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UPH IMPROVEMENT ON PRODUCTION LINE:

A CASE STUDY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UPH	Unit Per Hour
TPS	Toyota Production System
WIP	Work-in-Progress
PDCA	Plan-Do-Check-Act
UDE`s	Undesirable Effects
FMEA	Failure Mode and Effects Analysis
VSM	Value Stream Mapping
NAOT	Calculate Net Available Operating Time
USM	Universiti Sains Malaysia

ABSTRAK

Dalam industri perkilangan, Pembuatan Lean adalah falsafah yang diterima secara meluas. Pada mulanya, konsep Pembuatan Lean dimulakan dari Sistem Pengeluaran Toyota. Pada masa kini, kebanyakan pengeluar cenderung untuk melaksanakan Pembuatan Lean untuk meningkatkan pengeluaran dan prestasi mereka untuk mengekalkan kelebihan daya saing dalam persekitaran perniagaan. Tesis ini memberi tumpuan kepada penambahbaikan keluaran unit sejam dan pengurangan masa kitaran dalam barisan pengeluaran. Barisan pengeluaran adalah barisan pemasangan manual. Keadaan pengeluaran sebelum penambahbaikan seperti masa kitaran dan waktu taktik dikumpulkan dari masa kajian dan data telah dianalisis. Masa kitaran untuk barisan pengeluaran di setiap baris yang terdiri dari Left, Remote dan Right diberi perhatian untuk melihat stesen mana yang mempunyai masa kitaran tertinggi. Pendekatan pembuatan lean membantu mengenal pasti masalah dalam barisan pengeluaran dan membantu mengesan peluang penambahbaikan dalam barisan pengeluaran. Hasilnya selepas pelaksanaan penambahbaikan menunjukkan pengurangan masa kitaran untuk stesen bottleneck sekurang-kurangnya 37% dan output pengeluaran dapat mencapai 105 unit per jam.

ABSTRACT

In manufacturing industries, Lean Manufacturing is a broadly accepted philosophy. Initially, the Lean Manufacturing concept was started from the Toyota Production System (TPS). Nowadays, most of the manufacturers tend to implement lean manufacturing to improve their production and performance in order to maintain a competitive advantage in the business environment. The purpose of this paper is to study the unit per hour (UPH) improvement on the production line. This thesis focused on the improvement of UPH and the reduction of cycle time in a production line. The production line is a manual assembly line. The initial condition of the production of the product such as cycle time and takt time was collected from time study and the data was analyzed. The cycle time for a substation in each line which is Left, Remote and Right were given attention to see which station has the highest cycle time. The lean manufacturing approach helps to identify the problem in the production line and help detect the improvement opportunities in the production line. The outcome from the implementation of improvement shows the reduction of cycle time for the bottleneck station at least 37% and the output of the production able to achieve 105 units per hour.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The manufacturing process is the steps which raw material is transformed into a final product and the process begins with the product design and material specification from which the product is made. Then, the material is modified through the manufacturing process to become the required part. In manufacturing industry productivity is very important and productivity measure can be expressed as the ratio of output to the input used in the production process for example output per unit of input. The majority of the manufacturing industry aims for improvements such as output maximization, cycle time reduction, and cost reduction. Profit per hour or unit per hour is the target control metric that allows the manufacturing industry running at the optimal available operating point taking all revenue and cost drivers into account [1].

Usually, Lean manufacturing is the method that will be applied in the industry to make improvements. Lean manufacturing is a systematic method for waste minimization ("Muda") within a manufacturing system without sacrificing productivity, which can cause problems. There are many benefits of implementation of lean such as reduced inventory, less process waste, reduced Lead-Time, increased process understanding, financial saving, less rework and increase productivity. The five steps in solving problems in 'lean' are shown in Figure 1.1.

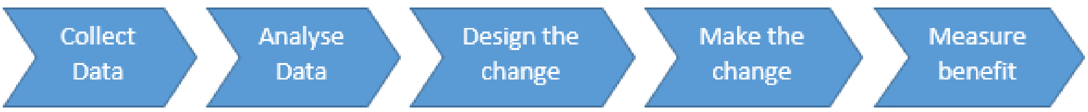

Figure 1.1 5 steps solving problems in lean. Source [2]

In production line unit per hour (UPH) control metric usually used to measure the production line performance and efficiency. To meet the customer demand, engineers need to ensure the production line can achieve the target of the output. The main focus in this research is UPH improvement in production line. There are many types of improvement that can be done in manufacturing industry such as elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time [3].

1.2 Project Background

UPH improvement in the production line is very important to increase productivity. High productivity can lead to greater profits. In this project, the observed company is a sound system designer and manufacturer located in Penang, Malaysia. It is an audio and accessories manufacturing company. A production line is given to make the improvements. The production lines produced wireless headphones. This production line consists of three lines. The production line has 95 substations and every station has a different process and most of its manual process.

In manufacturing industry productivity is a measure of the efficiency of production. Productivity serves as a measurement of output and it is normally expressed as some units per amount of time for example 90 units per hour. Meanwhile, efficiency relates to how well a goal is an archive and complete. Efficiency considers the number of resources used and the waste created in comparison to goods produced. Each phase of the production must be examined to evaluate production efficiency. To increase the efficiency in production, waste like materials and times must be reduced without affecting the quality standards and harming the other portion of the process.

Cycle time, takt time, bottleneck and work-in-progress (WIP) is the types of waste that must be optimized to increase the productivity of the production. Basically, cycle time is the total elapsed time to move a unit of work from the beginning to the end of a physical process and it is a variable that is used to reduce the cost and increase the output. Cycle time can measure the efficiency of the production process [4]. In production line cycle time for every substation need to meet the takt time that been set. Takt time comes from the German language which is taktzeit, meaning cycle time. In "kaizen" takt time it identifies the target time in manufacturing for producing one unit of output. Once, the takt time is achieved the production process will be balanced and maintained [5]. Bottleneck is one of the causes that reduce productivity. Bottleneck can be defined as the highest cycle time in the production line or it also can be defined as the cycle time that exceeds the takt time [6]. Bottleneck stations can cause process blocking or starving. Processing blocking occurs when there is no more room to store WIP before the bottleneck station. Process starvation occurs when the station after the bottleneck station is forced to stop or idle because of no material process until the bottleneck process can supply material to the next station.

To do the UPH improvement in this project, the lean manufacturing method which is PDCA (Plan-Do-Check-Act) will be used. Basically, PDCA is an iterative four-step management method used in business or industry for the control and continual improvement of products or processes. In this project, collection data of the cycle time for every substation will be taken to identify the bottleneck of the substation. Then the data will be used for further study to make the improvement.

1.3 Research Objective

The research objectives are

- To reduce the cycle time at the bottleneck station
- To increase the output in term of unit per hour (UPH)

1.4 Problem Statement

The main issue in this research is low output in term of unit per hour causing unable to meet the customer demand. High cycle time is the main reason that contributes to the low unit per hour of output. In this project, the production line is more to the manual assembly process. Hence, there is the problem in the consistency of manual work in term of time that causing the output of the production is not consistent.

1.5 Scope of Work

The scope of the study is limited to the manual assembly production line that produced the wireless headphones. Time study and relevant data of the current condition will be collected to identify the bottleneck stations. Suitable improvement will be identified for the bottleneck stations. In this context, cycle time and takt time are used as performance measures for the research. There are different approaches to implement the improvement, however, the study will focus on increasing the UPH of the production by reducing the cycle time at the bottleneck station. Several solutions will be proposed and chosen by using lean manufacturing tools. Finally, the time study and data collection will be conducted again to evaluate the performance after the implementation of improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Lean Manufacturing

The lean manufacturing concept was started from the Toyota Production System (TPS) [7]. Lean manufacturing is used to eliminate waste. There are several advantages from lean manufacturing which help to reduced inventory, less process waste, reduced Lead-Time, increased process understanding, financial saving and less rework [2]. Lean produce tools aim toward the prime quality, low cost, and simply in time delivery by shortening the assembly flow by eliminating waste [8].

2.2 Seven Waste

Waste is defined as any activity in a process that does not add value to the customer [9]. It used a pull system to move the product through the production process. The pull system helped to eliminate WIP inventory. Lead time is the amount of time required to convert a product from raw material to finished product. Reduction in lead time allows the manufacturer to gain more investment in time and material. Lean manufacturing help lead time to remove non-value added that causes waste in production. Waste can be described as non-value-added in a process. However, there are some waste acts as an added value to the process that cannot be eliminated for example financial control [2].

There are seven main types of waste that need to be considered in manufacturing industries which is overproduction, waiting, transportation, inventory, work in process (WIP), motion and defects [2, 10].

i. **Overproduction:** development of a product which is above requirement of the customer at that point.

ii. **Waiting:** Unnecessary waiting by the worker or the product is waiting to be processed on the next work station. It is not adding any value to the customer.

iii. **Transport:** During production there are unnecessary movement of the parts which does not add any value to the product and considered as a waste.

iv. **Inventory:** Stock of products waiting to be shipped or parts waiting to be finish. Inventory of any kind is carried as waste in the industries.

v. **Work in Process (WIP): I**tem is either just being fabricated or waiting for further process in a queue or buffer. Overproduction and waiting time also result in waste.

vi. **Motion:** Unnecessary movement or excessive movement of the workers who operate the manufacturing facility is a waste. Whilst they are in motion they cannot support the processing of the product.

vii. **Defects:** Error during the process either re-work or additional work. It can be considered as scrap and waste.

2.3 Method of Lean Manufacturing

In Lean Manufacturing there are several tools and methods that can be applied in industries which are [2, 11]:

- **Value Stream Mapping (VSM):** VSM is a graphical way of presenting material and information flow in the production system. VSM shows all the tasks undertaken in the process, from the purchase of raw materials and ending with the delivery of the finished products to the customer. VSM used to identify waste and orientation for further action in order to eliminate them.

- **5S method:** 5s is a visual housekeeping technique that devolved control to the shop floor. The method name is derived from the first letters of the Japanese words which are Seiri, Seiton, Seiso, Seiketsu, and Shitsuke.

  Seiri means sorting. The elimination of the workstation of all the items that are unnecessary to the job. This step is carried primarily of decreased inventory and better use of working space. The unnecessary item may be marked with any color such as red and placed in a designated area.

  Section means systematic. The workplace and tools are systematically designed and arranged. For example, each tool can be marked and arranged in a suitable place. This stage is performed to reduce unnecessary traffic employees performed when searching for tools and elimination of errors in the quality of products resulting from a mistake by properly marking items.

  Seiso means cleaning. The workplace must be properly cleaned and maintained. This stage aims to maintain a position in good condition, identify and eliminate the causes of pollution and care of machines.

  Seiketsu means standardize. In this stage, mainly defines the responsibilities of employees and creates instructions, supporting the execution of the previous steps. This stage provides a systematic procedure and repeatability previously entered changes.

  Shitsuke means discipline. This stage ratcheting up the habits of employees to comply with the previously introduce changes and act in accordance with the standards. It is a difficult and long stage because it forces workers to change the habits of both production workers and management.

- **Standardized work:** Standardization means uniformly operations or tasks by all operators. Standardized work is the best method of operation. This allows the exercise of all steps in the same way, in the same order and time, at a fixed cost. Standardization also assumes continuous development of new, better standards, so as to adapt to constantly changing customer requirements.

- **Kaizen:** Kaizen philosophy is a concept of continuous improvement, which assumes a constant search for ideas to improve all areas of the organization. It requires the involvement of all the company`s employees, operators, up to the highest level of management.
- **Poka-Yoke:** Poka-Yoke is a method of preventing errors coming from mistakes and it is an ‘error-proofing’ technique. The main principle in the Poka-Yoke us that the errors are to blame process not the employees. Poka-Yoke solution is characterized to prevent any error in the process.

2.4 Steps in Lean Manufacturing

Figure 2.1 shows five steps in lean manufacturing :

Step 1 Collect Data	Observe current processes & look for waste or Non-Value Added. It involve the people who run these processes daily.
Step 2 Analyse Data	Using cross-functional teams start to diagnose the issues through data analysis, e.g. What stops the process following? Look for undesirable effects (UDE`s) – incidents which you don`t want to occur but which are a part of the current process.
Step 3 Design the Change	Based on the data analysis a change can be designed – this usually involves the elimination of the Waste & UDE`s. A new process can then be defined. The design must encompass a sustainable change and will usually involve the cross-functional team who have collected and analyzed the data.
Step 4 Make the Change	The new process is put in place with appropriate training and measures i.e. so that the team operating the process can monitor the sustainability of the change and can adjust as necessary.
Step5 Measure Benefits	The new process is monitored, and the benefits evaluated on an ongoing basis. As the team running the new process continue to collect and analyze performance data further incremental improvements can be made and a culture of continuous improvement based on a data rational approach is developed.

Figure 2.1 Steps in Lean. Source [2, 12]

Numerous studies have attempted to explain the implementation of lean manufacturing. Research by Melton [2] found that lean thinking is applicable to all business processes within the industries. Moreover, research by Naveen [3] suggests that in order to meet the demand it is important to implement the suitable industrial engineering tools. Research from Mohd Shoeb [10] also suggest that proper successful implementation of lean manufacturing is a very essential part of manufacturing to enhance the quality and waste reduction.

2.5 Productivity and Efficiency

Study productivity helps us to understand the process of business, control the business process, asses the performance of a business, continuously improve processes, and determine a business ability to sustain the long run. Productivity improvement helps to achieve good financial and operational performances [3]. To compete with the business competitor all over the world it is essential for industries or organization to reach the optimal level.

Efficiency is based on both inputs and outputs. Basically, to consider any industries to be technically efficient they must able to produce maximum output from a specific amount of inputs or producing a given amount of output by using the minimum amount of inputs [13].

There are many types of improvement that can be done in the manufacturing industry such as elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time. The implementation of suitable engineering tools helps to achieve customer demand. Moreover, it helps to reduce waste hence it helps to improve the productivity [3].

2.6 Bottleneck

Bottleneck can be defined as the longest time consumption workstation [3]. There is some example of the bottleneck that had been defined which is if a machine has the smallest isolated production rate the machine is the bottleneck. Second, if the WIP inventory in a given buffer is the largest of all buffers in the system, then the machine immediately downstream of this buffer is the bottleneck. Third, if the sensitivity of the system production rate to a machine`s production rate is the highest of all machines in the system, then the machine is bottleneck [14].

2.7 Cycle Time

Cycle time can be defined as the total elapsed time to move a unit of work from the beginning to the end of a physical process and it is a variable that is used to reduce the cost and increase the output. The efficiency of the production process can be measured by using the cycle time. There is some example of cycle time, cycle time might start with a customer phone call and end with the order being ship. The overall process in the example is including many sub-processes such as order, assembly, inspection, packaging, and delivery [15]. Base on research by Vishnu Raj, cycle time also can be defined as the time required to finish one product or the total time takes before the product leaves the work station and move to the next workstation [16]. Cycle time can be divided into five categories which are design cycle, production cycle, distribution cycle supply management cycle, and order processing cycle.

Cycle time management seeks to reduce the total manufacturing cycle time which requires each sub-cycle time to be reduced. By implementing the cycle time management it can accomplish two objectives which are first, improve cost and quality. The cost can be reduced by identified unnecessary activities eliminate it and improved the necessary ones and quality improves because the poor-quality activities are eliminated or be improved. Second, the company become more flexible because of the times required to perform activities are all reduced, hence the company able to respond faster to changing conditions [17].

2.8 Takt Time

Basically, takt time comes from the German language which is taktzeit, meaning cycle time. In Kaizen, takt time is identifying the target time in manufacturing for producing one unit of output. Once the time is archived, the time will be maintained and a balance between the rate of output and market consumption. There is 4 step process to ensure balanced is achieved [5].

i. Calculate Net available Operating time (NAOT)

NAOT is the total available time for production. It is calculated by determine the total time available and adjust it for the presence of breaks, clean up and lunch.

ii. Converting Customer Requirements from Units to Takt Time

The number of units to be the demand of the system over a given period of time is identified.

iii. Calculate Operating Cycle Time and Machine Cycle-Times

Cycle time is total time for an operator to complete a cycle of process and machine cycle time is the total time for a machine to complete a cycle of the process. By using the cycle time data bottleneck at the station will be identified.

iv. Adjust Process Capacity to Achieve Balance Between Rate of Demand and Rate of Supply

The process with the cycle times is laid out. If the cycle time is low than takt time, there will be opportunities to combine the operations. If it exceeds takt time, capacity needs to be increased. With all the information we can make an improvement to ensure total cycle time is balanced with the takt time.

2.9 Plan-Do-Check-Act (PDCA) Cycle

Plan-Do-Check-Act is one type of tool for quality management and programs that are used in industries for continuous improvement. PDCA cycle or Deming`s cycle can be defined as repeated and continuous nature of improvement or continuously looking for a better method of improvement [12].

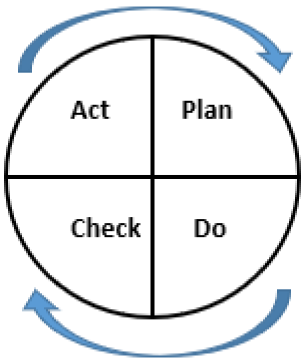

Figure 2.2 PDCA Cycle. Source [12]

The PDCA cycle approach is a cyclic process for planning and testing improvement activities. Every step in PDCA has its own ways to implement it. Explanation of four steps in PDCA [18, 19] :

1. **Plan:** This is the first step where the recognition of an opportunity and plan a change is started. This phase incorporates the definition of the problem. A thorough analysis of the current state issues is conducted in order to identify the root causes. Usually, a team will find that there are several problems, or quality improvement opportunities arise when programs or processes are investigated. Baselined data such as time, movement cost, and the number of steps will be collected. There are many tools are available to collect and interpret data in the process, such as Pareto charts,

histograms, scatter plots and control charts. A prioritization matrix will help in determining which one problem to be selected. Flow charts and value stream mapping are two examples of method helps to describe and understand the process and identify areas for improvement [19]. In this plan step, objectives and processes are established by using a form of brainstorming or cause-and-effect diagram (i.e., Ishikawa "fishbone diagram") to determine the problem [18].

2. **Do:** Once the current situation is fully understood and plan for improvement has been established, the "Do" phase is the second step where the improvements are implemented. The decide solution is implemented one by one. The people implementing the solutions will have to support the concerned people to make sure that the solution is fully understood and followed [18, 19].

3. **Check:** In this third step, the improvement that has been done needs to be monitor and evaluate the results. The test needs to be review and from the test, results are analyzed and need to identify what have we learned from the process [18]. The achieved state after the implementation of the improvements is then analyzed in order to verify the solutions. The improvement work will have to start over again at the planning phase if the results are negative. If the result is positive, the tested solution will continue to the Act phase. The new data will be compared to the baseline data to determine whether the improvement was achieved and whether the measures in the aim statement were met. There are several tools that can assist this analysis which is Pareto charts, histograms, run charts, scatter plots, control charts and radar charts [19].

4. **Act:** "Act" phase is where what had been learned in the check step needed to act. Once the improvement cycle reached this step, the solutions are prepared for final implementation by standardization and possibly spread to other parts within the organization. Review all steps and if necessary, the process will be modified to

improve it. To maintain continuous work, the key to success is to repeat the cycle in infinity to reach an even higher level. However, if the changes did not work, a different plan is needed to go through the cycle again [18, 19].

To perform the steps in the PDCA cycle, quality tools are required to be used as the indicator to analyze the possible problems and decide actions to be implemented. According to several journals, the several tools that mostly used in the PDCA cycle by the companies are brainstorming, Failure Mode and Effects Analysis (FMEA), 5s, statistical process control (SPC), Ishikawa diagram, histograms, Pareto diagram, flowchart, and Six Sigma [20-22]

Various research had shown the successful impact of PDCA implementation. Pratik M Patel [19] found that PDCA provides useful information for practitioners seeking ways to improve their organizational performance by suggesting a start point for deploying lean and/or quality improvement methods. Then, Abdelkader M. Kholif [23] found that factories that using PDCA cycle methodology will decrease losses and misuse, give immediate outcomes, enhance production and quality, and lessen costs. Moreover, Arturo [24] concludes that in general, the PDCA cycle is a tool that facilitates the detection of improvement opportunities, as well as the development and implementation of the same in lean manufacturing project.

CHAPTER 3

METHODOLOGY

3.1 Research Phases and Steps

The flow chart of the research was shown in Figure 3.1. The detail will be discussed in the next section. In this project, there are four Phases and 11 steps for the implementation plan. The four phases were Plan, Do, Check and Act. The tools used during the four phases included cause and effect diagram, effort and impact diagram, value stream mapping (VSM), histogram charts, box and whisker plots.

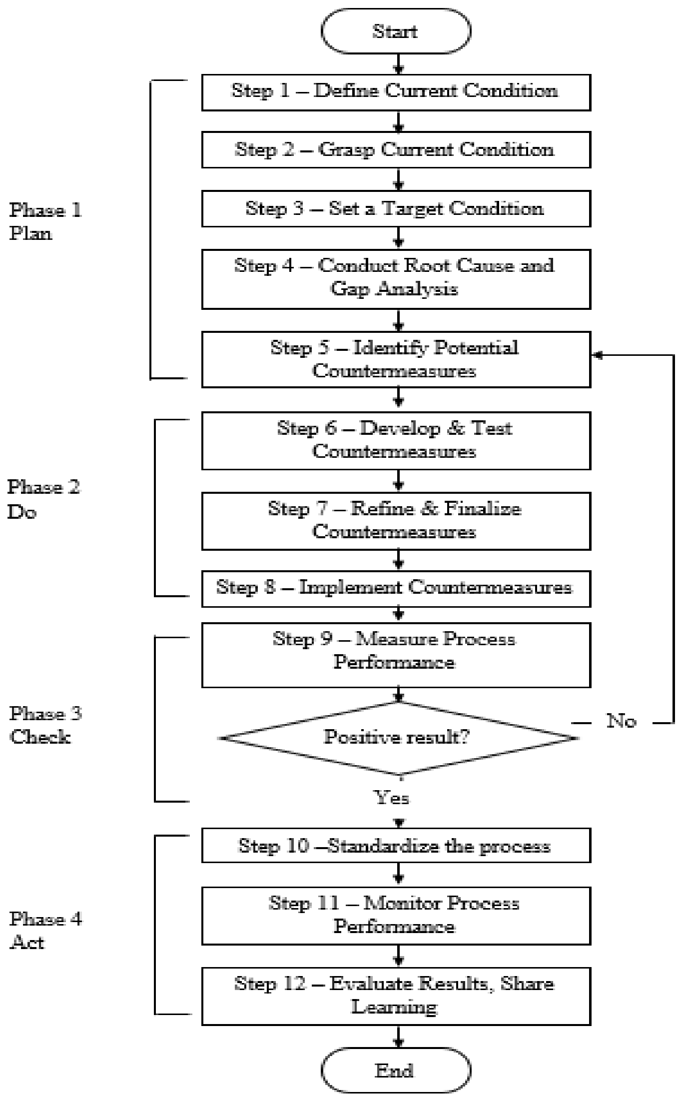

Figure 3.1 Flow Chart of the Project

3.2 Step 1: Define Current Condition

This step was conducted to have a full understanding of the condition, status quo and the details of the production line and product. The information listed below was collected.

a. Type of production

   (Example included what type of the production, Manual or Automated production and Continuous or Discrete production)

b. Value Stream Mapping

c. Problem faced in the production

   Gemba Walk is a method that is used to determine the problem. During the Gemba Walk interview with the operators, engineers and technicians were done to gain information and increase understanding about the current condition of the production line. Gemba is a Japanese word meaning "the real place", a place where ultimate work is actually done, or value is created. The objective of Gemba Walk is to understand the value stream and its problems rather than review results or make superficial comments.

3.3 Step 2: Grasp Current Condition

In this step, data were collected included cycle time and the Unit Per Hour (UPH) of the production. Both were decided as the performance measure for the project. The data listed in Figure 3.2 was collected with the listed tools.

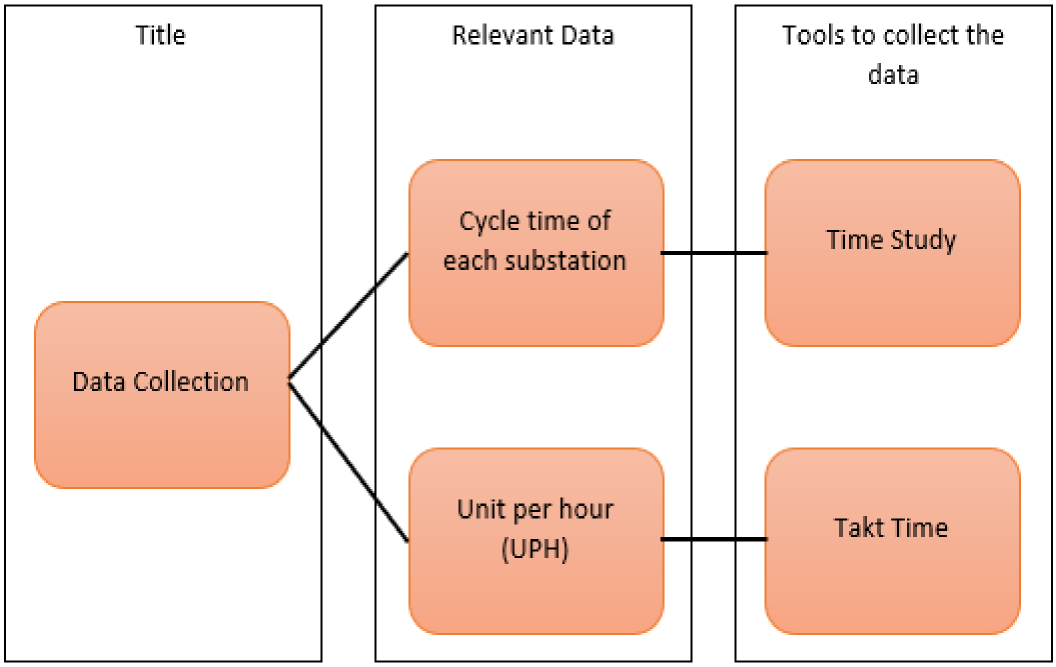

Figure 3.2 Relevant data and the tools used for data collection

Time study was used to collect the cycle time of each substation in the production line. It is one of the methods used in work measurement to set the basic time or standard time to conducting work. The steps in the time study method are including observe and understand the flow of the work, recording the manufacturing process and time for the operator to complete the work at every substation that each operator had been assigned. In this case, digital stopwatch and video cameras were used to recording the time.

The time study was conducted with the aid of time study sheet templates in Figure 3.3. Date, station, process, headcount, time, average time, and unit per hour (UPH) were included in the time study sheet. Each line had its own sheet of time study and every possibility of improvement or causes which can be seen during the process was written in the note section.

TIME STUDY PRODUCTION LINE:											
		DATE :		TIME , s							
No	STATION	PROCESS	Head Count	1	2	3	4	5	AVERAGE	UPH	*Note*
1											
2											
3											
4											
5											
5											
6											
7											
8											
9											
10											
11											

Figure 3.3 Example of Time Study Sheet Template

3.4 Step 3: Set Target Condition

From observation from previous steps, it helps to determine the target condition for this project. A target condition describes a desired future state and has a specified achieve by date. The target condition is a forward-looking new goal rather than a backward reflection of problems. It is about moving toward new achievement.

3.5 Step 4: Root Cause and Gap Analysis

The data collected in time study was analyzed to determine the bottleneck of the production line. The bottleneck in this project is defined as the cycle time that exceeds the takt time in the production line. In this step, there were three tools that were used which is histogram chart, fishbone diagram and effort, and impact diagram.

First, the histogram chart was used to represent the data collected. Basically, the histogram is used to summarize discretely or continues data and it provides a visual interpretation of numerical data. The height of each bar in the graph represents the mean of the cycle time of every substation. From the visualization of the data by using the histogram chart, it helps to easily determine the bottleneck process in the production line by looking at which bar in the graph exceed the takt time.

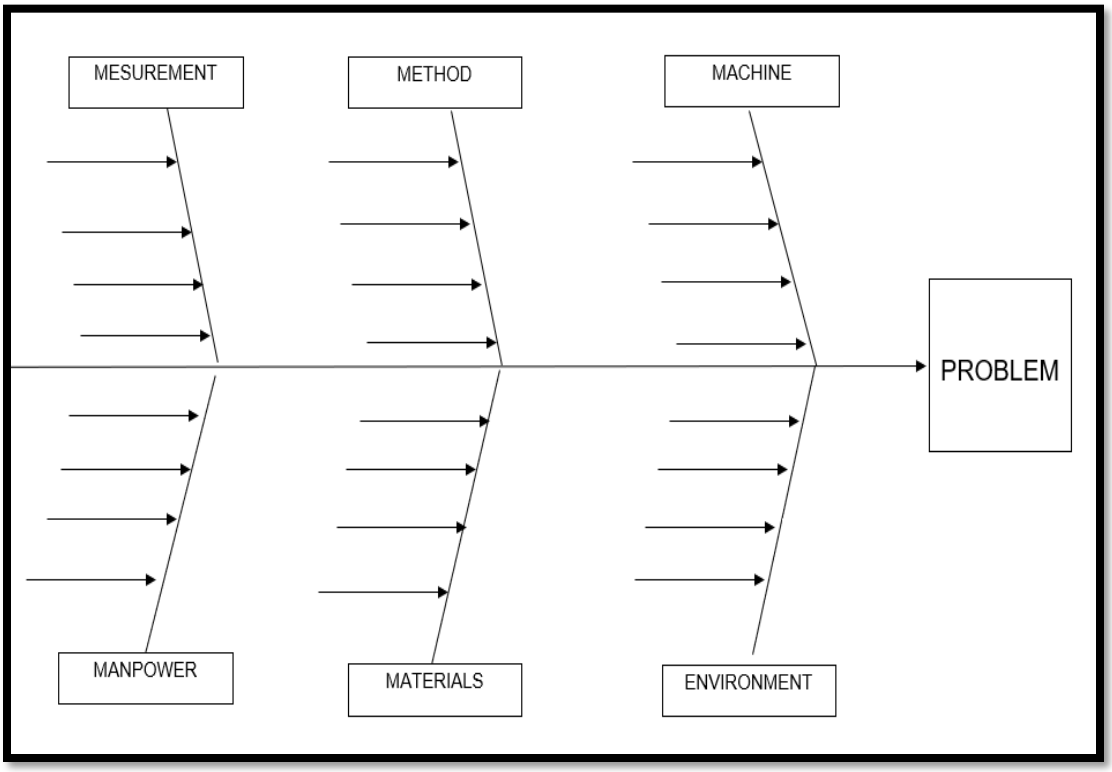

Figure 3.4 Example of Fishbone Diagram

After that, root cause and gap analysis were analyzed by using the fishbone diagram in Figure 3.4. The fishbone diagram also called a cause and effect diagram or Ishikawa diagram. It is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes. A fishbone diagram is useful in brainstorming sessions to focus the conversation on the problems. The head is representing the problem statement or issue to be studied in this project. There are six major categories of causes of the problem which are the measurement, manpower, materials, environment, method, and machine. Each of the major causes needs to be breaking down until the root causes have been identified.

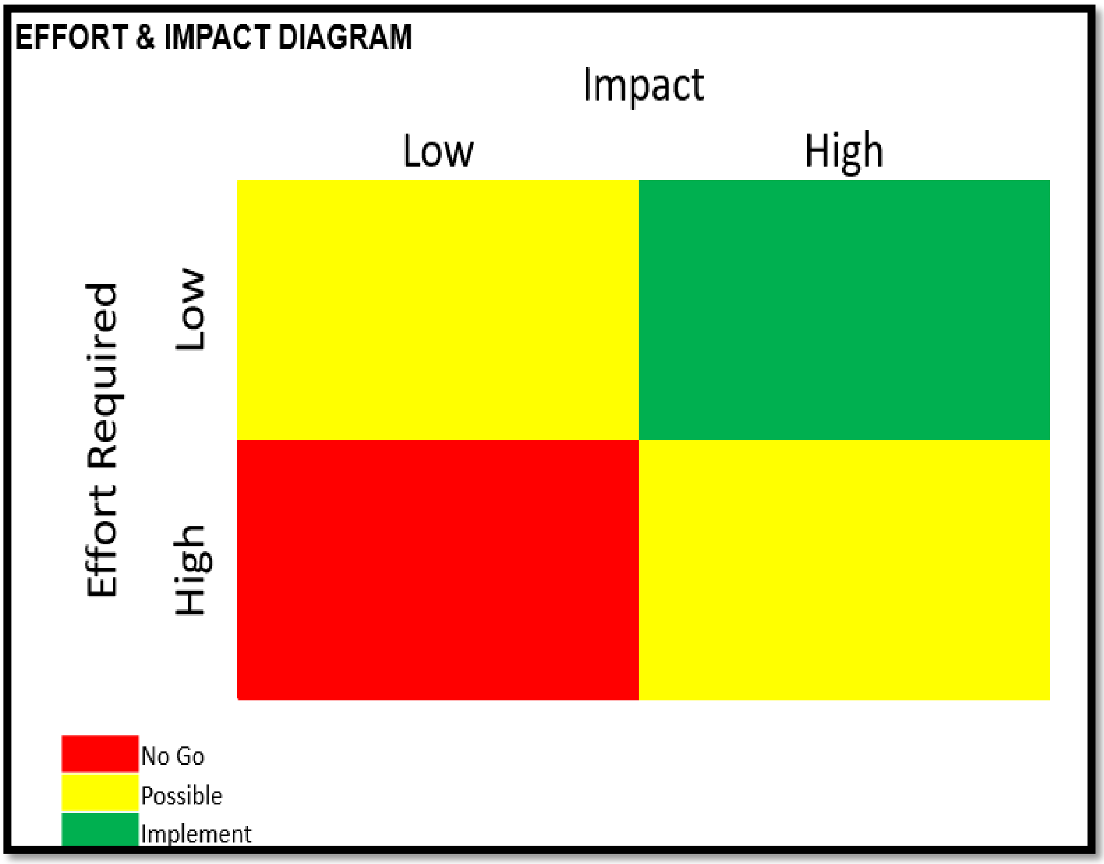

Figure 3.5 Example of Effort and Impact Diagram

Next, analysis using effort and impact diagram in Figure 3.5 was used to identify which root cause from the fishbone diagram should be considered. The effort and impact diagram is a tool that helps to decide which root causes should be pursued in order to implement the countermeasure. It also helps to determine which root causes are the easiest to create a solution with limited time and resources. Basically, the impact is relating to the benefits of the outcome and effort is what needs to be done to get the outcomes. In the effort and impact diagram, the root causes that have a higher impact and low effort required to make the improvement will be selected. This allows the team to focus on generating the ideas for the countermeasure on a specific root cause that will give the biggest impact with the least amount of effort.

3.6 Step 5: Identify Potential Countermeasures

There is always more than one way to solve a problem, Step 5 is where the potential countermeasures are identified. In this step, a meeting with the team member was conducted. The team member including engineers, technicians, and supervisors. The meeting was aimed to identify the potential countermeasures for the root causes of the problem causing the bottleneck. The potential countermeasures that were brainstormed were based on the effort and impact diagram from the previous step. There may be multiple root causes for the problem, however understanding the root cause of the problem is important because once understand the root cause, the solutions for it are obvious although the solution might not be easy to implement. Hence, brainstorming among team members helps to identify the potential countermeasures to overcome the problem.

3.7 Step 6 – 8: Develop, Test, Refine, Finalize and Implement Countermeasures

Based on the findings from the data analysis and brainstorming all the probability of the root cause of the problem, the countermeasures were developed. The countermeasures that had been tested will be refined and finalize before implementing it at the production line. The countermeasures that had been refined and finalize were implemented at the production line and will be monitored to see the effect of the implementation for the improvement at the production line.

3.8 Step 9: Measure Process Performance

After the implementation of countermeasures, the process performance was monitored, and data were collected to ensure there were consistency and stability in the process. All the data were recorded by using the same tool in Step 2 which is a time study sheet template as shown in Figure 1.3. The box and whisker plot was used to visualize the data that had been collected. The data will be compared to the baseline data to determine whether the improvement is achieved and whether the measures in the aim statement were met. If the results did not show positive results, this process will undergo back to step 5 to observe another potential countermeasure.

3.9 Step 10 – 12: Standardize, Monitor Performance and Share Learning

The countermeasures will be implemented to another production line that produces the same product to ensure the production line is standardized. The monitoring of the process helps to ensure the process is stable with the countermeasure that had been applied. The process performance that had been observed will be evaluated by the higher management in the company. If the countermeasures were approved by the higher management, there will be shared learning in the organization about the implementation of improvement.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Background of Case Study Company

The observed Company is a sound system designer and manufacturer located in Penang, Malaysia. It is an audio and accessories manufacturing company. Most of the product that been produced in this company is manual assembly by the operators. The volume of production varies for different products. The production line chosen for this project is producing the wireless sport earphones. The production line consists of three lines which are Left, Remote and Right. The company has more than 1000 employees and operates 24 hours in two shifts per day

4.2 Phase 1 – Planning

4.2.1 Step 1: Define Current Condition

a. Type of production

The production is manual assembly process. It is discrete production.

b. Value Stream Mapping

The value stream mapping was drawn in Microsoft Excel as shown in Appendices 1.

c. Problem faced in the production

The production suffered from the long cycle time at certain substations that causing them to have low productivity. Fire-fighting was a norm of the product