35	
	23	Apply elastic	0.82	
	24	Setup strap on quarter	0.22	
	25	Setup vamp on quarter	1.09	
	26	Set up counter	0.58	
	27	Setup counter on quarter	1.08	
	28	Stitch vamp with counter	0.71	
	29	Stitch back seam	1.18	
	30	Stitch side seam	0.3	
	31	Stitch counter seam	0.26	
	32	Stitch strap end	0.29	
	33	Insert Zipper and zipper lining	3.08	
	34	Stitch elastic	0.69	
	35	Rubbing with 14mm tape side	0.95	
	36	Trimming manual	1.76	
	37	Stitching Vamp on Quarter	1.23	

	38	Glue the Zipper	0.26	
	39	Apply reinforcement on Back seam	2.11	
	40	Apply 3mm cotton tape	1.1	
	41	Toe puff attaching	0.72	
	42	Line QC	1.7	
	43	Line loading	1.7	
	44	Line cleaner	1.7	
Assembling	1	Outsole priming	0.56	**29.79**
	2	Insole attaching	0.45	
	3	Back Part molding	1.2	
	4	Conditioning	1.38	
	5	Toe lasting	0.95	
	6	Side lasting	1.89	
	7	Seat lasting	0.85	
	8	Pounding	0.65	
	9	Outsole marking	1.24	
	10	Buffing	0.76	
	11	Glue apply first coat	0.96	
	12	Glue apply second coat	0.72	
	13	Heat reactivation	3.05	
	14	Outsole laying	1.65	
	15	Outsole pressing	0.68	
	16	Celling / Cooling	2.54	
	17	Unlasting	0.23	
	18	Insocks attaching	1.32	
	19	Cleaning	0.86	
	20	Finishing	2.65	
	21	Quality control	1.23	
	22	UV tunnel passing	0.65	
	23	Nail detection	0.65	
	24	Final QC	1.25	
	25	Packing	1.42	