A CASE STUDY IN PRODUCTIVITY IMPROVEMENT IN FOOTWEAR INDUSTRY

By

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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.

Noor Ali

This work is dedicated
to my loving

Father

&
Mother

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Abstract

At present, the country's footwear industry is at a preliminary position to play a larger role in Bangladesh's export fortunes in the next decade and what is urgently needed is to robust backward linkage and improves productivity. Emphasizing on improving productivity steps has been taken to investigate and apply line balancing in the footwear industry. It tries to identify the waiting time and bottle neck as well as eliminate it. Thus, it leads to improvement in productivity of manufacturing and service organizations and quality of products leading to a competitive advantage over others. Bangladeshi industries, especially footwear sector is new and very few have attempted to implement this, but a little research work is carried out in regarding its suitability. This research on applicability of line balancing helped the organization to visualize the bottle neck & waiting time generated in the sewing section and future possibilities of eliminating or reducing them. The research was administered with four footwear manufacturers in Bangladesh using personal interviews, secondary data and observations. The outcome of this observation reflected that an industry may gain higher productivity and profitability by proper line balancing and systematic layout. The findings can be extended to similar footwear industry in the future. A general overview over this development is given in this paper.

Chapter-1

Introduction

1.1 Introduction

Bangladesh is a country that promises great achievements in the years to come. Although the export basket of our country is heavily skewed towards RMG export, several new sectors have cropped up over the last decade. Footwear is one such sector which has tremendous potential to significantly boost country's export while diversifying the economy's export basket [**Amin 2015]**. The manufacturers believe Bangladesh's annual $550-million footwear industry may grow to a $15-billion sector within a few years, if the opportunity is seized. Total leather industry export marked a record with over USD 1 billion in fiscal year 2013-2014 of which footwear alone accounted for around 71 percent of this. An overview in the **Fig. 1.1** is showing the current footwear industry status in Bangladesh.

LFMEAB (Leather goods & Footwear Manufacturers & Exporters Association of Bangladesh) ex-President said at least 51 foreign companies had already expressed interest in establishing joint-venture footwear units in Bangladesh. "China, the world's largest footwear manufacturer, is now withdrawing from the global market. And our country is ready with huge potentials to attract foreign investments in the sector", he said.

Keystone Quarterly Review said Bangladesh is increasingly becoming a preferred destination for leather and footwear sourcing. "A number of Chinese firms have already relocated in Bangladesh because of its competitive advantages within the value chain which includes: low labor cost, high supply of raw hide, duty free and GSP facilities etc.", it said. Several orders which earlier used to go to China and India are now coming to Bangladesh.

Having business-friendly environment and imposing European Union's antidumping duties on the import of shoes from China, many global leather giants especially shoemakers are rushing to Bangladesh. USA-based Timberland, Germany-based PICARD, Korea-based Youngone and most notably Taiwan-based Pou Chen Group (one of the world's largest shoemakers, producing shoes for Timberland, Adidas, Reebok, Nike, Puma and so on) as well as many renowned companies from the leather-world have shifted here lately and many more is in the pipe line to come to Bangladesh **[Milan 2016].**

Overview of Bangladesh Footwear Industry 2017 [EPB 2017-2018].

- **8th position** in terms of footwear production in the world in 2016 with a **production of 399 million pairs (**1.6% 0f world share).
- **14% Growth in 2012-13 to ~20% by 2015-16.**
- **Increased export by almost 700%** in the last decade- world footwear yearbook 2017.

Domestic Footwear Market Size [EPB 2017-2018].

- Between 200 to 250 million pairs a year.
- Per capita including leather is 3 pairs, five years back was 1.7 pairs.
- Imported approximately 24 million pairs, FY' 2016-17

Business Productivity is the ability of an organization to utilize its available resources to produce profitable goods or services as desired by customers or clients. It is the productivity that measures the performance of an organization, and it can also be used for companies themselves to assess their own progress. The importance of productivity in business can be summarized as follows.

Productiveness increases the overall efficiency of an organization. When the efficiency of the organization increases, the production capacity of the company is utilized to the optimum level. Thus, all resources are used in an effective and efficient manner to get the best possible results. As is often indicated by business, the more products you make, the lower your overhead, and the higher your profits.

Enhanced production lowers the cost per unit of a product which in turn, results in lower prices for better quality, which enhances a business' competitiveness in the market. In the current turbulent world, every organization faces stiff competition from their counterparts. Hence, lower prices because of enhanced production give an edge to businesses to sell products at more competitive prices. If the rates are competitive, the business is in a better position to attract more customers and make more sales. This is the primary motive of any business organization.

Increased production due to efficient utilization of organizational resources leads to a lower cost production resulting in better sales and profits. If the profits of an organization shoot up, it increases the confidence of investors in the organization. Moreover, the share value of the company increases. Due to this, the reputation and goodwill of the organization increases.

Similarly, the business can share a portion of its profits because of enhanced production with its employees. This boosts the morale of the employees as they get to enjoy a part of the profits and the satisfaction of a job well done. Thus, their working efficiency tends to increase which in turn, further increases the production of the company.

Productivity is much more important than revenues and profits of the organization because profits only reflect the result whereas productivity reflects the increased efficiency as well as effectiveness of business policies and processes. Moreover, it enables a business to find out its strengths and weaknesses. A footwear company can increase its productivity by making suitable changes in its manufacturing process and policies to improve the weak areas and capitalize on strengths for betterment. Similarly, an organization can formulate strategies to turn threats in to opportunities. This results in increased profitability and stability which is vital for the continued success of any business organization **[Parthiban and Razu 2008].**

Chapter-2

Literature Review

2.1 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. Socks and other hosiery are typically worn additionally between the feet and other footwear for further comfort and relief.

Cultures have different customs regarding footwear. These include not using any in some situations, usually bearing a symbolic meaning. This can however also be imposed on specific individuals to place them at a practical disadvantage against shod people, if they are excluded from having footwear available or are prohibited from using any. This usually takes place in situations of captivity, such as imprisonment or slavery, where the groups are among other things distinctly divided by whether or whether not footwear is being worn. In these cases, the use of footwear categorically indicates the exercise of power as against being devoid of footwear, evidently indicating inferiority.

Footwear is in use since earliest human history, archeological finds of complete shoes date back to the copper age. Some ancient civilizations, such as Egypt however saw no practical need for footwear due to convenient climatic and landscape situations and used shoes primarily as ornaments and insignia of power.

The Romans saw clothing and footwear as unmistakable signs of power and status in society, and most Romans wore footwear, while slaves and peasants remained barefoot. The Middle Ages saw the rise of high-heeled shoes, also associated with power, and the desire to look larger than life, and artwork from that period often depicts bare feet as a symbol of poverty. Depictions of captives such as prisoners or slaves from the same period well into the 18th century show the individuals barefooted almost exclusively, at this contrasting the prevailing partakers of the scene. Officials like prosecutors, judges but also slave owners or passive bystanders were usually portrayed wearing shoes.

In some cultures, people remove their shoes before entering a home. Bare feet are also seen as a sign of humility and respect, and adherents of many religious worship or mourn while barefoot. Some religious communities explicitly require people to remove shoes before they enter holy buildings, such as temples.

In several cultures people remove their shoes as a sign of respect towards someone of higher standing. In a similar context deliberately forcing other people to go barefoot while being shod oneself has been used to clearly showcase and convey one's superiority within a setting of power disparity **[Uma 2015].**

2.1.1 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.

According to a newly released statistic (**fig. 2.1**) from the Export Promotion Bureau of Bangladesh, footwear exports from the country grew from US$419 million in the period of July-June 2012-2013 to $550 million in the same period of 2013-14, recording a growth of 31 percent. The next two economic years this figure is $672 & $714. Taking this rate of growth into account, shoe industry executives estimate that the current fiscal year's footwear export is likely to cross $800 million. Though in the next two years the existing factories are likely to export more shoes, it is the new capacity that will come on stream from early 2018 that is expected to cause the huge export in growth. 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].**

Fig. 2.1**:** Export Growth in Footwear ($M)

2.1.2 The Steps of Footwear Making

Cutting- Using cutting die to cut each necessary section of fabric or leather out using a machine. Layer system cutting is practices for non-leather materials. For leather, it is obviously single layer cutting. **Pre- Fabrication -** Fabric attaching, apply tape, skiving, crimping etc. operation done in this stage to prepare the cut components for making upper. Fabric attaching, taping at the edge of components make that strengthen. Skiving is for tapering the edge and crimping is for 3D shape. Screen printing and embossing are also part of this stage. **Sewing -** Stitching department join the components each other's, then attaching the lining and make upper. **Sole Making -** Different types of sole are used to make footwear. Rubber, PVC, EVA, PU are some materials of sole. By injecting or pouring raw materials to a mold, then cooling make it solid. Trim the excess edge. That makes the sole ready for assembly. **Assembly -** To shape the upper as like feet it is covered on a last by using cement in a systematic way. This process is called lasting. Then sole is attached to the lasted upper. Remove the last from shoe. **Finishing and Packing -** Lacing, oiling, spraying, cleaning, socks attaching are some steps of finishing department. According to the customer instruction tissue, silica, sticker, shoe tree, hangtag is applied with shoe in a box. Then several boxes are put in a carton and taped.

The above sections are showing in the **Fig. 2.2**

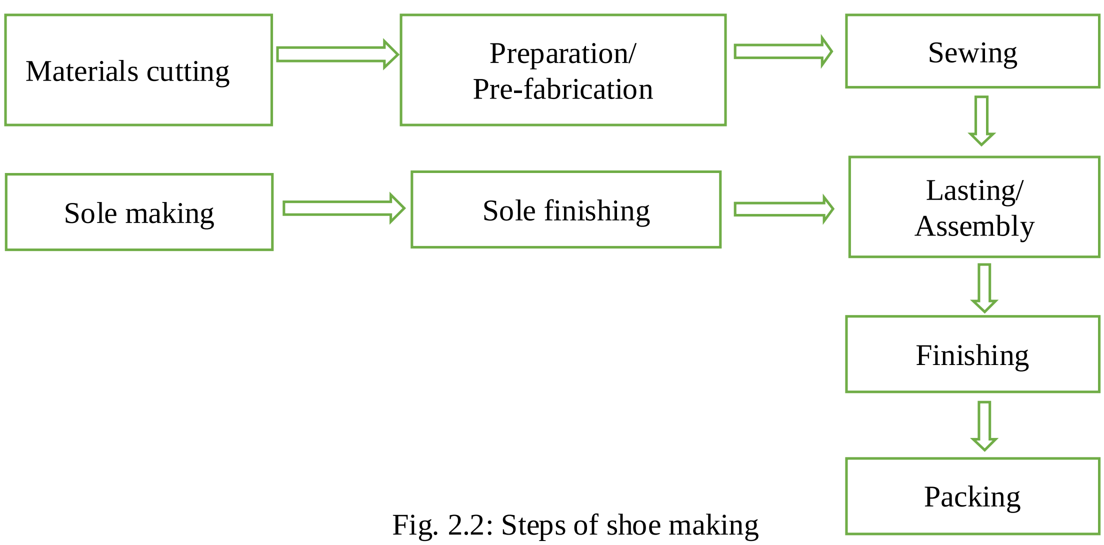

Fig. 2.2: Steps of shoe making

2.1.3 Components of Footwear

Fig. 2.3: Components of Footwear

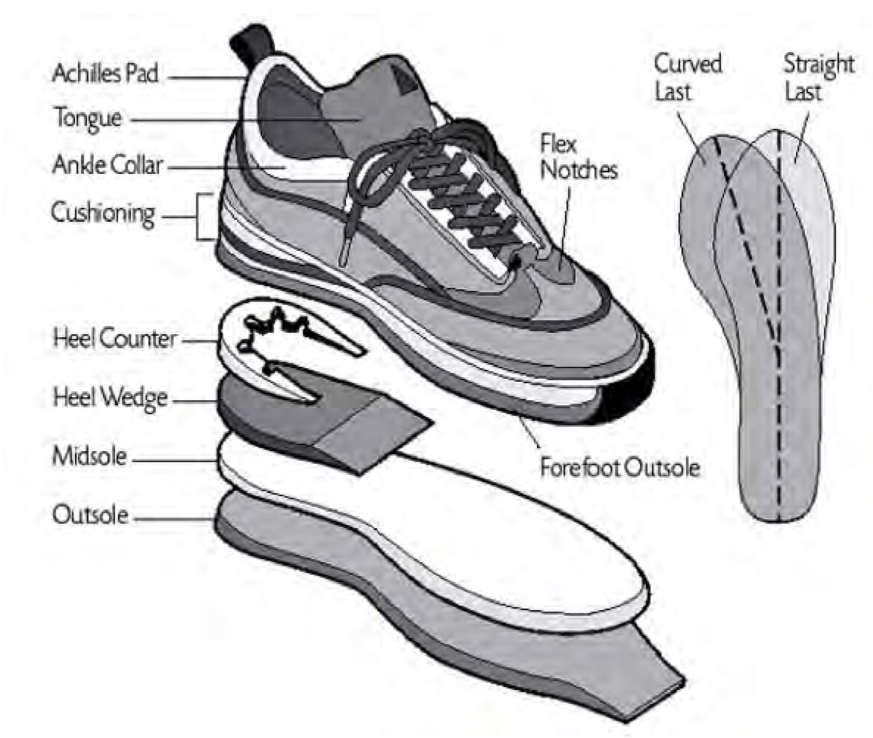

Fig 2.4: Skeleton of footwear

2.2 Productivity

Productivity is a measure of the efficiency and effectiveness to which organizational resources (inputs) are utilized or the creation of products or services (outputs). In footwear industry, “output” can be taken as the number of products manufactured, whilst “input” is the people, machinery and factory resources required to create those products within a given time frame. In fact, in an ideal situation, “input” should be controlled and minimized whilst “output” is maximized. Productivity can be expressed in many ways but mostly productivity is measured as labor productivity, machine productivity or value productivity. Productivity gains are vital to the economy because they allow us to accomplish more with less. The shoe industries need to produce momentous quantities in shorter lead times as footwear product is highly correlated with high level of productivity **[Parthiban and Razu 2008].**

2.2.1 Concept of productivity improvement

Production is a set of operations concerned with the activity of producing goods and/or services and productivity is concerned with the efficient utilization of resources (input) in producing goods and services (output). In a quantitative term, production is the quantity of output produced while productivity is the ratio of the output generated by production process to the input provided to create this output.

Thus, productivity is defined as the efficient use of resources in the production of various goods and services. The essence of productivity is working more intelligently not necessarily harder. A real productivity is not achieved by working harder; this results in a very limited increase in productivity due to man’s physical and mental limitations. The knowledge of productivity can help professional to get more done in less time with less stress. Higher labor productivity often benefits to higher machine and space productivity, which results in lower unit fixed cost. It also means higher production capacity, because one can produce more by same labor, machines, material and space.

The productivity concept is also increasingly linked with quality of output, input and process itself. An element of key importance is the quality of work force and its working conditions. Productivity must be considered in both social and economic terms. Attitudes towards work and achievements may be improved through worker participation in planning goals, implementing process and sharing productivity gains. Productivity improvements need to be worked out in the context of quality, quick response and other competitiveness related needs, including occupational health and safety.

The main method of improving competitiveness of a company is restructuring, reengineering and reinventing. Productivity improvement depends upon better utilization of equipment and resources and elimination of wastage in all forms. It can be done by reducing cost, managing growth, working smarter, paring down and working effectively **[Parthiban and Razu 2008].**

Productivity improvement happen when,

- More output is produced with the same or lesser input.
- The same output is produced with lesser input and
- More output is produced with more input, the proportional increase in output being more than the increase in input.

2.3 Efficiency

Efficiency is a word that is used very commonly by people in their daily lives. Many say that the efficiency of their air conditioner has gone down over the years resulting in poor cooling than when it was new. Others say the same thing about the mileage of their cars expressing disappointment. What this means is that the efficiency of products goes down with usage and wear and tear over a period of time. The concept of efficiency is used in power plants to express the result that is achieved as a percentage of what ideally could have been achieved. In power generation and transmission, there are always losses that lead to lower efficiencies than what are usually expected.

In daily life, it is a common perception that the private sector is more efficient than the public sector. It is also said that given the resources at the hands of public sector, it should really be much ahead of the private sector. Many believe that job security and promotions without any attention to performance is what is the primary reason of lower efficiency of the public-sector enterprises.

2.3.1 Difference between Efficiency and Productivity

- A car is said to be more fuel efficient than other cars in its class if it gives higher mileage than other cars per liter of gas.

- Using the same inputs, achieving higher outputs is said to be more productive than those achieving lower outputs

- If an economy produces more goods and services with the same inputs like natural resources and manual labor than another economy, it is said to be more efficient than the other economy.

- Higher productivity is not always a result of higher efficiency as there are other factors at work also

- A manufacturer is obviously more efficient than his competitors if he achieves lower cost per unit of goods

2.4 Work Study

Work study is the systematic examination of the methods of carrying out activities so as to improve the effective use of resources and to set-up standards of performance for the activities being carried out. It is one of the most powerful tools that management can use to improve productivity **[Kanawaty 1992].** It is a generic term for those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement Work study mainly focused at investigating the way an activity is being carried out, simplifying or modifying the method of operation to reduce unnecessary non-value adding activities in terms of rework, wastage, and finally fixing the standard time for an activity. Therefore, the relationship between productivity and work study is noticeable **[Yadav 2016].**

The objective of applying work study is to obtain the optimum use of the human and material resources, which are available to it. The benefit may stem from improvements in one or more of the following: increased production and productivity, reduced cost-labor, material, overheads, improvement of conditions, which involve an element of excessive fatigue or danger, improved quality and better control of cost.

Time study is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions, and for analyzing the data to obtain the time necessary for an operator to carry it out at a defined rate of performance. Most common methods of work measurements are stopwatch time study, historical time study, predetermined motion time system (PMTS) and work sampling. Among this time study by stopwatch is one of the most widely used means of work measurement. Time study leads to the establishment of work standard. Development of time standard involves calculation of three times such as observed time (OT) or cycle time (CT), normal time (NT) or basic time (BT) and standard time (ST). The basics steps in a time study are-

- Defining the task to be studied and informing it to the worker.
- Determination of number of cycles to be observed
- Calculating the cycle time and rating the worker's performance
- Computing the standard time

2.4.1 Techniques of Work Study

a. Method Study: Method study is the systematic recording and critical examination of existing and proposed ways of doing work. It is concerned with the reduction of work content of a job or operation. Sometimes it is called Work Method Design **(Kulkarni 2014)**. This method consists tools such as Process flow chart, man machine chart, SIMO chart and other.

The following steps depict the procedure for creating a method study.

- Select (the work to be studied),
- Record (all relevant information about that work),
- Examine (the recorded information),
- Develop (an improved way of doing things),
- Install (the new method as standard practice),
- Maintain (the new standard proactive)

b. Work Measurement:

Estimation of standard time for an activity that is the time specific for completing one job by using the predicted method. Standard time can be defined as the time utilized by an average experienced skillful operator for the job with provisions for delays beyond the operator's control [**Kulkarni 2014].**

The Critical Examination of the recorded facts is very important and is performed to determine the true reasons underlying each event and find out all possible improvements by applying some sequential questioning techniques. In this procedure, every activity should be subjected to the following questions asked one after the other in their proper sequence. The answers of these questions will form the basis for the development of the improved method **(Fig. 2.10) [Ahmed and Fatema-Tuj-Zohra 2005]**

1.Purpose?
What is being done?
Why is it necessary?
What else could be done?
What should be done?

2. Place?
Where is it done?
Why is it done there?
Where else could it be done?
Where should it be done?

3. Sequence?
When is it done?
Why is it done then?
Where else could it be done?
Where should it be done?

4. Method?
How is it done?
Why is it done that way?
How else could it be done?
How should it be done?

5. Person?
Who does it?
Why does that person do it?
Who else could do it?
Who should do it?

Fig. 2.5: The Questions to develop Improvement method.

When the purposes of the activities are challenged, the main objective is to see whether that activity could be eliminated entirely. If it proves to be necessary, then the objective is to modify the same by changing its sequence or by combining it with other activities. Improvements are often obtained by combining activities, changing the place of work, the sequence in which the person performing the activities **[Ahmed and Fatema-Tuj-Zohra 2005].**

2.5 Standard Minute Value (SMV)

Standard Time is also referred to as the 'Standard Minute Value' or 'SMV'. It is the time required for a qualified worker working at "Standard Performance" to perform a given task. The SMV includes additional allowances for Rest and Relaxation, Machine Delay and anticipated Contingencies.

The SMV is the universal measurement of time and its accuracy and consistency is essential as the foundation for measurement of key business processes such as Production Targets, Line Balancing, Production Planning, Incentive Schemes, and the quantification of Operator Performance and Factory Efficiency.

Establishing a precise SMV can, however, be extremely difficult when using traditional methods of work measurement. This is because production workers are neither robots nor machines, and do not work at a constant rate throughout the working day. Making accurate and consistent measurement is therefore very difficult. Moreover, people are affected by motivation, fatigue and job familiarity and therefore work at a varying performance level during the working period.

A reliable, predictive and ethical means of establishing Standard Time is therefore an essential element of today's business process – and GSD is the world leading means of achieving that goal.

$$\text{SMV for individual process} = \text{Basic time } (1 + \text{Allowance factor}) \quad [1.1]$$

$$\text{Basic time} = \text{Cycle time X Performance rating} \quad [1.2]$$

Process capacity and worker's efficiency were also determined by using SMV. Capacity of every process and working efficiency of all operators and helpers in a line were calculated by using Equation (1.3) and (1.4). Equation (1.5), (1.6) and (1.7) were used for the calculation of production line efficiency:

$$\text{Capacity/hour (Pieces)} = \frac{\text{Total work force} \times \text{Total minutes attended}}{\text{SMV}} \quad [1.3]$$

$$\text{Worker's efficiency} = \frac{\text{Total minutes produced}}{\text{Total minutes attended}} \times 100 \qquad [1.4]$$

$$\text{Line efficiency} = \frac{\text{Total output (minutes)}}{\text{Total input (minutes)}} \times 100 \qquad [1.5]$$

$$\text{Total output (minutes)} = \text{Total output (piece) per day} \times \text{SMV} \qquad [1.6]$$

$$\text{Total input (min)} = \text{Total work force/day} \times \text{Total min attended} \qquad [1.7]$$

Waiting time can be calculated by using Equation (1.8). Equation (1.9), (1.10) and (1.11) were used to calculate the man-machine ratio, labor productivity and machine productivity respectively.

$$\text{Waiting time/hr/line} = (\text{Process capacity - Actual output}) \times \text{SMV} \qquad [1.8]$$

$$\text{Man to machine ratio} = \frac{\text{Total workforce}}{\text{Total no. of available machines}} \qquad [1.9]$$

$$\text{Labor productivity/day/line} = \frac{\text{Total output (Pieces)}}{\text{Total workforce}} \qquad [1.10]$$

$$\text{Machine productivity/day/line} = \frac{\text{Total output (Pieces)}}{\text{Total no. of machines}} \qquad [1.11]$$

2.6 Line Balancing

Line balancing is mainly an arrangement of production line for even and smooth flow of production units from one workstation to the next. It utilizes the division of labor principle to assign the work elements to the workstations so that all stations have nearly an equal amount of work to do. Each workman is required to perform at his workstation an assign amount of work timely and repeatedly on each of the production unit as it passes the station.

In any Footwear industry, the products are made as they pass through several operations. Each operation performs a distinct part of the total work and the time required for that operation should be equalized to other individual operation and the speed of the conveyor or work flow. A balance of work in closing room can be achieved by comparing the work content to be done with the work potential available. If work content exceeds the work potential for any operation, a bottleneck will occur which restricts the flow of work to the subsequent operations and make them underutilized. They will also affect previous operations as the completed work cannot be accepted and the input must be re-balanced. Again, if work potential exceeds the work content, those operatives and workstation will be short of work. Both are equally undesirable and may involve no work or overtime payments. Thus, work-in-process (WIP) and throughput time will be more and ultimate output will be less. Therefore, the distribution of work content should be equalized in all workstations by proper arranging of machines and workforce for proper line balancing to achieve optimum productivity with acceptable quality. Idle time occurs for a station when the work assigned to it, takes less time than the set cycle time. Since such idle time lead to partial utilization of the facility, every attempt is made to balance for better utilization of the line while assigning work to the workstation. A perfect balance results when work allocations provide no idle time. Owing to proper balancing of line, the organization is able to utilize optimally all the facilities and thus the productivity is improved. In a balanced line, each and every workforce and machine can be exploited as good as possible for quality production.

2.6.1 Scope of line balancing

- Optimized use of manpower, machine and other resources
- Improved productivity.
- Balanced production sequences.
- Improved flow of production and process.
- Economized human efforts and the reduction of unnecessary fatigue.
- Improved physical working environment.
- Efficient material handling.
- Improved occupational health and safety standards.
- Reduced throughput time.

2.7 Lean Manufacturing

Lean Manufacturing can be defined as "A systematic approach to identifying and eliminating waste through continuous improvement of the product at the demand of the customer." TaiichiOhno once said that “Lean Manufacturing is all about looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non – value added wastes”. Lean always focuses on identifying and eliminating waste and fully utilizing the activities that add value to the final product. From the customer point of view, value is equivalent to anything he is willing to pay for the product or service he receives. Formally value adding activities can be defined as: activities that transform materials and information into products and services the customer wants. On the other hand, non-value adding activities can be defined as: activities that consume resources, but do not directly contribute to product or service. This non-value adding activities are the waste in Lean Manufacturing. Waste can be generated due to poor layout (distance), long setup times, incapable processes, poor maintenance practices, poor work methods, lack of training, large batches, ineffective production planning/scheduling, lack of workplace organization etc. By eliminating wastes in the overall process, through continuous improvements the product’s lead time can be reduced remarkably. By reducing lead time organization can obtain operational benefits (enhancement of productivity, reduction in work-in-process inventory, improvement in quality, reduction of space utilization and better work place organization) as well as administrative benefits (reduction in order processing errors, streamlining of customer service functions so that customers are no longer placed on hold, reduction of paperwork in office areas, reduction of labor turnover) [**Islam 2013].**

2.7.1 Wastage in lean Manufacturing

Overproduction – Producing more than the customer demands.

Waiting – Whenever goods are not being moving or being processed, the waste, waiting occurs. Typically, more than 99% of a product’s life cycle time in traditional mass production is spent in idling. This includes waiting for material, labor, information, equipment etc. Lean requires that all resources are provided on a just-in-time (JIT) basis –

not too soon, not too late by linking processes together so that one feeds directly into the next and can dramatically reduce waiting **[Islam and Khan 2013].**

Transportationorconveyance– Moving product between processes does not add value to the product. Excessive movements and handlings can cause damages and can lead to reduction in quality. Materials should be delivered to its point of use. Lean requires the material be shipped directly from the vendor to the location in the assembly line where it will be used. This is called Point-Of-Use-Storage (POUS) **[Islam and Khan 2013].**

Over processing or incorrect processing – Taking unneeded steps to process the parts. Some of the more common examples of this are reworking, inspecting, rechecking etc. This is due to poor layout, poor tools and poor product design, causing unnecessary motion and producing defects **[Islam and Khan 2013].**

Excess Inventory – Any type of inventory (raw material or in process or finish goods) does not add value to the product and it should be eliminated or reduced. Excess inventory uses valuable floor space and hides problems related to process in capabilities. Excess inventory results in longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay.

Defects – Defects can be either production defects or service errors. Having a defect results a tremendous cost to organizations. In most of the organizations the total cost of defects is often a significant percentage of total manufacturing cost. Repairing of rework, replacement production and inspection means wasteful handling time, and effort **[Islam and Khan 2013].**

Excess Motion – Any motion that employee must perform which does not add value the product is an unnecessary or excess motion. Unnecessary motion is caused by poor workflow, poor layout, poor housekeeping, and inconsistent or undocumented work methods **[Islam and Khan 2013].**

2.8 Fishbone Analysis

A recurring theme in a lean or six-sigma transformation is removing the clutter to allow you to see waste or opportunities for improvement. A fishbone diagram aims to break down and organize the Causes of an issue to reveal what elements have the greatest impact. Grouping the "causes" means you can think about the different elements of the problem as separate from the overall process. One or two of these "causes" will have a greater effect than the others and will guide you to the root of the problem. This structure also allows you to tackle smaller chunks which have a large impact on the problem. Looking at elements of the problem and not the whole process will likely make finding your solution less daunting and problem solving more manageable **[Archana 2012].**

2.9 Value Stream Mapping (VSM)

A tool of Kaizen, Special type of flow chart that uses symbols known as "*The Language of Lean*" to depict and improve the flow **[Hasan, Nirjher and Chowdhury 2017].**

- Lean-management method for analyzing the current state and designing a future state of the process.
- The mapping of the activities-from the acquisition of raw materials to the delivery of the product to the customer.
- The symbols-the VSM users can easily understand the processes and the connections between them.

Provide optimum value to the customer through a complete value creation process with minimum waste in:

- Design (concept to customer)
- Build (order to delivery)
- Sustain (in-use through life cycle to service)

Value stream mapping (VSM) originally developed by Toyota is used to first map the current state and then to identify the sources of waste and to identify lean tools to eliminate the waste. Diverging from other conventional recording approaches value stream mapping helps to visualize and record cycle times, inventories held, changeover times, modes of transportation, manpower deployment, utilization of resources etc. Beyond the advantages, VSM is unable to handle multiple products that do not have identical maps and tends to bias a factory designer to consider only continuous flow, assembly line layouts, Kanban-based pull scheduling, etc. that are suitable mainly for high volume and low variety manufacturing systems. Value stream improvement is not an event but it is an unending incrementally favorable process. In an internal manufacturing situation, three types of activities are taken into consideration. These are non-value adding (NVA), necessary but non-value adding (NVA) and value-adding (VA). VSM is a lean management tool which assists in establishing the current state of a process while aiding to uncover opportunities for improvement. The first of these is pure waste and involves unnecessary actions which should be eliminated completely by seven value stream mapping tools in the industries [**Hines and Rich 2005**].

Importance of enthusiastically vested cross-functional team work is vital to success of VSM process in the industry. VSM technique was used in the garments industry of Bangladesh to help in the visualization of material and information flow, cycle time and best utilization of the resources [**Islam and Sultana 2011**].

2.10 SWOT Analysis

SWOT stands for: **S**trength, **W**eakness, **O**pportunityand **T**hreat. A SWOT analysis guides you to identify your organization's strengths and weaknesses (S-W), as well as broader opportunities and threats (O-T). Developing a fuller awareness of the situation helps with both strategic planning and decision-making.

The SWOT method was originally developed for business and industry, but it is equally useful in the work of community health and development, education, and even for personal growth.

In a company, weaknesses are the constraints to pick the opportunities and again strengths resist the vulnerability of the threats. SWOT analysis allows businesses to define realistic goals, improve capability, overcome weaknesses with strengths and identify threats than can be turned into opportunities. The SWOT analysis provides information that is helpful in matching the firm's resources and capabilities to the competitive environment in which it operates.

SWOT analysis helped to identify the challenges of footwear industry, opportunities and threats of footwear sector in Bangladesh. According to the analysis, many problem areas were identified in the mill which is related to the global challenges offshore industry such as high prices of quality products, high rated gas, electricity and oil prices, political unrest and inadequate sales center for the local market etc. [**Mostafa 2006**]. Footwear industries of Bangladesh must need to overcome these challenges to expand its market growth locally and internationally.

In India, SWOT analysis was practiced to throw light on its present retail scenario and to identify weakness such as multi-diversified business, no bargaining markets etc. and various threats such as increasing competitors, government and local policies, unrecognized modern retailing etc. The analysis also discussed some customer-centric initiatives to be taken in future by the retailers [**Archana 2012**].

SWOT analysis also identified the weakness such as poor infra-structure, poor quality standards, less productivity, unstable political situation etc. in the Pakistan's textile industries and recommended alternative solutions and remedies to make the industries more competitive and efficient against its biggest challengers and competitors [**Akhlaq 2009**].

Footwear is a second largest sector in Bangladesh economy and SWOT analysis should be done on leather & shoe industries to identify the strengths, weakness, opportunities and threats for productivity improvement.

2.11 Objective of this work

Continuing from all the discussion from the above the main objective of our projects are follows:

- Observation of cycle time during footwear making and calculation of standard minute value (SMV) by considering allowances in different footwear industries.
- Assessment of existing capacity and productivity of selected footwear industries in Bangladesh by considering calculated SMV.
- Identification of bottleneck in process and its minimization through line balancing.
- Identification of problem areas for less production, more wastage and higher cost through fishbone diagram analysis in footwear industries.
- Comparison of labor efficiency, production line efficiency and factory efficiency among large and small industries.

2.12 Scope of thesis

The purpose of the work was to improve the productivity and decrease the shoe manufacturing cost in the footwear industries. In this report, various types of relevant contents such as introduction, literature review, objectives and methodology, data analysis and results, discussion on results and conclusion with scopes for future work are arranged chapter wise here.

Chapter 1 includes introduction part of the research report.

Chapter 2 covers literature review, research objectives

Chapter 3 includes outlines of the methodology.

Chapter 4 various types of data collection and its analysis with required graphs.

Chapter 5 Contains discussions on the results found after the time study and line balancing. The chapter also includes comparisons between existing and proposed situation of the footwear industries to evaluate the improvements.

Chapter 6 contains conclusion part of the research report which is followed by scopes for future work.

Chapter-3

Methodology

3. 1 Methodology

The methodologies are as follows:

i) Four footwear industries of Bangladesh (Appendix-A) have been selected and visited for the research purpose. By the time study SMV is calculated from the cycle time of every process for different shoe components. For the determination of total SMV, basic time and SMV for each operation is calculated separately. Process wise production capacity and worker's efficiency are calculated by using calculated SMV. After that, benchmarked production target is set for line balancing.

ii) After applying line balancing technique, those production lines are balanced considering existing bottlenecks in the processes. After line balancing new manpower setup is proposed and final capacity of each process is also reallocated. Finally, new production layouts are modeled with the balanced capacity to increase the productivity in footwear industries.

iii) Actual problem areas and causes for less productivity in the industries are identified and represented by Fish Bone Diagram.

iv) SWOT analysis is practiced on the present situation of footwear industries to identify the possible strength, weakness, opportunity and threat for productivity improvement.

v) One structured questionnaire (Appendix-B) was also used to conduct a survey on 50 production people in the footwear industries to identify other factors those are indirectly related to the productivity.

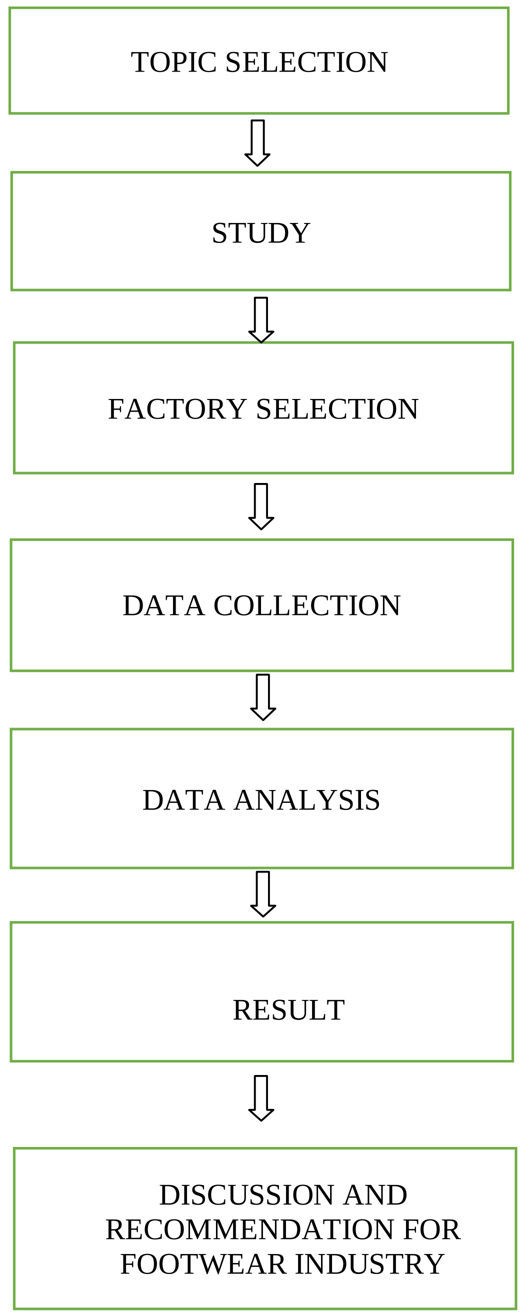

Fig. 3.1: Methodology

Chapter-4

Data Collection and Analysis

4.1 Time Studies and Data Collection

Work measurement is the main element of productivity analysis. For work measurement time study is very much essential tool 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. 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. Per 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 20% , personal and bundle allowance per paper presented [**Shumon 2010**]. Table 4.1 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 four products.

Process capacity and worker's efficiency were also determined by using SMV. Capacity of every process and working efficiency of all operators and helpers in a line were calculated by using Equation (1.3) and (1.4). Equation (1.5), (1.6) and (1.7) were used for the calculation of production line efficiency. Waiting time can be calculated by using Equation (1.8). Equation (1.9), (1.10) and (1.11) were used to calculate the man-machine ratio, labor productivity and machine productivity respectively.

Table 4.1: Product category with workers' performance rating and allowance factor

Product	Product Name	Average Worker's performance Rating	Allowance Factor
Product-1	Sports shoe	75%	20%
Product-2	Walking shoe	75%	20%
Product-3	BAF PT Shoe	75%	20%
Product-4	School shoe	75%	20%

Table 4.2: Process wise SMV and capacity per hour for product 1 in sewing section:

S.I	Work	Cycle time (sec)	SMV (min)	Operator	Production capacity (hr)	Balanced Capacity (hr)
1	Marking	35	0.55	1	108	108
2	Quarter strap stitch	32	0.51	1	118	118
3	Smal strap stitch	26	0.41	1	146	124
4	Big strap stitch	55	0.87	2	138	126
5	Zigzag stitch	33	0.52	1	115	115
6	Backtop stitch	40	0.63	1	95	106
7	Side deco stitch	41	0.65	1	92	106
8	Counter stepener cementing	33	0.52	1	115	115
9	Counter stitch	30	0.48	1	126	126
10	Lining join& center stitch	64	1.01	2	118	118
11	Foam cementing & bending	60	0.95	2	126	126
12	Lining stitching	41	0.65	1	92	106
13	Vamp zigzag	30	0.48	1	126	126
14	Toe cap cementing	32	0.51	1	118	118
15	Toe join stitch	58	0.92	2	131	126
16	Eyelet reinforcement Attach	30	0.48	1	126	126
17	Eyelet pc stitching	119	1.88	4	127	113
18	Tongue label set & stitch	28	0.44	1	135	115
19	Toung folding	30	0.48	1	126	126
20	Size stamping	29	0.46	1	131	120
21	Tongue join stitch	40	0.63	1	95	106
22	Quality Checking	41	0.65	1	92	106
23	Toe cementing	30	0.48	1	126	126
24	Strobel stitch	39	0.62	**1**	97	106
	Total		**15.77**	**31**		

Table 4.3 Process wise SMV and capacity per hour for product 2 in sewing section:

S.I	Work	cycle time (sec)	SMV (min)	operator	production Capacity (hr)	Balanced Capacity (hr)
1	Marking	22	0.35	1	172	172
2	Topline stitch	26	0.41	1	146	160
3	Binding	23	0.36	1	165	165
4	Side deco stitch	20	0.32	1	189	171
5	Label Stitch	18	0.29	1	211	172
6	Elastic Stitch	39	0.62	2	194	168
7	Strap stitch	27	0.43	1	140	161
8	Counter stitch	28	0.44	1	135	160
9	Riveting	22	0.35	1	172	172
10	Round Stitch	23	0.36	1	165	165
11	Cementing	65	1.03	3	175	175
12	Checking	23	0.36	1	165	165
13	Stroble stitch	23	0.36	1	165	165
		Total	**5.68**	**16**		

Table 4.4: Process wise SMV and capacity per hour for product 3 in sewing section:

S.I	WORK	cycle time (sec)	SMV (min)	Operator	Production Capacity (hr)	Balanced Capacity (hr)
1	Marking	24	0.38	1	158	150
2	Toe cap stitch	32	0.507	1	118	134
3	Apply cement	30	0.475	1	126	133
4	Vamp+ quater join stitch	25	0.396	1	152	134
5	Zigzag stitch	28	0.443	1	135	135
6	Label stitch	26	0.412	1	146	146
7	Lining stitch	24	0.38	1	158	142
8	Collar folding	28	0.443	1	135	138
9	Eyeleting	28	0.443	1	135	135
10	Collar joint stitch	60	0.95	2	126	133
11	Counter stitch	25	0.396	1	152	152
12	Single needle stitch	24	0.38	1	158	158
13	Double needle stitch	27	0.428	1	140	140
14	Thread burning	26	0.412	1	146	146
15	Strobel stitch	26	0.412	1	146	146
		Total	**6.856**	**16**		

Table 4.5: Process wise SMV and capacity per hour for product 4 in sewing section:

S.I	WORK	cycle time (sec)	SMV (min)	Operator	production Capacity (Pair)	Balanced capacity (pair)
1	Marking	25	0.40	1	152	152
2	Toe stitching	25	0.40	1	152	152
3	Toe Cap stitch	24	0.38	1	158	158
5	Counter stitch	53	0.84	2	143	143
6	Lining Stitch	54	0.86	2	140	133
7	Lining Folding	31.5	0.50	1	120	132
8	Center stitch	24	0.38	1	158	139
9	Eyelet piece stitch	110	1.74	4	138	136
10	Small Velcro stitch	26	0.41	1	146	146
11	Saddle join	32	0.51	1	118	132
12	Ring join stitch	30	0.48	1	126	133
13	Saddle round stitch	35	0.55	1	108	132
14	Saddle join double needle	52	0.82	2	146	146
15	Tongue Lining Stitch	22	0.35	1	172	135
16	Tongue Folding & Stitch	24	0.38	1	158	145
17	Tongue Join Stitch	31	0.49	1	122	132
18	Side cementing	24	0.38	1	158	134
19	Toe Cementing	33	0.52	1	115	132
20	Checking	27	0.43	1	140	140
21	Stroble stitch	26	0.41	1	146	146
		Total	11.22	26		

4.2 Production Line Balancing

Table: 4.6: Required data for line balancing of four products

Parameter	Product-1	Product-2	Product-3	Product-4
Total SMV	15.77	5.68	6.86	11.22
Calculated production capacity at 100% efficiency	118	169	140	139
Calculated production capacity 80-95% efficiency (benchmarked production target)	106	160	133	132

Before line balancing the existing capacity are show in the **Fig. 4.1, Fig. 4.3, Fig. 4.5** and **Fig. 4.7**. When Line balancing finished, production capacity is well-adjusted and reduced the waiting time. Calculated production output and waiting time also changed which are shown in **Fig. 4.2, Fig. 4.4, Fig. 4.6** and **Fig. 4.8**. Then for four products comparisons are made among the existing process capacity, benchmarked target and proposed capacity as shown respectively.

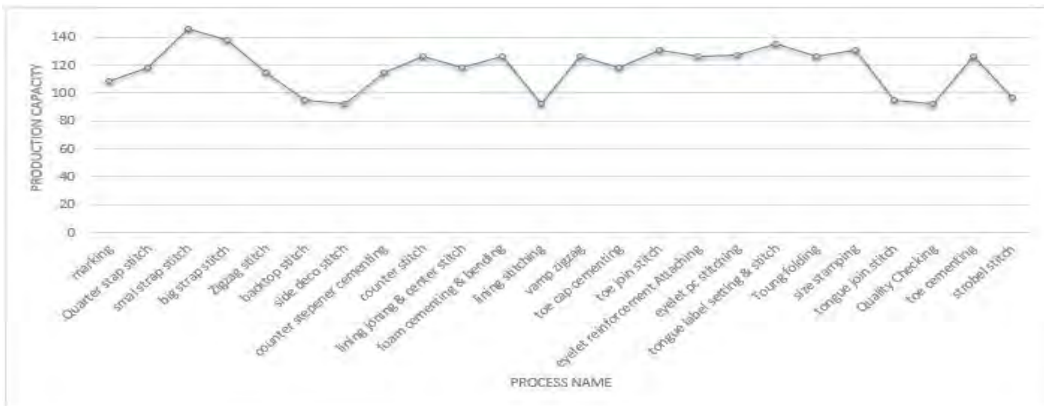

Fig. 4.1: Variation of existing production capacity with process name of product 1

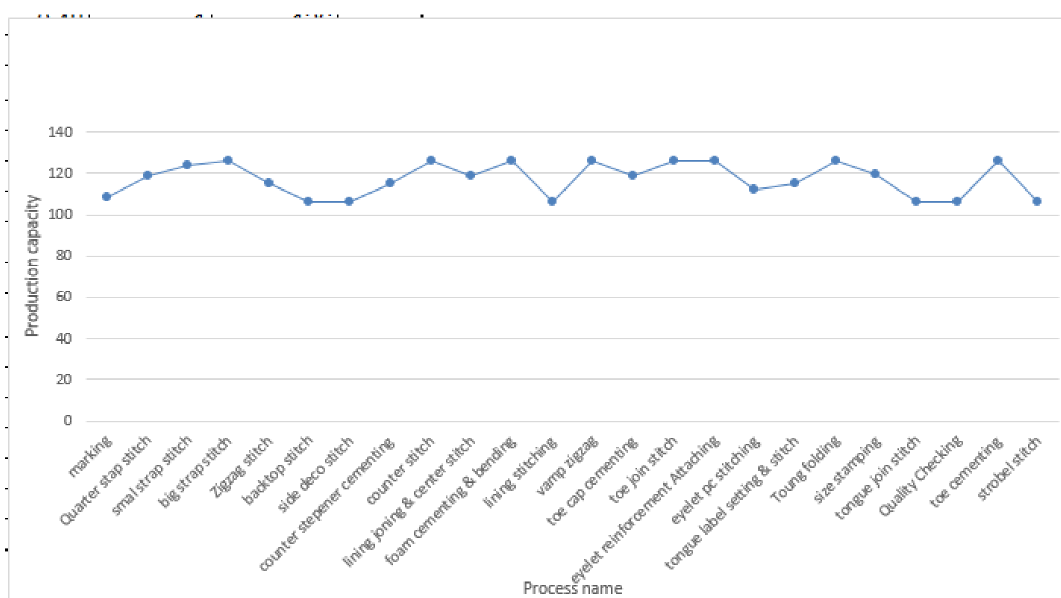

Fig. 4.2: After line balancing production capacity with process name of product 1

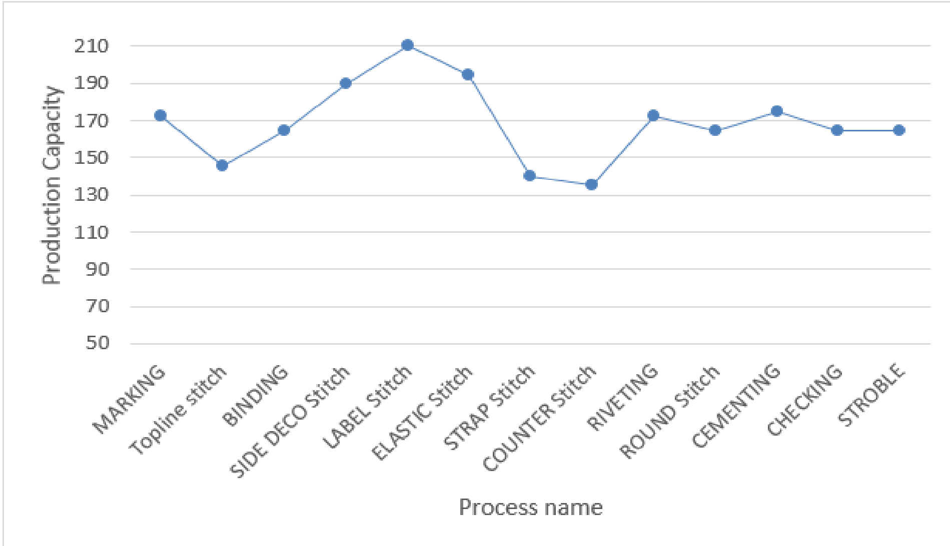

Fig 4.3: Variation of existing production capacity with process name of product 2

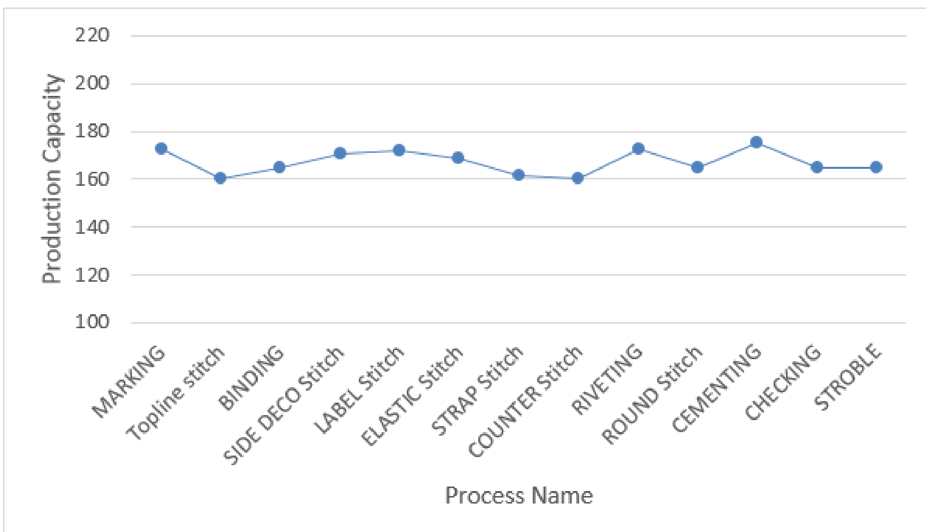

Fig. 4.4: After line balancing production capacity with process name of product 2.

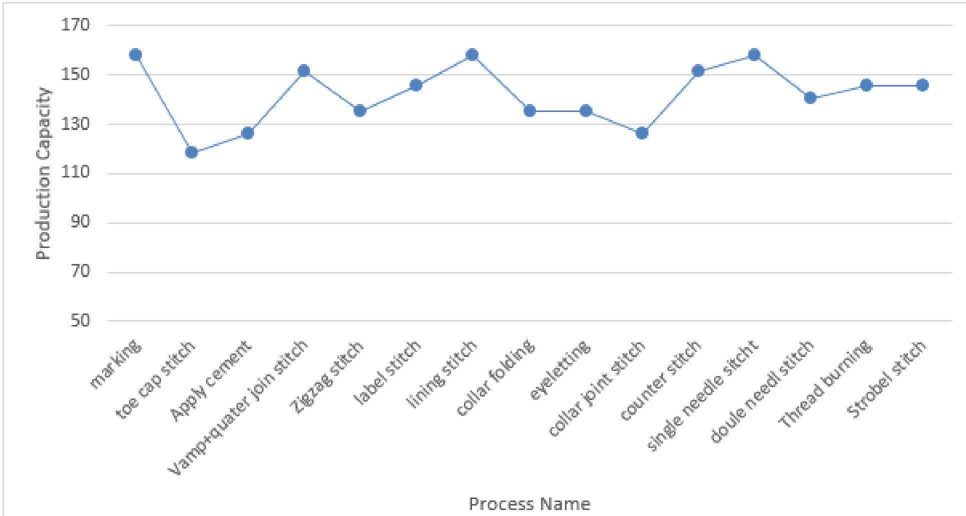

Fig. 4.5: Variation of existing production capacity with process name of product 3.

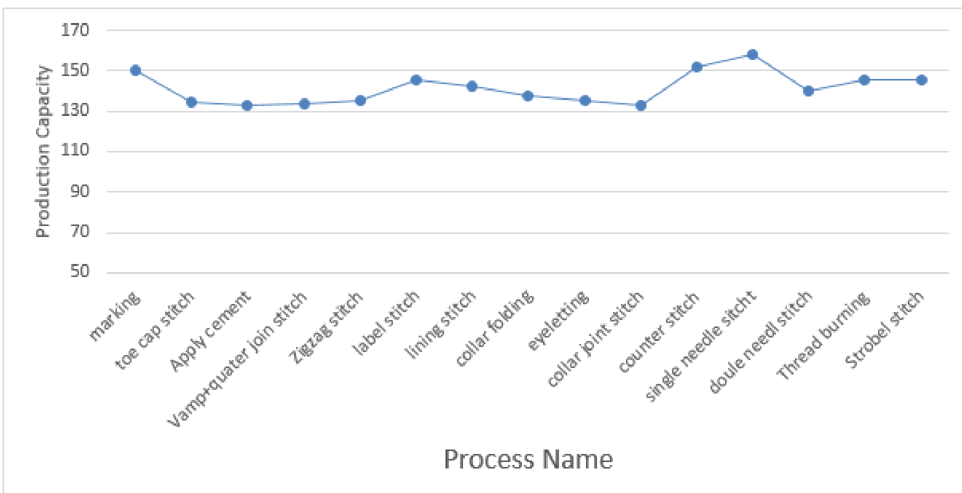

Fig. 4.6: After line balancing production capacity with process name of product 3.

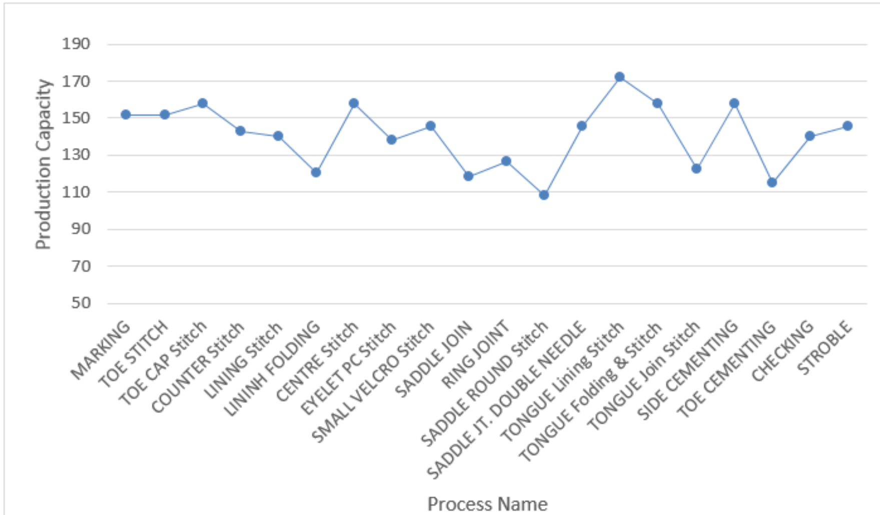

Fig. 4.7: Variation of existing production capacity with process name of product 4.

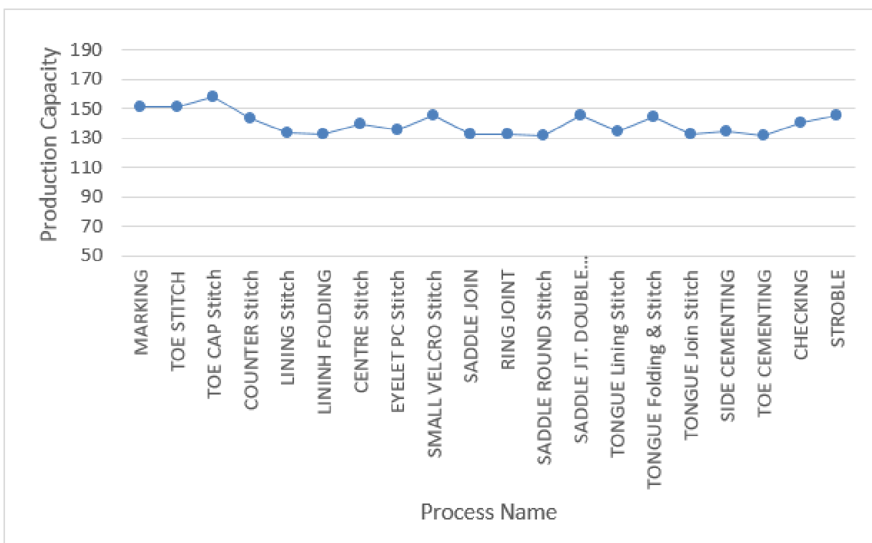

Fig. 4.8: After line balancing production capacity with process name of product 4.

For product 1 the Existing capacity, Target Capacity and proposed capacity all are shown in the Table 4.7 as well in the graph **Fig. 4.9**. For product 2 the Existing capacity, Target Capacity and proposed capacity all are shown in the Table 4.8 as well in the graph **Fig. 4.10**. For product 3 the Existing capacity, Target Capacity and proposed capacity all are shown in the Table 4.9 as well in the graph **Fig. 4.11**. For product 1 the Existing capacity, Target Capacity and proposed capacity all are shown in the Table 4.10 as well in the graph **Fig. 4.12**.

Table 4.7 Target production, total capacity and proposed capacity for product-1

S.I	Work	Target Production/hr (Pair)	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)
1	Marking	106	108	108
2	Quarter strap stitch	106	118	118
3	Smal strap stitch	106	146	124
4	Big strap stitch	106	138	126
5	Zigzag stitch	106	115	115
6	Backtop stitch	106	95	106
7	Side deco stitch	106	92	106
8	Counter stepener cementing	106	115	115
9	Counter stitch	106	126	126
10	Lining joning& center stitch	106	118	118
11	Foam cementing & bending	106	126	126
12	Lining stitching	106	92	106
13	Vamp zigzag	106	126	126
14	Toe cap cementing	106	118	118
15	Toe join stitch	106	131	126
16	Eyelet reinforcement Attach	106	126	126
17	Eyelet pc stitching	106	127	113
18	Tongue label setting & stitch	106	135	115
19	Toung folding	106	126	126
20	Size stamping	106	131	120
21	Tongue join stitch	106	95	106
22	Quality Checking	106	92	106
23	Toe cementing	106	126	126
24	Strobel stitch	106	97	106

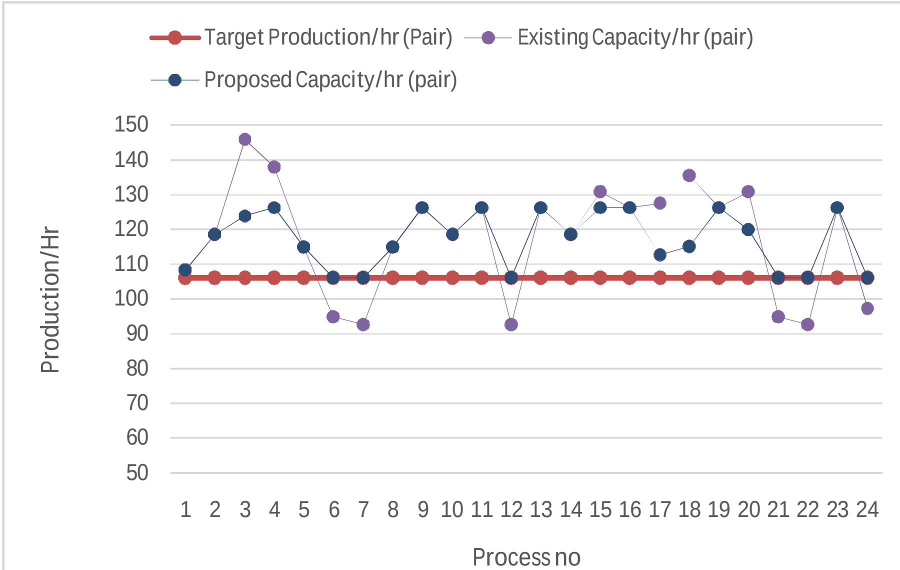

Fig. 4.9: Variation in production under different condition for product-1.

Table 4.8 Target production, total capacity and proposed capacity for product-2

S.I	WORK	Target Production/hr (Pair)	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)
1	Marking	160	172	172
2	Topline stitch	160	146	160
3	Binding	160	165	165
4	Side deco Stitch	160	189	171
5	Label Stitch	160	211	172
6	Elastic Stitch	160	194	168
7	Strap Stitch	160	140	161
8	Counter Stitch	160	135	160
9	Riveting	160	172	172
10	Round Stitch	160	165	165
11	Cementing	160	175	175
12	Checking	160	165	165
13	Stroble Stitch	160	165	165

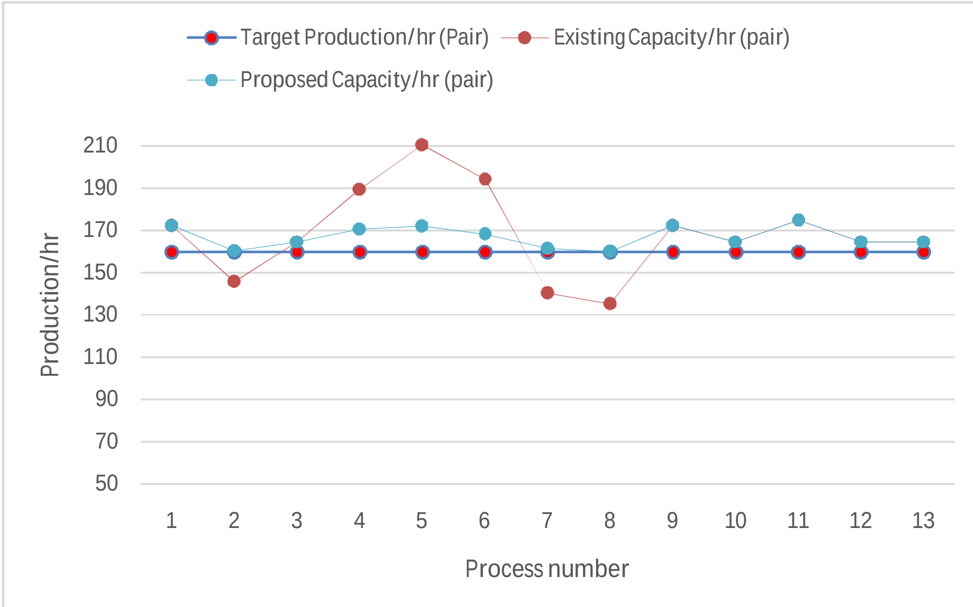

Fig. 4.10: Variation in production under different condition for product-2.

Table 4.9: Target production, total capacity and proposed capacity for product-3

S.I	Work	Target Production/hr (Pair)	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)
1	Marking	133	158	150
2	Toe cap stitch	133	118	134
3	Apply cement	133	126	133
4	Vamp+ quarter join stitch	133	152	134
5	Zigzag stitch	133	135	135
6	Label stitch	133	146	146
7	Lining stitch	133	158	142
8	Collar folding	133	135	138
9	Eyeleting	133	135	135
10	Collar joint stitch	133	126	133
11	Counter stitch	133	152	152
12	Single needle stitch	133	158	158
13	Double needle stitch	133	140	140
14	Thread burning	133	146	146
15	Strobel stitch	133	146	146

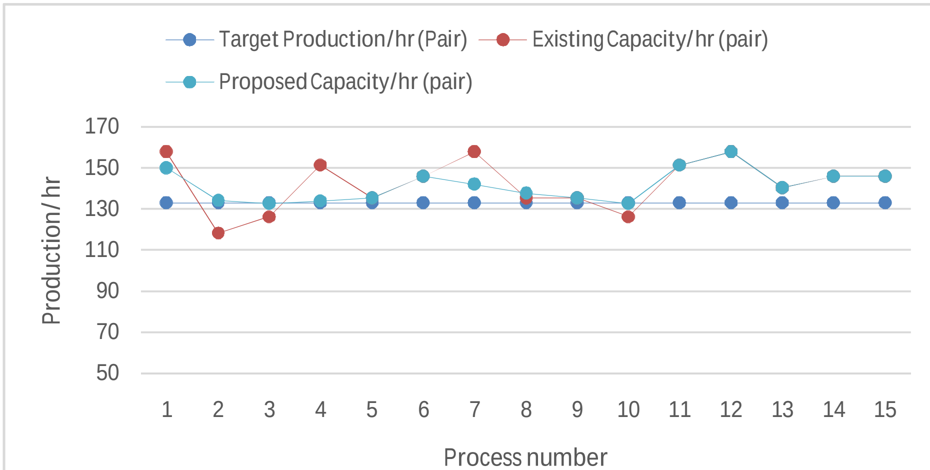

Fig. 4.11: Variation in production under different condition for product-3.

Table 4.10: Target production, total capacity and proposed capacity for product-4

S.I	Work	Target Production/hr (Pair)	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)
1	Marking	132	152	152
2	Toe stitching	132	152	152
3	Toe Cap stitch	132	158	158
5	Counter stitch	132	143	143
6	Lining Stitch	132	140	133
7	Lining Folding	132	120	132
8	Center stitch	132	158	139
9	Eyelet piece stitch	132	138	136
10	Small Velcro stitch	132	146	146
11	Saddle join	132	118	132
12	Ring join stitch	132	126	133
13	Saddle round stitch	132	108	132
14	Saddle join double needle	132	146	146
15	Tongue Lining Stitch	132	172	135
16	Tongue Folding & Stitch	132	158	145
17	Tongue Join Stitch	132	122	132
18	Side cementing	132	158	134
19	Toe Cementing	132	115	132
20	Checking	132	140	140
21	Stroble stitch	132	146	146

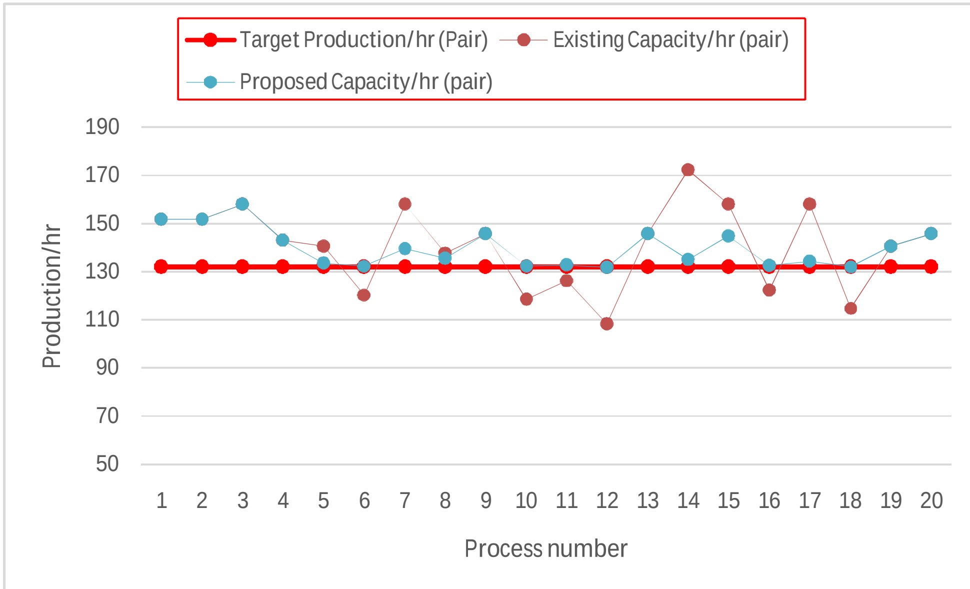

Fig. 4.12: Variation in production under different condition for product-4.

4.3 Fishbone Analysis

Fish bone diagram is also known as cause-effect diagram which identifies actual causes for any result. The problem areas in Footwear 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 Shoe industries as shown in **Fig.4.13.**

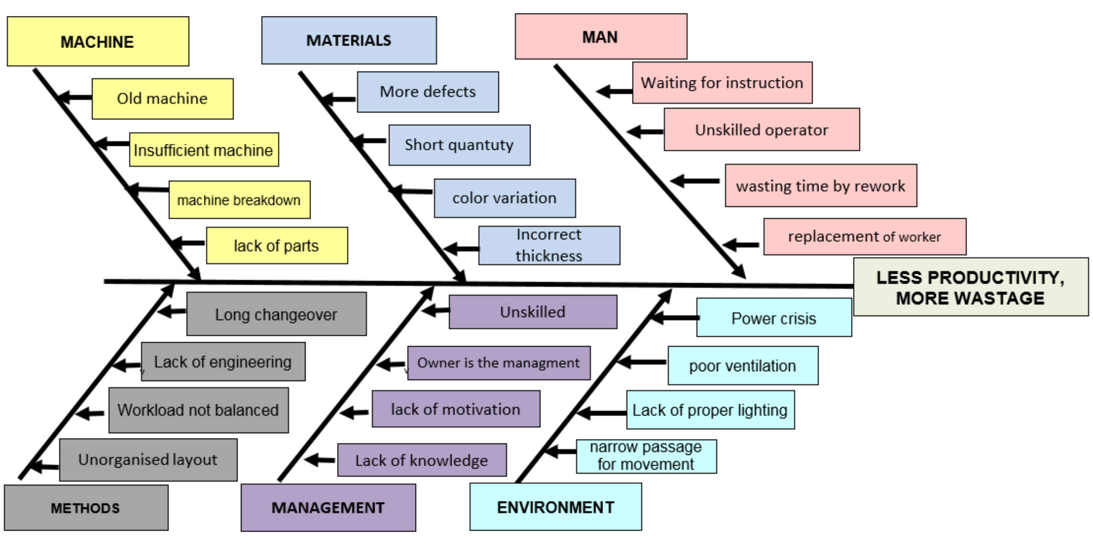

Fig. 4.13: Fishbone Analysis

Chapter-5

Discussion and Result

5.1 Production Line Balancing

In this work, all graphs have shown the results at 80-95% benchmarked production target to decrease the waiting time and increase the productivity. For the change of further benchmarked target of production the graphs will show different results. After balancing four production lines a comparison is made between existing and proposed system to observe the variations of various parameters like productivity, waste (waiting time), production time etc. as shown in Table 5.2, Table 5.4, Table 5.6 and Table 5.8.

Table 5.1 Balancing process to equalize the bottleneck process for product -1

Balancing Capacity per Hour									
	Bottleneck Process				Balancing Process				
Sl. No.	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour
1	6	Back top stitch	95	106	3	small strap stitch	146	124
	Process-3 can work for 44 min. and share work with Process-6 for last 16 min.							
2	7	Side deco stitch	92	106	4	Big strap stitch	138	126
	Process-4 can work for 46 min. and share work with Process-7 for last 14 min.							
3	12	Lining stitching	92	106	1 5	Toe join stitch	131	126
	Process-15 can work for 49 min. and share work with Process-12 for last 11 min.							
4	21	Tongue stitch	95	106	1 7	Eyelet pc stitch	127	113
	Process-17 can work for 50 min. and share work with Process-21 for last 10 min.							
5	22	Quality checking	92	106	1 8	label setting & stitch	135	115
	Process-18 can work for 47 min. and share work with Process-22 for last 13 min.							
6	24	Strobel stitch	97	106	2 0	Size stamping	13 1	120
	Process-20 can work for 49 min. and share work with Process-24 for last 11 min.							

Table 5.2 : Percentage of variation of various parameter after line balancing of product-1

Sl. No.	Parameters	Line Balancing		% of Variation
		Before	After	
1	Manpower	33	31	-6.1
2	Work Stations	25	24	-4.0
3	Machine	16	16	0.0
4	Man Machine Ratio	2.1	1.9	-6.1
5	Total Waiting Time (min)	149	63	-57.7
6	Total Bottlenecks (min)	62	12	-80.6
7	Output/Hour/Line (pieces)	95	112	17.9
8	Labour Productivity	67.9	75.7	11.5
9	Machine Productivity	47.2	56	18.6
10	Production lead time (days)	24	22	-8.3

After line balancing 8.8% manpower (2 operators) are decreased from the production line. This reduced manpower can be shifted to another production line to decrease the total labor cost. **Fig.4.9** shows some variations in the existing process capacity as compare to the benchmarked target and the lower capacity from the benchmarked target is identified as the bottleneck process as production flow would be trapped at those points. Comparing with the 90% bench marked production target, process no.-6, 7,12,21,22 and 24 (Table 5.1) are identified as bottleneck process in where total production has been blocked and large work in process has been stuck at those processes. Line balancing is an efficient method to make the production flow almost smoother while compare to the existing layout. Workers having extra time after completing their regular works can share works with other work stations containing bottlenecks. In case of product-1, production line was found with bottleneck processes which have been balanced through sharing of works by the process no.-3,4,15,17,18 and 20 (Table 5.1). **Fig.4.9** also shows process wise proposed capacity per hour after balancing all processes. Besides, for the removal of process bottlenecks and to maintain smooth production, it is recommended to place additional 1 Strobel machine to operation no 24 (Table 5.2). Man, machine ratio is also decreased from 2.1 to 1.9 after balancing the processes. For line balancing, total waiting time is decreased in a significant amount (57.7%) and thus, 32% production time is reduced for order completion. Finally, Labor productivity, machine productivity has been increased as 11.5% and 18.6% respectively. After line balancing outputs, have been increased from 795 to 896 pairs a day. Before line balancing 12000 pieces of uppers have been produced by 28 days where only 18 days are required to complete the same order quantity for line balancing. So, it is possible to save 10days' lead time for manufacturing of product-1 (Men's sports upper). Besides, it is also possible to save the working time of two helpers (480x2=960 minutes) per day which decreases total labor cost of the industry.

Table 5.3 Balancing process to equalize the bottleneck process for product -2

Balancing Capacity per Hour								
	Bottleneck Process				Balancing Process			
Sl. No.	Process No.	Process Name	Total Capacity/Hour	Balanced Capacity/ Hour	Process No.	Process Name	Total Capacity/Hour	Balanced Capacity/Hour
1	2	Topline stitch	146	160	4	Side deco stitch	189	171
	Process-4 can work for 51 min. and share work with Process-2 for last 9 min.							
2	7	Strap stitch	140	161	6	Label stitch	194	168
	Process-6 can work for 49 min. and share work with Process-7 for last 11 min.							
3	8	Counter stitch	135	160	5	Label stitch	211	172
	Process-5 can work for 46 min. and share work with Process-8 for last 14 min.							

Table 5.4: Percentage of variation of various parameters after line balancing of product-2

Sl. No	Parameters	Line Balancing		% of Variation
		Before	After	
1	Manpower	19	16	-15.8
2	Work Stations	13	13	0.0
3	Machine	11	11	0.0
4	Man Machine Ratio	1.7	1.45	-15.8
5	Total Waiting Time (min)	96	26	-72.9
6	Total Bottlenecks (min)	15	6	-60.0
7	Output/Hour/Line (pieces)	135	160	18.5
8	Labor Productivity	66	78	18.2
9	Machine Productivity	98	117	19.4
10	Production lead time (days)	24	21	-12.5

After line balancing manpower (2 helpers) are decreased from the production line. Fig.4.6 shows some variations in the existing process capacity as compare to the benchmarked target. Comparing with the 95% bench marked production target, process no.-2, 7 and 8 (Table 5.3) is identified as bottleneck process in where total production has been blocked and work in process has been stuck at that process. In case of product-2, production line was found with bottleneck processes which have been balanced through sharing of works by the process no.-4, 6 and 5 (Table 5.3). **Fig. 4.10** also shows process wise proposed capacity per hour after balancing all processes. Man, machine ratio is also decreased from 1.7 to 1.45 after line balancing. For line balancing, total waiting time is decreased to 72.9% and thus, 28.6% production time is reduced for order completion. Finally, labor productivity and machine productivity have been increased as 18.2% and 19.5% respectively. After line balancing output increased from 1080 to 1280 pairs a day. Before line balancing 17000 pairs of upper have been produced by 28 days where 20 days are required to complete the same order quantity for line balancing. So, it is possible to save 8days'lead time for manufacturing of product-2 (Men's walking Upper). Besides, it is also possible to save the working time of one worker (480x3=1440 minutes) per day which decreases total labor cost of the industry.

Table 5.5 Balancing process to equalize the bottleneck process for product -3

Balancing Capacity per Hour								
	Bottleneck Process				Balancing Process			
Sl. No.	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour
1	2	Toe cap Stitch	118	133	4	Vamp quarter join stitch	152	134
	Process-4 can work for 53 min. and share work with Process-2 for last 7 min.							
2	3	Apply cement	126	133	1	Marking	158	150
	Process-1 can work for 51 min. and share work with Process-3 for last 9 min.							
3	10	Collar stitch	126	133	7	Lining stitch	158	142
	Process-7 can work for 54 min. and share work with Process-10 for last 6 min.							

Table 5.6 :Percentage of variation of various parameters after line balancing of product-3

Sl. No.	Parameters	Line Balancing		% of Variation
		Before	After	
1	Manpower	17	16	-5.9
2	Work Stations	16	15	-6.3
3	Machine	12	11	-8.3
4	Man Machine Ratio	1.4	1.45	2.7
5	Total Waiting Time (min)	65	4	-93.8
6	Total Bottlenecks (min)	16	3	-81.3
7	Output/Hour/Line (pieces)	112	133	18.8
8	Labor Productivity	67	80	19.4
9	Machine Productivity	74	97	31.1
10	Production lead time (days)	24	21	-12.5

After line balancing, 6.3% work stations and 5.9% manpower (1 operator) are decreased from the production line. Fig.4.7 shows some variations in the existing process capacity as compare to the benchmarked target. Comparing with 95% bench marked production target, process no.-2, 3 and 10 (Table 5.5) are identified as bottleneck processes in where total production has been blocked and work in process has been stuck at those processes. In case of product-3, production line was found with bottleneck processes which have been balanced through sharing of works by the process no.-4, 1, and 7(Table 5.5). **Fig. 4.11** also shows process wise proposed capacity per hour after balancing the bottleneck processes. Man, machine ratio is increased from 1.4 to 1.45 after balancing the processes. After line balancing 93.8% waiting time is decreased and finally labor productivity and machine productivity have been increased as 19.4% and 31.1% respectively. After line balancing outputs have been increased from 896 to 1064 pairs a day. Before line balancing 15000 pairs of shoe uppers have been produced by 28 days whereas 20 days are required to complete the same order quantity for line balancing. So, it is possible to save 8days' lead time for manufacturing of product-3 (Armed forces Shoe). Besides, it is also possible to save the working time of six workers (480x1=480 minutes) per day which decreases total labor cost of the industry.

Table 5.7 Balancing process to equalize the bottleneck process for product -4

Balancing Capacity Per Hour								
Sl. No.	Bottleneck Process				Balancing Process			
	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour	Process No.	Process Name	Total Capacity/ Hour	Balanced Capacity/ Hour
1	7	Lining Folding	120	132	6	Lining stitch	140	133
	Process-6 can work for 56 min. and share work with Process-7 for last 4 min.							
2	11	Saddle join stitch	118	132	8	Center stitch	158	139
	Process-8 can work for 50 min. and share work with Process-11 for last 10 min.							
3	12	Ring join stitch	126	133	9	Eyelet pc stitch	138	136
	Process-9 can work for 57 min. and share work with Process-12 for last 3 min.							
4	13	Saddle round stitch	108	132	15	Tongue lining stitch	172	135
	Process-15 can work for 46 min. and share work with Process-13 for last 14 min.							
5	17	Tongue Join stitch	122	132	16	Tongue folding & stitch	158	145
	Process-16 can work for 50 min. and share work with Process-17 for last 10 min.							
6	19	Toe cementing	115	132	18	Side cementing	158	134
	Process-18 can work for 50 min. and share work with Process-19 for last 10 min.							

Table 5.8 : Percentage of variation of various parameter after line balancing of product-4

Sl. No.	Parameters	Line Balancing		% of Variation
		Before	After	
1	Manpower	28	26	-7.1
2	Work Stations	21	21	0.0
3	Machine	15	15	0.0
4	Man Machine Ratio	1.9	1.73	-7.1
5	Total Waiting Time (min)	78	23	-70.5
6	Total Bottlenecks (min)	50	4	-92.0
7	Output/Hour/Line (pieces)	111	132	18.9
8	Labour Productivity	57.02	79.82	40.0
9	Machine Productivity	40	60	50.0
10	Production lead time (days)	24	21	-12.5

After line balancing, 3 operators are shifted from the process no.-13, 14 and 19; 1 operator added to operation 9 (Table 5.7)to meet 95% benchmarked production target. Figure 4.12 shows some variations in the existing process capacity as compare to the benchmarked target. Comparing with the 95% bench marked production target, process no.-7, 11, 12, 17 and 19 (Table 5.7) are identified as bottleneck processes in where total production has been blocked and work in process has been stuck at those processes. In case of product-4, production line was found with bottleneck processes which have been balanced through sharing of works by the process no.-6, 9, 10, 15, 16 and 18 (Table 5.7). **Fig. 4.12** also shows process wise proposed capacity per hour after balancing the processes. Man, machine ratio is also decreased from 1.9 to 1.73 after balancing the process. After line balancing 70.5% waiting time and 92% bottlenecks were decreased and finally labor productivity and machine productivity have been increased as 40% and 50% respectively. After line balancing output increased from 890 to 1056 pairs a day. Before line balancing 10560 pairs of uppers have been produced by 28 days whereas 22 days are required to complete the same order quantity for line balancing. So, it is possible to save 6 days production lead time for manufacturing of product-4 (School Shoe). Table 5.9 shows the percentage variation of various parameters of different production lines after line balancing.

Table 5.9 Percentage variation of various parameters of different production lines after line balancing:

Sl. No.	Parameters	Product 1	Product 2	Product 3	Product 4
1	Manpower	-6.6%	-16.0%	-6.0%	-7.0%
2	Work Stations	-4.0%	0.0%	-6.0%	0.0%
3	Machine	0.0%	0.0%	-8.0%	0.0%
4	Man Machine Ratio	-6.06%	-16.0%	-2.7%	-7.0%
5	Total Waiting Time (min)	-57.7%	-73.0%	-93.8%	-70.5%
6	Total Bottlenecks (min)	-80.6%	-60.0%	-81.0%	-92%
7	Output/Hour/Line (pieces)	17.9%	18.5%	19.0%	18.9%
8	Labour Productivity	11.5%	18.0%	19.0%	40.0%
9	Machine Productivity	18.6%	19.4%	31.0%	50.0%
10	Production lead time (days)	-8.3%	-12.5%	-12.5%	-12.5%

Following points have been noted after comparing the percentage variation of various parameters of four balanced production lines:

- After line balancing total manpower is reduced for product-1, 2, 3 and 4
- Total work satiations are minimized for products 1 and 3.
- Man machine ratio is decreased for all types of products.
- Total waiting time and bottlenecks are reduced from four production lines
- Labor productivity, output and machine productivity are increased in momentous amount in case of product-1, 3 and 4 as compare to product-2.
- For all kinds of products production lead time is reduced to deliver four products in required quantity.
- To meet 95% benchmarked production target line required to add extra machine and manpower to increase the productivity. This is only happened because of having more critical and time consuming operations in the production line.

Line Balancing Data

Lines balancing perform on basis the data of SMV calculation, each line capacity, waiting time, bottleneck and manpower which are showing in the table 5.10, table 5.11, table 5.12 and table 5.13 for the product no 1, 2, 3 and 4 consecutively.

Table 5.10: Existing Waiting time, Bottleneck & Proposed manpower after line balancing for product-1

S.I	WORK	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)	Waiting Time (min)	Bottleneck (min)	Theoratical Manpower	Actual Manpower	Proposed Manpower
1	Marking	108	108	0	0	1.0	1	1
2	Quarter strap stitch	118	118	5	0	1.0	1	1
3	Small strap stitch	146	124	19	0	0.9	1	1
4	Big strap stitch	138	126	15	0	1.8	2	2
5	Zigzag stitch	115	115	4	0	1.0	1	1
6	Back top stitch	95	106	0	10	1.1	1	1
7	Side deco stitch	92	106	0	11	1.1	1	1
8	Counter stiffener cementing	115	115	5	0	1.0	1	1
9	Counter stitch	126	126	8	0	1.0	1	1
10	Lining join & center stitch	118	118	6	0	2.0	2	2
11	Foam cementing & bending	126	126	8	0	2.0	1	2
12	Lining stitching	92	106	0	11	1.1	1	1
13	Vamp zigzag	126	126	8	0	1.0	1	1
14	Toe cap cementing	118	118	6	0	1.0	2	1
15	Toe join stitch	131	126	10	0	1.9	2	2
16	Eyelet reinforcement Attach	126	126	8	0	1.0	2	1
17	Eyelet pc stitching	127	113	8	0	3.5	4	4
18	Tongue label setting & stitch	135	115	11	0	0.9	2	1
19	Tongue folding	126	126	8	0	1.0	1	1
20	Size stamping	131	120	10	0	0.9	1	1
21	Tongue join stitch	95	106	0	10	1.1	1	1
22	Quality Checking	92	106	0	11	1.1	1	1
23	Toe cementing	126	126	8	0	1.0	1	1
24	Strobel stitch	97	106	2	9	1.1	1	1
	Total			**149**	**62**	**30.68**	**33**	**31**

Table 5.11: Waiting time, Bottleneck & Proposed manpower after line balancing for product-2

S.I	Work	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)	Waiting Time (min)	Bottleneck (min)	Theoretical Manpower	Actual Manpower	Proposed Manpower
1	Marking	172	172	0	0	1.0	1	1
2	Topline stitch	146	160	0	11	1.1	2	1
3	Binding	165	165	3	0	1.0	1	1
4	Side deco Stitch	189	171	14	0	0.9	1	1
5	Label Stitch	211	172	17	0	0.8	1	1
6	Elastic Stitch	194	168	15	0	1.7	2	2
7	Strap Stitch	140	161	0	2	1.2	2	1
8	Counter Stitch	135	160	0	2	1.2	1	1
9	Riveting	172	172	11	0	1.0	1	1
10	Round Stitch	165	165	8	0	1.0	1	1
11	Cementing	175	175	12	0	3.0	3	3
12	Checking	165	165	8	0	1.0	1	1
13	Stroble Stitch	165	165	8	0	1.0	2	1
	Total			**96**	**15**		**19**	**16**

Table 5.12: Waiting time, Bottleneck & Proposed manpower after line balancing for product-3

S.I	Work	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)	Waiting Time (min)	Bottleneck (min)	Theoretical Manpower	Actual Manpower	Proposed Manpower
1	Marking	158	150	0	0	1.0	1	1
2	toe cap stitch	118	134	0	16	1.1	2	1
3	Apply cement	126	133	2	0	1.1	1	1
4	Vamp +quater join stitch	152	134	9	0	0.9	1	1
5	Zigzag stitch	135	135	5	0	1.0	1	1
6	label stitch	146	146	7	0	1.0	1	1
7	lining stitch	158	142	11	0	0.9	1	1
8	collar folding	135	138	0	0	1.0	1	1
9	Eyeleting	135	135	0	0	1.0	1	1
10	collar joint stitch	126	133	0	0	2.1	2	2
11	counter stitch	152	152	9	0	1.0	1	1
12	single needle stitch	158	158	11	0	1.0	1	1
13	double needle stitch	140	140	3	0	1.0	1	1
14	Thread burning	146	146	4	0	1.0	1	1
15	Strobel stitch	146	146	4	0	1.0	1	1
	Total			**65**	**16**	**16.0**	**17**	**16**

Table 5.13: Waiting time, Bottleneck & Proposed manpower after line balancing for product-4

S.I	WORK	Existing Capacity/hr (pair)	Proposed Capacity/hr (pair)	Waiting Time (min)	Bottleneck (min)	Theoretical Manpower	Actual Manpower	Proposed Manpower
1	Marking	152	152	0	0	1.00	1	1
2	Toe stitching	152	152	0	0	1.00	1	1
3	Toe Cap stitch	158	158	0	0	1.00	1	1
5	Counter stitch	143	143	0	0	2.00	2	2
6	Lining Stitch	140	133	0	0	1.90	2	2
7	Lining Folding	120	132	0	6	1.10	1	1
8	Center stitch	158	139	16	0	0.88	1	1
9	Eyelet piece stitch	138	136	9	0	3.93	3	4
10	Small Velcro stitch	146	146	4	0	1.00	1	1
11	Saddle join	118	132	0	17	1.12	1	1
12	Ring join stitch	126	133	3	3	1.05	2	1
13	Saddle round stitch	108	132	0	19	1.22	2	1
14	Saddle join double needle	146	146	13	0	2.00	2	2
15	Tongue Lining Stitch	172	135	8	0	0.78	1	1
16	Tongue Folding & Stitch	158	145	0	0	0.92	1	1
17	Tongue Join Stitch	122	132	0	2	1.08	1	1
18	Side cementing	158	134	10	0	0.85	1	1
19	Toe Cementing	115	132	0	3	1.15	2	1
20	Checking	140	140	9	0	1.00	1	1
21	Stroble stitch	146	146	6	0	1.00	1	1
	Total			**78**	**50**		**28**	**26**

5.2: Existing and Proposed Layout

On basis of the time study, SMV calculation and on the line balancing the following layout configured for the four products. The existing and proposed layout here shows on the **Fig. 5.1, Fig. 5.2, Fig. 5.3** and**Fig. 5.4** for the products 1, 2, 3 and 4 consecutively. In the proposed layout for product 1, no 1, 4, 8,17 and 18 operator consecutively sharing the work of operator no 3, 7, 11, 21 and 22; for product 2, operator no 4, 5 and 6 consecutively sharing the work of operator no 2, 8 and 7; for product no 3, operator no 1, 4, and 7 consecutively sharing the work of operator no 2, 3 and 8 and for product no 4, operator no 6, 8, 9, 15, 16 and 18 consecutively sharing the work of operator no 7, 11, 12, 13, 17 and 19.

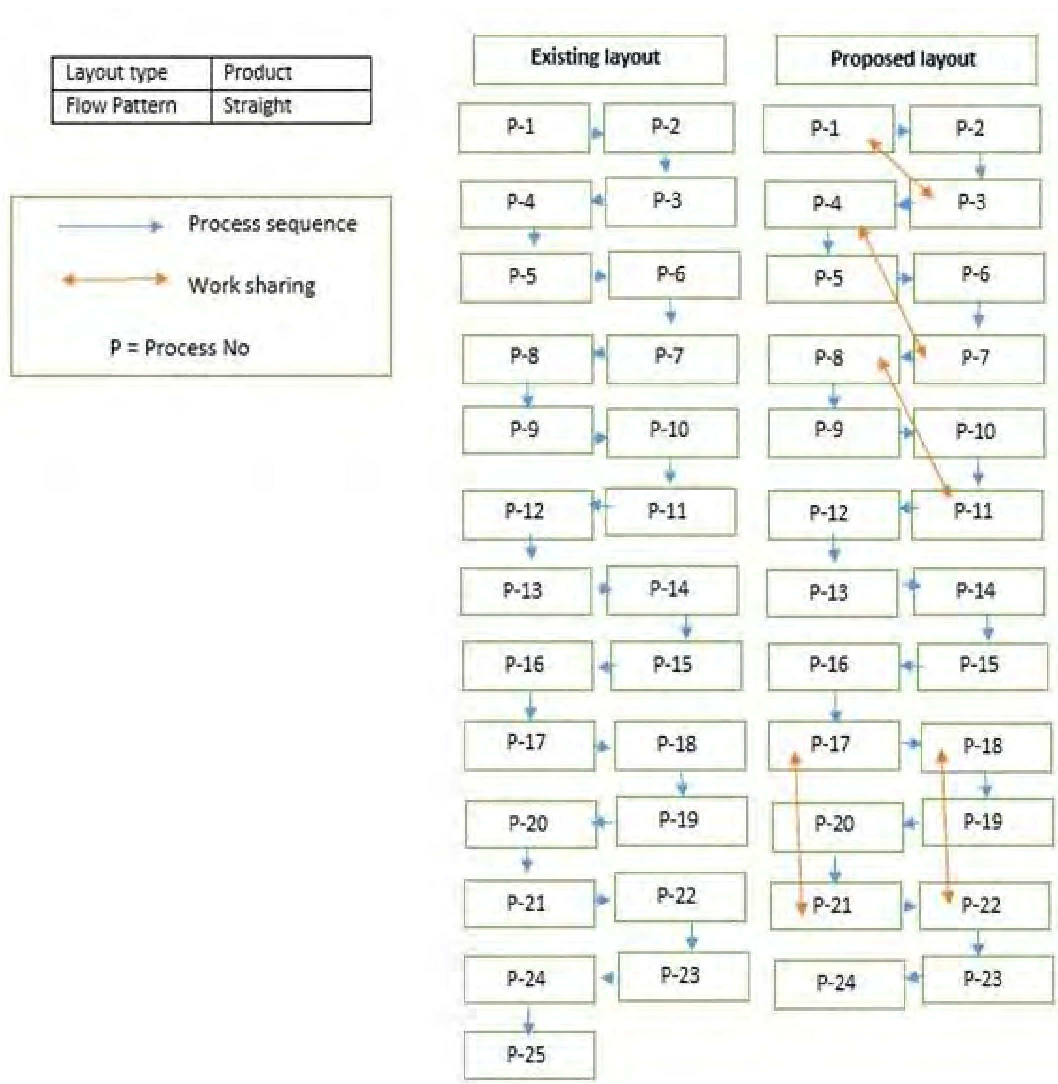

Fig. 5.1: Existing and proposed layout for product 1

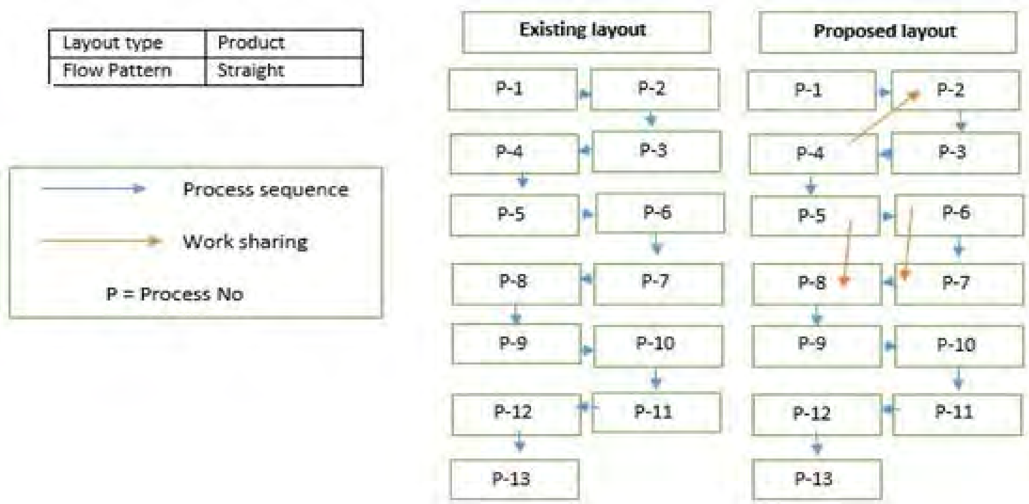

Fig. 5.2: Existing and proposed layout for product 2

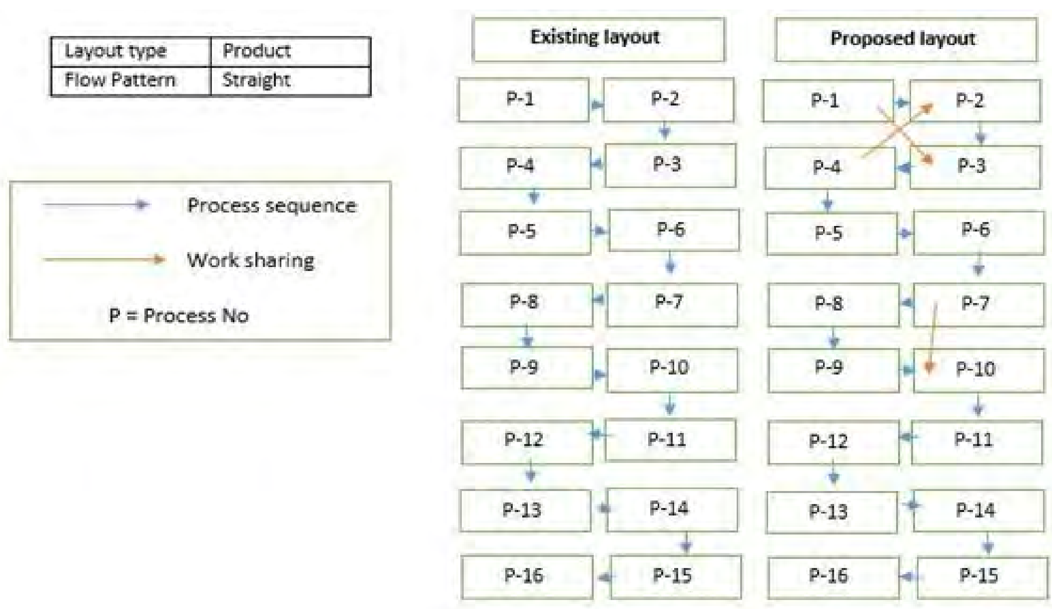

Fig. 5.3: Existing and proposed layout for product 3

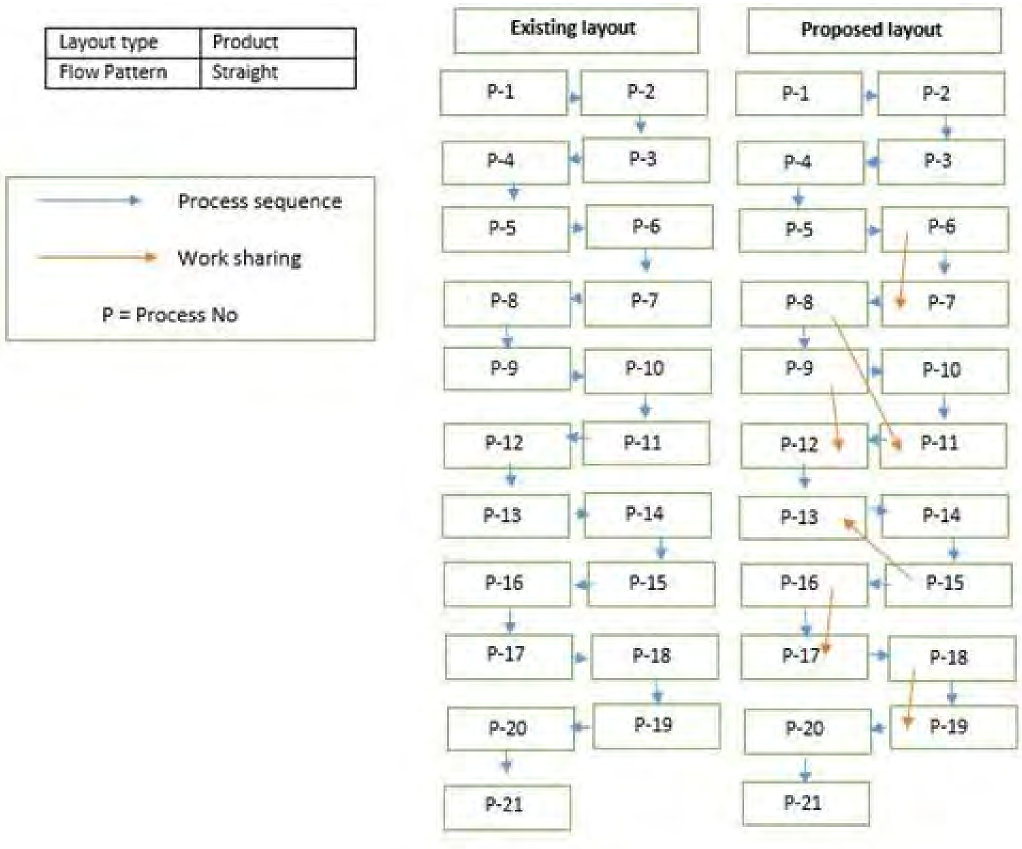

Fig. 5.4: Existing and proposed layout for product 4

Chapter-6

Conclusions and Future Recommendations

Conclusions

By time study, SMV and capacity of processes were calculated separately for four different production lines. Line balancing has decreased 6-16% workforce for the production of all 4 products. After line balancing 0-6% of work stations, 57-94% of waiting time and 60-92% of process bottlenecks were reduced from the production lines. After line balancing four production systems are proposed for four products and new production systems reduced 8-12.5% of production lead time for the improvement of 11-40% of labor productivity and 18-50% of machine productivity. Extra machinery or manpower is not required for any products.

Future Recommendation

- Time study and line balancing techniques are only used in the sewing section and the application of those techniques in the cutting and assembly dept. will increase more productivity in Footwear industries.
- Only skilled workers should be entitled for the production processes and that's why proper training is necessary to achieve the improvements in productivity.
- After the analysis of fishbone diagram different problem areas in Footwear industries for less productivity were identified this must be overcome to increase the productivity.

References

Ahmed S. and Fatema-Tuj-Zohra, “Productivity Improvement By Line Balancing In Closing Room For The Production Of Footwear”Leather and Footwear Journal · January 2005.

Ahmed S. N. and Hasin A. A., “Factors Affecting Productive Efficiency in Apparel Industry of Bangladesh” Proceedings of the International Conference on Mechanical Engineering, (ICME2009) 26- 28 December 2009.

Anbarasan E, “Chinese Factories Turn to Bangladesh as Labour Costs Rise.”http://www.bbc.com/ news/business-19394405, August 2012.

Apichotborworn C., Rashaniphon S., SarideepanW.andAmmarapala V.,” The Study of Production System Re-Allocation in Safety Shoes Manufacturing Company”, International conference on Engineering, Project and Production Management, Singapore, pp:33-42, 20-21 Sep 2011.

Chahal, V., “An Advance Lean Production System in Industry to Improve Flexibility and Quality in Manufacturing by Implementation of FMS & Green Manufacturing”, International Journal of Emerging Technology and Advanced Engineering, Vol.2(12), 2012.

Chakrabortty, R. K. and Paul, S. K., “Study and Implementation of Lean Manufacturing in a Garment Manufacturing Company: Bangladesh Perspective”, Journal of Optimization in Industrial Engineering, Vol.7, pp.11-22, 2011.

Ferdousi, F. and Ahmed A., “An Investigation of Manufacturing Performance Improvement through Lean Production: A Study on Bangladeshi Garment Firms”, International Journal of Business and Management, Vol.4 (9), pp.106-116, 2009.

Fernandes A M.,“Firm Productivity in Bangladesh Manufacturing Industries”, the World Bank, PP 03-11, September 08, 2006.

Hasan M. M. S., Nirjher A. I. &Chowdhury A. H., “Reduction of Production Lead Time using Value Stream Mapping (VSM) Technique”, Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering, Vol. 17 Issue 1, pp. 1-9, 2017

Hines P, & Rich N. (1997),"The Seven Value Stream Mapping Tools", International Journal of Operations & Production Management, Vol. 17 Iss: 1 pp. 46 – 64, 2005.

Islam M. M, Khan A M and Islam M. M, “Application of Lean Manufacturing to Higher Productivity in the Apparel Industry in Bangladesh”, International Journal of Science & Engineering. Research, Vol 4, Issue 2, ISSN 2229-5518, PP 01-10, Feb-2013.

Islam M. K, and Khan M. R., “Minimization of Reworks in Quality and Productivity Improvement in the Apparel Industry”, International Journal of Engineering and Applied Science, vol.1 (4), PP147-164, 2013.

Islam, M. S., “Labor Incentive and Performance of the Industrial Firm: A Case Study of Bangladeshi RMG Industry”, IOSR Journal of Business and Management, Vol.7(3), pp.52-63, 2013.

Islam, M. M., Khan, A. M. and Islam, M. M., “Application of Lean Manufacturing to Higher Productivity in the Apparel Industry in Bangladesh” International Journal of Scientific & Engineering Research, Vol.4(2), pp.1-10, 2013

Islam, M. M. N. and Sultana, M., “Starting the Lean Journey with Value Stream Mapping in the Garments Industry of Bangladesh”, Proceedings of the International Conference on Mechanical Eng., 18-20 December, Bangladesh, pp.1-6, 2011

Jannat, S., Hoque, M. M., Sultana, N. and Chowdhury, I. J., “Time Study of a Furniture Industry: A Case Study at Navana Furniture Industry”, Proceedings of the International Conference on Mechanical Engineering, 26-28 December, Bangladesh, pp.1-5, 2009

Kumar, V., “JIT Based Quality Management: Concepts and Implications in Indian Context”, International Journal of Engineering Science and Technology, Vol.2(1), pp.40-50, 2010.

Kumar, N. and Mahto, D., “Assembly Line Balancing: A Review of Developments and Trends in Approach to Industrial Application”, Global Journal of Researches in Engineering Industrial Engineering, Vol.13(2), pp.29-50, 2013.

Milan M I, “Problems and Prospects of Footwear Industry in Bangladesh.” https://www. Linkedin.com/pulse, Jan 2016.

Moktadir M. A., Ahmed S., Fatema-Tuj-Zohra and Sultana R., “Productivity Improvement by Work Study Technique: A Case on Leather Products Industry of Bangladesh”, Industrial Engineering Management, Vol 6, pp: 1-11, March 2017.

Parthiban. P. and Raju. R., “Productivity Improvement in Shoe Making Industry using Method Study’’,IOSR Journal of Mechanical and Civil Engineering, e-ISSN: 2278-1684, pp.1-8, 2008.

http://www.sixsigmaonline.org/ Six Sigma Training Certification Information/ The Importance of Productivity in Business, 9th April 2017.

Kanawaty G., “Introduction to work study” International Labour Office, Fourth Edition, pp 9-174, 1992

Kulkarni, S. S. (2014). Productivity Improvement Through Lean Deployment & Work Study Methods. International Journal of Research in Engineering and Technology, 429-434, 2014.

Satao, S. M., Thampi, G.T., Dalvi, S. D., Srinivas, B. and Patil, T. B., “Enhancing Waste Reduction through Lean Manufacturing Tools and Techniques, a Methodical Step in the Territory of Green Manufacturing”, International Journal of Research in Management & Technology, Vol.2(2), pp.253-257, 2012.

Singh M. P. &Yadav H., “Improvement In Process Industries By Using Work Study Methods: A Case Study”, International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 3, pp.426–436, 2016.

Shumon, M. R. H., Arif-Uz-Zaman, K. and Rahman, A., “Productivity Improvement through Line Balancing in Apparel Industries”, Proceedings of the International Conference on Industrial Engineering and Operations Management, January 9-10, Bangladesh, pp.100-110, 2010.

Uma VR, “Historical Background of footwear” pp1-11, 2015.

Wakjira, M. W. and Singh, A. P., “Total Productive Maintenance: A Case Study in Manufacturing Industry”, Global Journal of Researches in Engineering, Vol. 12(1), pp.24-32, 2012.

Appendix

Appendix A:Profile of the footwear Industries

Royal Shoe Industries limited		
	Location	: SataishTongi, Gazipur
	Nature	: Complete shoe. Stitched upper
	IE activities	: None
	Certification	: None
	Clients	: Bata Shoe Company (BD) Ltd & Export
	Proction Lines	: 6
	Production Capacity/day	: 2000 pairs
	Workforce	: 1000
	Type of products	: School shoe,sports shoe
Anonna Shoes		
	Location	: Silmun, Tongi, Gazipur
	Nature	: Complete shoe. Stitched upper
	IE activities	: None
	Certification	: None
	Clients	: Bata Shoe Company (BD) Ltd & Export
	Proction Lines	: 5
	Production Capacity/day	: 4000 pairs
	Workforce	: 300
	Type of products	: School shoe, sports shoe, Sandal
Crystal Footwear Ltd.		
	Location	: Ashulia, Dhaka
	Nature	: Complete shoe. Stitched upper
	IE activities	: None
	Certification	: None
	Clients	: Bata Shoe Company (BD) Ltd & Export
	Proction Lines	: 2
	Production Capacity/day	: 800 pairs
	Workforce	: 200
	Type of products	: School shoe, sports shoe, Sandal
Uttara shoes		
	Location	: Faidabad, Uttara, Dhaka
	Nature	: Complete sandal. Stitched upper
	IE activities	: None
	Certification	: None
	Clients	: Bata Shoe Company (BD) Ltd & Export
	Proction Lines	: 4
	Production Capacity/day	: 3000 pairs
	Workforce	: 275
	Type of products	: School shoe, sports shoe, Sandal

Appendix-B: Questionnaire

Questionnaire for the study on Productivity Improvement in Footwear Industries								
Name of the Industry			Location					
Address								
	Tel:		Fax:					
Type of products manufactured								
Employee no.								
Name of the employee								
Educational background					Training Achieved			
Sex	☐	Male			☐	Female		
Age (yrs)	☐	Below 15	☐	15-20	☐	20-25	☐	> 25
Job designation	☐	Supervisor	☐	Operator	☐	Helper		
Marital status	☐	Unmarried	☐	Married	☐	Separated	☐	Divorce
Number of child	☐	1-2	☐	2-3	☐	3-4	☐	> 4
Placement of child	☐	Babycare	☐	Home	☐	Other place		
Working duration	☐	0-3	☐	4-6	☐	7-9	☐	> 9
Skill level of the worker	☐	Skilled	☐	Semiskilled	☐	Unskilled		
Safety knowledge	☐	Yes			☐	No		
Training facilities	☐	Yes			☐	No		
Repetitive tasks	☐	Yes			☐	No		
Salary (BD Tk.)	☐	4000-5000	☐	5000-6000	☐	6000-7000	☐	> 7000
Satisfaction with the salary	☐	Agree	☐	Neither agree nor disagree			☐	Disagree
Overall satisfaction	☐	Satisfied	☐	Neither satisfied nor dissatisfied			☐	Dissatisfied
Influence of incentives and other benefits in performance	☐	More	☐	Less	☐	No opinion		
Consistency in pace of worker	☐	Yes			☐	No		
Baby daycare facilities	☐	Yes			☐	No		
Ventilation and lighting facilities	☐	Yes			☐	No		