DETERMINATION STANDARD TIME OF STITCHING LINE PROCESS

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Faculty of Industrial Technology as Partial Requirement for the Degree of Sarjana Teknik Industri
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Universitas Islam Indonesia

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ABSTRACT

Time is the necessary element in the process rate. Whether the motion time or the production rate, this element is taken care in any process in a company. When there is no standard time, any task could be finished out of planned. The time standard is determined to know the time required the process to be finished. It provides a yardstick for measuring work content and a unit for stating capacity. It is also used in loading and scheduling. In this study when was conducted on March 2014-May 2014, determined the standard time of stitching line process by using micro-motion study method which concerned about motion analysis using Methods-Time Measurement. With the application of Methods-Time Measurement, the motion analysis will be more detail which analyzes any manual operation or method into the basic motions required to perform and assigns to each motion which is determined by the nature of motion and the conditions under which it is made. By adding the percentage of allowance in worker performances, the result of standard time for stitching line process is equal to 1.6835 minutes with estimate production is 285 pairs per day. Standard time can be used as a tool to determine output capacity in order to estimate production plans and cost.

Keywords: Time and Motion Study, Micro-motion Study, Standard Time.

This Thesis is dedicated to my parent.

Dra. Ariati Yudi Martini

dr. Bambang Setiawan Soemitro (alm.)

For their endless love, support and encouragement.

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In this report contains a general overview of the footwear company and specific assignment under the title "Determination Standard Time of Stitching Line Process". Finally, the author hopes that this paper will be useful not only for the author but also for the readers.

Thailand, September 2014

The Author

Contents

Title Page i
Abstract ii
Preface iv
Contents vii
List of Tables viii
List of Figures ix
Chapter I Introduction 1
1.1 Background 1
1.2 Problem Formulation 5
1.3 Objectives of Study 5
1.4 Purpose and Benefit 5
1.5 Scope of Study 5
Chapter II Literature Review 7
2.1 Previous Research 7
2.2 Work Study 8
2.3 Time Study 10
2.4 Indirect Measurement 11
2.5 Motion Economy 11
2.6.1 Micro-motion Study 14
2.6.2 Memo-motion Study 15
2.6.3 Therblig's Motion 15
2.6.4 Left and Right Hand Chart 19
2.7 Flow Process Chart 20
2.8 Operation Analysis 22
2.8.1 Standard Time 24
2.8.2 Allowance Factor 25
2.8.3 Determination of Standard Time using Time Data Movement (Predetermined Time System) by using Methods Time Measurement (MTM) 26
2.8.4 Methods Time Measurement (MTM) Basic Motions 26
2.8.5 MTM-1 Motion Elements 27
2.8.6 Measuring Output Capacity 32
2.9 Motion and Time Study 33
2.9.1 Initial Preparation of Motion and Time Study 33
2.9.2 Element Breakdown 34
2.9.3 Observation and Measurement 34

2.10 Relationship of Motion and Time Study 35
Chapter III Research Methodology 36
3.1 Obeservation Flowchart 36
3.2 Project Methodology 37
3.3.1 Object of Research 37
3.3.2 Types and Resources of Data Used 37
3.3.3 Population and Project Sample 38
3.3.4 Product Structure and Bill of Materials 39
3.3.5 Production Process 41
3.3.6 Analysis Method and Application of Micro-motion Study 48
Chapter IV Experiment Result and Analysis 50
4.1 Stitching Line Analysis 50
4.1.1 Stitching Line Layout 50
4.1.2 Stitching Line Production Process 51
4.2.1 Workstation Analysis 53
Chapter V Conclusion & Recommendation 97
5.1 Conclusion 97
5.2 Recommendation 98
5.3 Extended Study 98
References 99
Appendix I 102
Appendix II 107

List of Tables

Table 2.1 Process Chart Symbols 21
Table 2.2 Work Factor Motion 23
Table 3.1 Bill Of Materials of Sandals 40
Table 4.1 Parts Name and Distance in the Workstation 1 Description 54
Table 4.2 Left and Right Hand Chart in Workstation 1 55
Table 4.3 Parts Name and Distance in the Workstation 2 Description 58
Table 4.4 Left and Right Hand Chart in Workstation 2 58
Table 4.5 Parts Name and Distance in the Workstation 3 Description 61
Table 4.6 Left and Right Hand Chart in Workstation 3 61
Table 4.7 Parts Name and Distance in the Workstation 4 64
Table 4.8 Left and Right Hand Chart in Workstation 4 64

Table 4.9 Parts Name and Distance in the Workstation 5 Description 66
Table 4.10 Left and Right Hand Chart in Workstation 5 66
Table 4.11 Parts Name and Distance in the Workstation 6 Description 68
Table 4.12 Left and Right Hand Chart in Workstation 6 69
Table 4.13 Parts Name and Distance in the Workstation 7 Description 71
Table 4.14 Left and Right Hand Chart in Workstation 7 71
Table 4.15 Parts Name and Distance in the Workstation 8 Description 74
Table 4.16 Left and Right Hand Chart in Workstation 8 74
Table 4.17 Parts Name and Distance in the Workstation 9 Description 76
Table 4.18 Left and Right Hand Chart in Workstation 9 76
Table 4.19 Parts Name and Distance in the Workstation 10 Description 78
Table 4.20 Left and Right Hand Chart in Workstation 10 79
Table 4.21 Parts Name and Distance in the Workstation 11 Description 80
Table 4.22 Left and Right Hand Chart in Workstation 11 81
Table 4.23 Parts Name and Distance in the Workstation 12 Description 83
Table 4.24 Left and Right Hand Chart in Workstation 12 84
Table 4.25 Parts Name and Distance in the Workstation 13 Description 86
Table 4.26 Left and Right Hand Chart in Workstation 13 86
Table 4.27 Parts Name and Distance in the Workstation 14 Description 89
Table 4.28 Left and Right Hand Chart in Workstation 14 89
Table 4.29 Parts Name and Distance in the Workstation 15 Description 91
Table 4.30 Left and Right Hand Chart in Workstation 15 92
Table 4.31 Flow Process Chart Spreadsheet 93
Table 4.32 Production Data of GM31052 Style 95
Table 5.1 Standard Operation Procedure and Standard Time 97

List of Figures

Figure 1.1 Total production Based on Category of Sandals 2
Figure 1.2 In-house Production for Each Style for PU Category (Top 10) 3
Figure 1.3 Gambol Sandals Style GM31052 3
Figure 2.1 Components of Work Study 9
Figure 3.1 Observation Flowchart 42
Figure 3.2 Observation Flowchart (cont'd) 43
Figure 3.3 Product Structure of Sandals 45
Figure 3.4 Cutting, Lining and Screening Process Flowchart 46

Figure 3.5 Stitching Process Flowchart 49
Figure 3.6 Buffing Process Flowchart 51
Figure 3.7 Packaging Process Flowchart 53
Figure 4.1 Stitching Process Layout 56
Figure 4.2 Presedence Diagram 57
Figure 4.3 Screen-captured workstation 1 62
Figure 4.4 Layout of Workstation 1 63
Figure 4.5 Screen-captured workstation 2 66
Figure 4.6 Layout of Workstation 2 67
Figure 4.7 Screen-captured workstation 3 69
Figure 4.8 Layout of Workstation 3 70
Figure 4.9 Screen-captured workstation 4 71
Figure 4.10 Layout of Workstation 4 72
Figure 4.11 Screen-captured workstation 5 74
Figure 4.12 Layout of Workstation 5 75
Figure 4.13 Screen-captured workstation 6 76
Figure 4.14 Layout of Workstation 6 77
Figure 4.15 Screen-captured workstation 7 79
Figure 4.16 Layout of Workstation 7 80
Figure 4.17 Screen-captured workstation 8 81
Figure 4.18 Layout of Workstation 8 82
Figure 4.19 Screen-captured workstation 9 84
Figure 4.20 Layout of Workstation 9 85
Figure 4.21 Screen-captured workstation 10 86
Figure 4.22 Layout of Workstation 10 87
Figure 4.23 Screen-captured workstation 11 89
Figure 4.24 Layout of Workstation 11 89
Figure 4.25 Screen-captured workstation 12 91
Figure 4.26 Layout of Workstation 12 92
Figure 4.27 Screen-captured workstation 13 94
Figure 4.28 Layout of Workstation 13 95
Figure 4.29 Screen-captured workstation 14 96
Figure 4.30 Layout of Workstation 14 97
Figure 4.31 Screen-captured workstation 15 99
Figure 4.32 Layout of Workstation 15 100

Chapter I

Introduction

1.1 Background

In the production process, humans serve as a planners, implementers, controllers and evaluators of a production process. Thus, to be able to produce a good product it is necessary to recognize the properties, limitations and all of the human beings abilities. Moreover, to produce a good product a company should create some performance improvement from time to time. The improvement itself is increasing the process which provides a continuously added value.

To build a process improvement is by doing planning and controlling of production process. The production process is important to be controlled because the production process performance is where the improvement comes from. By conducting a production control, the company will achieve company's goal which is to produce a good product. Production control is measuring all of the activity in the production process.

In order to determine the performance of a company is by using a measurement tools that shows the level of company's performance. The successful of the product or service would be known through the motion and time study by work sampling. By using motion and time study method, could understand the productivity time and motion authority that used compared by the result that company has achieved. It shows that time is the necessary thing in determining performance and develop the operation level of the company.

In the footwear company which produce a sandals product in mass production according to various categories and styles and serve a job order in the number of parties by always fulfill the order in time. This is conducted to give a satisfaction to the customer and to keep the customer loyalty.

In the footwear production process of Footwear Company is using manpower which means that the process is done manually assisted by semi-automatic machine so that the production process run smoothly as a plan. The products are devided into 14 categories and each category have more than 100 styles. Canvas Local leader footwear manufacturer and exporter of EVA ,Phylon, Air Blow ,PU sandals and slippers. Footwear company well-known brands are GAMBOL and KITO.

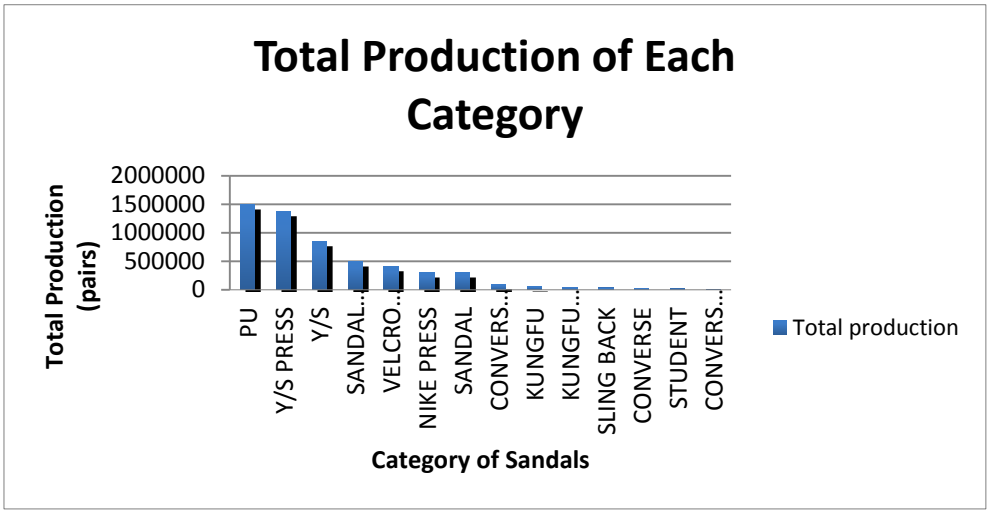


Figure 1.1 Total Production Based on Category of Sandals

Figure 1.1 shows that the highest total production at the footwear company is sandals PU category which the company can produce more than 1,400,000 pairs with more than 100 styles for one year production.

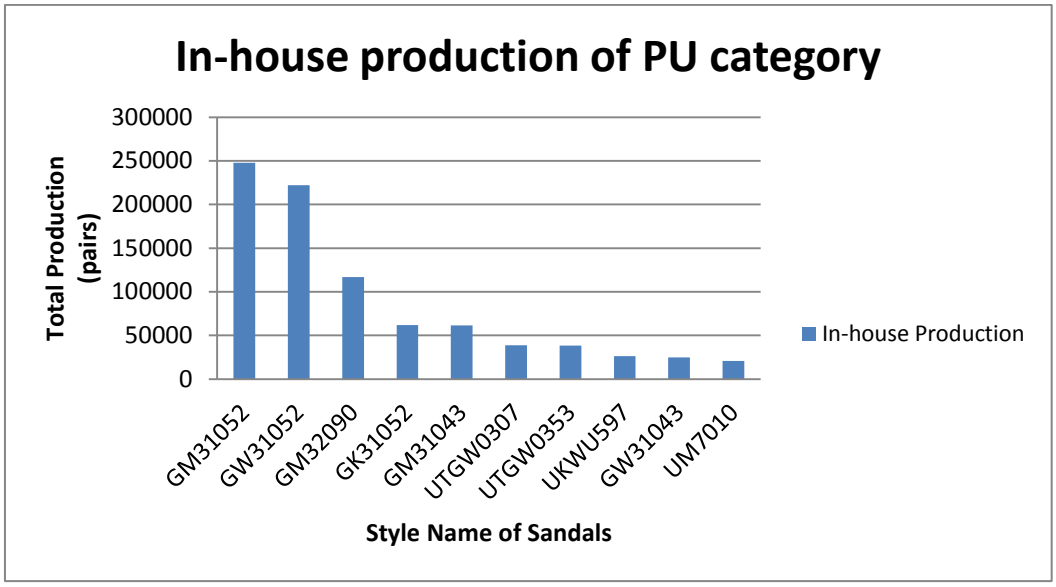


Figure 1.2 In-house Production for Each Style for PU Category (Top 10)

Figure 1.2 shows that the highest in-house production of PU category is sandals Gambol style GM31052 see as Figure 1.3, with in-house production more than 200,000 pairs a year.



Figure 1.3 Gambol Sandals Style GM31052

This project focuses on the production of Gambol sandals style GM31052 as the highest production at this company. As focusing on the highest production, will represent average of all of the production productivity. Because the highest production will have the highest material required, the highest processing time required and the highest inventory.

Time and motion study is the important aspect in business to determine the production rate, the factors which affect the production rate comprised to raw material, operation cost, work force and others [1]. Time is the necessary element in this rate. Whether the motion time or the production rate, this element is taken care in any process in a company. In this study, the footwear company is takes extra time in producing their products by makes an overtime work. The work content of a product is expressed as the time required to make the product using a given method of manufacture. Using time-study techniques, the standard time for a job can be determined—that is, the time it would take a qualified operator working at a normal pace to do the job. It provides a yardstick for measuring work content and a unit for stating capacity. It is also used in loading and scheduling [2]. Unfortunately, the production department does not have any fixed or standard time for each process. The company merely estimates the time for each process and frequently occur the longer time than the time estimated. Thus, might be difficult for the company to increase productivity and competes with the competitor.

When there is no standard time, any task could be finished out of planned. In this study concerned about motion analysis using Methods-Time Measurement. With the motion analysis, the time standard is determined to know the time required the process to be finished and the total output. With the application of Methods-Time Measurement, the motion analysis will be more detail which analyzes any manual operation or method into the basic motions required to perform and assigns to each motion which is determined by the nature of motion and the conditions under which it is made. [3].

1.2 Problem Formulation

Based on the background of the problem, the problem can be formulated:

"How is the standard time required to a worker to complete the process?"

1.3 Objectives of Study

The objectives towards accomplishing the study are:

(i) To determine the standard time of stitching line process by using micro-motion study method.

(ii) To identify the motion elements in the work process in order to give the detail about each activity process.

1.4 Purpose and Benefit

The purpose and benefits from this study are:

(i) Understand various aspects of the company's activities.

(ii) Obtain standard time for each work station.

(iii) As an input for the owner of the company in order to promote development in education and for an improvement.

1.5 Scope of Study

The scopes of this research are:

(i) Collecting data only in one workstation and one type of sandals, which is stitching line station 1 for GM31052 type.

The stitching station line 1 selected because the stitching process has a lot of steps that should be done. Thus, make the stitching process complicated and complex. The company give a recommendation to work on the stitching station because the first thing that should be determined is the total output production for a pairs of sandals that can be obtained from the

stitching station. Thus, the stitching station represent the whole production system.

(ii) Using Methods Time Measurement (MTM) Basic Motions to identify motion elements in the activities.

(iii) Using left and right hand chart analysis to analyze the motion in each activities of worker and determine the total time measurement unit.

(iv) The allowance factor for personal time is regarding to the company policy.

Chapter II

Literature Review

2.1 Previous Research

There are some previous researches related to motion and time study, such as:

1. Umi Tri Widiawati (2009)

   The tittle of the research is Deskripsi Time And Motion Study Untuk Mengetahui Waktu Baku di Produksi Sambal PT. Heinz ABC Indonesia Karawang. The framework of this research is the measurement of a time and motion study of packing pet bottle job label alpha conveyor 10 which the work steps are includes arrange the cardboard and pack the pet bottles into cartons and then understand the standard time for each work steps. From the measurement obtained the number of standard time = 0.026 minutes. This standard time is includes the work steps of arrange the cardboard and pack the pet bottles into cartons [4].

2. Thia Tastanny (2011)

   The research titled "Analisis Studi Gerakan dan Waktu pada Proses Produksi Minuman Lidah Buaya di UMKM (Studi kasus: PT. Driyama Purwana, Bogor)" showed that the workers movement in the production process of Aloe Vera drinks product in PT. Driyama Purwana consists of seven Therblig movements comprised to hold, position, transport empty, transport loaded, release, use and inspect. The standard time of the production process is equal to 111.62 seconds/cup or 1 minute 51 seconds/cup. The elimination of ineffective movement: (1) Put the sealer cup on the table, (2) Move the drink cup into the

pasteurization pot and (3) Reduce the immersion washing time. If eliminates those movement, then the result will savings of 10.84 seconds/cup of time which can save 180 cup in a single production process of Aloe Vera drinks [5].

3. Tulus Puji Ruswanto (2012)

   The research is conducted in the random re-inspect working conditions before improvement and after improvement. The tittle of this research is "Analisa Perbaikan Metode Kerja serta Penetapan Waktu Baku Kerja Hasil Perbaikan dengan Time Study untuk Pemeriksaan Ulang Acak Ban Radial pada PT. XYZ Tbk". Methodology of the study was conducted using motion study to analyze the process flow chart type, chart of right and left hand, analysis of Nordic chart, time measurement and anthropometry analysis of the workers. The improvement is conducted by changing methods of work, changing the work place, complete the random work re-inspection by examining the design of table and adjusting the body anthropometric and determination of standard time [6].

2.2 Work Study

Work study is the systematic examination of the methods of carrying out activities such as to improve the effective use of resource and to set up standards of performance for the activities.

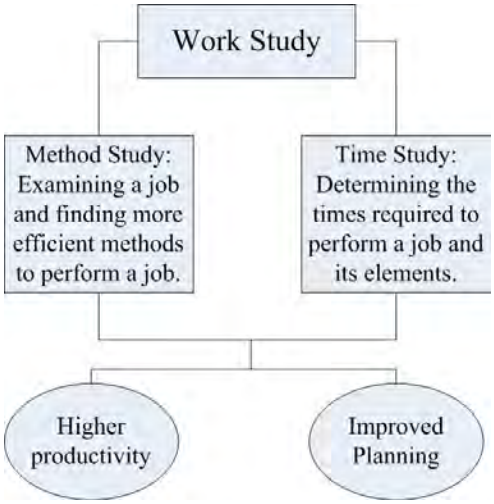


Figure 2.1 Components of Work Study

Work study contains method study and work measurement technique which are used in the examination of human work in all contexts and which lead systematically to the investigation of all factors which affect the efficiency and economy of the situation in order to effect improvement. This has to do with productivity improvement, also improvement of quality and safety.

Method study and work measurement are two principal activities of work study which originated in the work of F. W. Taylor (see Rose: 1978). FW's "scientific management" imperatives are:

Investigate the work situation and identify weaknesses - where and why is poor performance happening. The "scientific" title for this approach to management means placing emphasis on:

- Data collecting and rational analysis.
- Certain narrow assumptions about the objectivity of efficiency criteria.
- The existence of direct, deterministic relationships between worker performance and incentive payments.

- Consideration of the worker to some extent as a machine. Thus we can evaluate and introduce improvements in operating methods. This includes type of equipment, its use, layout of operations, supply and use of materials, materials handling, work organization, effectiveness of planning procedures and so on [7].

2.3 Time Study

The main aspects of time study are consisting of a diversity procedure to determine the length of time required by using the specified time measurement, for any activity that which involves human, machine or combination of activity [8].

In time study there are two types of measurement:

1. Direct Measurement

   The measurement is conducted directly by observing the operator and recorded the time required in performing their job by dividing the work as detail elements and able to be observed and measured. In direct measurement usually using:

   - Stop watch time study.
   - Work sampling.

2. Indirect Measurement

   The measurement is conducted by calculating the time which the observers were not measured in the workstation. Directly measure using historical data, such as:

   - Standard time data.
   - Motion time data [9].

2.4 Indirect Measurement

Indirect measurement is calculating the working time without using of stopwatch and does not required a direct observe in the site. This measurement performs by conducting a calculation of working time by understanding the work activities through the work elements or motion elements and reading the time table provided. This method can be performed in the activities of standard time and predetermined time system.

2.5 Motion Economy

The principles of motion economy are guidelines that can be used to help determine the work method, workplace layout, tools and equipment that will maximize the efficiency and minimize the fatigue of worker. The principles of motion economy can be organized into three categories:

1. Principles related to the use of the human body.

   The principles of motion economy that are related to the use of the human body can be used to design the most appropriate methods and motions of the human worker in performing a given task. They are the most applicable to manual work, either repetitive or non-repetitive.

   a. Both hands should be fully utilized.
   b. The two hands should begin and end their motions at the same time.
   c. The motions of the hands and arms should be symmetrical and simultaneous.
   d. The work should be designed to emphasize the worker's preferred hand.
   e. The worker's to hands should never be idle at the same time.
   f. The method should consist of smooth continuous curved motions rather than straight-line motions with abrupt changes in direction.

g. Momentum should be used to facilitate the task wherever possible.

h. The method should take advantage of gravity instead of opposing it.

i. The method should achieve a natural rhythm of the motions involved.

j. The lowest classification of hand and arm motions should be used.

k. Minimize eye focus and eye travel activities.

l. The method should be designed to utilize the worker's feet and legs when appropriate.

2. Principles related to workplace arrangement.

The principles of motion economy in this section are directed at the design of the workplace includes the layout of the workstation and the arrangement of tools and parts in it. The first three principles deal with the immediate work area and contribute to a natural rhythm in the work cycle. The other principles cover the use of gravity and the general conditions of the workplace.

a. Tools and materials should be located in fixed positions within the work area.

b. Tools and materials should be located close to where they are used.

c. Tools and materials should be placed in locations that are consistent with the sequence of work elements in the work cycle.

d. Gravity feed bins should be used to deliver small parts and fasteners.

e. Gravity drop chutes should be used for completed work units where appropriate.

f. Adequate illumination must be provided for the workplace.

g. A proper chair should be provided for the worker.

3. Principles related to the design of tooling and equipment.

   The principles of motion economy in this section are helpful for designing special tools and controls on equipment used in the workplace.

   a. Workholding devices should be designed for the task; a worker's hand should not be used as a workholder.
   b. The hands should be relieved of work elements that can be performed by feet.
   c. Multiple tooling functions should be combined into one tool whenever possible.
   d. Multiple operations should be performed simultaneously rather than sequentially.
   e. Where feasible, an operations should be performed on multiple parts simultaneously.
   f. Equipment controls should be designed for operator convenience and error avoidance.
   g. Hand tools and portable powered tools should be designed for operator comfort and convenience.
   h. Manual operations should be mechanized or automated wherever economically and technology feasible [10].

1.6 Motion Study

Motion study is to eliminate unwanted waste known as work simplification by analyzing the motion used by the workers and possessed for analyzing work motion situations to enhance ability for shorter or less fatiguing motions to improve the work environment [11].

Motion study is usually conducted manually, which is for the type of work that proceeds using a motion hands. The main objective of this study is to eliminate or reduce unnecessary motions. The aspects of motion study consists of a description, analysis and systematic development of working methods in determining the raw material, design output, process, tools, workplace and equipment for each step in the process. The purpose of motion study method is to determine and design the appropriate method to complete an activity process.

Motion study generally classified into 2 kinds of study, the Visual Motion Study and Micro-motion Study often applied as these studies are more economical. It is merely conduct a visual observation to the on-going work process and then create an Operator Process Chart (OPC) by applying Therblig's symbols. The next step is conduct an analysis to the work motion refers to the principles of motion economy.

In the implementation of Micro-motion Study will require a higher cost, commonly used for a repetitive and fast work. The analysis would be more detail because in the observation required a specific equipment to record the work motions.

2.6.1 Micro-motion Study

Micro-motion analysis is a detailed recording of the motions involved in performing a job. The activities of the hands (and other body members as may be desirable) are usually recorded in terms of 17 separate categories. These categories are called Therblig's. These 17 Therblig's are common to all human activity and provide a most convenient set of categories for the classification of all physical acts and for use as a framework for the classification of basic ways of improving these acts.

2.6.2 Memo-motion Study

Memo-motion study was first developed by Marvin Mundel. On the principles, there are no different from micro-motion study but in memo-motion study used slow speed of film approximately 60-100 fpm, which among other things conserved the use of expensive film. The same effects are obtained by making the analysis at discrete steps on the video recorded or by viewing the video recorded at high transport speeds. It is merely another means of performing the second step of the scientific method-analysis-and requires three phases: recording, analysis and graphic presentation.

2.6.3 Therblig's Motion

In the whole work process can be decomposed into a basic movement, which is decomposed by Gilberth into 17 Therblig's motions. The process has a different decomposition compared to the other process. It is depends on the work types. The Therblig motions comprised to:

1. Grasp

   Begins when hand or body member touches an object. Consists of gaining control of an object. Ends when control is gained.

2. Position

   Begins when hand or body member causes part to begin to line up or locate. Consists of hand or body member causing part to lineup, orient, or change position. Ends when body member has part lined up.

3. Pre-position

   Same as position except used when lineup is previous to use of part or tool in another places.

4. Use

   Begins when hand or body member actually begins to manipulate tool or control. Consists of applying tool or manipulating control. Ends when hand or body member ceases manipulating tool or control.

5. Assemble

   Begins when the hand or body member causes parts to begin to go together. Consists of actual assembly of parts. Ends when hand or body member has caused parts to go together.

6. Disassemble

   Begins when hand or body member causes parts that were integral to begin to separate . Consists of taking objects apart. Ends when hand or body member has caused complete separation of the parts.

7. Release load

   Begins when hand or body member begins to relax control of object. Consists of letting go of an object. Ends when hand or body member has lost contact with object.

8. Transport Empty

   Begins when hand or body member begins to move without load. Consists of reaching something. Ends when hand or body member touches part of stops moving.

9. Transport Loaded

   Begins when hand or body hand or body member begins to move with an object. Consists of hand or body member changing location of an object. Ends when hand or body member carrying object arrives at general destination or movement cases.

10. Search

    Begins when hand or body member gropes or hunts for part. Consists of attempting to find an object. Ends when hand or body member has found location of object.

11. Select

    Begins when hand or body member touches several objects. Consists of locating an individual object from a group. Ends when the hand or body member has located an individual object.

12. Hold

    Begins when movement of part of object, which hand or body member has under control, ceases. Consists of holding an object in a fixed position and location. Ends with any movement.

13. Unavoidable delay

    Begins when hand or body member is idle. Consists of a delay for other body member or machine when delay is part of method. Ends when the hand or body member begins any work.

14. Avoidable delay

    Begins when hand or body member deviates from standard method. Consists of some movement or idleness not part of method. Ends when hand or body member returns to standard routine.

15. Rest to overcome fatigue

    Begins when hand or body member is idle. Consists of idleness which is part of cycle and necessary to overcome fatigue from previous work. Ends when hand or body member is able to work again.

16. Plan

    Begins when hand or body members are idle or making random movements while worker decides on course an action. Consists of determining a course of action. Ends when course of action is determined.

17. Inspect

    Begins when hand or body member begins to feel or view an object. Consists of determining a quality of an object. Ends when hand or body member has felt or seen [12].

According to Mr. Shiego Shingo a famous "method engineering" consultant, the 17 of Therblig elements, can be classified as follows [13]:

Effective Therblig	**Ineffective Therblig**
Physical Basic Divisions	Mental or semi-mental basic divisions
a. Reach	a. Search
b. Move	b. Select
c. Release	c. Position
d. Grasp	d. Inspect
e. Pre-position	e. Plan
Objective Basic Divisions	Delay
a. Use	a. Unavoidable delay
b. Assemble	b. Avoidable delay
c. Disassemble	c. Rest for overcoming fatigue
	d. Hold

2.6.4 Left and Right Hand Chart

Is an analysis chart to analyze the human hands movements in conducting the processes manually. This chart describes all of the motion or delays that occur and conduct by the left and right hand in detail refers to the Therblig's motion. By a detail motion analysis, hence the way of improvement could be suggested. The chart will be useful for repetitive motion and conducted manually. From the analysis, the pattern of hands motion for left and right hand which considered inefficient and contrary from the principles of motion economy could be suggested to be improved. Also expect that the movements of left and right hand are balance, so that the wok cycle will be run smoothly in the better motion rhythm and in the end could reduce delays or create a minimum operator fatigue.

Although Franks and Lilian Gilberth have been states that the human work motions conducted by referring to 17 Therblig's basic motion elements or the combination of Therblig's elements, but in creating this chart will be more effective to use merely 8 Therblig's motion elements, there are:

18. Reach (RE)
19. Grasp (G)
20. Move (M)
21. Position (P)
22. Use (U)
23. Release (RL)
24. Delay (D)
25. Hold (H)

2.7 Flow Process Chart

Process chart is a systematic and logical communication tools in order to analyze the work process from begin to the end of the process. According to Sutalaksana (2006), process chart is a tool that describes the work process in a systematic and explicit way.

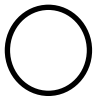
Process chart is a tool to analyze an operation work in order to simplify the existing work processes. If conduct a carefully study towards process chart, then the effort to improve the working methods of the production process will be more easily implemented. The improvements that may be done include:

a. Eliminate inefficient handling process.
b. Reduce the work operations movement distance from one operation to another.
c. Reduce unproductive times such as waiting time (delay).
d. Arrange the work operations according to the work steps which more effective and efficient.
e. Combine work operations by other work operations if possible.
f. Determine the more effective work operations in order to simplify the implementation.
g. Determine the machine or production facilities which able to work more productive.
h. Indicates the excessive inspection activities.

Through the process chart could be determine the process steps by the product, also describes the whole steps that occur such as transportation, work operations, inspection, delay, and storage until being a finished goods product.

American Society of Mechanical Engineers have been define five basic symbol. This symbols are modified by shorten the Gilberth symbols. The five symbols that used are:

Table 2.1 Process Chart Symbols

 Operation	Operation occurs when the object changed from its basic characteristic.
 Transportation	Transportation occurs when the work piece, the workers or the equipment are displacement which are not a part of operation.
 Inspection	Inspection occurs when the object is being inspect, either inspect for the quality or quantity.
 Delay	Delay occurs when the work piece, the workers or the equipment does not run into any activities.
 Storage	Storage occurs when the objects are being stored for long periods of time.

Basically, work charts are divided into two major groups based on the activities. There are:

1. Work charts used to analyze the activities of the whole work.
2. Work charts used to analyze the local work activities.

An activity called as a whole work activity if the activity involves most or all of the facilities required to process a product. A work activity called a local work activity if the activity occurs in a work station. The relationship between those kinds of activity is to complete a product required several work stations, where related to each other. In this case, the smoothness of whole production process will be depends on the smoothness on each work station.

The various kinds of chart are generally used to analyze whole work process, such as operation process chart, multi product process chart, flow process chart, flow diagram or string diagram, man and machine process chart, left and right hand process chart or operator process chart.

2.8 Operation Analysis

Operation analysis is a procedure for analyzing a work operation either related to productive work elements or without an improvement objective in order to improve the work methods. This activity conducted in order to increase a product output per unit of time and reduce cost. The difference between work factor system measurement method, basic motion and micro-motion time measurement (MTM) are as follows:

a. Work Factor System

   Work factor system is one system of predetermined Time System is the most initial and widely applied. This system is allows to determine time for a

manual jobs by using motion time that have been determined before. The first steps conducted is create a detail analysis about the work steps based on 4 variables which are the main basis of the work implementation, such as: body limb, work movements, manual control and weight or constraints. And using work factor data as a measurement unit. The next step is determined the standard time.

In Work Factor System, a job is divided based on the basic work movements such as: Transport or reach & Move (TRP), Grasp(GR), Pre-Position(PP), Assemble (ASY), Use (manual, process or machine time)-(US), Disassemble (DSY), Mental Process (MP) and Release (RL). And the symbols that used and the standardize work factors are as follows:

Table 2.2 Work Factor Motion

Body Limb	Symbol	Work Factors (wrote Ascendingly)	Symbol
Finger	F	Weight of Resistance	W
Hand	H	Directional Control	S
Arm	A	Steer	S
Forearm	FS	Care (Precaution)	P
Trunk	T	Change Direction	U
Foot	FT	Define Stop	D
Leg	L		
Head Turn	HT		

The symbols above used to record and evaluate the motions. The body limb used, will be indicate first, then indicate the distance and the work factors will be determine the motions.

b. Basic Motion

Basic motion was developed in 1949-1953 by Gerald B. Bailey and Ralph Presvage. The data in Basic Motion is a revision form MTM and add some predetermined system pattern. This is aims to simplify application and the standard time calculation deviation is relatively small and the approach is more feasible.

c. Methods-Time Measurement

In analyzing the work movement often encountered difficulties in determining the scope of elements from the Therblig motions because the working time is short. To simplify this difficulty, using a recorder to record the worker movements (video recorder). The micro-motion study activity requires recording every work movements in detail and gives the possibilities of movement analysis in detail and better way [14].

2.8.1 Standard Time

Standard time is the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method [15]. Definition of standard time is calculate time required for assemble a product by paying an attention to the workers motion elements. Cycle time is a time required to assemble a product which the time calculation taken from a raw data that obtained from the observation. The equation of standard time:

$$T_{std} = T_n \left(1 + A_{pfd}\right)$$

Where:

T_n = normal time

A_{pfd} = allowance factor for personal time, fatigue and delays

2.8.2 Allowance Factor

Allowance factor is given regarding to the number of needs from the workers that occur during the work hour such as personal needs, workers' barriers that can not be eliminated and the need to unwind.

A worker needs an allowance time which are classified into 3 kinds [16]:

1. Allowance time for personal needs (Personal Allowance).

   Included in the personal allowances are things like dringking to just relieve thrist, eliminates stress and surfeit during work. For jobs that are relatively easy in which the operator works for 8 hours per day without an exact break time, will have 2%-% (or 10 minutes – 24 minutes) each day for this personal needs. And for difficult jobs and bad working conditions because of high temperature, will needs more time.

   For Man : 2% - 5% (from normal time)

   For Woman : 5% (from normal time)

2. Allowance time to eliminates fatigue (Fatigue Allowance).

   Fatigue occur when there is a decrease number on both quantity and quality of production. If the fatigue occurs and the workers should work to result the normal performance, so the workers will put more effort and this will cause more fatigue.

3. Allowance time for the unavoidable delays (Delay Allowance).

Anavoidable delays include receive or ask the supervisory guidance, machine adjustment, decrease bottleneck, machine inspection, *etc*.

2.8.3 Determination of Standard Time using Time Data Movement (Predetermined Time System) by using Methods Time Measurement (MTM)

Methods Time Measurement (MTM) is an initial application of standard time (predetermined time standard) were developed based on a frame study of work movements from a work operation film. This system is identified as a procedure to analyze each operation or work method (manual operation) to the basic movements required to conduct the job, then determine the standard time of each motion based on the kinds of movements and the current work condition.

Time measurement method is dividing the work movements comprised to reach, move, turn, grasp, position, release, disassemble, eyes movement and other body limb movements. The time for each movement element is determined according to some condition as "classes". These classes can be related to stop condition, object condition to be reached or hold, manual handling difficulties, *etc.*

2.8.4 Methods Time Measurement (MTM) Basic Motions

Methods Time Measurement is a Predetermined Motion Time Systems that can be used to analyze the method for performing a given task and to set a time standard for the task. Methods Time Measurement is a procedure which analyzes any manual operation of method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made. MTM is actually a family of predetermined motion time systems, the original MTM is now called MTM-1. It is the first level of predetermined motion time systems upon which all of the other MTM

systems are based. In recent years, there are some system or method development such as MTM-GPD, MTM-2, MTM-3, MTM-V, MTM-M, MTM-C and 4M DATA.

Time units in MTM are called TMUs (Time Measurement Units). MTM was developed by studying motion pictures of work activity, and the time units for MTM were originally defined as the time per frame of motion picture film. The TMU is defined as follows:

1 TMU = 0.00001 hour = 0.0006 minutes = 0.036 sec.

2.8.5 MTM-1 Motion Elements

MTM-1 is the most accurate method compared to the others MTM methods. MTM-1 method comprised to motion elements such as reach, move, apply pressure, turn, grasp, release, position and disengage motion. Methods Time Measurement using Normal Time Values for motion element which comprised to:

a. Reach

   A basic motion element involving movement of the hand or fingers. Its purpose is to move the hand or finger to a new destination. The corresponding Therblig is “transport empty”. If the hand is holding something during the motion, it is still classified as a reach if its primary purpose is to reposition the hand or fingers and not to move the object. There are 5 Reach classes (Reach-R table) where the time to conduct each reach motion will be affected by an object condition.

   The way of writing Reach motion element is mapped in sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbols				
1	2	3	4	5
m	R	f	case	m

The first and fifth symbols describe the other motions that incorporated and integral with reach motion. And wrote the motion united with the other motions only. The writing should be with the letter ‘m’. When using the uppercase letters such as ‘M’, it will describe the other elements of the basic motions. The second symbol is a symbol that describes reach movements. The third symbol filled with distance moved by hand. The distance should be in units of inches, because the tables are available in units of inches. When the motion distance is less of ¾, then the writing is simply put letter ‘f’. The fourth symbol is describes the cases within the reach motion. Filled the case using letter A, B, C, D or E based on the case that written on the table.

b. Move

A hand or finger motion whose primary purpose is to relocate an object. The corresponding Therblig’s is “transport loaded”. The move element includes pushing or sliding an object across a surface, so long as the hand controls the object.

The way of writing Move motion element is mapped in a sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbols					
1	2	3	4	5	6
m	M	f	case	m	weight

The first and fifth symbols describe another motion that joined and integral with Move motion. And wrote the motion is united with other motions only. The writing should be with letter ‘m’. The second symbol is describes the Move motion. The third symbol filled with distance moved by hand. Distance is written in here should be in units of inches, because the tables are available in units of inches. When the movement is less than ¾ inches, the writing is simply by write the letter ‘f’. The fourth symbol is describes cases of Move motion. Filled with letter A, B or C. the sixth symbol is describes the weight of the objects that apply the movement of Move motion. According to the table, the weight is identified in units of lbs. The weight will be calculated if the weight is exceeds to 2 lbs.

c. Turn

A basic motion element that involves rotation of the hand and wrist about the long axis of the forearm. The hand can either holding an object or empty. The way of writing Turn motion element is mapped in sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbols		
1	2	3
T	degrees of rotation	S/M/L

The first symbol wrote in letter ‘T’ which describes the Turn motion. The second symbol describes the degrees of hand rotation. The third symbol describes the adjustment of the rotation load category.

d. Apply Pressure

An element that involves the application of force, but the force results in little or no movement. The force is usually applied by the hand and/or fingers, but the element applies to a force applied by anybody member. The way of writing Apply Pressure motion is simply by put the symbol that used in the Apply Pressure motion in the frame. If there is more than one symbol used, simply put ‘+’ to sum the TMU number.

e. Grasp

A motion element used by the fingers and hand to gain control of one or more objects. It is commonly employed as a prerequisite motion for performing the next basic motion, which is likely to be to be a move.

The way of writing Grasp motion element is mapped in sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbol	
1	2
G	category

The first symbol describes the Grasp motion using letter ‘G’. The second symbol filled with the grasp motion category. There are 11 grasp categories provided in the table with the description of each category.

f. Release

A hand and finger motion element whose purpose is to surrender control of an object. Usually, if the grasp motion in the G1, G2, G3 or G4 category, then the release motion is RL1. If the grasp motion in the G5 category, then the release motion is RL2. The writing is simply put the symbol either RL1 or RL2.

g. Position

A relatively short hand motion employed to align, orient or engage one object relative to another. It is usually preceded by a move. Accordingly, the position element may occur several times together depending on the number of separate positioning moves required. The way of writing Position motion element is mapped in sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbols			
1	2	3	4
P	1/2/3	S/SS/NS	E/D

The first symbol describes the Position motion using letter ‘P’. The second symbol describes the category of position motion that comprised to:

1 = Loose, means there is no pressure/forced/difficulties.

2 = Close, means there is a light pressure.

3 = Exact, means required a heavy pressure.

The third symbol describes the shape of object. The shape of object that being positioned comprised to:

S = Symmetry

SS = Semi-Symmetry

NS = Non-Symmetry

The meaning of symmetry object is if the object easy and freely to be positioned and inserted. The semi-symmetry object is the object has the limitation of being positioned and inserted. The non-symmetric object is when the object only have one way of positioned and inserted. The fourth symbol describes the convenience level of object handling in the motion.

h. Disengaged

A hand and finger motion that causes the separation of two objects from one another, where the objects were previously held together by some force. Thus, disengagement breaks the force, resulting in a recoil action by the hand. The way of writing disengaged motion element is mapped in sequenced symbols and for each symbol contains a meaning. The way of writing is described as follows:

Symbols		
1	2	3
D	1/2/3	E/D

The first symbol describes Disengaged motion using letter 'D'. The second symbol describes the effort level of disengaged motion. The third symbol describes the difficulties of handling object in the disengaged motion [17].

2.8.6 Measuring Output Capacity

After the standard time don calculated using micro-motion study, it is better to calculate the output capacity into a production standard. The formula can be determined as follows: [18]

$$\frac{working\ time/day}{production\ time/unit}$$

2.9 Motion and Time Study

Motion and time study study is an activity to determine time required by a worker (who have an average skill and trained) in performing an activity in the working conditions and a normal tempo (Adi, 2009). According to Yuliarto (2008), motion and time study can be define as an engineering approach in deciding related methods in designing a desired workstation either by the designer or the company itself.

Motion and time study is a systematic study of the working system with the objective to develop the systems and develop better methods, standardize the systems, train the operators and specify the standard time.

The criteria that should be fulfilled in the measurement time activity and motion study is the activities should be conducted repetitively and uniformly, the contents or types of the works should be homogeneous, the output should be calculate quantitatively in whole process or in each on-going work elements and the work is conducted quite a lot regularly. Thus, the work will be sufficient to measure and calculate the standard time.

To obtain optimal result, hence in conduct measurement and motion study should consider several factors such as work conditions, measurement technique and number of work cycles measured.

2.9.1 Initial Preparation of Motion and Time Study

The initial preparation aims to study the conditions and methods of work then doing improvements and standardize. Standardization of working conditions and the method is known as motion study. In addition to prepare the condition and methods, also required step in deciding which worker will perform the job to be measured. The

selected operator should be has a normal skill. Thus, after obtained the standard time could be followed by the other workers.

The main equipment used in the motion and time study is a stopwatch. In addition to a stopwatch, work measurement support equipment is an observation sheet which serves to record all of the information related to the work measured.

2.9.2 Element Breakdown

Before conducting the motion and time study, it is necessary to dividing the process into more detailed work elements first. Hence, there are three rules that required to be known:

1. The elements of work created as detail and as short as possible, but still able to be measured accurately.
2. Handling such as loading and unloading time should be separated from the machining time. Handling is consists of works that conducted manually by the worker and the works measurement activity in here is absolutely concentrate as will relate to the performance rating.
3. The constant work elements and variable elements should be separated. The constant work elements are the independent element out from the effect of size, weight, length or shape of the work piece.

2.9.3 Observation and Measurement

There are three stop watch time study methods to measure work elements as follow:

1. Continous Timing

   In this method, stopwatch run continously during the observation. Stopwatch will be stopped while the observation has been completed and record the time at the end of the observation. In addition to obtain time for each individuals, it is necessary to process reduction.

2. Repetitive Timing

   For this method using a stopwatch which the stopwatch must simultaneously read and the number on the stopwatch reset to zero after each process is completed. This method can be directly done without a reduction process.

3. Accumulative Timing

   In this method using two or more stopwatches. Because the method used is when the first stopwatch stopped, then run the second stopwatch. And when the second stopwatch stopped, then run the third stopwatch.

2.10 Relationship of Motion and Time Study

Motion and time study helps management to determine how much the product is produce by the workers in a specific period of time. Therefore, making it easier to predict work schedule and predict the output. Motion and time study is a scientific method to increase productivity and reduce time. The method evaluates work and tries to find ways to improve the processes. Motion and time study is very important in production control.

Chapter III

Research Methodology

3.1 Obeservation Flowchart

Observation flowchart consist of steps, which did before the writing processed. The observation chart used to easier processes during the progress of writing as a guideline.

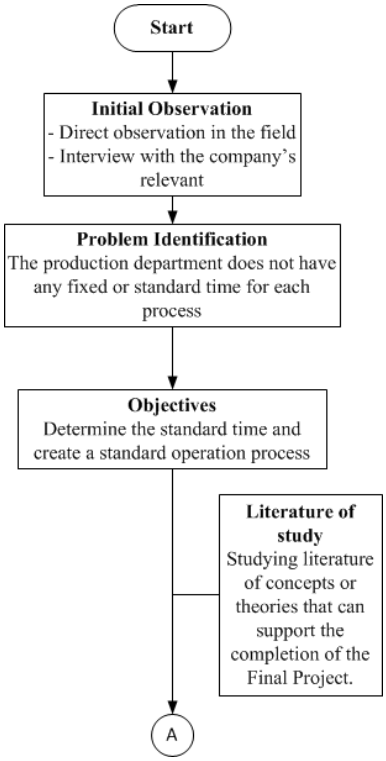


Figure 3.1 Observation Flowchart

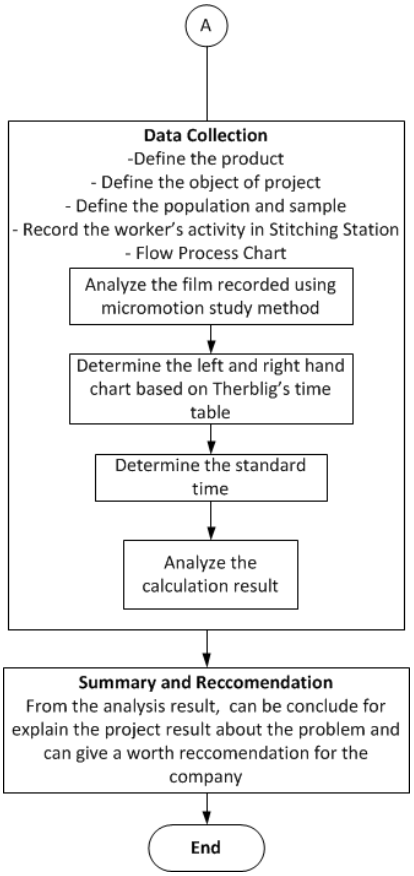


Figure 3.2 Observation Flowchart (cont'd)

3.2 Project Methodology

3.3.1 Object of Research

The object of this project is the production system that have highest output of product which is sandals style GM30152 at footwear company.

3.3.2 Types and Resources of Data Used

In this project, used two types of data as a data researches: primary data and secondary data.

1. Primary Data

The data is obtained directly from the object of research through direct observation, interviews and other method. The primary data form as an overview of production line, production methods, production process, *etc.*

2. Secondary Data

The data is obtained from the historical data that possessed by the company. Secondary data can be the data about production per year or per day, plant layout, production reports, *etc.*

3.3.3 Population and Project Sample

1. Project Population

Define that the population by the overall production system of product sandals style GM31052 at footwear company.

2. Project Sampling

Samples taken from the population using purposive sampling method, which is the samples are chosen deliberately, because of the limited of time and considered quite well to present the condition of the population.

3. Project Samples

The samples is the stitching station that produce sandals type GM31052 at the certain period of time.

4. Data Collection

To obtain various kind of data required, in this project used several techniques of data collection. These techniques are:

1. Field Research

Obtain the data directly by visiting the project site and collecting data that consist these following activities:

a. Interview

Interview the worker and the efficiency manager related to the infrmation that required in the project.

b. Observation

Direct observation of the object of research, such as the production process.

2. Documentation Study

Perform data collected by observing various documents and historical data that owned by the footwear company.

3.3.4 Product Structure and Bill of Materials

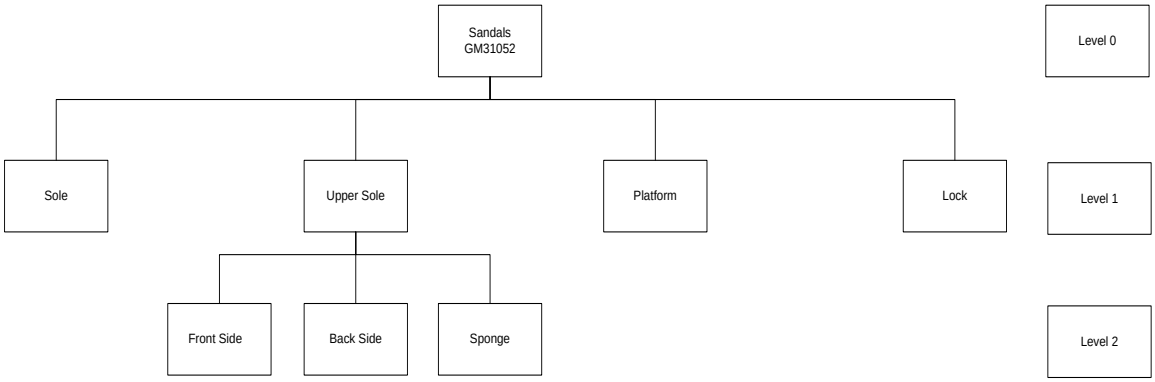


Figure 3.3 Product Structure of Sandals

Figure 3.3 shows that to make a pairs of sandals style GM31052, required sole, upper sole, platform and lock. The quantity of sole, upper sole, platform and lock are 2 for one pairs of sandals. For make an upper sole, required front side, back side and sponge. The quantity of those materials are 2 for one pairs of sandals.

Table 3.1 Bill Of Materials of Sandals

Level	Description	Quantity (unit)	Unit of Measure	Make or Buy?
0	Sandals GM31052	2	Each	Make
1	Sole	2	Each	Make
1	Upper Sole	2	Each	Make
1	Platform	2	Each	Make
1	Lock	2	Each	Make
2	Front Side	2	Each	Make
2	Back Side	2	Each	Make
2	Sponge	2	Each	Make

Table 3.2 shows that the company produce the material for make a pairs of sandals style GM31052 by itself. The company merely buy the raw material to the vendors and process the raw material to be a finish goods.

3.3.5 Production Process

a. Cutting, Lining and Screening Process.

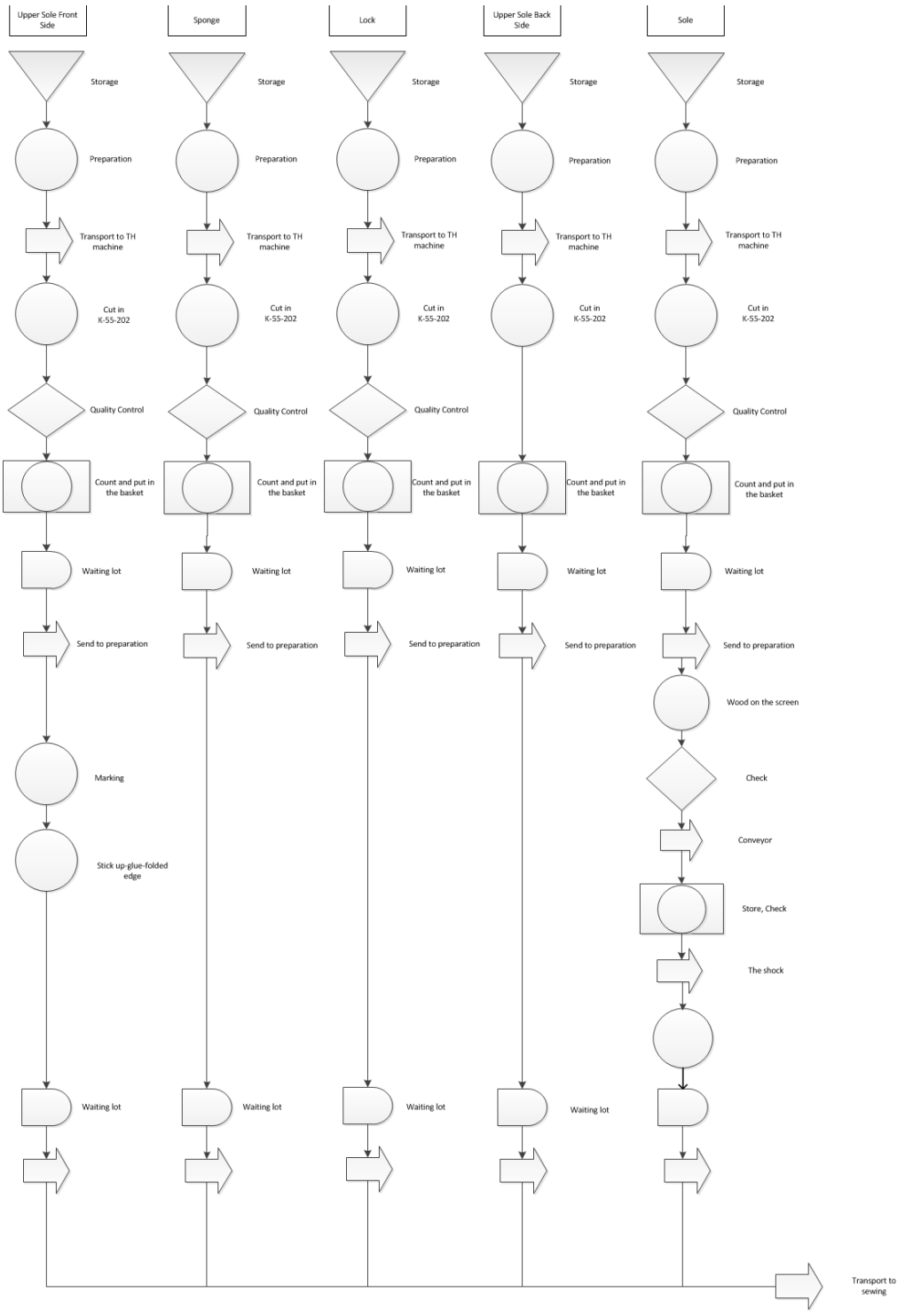


Figure 3.4 Cutting, Lining and Screening Process Flowchart

First step of production processes are cutting, lining and screening. Figure 3.4 shows the process flow of cutting, lining and screening of PVC raw material that would be process as upper sole front side, upper sole back side and sole. After cutting the sole, would be transport to the screening process. The cutting processes include cutting the sponge with the same shape as the upper soles and process the nylon board to make the lock. After this steps of production are finished, the output will be transport to the stitching station.

b. Stitching Process

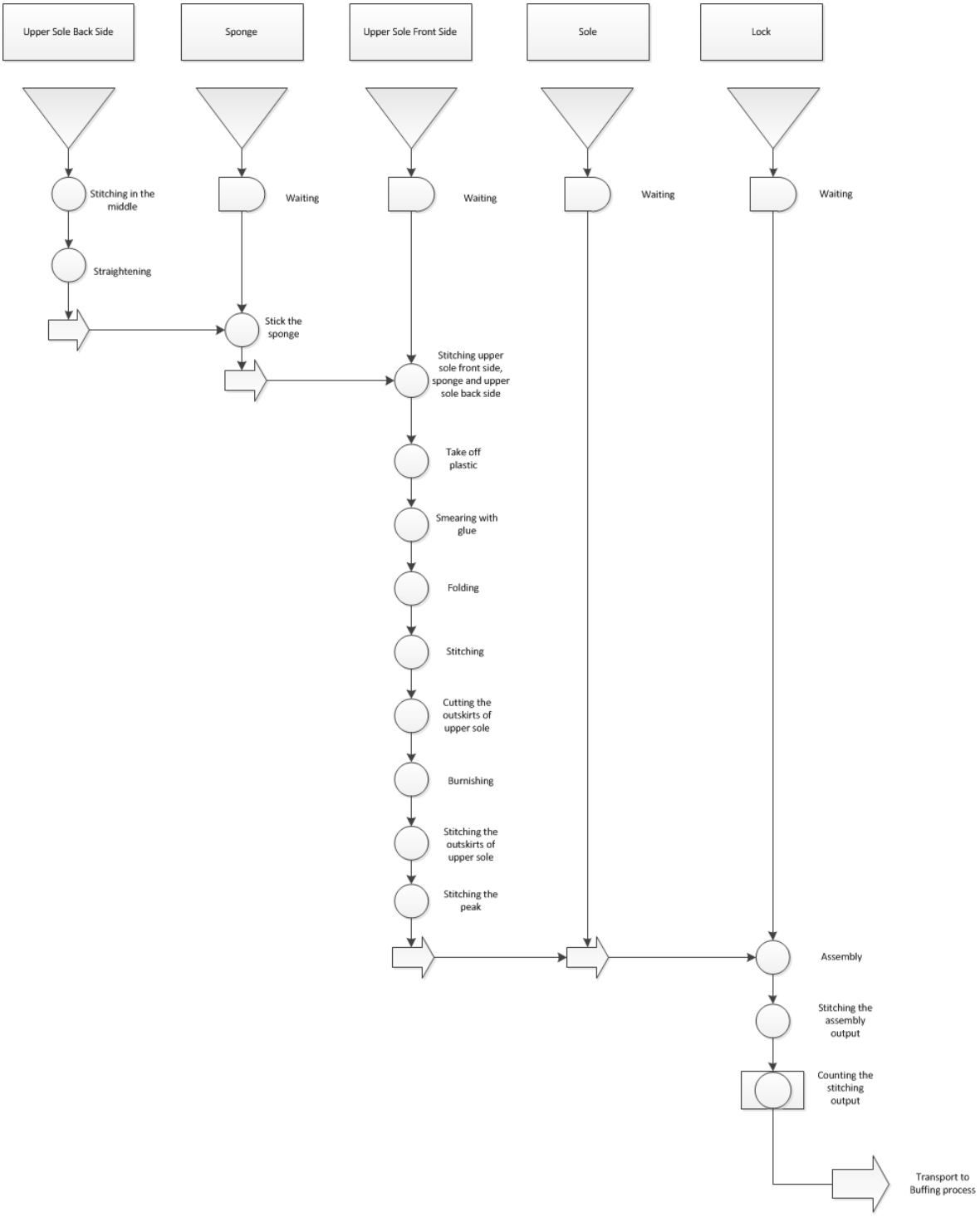


Figure 3.5 Stitching Process Flowchart

Figure 3.5 shows the process flowchart in the stitching production line. After upper sole back side finished cut, firstly the upper sole should be stitch in the middle and should be straightened. The upper sole then transported to stick the sponge on it. After done sticking the sponge, transport to assemble the upper sole front side by stitch it with the upper sole back side. To prevent material sticking to each other, there is a plastic on one side of material. Thus, the plastic should be removed first before smearing the glue on it. After smearing the glue, fold the upper sole front side and back side include the sponge on it to hide the sponge. After upper sole done assembled, next process is stitching process. In the stitching process, the operator will sticth the upper sole based on the line that has been done in the lining process. After the stitching process done, next process is cut the outskirts of upper sole then burnish it to obtain more presentable output. After that, the outskirts of upper sole should be stitch and also the peak of upper sole should be stitch to make the peak strenght. Next process is assembly the upper sole to the sole with lock to keep the upper sole stick to the sole. The assembly output should be stitched again to make the upper sole and the sole attached sustainable. Before the output transport to the buffing process, the output should be counted first to make sure that the materials are correctly done.

c. Buffing Process

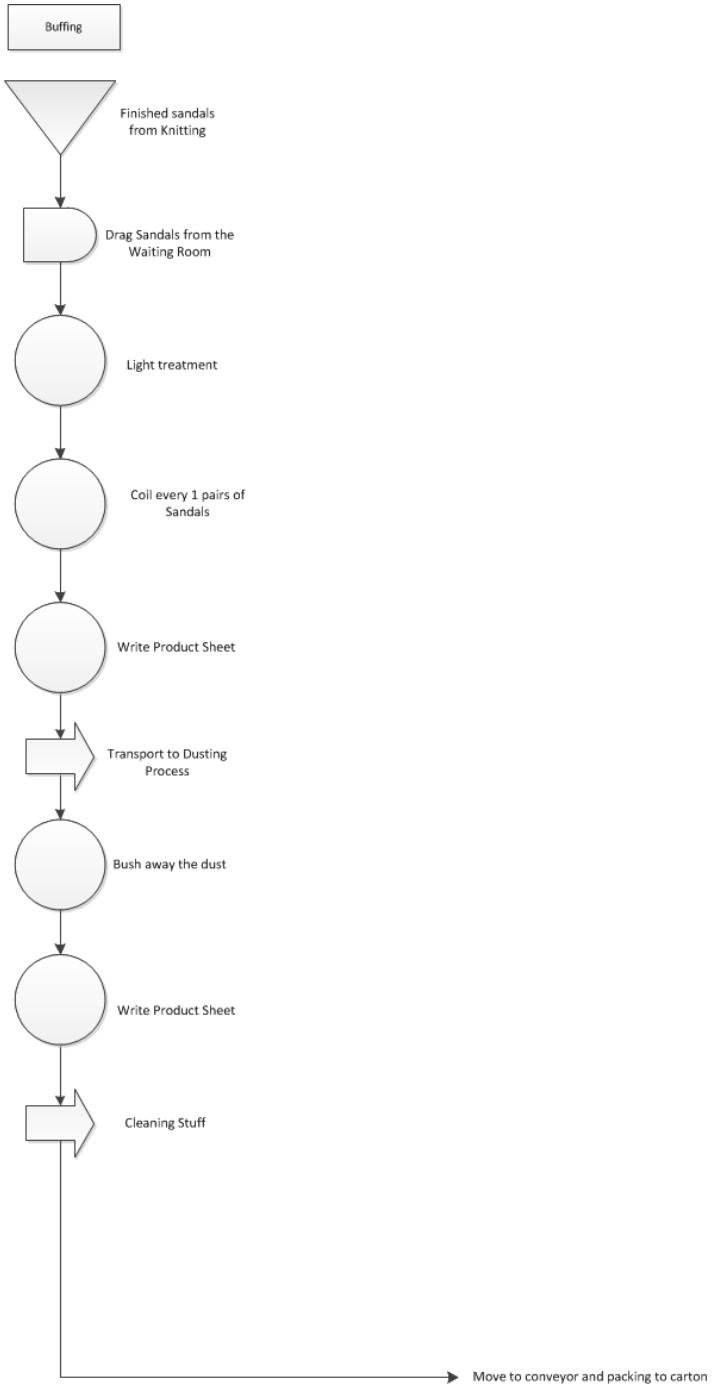


Figure 3.6 Buffing Process Flowchart

Figure 3.6 shows the buffing processed. After the finished sandals from stitching station arrived, the sandals will be drag to the waiting room to be processed. The operator will give a light treatment to the sandals and coil every pairs of sandals. The operator also should write the product sheet before transport the sandals to the dusting process. After the operator bushing away the dust, should write the production sheet again and then clean the sandals. After the buffing process done, the sandals will be move to the conveyor ready to transport to the packaging process.

d. Packaging Process

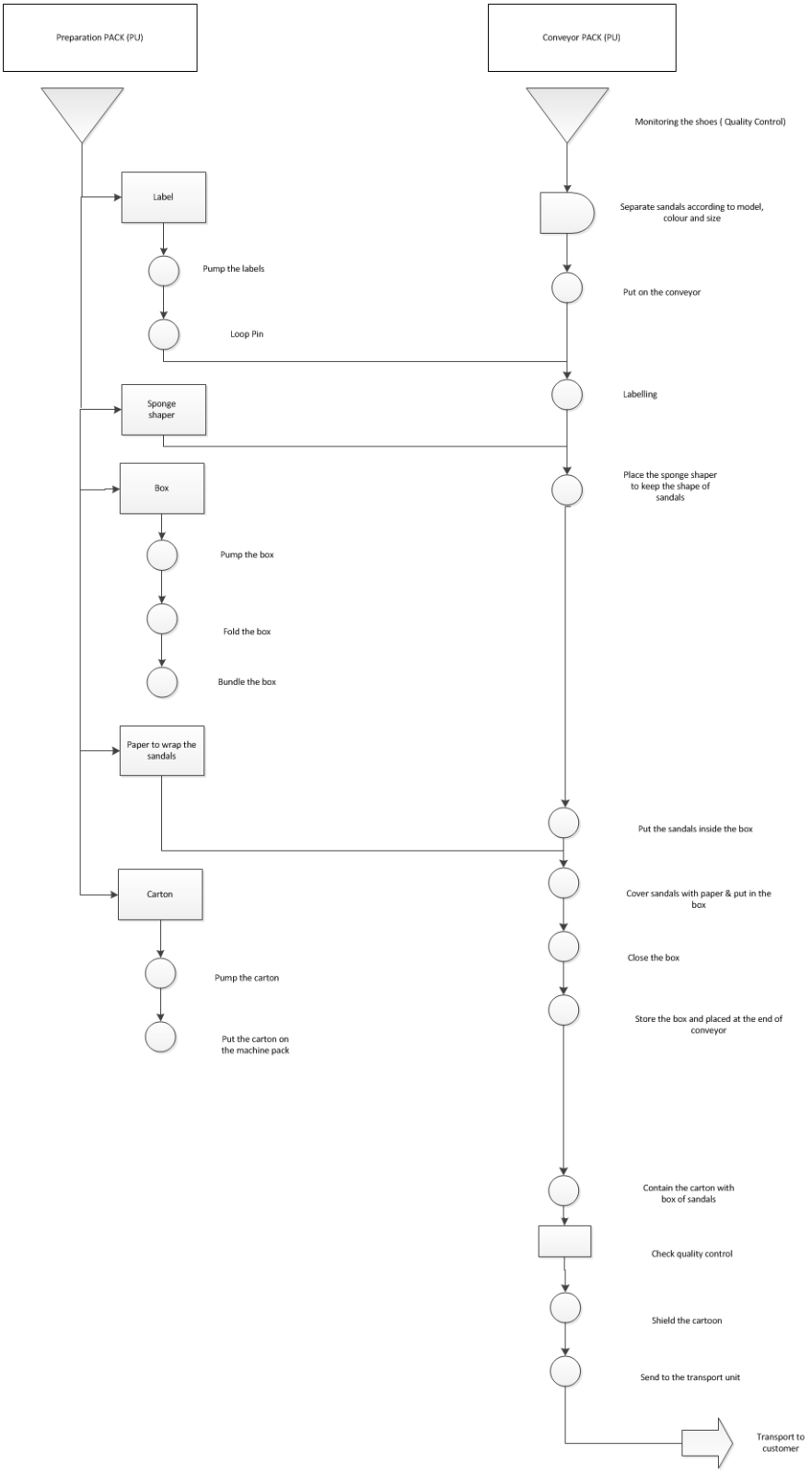


Figure 3.7 Packaging Process Flowchart

Figure 3.7 shows the sandals transport from buffing process by conveyor will be check first at Quality Control. Because all of the type of sandals are being processed at the same time, so the sandals need to be seperate according to the model, colour and size to easier the lebelling process. After put the label or price tag to the sandals, put the sponge shaper to keep the shape of sandals and wrap the sandals with a paper. After that put sandals inside the box and store to the end of conveyor. After all of the sandals done with packaging process, the boxes will be put inside the carton and transport to the transport unit then transport the sandals to the customers.

3.3.6 Analysis Method and Application of Micro-motion Study

Analyze the systems production of the company as an initial condition analysis of the company and then make an assessment of the condition result of micro-motion study application. Furthermore, the result of standard time will be the output production and will be multiplied by the usage data. These steps will be discussed further in the following explanation:

1. Production Process Analysis.

   Analyze the initial condition of the process of Gambol sandals GM31052 type production. In the analysis of the production process can defines as follows:

   1. Flow of stitching process.

      Analyze the flow of stitching process and create a flow process chart.

   2. Number of existing jobs production and presedence rules (the order task predecessors and followers) of these jobs.

2. Data Collecting.

   The data collected form the production site comprised to:

   1. Collect the data from the site by recording the job activities of stitching station using camera recorder.

2. Collect the data about distance between the worker and the work equipment or materials from the workbench to the workers body center.
3. Collect the transportation data time and idle time by using stopwatch.

3. Application of Micro-motion Study.

   The steps of Micro-motion Study application can define as follows:

   1. Identify the video recorded by using slow motion speed carefully and determine the motion elements for each activity. So that the information is properly identified for future reference.
   2. Create a workplace layout based on the video recorded to describe the position of workbench, the workers, equipment and materials.
   3. Write down the motion elements for each hand to the left and right hand chart spreadsheet.
   4. Read the time table and match the motion and distance for each motion element to obtain the TMU number.

4. Standard Time Determination.

   Determine the standard time by calculate the total TMU from the left and right hand chart then converting TMU to seconds for the time unit and adding the allowance percentage for the worker in each workstation. The allowance is according to company policy for the stitching line jobs.

5. Data analysis.

   Analyze the data standard time data result for each workstation and analyze the workplace, unnecessary motions and the possibility of abnormal conditions.

6. Conclusion and suggestion.

   Advice a suggestion and recommendation based on the data result and the company's condition.

Chapter IV

Experiment Result and Analysis

4.1 Stitching Line Analysis

Analyze the production process in the stitching station by build a Presedence Diagram. From the diagram can be determine the number of workstation and the job sequence. As the company has produced Gambol sandals type GM31052, therefore can be determined the standard time required in each workstation.

4.1.1 Stitching Line Layout

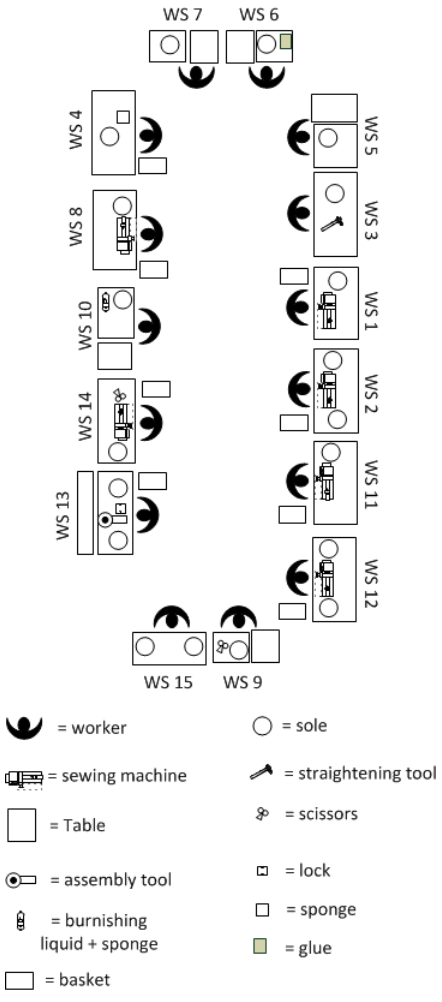


Figure 4.1 Stitching Process Layout

4.1.2 Stitching Line Production Process

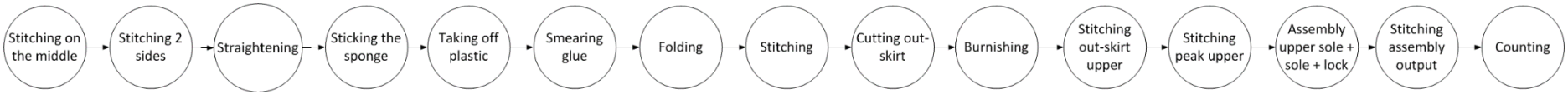


Figure 4.2 Presedence Diagram

Figure 4.1 shows the layout process in the stitching station. The layout process is not efficient because the position of workstation not based on the presedence diagram, thus cause the material flow to each workstation inefficient. Figure 4.2 shows the presedence diagram of the stitching process. The stitching process begins with stitching on the middle of upper sole, then stitching the upper sole front side and upper sole back side in order to make the upper sole thicker, after that straightening the upper sole to sticking the sponge easier. After straightening the upper sole, begins to sticking sponge to the upper sole to make the upper sole have a firm structure. After the sponge stick on the upper sole, the plastic on upper sole back side should be take off first before smearing it with glue. After the surface of upper sole back side have been smeared with glue, next process is folding the upper sole, then the upper sole is done. Next is stitching process which done by 4 workers. In this process, stitch the drawing line on the top of upper sole. After the stitching process is done, the upper sole will be trimmed by cutting the out-skirt of upper sole. After done cutting, burnishing the upper sole in order to make the upper sole glossy. To make the upper sole more presentable, stitching the out-skirt of upper sole and stitching the peak upper sole to make the peak stronger, because the peak upper is the center point of burden when using sandals. After done stitching the peak upper, assembly the upper sole to the sole and to keep the assembly, lock it with a lock that made by the company. After the assembly process done, stitching again the assembly output to make the lock stronger. The last is counting the output in the stitching station process.

4.2 Application of Micro-motion Study

There are 15 workstations and 18 workers in the stitching line production. The workstations in stitching line are: stitching on the middle, stitching 2 sides,

straightening, sticking sponge, taking off plastic, smearing glue, folding, stitching, cutting out-skirt, burnishing, stitching out-skirt upper sole, stitching peak upper, assembly, stitching assembly output and counting. There are 4 workers in the stitching workstation and one worker in each other workstation. There are 15 female workers and 3 male workers. For each station conduct a different job for another and the worker conduct a job by sitting position. The motion layout and the job activities for each workstation will be comprised in this chapter.

4.2.1 Workstation Analysis

a. Workstation 1: Stitching on the middle.



Figure 4.3 Screen-captured workstation 1 (Left to Right)

In the workstation 1 there is 1 worker with 3 parts locations. The activity conducted in stitching on the middle workstation is creates a shape for toes. By using sewing machine to stitched the peak of upper sole. The job is completed by using sewing machine and place the output to the basket. The job activities in the workstation 1 described as follows:

1. Pick the sole using left hand.
2. Hold and fold the sole using both hands.
3. Position the sole on the sewing machine.

4. Holding while sewing.
5. Turn on switch using right hand.
6. Turn on switch using right hand.
7. Collect finished sole to be placed in basket.

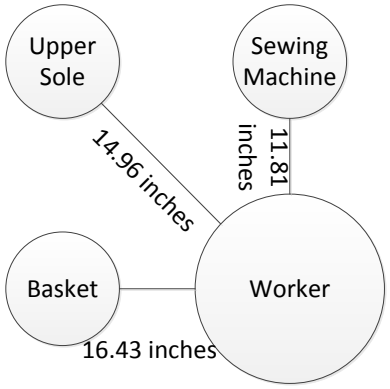


Figure 4.4 Layout of workstation 1

Table 4.1 Parts Name and Distance in the Workstation 1 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	14.96
B	Sewing machine	11.81
C	Basket	16.53

Figure 4.3 shows the position of worker and the position of each part in the stitching on the middle workstation. Table 4.1 shows the distance of each part from the worker is 14.96 inches to the upper sole, 11.81 inches to the sewing machine and 16.53 inches to the basket.

Table 4.2 Left and Right Hand Chart in Workstation 1

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inch)	Right Hand
Reach A Grasp A Move A	14.96	R14.96A G1A M14.96C	10.932 2 17.76				
Regrasp A		G2	5.6	9.1	P1SSE		Grasp A
Position A		P1SSE	9.1	6.4	AF+RLF		Apply Pressure A
Regrasp A		G2	5.6	9.1	P1SSE		Position A
				9.5	R11.81A		Reach B
Position A		P1SSE	9.1				
				6.4	AF+RLF		Apply Pressure B
				9.1	P1SSE		Position A
Release A		RL1	2				
		Total TMU	111.71				

From the video recorded, the left and right hand chart is beginning by the left hand picked up the material with the distance of 14.96 inches. The reach movement are contains 3 motion elements which are Reach, Grasp and Move. To write down the Reach code refers to the chapter III, the sequence of code is R14.96A (see Table R). And the TMU score is obtained from the interpolation of the distance. Refer to the table R, 14.96 inches are between 14 and 16 inches. And the interpolation between 14 and 16 for 14.96 inches is 10.932 inches. For the Grasp motion, the motion is classified to 1A case, because the object is easily grasped (see table G). For the Move motion, the way to write down the symbol is the same as Reach motion (see table M) and the TMU score is obtained from the interpolation of the distance. Refer to the table M, 14.96 inches are between 14 and 16 inches. And the interpolation between 14 and 16 for 14.96 inches is 17.76 inches. The next motion is conducted by right hand. The right hand conducted position motion and the material classified to semi-symmetry shape. So, the TMU score is 9.1

(see table P). Next, the left hand conducted a re-grasp motion to the object. The re-grasp motion has its own score, which is 5.6 (see table G). Next, the right hand conducted Apply Pressure motion. This Apply Pressure motion is classified to Apply Force (AF) and Release Force (RLF), so the TMU score is 3.4+3.0 = 6.4 (see table AP). The way of writing is stand in the same way for all motion, but remains to see the time table for each motion. This calculation method is also applicable for the rest of left and right hand chart analysis.

Table 4.2 shows the motion elements in the stitching on the middle workstation based on the video recorded analysis, the activities in this workstation comprised to the motion elements based on Therblig's motion elements. The result of the Therblig's motion elements analysis, there are 6 motion elements in the stitching on the middle workstation such as: Reach, Grasp, Move, Position, Apply pressure and Release. The table also shows the Total Measurement Unit of stitching on the middle workstation is 111.71 TMU which equal to 0.00105 hour, or equal to 0.06296 minutes, or equal to 3.778 seconds. Hence, the normal time in the stitching on the middle workstation is 3.778 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The allowance percentage is regarding to the company policy. The equation as follows:

$$T_{std} = 3.778\ (1 + 0.07)$$

$$T_{std} = 4.042 \text{ seconds}$$

The standard time in the stitching on the middle workstation is 4.042 seconds.

b. Workstation 2: Stitching 2 sides.

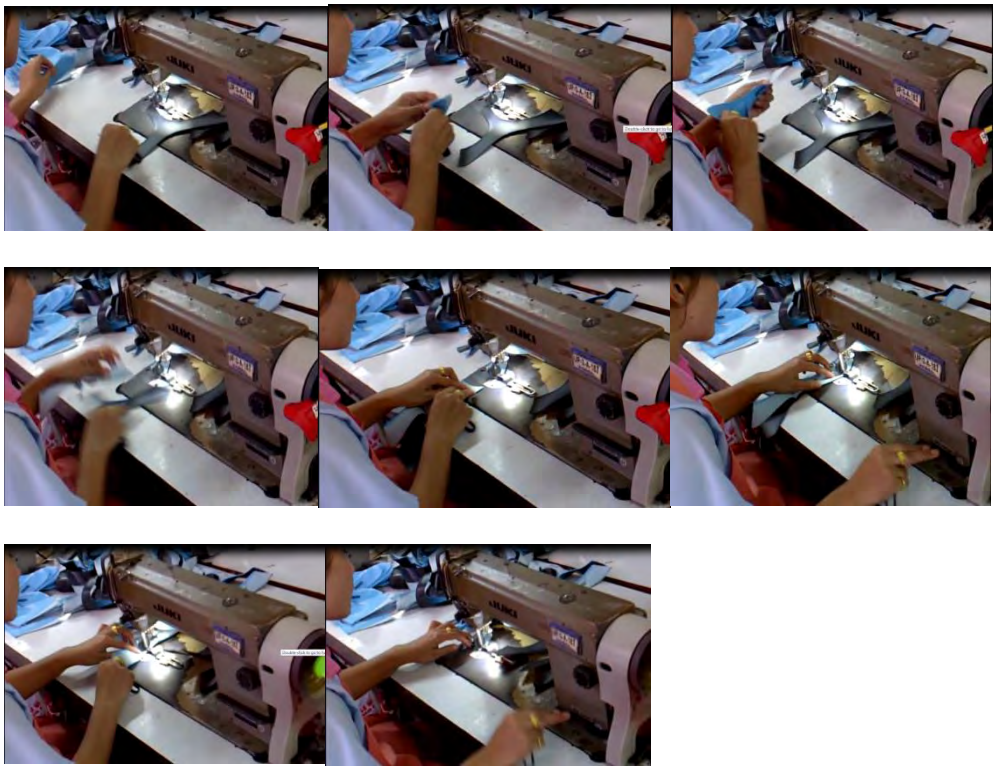


Figure 4.5 Screen-captured workstation 2 (Left to Right)

In the workstation 2 there is 1 worker and 4 parts locations. In the stitching 2 sides workstation conducted a stitches process between upper sole font side and upper sole backside by using sewing machine. The activities in the stitching 2 sides workstation comprised to:

1. Pick upper sole back side using right hand.
2. Pick upper sole front side using left hand.
3. Adjust upper sole front side using left hand.
4. Position the upper sole back side equal to front side.
5. Position the upper sole to the sewing machine.
6. Hold while sewing.
7. Turn on switch using right hand.
8. Turn off switch using left hand.

9. Position the upper sole to the sewing machine.
10. Collect finished sole to be placed in basket.

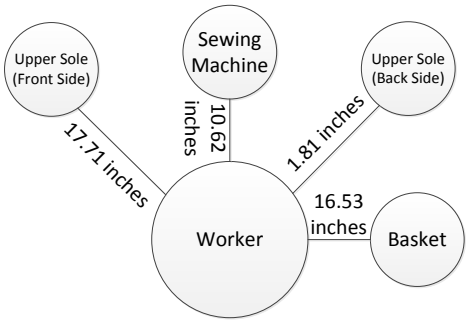


Figure 4.6 Layout of workstation 2

Table 4.3 Parts Name and Distance in the Workstation 2 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole (front side)	17.71
B	Upper sole (back side)	11.81
C	Sewing Machine	10.62
D	Basket	16.53

Figure 4.4 shows the layout interaction between worker and each part in each location. Table 4.2 shows the distance of each part to the worker. The upper sole front side distance is 17.71 inches to the worker and the upper sole backside distance is 11.81 inches to the worker. The distance of worker to the sewing machine is 10.62 inches and the distance of the basket is 16.53 inches to the worker.

Table 4.4 Left and Right Hand Chart in Workstation 2

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				9.51	R11.81A		Reach B
				2	G1A	11.81	Grasp B
				15.03	M11.81C		Move B
Reach A		R17.71A	12.16				
Grasp A	17.71	G1A	2				
Move A		M17.71C	20.15				

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Disengaged A		D1E	4	4	D1E		Disengaged A
				9.1	P1SSE		Position B
Position A		P1SSE	9.1				
				6.4	AF+RLF		Apply pressure A+B
Postion A+B		P1SSE	9.1	9.1	P1SSE		Position A+B
				6.4	AF+RLF		Apply pressure A+B
				8.97	R10.62A		Reach A+B
				2	G1A	10.62	Grasp A+B
				14.02	M10.62C		Move A+B
				2	RL1		Release A+B
		TMU	145.04				

Table 4.4 shows that in the stitching 2 sides workstation, there are 7 motion elements used in the activities, such as: Reach, Grasp, Move, Disengaged, Position, Apply pressure and Release. The analysis of Total Measurement Unit in the stitching 2 sides job activities performed a result of 145.04 TMU which equal to 0.00145 hour, or equal to 0.08702 minutes, or equal to 5.221 seconds. Hence, the normal time in the stitching 2 sides workstation is 5.221 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 5.221(1 + 0.07)$$

$$T_{std} = 5.586 \text{ seconds}$$

The standard time in the stitching 2 sides workstation is 5.586 seconds.

c. Workstation 3: Straightening.

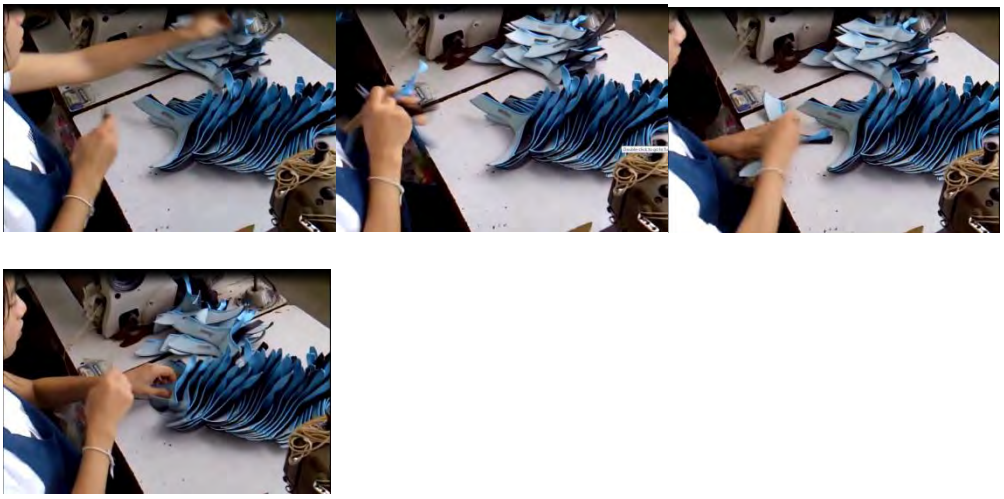


Figure 4.7 Screen-captured workstation 3 (Left to Right)

In the workstation 3, there is 1 worker with 3 parts locations. In the straightening process conducted straighten the upper sole in order to simplify the activities in the next job. The job is simply to straighten the upper sole. The activities of straightening are comprised to:

1. Pick straightening tool using right hand.
2. Pick upper sole using left hand.
3. Adjust the upper sole.
4. Straighten the upper sole using tools by right hand.
5. Place the upper sole on the workbench.
6. Collected finished upper sole.

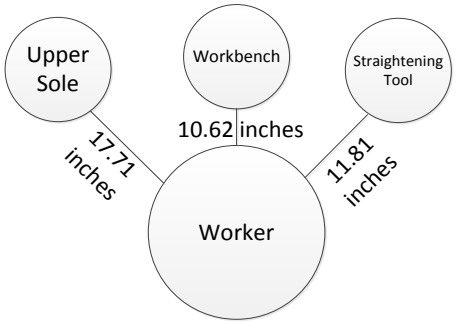


Figure 4.8 Layout of workstation 3

Table 4.5 Parts Name and Distance in the Workstation 3 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	17.71
B	Straightening tool	11.81
C	Workbench	10.62

Figure 4.5 shows the layout of workstation 3 which is the location of each part and the worker position from each part. For each location has a distance to one another. Table 4.5 shows the parts name and distance of each part. The distance of upper sole to the worker is 17.71 inches, the distance of straightening tool to the worker is 11.81 inches and the distance of workbench to the worker is 10.62 inches.

Table 4.6 Left and Right Hand Chart in Workstation 3

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				8.63 2 13.37	R9.84A G1A M9.84C	9.84	Reach B Grasp B Move B
Reach A Grasp A Move A	14.96	R14.96A G1A M14.96C	10.932 2 17.76				
Disengaged A		D1E	4	4	D1E		Disengaged A
Regrasp A		G2	5.6				
Apply pressure A		AF+RLF	6.4	6.4	AF+RLF		Apply pressure A
Reach A		R10.62A	8.97				

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Grasp A	10.62	G1A	2				
Move A		M10.62C	14.02				
Release A		RL1	2				
		TMU	108.082				

Table 4.6 shows the analysis of micro-motion study using left and right hand chart which describe the motion elements used in the straightening activities. Straightening activities used 7 motion elements, such as: Reach, Grasp, Move, Disengaged, Re-grasp, Apply pressure and Release. The Total Measurement Unit for straightening workstation is 108.082 TMU which equal to 0.00108 hour, or equal to 0.06485 minutes, or equal to 3.891 seconds. Hence, the normal time in the straightening workstation is 3.891 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.891(1 + 0.07)$$

$$T_{std} = 4.163 \text{ seconds}$$

The standard time in the straightening workstation is 4.163 seconds.

d. Workstation 4: Sticking the sponge.



Figure 4.9 Screen-captured workstation 4 (Left to Right)

In the workstation 4, there is 1 worker and 3 parts locations. In the sticking the sponge conducted a sticks sponge to the upper sole in order to make the upper sole thicker and stronger. The upper sole is sticking between upper sole font side and upper sole back side. The activities of sticking the sponge are comprised to:

1. Pick upper sole using left hand.
2. Pick sponge using right hand.
3. Position sponge to the upper sole.
4. Stick the sponge fit the upper sole.
5. Stick the sponge on the workbench.
6. Collected finished sole.

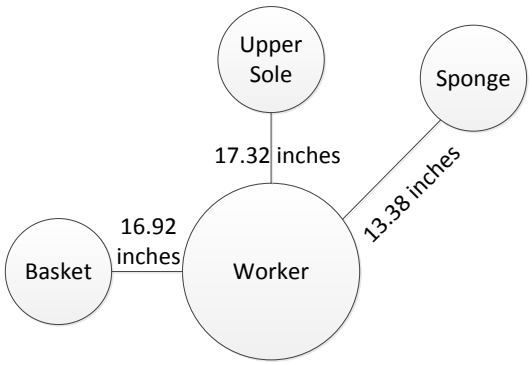


Figure 4.10 Layout of workstation 4

Table 4.7 Parts Name and Distance in the Workstation 4 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	17.32
B	Sponge	13.38
C	Basket	16.92

Figure 4.6 shows the layout of sticking sponge workstation which is the position of the worker and the location of each part. There is a distance between the worker and each part location. Table 4.7 shows the distance between the worker and parts. The distance of upper sole to the worker is 17.32 inches, the distance of sponge to the worker is 13.38 inches and the distance of basket to the worker is 16.92 inches.

Table 4.8 Left and Right Hand Chart in Workstation 4

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A		R17.32A	11.99				
Grasp A	17.32	G1A	2				
Move A		M17.32C	19.82				
				10.22	R13.38A		Reach B
				2	G1A	13.38	Grasp B
				16.37	M13.38C		Move B
Position B		P1SSE	9.1	9.1	P1SSE		Position B
Position B		P1SSE	9.1				
				9.1	P1SSE		Position B
Position B		P1SSE	9.1				
Reach A+B		R15.74A	11.28				
Grasp A+B	15.74	G1A	2				
Move A+B		M15.74C	18.46				
Release A+B		RL1	2				
		TMU	141.64				

Table 4.8 shows the analysis of motion elements based on the Normal Time Values table in the methods Time Measurement. The motion elements used in the sticking sponge activities are 5 motions, such as: Reach, Grasp,

Move, Position and Release. The Time Measurement Unit obtained in the sticking 2 sides activities motions is 141.64 TMU which equal to 0.00142 hour, or equal to 0.08498 minutes, or equal to 5.099 seconds. Hence, the normal time in the sticking sponge workstation is 5.099 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 5.099(1 + 0.07)$$

$$T_{std} = 5.455 \text{ seconds}$$

The standard time in the sticking sponge workstation is 5.455 seconds.

e. Workstation 5: Taking off plastic.

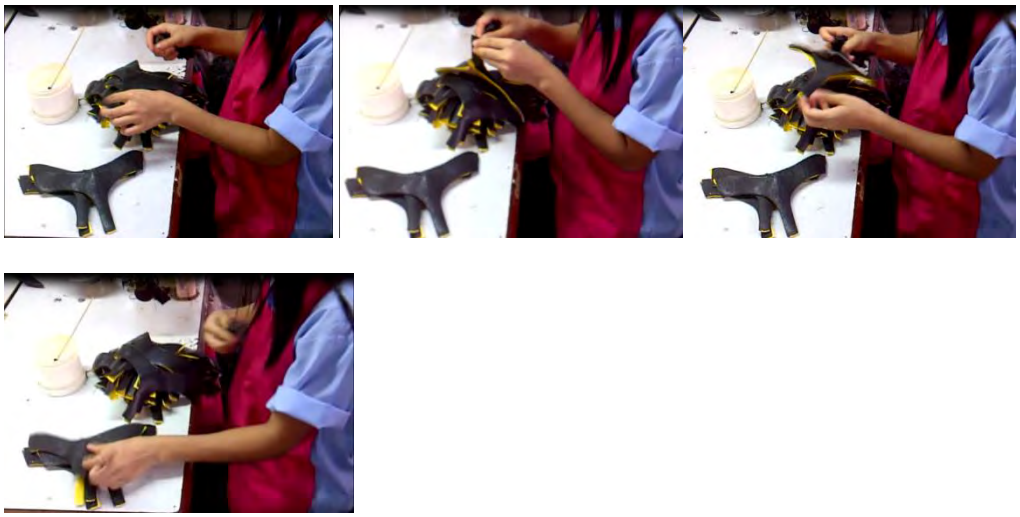


Figure 4.11 Screen-captured workstation 5 (Left to Right)

In the workstation 5, there is 1 worker and 2 parts locations. Taking off plastic is simply taking off the plastic of upper sole that sticking in the upper sole. The plastic is to prevent sticky to each other. Taking off the plastic is to remove undesirable material. Taking off plastic activities are comprised to:

1. Pick upper sole using left hand.
2. Take the plastic off of upper sole.

3. Hold the plastic using right hand.
4. Place the finished upper sole on the table.

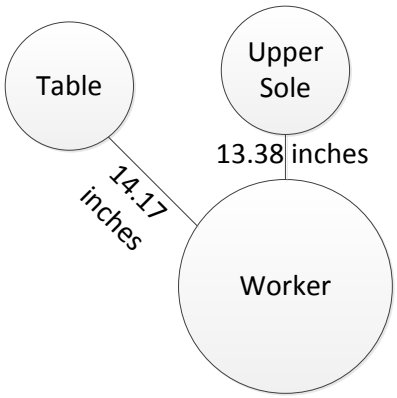


Figure 4.12 Layout of workstation 5

Table 4.9 Parts Name and Distance in the Workstation 5 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	13.38
B	Table	14.17

Figure 4.7 shows the layout of workstation 5. The layout shows the position of the worker through the parts. There is a distance to reach each location of the parts. Table 4.9 shows the distance between the worker and each part. The distance of upper sole to the worker is 13.38 inches and the distance of table to the worker is 14.17 inches.

4.10 Left and Right Hand Chart in Workstation 5

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A		R13.38A	10.22				
Grasp A	13.38	G1A	2				
Move A		M13.38C	16.37				
				4	D1E		Disengaged A
Regrasp A		G2	5.6				
Release A		RL1	2				
		TMU	40.19				

Table 4.10 shows the analysis of left and right hand chart by selecting the Therblig's motion elements for each activity. The Therblig's motion elements used in the taking off plastic activities are Reach, Grasp, Move, Disengaged, Re-grasp and Release. In taking off plastic activities there are 6 motions used with the Total Measurement Unit 40.19 TMU which equal to 0.00040 hour, or equal to 0.02411 minutes, or equal to 1.447 seconds. Hence, the normal time in the taking off plastic workstation is 1.447 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 1.447(1 + 0.07)$$

$$T_{std} = 1.548 \text{ seconds}$$

The standard time in the taking off plastic workstation is 1.548 seconds.

f. Workstation 6: Smearing glue.



Figure 4.13 Screen-captured workstation 6 (Left to Right)

In the workstation 6, there is 1 worker and 3 parts locations. In smearing glue workstation conducted smears glue to the upper sole before covering the edge

between upper sole front side and upper sole back side. In the smearing glue activities using stick as a tool. The smearing glue activities are comprised to:

1. Pick the glue stick using right hand.
2. Pick the upper sole using left hand.
3. Place the upper sole.
4. Smear the glue over the upper sole.
5. Place the finished upper sole on the table.

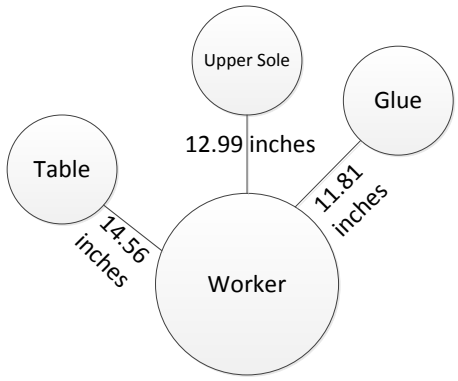


Figure 4.14 Layout of workstation 6

Table 4.11 Parts Name and Distance in the Workstation 6 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	12.99
B	Glue	11.81
C	Table	14.56

Figure 4.8 shows that the worker position is facing the parts locations. Each part location has a distance to the worker position. Table 4.11 shows the distance of parts locations to the worker position. The distance of upper sole to the worker is 12.99 inches, the distance of glue to the worker is 11.81 inches and the distance of table to the worker is 14.56 inches.

Table 4.12 Left and Right Hand Chart in Workstation 6

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				9.51	R11.81A		Reach B
				2	G1A	11.81	Grasp B
				15.03	M11.81C		Move B
Reach A		R14.56A	10.75				
Grasp A	14.56	G1A	2				
Move A		M14.56C	17,4				
				6.4	AF + RLF		Apply pressure B
Reach A		R12.99A	10.04				
Grasp A	12.99	G1A	2				
Move A		M12.99C	16.04				
Release A		RL1	2				
		TMU	93.17				

Table 4.12 shows that in the smearing glue workstation there are 5 motion elements used, such as: Reach, Grasp, Move, Apply pressure and Release. The motion elements are determined based on the video recorded analysis and refer to the Therblig's motion elements. The Total Measurement Unit for smearing glue workstation is 93.17 TMU which equal to 0.00093 hour, or equal to 0.05590 minutes, or equal to 3.354 seconds. Hence, the normal time in the smearing glue workstation is 3.354 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.354(1 + 0.07)$$

$$T_{std} = 3.588 \text{ seconds}$$

The standard time in the smearing glue workstation is 3.588 seconds.

g. Workstation 7: Folding.

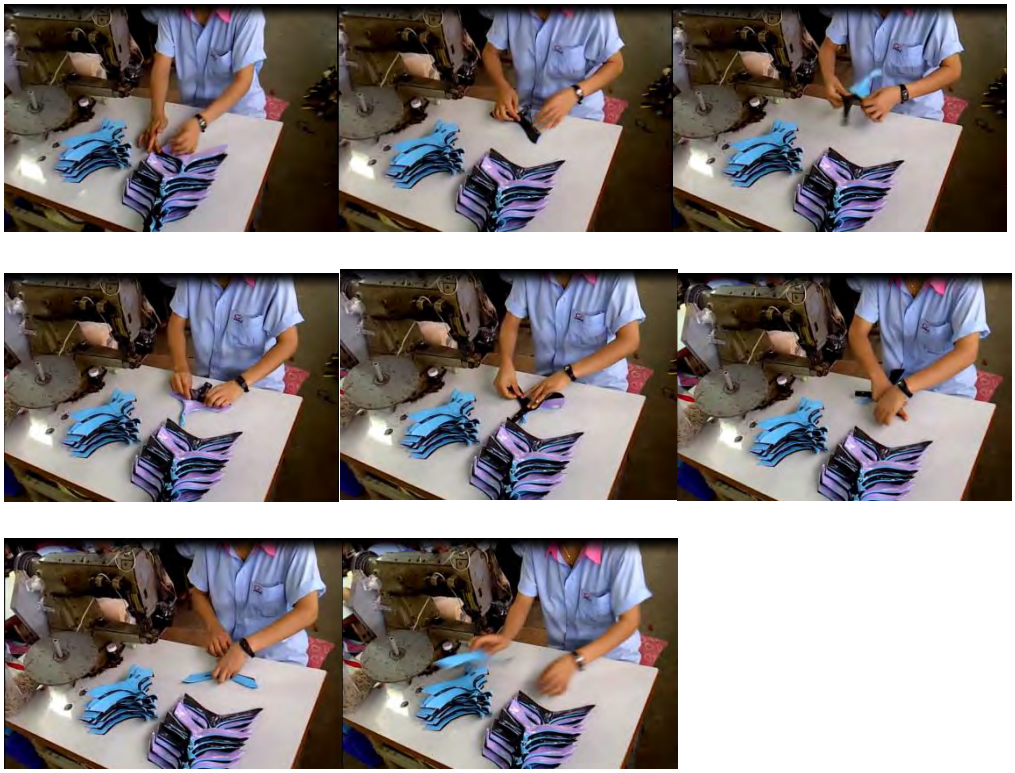


Figure 4.15 Screen-captured workstation 7 (Left to Right)

In the workstation 7 there is 1 worker and 3 parts locations. In the folding workstation conducted folds the upper sole back side in order to glue the upper sole front side and cover the sponge inside. The activities of folding are comprised to:

1. Pick and hold upper sole using both hands.
2. Flip the upper sole.
3. Fold the upper sole back side.
4. Adjust the upper sole back side.
5. Flip the upper sole.
6. Adjust the upper sole front side.
7. Place finished upper sole on the table.

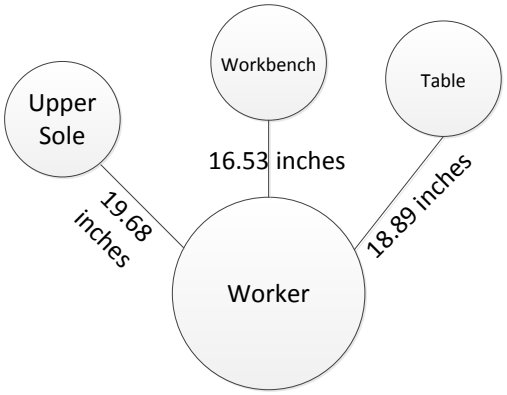


Figure 4.16 Layout of workstation 7

Table 4.13 Parts Name and Distance in the Workstation 7 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	19.68
B	Workbench	16.53
C	Table	18.89

Figure 4.9 shows the layout of folding workstation where the worker position is facing the 3 parts locations by each distance. Table 4.13 shows the distance of the worker position to each part locations. The distance of the worker is 19.68 inches to the upper sole. The distance of the worker is 16.53 inches to the workbench and the distance of the worker is 18.89 inches to the table.

Table 4.14 Left and Right Hand Chart in Workstation 7

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A	19.68	R19.68A	12.97				
Grasp A		G1A	2				
Move A		M19.68C	21.82				
				6.4	AF + RLF		Apply pressure A
Position A		P1SSE	9.1	9.1	P1SSE		Position A
Apply pressure A		AF + RLF	6.4	6.4	AF + RLF		Apply pressure A
				11.63	R16.53A		Reach A

Left Hand	Distance	Code	TMU	TMU	Code	Distance	Right Hand
	(inches)					(inches)	
				2	G1A	16.53	Grasp A
				19.15	M16.53C		Move A
				2	RL1		Release A
		TMU	108.97				

Table 4.14 shows the analysis of left and right hand motion elements. In the table shows that the motion elements of the folding activities are 6 motions, there are: Reach, Grasp, Move, Apply pressure, Position and Release. In the table also shows the Total Measurement Unit of folding workstation is 108.97 TMU which equal to 0.00109 hour, or equal to 0.06538 minutes, or equal to 3.923 seconds. Hence, the normal time in the folding workstation is 3.923 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.923(1 + 0.07)$$

$$T_{std} = 4.197 \text{ seconds}$$

The standard time in the folding workstation is 4.197 seconds.

h. Workstation 8: Stitching.



Figure 4.17 Screen-captured workstation 8 (Left to Right)

In the workstation 8, there are 4 workers and 3 parts locations. The analysis picks one worker as a sample to other workers. Stitching workstation conducted stitches the upper sole to keep the upper sole firm and stitching the pattern for the upper sole. The activities of stitching workstation comprised to:

1. Pick and hold the scissors using right hand.
2. Pick upper sole using right hand.
3. Position the sole on the sewing machine.
4. Hold while sewing.
5. Cut the string using right hand.
6. Place the finished upper sole in basket.

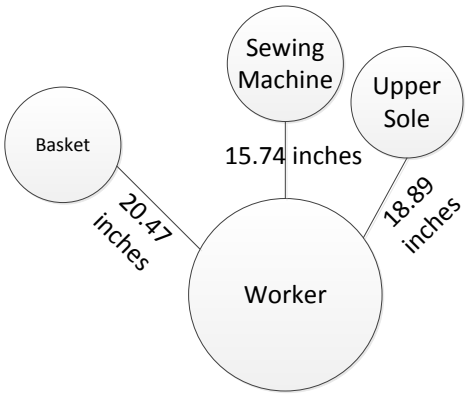


Figure 4.18 Layout of workstation 8

Table 4.15 Parts Name and Distance in the Workstation 8 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	18.89
B	Sewing machine	15.74
C	Basket	20.47

Figure 4.10 shows the stitching workstation layout where the position of the worker and the parts locations. Table 4.15 shows that the distance of worker is 18.89 inches to the upper sole, 15.74 inches to the sewing machine and 20.47 inches to the basket.

Table 4.16 Left and Right Hand Chart in Workstation 8

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A Grab A Move A	18.89	R18.89A G1A M18.89C	12.65 2 21.15				
Position A		P1SSE	9.1	9.1	P1SSE		Position A
Apply pressure A		AF + RLF	6.4	6.4	AF + RLF		Apply pressure A
				5.6	G2		Regrasp A
Apply pressure A		AF+RLF	6.4				
Regrasp A		G2	5.6				
				6.4	AF+RLF		Apply pressure A
				5.6	G2		Regrasp A
Reach A Grab A Move A	15.74	R15.74A G1A M15.74C	11.28 2 18.46				
Release A		RL1	2				
		TMU	130.14				

Table 4.16 shows the analysis of left and right hand motions element in the stitching activities. The table shows that there are 7 motions used in the

stitching activities. The 7 motions are: Reach, Grab, Move, Position, Apply pressure, Re-grasp and Release. From the analysis obtained the Total Measurement Unit is 130.14 TMU which equal to 0.00130 hour, or equal to 0.07808 minutes, or equal to 4.685 seconds. Hence, the normal time in the stitching workstation is 4.685 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 4.685(1 + 0.07)$$

$$T_{std} = 5.012 \text{ seconds}$$

The standard time in the stitching workstation is 5.012 seconds.

i. Workstation 9: Cutting out-skirt upper.

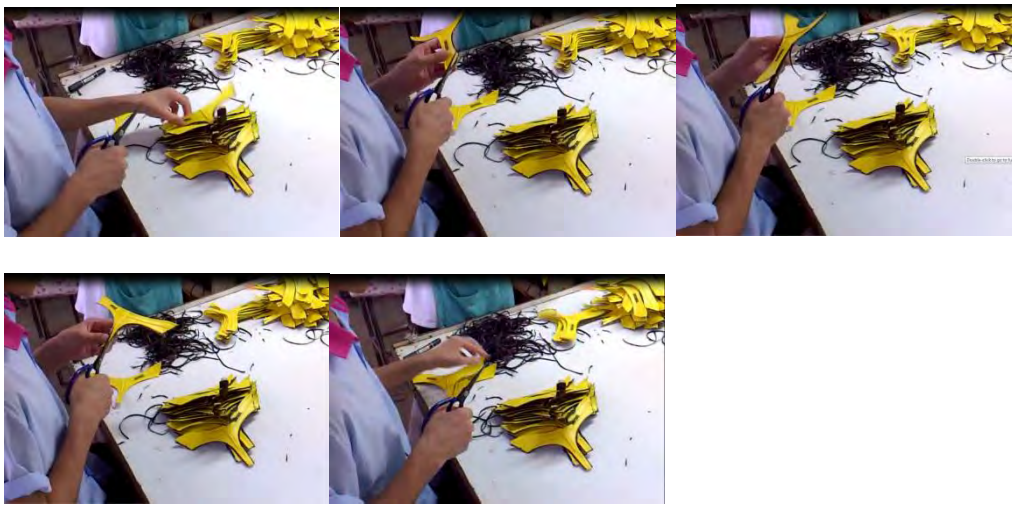


Figure 4.19 Screen-captured workstation 9 (Left to Right)

In the workstation 9, there is 1 worker and 3 parts locations. In the cutting out-skirt upper conducted cuts the out-skirt of upper sole to remove the material left around the upper sole edge in order to create a presentable output. This job is using a scissor to cuts the outskirt of upper sole. The activities in cutting the out-skit upper are comprised to:

1. Pick the scissors using left hand.
2. Position the upper sole on the scissors.
3. Hold while cutting.
4. Place finished upper sole on the table.

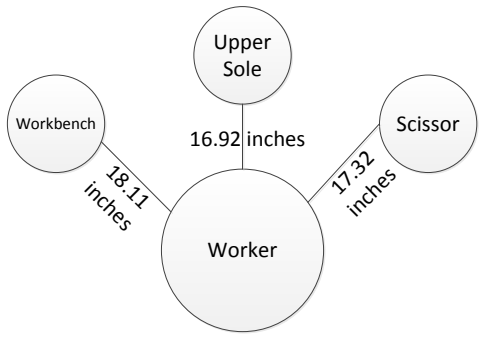


Figure 4.20 Layout of workstation 9

Table 4.17 Parts Name and Distance in the Workstation 9 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	16.92
B	Scissor	17.32
C	Workbench	18.11

Figure 4.11 show that the worker position is facing the parts locations which from each part location to the worker position is measure by a distance. Table 4.17 shows that the distance of the worker position to each part is 16.92 inches to the upper sole, 17.32 inches to the scissor and 18.11 inches to the workbench.

Table 4.18 Left and Right Hand Chart in Workstation 9

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				11.99	R17.32A		Reach B
				2	G1A	17.32	Grab B
				19.82	M17.32C		Move B
Reach A		R16.92A	11.81				
Grab A	16.92	G1A	2				
Move A		M16.92C	19.48				

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Regrasp A		G2	5.6	9.1	P1SSE		Position B
Release A		RL1	2				
		TMU	83.8				

Table 4.18 shows that in the cutting out-skirt upper workstation used 6 motion elements. The motion elements that in used are: Reach, Grab, Move, Position, Re-grasp and Release. And the left and right hand chart for cutting the out-skirt upper workstation shows the result of Total Measurement Unit is 83.8 TMU which equal to 0.00084 hour, or equal to 0.05028 minutes, or equal to 3.017 seconds. Hence, the normal time in the cutting the out-skirt upper is 3.017 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.017(1 + 0.07)$$

$$T_{std} = 3.228 \text{ seconds}$$

The standard time in the cutting out-skirt upper workstation is 3.228 seconds.

j. Workstation 10: Burnishing.



Figure 4.21 Screen-captured workstation 10 (Left to Right)

In the workstation 10, there is 1 worker and 4 parts locations. In the burnishing workstation conducted a burnishes the upper sole using burnishing liquid in order to clean the upper sole and make the upper sole glossy. The activities in the burnishing workstation are comprised to:

1. Pick the sponge and apply burnish liquid to the sponge.
2. Pick the upper sole using left hand.
3. Position the sponge on the upper sole.
4. Hold while burnishing.
5. Place finished upper sole on the table.

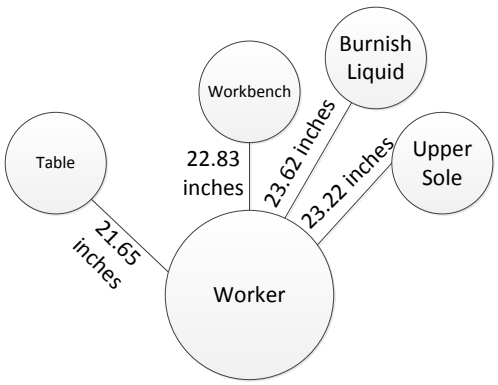


Figure 4.22 Layout of workstation 10

Table 4.19 Parts Name and Distance in the Workstation 10 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	23.22
B	Burnish liquid	23.62
C	Table	21.65
D	Workbench	22.83

Figure 4.12 shows the layout of workstation 10 which the position of worker and parts locations are facing one another. Table 4.19 shows the distance of worker position to each part location. The distance of worker to the upper sole is 23.22 inches, the distance of worker to the burnish liquid is 23.62

inches, the distance of worker to the table is 21.65 inches and the distance of worker to the workbench is 22.83 inches.

Table 4.20 Left and Right Hand Chart in Workstation 10

Left Hand	Distance	Code	TMU	TMU	Code	Distance	Right Hand
	(inches)					(inches)	
				14.72	R23.62A		Reach B
				2	G1A	23.62	Grab B
				25.17	M23.62 C		Move B
Reach A		R23.22A	14.54				
Grab A	23.22	G1A	2				
Move A		M23.22 C	24.83				
Position A		P1SSE	9.1	9.1	P1SSE		Apply pressure B
Release A		RL1	2				
		TMU	103.46				

Table 4.20 shows that the analysis of left hand and right hand are used 6 motions in the burnishing activities. The 6 motions are: Reach, Grab, Move, Position, Apply pressure and Release. The left and right hand chart also shows the Total Measurement obtained in the burnishing workstation is 103.46 TMU which equal to 0.00103 hour, or equal to 0.06208 minutes, or equal to 3.725 seconds. Hence, the normal time in the burnishing workstation is 3.725 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.725(1 + 0.07)$$

$$T_{std} = 3.985 \text{ seconds}$$

The standard time in the burnishing workstation is 3.985 seconds.

k. Workstation 11: Stitching the out-skirt upper.



Figure 4.23 Screen-captured workstation 11 (Left to Right)

In the workstation 11, there is 1 worker and 3 parts locations. In the stitching the out-skirt upper conducted stitches the left side and right side of upper sole in order to give strength to the upper sole when in use. The activities of stitching the out-skirt upper are comprised to:

1. Pick the upper sole using right hand.
2. Position the upper sole to the sewing machine using left hand.
3. Hold while stitching.
4. Collect the finished upper sole in basket.

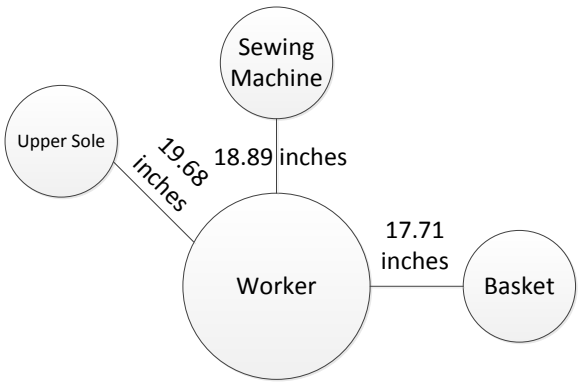


Figure 4.24 Layout of workstation 11

Table 4.21 Parts Name and Distance in the Workstation 11 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	19.68
B	Sewing machine	18.89
C	Basket	17.71

Figure 4.13 shows the layout of stitching out-skirt upper workstation. The layout shows the position of worker and parts locations. Table 4.12 shows the distance of worker to each part location. The distance of upper sole to the worker is 19.68 inches, the distance of sewing machine is 18.89 in front of the worker and the distance of basket where to place to output is 17.71 inches from the worker.

Table 4.22 Left and Right Hand Chart in Workstation 11

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A Grab A Move A	19.68	R19.68A G1A M19.68C	12.97 2 21.82				
Regrasp A		G2	5.6				
Position A		P1SSE	9.1				
Apply pressure A		AF + RLF	6.4				
				12.65 2 21.15	R18.89A G1A M18.89C	18.89	Reach A Grab A Move A
				2	RL1		Release A
		TMU	95.69				

Table 4.22 shows the left and right hand chart of stitching out-skirt upper workstation. In this workstation the motion elements used are Reach, Grab, Move, Re-grasp, Position, Apply pressure and Release. There are 7 motion elements used. The Total Measurement Unit of those 7 motion elements used by left and right hand in the stitching the out-skirt upper is 95.69 TMU which equal to 0.00096 hour, or equal to 0.05741 minutes, or equal to 3.445 seconds. Hence, the normal time in the stitching the out-skirt upper is 3.445 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.445(1 + 0.07)$$

$$T_{std} = 3.686 \text{ seconds}$$

The standard time in the stitching out-skirt upper workstation is 3.686 seconds.

l. Workstation 12: Stitching peak upper.

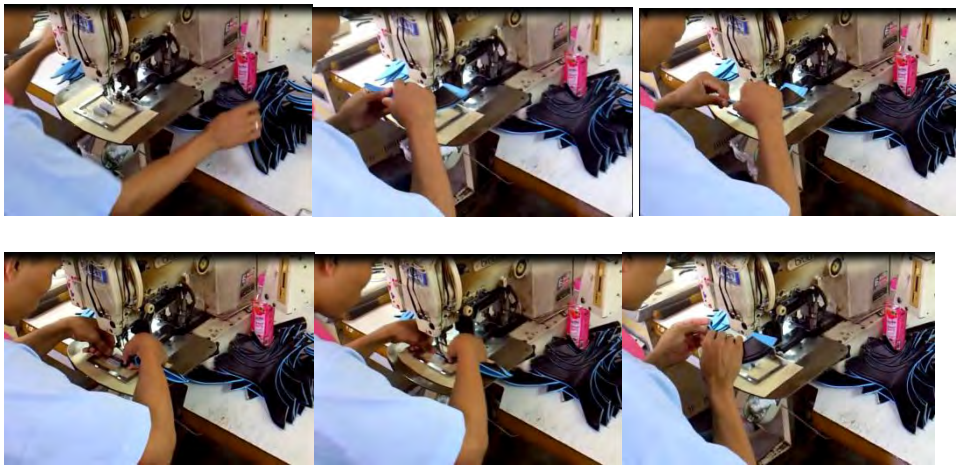


Figure 4.25 Screen-captured workstation 12 (Left to Right)

In the workstation 12, there is 1 worker and 3 parts locations. in the stitching peak upper conducted stitches to the peak of the upper sole in order to give strength to the peak upper and simplify when assembly to sole. The activities in the stitching peak upper workstation are comprised to:

1. Pick the upper sole using right hand.
2. Fold the upper sole.
3. Position upper sole to the sewing machine.
4. Hold while stitching.
5. Adjust the peak upper using left hand.
6. Place the finished upper sole on the table.
7. Collect finished upper sole in basket.

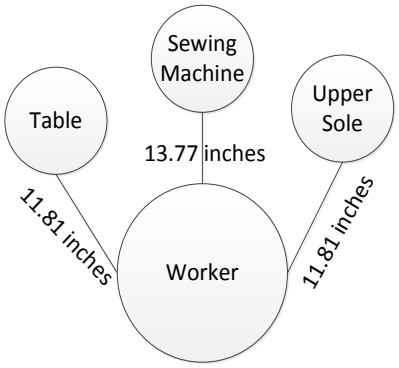


Figure 4.26 Layout of workstation 12

Table 4.23 Parts Name and Distance in the Workstation 12 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Upper sole	11.81
B	Sewing machine	13.77
C	Table	11.81

Figure 4.14 shows the layout of stitching peak upper workstation. The figure is describes the position of worker and the location of each part. Table 4.23 shows the distance of the layout. Where the position of upper sole is 11.81 inches to the worker, and the position of sewing machine is 13.77 inches to the worker also the position of table is same with the position of upper sole which is 11.81 inches to the worker.

Table 4.24 Left and Right Hand Chart in Workstation 12

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				9.51	R11.81A		Reach A
				2	G1A	11.81	Grab A
				15.03	M11.81C		Move A
				5.6	G2		Regrasp A
Position A		P2SSE	19.7	19.7	P2SSE		Position A
Position A		P1SSE	19.7				
Release A		RL1	2				
		TMU	93.24				

Table 4.24 shows the left and right hand chart of stitching peak upper workstation. In the stitching peak upper workstation there are 6 motions used. The 6 motions used are Reach, Grab, Move, Re-grasp, Position and Release. The motion elements that used by left and right hand resulted the Time Measurement Unit as 93.24 TMU which equal to 0.00093 hour, or equal to 0.05594 minutes, or equal to 3.357 seconds. Hence, the normal time in the stitching peak upper workstation is 3.357 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.357(1 + 0.07)$$

$$T_{std} = 3.591 \text{ seconds}$$

The standard time in the stitching peak upper workstation is 3.591 seconds.

m. Workstation 13: Assembly.

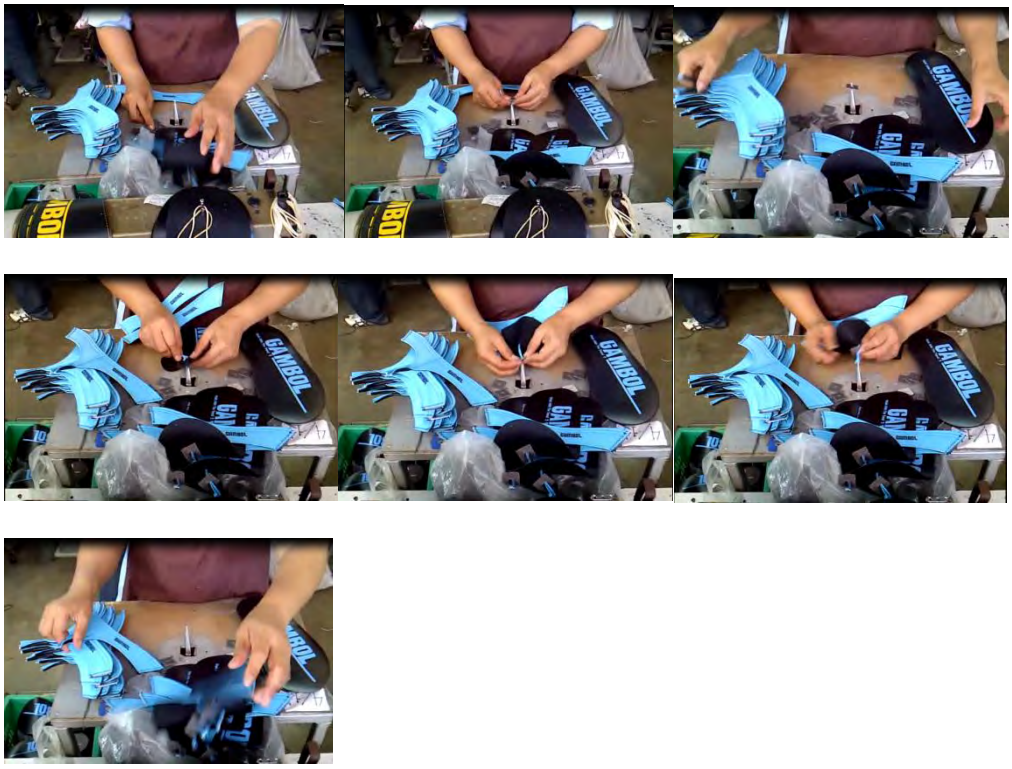


Figure 4.27 Screen-captured workstation 13 (Left to Right)

In the workstation 13, there is 1 worker and 5 parts locations. The assembly workstation conducted assembly between upper sole, lock and sole. The function of lock is to lock and give strength to assemble. The process is using assembly tool. The activities in the assembly workstation are comprised to:

1. Pick the lock using right hand.
2. Position the lock to the assembly tool.
3. Pick sole and upper sole using both hands.
4. Position the sole and upper sole to the assembly tool.
5. Adjust the sole.
6. Adjust the lock.
7. Place the upper sole on the table.

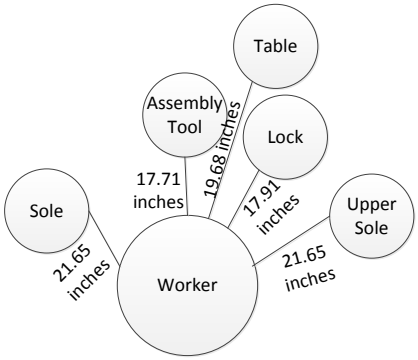


Figure 4.28 Layout of workstation 13

Table 4.25 Parts Name and Distance in the Workstation 13 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Sole	21.65
B	Upper sole	21.65
C	Lock	17.91
D	Assembly tool	17.71
E	Table	19.68

Figure 4.15 shows the position of worker and each part location. The worker position is facing the parts locations. There is a distance between the worker position to the each part location. Table 4.25 shows the distance of assembly workstation layout. The distance of the worker to the sole and upper sole is 21.65 inches, to the lock is 17.91 inches, to the assembly tool is 17.71 inches and to the table is 19.68 inches.

Table 4.26 Left and Right Hand Chart in Workstation 13

Left Hand	Distance	Code	TMU	TMU	Code	Distance	Right Hand
	(inches)					(inches)	
				12.25	R17.91A		Reach C
				2	G1A	17.91	Grab C
				20.32	M17.91C		Move C
Apply Pressure C		P2SE	16.2	16.2	P2SE		Apply pressure C
Reach A		R21.65A	13.84	13.84	R21.65A		Reach B
Grab A	21.65	G1A	2	2	G1A	21.65	Grab B
Move A		M21.65C	23.5	23.5	M21.65C		Move B
				19.7	P2SSE		Position B

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Position C		P2SE	16.2				
				19.7	P2SSE		Position B
Release A+B+C		RL1	2				
		TMU	203.25				

Table 4.26 shows that the assembly workstation used 5 motions element in the activity. The 5 motion elements used are Reach, Grab, Move, Apply pressure, Position and Release. From the 5 motions that used by left and right hand, the activities resulted the Total Measurement Unit as 203.25 TMU which equal to 0.00203 hour, or equal to 0.12195 minutes, or equal to 7.317 seconds. Hence, the normal time in the assembly workstation is 7.317 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 7.317(1 + 0.07)$$

$$T_{std} = 7.829 \text{ seconds}$$

The standard time in the assembly workstation is 7.829 seconds.

n. Workstation 14: Stitching output assembles.



Figure 4.29 Screen-captured workstation 14 (Left to Right)

In the workstation 14, there is 1 worker and 4 parts locations. In the stitching assembly output workstation conducted stitches the peak of upper sole to the lock in order to give strength to the assemble sole when in use. The activities in the stitching assembly output workstation are comprised to:

1. Pick the upper sole using left hand.
2. Adjust the peak upper sole.
3. Position upper sole to the sewing machine.
4. Hold while stitching
5. Cut the string.
6. Collect the finished upper sole in basket.

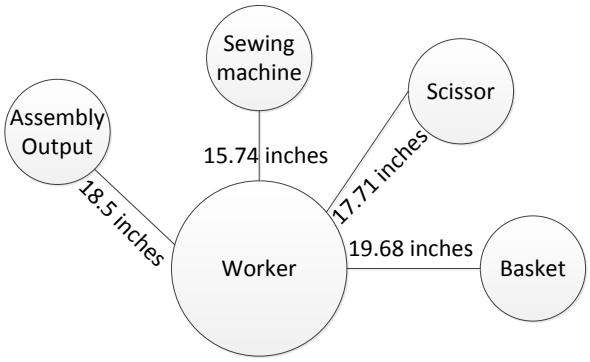


Figure 4.30 Layout of workstation 14

Table 4.27 Parts Name and Distance in the Workstation 14 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Assembly output	18.5
B	Scissor	17.71
C	Sewing machine	15.74
D	Basket	19.68

Figure 4.16 shows the layout of stitching assembly output workstation. The layout describes the position of worker and each part location. There is a distance between worker position and each part location. Table 4.27 shows the distance between worker and each part location. The distance of the worker to the assembly output is 18.5 inches, to the scissor is 17.71 inches, to the sewing machine is 15.74 inches and to the basket is 19.68 inches.

Table 4.28 Left and Right Hand Chart in Workstation 14

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A	18.5	R18.5A	12.5				
Grab A		G1A	2				
Move A		M18.5C	20.82				
Regrasp A		G2	5.6	5.6	G2		Regrasp A
Position A		P1SSE	9.1	9.1	P1SSE		Position A
				11.28	R15.74A		Reach B
				2	G1A	15.74	Grab B
				18.46	M15.74C		Move B
							Position B
							Apply pressure B
Regrasp A		G2	5.6				
Release A		RL1	2				
				2	RL1		Release A
		TMU	106.06				

Table 4.28 shows the motion elements used in the activities of stitching assembly output. There are 7 motions used in the station 13 activities. The

motion elements are Reach, Grab, Move, re-grasp, Position, Apply pressure and Release. The Total Measurement Unit of stitching assembly activities is 106.06 TMU which equal to 0.00106 hour, or equal to 0.06364 minutes, or equal to 3.818 seconds. Hence, the normal time in the stitching assembly output is 3.818 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.818(1 + 0.07)$$

$$T_{std} = 4.085 \text{ seconds}$$

The standard time in the stitching assembly output workstation is 4.085 seconds.

o. Workstation 15: Counting.

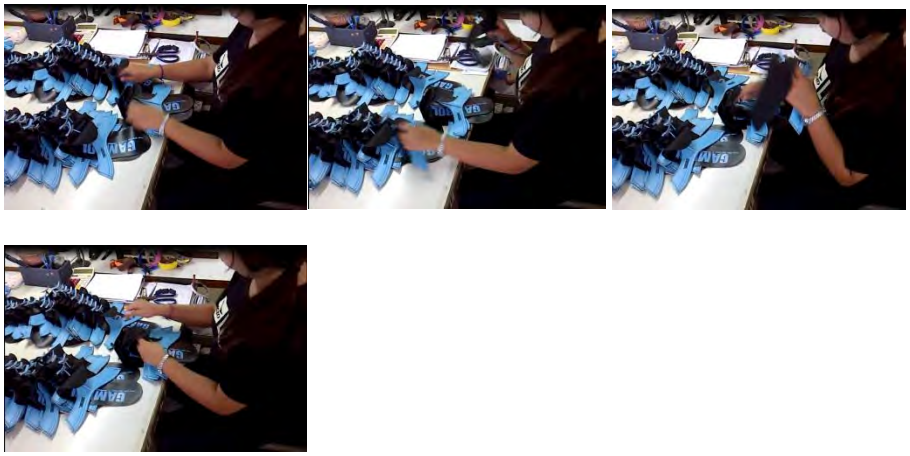


Figure 4.31 Screen-captured workstation 15 (Left to Right)

In the workstation 15, there is 1 worker and 4 parts locations. In the counting workstation conducted counts the output and sort the output (left side and right side) in order to prevent lose the pair. The activities in the counting workstation comprised to:

1. Pick the right sole using right hand.
2. Place the right sole on the workbench.
3. Pick the left sole using right hand.
4. Place the left sole on the workbench.
5. Collect the sole in to basket.

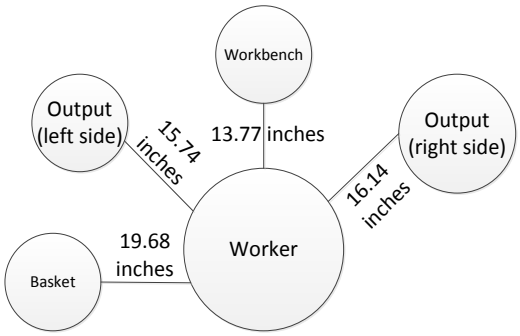


Figure 4.32 Layout of workstation 15

Table 4.29 Parts Name and Distance in the Workstation 15 Description

Parts Code	Parts Name	Distance from worker to the part (inches)
A	Output (left)	15.74
B	Output (right)	16.14
C	Workbench	13.77
D	Basket	19.68

Figure 4.17 shows the layout of counting workstation. The worker is in front of the parts locations and there is a distance between the worker and each part location. Table 4.29 shows the distance between the worker and each part location. The distance of output left side is 15.74 inches to the worker, the output right side is 16.14 inches to the worker, the workbench is 13.77 inches to the worker and the basket is 19.68 inches to the worker.

Table 4.30 Left and Right Hand Chart in Workstation 15

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
				11.58 2 19.04	R16.4A G1A M16.4C	16.4	Reach B Grab B Move B
Reach A Grab A Move A	15.74	R15.74A G1A M15.74C	11.28 2 18.46				
Position A+B		P1SSE	9.1	9.1	P1SSE		Position A+B
Release A+B		RL1	2				
		TMU	84.56				

Table 4.30 shows the sequence of activities by the motion elements of Therblig's motion. In the counting activities used 5 motions such as Reach, Grab, Move, Position and Release. The left and right hand chart resulted the Time Measurement Unit in the counting workstation is 84.56 TMU which equal to 0.00085 hour or equal to 0.05074 minutes or equal to 3.044 seconds. Hence, the normal time in the counting workstation is 3.044 seconds.

From the normal time result, calculate the standard time by adding 7% of allowance. The equation as follows:

$$T_{std} = 3.044(1 + 0.07)$$

$$T_{std} = 3.257 \text{ seconds}$$

The standard time in the counting workstation is 3.257 seconds.

From the normal time result in the stitching line, the process flow in the stitching line can be summarized in the flow process chart as follows:

Table 4.31 Flow Process Chart Spreadsheet

	Summary			
	Activity	Present	Proposed	Savings
Location: Efficiency Department	Operation	15		
Activity: Stitching	Transport	15		
Operator:	Delay	14		
Method and Type:	Inspection	0		
Method: (Present) Proposed	Storage	0		
Type: (Worker) Material Machine	Time(min)	1.6835		
Remarks:	Distance (m)	78		
Analyst:	Cost			

Activity Description	Symbol	Time (seconds)	Distance (m)	Method Recommendation
Material transport from cutting, bordering and screening department		2.1	15	Use a cart to transport the material
Stitching in the middle of upper sole		4.042		
Stored the stitched upper sole to the basket		1.3		
Transport the stitched upper sole to straightening process		2.53	1	
Sticking sponge to the upper sole		5.586		
Stacked the upper sole on the table		1.5		
Straightening the upper sole		4.163		
Stored the upper sole to the basket		1.4		
Transport the upper sole to stitching 2 sides process		2.56	2	
Stitching 2 sides of upper sole		5.455		
Stored the upper sole to the basket		1.6		
Transport to taking off plastic process		2.55	3	
Taking off plastic		1.548		
Transport the upper sole to smearing glue process		1.38	1	
Smearing glue		3.588		

Stacked the upper sole on the table						1.5		
Transport the upper sole to folding process						2.25	1	
Folding process						4.197		
Stored the upper sole to the basket						1.8		
Transport the upper sole to stitching process						2.6	4	
Stitching upper sole						5.012		
Stored the upper sole to the basket						1.78		
Transport the upper sole to cutting out-skit processa						1.54	6	
Cutting the out-skirt of upper sole						3.228		
Stacked the upper sole on the table						1.88		
Transport the upper sole to burnishing process						1.47	3	
Burnishing upper sole						3.985		
Stacked the upper sole on the table						1.7		
Transport the upper sole to stitching out-skirt process						1.52	4	
Stitching the out-skirt of upper sole						3.686		
Stacked the upper sole on the table						1.67		
Transport upper sole to stitching peak upper sole process						1.43	1	
Stitching the peak upper sole						3.591		
Stacked the upper sole on the table						0.65		
Transport the upper sole to assembly process						1.76	3	
Assembly the upper sole, sole and lock						7.829		
Stacked the upper sole on the table						1.7		

Transport the assembled to stitching output assembly process						1.55	1	
Stitching output assembly						4.085		
Stored the output assembly to the basket						0.76		
Transport the output assembly to counting process						2.48	3	
Counting the output						3.257		
Stored the output assembly to the basket						1.4		
Transport the output to the next process						5.1	30	

Table 4.31 shows the flow process in stitching line and detail of the process from the beginning until the end of the process. The total standard time for stitching process is 1.6835 minutes includes the transportation and storage time which collected from the company site using stopwatch. From the total time, the output production can be determined as follows:

$$\frac{480 \text{ min/day}}{1.6835 \text{ min/pairs}} = 285.12 = 285 \text{ pairs/day}$$

Compared to the actual condition in the company side, the output per day based on the order data are collected as follows:

Table 4.32 Production Data of GM31052 Style

Category	Customer	Brand	Style	Output/day
PU	Footwear	X	GM31052	162
PU	Footwear	X	GM31053	272
PU	Footwear	X	GM31054	232
PU	Footwear	X	GM31055	134

Category	Customer	Brand	Style	Output/day
PU	Footwear	X	GM31056	140
PU	Footwear	X	GM31057	202
PU	Footwear	X	GM31058	375
PU	Footwear	X	GM31059	165
PU	Footwear	X	GM31060	460
PU	Footwear	X	GM31061	72
			Average	221,4

The average output in the company is about 221 pairs per day. It means that the calculation of standard time can be used to determine the output capacity since the company can produce more product refer to the standard time.

Chapter V

Conclusion & Recommendation

5.1 Conclusion

From the data and micro-motion study application using left and right hand chart result above, the conclusion of project can be determined as follows:

1. In the stitching production process, there are 7 motion elements of Therblig motion elements used, such as Reach, Grasp, Move, Position, Re-grasp, Apply pressure and Release.
2. Total standard operation time in the stitching line are determined as follow:

Table 5.1 Total Standard Operation Time

No	Work Element	Work Station	Standard Time (seconds)
1	Stitching on the middle of upper sole.	1	4.042
2	Stitching upper sole front side and upper sole back side.	2	5.586
3	Straightening the upper sole.	3	4.163
4	Sticking the sponge between upper sole front side and upper sole back side.	4	5.455
5	Taking off plastic of upper sole.	5	1.548
6	Smearing the upper sole with glue.	6	3.588
7	Folding the upper sole back side to cover the sponge.	7	4.197
8	Stitching the upper sole.	8	5.012
9	Cutting the material left in the out-skirt of upper sole.	9	3.228
10	Burnishing the upper sole using burnish liquid.	10	3.985
11	Stitching the out-skirt of upper sole.	11	3.686
12	Stitching the peak of upper sole.	12	3.591
13	Assembly the upper sole, sole and lock it.	13	7.829
14	Stitching the upper sole to the lock.	14	4.085
15	Counting the assembly output.	15	3.257
		Total Standard Time	63.252

5.2 Recommendation

Suggestion that could be given based on the application of micro-motion study are as follow:

1. The future research of this study should re-layout the existing layout in order to eliminate ineffective motion.
2. Standard time can be used as a tool to determine time required to the finished an order. Standard time is expected to reduce the overtime hours for the worker and certainly reduce the overtime cost.
3. Standard time can be used as a tool to determine output capacity in order to estimate production plans and cost.

5.3 Extended Study

Therblig's term is aimed to simplify the movement and needs to be more careful to identifying motion based on Therblig's term. Furthermore, there are some corrections & differences between video recording and Methods Time Measurement.

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APPENDIX I

TABLE OF MTM-1

1. Table Reach (R)

Distance Moved (inches)	Time TMU				Hand in Motion		Case and Description
	A	B	C or D	E	A	B	
¼ or less	2.0	2.0	2.0	2.0	1.6	1.6	A. Reach the object in fixed location, or to object in other hand or on which other hand rest.
1	2.5	2.5	3.6	2.4	2.3	2.3	
2	4.0	4.0	5.9	3.8	3.5	2.7	
3	5.3	5.3	7.3	5.3	4.5	3.6	B. Reach to single object in location which may very slightly from cycle to cycle.
4	6.1	6.4	8.4	6.8	4.9	4.3	
5	6.5	7.8	9.4	7.4	5.3	5.0	
6	7.0	8.6	10.1	8.0	5.7	5.7	
7	7.4	9.3	10.8	8.7	6.1	6.5	C. Reach to object jumbled with other objects in a group so that search and select occur.
8	7.9	10.1	11.5	9.3	6.5	7.2	
9	8.3	10.8	12.2	9.9	6.9	7.9	
10	8.7	11.5	12.9	10.5	7.3	8.6	
12	9.6	12.9	14.2	11.8	8.1	10.1	
14	10.5	14.4	15.6	13.0	8.9	11.5	D. Reach to a very small object or where accurate grasp is required.
16	11.4	15.8	17.0	14.2	9.7	12.9	
18	12.3	17.2	18.4	15.5	10.5	14.4	
20	13.1	18.6	19.8	16.7	11.3	15.8	
22	14.0	20.1	21.2	18.0	12.1	17.3	E. Reach to indefinite location to get hand in position for body balance or next motion or out of way.
24	14.9	21.5	22.5	19.2	12.9	18.8	
26	15.8	22.9	23.9	20.4	13.7	20.2	
28	16.7	24.4	25.3	21.7	14.5	21.7	
30	17.5	25.8	26.7	22.9	15.3	23.2	
Additional	0.4	0.7	0.7	0.6			TMU per inch over 30 inches

2. Table Move (M)

Distance Moved (inches)	Time TMU				Wt. Allowance			Case and Description
	A	B	C	Hand in Motion B	Wt. (lb) Up to	Dynamic Factor	Static Constant TMU	
¾ or less	2.0	2.0	2.0	1.7				
1	2.5	2.9	3.4	2.3	2.5	1.00	0	A. Move object to other hand or against stop.
2	3.6	4.6	5.2	2.9				
3	4.9	5.7	6.7	3.6	7.5	1.06	2.2	
4	6.1	6.9	8.0	4.3				
5	7.3	8.0	9.2	5.0	12.5	1.11	3.9	
6	8.1	8.9	10.3	5.7				
7	8.9	9.7	11.1	6.5	17.5	1.17	5.6	
8	9.7	10.6	11.8	7.2				B. Move object to approximate or indefinite location.
9	10.5	11.5	12.7	7.9	22.5	1.22	7.4	
10	11.3	12.2	13.5	8.6				
12	12.9	13.4	15.2	10.0	27.5	1.28	9.1	
14	14.4	14.6	16.9	11.4				
16	16.0	15.8	18.7	12.8	32.5	1.33	10.8	
18	17.6	17.0	20.4	14.2				
20	19.2	18.2	22.1	15.6	37.5	1.39	12.5	
22	20.8	19.4	23.8	17.0				C. Move object to exact location.
24	22.4	20.6	25.5	18.4	42.5	1.44	14.3	
26	24.0	21.8	27.3	19.8				
28	25.5	23.1	29.0	21.2	47.5	1.50	16.0	
30	27.1	24.3	30.7	22.7				
Additional	0.8	0.6	0.85		TMU per inch over 30 inches			

3. Table Turn (T)

Weight	Time TMU for Degrees Turned										
	30°	45°	60°	75°	90°	100°	120°	130°	150°	165°	180°
Small – 0 to 2 pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium – 2.1 to 10 pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large – 10.1 to 35 pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

4. Table Apply Pressure (AP)

Full Cycle			Components		
Symbol	**TMU**	**Description**	**Symbol**	**TMU**	**Description**
APA	10.6	AF + DM + RLF	AF	3.4	Apply Force
			DM	4.2	Dwell, Minimum
APB	16.2	APA + G2	RLF	3.0	Release Force

5. Table Grasp (G)

Type of Grasp	**Case**	**Time TMU**	**Description**	
Pick-up	1A	2.0	Any size object by itself, easily grasped	
	1B	3.5	Object very small or lying close against a flat surface	
	1C1	7.3	Diameter larger than ½"	Interference with Grasp on bottom and one side of nearly cylindrical object.
	1C2	8.7	Diameter ¼" to ½"	
	1C3	10.8	Diameter less than ¼"	
Regrasp	2	5.6	Change grasp without relinquishing control	
Transfer	3	5.6	Control transferred from one hand to the other	

Type of Grasp	**Case**	**Time TMU**	**Description**	
Select	4A	7.3	Larger than 1" × 1" × 1"	Object jumbled with other objects so that search and select occur.
	4B	9.1	¼" × ¼" × ⅛" to 1" × 1" × 1"	
	4C	12.9	Smaller than ¼" × ¼" × ⅛"	
Contact	5	0	Contact, Sliding, or Hook Grasp	

6. Table Release (RL)

Case	Time TMU	Description
1	2.0	Normal release performed by opening finger as independent motion
2	0	Contact release

7. Table Position (P)

Class of Fit		Symmetry	Easy to Handle	Difficult to Handle
1 – Loose	No pressure required	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2 – Close	Light pressure required	S	16.2	21.8
		SS	19.7	25.3
		NS	21.0	26.6
3 – Exact	Heavy pressure required	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4
Supplementary Rule for Surface Alignment				
P1SE per alignment: > 1/16" ≤ 1/4"		P2SE per alignment: ≤ 1/16"		

* Distance moved to engage - 1" or less

8. Table Disengaged (D)

Class of Fit	Height of Recoil	Easy to Handle	Difficult to Handle
1 – Loose – Very slight effort, blends with subsequent move	Up to 1"	4.0	5.7
2 – Close – Normal effort, slight recoil	Over 1" to 5"	7.5	11.8
3 – Tight – Considerable effort, hand recoils markedly	Over 5" to 12"	22.9	34.7

APPENDIX II

JOURNAL

Determination Standard Time of Stitching Line Process

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ABSTRACT: Time is the necessary element in the process rate. Whether the motion time or the production rate, this element is taken care in any process in a company. When there is no standard time, any task could be finished out of planned. The time standard is determined to know the time required the process to be finished. It provides a yardstick for measuring work content and a unit for stating capacity. It is also used in loading and scheduling. In this study when was conducted on March 2014-May 2014, determined the standard time of stitching line process by using micro-motion study method which concerned about motion analysis using Methods-Time Measurement. With the application of Methods-Time Measurement, the motion analysis will be more detail which analyzes any manual operation or method into the basic motions required to perform and assigns to each motion which is determined by the nature of motion and the conditions under which it is made. By adding the percentage of allowance in worker performances, the result of standard time for stitching line process is equal to 1.6835 minutes with estimate production is 285 pairs per day. Standard time can be used as a tool to determine output capacity in order to estimate production plans and cost.

Keywords: *Time and Motion Stud; Micro-motion Study; Standard Time.*

1. INTRODUCTION

Nowadays, to produce a good product the company should create some performance improvement from time by time. To be able to produce a good product it is necessary to recognize the properties, limitations and all of the human beings abilities. Furthermore, to build a process improvement is by doing planning and controlling of production process which important to be controlled because the production process performance is where the improvement comes from. The production control is for achieved the company goal to produce a good product. The company measured all of the activity in the production process. By using micro-motion study method that applied to standard time, the purposed of this study was to obtain standard time in each workstation.

1.1 Research Background

Time and motion study is the important aspect in business to determine the production rate, the factors which affect the production rate comprised to raw material, operation cost, work force and others [1]. Time is the necessary element in this rate. Whether the motion time or the production rate, this element is taken care in any process in a company. With the motion analysis, the time standard is determined to know the time required the process to be finished and the total output. With the application of Methods-Time Measurement, the motion analysis will be more detail which analyzes

any manual operation or method into the basic motions required to perform and assigns to each motion which is determined by the nature of motion and the conditions under which it is made.

1.2 Problem Statement

Time is the necessary element in this rate. Whether the motion time or the production rate, this element is taken care in any process in a company. In this study, the footwear company is takes extra time in producing their products by makes an overtime work. The work content of a product is expressed as the time required to make the product using a given method of manufacture. Using time-study techniques, the standard time for a job can be determined—that is, the time it would take a qualified operator working at a normal pace to do the job. It provides a yardstick for measuring work content and a unit for stating capacity. It is also used in loading and scheduling [2]. Unfortunately, the production department does not have any fixed or standard time for each process. The company merely estimates the time for each process and frequently occur the longer time than the time estimated. Thus, might be difficult for the company to increase productivity and competes with the competitor.

1.3 Research Objective

The objectives in this study are to determine the standard time of stitching line process using micro-motion study method. Identify the work elements in the work process in order to give the detail about each production process. And identify motion elements by analyzing the effective and ineffective motion and using video to understand the motion in each work element and identify the activity as a reference to measure the standard time of each workstation.

2. MATERIALS AND METHOD

Motion study is to eliminate unwanted waste known as work simplification by analysing the motion used by the workers and possessed for analysing work motion situations to enhance ability for shorter or less fatiguing motions to improve the work environment [3].

2.1 Motion Economy

The principles of motion economy are guidelines that can be used to help determine the work method, workplace layout, tools and equipment that will maximize the efficiency and minimize the fatigue of worker. The principles of motion economy can be organized into three categories [4]:

1. Principles related to the use of the human body.
   The principles of motion economy that are related to the use of the human body can be used to design the most appropriate methods and motions of the human worker in performing a given task. They are the most applicable to manual work, either repetitive or non-repetitive.
2. Principles related to workplace arrangement.
   The principles of motion economy in this section are directed at the design of the workplace includes the layout of the workstation and the arrangement of tools and parts in it. The first three principles deal with the immediate work area and contribute to a natural rhythm in the work cycle. The other principles cover the use of gravity and the general conditions of the workplace.
3. Principles related to the design of tooling and equipment.
   The principles of motion economy in this section are helpful for designing special tools and controls on equipment used in the workplace.

2.2 Micro-motion Study

Micro-motion analysis is a detailed recording of the motions involved in performing a job. The activities of the hands (and other body members as may be desirable) are usually recorded in terms of 17 separate categories. These categories are called Therblig's. These 17 Therblig's are common to all human activity and provide a most convenient set of categories for the classification of all physical acts and for use as a framework for the classification of basic ways of improving these acts.

2.3 Therblig's Motion

In the whole work process can be decomposed into a basic movement, which is decomposed by Gilberth into 17 Therblig's motions. The process has a different decomposition compared to the other process. It is depends on the work types [4]. According to Mr. Shiego Shingo a famous "method engineering" consultant, the 17 of Therblig's elements, can be classified as follows [5]:

Effective Therblig	**Ineffective Therblig**
Physical Basic Divisions f. Reach g. Move h. Release i. Grasp j. Pre-position Objective Basic Divisions d. Use e. Assemble f. Disassemble	Mental or semi-mental basic divisions f. Search g. Select h. Position i. Inspect j. Plan Delay e. Unavoidable delay f. Avoidable delay g. Rest for overcoming fatigue h. Hold

2.4 Left and Right Hand Chart

Is an analysis chart to analyze the human hands movements in conducting the processes manually. This chart describes all of the motion or delays that occur and conduct by the left and right hand in detail refers to the Therblig's motion. The chart will be useful for repetitive motion and conducted manually. From the analysis, the pattern of hands motion for left and right hand which considered inefficient and contrary from the principles of motion economy could be suggested to be improved. Although Franks and Lilian Gilberth have been states that the human work motions conducted by referring to 17 Therblig's basic motion elements or the combination of Therblig's elements, but in creating this chart will be more effective to use merely 8 Therblig's motion elements, there are [6]:

1. Reach (RE)
2. Grasp (G)
3. Move (M)
4. Position (P)
5. Use (U)
6. Release (RL)
7. Delay (D)
8. Hold (H)

2.5 Workstation Analysis

There are 15 workstations and 18 workers in the stitching line production. The workstation in stitching line begin with stitching on the middle job process (workstation 1) which is in this workstation has 1 worker. The micro-motion study implementation is by comprising the motion layout and the job activities for each workstation. The job activities in the workstation 1 described as follows:

1. Pick the sole using left hand.
2. Hold and fold the sole using both hands.
3. Position the sole on the sewing machine.
4. Holding while sewing.

5. Turn on switch using right hand.
6. Turn on switch using right hand.
7. Collect finished sole to be placed in basket.

Workstation 1: Stitching on the middle.

Table 1: Left and Right Hand Chart in

Left Hand	Distance (inches)	Code	TMU	TMU	Code	Distance (inches)	Right Hand
Reach A		R14.96A	10.932				
Grasp A	14.96	G1A	2				
Move A		M14.96C	17.76				
				9.1	P1SSE		Position A
Regrasp A		G2	5.6				
							Apply
				6.4	AF+RLF		Pressure A
Position A		P1SSE	9.1	9.1	P1SSE		Position A
							Apply
				6.4	AF+RLF		Pressure A
Reach A		R11.81	9.51				
Grasp A	11.81	G1A	2				
Move A		M11.81C	15.03				
Release A		RL1	2				
		TMU	104.932				

3. RESULT AND DISCUSSION

Table 1 shows the motion elements in the stitching on the middle workstation based on the video recorded analysis, the activities in this workstation comprised to the motion elements based on Therblig's motion elements. The result of the Therblig's motion elements analysis, there are 6 motion elements in the stitching on the middle workstation such as: Reach, Grasp, Move, Position, Apply pressure and Release. The table also shows the Total Measurement Unit of stitching on the middle workstation is 104.932 TMU which equal to 0.00105 hour, or equal to 0.06296 minutes, or equal to 3.778 seconds. Hence, the normal time in the stitching on the middle workstation is 3.778 seconds.

To calculate the standard time required an allowance regarding to the company decision. In this company, the allowance given is 7% for all workers, both man and woman. The result of standard time by adding 7% of allowance is as follows:

$$T_{std} = 3.778\ (1 + 0.07)$$

$$T_{std} = 4.042 \text{ minutes}$$

The standard time for the standard operation procedure in the stitching line is determined as follow:

Table 2: Total Standard Operation Time

No	Work Element	Work Station	Standard Time (seconds)
1	Stitching on the middle of upper sole.	1	4.042
2	Stitching upper sole front side and upper sole back side.	2	5.586
3	Straightening the upper sole.	3	4.163
4	Sticking the sponge between upper sole front side and upper sole back side.	4	5.455
5	Taking off plastic of upper sole.	5	1.548
6	Smearing the upper sole with glue.	6	3.588
7	Folding the upper sole back side to cover the sponge.	7	4.197
8	Stitching the upper sole.	8	5.012
9	Cutting the left material in the out-skirt of upper sole.	9	3.228
10	Burnishing the upper sole using burnish liquid.	10	3.985
11	Stitching the out-skirt of upper sole.	11	3.686
12	Stitching the peak of upper sole.	12	3.591
13	Assembly the upper sole, sole and lock it.	13	7.829
14	Stitching the upper sole to the lock.	14	4.085
15	Counting the assembly output.	15	3.257
		Total Standard Time	63.252

From the total time, the output production can be determined as follows:

$$\frac{480\,\frac{\text{min}}{\text{day}}}{1.6835\,\frac{\text{min}}{\text{pairs}}} = 285.12 = 285\ \text{pairs/day}$$

Compared to the actual condition in the company side, the output per day based on the order data are collected as follows:

Table 3: Production Data of GM31052

Category	Customer	Brand	Style	Output/day
PU	Footwear	X	GM31052	162
PU	Footwear	X	GM31053	272
PU	Footwear	X	GM31054	232
PU	Footwear	X	GM31055	134
PU	Footwear	X	GM31056	140
PU	Footwear	X	GM31057	202
PU	Footwear	X	GM31058	375
PU	Footwear	X	GM31059	165
PU	Footwear	X	GM31060	460
PU	Footwear	X	GM31061	72
			Average	221,4

The average output in the company is about 221 pairs per day. It means that the calculation of standard time can be used to determine the output capacity since the company can produce more product refer to the standard time.

4. CONCLUSION

From the data and micro-motion study application using left and right hand chart result above, the conclusion of project can be determined as follows:

4.1 In the stitching production process, there are 7 motion elements of Therblig's motion elements used, such as Reach, Grasp, Move, Position, Re-grasp, Apply pressure and Release.

4.2 Total standard operation time in the stitching line is 63.252 seconds.

5. RECOMMENDATION

Suggestion that could be given based on the application of micro-motion study are as follows:

5.1 The future research of this study should re-layout the existing layout in order to eliminate ineffective motion.

5.2 Standard time can be used as a tool to determine time required to the finished an order. Standard time is expected to reduce the overtime hours for the worker and certainly reduce the overtime cost.

5.3 Standard time can be used as a tool to determine output capacity in order to estimate production plans and cost.

5.4 Therblig's term is aimed to simplify the movement and needs to be more careful to identifying motion based on Therblig's term. Furthermore, there are some corrections & differences between video recording and Methods Time Measurement.

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