PRODUCTIVITY IMPROVEMENT OF SUB-ASSEMBLY PROCESS IN CASTING INDUSTRY USING LEAN MANUFACTURING TOOL

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled "Productivity Improvement of Sub-Assembly Process in Casting Industry Using Lean Manufacturing Tool" is the result of my own research except as cited in references.

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Date : 11 FEBRUARY 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

………………………………………………………………………

(PROFESOR MADYA DR. MOHD RIZAL BIN SALLEH)

ABSTRAK

Kualiti dan kuantiti adalah elemen utama yang membantu syarikat untuk terus bersaing dengan yang lain. Teknologi terus meningkat dari hari ke hari dan ini secara tidak langsung menyumbang kepada peningkatan permintaan pelanggan. Pembuatan kejat dapat membantu mengurangkan kos, pembaziran, masa menunggu, kecacatan dan meningkatkan kepantasan penghantaran produk. Projek ini bertujuan untuk menganalisis aliran produk di jabatan sub-pemasangan Dormakaba Production Malaysia Sdn Bhd, yang terletak di Cheng, Melaka. Pernyataan masalah dalam hal ini adalah bagi pihak pengurusan untuk mewujudkan alat visual untuk proses baru industri tuangan yang merupakan proses sub-pemasangan. Proses sub-pemasangan adalah proses baru dalam Dormakaba Production Malaysia Sdn Bhd dan pembuatan kejat perlu diterapkan untuk meningkatkan produktiviti untuk merealisasikan produk mereka. Tidak ada pautan kawalan produksi dan penjadualan seperti perencanaan produksi dan peramalan permintaan terhadap penjadualan pengeluaran menggunakan parameter operasi untuk sistem pembuatan yang menentukan kadar produksi. Objektif utama projek ini adalah untuk menyiasat proses semasa setiap model di jabatan sub-pemasangan berdasarkan matriks keluarga produk, untuk mengenal pasti model yang perlu menjalankan alat ramping untuk mengurangkan kos, pembaziran, masa menunggu, kecacatan dan kelajuan penghantaran produk dan untuk mengembangkan Pemetaan Aliran Nilai (VSM) untuk model yang dipilih. Jumlah nama stesen / model seperti SAS, MSB, omboh and galas dianalisis berdasarkan proses bilangan, kuota per shif, berat kasar (kg) dan tenaga manusia di jabatan sub-pemasangan selama 9 bulan yang lalu. Masalah seperti *Standard Work sheet* yang tidak cekap dan kemacetan proses dianalisis. VSM masa depan diciptakan, peta kawasan kerja disusun semula dan reka bentuk alat sokongan plat bawah dibuat untuk mengurangkan masa kitaran dan waktu tunggu. Pelaksanaan alat pembuatan kejat ini meningkatkan peningkatan produktiviti proses sub-pemasangan di Dormakaba Production Malaysia Sdn Bhd

ABSTRACT

Quality with quantity is the key element that helps the company remain in competition with others. Technology continues to rise day by day and this indirectly contributes to client demands rising. Lean manufacturing can help to reduce the costs, waste, waiting time, defect and improve product delivery speed. This project seeks to analyse the product flow in an assembly line of Dormakaba Production Malaysia Sdn Bhd, located in Cheng, Melaka. The problem statement in this is for management to establish a visualized tool for the new process of casting industry which is sub assembly process. The sub-assembly process is a new process in Dormakaba Production Malaysia Sdn Bhd and therefore lean manufacturing need to be apply to improve the productivity for their product realization. There is no links production control and scheduling functions such as production planning and demand forecasting to production scheduling using operating parameters for the manufacturing system which determines the production rate. The main objectives of this project are to investigate the current process of each model in sub-assembly department based on the product family matrix, to identify the model that need to carry out lean tools to reduce the cost, waste, waiting time, defect and product delivery speed and to develop the Value Stream Mapping (VSM) for selected model. The total station name/model such as SAS, MSB, Piston and Bearing is analysed based on the number process, quota per shift, gross weight (kg) and man power in sub-assembly department for past 9 month. The problem such as inefficient Standard Work sheet and bottleneck of process was analysed. The Future VSM was created, the map of work area is restructured and the design of base plate supporting tool is created to reduce the cycle time and waiting time. This implementation of lean manufacturing tool increased the productivity improvement of sub-assembly process in Dormakaba Production Malaysia Sdn Bhd.

DEDICATION

I dedicate this work to my father Mr. Aznam bin Abdullah, my mother Mrs. Rohaya binti Zakaria, and my adored brother and sister, Amir and Ezzah who has always encouraged me all the way from the beginning to end and make sure this report is finished. Thank you, for the support and my love for you all can never be quantified.

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LIST OF ABBREVIATIONS

PSM	-	Projek Sarjana Muda
LM	-	Lean Manufacturing
TPM	-	Total Productive Maintenance
VSM	-	Value Stream Mapping
SAS	-	Spring Adjustment Screw
MSB	-	Manual Screw Bag
MIT	-	Massachusetts Institute of Technology
ASSY	-	Assembly
BC	-	Bolt Circle
ANSI	-	American National Standards Institute
PDCA	-	Plan Do Check Action
TQM	-	Total Quality Management
SWCS	-	Standard Work Combination Sheet
VA	-	Value Added
NVA	-	Non-Value Added
JIT	-	Just-In-Time
PLV	-	Pressure Loading Valve
RH	-	Right Hand
LH	-	Left Hand

LIST OF SYMBOL

kg	-	Kilogram

CHAPTER 1

INTRODUCTION

1.1 Background

In today's rising competitive world, it is very important for manufacturing and service industry to constantly develop. Quality with quantity is the main element which helps company to stay compete with others. Technology keep rising day by day and this indirectly leads the rising of customer demands. Parihar et al. (2012) found that many company and organizations has realized that quality is the most important competitive tools especially for product and service development. In order to stay in this competition of the current markets, manufacturing companies need to analyse, evaluate and continuously improve their manufacturing systems. In order for this to happen, the application of Lean is needed so that any problems, improvement and opportunities can be recognised (Mitrogogos et al 2018). Liker and Lander (2007) stated that during late 1980's, International Motor Vehicle Program in Massachusetts Institute of Technology (MIT) invented the term "lean production". However, in early 1950's, the first idea was originate by Taiichi Ohno of Toyota Motors. There is a lot of varieties of Lean Manufacturing (LM) tools and techniques which are very useful such as Value Stream Mapping (VSM), Quality Circle, Plan Do Check Action (PDCA), 5S housekeeping, 5 Whys, Total Productive Maintenance (TPM), etc (Netland et al 2016).

Lean also mainly focus on any cost reduction by eliminate the non-value-added activities which by apply, identify and eliminate waste from each procedure in the production chain including the time, motion, energy and resources (Choomlucksana et al, 2015). Manufacturing organizations can be more competitive, productive and more profitable by focusing on reducing and eliminate the waste (Gunaki and Teli, 2015). Lean is very useful in term of assisting and eliminating waste which is then can improve the cost and production time. With a very little inventory, lean manufacturing has high service demands as well as throughput. Waste include the excessive amount of equipment, materials, working time and parts which is very important in any production. Although, many organizations have the availability and knowledge in operation management and resources, they still struggling to become lean (Nguyen et al 2016). Therefore, it is very important for them to evaluate the current operation in their system and operation. There are 7 type of waste that usually take place which are Transportation, Inventory, Motion, Waiting, Over-processing, Over-production and Defect (Rajule et al. 2018).

To make sure any industry or organization to keep compete, surviving and growing, they must make sure that their product, design and service is better. To achieve this, lean manufacturing practice need to be used so that operational performance can improve better. Rajule et al. (2018) also stated that unsuccessful Lean may happen if the application is poor and have only partial vision. The study is conducted at Dormakaba Production Malaysia Sdn Bhd. which is one of the casting industry and a multinational manufacturing company with worldwide operation. This study is about productivity improvement for sub-assembly process in casting industry using lean manufacturing tool method.

1.2 Problem Statement

One of the most important things for any company to keep competing and surviving is to always meet their customer's demand. Product realization process can been affected by the nature of the market. Therefore, it is important for companies to do improvement in their productivity for their product realization process. The problem statement in this research of lean manufacturing and productivity improvement is for management to establish a visualized tool for the new process of casting industry which is sub assembly process. Based on the Table 1.1 and Figure 1.1 below, it is shown the total number product/model in sub-assembly department with different number of process, quota per shift, gross weight (kg) and man power for the past 9 months. Because this is a new process, Dormakaba Production Malaysia Sdn Bhd has been under continuous pressure especially to reduce the costs, waste, waiting time, defect and improve product delivery speed. There is no links production control and scheduling functions such as production planning and demand forecasting to production scheduling using operating parameters for the manufacturing system which determines the production rate. Thus, this study is needed to solve this problem.

Table 1.1: Total station name/model run with the number process, quota per shift, gross weight (kg) and man power in sub-assembly department for past 9 month.

(Source: Dormakaba Production Malaysia Sdn Bhd).

STATION NAME / MODEL RUN	MATERIAL	PROCESS	QUOTA PER SHIFT	GROSS WEIGHT (KG)	MAN POWER
Spring Adjustment Screw (SAS)					
Spring adj. Screw assy ts73v bl	28140903150	5	1000	64	1
Spring adj. Screw assy ts83 bl	28140901150	5	1600	93	1

Spring adj. Screw assy ts83 en 2-5 bl	28140904150	5	1600	93	1
Spring adj. Screw assy ts92 – new	24336402150	6	1000	64	2
Spring adj. Screw assy ts93 en2-5	24305501150	6	2300	128	2
Spring adj. Assy ts73v - new	28131004150	6	1000	64	1
Manual screw bag (MSB)					
Cushion bc valve assy	28227101150	1	4800	237	1
Piston					
Damping piston assy ts91/92	24335501150	6	1260	100	1
Damping piston assy ts90 fork pusher	24500506150	5	1170	202	1
Opening piston assy ts90 fork pusher	24500806150	7	1170	163	1
Piston assy 7/8600	9800008200150	9	1650	145	1
Bearing					
Bearing housing assy 700/8600 sta	9800008210060	4	1300	77	1
Bearing housing assy ts83/73v bl-nanfang	28140604150	4	100	9	1
Bearing housing assy ts90 bc	24500402150	4	1100	63	1
Bearing housing assy ts90 (O-ring fx428 w)	24500403150	4	1100	63	1
Pinion bearing bottom assy ts93 ansi 1-5	24300402150	4	100	12	1
Pinion bearing top assy ts93 en5-7	24303001150	4	100	12	1

Bearing housing assy 8900	9800008085020	4	600	46	1
Bearing housing assy gr400 (nanfang)	25300402150	4	800	47	1
Bearing housing assy gr500	25300401150	4	200	24	1
Bearing housing assy ts83/89	24120401150	4	200	10	1
Bearing housing assy 7400/8600	9800008200320	4	1300	77	1
Bearing housing assy ts90	24500401150	4	1100	63	1
Bearing housing assy ts92	24335401150	4	1200	68	1
Pinion bearing bottom assy 2-5	24306301150	4	2300	136	1
Pinion bearing top assy 2-5	24306301151	4	2300	128	1
Bearing housing assy (bl) 2/1865 (ts73bl)	28140604150	4	1200	71	1
Bearing housing assy ts83/73v bl	28140601150	4	3200	166	1

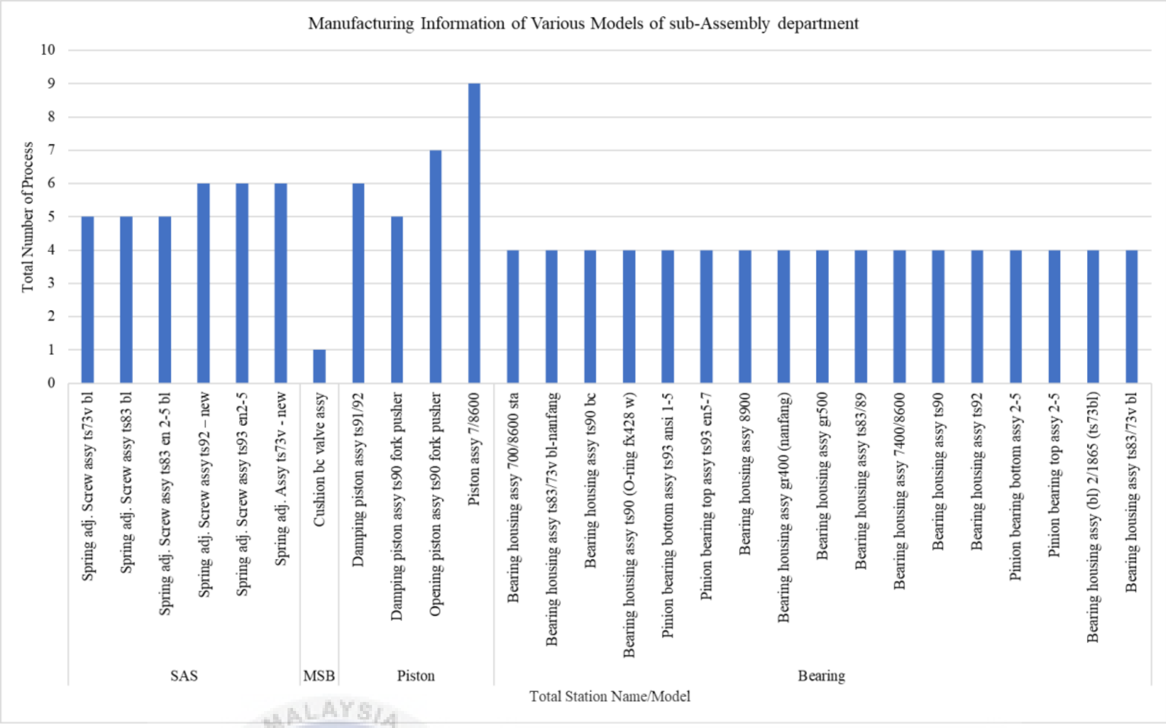


Figure 1.1: Manufacturing Information of Various Models of sub-Assembly department (Source: Dormakaba Production Malaysia Sdn Bhd).

1.3 Objectives

The objectives of this project are as follows:

- To investigate the current process of each model in sub-assembly department based on the product family matrix
- To identify the model that need to carry out lean tools to reduce the cost, waste, waiting time, defect and product delivery speed.
- To develop the Value Stream Mapping (VSM) for selected model.

1.4 Scopes

The scope of this project are as follows:

- This study was carried out only at the sub-assembly department.
- Only product, model and activities that involved in sub-assembly department
- The analysis of the lean manufacturing tools was based in the current sub-assembly process.
- Only one model is used for lean manufacturing tools.

CHAPTER 2

LITERATURE REVIEW

2.1 Company background and Introduction

Dormakaba Production Malaysia Sdn Bhd is an enterprise based in Malaysia which its main office is in Melaka. The Enterprise currently operates in the field Door Closer, Aluminium Casted Body and Accessories. The company was founded on February 08, 1995. The latest annual report from the company reveals a 28.73% rise in net sales revenue in 2018. Its total assets declined by 9.8% over the same period. Dormakaba Production Malaysia Sdn Bhd has increased the net profit margin in 2018 by 0.21%.

This chapter discusses the literature of lean manufacturing, quality and its detailed principle. Moreover, this chapter provide a short review of the Lean tools and techniques such as Product Family Matrix, Time Observation Sheet, Standard Work Combination Sheet, KAIZEN and Value Stream Mapping (VSM).

Quality is very important especially in today's competitive market because it is the main key to ensure the development of product and service that can lead to success (Andrés-López et al 2015). To understand and involve the employees toward a successful goal is by set the quality system in clear direction for any organization to follow. The term "doing right at the first time" is very important especially in eliminating early stage waste. Boztinaztepe and Canan (2008) stated that defect on product sometimes can be detected before sending it to the customer but unfortunately this process is wasteful because it still needs to be fix. Although the defect on product is detected at early stages, still the company may losses their existing and might also potential customers (Parihar et al., 2012). Quality management helps to improve quality planning, control, assurance and improvement within the organizations. These components helps to improve the quality of product and process which the will lead to the Total Quality Management (TQM). Al-Ibrahim (2014) found that TQM is a structured system as shown in Figure 2.1 and Figure 2.2 below which helps to integrate the business environment, improvement, development and maintenance while organizational culture is changing to meet internal and external satisfaction of customer and also suppliers.

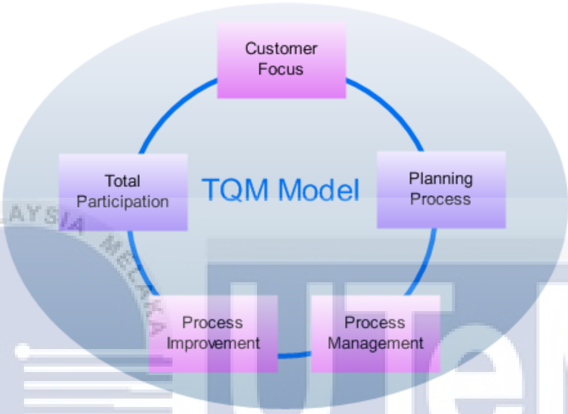


Figure 2.1: TQM structured system model.

(Source: Al-Ibrahim, 2014).

Figure 2.2: Principle of TQM

(Source: Ibrahim, 2014).

The application of Lean is needed in order to make sure the quality of product and services is the best so that any problems, improvement and opportunities can be recognised (Jaafar et al, 2015). The definition of leans is manufacturing without waste. Lean has a positive feedback in industry with many successful cases that is recorded in the literature (Hines et al., 2008). There are seven types of waste which include overproduction, waiting, Inappropriate Processing, Transportation, Unnecessary Motion. Unnecessary Inventory and Rework. A.Rahman et al. (2013) found that many companies still struggling to become lean although they have wide resources and knowledge. The ultimate objective of lean manufacturing are to reduce any waste in human effort, inventory, market, stock and customer demand and ensure the product is efficient and economical (Singh et al., 2010). Lean manufacturing helps to control the value added and non-value added activities to the process .Lean manufacturing is mainly focus on efficiency to make sure that produce product or services is in the lowest cost as possible (Antony, 2011). There were five lean principle and approach that is recommended for project implementation in every organization which Specify Value, Identify the Value Stream, Flow, Pull and Perfection (Nikiforova and Bicevska, 2018).

2.1.1 Specify Value

Specify value means that any organization need to discover what is the value that is creates for customer in development or supply chain of project. Pearce et al. (2018) investigated that this first step is very crucial in lean thinking and need to be done with a conscious and precise define value when dealing with customer in terms of specific product capabilities and price offered. To achieve this, organization need to ignore any existing technologies or assets and need to rethink the firm’s product line with dedicated and strong product teams. Therefore, it is really important to create a clear view to make sure they know what is really needed.

2.1.2 Identify the Value Stream

Value Stream helps to create a visualized activities and process in the organization. Discovering the entire values stream of each product and family is the second step in lean thinking. It set all the specific action and product that is necessary which bring through the three critical management of task in any business. Based on Rohani et al (2015), Figure 2.3 shown the example of Value Stream Mapping. The first one is problem solving task which started from concept to production launch through detailed engineering design. The second one is information management task which it takes from order taking to delivery through the detailed scheduling. The third one is physical information task which started from raw materials to the customer with finished product.

There were three types of action that will occur in value stream which are:

i. Lot of steps will be found to clearly create value.

ii. Lot of steps will be found to create the non-value but it can't be avoided with the current production and technologies assets.

iii. Lot of additional steps will be found to avoid immediately and create the non-value.

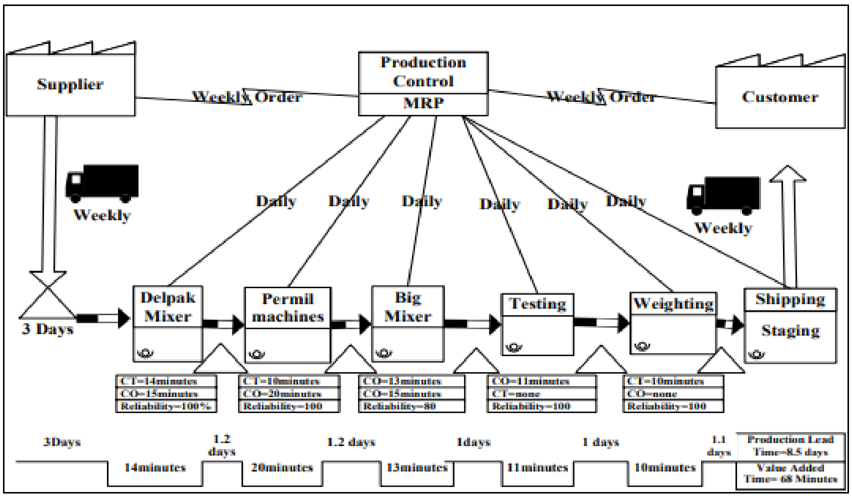


Figure 2.3: Example of VSM.

(Source: Rohani et al, 2015).

2.1.3 Flow

Flow is a step requires a complete rearrangement of the furniture and also to reduce the amount of variation for the output and process with the work instructions. Flow create a cellular design compare than a traditional straight line which helps to utilized people and communication much better (Pârv, L, 2017). This principle is stated that when you focus on the product and its needs, things become much better compare with the equipment or the organization. This is because all the activities are needed to order, provide and design a product that occur in continuous flow. However, the main problem is most people things that performing in batches is the best whereas rethink the task is more efficient and might permit continuous flow. Flow thinking is counterintuitive and the lean alternative is to redefine the department, firms and work of functions. This leads to a positive contribution to value creation and make the employees to have interest to make value flow because of the real needs at every point along the stream.

2.1.4 Pull

A pull system is simple and flexible method which balance and control the flow of the resources. The production and service is based on the customer demand compare that the forecasting. Blair (2010) found that pull can schedule, design and make what customer really need. The company or organization will let the customer to pull the product from them rather than pushing the products which is often unwanted to the customer. This indirectly will make the customer demand become more stable because they can get what they want straight away.

2.1.5 Perfection

Perfection is a continuous result improvement even in case of success because lean principle facilitates striving for perfection. There is no end to the process of reducing the time, effort, cost, mistake and space while offering a product nearly what customer wants (Pârv, 2017). The most important things in perfection is transparency and it is easy to find better ways to create value. Moreover, perfection helps employees to keep making improvement and this is a key feature for lean work and effort improvement.

2.2 Product Family Matrix

2.2.1 Concept of Product Family Matrix

For grouping products into groups, a Product Family Matrix may be used. It indicate which process steps are used by each product. Look for groupings of common steps of the method, then. The groupings are the families of items. According to Duggan (2018), the process phases are arranged with the last downstream processes by flow order. Downstream steps are phase steps that are closer to the client. For product families, by creating detours and arranging for the use of portable equipment, workflow layouts can be designed to accommodate minor variations in the workflow. Families with goods do not have to serve the same demand. Think in terms of processes exchanged, not markets shared. Table 2.1 below shows the example of Product Family Matrix (Chaple and Narkhede, 2017).

Table 2.1: Example of Product Family Matrix

			PRODUCT															
			P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16
PROCESS	SUB-ASSEMBLY 1	W-1	√	√	√	√	√	√	√	√	√						√	
		W-2	√	√	√	√	√	√	√	√	√							
		W-3	√	√	√	√	√	√	√	√	√							
		W-4																
		W-5																√
		W-6																√
		W-7										√	√	√	√	√		√
		W-8										√	√	√	√	√		
		W-9										√	√	√	√	√		
		W-10										√	√	√	√	√		
	PART 1	S-1				√	√	√	√	√		√	√	√	√		√	
		S-2				√	√	√	√	√		√	√	√	√		√	
		S-3				√	√	√	√	√		√	√	√	√		√	
		S-4	√	√	√	√	√	√	√	√		√	√	√	√		√	
	SUB-ASSEMBLY 2	R-1	√	√	√		√	√	√	√							√	
		R-2					√	√	√	√							√	
		R-3	√	√	√	√	√	√	√									
		R-4								√	√				√	√	√	√
		R-5								√	√				√	√	√	√
		R-6	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		R-7	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
		R-8	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
		R-9	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
	ASSEMBLY	A-1																√
		A-2	√	√	√													
		A-3	√	√	√													
		A-4				√	√	√	√	√	√	√	√	√	√	√	√	
		A-5				√	√	√	√	√	√	√	√	√	√	√	√	
		A-6																√
		A-7																√
		A-8																√
		A-9	√	√	√	√	√											
		A-10						√	√	√	√	√	√	√	√	√	√	
		A-11	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

2.2.2 Creating Product Family Matrix

It is important to take some time up front in order to define the product family for research and develop in order to achieve full benefits from the value stream mapping efforts (Bärring et al, 2017). The fundamental principle is higher volume goods is prioritized for enhancement. There are 2 steps for doing the product family matrix which are:

1. Collect data on production performance, both in delivered units and sales figures. The data is recommended to collect between 6 to 12 months.
2. In an attempt to define where to concentrate first, construct a Pareto map with this information for example that has highest volume products.

2.2.3 Product Routing Matrix

Another method that can be used if the results of the product quantity matrix are inconclusive is the product routing matrix. The product routing matrix supports how the process passes through each product family. The product can be grouped together and one set of value stream maps covering both products can be generated. The product routing matrix of the metal fabrication process is shown in Table 2.2 below (Rasi et al, 2014). The Table shows the eight goods and the procedures that each object requires to go through. Three products, for example; Hook ABC Suspension LV, ST LTG Bracket (Short Arm), and ST LTG Long Bracket (Long Arm) have passed through comparable processing steps and standard equipment.

Table 2.2: Metal Manufacturing Product Routing Matrix

Qty.	PRODUCT \ PROCESS	Cutting	Stamping	Rolling	Threading	Welding	Platting	Assembly	Resupply
77000	Hook ABC Suspension LV	X	X		X		X	X	
52000	Bolt & Nut GVD HRH Dia 5/8" x 7"								X
42000	Band Universal 7.5m & 9m		X				X	X	
32000	ST LTG Long Bracket (Long Arm)	X	X	X		X	X		
31000	Stay Rod 2.5m x 19mm	X			X		X	X	
29500	Bow With Thimble	X	X				X	X	
29000	Triangular Bracket For HV ABC		X				X	X	
26500	ST LTG Bracket (Short Arm)	X	X	X		X	X		

2.3 Time Observation Sheet

A basic and often-used tool for lean practitioners is the time observation sheet which also referred as a process study form. The Time Observation Sheet is used to observe the cycle times of the regular work measures (Starovoytova, 2017). The type serves several purposes in combination with a stop watch, including:

- Facilitating direct process observation such as one form per operator.
- Requiring the identification of the smallest measurable part tasks, operator and system time separation.
- Task times for recording components which may sometimes be grouped, if appropriate.
- Encouraging multi-cycle observation to help assess the lowest repeatable cycle times.
- Highlighting the difference in cycle time with the same and different operators and giving insight into the variability causes.
- Enabling waste to be detected.
- Facilitating the growth of standard work.

According to Brown (2020), time observations are a unique way of recording an entire process in a manner that is thorough and objective, from setup to cleanup. On the other hand, time studies essentially document the amount of time needed for such processes to be completed. Additionally, within each element, time studies start and stop, while a time observation records the entire process. Table 2.3 shows the example of Time Observation Sheet.

Table 2.3: Example of Time Observation Sheet

Time Observation Sheet

Project Area / Machine ______________________ Date ______________

NO.	Component Task	1	2	3	4	5	6	7	8	9	10	Component Task time	Points Observed
1													
2													
3													
4													
5													
6													
7													
8													
9													
11													
12													
10													
13													
14													
	TIME FOR 1 CYCLE												

2.4 Standard Work Combination Sheet

The number of separate operations that each worker should be assigned must be determined after deciding the manual process time and cycle time for each operation. At the same time, it is important to establish the order of actions that each worker must perform within a given cycle time. Lu et al (2014) stated that a Standard Work Combination Sheet is a common work method that is based on the type of time observation and defines the sequence in which machines are visited and the relationship between operators or machines.

As a basis for allocating the function of the time observation form, Standard Work Combination Sheet uses takt time. In addition, this step visually differentiates between operator and machine operation. It also reveals issues related to the operator and computer combination. During a work cycle, the traditional work combination table schedules the work of one operator. It is therefore primarily useful for manual cyclic work that repeats almost identically for each component generated. All assembly procedures are prime examples but other manual methods which are mainly cyclic may also be included.

2.4.1 TAKT Time

The rate of production in harmony with the pulse of customer orders is TAKT Time. 'TAKT' is the German term for a musical beat or rhythm (Pereira et al, 2016). As the metronome holds the beat for music, working to TAKT time maintains the beat for consumer demand. This results in a constant and smooth flow of products. TAKT time is not measured or observed but determined by the performance required as the quotient of the available time. The management of TAKT time output makes it possible to detect any irregular condition and respond accordingly. There are many concepts to define and measure the output rate to understand total cycle time, activity cycle time, operator cycle time, machine cycle time, end-of-line rate, TAKT time and pitch. The total cycle time is the time from when the raw material enters a plant to the shipping of a finished product.

2.4.2 Creating Standard Work Combination Sheet

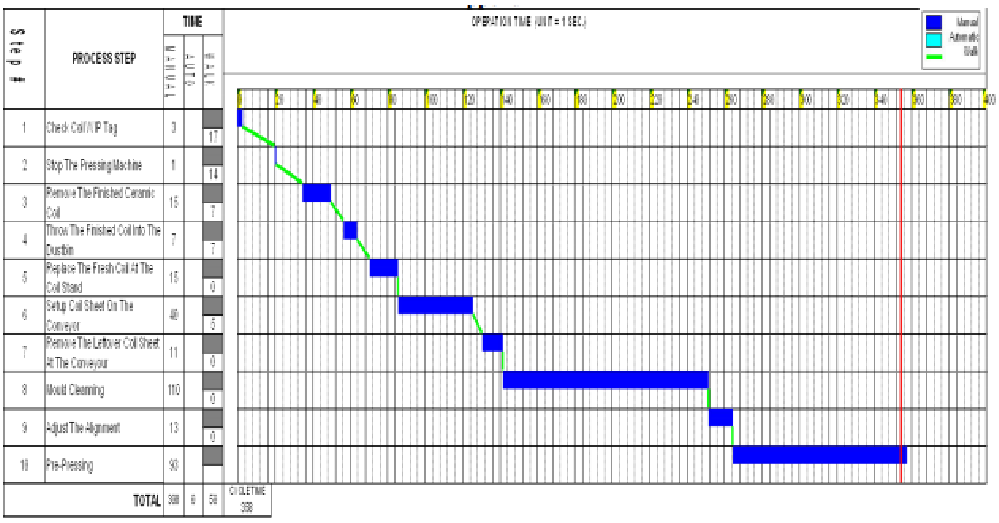
Different ways of research carry together the collected data. For deciding whether there is any substantial amount of waste in the delays between separate process phases, the Combination Sheet can be very useful. In order to solve such problems, it can also provide a clear example of the kind of direction the organization wants to operate in.

The time needed for human movement, as well as machine movement, all based on TAKT time are the most significant points reported in the Combination Sheet. The organization will calculate just how much an individual worker is responsible for with the correct use of a Combination Sheet and if an employee is overburdened by their current duties, it will become more apparent.

It may also demonstrate whether a specific employee might be best used. It's not unusual for a business to not realize that one of its staff is substantially underutilized, spending even less time doing real work than the suspect. Also, in a smaller company with more supervision, it's always possible for these concerns to slip through the cracks.

But when everything is properly registered and accounted for, you will have all the data right in front of you using all the appropriate resources to build a structured working environment. Table 2.4 below shows the example of Standard Work Combination Sheet (Puvanasvaran, 2018).

Table 2.4: Example of Standard Work Combination Sheet



Step	PROCESS STEP	MANUAL	AUTO	WALK
1	Check Coil WIP Tag	3		17
2	Stop The Pressing Machine	1		14
3	Remove The Finished Ceramic Coil	15		7
4	Throw The Finished Coil Into The Dustbin	7		7
5	Replace The Fresh Coil At The Coil Stand	15		0
6	Setup Coil Sheet On The Conveyor	40		5
7	Remove The Leftover Coil Sheet At The Conveyour	11		0
8	Mould Cleaning	110		0
9	Adjust The Alignment	13		0
10	Pre-Pressing	93		
	TOTAL	308	0	50

CYCLE TIME 358

2.4.8 KAIZEN

KAIZEN is basically means "improvement" and its policy calls for relentless efforts to boost involving everyone in the organization, including administrators and staff. KAIZEN is a Japanese word that means constant gradual, orderly and improvement. The KAIZEN business strategy includes everybody in an organization working together to achieve improvements without large investments in capital (Ravee, 2014). KAIZEN philosophy is continuous improvement oriented towards the reduction of waste in all processes and organizational methods, beginning with the GEMBA. The principle of KAIZEN are human resources is the most important asset to the company. Next, the processes must develop by incremental development rather than drastic reform. Lastly, the progress shall be based on statistical or quantitative method efficiency evaluations.

2.4.8.1 KAIZEN key features

1) Improvements are based on many, minor changes rather than the radical changes that could result from the Research and Evolution.
2) As the ideas come from the workers themselves, they are less likely to be radically different and therefor it is easier to deploy.
3) Small improvements are less likely to require significant capital investment than major changes to the processes.
4) The ideas originate from the skills of the local workers and not from the use of R&D, consultants or equipment that may be really costly.
5) All workers should be actively searching for ways to enhance their own results.
6) It helps encourage employees to take ownership of their work and can help strengthen the team's work and enhancing workplace motivation.

2.4.8.2 KAIZEN strategy

The Kaizen approach involves other approaches and techniques essential for the effective implementation of the strategy in an organization (Markulik, 2016). Kaizen Management System (KMS) creates a wholesome system by integrating both methods and tools. It is a system for an organization's long-term growth. All workers and their creativity are included in the key tools, setting all procedures, zero tolerance to all errors and faults, productive use of equipment and technology, use of lean production systems and Quality Cost Delivery (QCD) which is shown in Figure 2.4 below (Cierna et al, 2016). It has four fundamental pillars which are Total Flow Management (TFM), Total Productive Maintenance (TPM), Total Quality Management (TQM), Total Service Management (TSM) and its distinct thinking is related to Total Change Management (TCM). The key objective of KMS is to continuously boost the supply of materials and subcontracts to meet the needs of customers (Nenadal, 2015).

Figure 2.4: Kaizen Management System

(Source: Cierna et al, 2016).

2.4.8.3 Toyota Production System

Paraschivescu et al (2015) claims that the accomplishments of Toyota Company known as Toyota Production System can be found in the best practices in the field of Kaizen theory. The Toyota Production System became the foundation for Lean Manufacturing, and since the early 1990s, Six Sigma philosophies have been prevalent in the industry. The Toyota Production System contains 14 management principles which can be correlated into 4 keys categories of Philosophy, Process, People and Partners and Problem solving as shown in Figure 2.5 below.

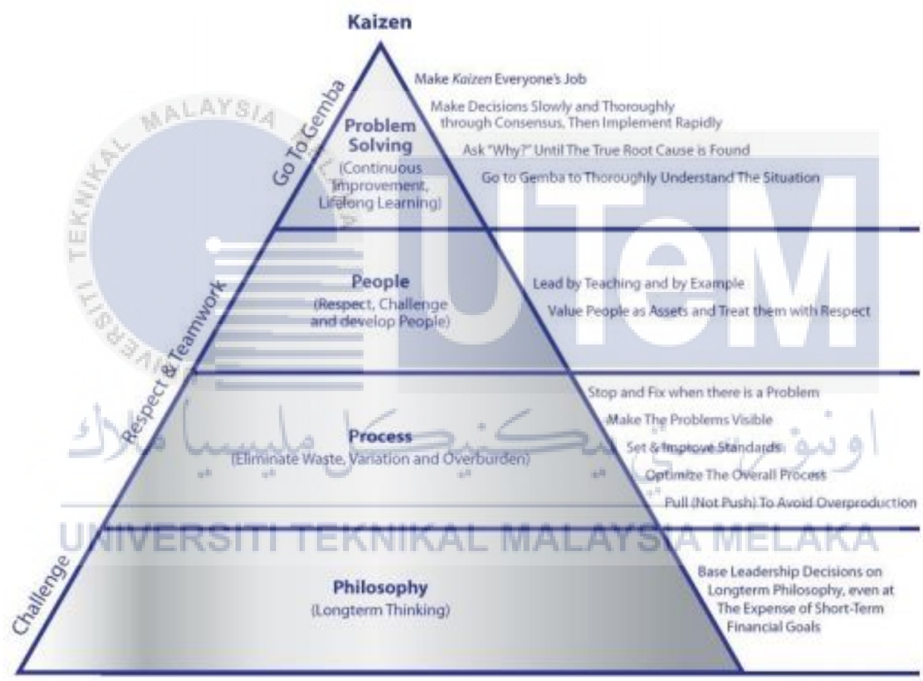


Figure 2.5: 4 Keys Categories of Toyota Production System

(Source: Paraschivescu et al, 2015)

2.4.8.4 Example of KAIZEN analysis tools

A Successful KAIZEN activity has three important factors. First of all, all the employees at Gemba which are the workers at the Production site must grasp the principle of KAIZEN and be optimistic and enthusiastic about the benefits from practicing KAIZEN activity vigorously. Secondly, top management needs to understand, promote and learn how to better assess the outcome of the KAIZEN efforts of the employees which only the introduction of KAIZEN activities at the workplace can lead to a false sense of the achievement, without quantifiable results. Thirdly, based on Shettar et al. (2015), everyone involves must understand and practice KAIZEN techniques on a daily basis and also need to understand the spirit and philosophy that underlies it. The concept of KAIZEN is composed of four elements which are quality, effort, willingness to improve and communication. Figure 2.6 below shown the example of KAIZEN.

Figure 2.6: Example of KAIZEN

(Source: Shettar et al., 2015).

2.4.9 Value Stream Mapping (VSM)

According to Pambhar and Awasthi (2017), Value Stream Mapping (VSM) can be a business planning and communication tool to lead the change in process. The goals and objectives of VSM are to discover and observe the material flow from raw material to final customer in real time. VSM also helps visualize any losses in the process by using symbols as the representation of the process visually and clearly (Forno et al., 2014).

By creating VSM, it allow company to document current inventory levels, cycle times and production lead time. This helps to identify the ration of any value added to the total lead time of the service or product and indirectly creating a vision for ideal value flow. This process of documenting relationship is very important in VSM. This is very different with other mapping techniques which has only map product flow (Muniyappa and Prasad, 2014).

According to Yuvamitra et al. (2017), VSM is an essential tools for these reasons:

1) The information of the material flow in VSM helps to visualize the multiple process including the overall manufacturing material flow instead of single operation.
2) Any problem areas, waste and source of waste also can be identified by using VSM.
3) VSM is served as a blueprint for Lean application.
4) It shows the linkage or relationship of the material and information flow.
5) VSM can be also been use as quantitative or qualitative tools and it ties the Lean techniques and concept together.

2.4.9.1 Value Stream Mapping analysis tools

Construction of VSM requires three steps which are current, future and next future state as shown in Figure 2.7, 2.8 and 2.9 below. Akçagün (2012) investigated that improvement efforts may be based on those by drawing and examining the current state map areas which will give process flow the greatest benefit. In addition to priority incremental improvements, VSM can be used as a Continuous Strategic tool for change, by building an optimistic future state focused on the principles of Lean Manufacturing. The Future state map is the basis for a long-term improvement plan that can be implemented within an organization and their supply chain. Production value is defined as a capability offered to a customer of the highest performance, on time and quality at a fair price (Xia and Sun, 2013).

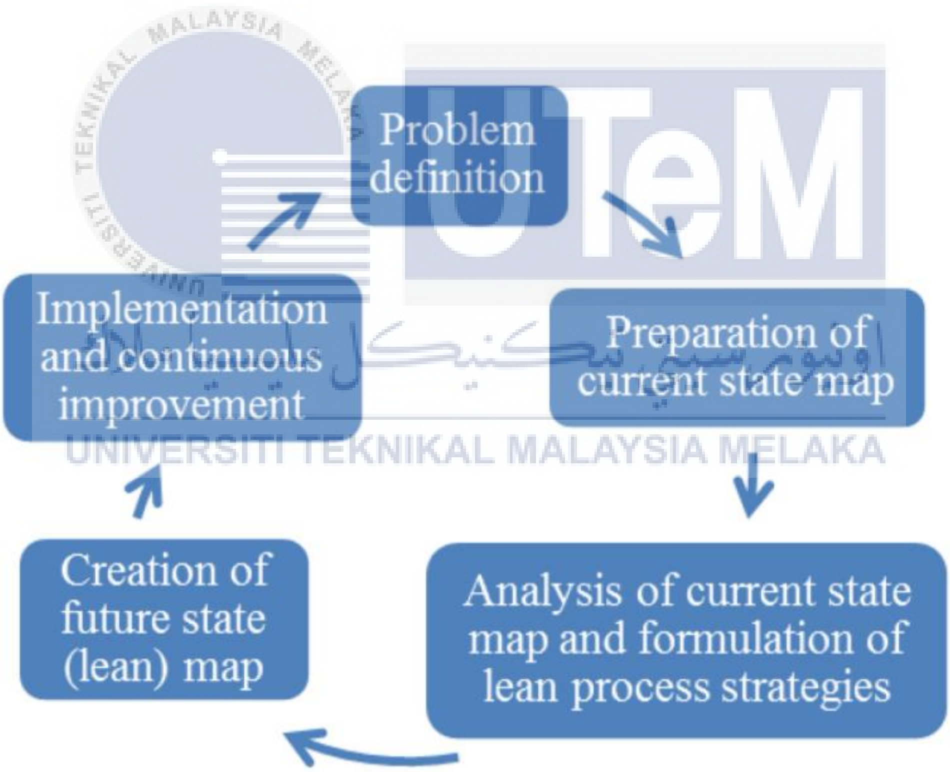


Figure 2.7: VSM Steps

(Source: Jeong et al, 2016).

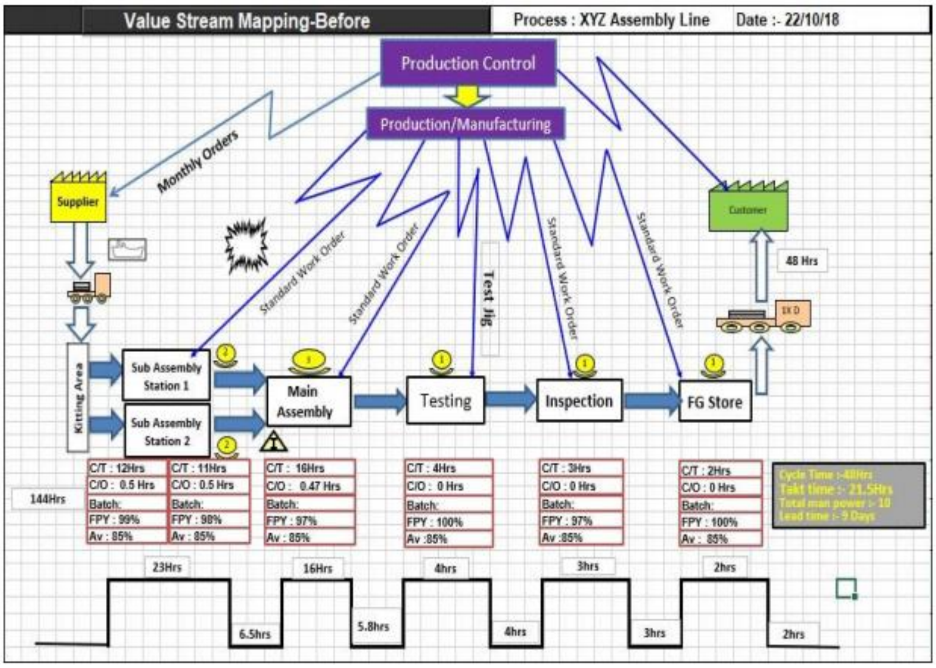


Figure 2.8: Current state VSM.

(Source: Rajule et al, 2018)

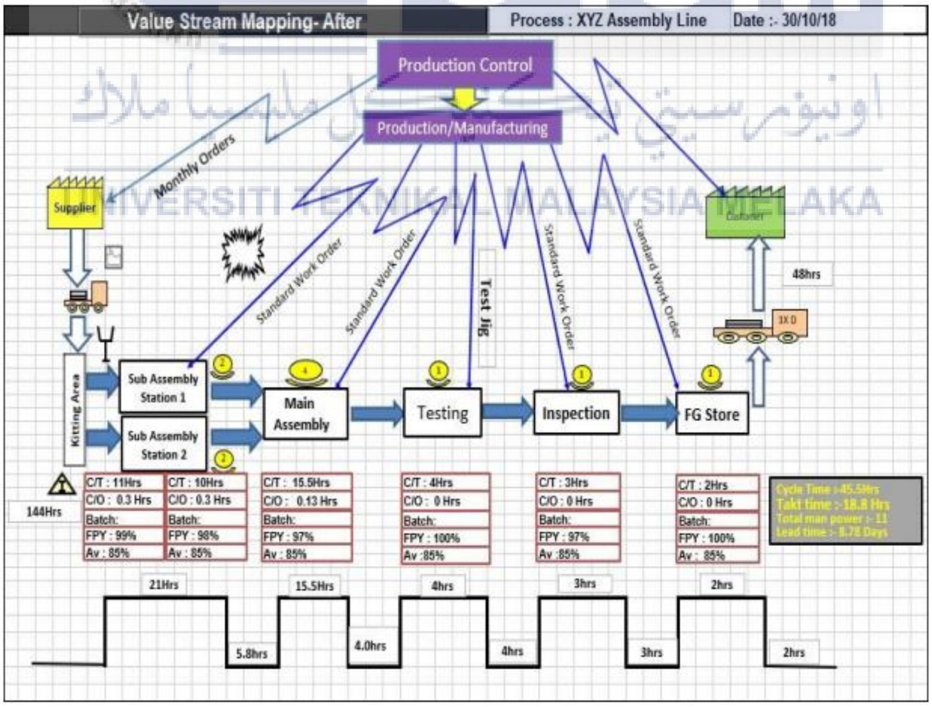
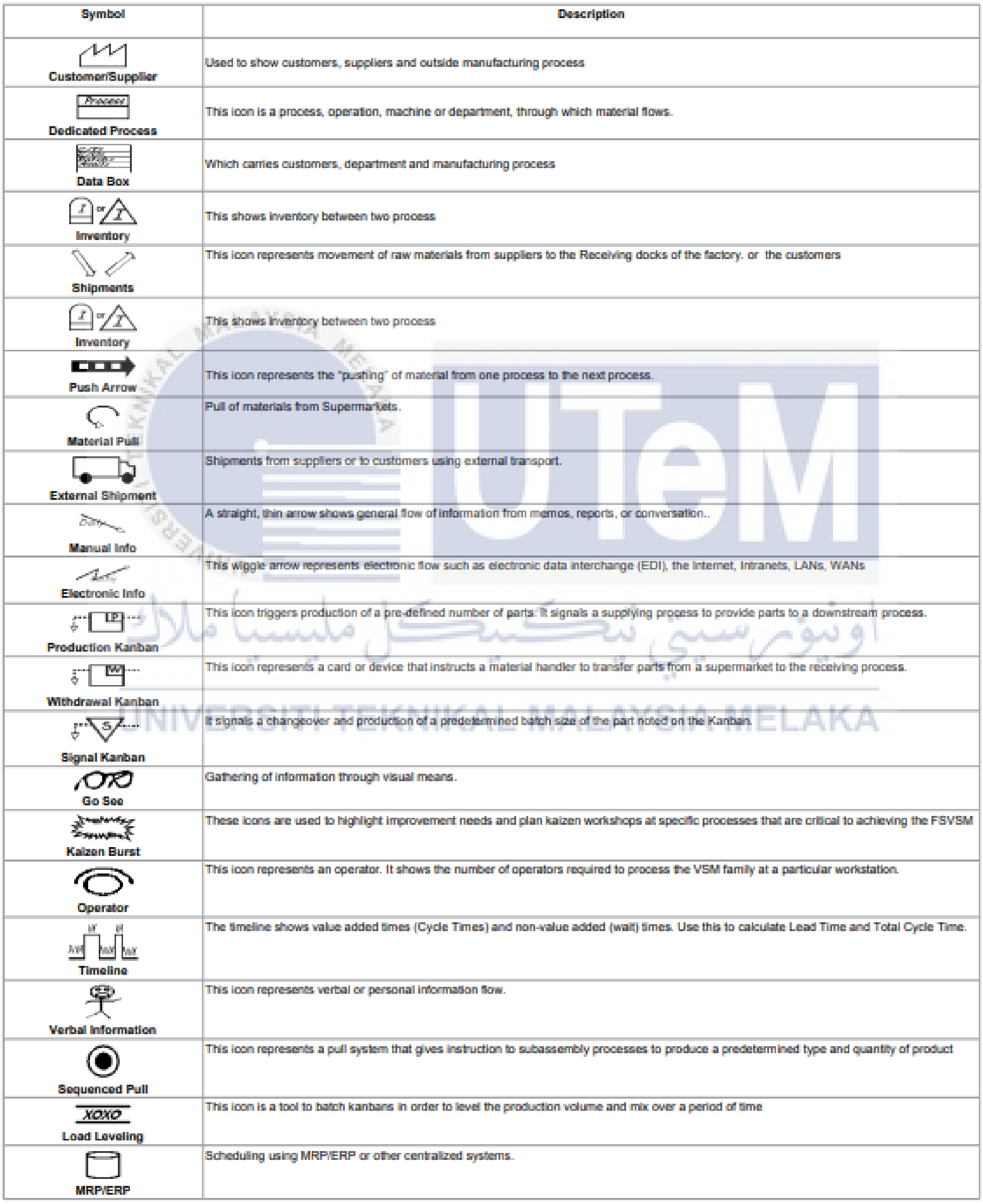


Figure 2.9: Future state VSM.

(Source: Rajule et al, 2018)

2.4.9.2 Value Stream Mapping Symbols

Dushyan et al (2015) investigated that the VSM symbols and terminologies for present and future preparations of value stream mapping is shown in Figure 2.10 below.



Symbol	Description
Customer/Supplier	Used to show customers, suppliers and outside manufacturing process
Dedicated Process	This icon is a process, operation, machine or department, through which material flows.
Data Box	Which carries customers, department and manufacturing process
Inventory	This shows inventory between two process
Shipments	This icon represents movement of raw materials from suppliers to the Receiving docks of the factory. or the customers
Inventory	This shows inventory between two process
Push Arrow	This icon represents the "pushing" of material from one process to the next process.
Material Pull	Pull of materials from Supermarkets.
External Shipment	Shipments from suppliers or to customers using external transport.
Manual Info	A straight, thin arrow shows general flow of information from memos, reports, or conversation..
Electronic Info	This wiggle arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs, WANs
Production Kanban	This icon triggers production of a pre-defined number of parts. It signals a supplying process to provide parts to a downstream process.
Withdrawal Kanban	This icon represents a card or device that instructs a material handler to transfer parts from a supermarket to the receiving process.
Signal Kanban	It signals a changeover and production of a predetermined batch size of the part noted on the Kanban.
Go See	Gathering of information through visual means.
Kaizen Burst	These icons are used to highlight improvement needs and plan kaizen workshops at specific processes that are critical to achieving the FSVSM
Operator	This icon represents an operator. It shows the number of operators required to process the VSM family at a particular workstation.
Timeline	The timeline shows value added times (Cycle Times) and non-value added (wait) times. Use this to calculate Lead Time and Total Cycle Time.
Verbal Information	This icon represents verbal or personal information flow.
Sequenced Pull	This icon represents a pull system that gives instruction to subassembly processes to produce a predetermined type and quantity of product
Load Leveling	This icon is a tool to batch kanbans in order to level the production volume and mix over a period of time
MRP/ERP	Scheduling using MRP/ERP or other centralized systems.

Figure 2.10: VSM symbols.

(Source: Dushyan et al., 2015).

CHAPTER 3

METHODOLOGY

This chapter describes the method applied in this project. The methodology implemented was based on previous research as highlight in the literature review.

3.1 Introduction

The methodology describes the process involved in gathering the information including the process flow of this study and the data collection in sub-assembly process area at Dormakaba Production Malaysia Sdn Bhd. Methodology is the specific procedures used to identify and analyse the information in preparation for further lean manufacturing techniques. Methodology helps in order to achieve the objectives of the project stated.

3.2 Flow chart

A process flowchart is a business process which represent the graphical view of overall procedure involved in this study. It is used to get the detailed and top-down view on the process flow, procedure and event outcomes. The flow chart shown in Figure 3.1 below describes the whole view of the development of lean manufacturing approach in this study.

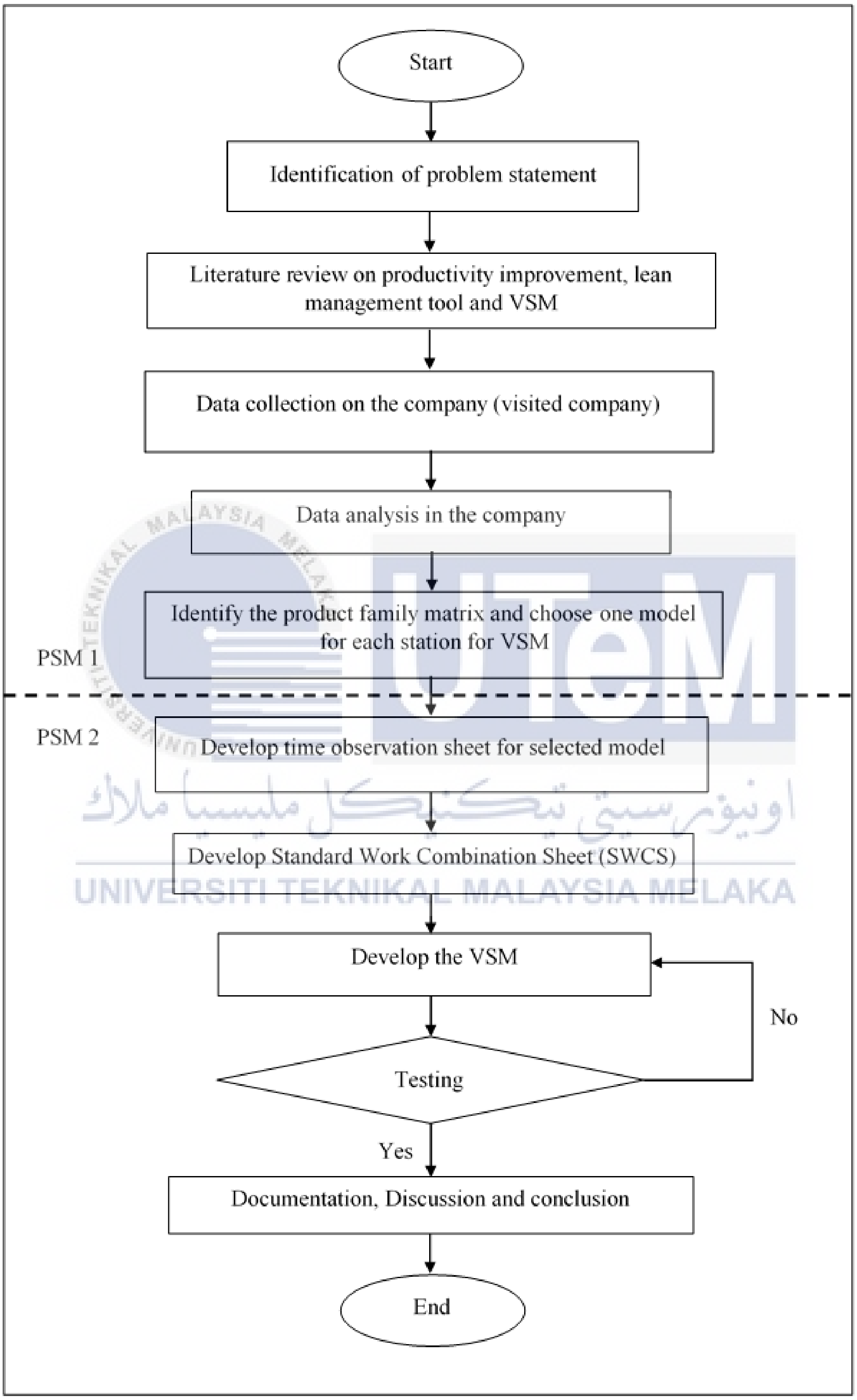


Figure 3.1: Flow chart of the whole view on the development of lean manufacturing for research in PSM 1 and PSM 2.

3.2.1 Identification of problem statement

A problem statement is a concise explanation of a problem to be dealt with or a condition to be built upon. Identifying the problem statement requires listing the problem statement, deciding the goal of the project and describing the nature of the project.

3.2.2 Literature review

Literature review consist of scholarly paper which provide the current knowledge, analytic observations, reviewing the theoretical and also methodological that contributes to a specific field or topic of the project. The literature review will identify, determine and provide the historical analysis of literature research and theory. The literature review definitely important especially on the subject of the project because it can give special emphasis on the topic of the project. The summary of the research is drawn up and focus mainly on productivity improvement, lean manufacturing tool and VSM.

3.2.3 Data collection

The process of collecting the data include the compilation of the qualitative and quantitative of information on variables which the main target is analysing the outcomes and gaining the actionable insights. The collected data in this project are more on quantitative research because most of the data can be counted, measured and also expressed using numbers. Table 3.1 below manufacturing information of various models of sub-asssembly department for the past 9 months and the graph of station name/model run with the number of process. This method can help to achieve the first objective of this project which is investigation of the current process for each model in sub-assembly department.

Table 3.1: Manufacturing Information of Various Models of Sub-Assembly department (Dormakaba Production Malaysia Sdn Bhd; March 6, 2020).

STATION NAME / MODEL RUN	MATERIAL	PROCESS	QUOTA PER SHIFT	GROSS WEIGHT (KG)	MAN POWER
Spring Adjustment Screw (SAS)					
Spring adj. Screw assy ts73v bl	28140903150	5	1000	64	1
Spring adj. Screw assy ts83 bl	28140901150	5	1600	93	1
Spring adj. Screw assy ts83 en 2-5 bl	28140904150	5	1600	93	1
Spring adj. Screw assy ts92 – new	24336402150	6	1000	64	2
Spring adj. Screw assy ts93 en2-5	24305501150	6	2300	128	2
Spring adj. Assy ts73v - new	28131004150	6	1000	64	1
Manual screw bag (MSB)					
Cushion bc valve assy	28227101150	1	4800	237	1
Piston					
Damping piston assy ts91/92	24335501150	6	1260	100	1
Damping piston assy ts90 fork pusher	24500506150	5	1170	202	1
Opening piston assy ts90 fork pusher	24500806150	7	1170	163	1
Piston assy 7/8600	9800008200150	9	1650	145	1
Bearing					

Bearing housing assy 700/8600 sta	9800008210060	4	1300	77	1
Bearing housing assy ts83/73v bl-nanfang	28140604150	4	100	9	1
Bearing housing assy ts90 bc	24500402150	4	1100	63	1
Bearing housing assy ts90 (O-ring fx428 w)	24500403150	4	1100	63	1
Pinion bearing bottom assy ts93 ansi 1-5	24300402150	4	100	12	1
Pinion bearing top assy ts93 en5-7	24303001150	4	100	12	1
Bearing housing assy 8900	9800008085020	4	600	46	1
Bearing housing assy gr400 (nanfang)	25300402150	4	800	47	1
Bearing housing assy gr500	25300401150	4	200	24	1
Bearing housing assy ts83/89	24120401150	4	200	10	1
Bearing housing assy 7400/8600	9800008200320	4	1300	77	1
Bearing housing assy ts90	24500401150	4	1100	63	1
Bearing housing assy ts92	24335401150	4	1200	68	1
Pinion bearing bottom assy 2-5	24306301150	4	2300	136	1
Pinion bearing top assy 2-5	24306301151	4	2300	128	1
Bearing housing assy (bl) 2/1865 (ts73bl)	28140604150	4	1200	71	1

Bearing housing assy ts83/73v bl	28140601150	4	3200	166	1

3.2.4 Data analysis

After collecting the data from the site visit, the data need to be clean and transform to discover any useful information. For VSM, only one model has been chosen based on its process, quota per shift, gross weight and man power. Based on Figure 3.2 below, the chosen product for VSM implementation is Piston assy 7/8600 because it has highest process which is 9. It also has high quota per shift compare with other model which is 1650. Therefore, VSM is needed for the model Piston assy 7/8600. This method can helps to achieve the second objectives of this project which is the identification of the model that need to carry out lean tools to reduce the cost, waste, waiting time, defect and product delivery speed.

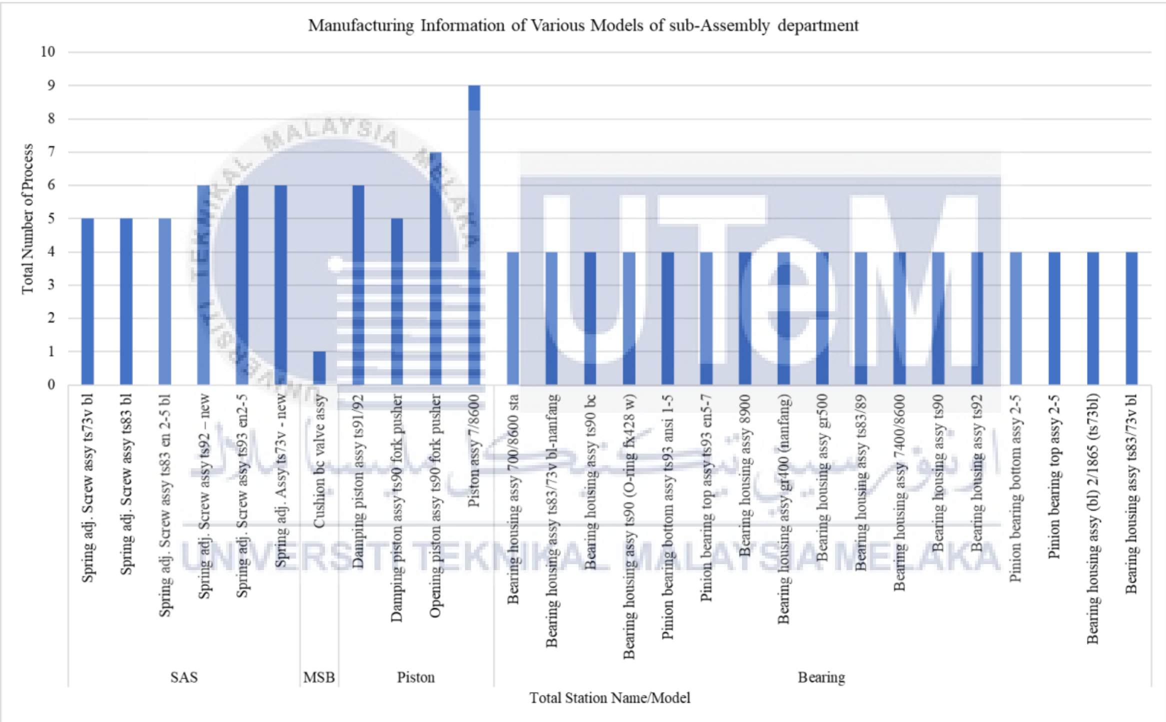


Figure 3.2: Manufacturing Information of Various Models of sub-Assembly department

(Dormakaba Production Malaysia Sdn Bhd; March 6, 2020).

3.2.5 Identify the product family matrix

VSM only focus fewer part, service, transaction or process. Product family derived from a common or similar product platform, process and machine. It also have similar physical characteristics and share customer segment, pricing, distribution and also promotional campaigns. The reason why product family matrix is crucial in lean technique is because it can segment the product/models into the right product/model families. It also maximize the lean flow and manage the total demand for the entire product family. Table 3.2, 3.3, 3.4 and 3.5 below shown the product family matrix for SAS, Piston and Bearing. This method can helps to achieve the third objectives of this project which is to validate the data for product family matrix for the model.

Table 3.2: Product family matrix for Spring Adjustment Screw (SAS).

(Source: Dormakaba Production Malaysia Sdn Bhd).

Spring Adjustment Screw (SAS)		PROCESSING STEPS AND MACHINES									
		Insert pressure disc	Insert O-ring	Place on the jig	Place adjustment screw	Drill screw	Place retainer	Place disc washer	Place precision tip	Activate gripper	Place complete model in box
MODEL	SAS ts73v bl	X	X		X		X	X			X
	SAS ts83 bl	X	X		X		X	X			X
	SAS ts83 en 2-5 bl	X	X		X		X	X			X
	SAS ts92 – new	X	X	X	X			X	X	X	X
	SAS ts93 en2-5	X	X	X	X				X		X
	SAS ts73v - new	X			X		X	X			X

Table 3.3: Product family matrix for Piston.

(Source: Dormakaba Production Malaysia Sdn Bhd).

Piston		PROCESSING STEPS AND MACHINES											
		Arrange Piston	Place PLV	Place roller	insert bolt	Activate hydraulic cylinder press	Knock PLV	Air blow PLV	Load on clamping sleeve	Load on sleeve punch machine	Load on crimping station	Crimp piston	Arrange piston in box.
MODEL	Damping piston assy ts91/92	X		X	X						X	X	X
	Damping piston assy ts90 fork pusher	X		X						X			X
	Opening piston assy ts90 fork pusher	X		X	X				X	X			X
	Piston assy 7/8600	X	X			X	X	X					X

Table 3.4: Product family matrix for Bearing.

(Source: Dormakaba Production Malaysia Sdn Bhd).

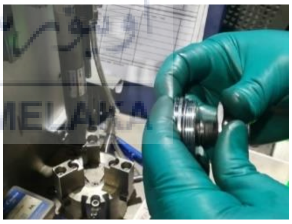
Bearing		PROCESSING STEPS AND MACHINES				
		Pick pinion bearing	Insert and press O-Ring first	Place needle bearing top	Place the bearing housing under Press machine	Blow and Insert O-Ring last
MODEL	700/8600 STA	X		X	X	X
	TS83/73V BL-NANFANG	X		X	X	X
	TS90 BC	X	X	X	X	
	TS90 (O-ring FX428 W)	X	X	X	X	
	TS93 ANSI 1-5	X		X	X	X
	TS93 EN5-7	X		X	X	X
	8900	X		X	X	X
	GR400 (NANFANG)	X		X	X	X
	GR500	X		X	X	X
	TS83/89	X		X	X	X
	7400/8600	X		X	X	X
	TS90	X	X	X	X	
	TS92	X	X	X	X	
	BOTTOM ASSY 2-5	X	X	X	X	
	TOP ASSY 2-5	X	X	X	X	
	(BL) 2/1865 (TS73BL)	X	X	X	X	
	TS83/73V BL	X	X	X	X	

Noted: Last process is transfer the finished part to the box

Table 3.5: The detail process of station name/model run

(Source: Dormakaba Production Malaysia Sdn Bhd).

STATION NAME / MODEL RUN	PROCESS	PRODUCT FIGURE
Spring Adjustment Screw (SAS)		
• Spring adj. Screw assy ts73v bl • Spring adj. Screw assy ts83 bl • Spring adj. Screw assy ts83 en 2-5 bl	1) Left hand pick pressure disc and right hand pick O-ring and hold it on right hand. 2) Left hand pick the adjustment screw and insert into pressure disc. Right hand pick O-ring and insert into the adjustment screw. 3) Place the part downward onto the fixture and right hand pick one retainer and place it on the fixture and follow by pressing the retainer with a lever. 4) Place the part in the hole facing upwards and right hand pick two disc washer and follow by O-ring. 5) Place the complete spring adjustment screw in the box.	 **Figure 3.3**: SAS ts73v bl  **Figure 3.4**: SAS ts83 bl  **Figure 3.5**: SAS ts83 en 2-5 bl
• Spring adj. Screw assy ts92 – new	1) Right hand take pressure disc and left hand take adjustment screw. Insert pressure disc on the adjustment screw and place in on the jig. 2) Pick one washer and place it into the adjustment screw. Pick precision tip with left hand and take an O-ring with right	 **Figure 3.6**: SAS ts92 – new

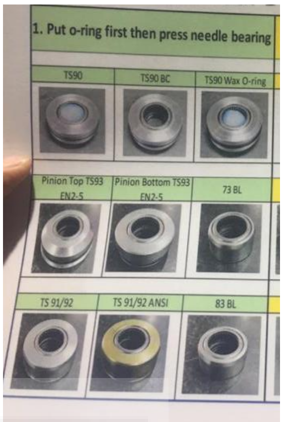
	hand. Place the precision tip and press the O-ring into the O-ring groove. Place the finished part into the box. Pick all at the same time. 3) Right hand pick the finished part, check for the O-ring before load it on the fixture. Left hand pull the lever to activate the gripper to lock the pressure disc. 4) Right hand pick end cap and left hand pick O-ring. Place O-ring into the end cap. 5) After the torque test is done and cylinder is going up unlock the gripper with left hand. Right hand pick finished part from fixture and press the finished part into the end cap. 6) Place the final part in the box.	
Spring adj. Screw assy ts93 en2-5	1) Left hand take pressure disc and right hand take adjustment screw. Insert pressure disc on the adjustment screw and place it on the jig. 2) Pick two washers and place it into the adjustment screw. Pick precision tip with left hand and take an O-ring with right hand. Place the precision tip and press the O-ring into the O-ring groove. Place the finished part into the box. 3) Pick the finished part with right hand and place it into fixture of the torque test. Press the green button to start the torque test.	 **Figure 3.7**: SAS ts93 en2-5

	4) Left hand pick end cap and right hand pick O-ring. 5) Place O-ring into the end cap. Right hand pick finished part from fixture and press the finished part into the end cap.	
Spring adj. Assy ts73v - new	1) Pick 12 pcs pressure disc with both hand and placed it onto dummy. 2) Insert SAS Ts73 screw at the centre of pressure disc. 3) RH drill the screw into pressure disc for 5mm (±1.0mm) while LH hold copper brush to remove remaining stains at the part. 4) Pick 1 pcs part at fixture and place O-ring Ø8x1.5 follow by inserting washer then used RH press the retaining ring in with a lever. 5) Pick and insert O-ring Ø8.5x2 using RH. 6) Lastly, place the completed part into the box.	 **Figure 3.8**: SAS ts73v - new
Manual screw bag (MSB)		
Cushion bc valve assy	1) Use both hand to count the screws and drop into the chute.	 **Figure 3.9**: Cushion bc valve assy

Piston		
Damping piston assy ts91/92	1) Pick & Arrange Piston On Work Station. 2) Pick & place roller into piston. 3) Pick & insert bolt between roller and piston. 4) Load piston on crimping station. 5) Crimp piston by push 2 button. 6) Pick & arrange piston assy inside nylon box.	 **Figure 3.10**: Damping piston assy ts91/92
Damping piston assy ts90 fork pusher	1) Pick & Arrange Piston On Work Station. 2) Pick & place roller into piston. 3) Lift piston guide, pick & insert piston inside sleeve punch machine. 4) Pick & insert roller & sleeve pins inside machine. Lift piston guide & take out piston. 5) Pick & arrange piston assy inside nylon box.	 **Figure 3.11**: Damping piston assy ts90 fork pusher
Opening piston assy ts90 fork pusher	1) Pick & Arrange Piston On Work Station. 2) Pick & place roller into piston. 3) Pick & insert bolt between roller and piston. 4) Push bolt with tools. 5) Pick & insert clamping sleeve into piston. 6) Punch clamping sleeve with hammer & punching tools. 7) Pick & arrange piston assy inside nylon box.	 **Figure 3.12**: Opening piston assy ts90 fork pusher

<table>
<tr><td>Piston assy 7/8600</td><td>1) Pick & Arrange Piston.
2) Pick & arrange PLV at piston hole.
3) Knock slightly PLV to piston.
4) Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press (2 piston each).
5) Pick & arrange PLV at other piston hole.
6) Knock slightly PLV to piston.
7) Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press (2 piston each).
8) Air Blow & Clean Both PLV area.
9) Arrange piston assy inside nylon box.</td><td>
Figure 3.13: Piston assy 7/8600</td></tr>
<tr><td>Bearing</td><td></td><td></td></tr>
<tr><td>List of bearing which put needle bearing first then put O-ring:
• 700/8600 sta
• ts83/73v bl-nanfang
• ts90 bc
• ts90 (O-ring fx428 w)
• ts93 ansi 1-5
• ts93 en5-7
• 8900</td><td>1) Pick pinion bearing approx. 1 pcs and place on work table.
2) Place needle bearing on top of the bearing housing with numbering facing upward.
3) Place the bearing housing under the Pressing fixture. Both hand press the Press button to activate the pressing motion. Press the bearing fully and release the push button to end motion.
4) Put the bearing housing in fixture blow the O-ring area before insert O-ring. Insert O-ring properly into the groove. Place the complete bearing housing assembly inside the container.</td><td>

Figure 3.14: List of bearing which put needle bearing first then put O-ring</td></tr>
</table>

• gr400 (nanfang) • gr500 • ts83/89 • 7400/8600		
List of bearing which put O-ring first then put needle bearing: • ts90 • ts92 • bottom assy 2-5 • top assy 2-5 • (bl) 2/1865 (ts73bl) • ts83/73v bl	1) Pick bearing housing approx. 1 pcs and place on work table. Insert O-ring into bearing housing. Press the O-ring fully inside the B.hsg by mean of a pressing tool. 2) Place needle bearing on top of bearing housing. Ensure orientation of needle bearing is correct. (Wording on top). 3) Place bearing under press machine and press push button with both hands. Needle bearing were insert in. 4) Transfer assemble part to the box.	 **Figure 3.15**: List of bearing which put O-ring first then put needle bearing

3.2.6 Develop time observation sheet

Time observation sheet is a method of gathering the data such as cycle time of the procedure of standard work for the each of model. This data is then used for further analysation to prove a theory or opinion and also to detect any pattern in a process. Figure 3.16 below shown the flowchart of developing the time observation sheet.

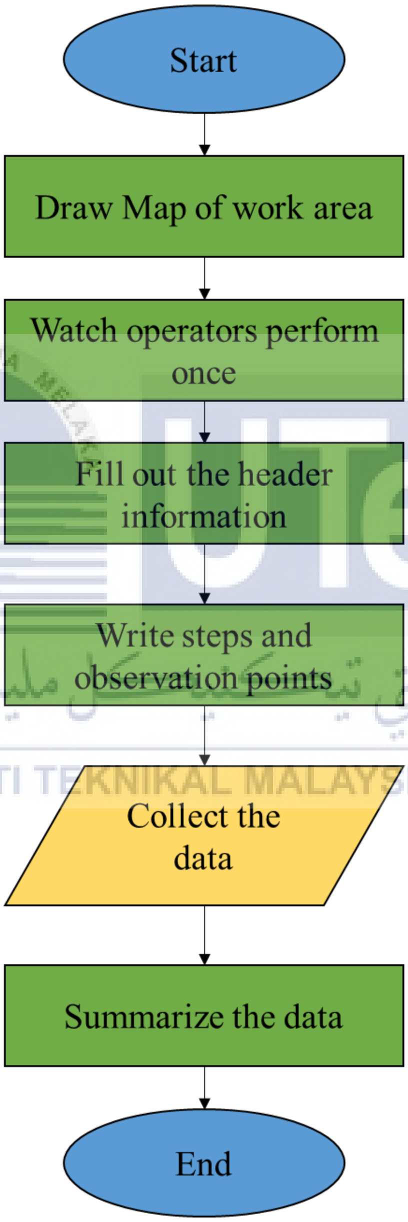


Figure 3.16: Flowchart of developing the time observation sheet.

The time observation form, also known as a form of process analysis, is a fundamental and often-used tool for lean practitioners and the implementation of the method of continuous time observation and not the method of work sampling. The first step is to draw the map of the work area. Mapping the work area is a strategic tool which helps organize successfully by providing a picture of the focus working areas. The information gather will give an accurate idea of the areas that need to be organized step-by-step. On a Standard Work Paper, draw a map of the working area. This is not the final edition of the Standard Work Sheet and it is merely a working document. It also recommend to make photocopy of the prototype map without any more markings on it so that if there is any error, this will speeds things along. Figure 3.17 below shown the map of the work area for Piston Assy 7/8600 model.

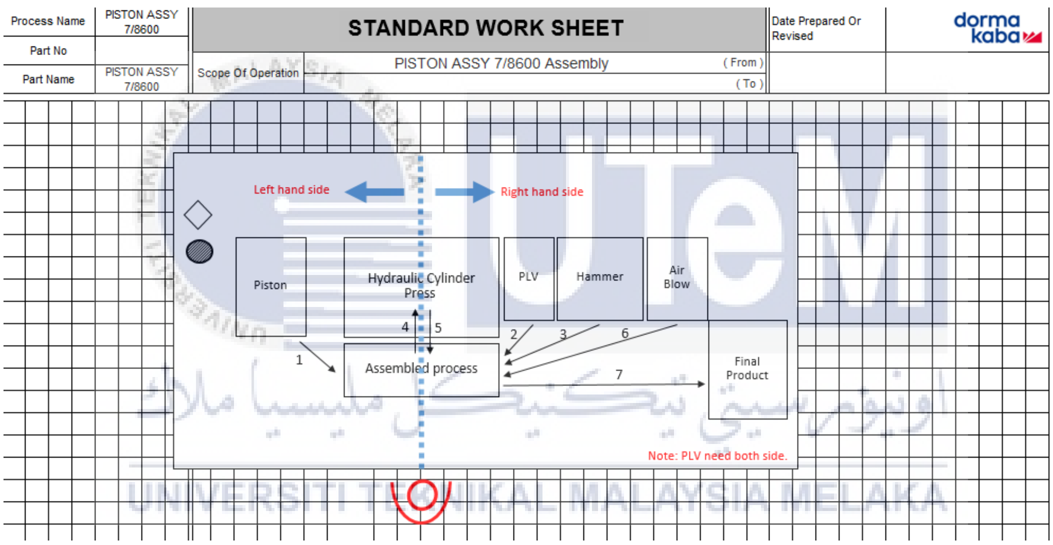


Figure 3.17: Standard Work Sheet for Piston Assy 7/8600 model

Next, watch the operators to perform once see the operator do his or her job once without having to write something, just to get a feel for the process. The operator will be an ordinary operator running at a reasonable speed not an expert or the slowpoke. On the Standard Work Sheet, watch the operator a second time, draw the operator's direction, and write down process steps. Include in the notes observation points. These are unique points of change that serve as limits between steps. They must be readily measurable, points that are discrete. This produces continuity in how the steps are recorded, eliminating variance that makes it more difficult to set a norm.

Fill out the header information such the type/name of model, date, time, and person in charge. Different model has different steps and observation points. It is very important to write every detail for the steps to get accurate data. Write steps and observation points on the sheet and on your clipboard, put a blank sheet of paper under the observation sheet. This will be used to make any notes on issues the face. Collect the data by start the stopwatch at the beginning of the process until the last process. Record between 8-10 cycles to make the accurate cycle time for each steps. Finally summarize the data by calculate the total cycle time for each column, average time for each row and add up all the step times to get to total cycle time for developing the Standard Work Combination Sheet. The tallied stage times are compared with the actual times observed. This is because sometimes the operator is specified above and sometimes under the individual step times that are defined. If there is no special trigger that slows things down, they will normally come out of a fairly relatively near range.

3.2.7 Develop Standard Work Combination Sheet

Standard Work Combination Sheet is the most critical document to ensure the successfulness of lean, quality and management tool. When any problem is discovered, the first step that need to be confirmed is to make sure the procedures consistently followed. It also helps to produce the TAKT Time to make sure that the process is running smoothly. Standard Work Combination Sheet also can highlight out the incidents of waste and this indirectly helps eliminate waste which is very useful in VSM. Figure 3.18 below shown the flowchart of developing Standard Work Combination Sheet.

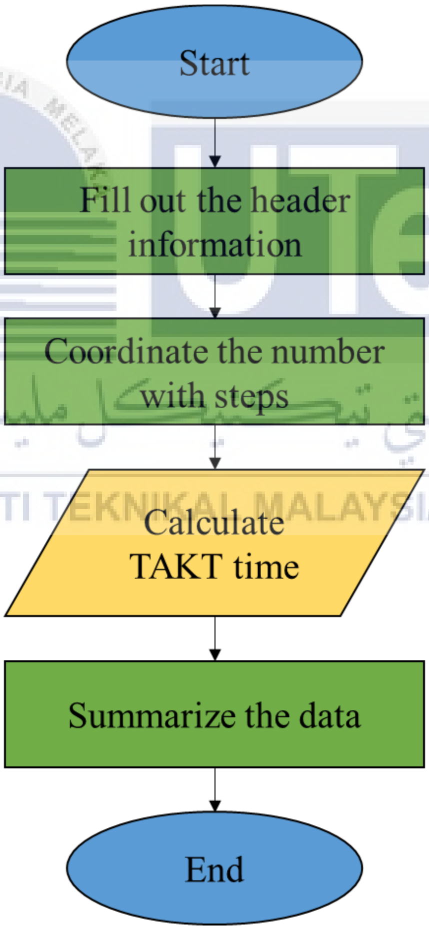


Figure 3.18: Flowchart of developing the Standard Work Combination Sheet

The key details related to the Standard Work Combination Sheet is the relationship between various parts of the working process and the pacing necessary between the different steps involved. As the sheet name indicates, it demonstrates how the various timing values, including the manual working time, walking time, as well as computer processing time, combine. First the header information is fill out such the type/name of model, date, time, and person in charge. For any individual operator working on the floor, these are further registered, and the data is then collected through different means of analysis. For deciding whether there is any substantial amount of waste in the delays between separate process phases, the Standard Work Combination Sheet can be very useful. Next, Coordinate the number with steps. Different model has different steps and observation points. It is very important to write every detail for the steps to get accurate data. The time taken for human movement as well as machine movement are the most significant points reported in the Standard Work Combination Sheet.

Furthermore, the TAKT time is calculated from the data that is collected. TAKT time is a calculation and a discipline that is focused on established and current concepts and practices of production. The maximum reasonable time to fulfil the customer's demands is TAKT time. In other words, TAKT Time is the pace at which the product must be produced to fulfil the customer's needs. Make sure to calculate and clearly mark the TAKT time on the Standard Work Combination Sheet. Knowing exactly where an employee is supposed to be at any point in a TAKT time allows managers to get immediate help when things go south. The formula of the TAKT time is as below:

$$T = \frac{T_a}{D}$$

T = TAKT time

Ta = Total Available Production Time

D = Average Customer Demand

Summarize the data by write in the name, and get the Standard Work Combination Sheet reviewed by the leader who is responsible for the work area. Standard Work Combination Sheet help keep stuff going smoothly. For the professional eye the Traditional Job Combination Sheet calls out waste accidents. When this waste is easily identified, removal of it is far more possible. Based on data recorded in a Standard Work Combination Sheet, some examples of waste that can be removed by some findings include the time an operator spends waiting for the machine to complete its mission, waiting for feedback from another machine, or waiting for another operator to perform some part of their job. This waiting is necessary often, and an integral part of the main line of work, but the two forms of downtime can be difficult to distinguish. This is where there is a Mix Sheet in play. It gives all the data and the current state of the production process, including an objective summary of the individual participation of each.

3.2.8. Develop the Value Stream Mapping (VSM)

VSM can create a comprehensive diagram of all steps in the work process. It is a reflection of the movement of products through your company from the supplier to the client. VSM shows all of the critical steps taken to produce value from start to finish in work process. It helps to imagine every mission on which the team operates and offers single status updates on the progress of each assignment. The flow chart shown in Figure 3.19 below describes as the whole view on the development of VSM.

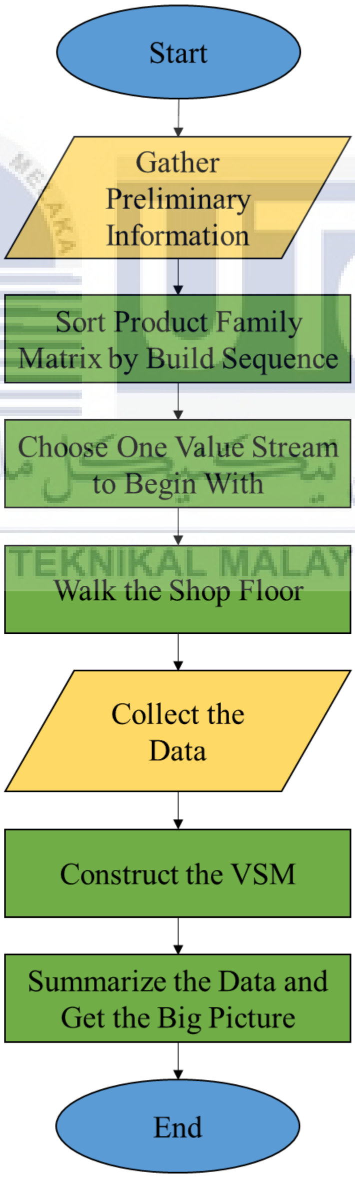


Figure 3.19: Flow chart of the whole view on the development of VSM.

Before creating VSM, this following information need to gather first:

- Station Name / Model Run.
- Process.
- Quota per Shift.
- Gross Weight (Kg).
- Man Power.

Next, sort the Product Family Matrix by build sequence. A Product Family Matrix can be used to group the products into families. In order to use the matrix, state which process steps each product will use. Instead, look for groupings of specific steps in the process. The groupings are families of the products. The process steps are arranged with downstream processes last by order of flow. Downstream steps are certain steps in the process that are closest to the customer. The main difference between product families often is the use of downstream process steps. For product families, workflow configurations can be optimized by building in detours and arranging for the use of portable equipment to accommodate minor variations in the workflow.

Furthermore, choose one value stream to begin with. It is important to know which products or piece parts make up 80 per cent of the business and which products or piece parts make sense to group as a value stream (product family) together. Start by mapping a value stream at a time to keep things simple. It may benefit when when the research discusses 80 percent of what the company are creating, grouping together items or component parts from the other 20 percent with other value streams. This because they follow the same sequence of builds and have identical form, fit and function. Consider the impact that value stream has on the business unit when choosing the value stream to begin with, such as:

- Highest per cent of the volume of sales.
- Highest process.
- Highest Quota per Shift.
- Changes in the market which affect consumer demand.

It is needed to take a stroll around the shop floor when it's time to chart the family of items. This is a sure way to miss wasteful activity which is not reported by the system. Start at the end of the process, work the way upstream to the start to get a client-supplier perspective at every stage. Any waste can occur whether it's unnecessary or acceptable. In creating VSM, this data is needed:

- TAKT time.
- Cycle time or processing time.
- Lead-time
- Changeover time or waiting time
- Uptime.
- Yield.
- Element work time or operation time.

After all the data is collected, start building the VSM on a separate sheet of blank paper using symbols to indicate what's happening at each process. Measure the appropriate metrics on every step as they apply to the process. When all the steps in VSM have been identified and all the data applicable to the VSM have been filled in, summarize the data to get the big picture with the model of VSM. The data will tell about the flow of the process. With VSM, the list of kaizen opportunities will be identified in this process and start to prioritize them by level of impact that will make an improvement to the flow of the value stream. This will have an organized action plan to begin in making the improvements to the value stream and waste can be detected and eliminated.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Data collection

4.1.1 Time Observation Sheet

Time observation sheet is a method of gathering the data such as cycle time of the procedure of standard work for the each of model. This data is then used for further analysis to prove a theory or opinion and also to detect any pattern in a process. Table 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 below shows the time observation sheet of selected model based on the product family matrix. The steps of collecting the Time Observation Sheet are:

1. Drawn the map of the work area on a Standard Work Sheet.
2. Without wrote anything, watched the operator performed their work once just to get a feel for the process. An average operator is needed.
3. The operator is watched on a second time. The operator's path is drawn and the process steps is wrote down on the Standard Work Sheet.
4. Wrote down the header information, steps and observation points on a Time Observation Sheet.
5. Start the stopwatch at the beginning of the process. The observation point to start a cycle and that ends the previous cycle must be same.
6. Recorded between 10 cycles to make accurate estimates of cycle times for each step.
7. Calculate the total cycle time on the Time Observation Sheet.

Table 4.1: Time Observation Sheet for Piston Assy 7/8600 model

Process	Assembly Model : PISTON ASSY 7/8600	TIME OBSERVATION SHEET	Date: 6/3/2020	Time: 11.00 AM	No	Person In Charge	dorma kaba

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	18	19	17	20	18	19	19	18	20						17	3	18	
2	Pick & arrange PLV at piston hole	17	18	17	18	19	17	16	21	18	17						16	5	17	
3	Knock slightly PLV to piston	6	6	7	6	6	7	7	6	7	6						6	1	6	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	20	22	19	22	20	23	20	20						19	4	20	
5	Pick & arrange PLV at other piston hole	27	28	27	27	29	30	27	27	28	27						27	3	28	
6	Knock slightly PLV to piston	6	6	7	7	8	6	7	6	6	7						6	2	6	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	24	21	20	20	19	21	21	20	22						19	5	20	
8	Air Blow & Clean Both PLV area	30	30	30	29	31	31	29	30	30	29						29	2	30	
9	Arrange piston assy inside nylon box	13	11	13	12	13	13	13	12	13	12						11	2	12	
10																				
11																				
12																				
	CYCLE TIME	157	162	161	158	165	163	159	165	160	160						150	27	157	

Form : L002 - TOS - Rev 2

Rules:
1. at least 10 cylces observation; 2 take the shortest cycle time from observed cycles;

Table 4.2: Time Observation Sheet for Spring adj. Screw assy ts73v bl model

Process	Assembly Model : SPRING ADJ. SCREW ASSY TS73V BL	TIME OBSERVATION SHEET	Date	Time	No	Person In Charge	dorma kaba

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Left hand pick pressure disc and right hand pick o-ring and hold it on right hand	10	10	20	10	10	30	10	10	10	10						10	20	10	
2	Left hand pick the adjusment screw and insert into pressure disc. Right hand pick o-ring and insert into the adjustment screw	80	60	70	70	60	60	70	8	8	70						60	20	70	
3	Place the part downward onto the fixture and right hand pick one retainer and place it on the fixture and follow by pressing the retainer with a lever	40	50	30	30	50	40	20	30	20	30						20	30	30	
4	Place the part in the hole facing upwards and right hand pick two disc washer and follow by o-ring	40	50	60	60	50	60	50	60	50	50						40	20	40	
5	Place the complete spring adjustment screw in the box	10	10	10	10	10	10	10	10	10	10						10	0	10	
6																				
7																				
8																				
9																				
10																				
11																				
12																				
	CYCLE TIME	180	180	190	180	180	200	160	118	98	170						140	90	160	

Table 4.3: Time Observation Sheet for Spring Adj. Screw Assy Ts92 – New model

Process	Assembly / Model : SPRING ADJ. SCREW ASSY TS92 - NEW	TIME OBSERVATION SHEET	Date	6/3/2020	No		dormakaba
			Time	11.00 AM	Person In Charge		

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Right hand take pressure disc and left hand take adjustment screw. Insert pressure disc on the adjustment screw and place in on the jig	47	45	45	47	46	48	46	50	47	48						45	5	47	
2	Pick one washer and place it into the adjustment screw. Pick precision tip with left hand and take an o-ring with right hand. Place the precision tip and press the o-ring into the o-ring groove. Place the finished part into the box. Pick all at the same time.	59	57	58	58	58	59	57	60	58	59						57	3	58	
3	Right hand pick the finished part,check for the o-ring before load it on the fixture. Left hand pull the lever to activate the gripper to lock the pressure disc.	120	120	121	120	118	119	120	119	117	121						118	2	119	
4	Right hand pick end cap and left hand pick o-ring. Place O-ring into the end cap	24	24	23	25	27	27	25	25	25	26						23	4	25	
5	After the torque test is done and cylinder is going up unlock the gripper with left hand. Right hand pick finisned part from fixture and press the finished part into the end cap	24	27	26	26	28	27	23	22	27	26						22	6	23	
6	Place the final part in the box	12	13	10	11	14	15	15	11	11	12						10	5	11	
7																				
8																				
9																				
10																				
11																				
12																				
	CYCLE TIME	286	286	283	287	291	295	286	287	285	292						275	25	283	

Table 4.4: Time Observation Sheet for Damping Piston Assy ts91/92 model

Process	Assembly / Model : DAMPING PISTON ASSY TS91/92	TIME OBSERVATION SHEET	Date	6/3/2020	No		dormakaba
			Time	11.00 AM	Person In Charge		

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston On Work Station	10	9	10	11	10	9	9	10	10	10						9	2	10	
2	Pick & place roller into piston	15	13	15	15	16	15	14	14	13	15						13	2	14	
3	Pick & insert bolt between roller and piston	29	30	29	29	28	29	30	28	30	28						28	2	29	
4	Load piston on crimping station	30	31	31	30	29	30	31	30	29	29						29	2	30	
5	Crimp piston by push 2 button	27	27	28	29	28	27	27	28	27	29						27	2	27	
6	Pick & arrange piston assy inside nylon box	12	11	12	13	9	10	11	13	12	12						9	4	10	
7																				
8																				
9																				
10																				
11																				
12																				
	CYCLE TIME	123	121	125	127	120	120	122	123	121	123						115	14	120	

Table 4.5: Time Observation Sheet for Pinion Bearing Bottom Assy 2-5 model

Process	Assembly Model : PINION BEARING BOTTOM ASSY 2-5	TIME OBSERVATION SHEET	Date	6/3/2020	No		dorma kaba
			Time	11.00 AM	Person In Charge		

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick bearing housing approx. 1 pcs and place on work table. Insert O-Ring into bearing housing. Press the O-ring fully inside the B.hsg by mean of a pressing tool.	59	60	58	57	59	61	60	59	59	58						57	4	58	
2	Place needle bearing on top of bearing housing. Ensure orientation of needle bearing is correct. (wording on top)	19	19	21	20	22	18	19	19	21	20						18	3	19	
3	Place bearing under press machine and press push button with both hands. Needle bearing were insert in.	24	24	23	24	27	25	23	23	23	24						23	4	24	
4	Transfer assemble part to the box.	10	10	9	8	9	10	8	9	10	11						8	3	9	
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
CYCLE TIME		112	113	111	109	117	114	110	110	113	113						106	14	110	

Table 4.6: Time Observation Sheet for Bearing Housing Assy 7400/8600 model

Process	Assembly Model : BEARING HOUSING ASSY 7400/8600	TIME OBSERVATION SHEET	Date		No		dorma kaba
			Time		Person In Charge		

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick pinion bearing approx. 1 pcs and place on work table.	20	20	20	20	20	20	20	20	20	20						20	0	20	
2	Place needle bearing on top of the bearing housing with numbering facing upward.	20	20	20	20	20	20	20	20	20	20						20	0	20	
3	Place the bearing housing under the Pressing fixture. both hand press the Press button to activate the pressing motion. Press the bearing fully and release the push button to end motion.	30	40	30	30	30	30	40	50	30	40						30	20	30	
4	Put the bearing housing in fixture blow the oring area before insert O-ring. Insert O-ring properly into the groove. Place the complete bearing housing assembly inside the container .	60	80	60	60	60	70	50	70	50	60						50	30	50	
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
CYCLE TIME		130	160	130	130	130	140	130	160	120	140						120	50	120	

4.1.2 Standard Work Combination Sheet

Standard Work Combination Sheet is the most critical document to ensure the successfulness of lean, quality and management tool. When any problem is discovered, the first step that need to be confirmed is to make sure the procedures consistently followed. It also helps to produce the TAKT Time to make sure that the process is running smoothly. Table 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12 below shows the Standard Work Combination Sheet of selected model based on the Time Observation Sheet. Standard Work Combination Sheet also can streams out the incidents of waste and this indirectly helps eliminate the waste which is very useful in VSM.

Table 4.7: Standard Work Combination Sheet for Piston Assy 7/8600 model

	STANDARD WORK COMBINATION SHEET			Operator Number	1	dorma kaba
Model No And Name	PISTON ASSY 7/8600	Date Prepared	6/3/2020	Quota Per Shift	1650	Manual ——
Process	Assembly	Department	FINISHING	Takt Time	154.5	Automatic ····· Walking ^^^^

Step No	Decription of Operation	Time Man	Time Auto	Time Walk
1	Pick & Arrange Piston	18		
2	Pick & arrange PLV at piston hole	17		
3	Knock slightly PLV to piston	6		
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
5	Pick & arrange PLV at other piston hole	28		
6	Knock slightly PLV to piston	6		
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
8	Air Blow & Clean Both PLV area	30		
9	Arrange piston assy inside nylon box	12		
	Totals	147	10	

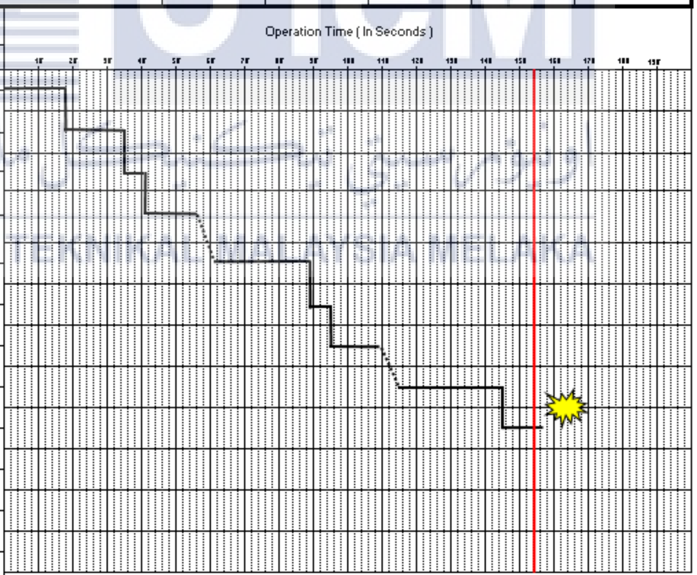


Table 4.8: Standard Work Combination Sheet for Spring adj. Screw assy ts73v bl model

	STANDARD WORK COMBINATION SHEET			Operator Number	1	dorma kaba
Model No And Name	SPRING ADJ. SCREW ASSY TS73V BL	Date Prepared	18/10/2018	Quota Per Shift	1000	Manual / Automatic / Walking
Process	Assembly	Department	FINISHING	Takt Time	255.0	

Step No	Decription of Operation	Time: Man	Time: Auto	Time: Walk
1	Left hand pick pressure disc and right hand pick o-ring and hold it on right hand	10		
2	Left hand pick the adjusment screw and insert into pressure disc. Right hand pick o-ring and insert into the adjustment screw	70		
3	Place the part downward onto the fixture and right hand pick one retainer and place it on the fixture and follow by pressing the retainer with a lever	30		
4	Place the part in the hole facing upwards and right hand pick two disc washer and follow by o-ring	40		
5	Place the complete spring adjustment screw in the box	10		
	Totals	160		

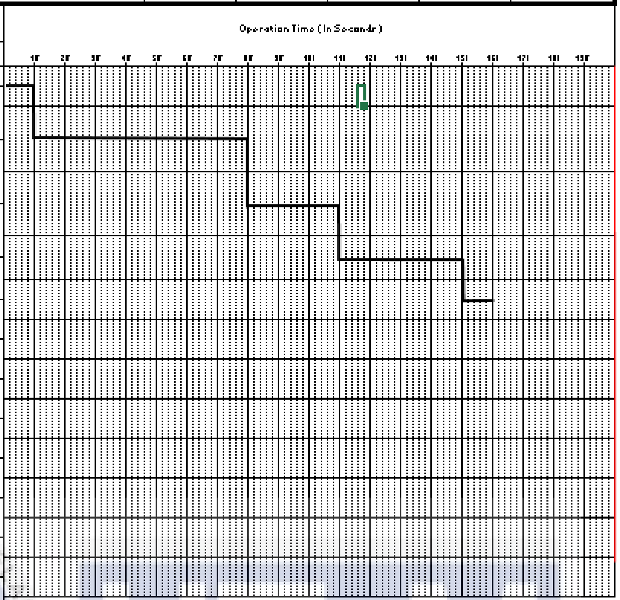


Table 4.9: Standard Work Combination Sheet for Spring Adj. Screw Assy Ts92 – New

	STANDARD WORK COMBINATION SHEET			Operator Number	2	dorma kaba
Model No And Name	SPRING ADJ. SCREW ASSY TS92 - NEW	Date Prepared	18/10/2018	Quota Per Shift	2300	Manual / Automatic / Walking
Process	Assembly	Department	FINISHING	Takt Time	110.9	

Step No	Decription of Operation	Time: Man	Time: Auto	Time: Walk
1	Right hand take pressure disc and left hand take adjustment screw. Insert pressure disc on the adjustment screw and place in on the jig	47		
2	Pick one washer and place it into the adjustment screw. Pick precision tip with left hand and take an o-ring with right hand. Place the precision tip and press the o-ring into the o-ring groove	41		34
3	Right hand pick the finished part, check for the o-ring before load it on the fixture. Left hand pull the lever to activate the gripper to lock the pressure disc.		100	
4	Right hand pick end cap and left hand pick o-ring. Place O-ring into the end cap	25		
5	After the torque test is done and cylinder is going up unlock the gripper with left hand. Right hand pick finished part from fixture and press the finished part into the end cap	23		
6	Place the final part in the box	13		
	Totals	149		

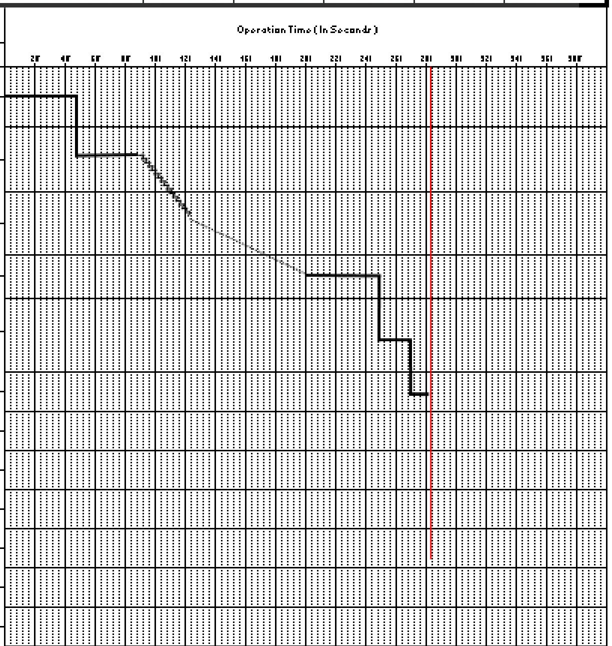


Table 4.10: Standard Work Combination Sheet for Damping Piston Assy ts91/92 model

	STANDARD WORK COMBINATION SHEET		Operator Number	1	dorma kaba
Model No And Name	DAMPING PISTON ASSY TS91/92	Date Prepared	11/3/2020	Quota Per Shift	1260
Process	Assembly	Department	FINISHING	Takt Time	202.4

Manual —— Automatic ····· Walking ∧∧∧∧

Step No	Decription of Operation	Time: Man	Time: Auto	Time: Walk
1	Pick & Arrange Piston On Work Station	10		
2	Pick & place roller into piston	14		
3	Pick & insert bolt between roller and piston	29		
4	Load piston on crimping station	30		
5	Crimp piston by push 2 button		27	
6	Pick & arrange piston assy inside nylon box	10		
	Totals	93	27	

Operation Time (In Seconds)

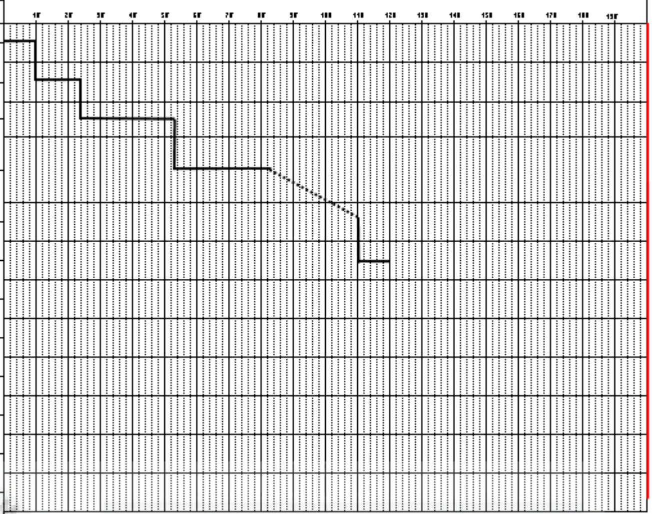


Table 4.11: Standard Work Combination Sheet for Pinion Bearing Bottom Assy 2-5 model

	STANDARD WORK COMBINATION SHEET		Operator Number	1	dorma kaba
Model No And Name	PINION BEARING BOTTOM ASSY 2-5	Date Prepared	18/10/2018	Quota Per Shift	2300
Process	Assembly	Department	FINISHING	Takt Time	110.9

Manual —— Automatic —— Walking ∧∧∧∧

Step No	Description of Operation	Time: Man	Time: Auto	Time: Walk
1	Pick bearing housing approx. 1 pcs and place on work table. Insert O-Ring into bearing housing. Press the O-ring fully inside the B.hsg by mean of a pressing tool.	58		
2	Place needle bearing on top of bearing housing. Ensure orientation of needle bearing is correct. (wording on top)	19		
3	Place bearing under press machine and press push button with both hands. Needle bearing were insert in.		24	
4	Transfer assemble part to the box.	9		
	Totals	86	24	

Operation Time (In Seconds)

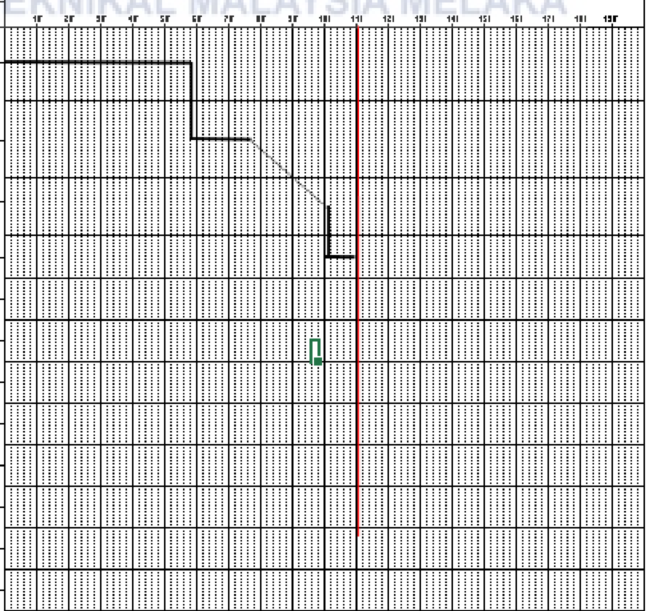
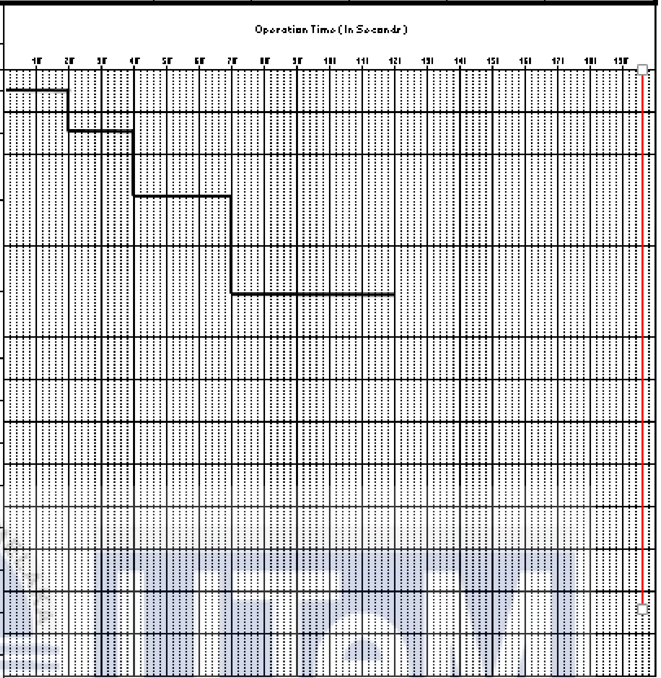


Table 4.12: Standard Work Combination Sheet for Bearing Housing Assy 7400/8600 model

	STANDARD WORK COMBINATION SHEET			Operator Number	1	dorma kaba
Model No And Name	BEARING HOUSING ASSY 7400/8600	Date Prepared	18/10/2018	Quota Per Shift	1300	Manual — Automatic — Walking ΛΛΛΛ
Process	Assembly	Department	FINISHING	Takt Time	196.2	

Step No	Description of Operation	Time		
		Man	Auto	Walk
1	Pick pinion bearing approx. 1 pcs and place on work table.	20		
2	Place needle bearing on top of the bearing housing with numbering facing upward.	20		
3	Place the bearing housing under the Pressing fixture. both hand press the Press button to activate the pressing motion. Press the bearing fully and release the push button to end motion.	30		
4	Put the bearing housing in fixture blow the oring area before insert O-ring. Insert O-ring properly into the groove. Place the complete bearing housing assembly inside the container.	50		
	Totals	120		



4.2 Current State Value Stream Mapping

4.2.1 Process Flow at the Production Line

To collect data for material and information flow, the production line in Sub-assembly department was observed. The goal of mapping the current state is to come up with real events of production material and informational flow. From the data collected in Table 4.13 below, the basic steps in VSM and waiting time between each process can be developed. Figure 4.1 below shows the VSM with data such as cycle time, TAKT time, defect, Value Added (VA) and Non-Value Added (NVA) of Piston Assy 7/8600 model.

First, the operator picked and arranged 10 piston onto the work place by using left hand. By using the right hand, the PLV is inserted into one end of the piston hole. The PLV is then knocked slightly by using hammer so that it locked inside the piston. This will ensure the PLV doesn't move so that it can increase the process efficiency of inserting the PLV using the hydraulic cylinder pressing machine.

Next, 2 piston is arranged onto the hydraulic cylinder pressing machine. This is because the hydraulic cylinder pressing machine can only process 2 piston in one cycle due to the limitation of the pressing rod's size. There is two end in each piston. Therefore, 10 cycle is needed to process 10 piston with 20 PLV. The operator used two press button to activate the hydraulic cylinder pressing machine and the machine will automatically press the PLV inside the piston.

The operator will then invert the piston, pick the PLV and insert the PLV into the other end of the piston hole. The PLV is knocked slightly by using hammer so that it locked inside the piston. The operator used two press button to activate the hydraulic cylinder pressing machine and the machine will automatically press the PLV inside the piston. After all 20 PLV are inserted in both end of the piston, the operator will clean up both end of the PLV area by using air blower. Lastly, the completed piston is arranged into the nylon box.

Table 4.13: Time Observation Sheet for Piston Assy 7/8600 model

Process	Assembly Model : PISTON ASSY 7/8600	TIME OBSERVATION SHEET	Date	6/3/2020	No	
			Time	11.00 AM	Person In Charge	

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	18	19	17	20	18	19	19	18	20						17	3	18	
2	Pick & arrange PLV at piston hole	17	18	17	18	19	17	16	21	18	17						16	5	17	
3	Knock slightly PLV to piston	6	6	7	6	6	7	7	6	7	6						6	1	6	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	20	22	19	22	20	23	20	20						19	4	20	
5	Pick & arrange PLV at other piston hole	27	28	27	27	29	30	27	27	28	27						27	3	28	
6	Knock slightly PLV to piston	6	6	7	7	8	6	7	6	6	7						6	2	6	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	24	21	20	20	19	21	21	20	22						19	5	20	
8	Air Blow & Clean Both PLV area	30	30	30	29	31	31	29	30	30	29						29	2	30	
9	Arrange piston assy inside nylon box	13	11	13	12	13	13	13	12	13	12						11	2	12	
10																				
11																				
12																				
	CYCLE TIME	157	162	161	158	165	163	159	165	160	160						150	27	157	

Form : L002 - TOS - Rev 2

Rules:
1. at least 10 cylces observation; 2 take the shortest cycle time from observed cycles;

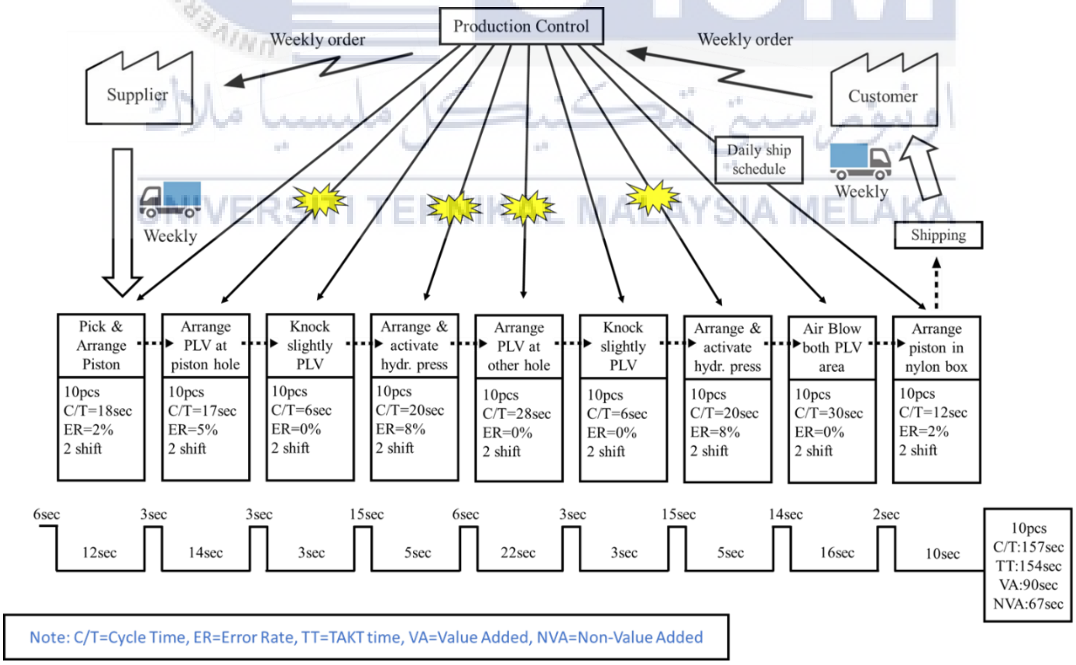


Figure 4.1: Current Value Stream Mapping for Piston Assy 7/8600 model

4.3 Problem Analysis

Before developing the future state VSM, the problem need to be analysed. Figure 4.2 below shown the Fishbone or Ishikawa cause and effect diagram of the potential problem of the assembly the Piston Assy 7/8600 model. There are several main issues in which should be considered by Dormakaba Production Malaysia Sdn Bhd such as:

1) The waiting time is exceed the TAKT time.
2) The inconsistency and bottleneck of certain process.
3) Inefficient Standard Work Sheet.
4) Too many repetitive process.

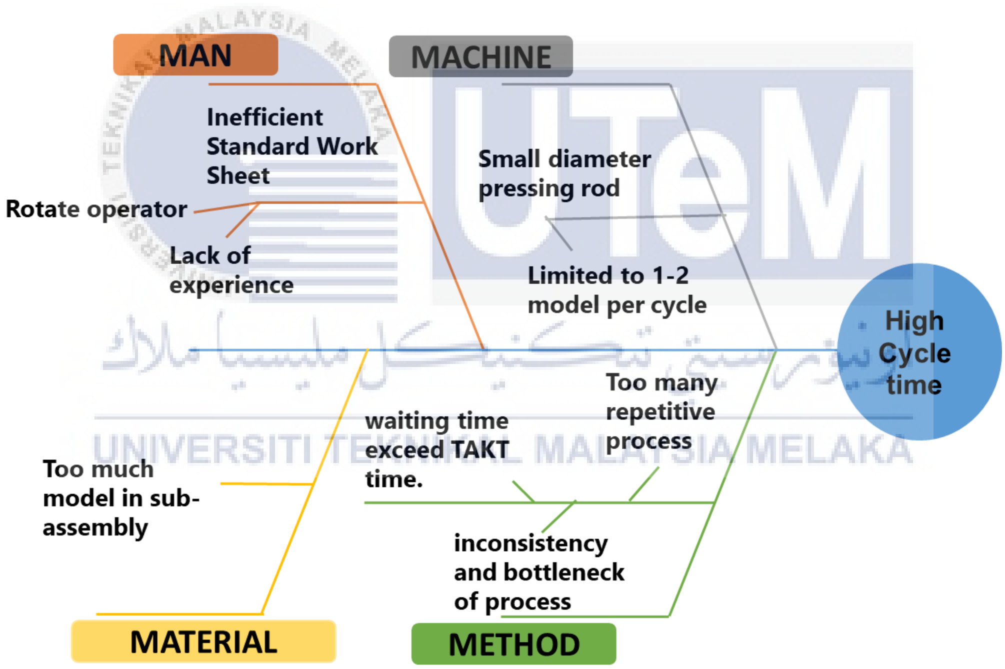


Figure 4.2: Fishbone or Ishikawa cause and effect diagram of the potential problem for Piston Assy 7/8600 model.

4.4 Future State Value Stream Mapping

A future state value stream mapping or future state map provides teams or people with a visual representation of the steps in a process after 6 or 12 months of improvements once the current state process map is complete. Problem areas become visible when a current state VSM is produced. Kaizen bursts should all mark the bottlenecks where inventory piles up, processes with the low efficiency, and operations that need excessive coordination, which suggest areas of focus for the future value stream map of the state. It should also illustrate the operations where work is moved downstream. The future value stream mapping is different from the current value stream mapping. The current value stream mapping helps to identify the overall objectives for progress, while future value stream mapping gives a plan on how continue to improve the current process. The aim of the future value stream mapping is to establish a mechanism that removes the obstacles in the current value stream mapping that have found. Figure 4.3 below shown the future value stream mapping for Piston Assy 7/8600 model.

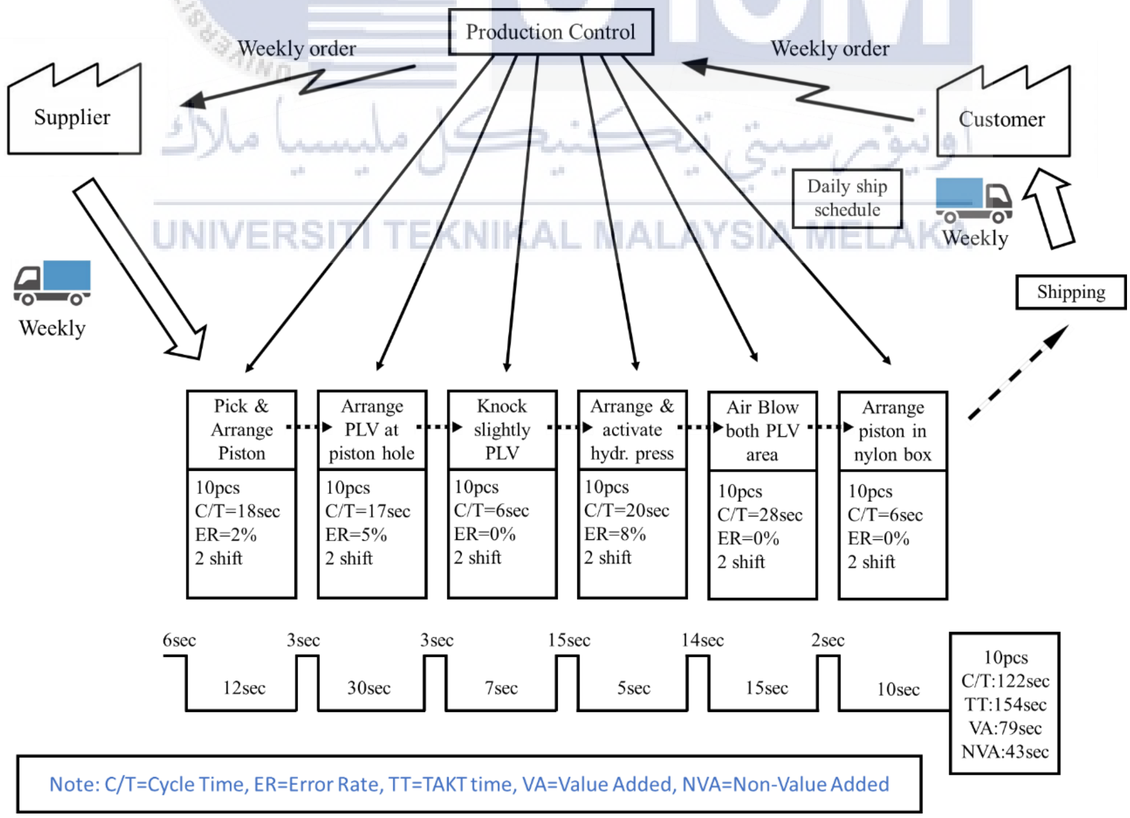


Figure 4.3: Future Value Stream Mapping for Piston Assy 7/8600 model

4.4.1 Restructured the map of the work area of Standard Work Sheet

Based on the Time Observation Sheet on Piston Assy 7/8600 model in Table 4.14 below, there is inconsistency and also huge different on the Element Work Time between process No.2 and No.5 although the process is similar. The Element Work Time on process No.2 is 17 seconds while Element Work Time on process No.5 is 28 seconds. This inconsistency value may be influenced by the current map of the work area of Standard Work Sheet in Figure 4.4 below. Based on the observation on the work area, the operator always makes mistakes and causing them to spend more time when installing PLV into the piston. There is too much part on the right hand side (PLV, Hammer, Air Blow and Final Product) compared to left hand side which only has one part (Piston). This will cause a lot of stress on the operator's right hand and indirectly lead to few error which can cause bottleneck on the process.

Table 4.14: Time Observation Sheet for Piston Assy 7/8600 model

Process	Assembly Model : PISTON ASSY 7/8600	TIME OBSERVATION SHEET	Date	6/3/2020	No	dorma kaba
			Time	11.00 AM	Person In Charge	

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	18	19	17	20	18	19	19	18	20						17	3	18	
2	Pick & arrange PLV at piston hole	17	18	17	18	19	17	16	21	18	17						16	5	17	
3	Knock slightly PLV to piston	6	6	7	6	6	7	7	6	7	6						6	1	6	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	20	22	19	22	20	23	20	20						19	4	20	
5	Pick & arrange PLV at other piston hole	27	28	27	27	29	30	27	27	28	27						27	3	28	
6	Knock slightly PLV to piston	6	6	7	7	8	6	7	6	6	7						6	2	6	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	24	21	20	20	19	21	21	20	22						19	5	20	
8	Air Blow & Clean Both PLV area	30	30	30	29	31	31	29	30	30	29						29	2	30	
9	Arrange piston assy inside nylon box	13	11	13	12	13	13	13	12	13	12						11	2	12	
10																				
11																				
12																				
	CYCLE TIME	157	162	161	158	165	163	159	165	160	160						150	27	157	

Form : L002 - TOS - Rev 2

Rules:
1. at least 10 cylces observation; 2 take the shortest cycle time from observed cycles;

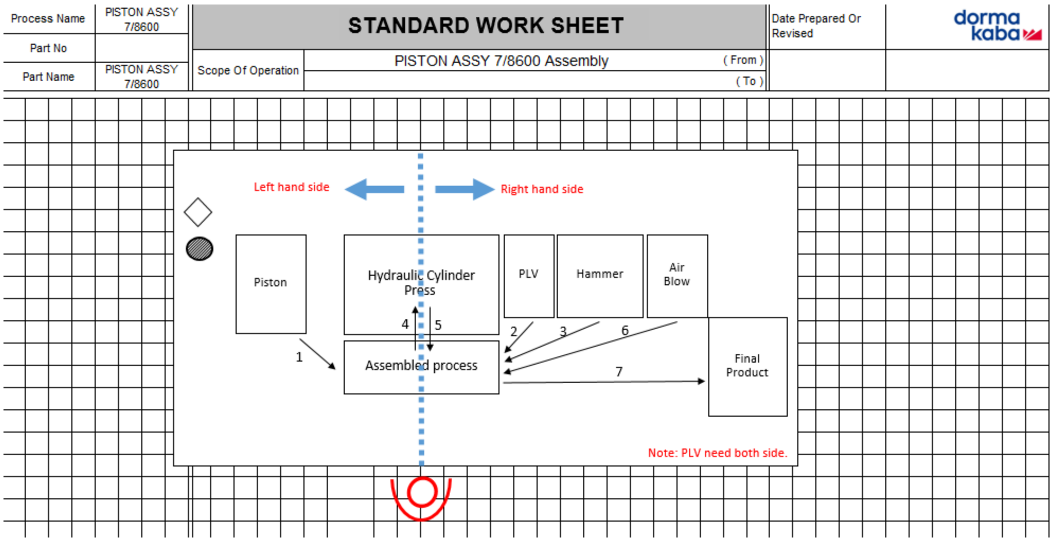


Figure 4.4: Standard Work Sheet for Piston Assy 7/8600 model

Furthermore, the other problem that is detected during the observation is the operator spend more time inverting the piston position on process No.5. Currently, the operator will invert the piston after all 10 pieces is finishing the pressing process as shown in Figure 4.5 below. This process is inefficient and also time consuming.

Figure 4.5: The operator invert the piston after all 10 pieces is completed the pressing process

Overcoming this issue, the map of the work area of Standard Work Sheet is restructured. The part on the left and right hand side need to be balanced so that it doesn't cause a lot of stress on one of the hand. Figure 4.6 below shown the restructured map of the work area of Standard Work Sheet.

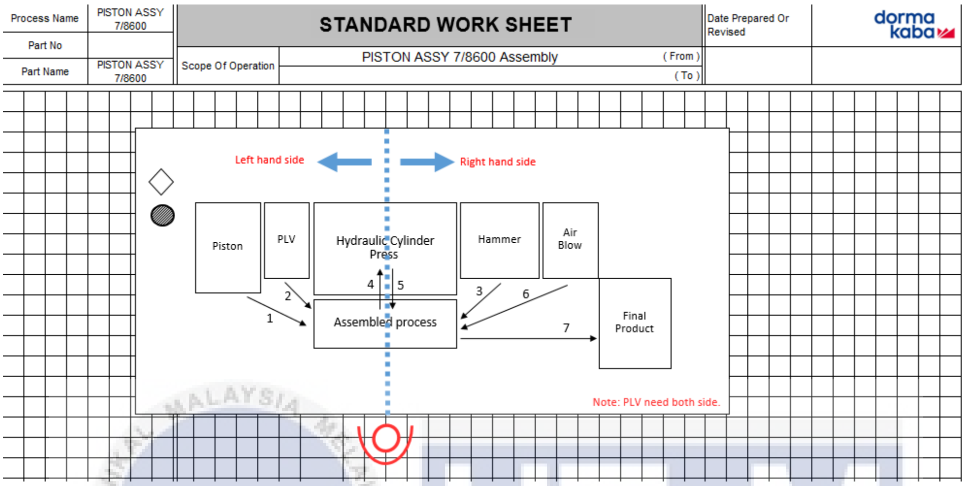


Figure 4.6: Standard Work Sheet for Piston Assy 7/8600 model

Moreover, the operator should immediately invert the piston each time after pressing the PLV inside the piston (after 2 pieces). This can eliminate the time wasting on process No.5. To validate this hypothesis, an experimental of assembling the Piston Assy 7/8600 model had been done. The operator had been asked to assembled the part using the proposed map of work area and also immediately invert the piston each time after pressing the PLV inside the piston (after 2 pieces) as shown in Figure 4.7 below.

Figure 4.7: The operator immediately invert the piston each time after pressing the PLV inside the piston (after 2 pieces)

Table 4.15 and 4.16 below shown the before and after improvement of Time Observation Sheet for assembling the Piston Assy 7/8600 model. It is shown that there was huge improvement in the Element Work Time for process No.5 compared to previous Element Work Time in Figure 4.10. The improvement is from 28 seconds to 17 seconds.

Table 4.15: Time Observation Sheet for Piston Assy 7/8600 model before improvement

Process	Assembly / Model : PISTON ASSY 7/8600	TIME OBSERVATION SHEET	Date	6/3/2020	No	dorma kaba
			Time	11.00 AM	Person In Charge	

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	18	19	17	20	18	19	19	18	20						17	3	18	
2	Pick & arrange PLV at piston hole	17	18	17	18	19	17	16	21	18	17						16	5	17	
3	Knock slightly PLV to piston	6	6	7	6	6	7	7	6	7	6						6	1	6	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	20	22	19	22	20	23	20	20						19	4	20	
5	Pick & arrange PLV at other piston hole	27	28	27	27	29	30	27	27	28	27						27	3	28	
6	Knock slightly PLV to piston	6	6	7	7	8	6	7	6	6	7						6	2	6	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	24	21	20	20	19	21	21	20	22						19	5	20	
8	Air Blow & Clean Both PLV area	30	30	30	29	31	31	29	30	30	29						29	2	30	
9	Arrange piston assy inside nylon box	13	11	13	12	13	13	13	12	13	12						11	2	12	
10																				
11																				
12																				
	CYCLE TIME	157	162	161	158	165	163	159	165	160	160						150	27	157	

Form : L002 - TOS - Rev 2

Rules:
1. at least 10 cylces observation; 2 take the shortest cycle time from observed cycles;

Table 4.16: Time Observation Sheet for Piston Assy 7/8600 model after improvement

Process	Assembly / Model : PISTON ASSY 7/8600	TIME OBSERVATION SHEET	Date	6/3/2020	No	dorma kaba
			Time	11.00 AM	Person In Charge	

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	19	18	20	17	18	19	19	18	18						17	3	18	
2	Pick & arrange PLV at piston hole	16	18	16	16	15	17	19	17	16	16						15	4	16	
3	Knock slightly PLV to piston	5	5	6	5	4	6	5	5	5	5						4	2	5	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	19	22	20	20	21	19	20	20						19	3	21	
5	Pick & arrange PLV at other piston hole	19	17	17	18	17	16	16	17	17	17						16	3	17	
6	Knock slightly PLV to piston	6	6	5	5	6	6	5	4	5	5						4	2	5	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	19	20	20	19	20	20	21	20	21						18	3	20	
8	Air Blow & Clean Both PLV area	30	31	31	30	31	29	28	30	30	29						28	3	29	
9	Arrange piston assy inside nylon box	13	11	13	12	14	13	13	11	13	12						11	3	12	
10																				
11																				
12																				
	CYCLE TIME	147	147	145	148	143	145	146	143	144	143						132	26	143	

Table 4.17 and 4.18 below shown the before and after improvement of Standard Work Combination Sheet for Piston Assy 7/8600 model. It clearly shown that there was improvement in the waiting time. The waiting time is improved from +2.5 seconds to -11.5 seconds.

Table 4.17: Standard Work Combination Sheet before improvement

STANDARD WORK COMBINATION SHEET		Operator Number	1	dorma kaba
Model No And Name	PISTON ASSY 7/8600	Date Prepared	6/3/2020	Quota Per Shift: 1650
Process	Assembly	Department	FINISHING	Takt Time: 154.5

Step No	Decription of Operation	Time: Man	Auto	Walk
1	Pick & Arrange Piston	18		
2	Pick & arrange PLV at piston hole	17		
3	Knock slightly PLV to piston	6		
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
5	Pick & arrange PLV at other piston hole	28		
6	Knock slightly PLV to piston	6		
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
8	Air Blow & Clean Both PLV area	30		
9	Arrange piston assy inside nylon box	12		
	Totals	147	10	

Manual ——— Automatic ····· Walking ^^^^

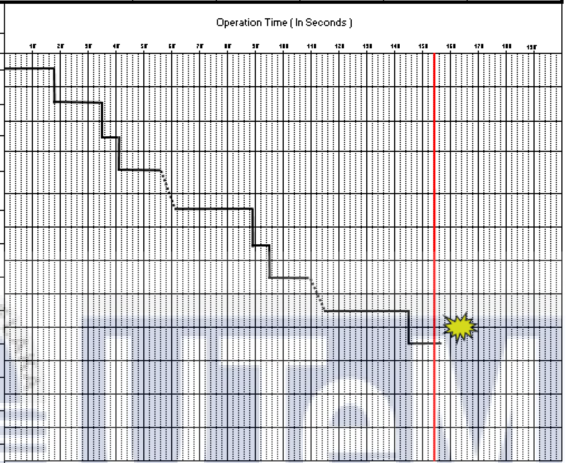
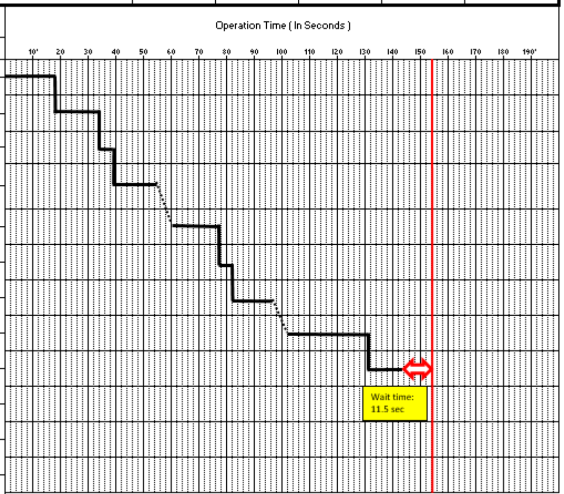


Table 4.18: Standard Work Combination Sheet after improvement

STANDARD WORK COMBINATION SHEET		Operator Number	1	dorma kaba
Model No And Name	PISTON ASSY 7/8600	Date Prepared	6/3/2020	Quota Per Shift: 1650
Process	Assembly	Department	FINISHING	Takt Time: 154.5

Step No	Decription of Operation	Time: Man	Auto	Walk
1	Pick & Arrange Piston	18		
2	Pick & arrange PLV at piston hole	16		
3	Knock slightly PLV to piston	5		
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	16	5	
5	Pick & arrange PLV at other piston hole	17		
6	Knock slightly PLV to piston	5		
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
8	Air Blow & Clean Both PLV area	29		
9	Arrange piston assy inside nylon box	12		
	Totals	133	10	

Manual ——— Automatic ····· Walking ^^^^



4.4.2 Base plate supporting tool

The size of PLV and piston is shown in Figure 4.8 below. Currently, the process of inserting PLV inside the piston using the hydraulic cylinder press is limited to two piston per cycle. This is due to the size limitation of the hydraulics' pressing rod as shown in Figure 4.9 below. The PLV also can only be inserted in one end only per cycle. This is because the piston is quite unstable to stand if both end is inserted simultaneously. These two condition influenced the time taken to assemble the Piston Assy 7/8600.

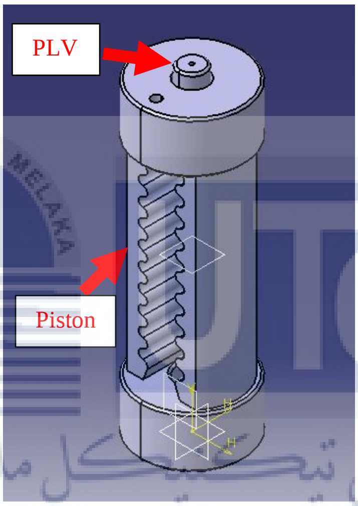


Figure 4.8: The size of PLV and piston

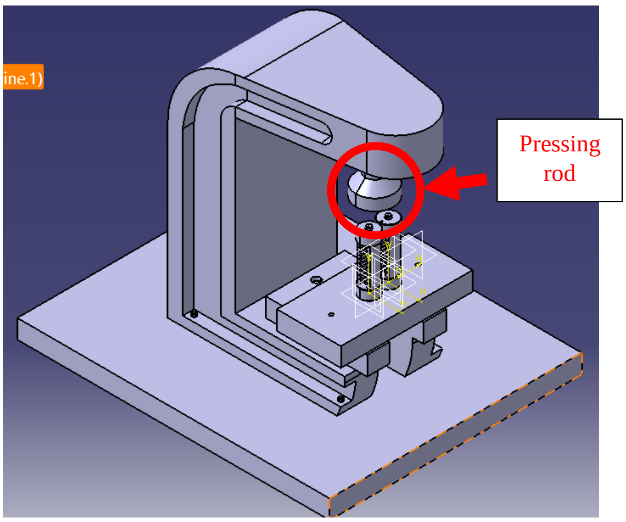


Figure 4.9: The size of the hydraulics' pressing rod

To overcome this problem, a base plate supporting tool is needed. A base plate supporting tool helps to stabilize the position of the piston and enables the PLV to be inserted in both end simultaneously in one cycle. Figure 4.10 and 4.11 shows two design idea of base plate supporting tool. Design 1 allows 8 PLV to be inserted in one cycle. This design certainly saves a lot time because 8 PLV can be inserted in both end simultaneously in one cycle. However, the current size of the hydraulics' pressing rod is limited to two piston at one time. Therefore, if this design is applied, the hydraulics' pressing rod need to be replaced to a bigger size rod and this will increase the cost.

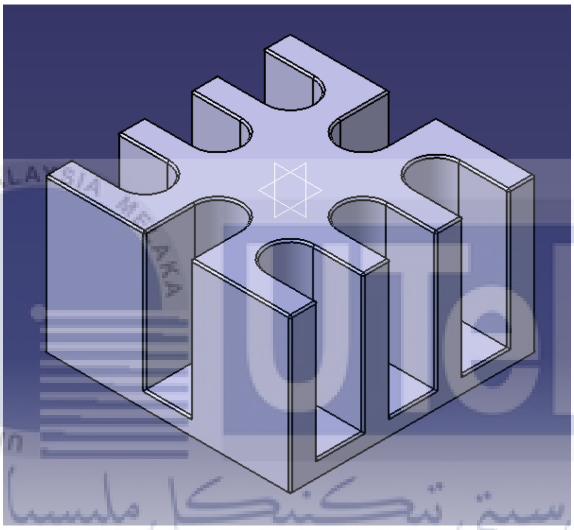


Figure 4.10: Design 1 of base plate supporting tool

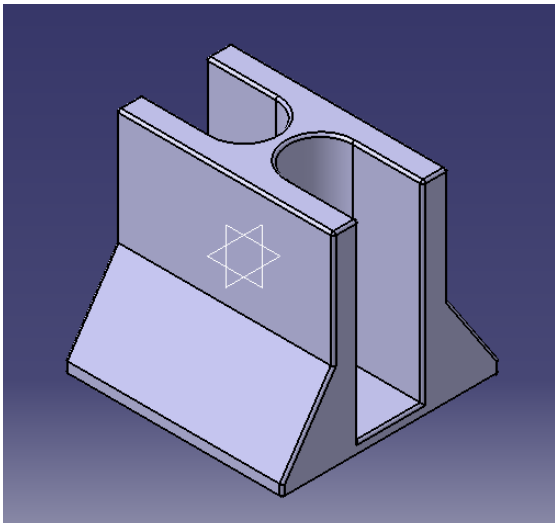


Figure 4.11: Design 2 of base plate supporting tool

Design 2 allows 2 PLV to be inserted in both end simultaneously in one cycle. This design is the most suitable for the current process and size of the hydraulics’ pressing rod as shown in Figure 4.12 below. It also eliminates few process of assembling the Piston Assy 7/8600 model.

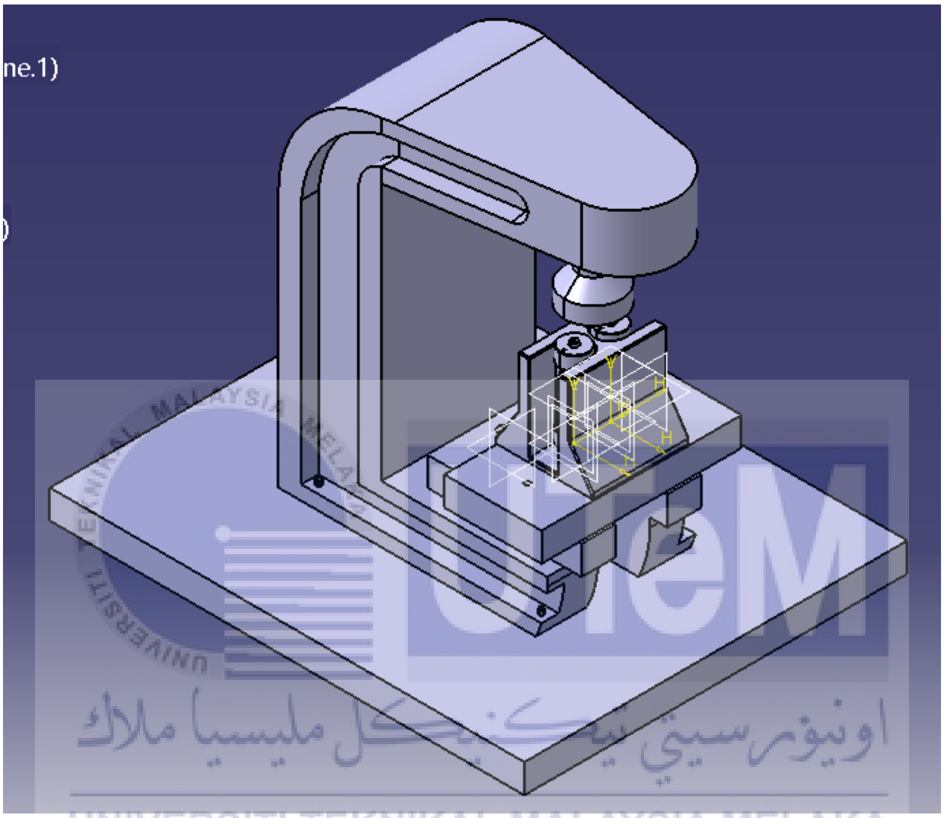


Figure 4.12: Design 2 Base plate supporting tool with piston in hydraulic press machine

Table 4.19 and 4.20 shows the current and expected Time Observation Sheet after applied base supporting tool. The cycle time is improved from 157 seconds to 122 seconds.

Table 4.19: Current Time Observation Sheet for Piston Assy 7/8600 model

TIME OBSERVATION SHEET — Process: Assembly; Model : PISTON ASSY 7/8600 — Date: 6/3/2020 — Time: 11.00 AM — No — Person In Charge — dorma kaba

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	18	19	17	20	18	19	19	18	20						17	3	18	
2	Pick & arrange PLV at piston hole	17	18	17	18	19	17	16	21	18	17						16	5	17	
3	Knock slightly PLV to piston	6	6	7	6	6	7	7	6	7	6						6	1	6	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	20	22	19	22	20	23	20	20						19	4	20	
5	Pick & arrange PLV at other piston hole	27	28	27	27	29	30	27	27	28	27						27	3	28	
6	Knock slightly PLV to piston	6	6	7	7	8	6	7	6	6	7						6	2	6	
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	24	21	20	20	19	21	21	20	22						19	5	20	
8	Air Blow & Clean Both PLV area	30	30	30	29	31	31	29	30	30	29						29	2	30	
9	Arrange piston assy inside nylon box	13	11	13	12	13	13	13	12	13	12						11	2	12	
10																				
11																				
12																				
	CYCLE TIME	157	162	161	158	165	163	159	165	160	160						150	27	157	

Form : L002 - TOS - Rev 2

Rules:
1. at least 10 cylces observation; 2 take the shortest cycle time from observed cycles;

Table 4.20: Expected Time Observation Sheet for Piston Assy 7/8600 model

TIME OBSERVATION SHEET — Process: Assembly; Model : PISTON ASSY 7/8600 — Date: 6/3/2020 — Time: 11.00 AM — No — Person In Charge — dorma kaba

No	Work Content	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Xmin	R	Element Work Time	Problem
1	Pick & Arrange Piston	18	19	18	20	17	18	19	19	18	18						17	3	18	
2	Pick & arrange PLV at piston hole	35	35	33	34	32	33	35	34	33	33						32	3	33	
3	Knock slightly PLV to piston	11	11	11	10	10	12	10	9	10	10						9	3	10	
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	20	21	19	22	20	20	21	19	20	20						19	3	20	
5	Air Blow & Clean Both PLV area	30	31	31	30	31	29	28	30	30	29						28	3	29	
6	Arrange piston assy inside nylon box	13	11	13	12	14	13	13	11	13	12						11	3	12	
7																				
8																				
9																				
10																				
11																				
12																				
	CYCLE TIME	127	128	125	128	124	125	126	122	124	122						116	18	122	

Table 4.21 and 4.22 on the other hand shows the current and expected Standard Work Combination Sheet after applied base supporting tool. The waiting time is improved from +2.5 seconds to -32.5 seconds.

Table 4.21: Current Standard Work Combination Sheet for Piston Assy 7/8600 model

	STANDARD WORK COMBINATION SHEET		Operator Number	1	dorma kaba
Model No And Name	PISTON ASSY 7/8600	Date Prepared	6/3/2020	Quota Per Shift	1650
Process	Assembly	Department	FINISHING	Takt Time	154.5

Legend: Manual ——— ; Automatic ····· ; Walking ʌʌʌʌ

Step No	Decription of Operation	Time: Man	Time: Auto	Time: Walk
1	Pick & Arrange Piston	18		
2	Pick & arrange PLV at piston hole	17		
3	Knock slightly PLV to piston	6		
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
5	Pick & arrange PLV at other piston hole	28		
6	Knock slightly PLV to piston	6		
7	Arrange piston & Press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
8	Air Blow & Clean Both PLV area	30		
9	Arrange piston assy inside nylon box	12		
	Totals	147	10	

Operation Time (In Seconds)

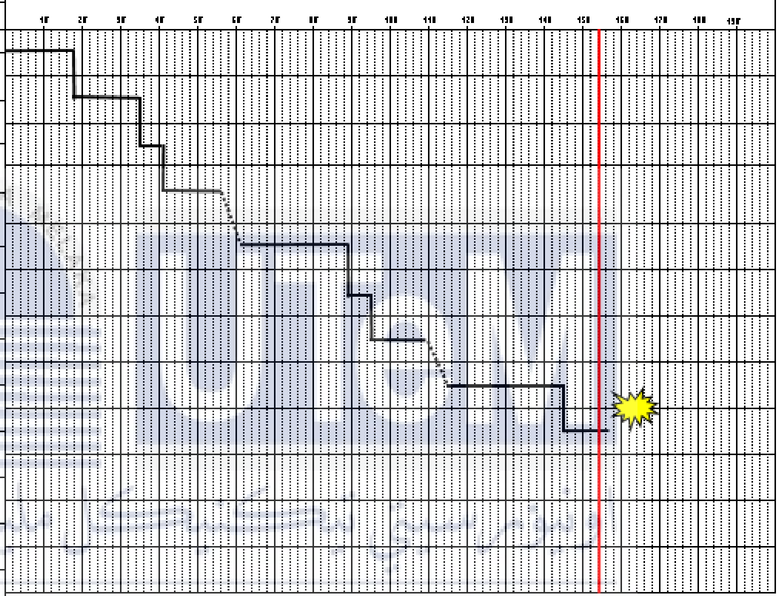
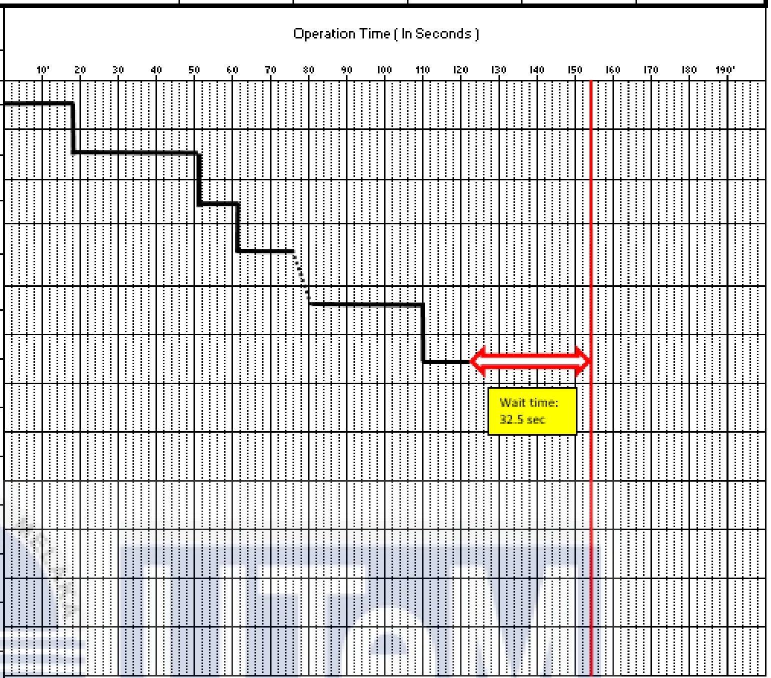


Table 4.22: Expected Standard Work Combination Sheet for Piston Assy 7/8600 model

	STANDARD WORK COMBINATION SHEET			Operator Number	1
Model No And Name	PISTON ASSY 7/8600	Date Prepared	6/3/2020	Quota Per Shift	1650
Process	Assembly	Department	FINISHING	Takt Time	154.5

dormakaba — Manual ——; Automatic ······; Walking ^^^^

Step No	Decription of Operation	Time: Man	Time: Auto	Time: Walk
1	Pick & Arrange Piston	18		
2	Pick & arrange PLV at piston hole	33		
3	Knock slightly PLV to piston	10		
4	Arrange piston & press PLV inside piston by using two hand button to activate hydraulic cylinder press	15	5	
5	Air Blow & Clean Both PLV area	29		
6	Arrange piston assy inside nylon box	12		
7				
8				
	Totals	117	5	



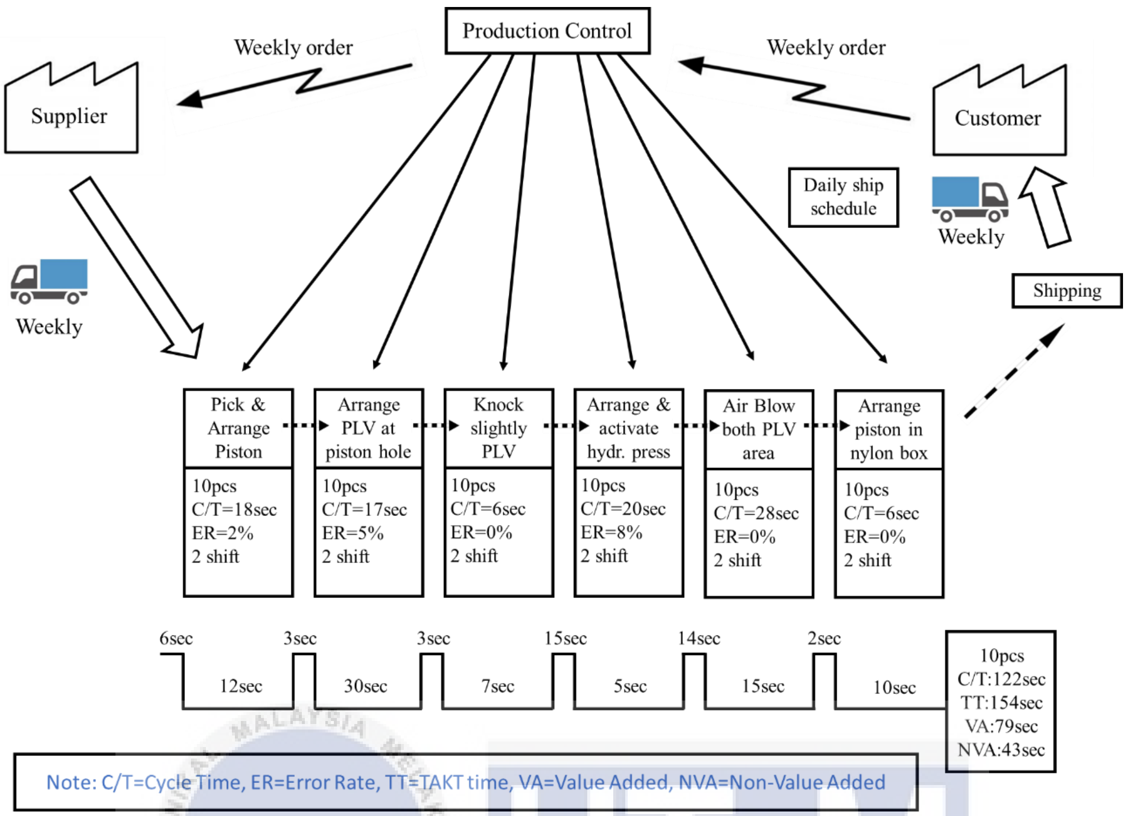


Figure 4.13: Future Value Stream Mapping for Piston Assy 7/8600 model

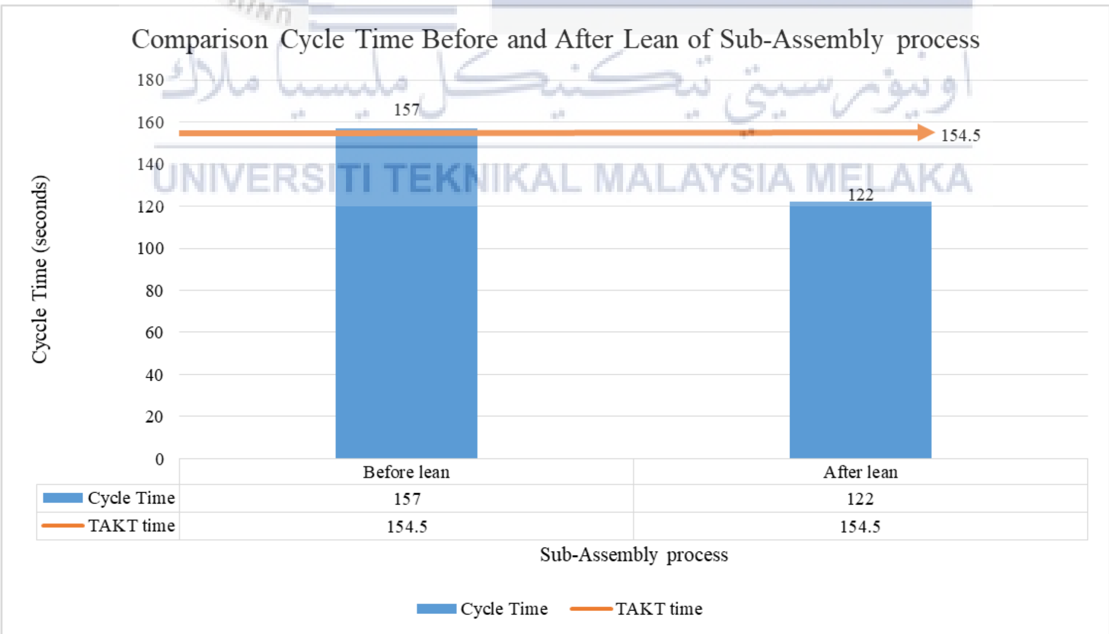


Figure 4.14: Comparison Cycle Time and TAKT time before and after lean for Piston Assy 7/8600 model based on demand

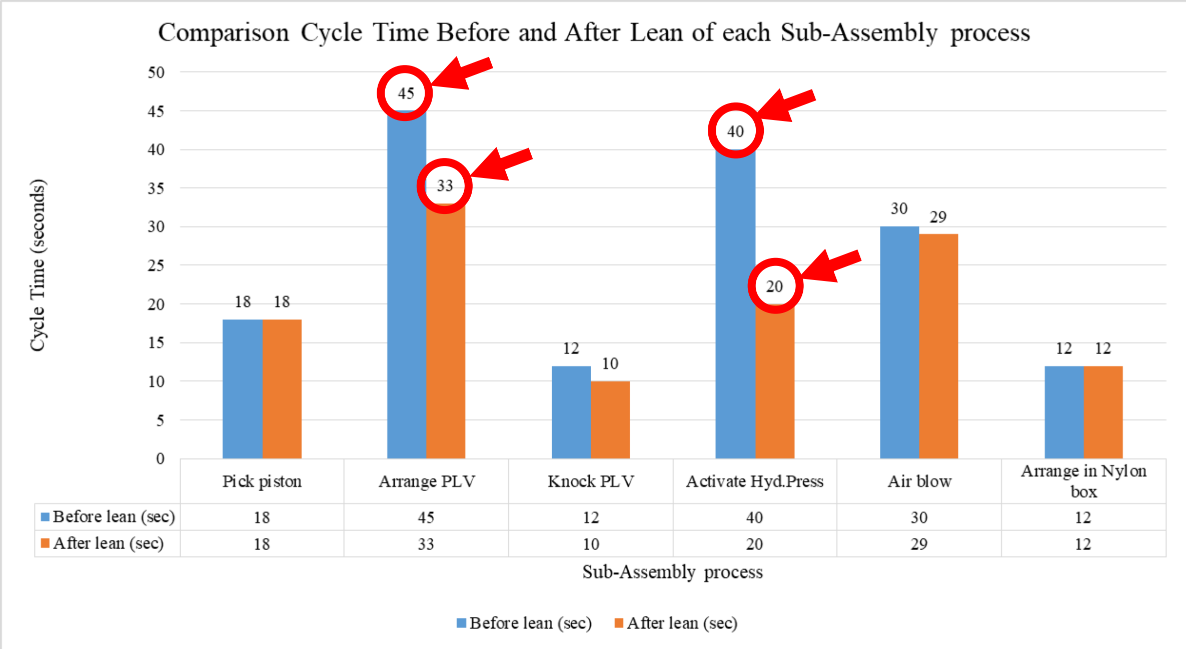


Figure 4.15: Cycle time and TAKT time before and after lean for Piston Assy 7/8600 model

Based on the Future VSM in Figure 4.13 above, the process of assembling the Piston Assy 7/8600 model had been reduced from 9 process to 6 process only. The process of arranging the PLV at piston hole is merge into one process only. This indirectly eliminated the inconsistency of the previous process of arranging the PLV at piston hole due to the mistake made by the operator causing them to spend more time when installing PLV into the piston. The process of inserting the PLV using the hydraulics' pressing rod also had been merged into one process only. With the help of base supporting tool, the process of inverting the piston is not necessary anymore. This is because the base supporting tool provide the pressure in both end of the PLV simultaneously in one cycle. The design of base supporting tool used is the most suitable for the current process and size of the hydraulics' pressing rod. Based on Figure 4.14 above, the cycle time after lean implementation is reduced from 157 seconds to 122 seconds. The waiting time is improved from +2.5 seconds to -32.5 seconds. Figure 4.15 above shown there is two major reduction in cycle time of the process which is process of Arranging the PLV inside the piston and process of pressing the PLV using the Hydraulic Press machine. The process of Arranging the PLV inside the piston is reduced from 45 seconds to 33 seconds while the process of pressing the PLV using the Hydraulic Press machine reduced from 40 seconds to 20 seconds.

CHAPTER 4

CONCLUSION AND RECOMMENDATION

In conclusion, the new process of sub-assembly in Dormakaba Production Malaysia Sdn Bhd need to apply lean manufacturing to improve the productivity for their product realization process because it is a new process in the company. This first objectives to investigate the current process of each model in sub-assembly department based on the product family matrix and therefore only one total station name/model is selected based on the analysis and product family matrix with the most effective manufacturing process. Based on second objectives, after all process of data collection and analysis, the model that need to carry out lean tools to reduce the cost, waste, waiting time, defect and product delivery speed is Piston Assy 7/8600 model. The problem such as inefficient Standard Work sheet and bottleneck of process was analysed. Third objectives were achieved by developed the Current and Future state VSM, restructured the map of work area and created the design of base plate supporting tool to reduce the cycle time and waiting time. The results showed that the current cycle time for Piston Assy 7/8600 model was high and exceed the TAKT time. This is likely due to the inefficient Standard Work Sheet. Further research is recommended such as more innovative based supporting tool that suited the machine. This implementation of lean manufacturing tool will increase the productivity improvement of sub-assembly process in Dormakaba Production Malaysia Sdn Bhd.

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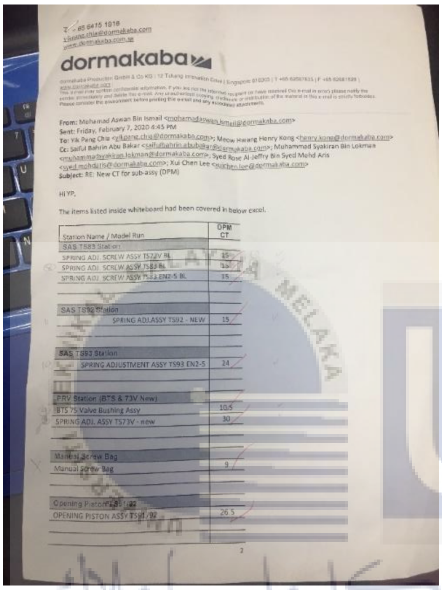
APPENDICES

A. List of The total station name/model run in sub-assembly department



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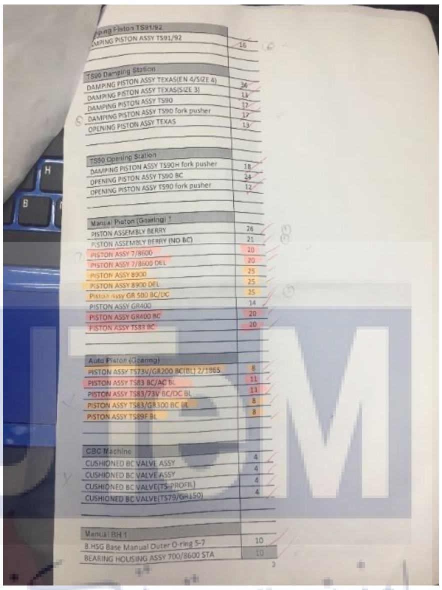
From: Mohamad Aswan Bin Ismail <mohamadaswan.ismail@dormakaba.com>
Sent: Friday, February 7, 2020 4:45 PM
To: Yik Pang Chia <yikpang.chia@dormakaba.com>; Meow Hwang Henry Kong <henry.kong@dormakaba.com>
Cc: Saiful Bahrin Abu Bakar <saifulbahrin.abubakar@dormakaba.com>; Muhammad Syakiran Bin Lokman <muhammadsyakiran.lokman@dormakaba.com>; Syed Rose Al-Jeffry Bin Syed Mohd Aris <syed.mohdaris@dormakaba.com>; Xui Chen Lee <xuichen.lee@dormakaba.com>
Subject: RE: New CT for sub-assy (DPM)

Hi YP,

The items listed inside whiteboard had been covered in below excel.

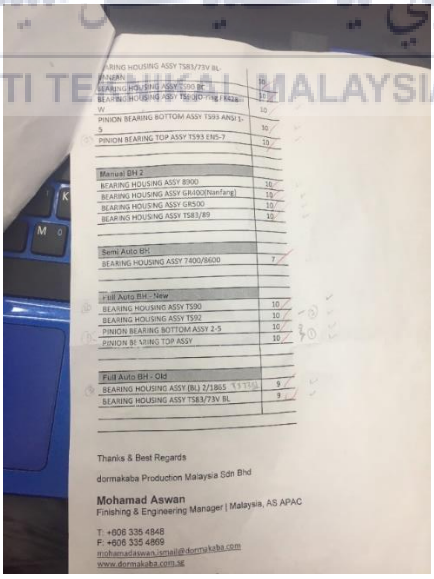
Station Name / Model Run	DPM CT
SAS TS83 Station	
SPRING ADJ. SCREW ASSY TS72V BL	15
SPRING ADJ. SCREW ASSY TS83 BL	15
SPRING ADJ. SCREW ASSY TS83 EN2-5 BL	15
SAS TS92 Station	
SPRING ADJ.ASSY TS92 - NEW	15
SAS TS93 Station	
SPRING ADJUSTMENT ASSY TS93 EN2-5	24
PRV Station (BTS & 73V New)	
BTS 75 Valve Bushing Assy	10.5
SPRING ADJ. ASSY TS73V - new	30
Manual Screw Bag	
Manual Screw Bag	9
Opening Piston TS91/92	
OPENING PISTON ASSY TS91/92	26.5

2



Damping Piston TS91/92	
DAMPING PISTON ASSY TS91/92	16
TS90 Damping Station	
DAMPING PISTON ASSY TEXAS(EN 4/SIZE 4)	36
DAMPING PISTON ASSY TEXAS(SIZE 3)	13
DAMPING PISTON ASSY TS90	17
DAMPING PISTON ASSY TS90 fork pusher	17
OPENING PISTON ASSY TEXAS	13
TS90 Opening Station	
DAMPING PISTON ASSY TS90H fork pusher	18
OPENING PISTON ASSY TS90 BC	24
OPENING PISTON ASSY TS90 fork pusher	12
Manual Piston (Gearing) 1	
PISTON ASSEMBLY BERRY	26
PISTON ASSEMBLY BERRY (NO BC)	21
PISTON ASSY 7/8600	20
PISTON ASSY 7/8600 DEL	20
PISTON ASSY 8900	25
PISTON ASSY 8900 DEL	25
Piston assy GR 500 BC/DC	25
PISTON ASSY GR400	14
PISTON ASSY GR400 BC	20
PISTON ASSY TS83 BC	20
Auto Piston (Gearing)	
PISTON ASSY TS73V/GR200 BC(BL) 2/1865	8
PISTON ASSY TS83 BC/AC BL	11
PISTON ASSY TS83/73V BC/DC BL	11
PISTON ASSY TS83/GR300 BC BL	8
PISTON ASSY TS89F BL	8
CBC Machine	
CUSHIONED BC VALVE ASSY	4
CUSHIONED BC VALVE ASSY	4
CUSHIONED BC VALVE(TS-PROFIL)	4
CUSHIONED BC VALVE(TS79/GR150)	4
Manual BH 1	
B.HSG Base Manual Outer O-ring 5-7	10
BEARING HOUSING ASSY 700/8600 STA	10

3



BEARING HOUSING ASSY TS83/73V BL-NANFAN	10
BEARING HOUSING ASSY TS90 BC	10
BEARING HOUSING ASSY TS90(O-ring FX428 W	10
PINION BEARING BOTTOM ASSY TS93 ANSI 1-5	10
PINION BEARING TOP ASSY TS93 EN5-7	10
Manual BH 2	
BEARING HOUSING ASSY 8900	10
BEARING HOUSING ASSY GR400(Nanfang)	10
BEARING HOUSING ASSY GR500	10
BEARING HOUSING ASSY TS83/89	10
Semi Auto BH	
BEARING HOUSING ASSY 7400/8600	7
Full Auto BH - New	
BEARING HOUSING ASSY TS90	10
BEARING HOUSING ASSY TS92	10
PINION BEARING BOTTOM ASSY 2-5	10
PINION BEARING TOP ASSY	10
Full Auto BH - Old	
BEARING HOUSING ASSY (BL) 2/1865	9
BEARING HOUSING ASSY TS83/73V BL	9

Thanks & Best Regards

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Figure 5.1, 5.2, and 5.3: List of The total station name/model run in sub-assembly department.

(Source: Dormakaba Production Malaysia Sdn Bhd)

B. Good and information flow

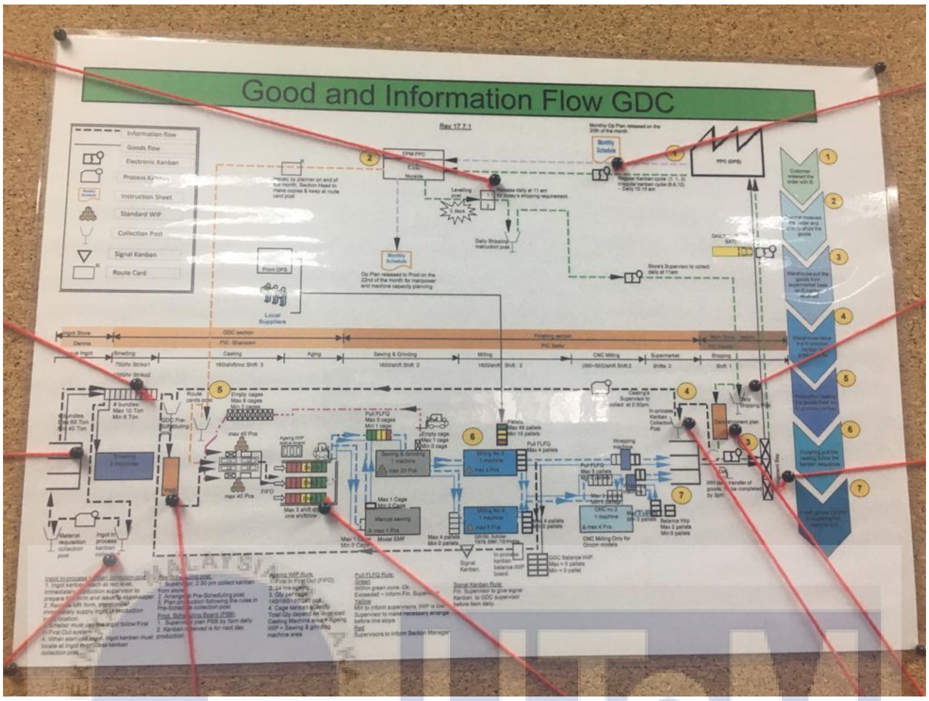

Figure 5.4: Good and information flow

(Source: Dormakaba Production Malaysia Sdn Bhd)

C. Project planning schedule for PSM 1 and PSM 2

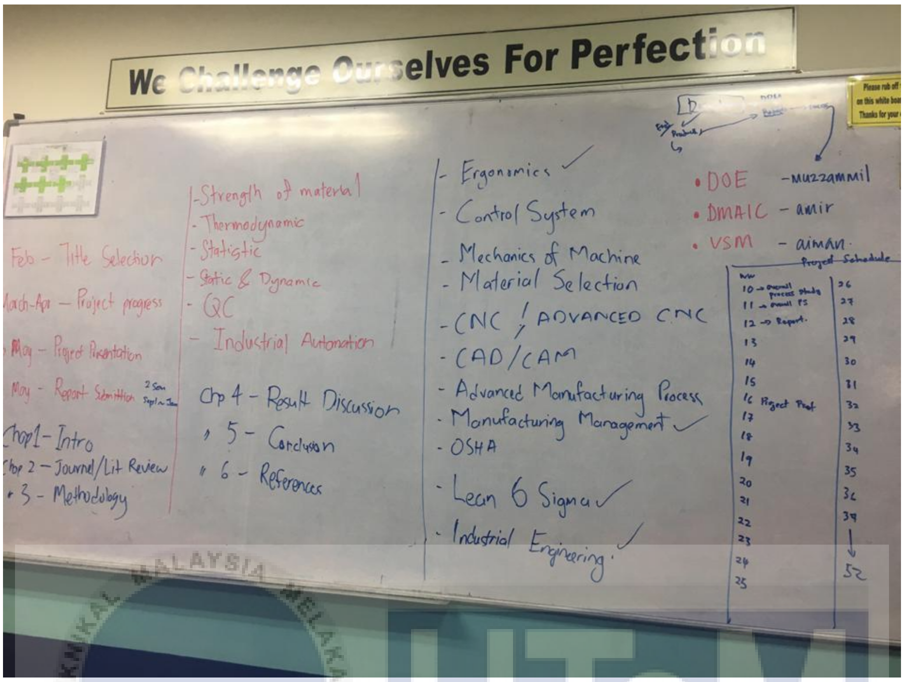

Figure 5.5: Project planning schedule for PSM 1 and PSM 2

(Source: Dormakaba Production Malaysia Sdn Bhd)

D. Product workplace in Sub-Assembly Department

Figure 5.6: Bearing housing workplace

(Source: Dormakaba Production Malaysia Sdn Bhd)

Figure 5.7: CBC machine

(Source: Dormakaba Production Malaysia Sdn Bhd)

Figure 5.8: Piston workplace

(Source: Dormakaba Production Malaysia Sdn Bhd)

Figure 5.9: SAS workplace

(Source: Dormakaba Production Malaysia Sdn Bhd)

Figure 5.10: Screw bag workplace

(Source: Dormakaba Production Malaysia Sdn Bhd)