New Horizons, Vol. 16 No. 2, 2022, pp 93–110 *DOI:10.29270/NH.16.2(22).05*

CONSTRAINTS IDENTIFICATION AND ANALYSIS USING PARETO CHART AND CAUSE & EFFECT DIAGRAM IN THE GARMENT INDUSTRY: A CASE STUDY OF THE APPAREL INDUSTRY IN PAKISTAN, KARACHI

Afzal Adamjee, Faiza Azeem, and Adeel Shah

ABSTRACT

Readymade garments are a major textile value chain industry and play a significant role in Pakistan's economic growth, as they make up approximately 54% of export revenues in the textile sector. Because of its importance, companies face intense local and international competition in this region. Currently, textile companies compete for consistency, reliability, customer loyalty, process efficiency, consistency, and distribution costs. Bottlenecks are the key causes of the decreased production, performance, and power of the entire system. It is often within the scheme in various forms, such as management constraints, resources, materials, facilities, procedures, policies, environment, etc., but the approaches and methods for finding the bottlenecks are almost the same. The primary purpose of this paper is to provide a wider range of bottlenecks in the garment production unit, identify root causes, and evaluate and suggest possible solutions to eliminate these bottlenecks from a selected garment industry in Karachi, Pakistan. To do this, we have worked in a specific section (i.e., cutting and stitching) on a specific product (i.e., woven pants). Data from factory records, management, and observations have been collected for two months. Pareto Analysis is carried out on the data to find the bottleneck's key area. Cause-Effect Diagrams are then arranged to define hierarchies of causes for individual problems. Finally, potential solutions are being presented for eliminating these bottlenecks to improve the company's performance and productivity.

Keywords: *Bottlenecks, Pareto Analysis, Root Cause, Fishbone diagram, Garment, cause-effect diagram.*

INTRODUCTION

In today's era, the textile industry is facing a lot of hurdles in keeping productivity and efficiency high of the production floor. The cost of production rises due to several factors such as inefficient workload management and system failures etc. Such issues pose major challenges to manufacturing operations which are referred to as a bottleneck. Bottlenecks are also considered as the weakest link in the manufacturing process as every manufacturing unit is running after productivity but the real game changer is throughput which simply means the quantity produced in one process should be completely consumed or used in the next process in a given amount of time. The bottleneck is the clogged point in the process which resists smooth flow. For example, the piling up of inventory is a major bottleneck observed in several units.

A bottleneck can be anywhere and can be anything in the process that lags the performance of a process resulting in lower efficiency. For instance, a production floor has multiple lines with multiple processes; each process is interlinked to another process i.e., the output created from one process is the input for the following process. So, if any process faces any sort of problem, the following process is directly affected which results in a lower level of output. There can be many reasons behind the inefficient performance; it can be due to machine, labour, design, assembly and operation of the process. Anyone of these constraints can result in a bottleneck on the production floor.

Identifying a bottleneck is a very critical task in any production system. It is a continuing process that must be performed after every defined interval of time, to smoothen the flow of a process. This will reduce operational expenses, and inventory cost and increase the return on investment of the firm. The main purpose of our project is to give a wide spectrum of bottlenecks that are found on the production floor; how to find that bottlenecks and to propose possible solutions for it. This study suggests the removal of different constraints and to optimization the productivity of the system. Cecil C. Bozarth & Robert B. Handfield (2008) stated that a bottleneck is a hurdle in the manufacturing process that resists the flow of production. The bottleneck can vary according to time and continuously transfer from one process to another.

Vilarinho & Simaria (2002) stated that on the production floor, the production line is the set of multiple workstations each of which successively performs a specific task. The productivity of the line in production is specified by the cycle time. The cycle time is the time taken by the process from the beginning to completion. If the cycle time surpasses the targeted time, the efficiency of the line is decreased.

To improve the bottleneck, you need to locate it. For daily operations management, most firms use key performance indicators (KPIs). They are the figures that represent the performance of the organization either profit or average production per unit of time for a machine.

As businesses, the ultimate objective is directed towards profit making, for which every firm wishes to cut down their cost of production but they are unable to achieve it just because of the bottlenecks. By removing the bottleneck, higher throughput can be achieved that will cut down the operational expenses and inventory costs, which will contribute to higher profitability for the firm. The major hurdles or constraints for the system's performance are bottlenecks (Li, Chang, & Ni, 2008). Identifying bottlenecks and setting it would result in high quality and increased productivity." An hour saved at the non-bottleneck is a mirage" (Goldratt, 1986).

Bottlenecks in Manufacturing System

The flow of materials in the line is bound by the capacity of distinctive processes; some processes relatively affect the system output more than others. These processes are known as bottlenecks. "An hour lost at the bottleneck is an hour loss of the entire system" (Goldratt, 1986). There can be various types of bottlenecks on the production floor i.e., labour, time, material, machine etc. Described below are some major types of bottlenecks:

Material constraints

Poor treatment of merchandise, poor handling of goods, poor forecast, insufficient production designing, insufficient finance etc. Each of these factors might cause a reduction in overall production and increased lead time due to improper flow of material.

Equipment constraints

Production equipment ought to meet the present demand. However, sometimes a breakdown of equipment, lack of designing, improper maintenance, inconvenience of spare parts, low level of infrastructure, machines and equipment becomes a constraint for manufacturing.

Process constraints

In the production line, a process constraint can be due to a shortage of resources, quality issues, inflexible processes, and poor plant layout. The constraint can be anywhere, it can be in the policy, process, customer, supply chain and supplier etc. hence any constraint affecting the output of the process is known as process constraint.

People constraint

People are the most important factor which plays a vital role in the production floor. In every production line, there are usually different types of people working together that belong to different backgrounds and having different experiences and qualifications.

Management constraint

Efficient management means that performance should result in increased throughput and profits. Management of the firm should align their aim to the objectives and goals of the firm. Sometimes the management is not able to fulfil the requirements of the firm which causes problems such as disruptive flow of material and information, de-motivation of employee and many more.

Policy constraints

A production unit's strategy should follow the organisational goal. It should explicitly state how to take action in what cases. Management usually can not identify all the problems that might lead to a restriction. This is every company's most popular form of issue.

Environmental constraint

The operating environment of any business includes competitor activities, rules and laws formulated by the government, client demands, client expectations, labor law, union law, economical situation, technological improvement, development in infrastructure etc. Simultaneously, the company can assume social obligations. These all factors influencing the company are referred to as environmental constraints (The times 100 business case studies, 2012).

Approaches to Find Bottleneck

It is essential to find the right bottleneck in the process to improve the throughput. Assuming the wrong problem as the weakest link in the process can result in an increase in cost rather than decreasing it. The methods should therefore be clearly understood. Below are some of these methods which are used to define the bottleneck.

Benchmarking

A method of linking the company's own activities to the best practices on the market to pursue the best possible options to enhance or develop particular operations is known.

Five Process Why

Introduced by Japanese industrialist Sakichi Toyoda "Five Why" is the basic and easiest method to reach down for the cause of the problem. Once the bottleneck is found, one must keep questioning why to reach the root cause at every move.

Fishbone Diagram

Fishbone diagram is also known as the Ishikawa Diagram or cause-effect diagram. It also helps to think clearly and to reach to the root cause of the subject.

Pareto Analysis

The purpose of the Pareto Chart is to visualize the most important factors of a particular issue or problem. In the world of manufacturing, a Pareto is often used to highlight downtime and scrap reasons as well as finding bottlenecks in production lines.

By using Pareto Analysis one can identify the bottlenecks in the system and can analyze the causes of decreased output or inefficient production on the factory floor and determine a course of action for fixing such problems.

Theory of Constraints

It focuses on the continuous improvement of the process. Every system consists of several sub-independent systems which focus on to meet a particular target. For example, a garment industry has multiple departments working on different parts of the garment, so the final throughput of the company determines the progress and productivity of each department. It highlights the weakest place that needs improvement. Following are some basic steps to find constraints:

- Identify the constraints
- Exploit the constraints
- Elevate the constraints and
- Repeat the cycle

Failure Model and Effect Analysis (FMEA)

Failure Model and Effect Analysis provide the possible factors that can result in failure of the process, at the initial stage when the process is being developed. It indicates the subject's estimation and severity and also helps provide solutions. It focuses on improving product reliability, protection, and reducing external costs such as warranty costs, service delivery barriers, etc.

It generally identifies the issues of examined process, such as:

- Potential failure mode
- Potential effects of failure
- Times of occurrence
- Present control methods
- Recommend actions

Objectives

The objectives of this research are:

1. To identify the bottlenecks in the process.
2. To analyze the root cause of bottleneck in order to improve productivity in the production department.
3. Recommending the necessary changes to smoothen the flow of the process.

LITERATURE REVIEW

Lawrence & Buss (1995) illustrated that bottleneck has become a major part in planning and managing production systems. They have identified bottlenecks from an economic perspective in their study. They have used a queueing model to describe that bottlenecks are unavoidable problems in the production due to several differences: in job arrival rates, processing rates, or costs of production resources. These differences creates problem in facility and demand planning decisions.

Goldratt (1986) stated that the firm's productivity is measured and improved through three basic elements: holding inventory, operation expense and throughput. Any bottleneck that effects them directly or indirectly will result in inefficiency and in the firm's profitability. Simatupang, Wright &

Sridharan (2004) declared that there are multiple problems and constraints in a supply chain network. They have used the Theory of Constraint approach to solve supply chain collaboration problems so that the entire network can work together and increase a firm's overall profitability.

Watrous & Pegel (2005) demonstrated the successful TOC application in a manufacturing plant operations problem. This application is used to identify the constraint in the process which is causing a problem in increasing throughput and has a negative effect on the plant's productivity. Chakravorty & Atwater (2007) discussed in their study that a bottleneck resource is a major hindrance in operations that slow down the system and causes losses. They proposed that the maximum bottleneck utilization should not exceed 100%. Efficient bottleneck management is critical to improve and maintaining performance.

Li, Chang, Ni & Xiao (2009) said that by identifying the bottleneck's root cause correctly and efficiently, a company can improve the utilization of the resources, can increase the company's throughput, and can decrease the total cost of production.

Lorentzen, Deuse & Roser (2015) in their study they proposed that bottleneck identification is a key element for running a successful production system. They have used a new methodology which is used to identify bottlenecks in processes and in inventory levels. The method is already in use at Robert Bosch GmbH, where it is called Bottleneck walk.

Jadayil, Khraisat & Shakoor (2017) studied a company's case study regarding production problems to ascertain the main reasons and factors that are affecting production capacity and enquired their influence to increase the production capacity to the optimum level. They have analyzed various factors like speed of a running machine, number of workers running a machine, operating shifts, working environments and machine utilization. They have found that all these factors contribute in improving the company's production capacity.

Huff & Al Mansouri (2017) gave a study for evaluating bottleneck detection techniques. They intended to carry out this study to find the best bottleneck detection method. Discrete Event Simulation will assist in carrying out this algorithm evaluation task. Yemane, Haque & Malfanti (2017) illustrated a study which deals with bottleneck detection techniques like simulation and time study. Modelling and simulation techniques are probable ways for examining assembly lines such as in a garment factory, therefore for that, researchers experimented 160 numbers of replications in arena tool. In this study, A Ronny t-shirt sewing has been measured by researchers. The collected data is further analyzed statistically in arena and simulation model.

Kolinska & Domansci (2017) stated that there is continuous process management for which the Theory of Constraint is used for controlling and planning the production. The basic step in scrutinizing the production system is to identify bottlenecks in the production floor. This research is conducted on some factors like tact time, profit margin, productivity and extent of machine's excessive use and shows that with the application of TOC production managers can got assistance in decision-making process with out affecting any other process or system of production floor.

RESEARCH METHODOLOGY

Research Approach

Our approach for the research is the Deductive Approach because we are not providing a new theory rather, we are applying existing concepts to our research to observe the results. The type of research we are using is descriptive and follows a qualitative methodology to discover bottlenecks in the CMT unit of the garment factory. We studied the phenomenon on site in its natural setting and provide a descriptive analysis on the subject.

Research Design

There are generally two designs for research, Qualitative and Quantitative. We are collecting data in qualitative forms that is observation and interviews and providing descriptive analysis for research. For our study, we selected a case study of the garment industry located in Karachi, Pakistan. They are primarily involved in the production of denim pants. Cutting, stitching, washing, finishing, quality control to clearance, and delivery of denim apparel are performed in this garment unit. The key objective of our research is to eliminate the bottlenecks in the CMT department of this industry.

Population, Sample, and Sampling Technique

According to Sekaran (2003), population refers to the entire group of people, events, or things of interest that the researcher wishes to investigate. Our area of interest is to investigate bottlenecks in the Textile Industry of

Pakistan, so our population is garment industries in Karachi and the sample is a single garment unit selected by using a convenient sampling technique as we are doing a case study.

Data Collection Method

The data used in this research consist of two types, which is primary and secondary data. The Primary data collection method is based on observations and in-depth interviews. Information acquired through this is the most reliable for our project. The secondary data is collected through research journals, books, relevant literature from internet and past-production data of factory to gain most relevant and supportive information related to our research. This data helped us to look for the bottlenecks with a different perspective, while production reports provided us the statistics and a complete picture of the situation.

Respondents

Firstly, our respondents are front line managers who are line in-charge and supervisors. They have firsthand knowledge of what is going on and what hurdles they face on the production lines. Secondly, we interviewed middle-level managers, factory managers and general managers.

DATA ANALYSIS

We have conducted our study with the help of observations & interviews as a source of getting information; also, we have acquired data and reports of two months (November & December) from the factory officials. We have identified and analyzed this data by using Pareto Analysis in order to find the actual problem (bottleneck) and its root cause by using fishbone diagram, due to which production was affected.

RESULTS AND DISCUSSION

Findings

The company officials briefed us about the CMT department of the company so that we can understand the functioning and system of both departments which will help us in investigating finding bottlenecks and identifying the Root cause of the problem.

Cutting Department

Cutting is the first process, after the arrival of fabric in the factory. The department does cutting in advance for three days so that there would be no gap or pause in the production lines of the stitching floor. There are three cutting tables in the cutting department which are operated manually. The cutting floor specifications are as under:

- Length: 99’9”
- Width: 86”
- Area: 8514 sq. ft.

Stitching Department

The process of this department is complex and includes three stages of garment production. The first stage is the front part manufacturing of a garment, the second stage is back part manufacturing and finally, the third stage is assembling the front and back parts of a garment. One of the reasons for the complexity of this department is the lack of educated and trained people in the department. The stitching floor has nine production lines working on the chain system. All the lines are on wages except line no. 1 which is being operated on a salary basis. The stitching floor specifications are as under:

- Width: 170’
- Length: 172’
- Area: 29240 sq. ft.

The officials further informed us that the unit works with around 100% efficiency. However, they mainly face problems in production due to the stitching department.

Analysis of Cutting Department

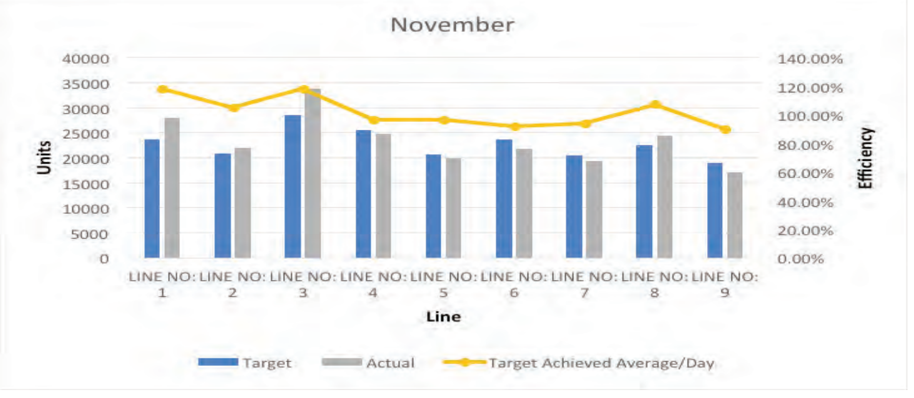
First, we have analyzed data of the cutting department with the help of a Pareto chart which is shown below:

The above graph shows how efficiently the cutting department was working. Through this graphical representation, we came to know that the cutting department is working on an efficiency level of above 100% for each line with respect to their target. As mentioned above, they also maintain a buffer of three days in advance. There is no bottleneck in this stage of the process. So, our next target was to move on to the Stitching department.

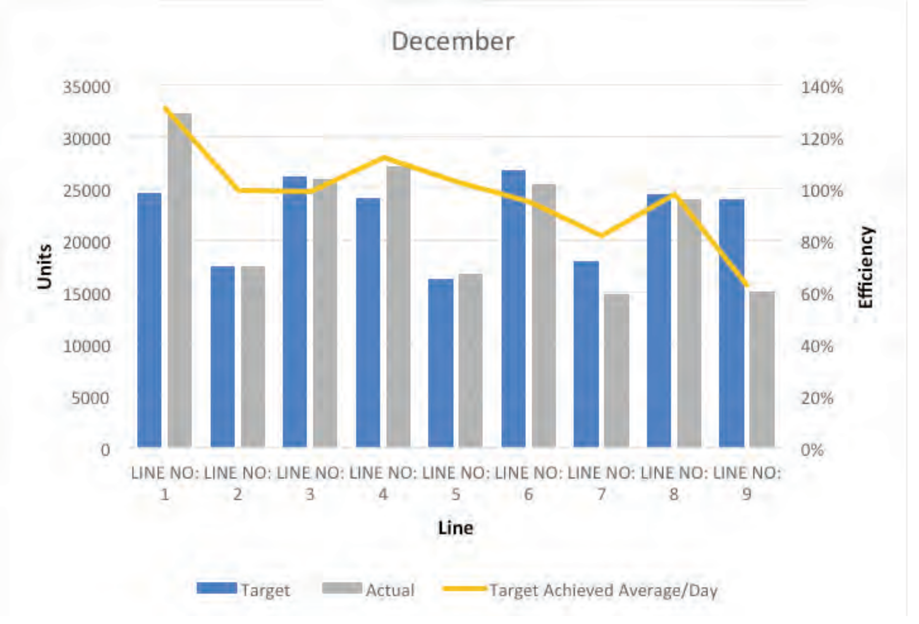
Analysis of the Stitching Department

The data we obtained from the stitching department was analyzed as follows, which is separately shown for two months with the help of the Pareto chart:

With the help of this graphical representation, we can see the efficiency level of each line on the stitching floor in the month of November. The blue bar denotes the target which has to be achieved, whereas the grey bar denotes the actual target achieved. The orange line denotes the percentage of efficiency level. According to this representation, we can see that there are problems in line no 6, 7 and 9 as the targets given were not met. Despite the fact that line no 4 and 5 are likewise demonstrating some distinction among real and target levels however it is insignificant, so we chose to study line no 6, 7 and 9 to identify the real bottleneck.



This graph illustrates the efficiency of each line on the sewing floor throughout the month of November. The blue bar represents the required objective, while the grey bar represents the actual target reached, and the orange line represents the percentage of efficiency level. According to this depiction, there are issues with lines 6, 7, and 9, since the specified objectives were not completed. Despite the fact that lines no. 4 and 5 also demonstrate a little difference between actual and goal levels, we selected to examine lines no. 6, 7, and 9 to determine the actual bottleneck.

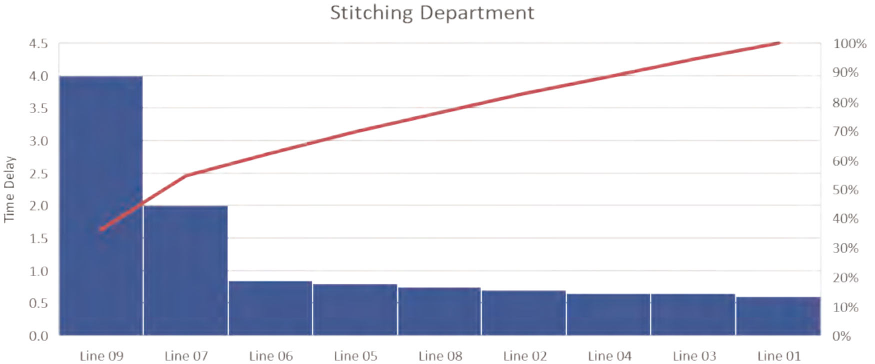


In the chart above, it is seen that line No 6 has improved to achieve the target by December but line No 7 and 9 could not meet the target provided and proceeded with low efficiency to the negative side. In December, line 7 and 9 working efficiency decreased more than in November. Therefore, we narrowed our analysis to focus on line 7 and 9.

The above chart sums up the performance of two months (November and

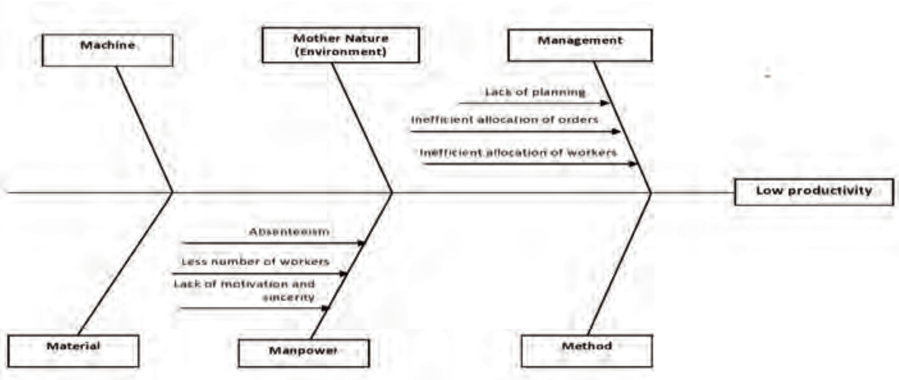
December) from which we can see that Line no 6 is showing negativity for the average of two months as in both months the set target was not achieved. But, based on the above data we observed that it started to increase in efficiency and was at a 100% efficiency level in the month of December. On the contrary, as discussed above, the major issues are in line no 7 and 9 as they did not show any improvement on average of two months as well and were on low efficiencies making it difficult to reach up to the actual target. Furthermore, the above graph also depicts that line no 9 is at greater risk as compared to line no 7. Hence, we focused on these two lines and started to look for the main bottleneck and its root cause in both of the lines separately.

First, we studied line no 9. The daily target of this line was 1000 pieces and they were only making 580 pieces approximately. We observed and inquired about a few factors which were likely to be the reason for low production. At first, we analyzed the line balancing which was done properly with respect to the standard allowed a minute of the garment and available operators, then we moved towards bundling process which was also correct and up to the mark. The main problem identified in line no 9 was a smaller number of workers available per operator with an excessive workload.



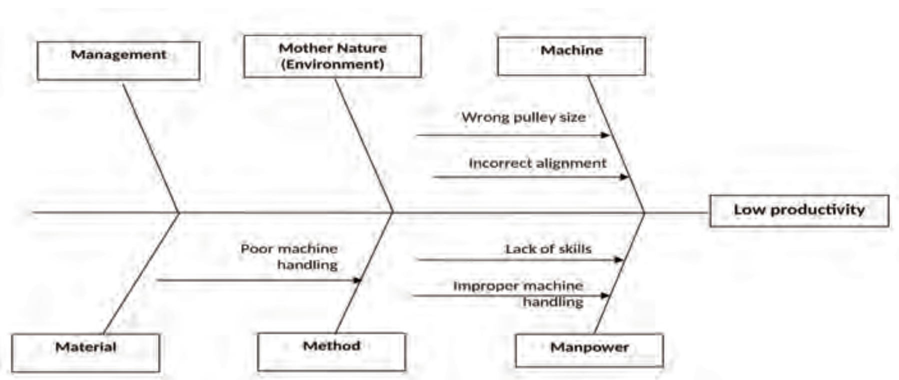
Root cause Analysis

With the help of the fishbone diagram, we have reached to the root cause of our problem i.e., low efficiency due to labor shortage. This issue arises due to the planning department as they are not allocating orders and workers properly within this line. They employed daily wagers in this line due to the processing of small orders. Such workers did not have any motivation to work attentively and have no expectation of consistency regarding their salaries due to which they did not complete their targets on time and ultimately industry has to suffer.



When we studied Line 7, it was observed that the workload was spread over the whole line evenly and there was no problem with the placing of orders, but the objective was still not achieved. The daily production capacity was 1000 pieces and they were only making 800 pieces approximately. To analyze the reason behind this unaccomplished target, we have examined a few factors related to this line, like line balancing, bundling process, and workers' attendance, all of which are satisfactory and up to par.

To find the real root cause, we then interviewed in a more detailed manner to the supervisor and line in charge there. As a result, it was revealed that the bottleneck which was creating hurdles in achieving the target was Kansai machine that was used for attaching belts to the garment. The machine was complicated and difficult to execute for workers that were employed on it as it was attached to the inappropriate size of the pulley, due to which work piled up there. Also, at this stage workers sew different parts as per pre-determined manner according to the machine layout for ensuring the right operation, so in this Kansai process, inefficient handling of the machine accumulated the work, which means that operators could not reach their actual target.



CONCLUSION

The lowest output point in the production line is called a bottleneck which is an extreme point that hindered the flow of production. In the garments industry bottleneck means the lowest capacity of one or more operations which results in low production and ultimately low profit. So, identifying bottleneck operation and removing it is a very significant task to get the highest capacity production. There are several problems during the manufacturing a garment that causes inefficiency in operations and makes it difficult to achieve the target; however, to analyze such problems and to find the real bottlenecks on the floor is quite a time-consuming process and requires a lot of effort.

Our research is based on the identification of actual problems in the production lines of cutting and stitching departments which are the weakest link (bottleneck) on the production floor and to propose possible solutions for those problems. We analyzed the data thoroughly, evaluated different factors by going on the floor, and observed machines, trims, fabric, line balancing, the accuracy of laborers and their way of carrying out the operation, and further crucial leads.

There was total nine lines on the stitching floor and three lines on the cutting floor. When we analyzed and observed the cutting floor, we found that all the processes in this department were going smoothly as all the lines were on above 100% efficiency level, whereas in the stitching department, we found differences in actual production and set targets, which were not achieved because of inappropriate process flow and several inefficiencies in it. We studied and inquired about stitching floor's data further and came up with the conclusion that the main problem areas in this section are line no 7 and 9.

We discovered that in line no 7 the waistband attachment was the actual problem behind incomplete production which is done by the Kansai machine and in line no 9 the root cause of low production is inappropriate planning which causes a smaller number of workers with demotivated behavior with an excessive workload.

RECOMMENDATIONS

We have proposed some possible solutions for the problems we have identified in both lines i.e., line no 9 and line no 7.

As in line no 7 the main constraint is an inefficient use of the Kansai machine as it was attached to the small size pulley that was limiting the speed of the machine and making the flow of operation slow, we proposed installing the appropriate size pulley to carry out the process smoothly and efficiently.

For line no 9, after discussing a number of solutions with the planning department's management we have come up with a reasonably clear and practical solution that, alternately small and large orders should be allocated in this line so that the workers employed in this line do not feel insecure about their earnings. This will also motivate them to work wisely and rapidly in order to maintain the stability of heir salaries due to their role at the end of each month.

REFERENCES

Cecil C. Bozarth & Robert B. Handfield, (2008), "Introduction to Operations and Supply Chain Management." published by Pearson Prentice Hall.

Chakravorty, S. &Atwaters, J. (2007) "Bottleneck management: Theory and practice" Production planning and control, The management of operations, Vol. 17 Issue: 5, pp. 441-447.

Cox, Jeff; Goldratt, Eliyahu M. (1986). The goal: a process of ongoing improvement. [Croton-on-Hudson, New York]: North River Press. ISBN 0-88427-061-0.

Huff, B. & Al Mansouri, M. (2017). "Systematic evaluation for bottleneck detection methods", International Journal of Industrial and system engineering, Vol. 27 Issue :3, pp. 365-389.

Jadayil, W. Khraisat, W.&Shakoor, M. (2017). "Different strategies to improve the production to reach the optimum capacity in the plastic company". Cogent Engineering, Vol.4 Issue: 1.

Kolinska, J. &Domansci, R. (2017). "The Analysis of Production Line Bottlenecks - Identification and Ways of Management", Osijek, Croatia: 17th International scientific conference Business logistics in modern management, October 12-13.

Li, L., Chang, Q., and Ni, J., (2008), "Data-driven bottleneck detection of manufacturing systems", International Journal of Production Research, Vol. 47, No. 18, pp. 5019-5036.

Li, L. Chang, Q. Ni, J & Biller, S. (2009). "Real-time production improvement through bottleneck control", International journal of production research, Vol. 47 Issue: 21, pp. 6145- 6158.

Lawrence, S. & Buss, A. (1995) "Economic analysis of production bottlenecks". Colorado, Boulder: Mathematical problems in engineering, Vol. 1 Issue: 4, pp. 341-363.

Pegels, C. &Watrous, C. (2005) "Application of the theory of constraints to a bottleneck operation in a manufacturing plant", Journal of manufacturing technology management, Vol. 16 Issue: 3, pp. 302-311.

Roser, C. Lorentzen, K. &Deuse, J. (2015). "Reliable shop floor bottleneck detection for flow lines through process and inventory observations: the bottleneck walk" , Logistics Research, Vol. 8 Issue: 1, p.1.

Sekaran, U. (2003) Research Methods for Business: A Skill-Building Approach. 4th Edition, John Wiley & Sons, New York.

Sitatunga, T. Wright, A. &Sridharan, R. (2004) "Applying the theory of constraints to a supply chain collaboration" Palmerston North, New Zealand: Supply chain management: An international journal, Vol. 9 Issue: 1, pp. 57-70.

Vilarinho, P. M., and Simaria, A. S., (2002), "A two-stage heuristic method for balancing mixedmodel assembly lines with parallel workstations", International Journal of Production Research, Vol. 40, No. 6, pp. 1405-1420.

Yemane, A. Haque, S. &Malfanti, I. (2017) "Bottleneck identification using time study and simulation modelling of apparel industries" Bogota, Columbia: Proceedings of the International conference on industrial engineering and operations management.