UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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PRODUCTIVITY IMPROVEMENT USING LEAN SIX SIGMA TECHNIQUES: A CASE STUDY AT SEMICONDUCTOR EQUIPMENT MANUFACTURER

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SEOW LIANG HAU

**A thesis submitted
in fulfillment of the requirements for the degree of Master of
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DEDICATION

I would like to dedicate my dissertation work to my family. A special feeling of gratitude to my loving parents whose words of encouragement and push for tenacity ring in my ears. My sister who have supported me throughout the process. I also dedicate this dissertation and give special thanks to Dr. Zuhriah Binti Ebrahim for her guidance throughout the entire master program.

ABSTRACT

Semiconductor equipment manufacturer operates in a high mix low volume environment where the products are produced according to customer specification. Company A in this project is a semiconductor equipment manufacturer that currently manufacture test handler MX in Malaysia. The current leadtime to assemble the MX test handler is 14 days. It is a challenge to meet customer requirements as the order received is more than the capacity. The purpose of this study is to improve the productivity by lead-time reduction. Lean Six Sigma approach is being deployed to achieve the objective. DMAIC framework of Six Sigma is used to analyze the critical non-value added and not necessary activities. In the meantime, qualitative data is collected. The assembly time per activity is collected with time study and categorized into three categories. Factors causing non-value added and not necessary activities such as NCR process, quantity check, reporting, damaged part etc are identified. Qualitative analysis is achieved through interview with assembly personnel and leaders to identify rootcauses for the factors. Proposal to improve or eliminate the non-value added and not necessary activities are derived based on lean approaches.

ABSTRAK

Pengeluar peralatan semikonduktor beroperasi dalam sektor pembuatan berskala rendah dengan variasi tinggi di mana produk yang dihasilkan adalah mengikut spesifikasi pelanggan. Syarikat A yang dibincangkan dalam projek ini adalah pengeluar peralatan semikonduktor yang mengeluarkan pengendali ujian MX di Malaysia. Masa pemasangan untuk pengendali ujian MX adalah 14 hari. Ia adalah satu cabaran untuk memenuhi keperluan pelanggan kerana pesanan yang diterima adalah lebih daripada kapasiti. Tujuan kajian ini adalah untuk meningkatkan produktiviti melalui pengurangan masa pemasangan. Pendekatan Lean Six Sigma digunakan untuk mencapai matlamat itu. Rangka kerja DMAIC dalam Six Sigma digunakan untuk menganalisis aktiviti yang tidak menambah nikai dan tidak diperlukan. Dalam pada itu, data kualitatif juga dikumpulkan. Masa pemasangan untuk setiap aktiviti dikumpul dengan kajian masa dan dikategorikan kepada tiga kategori. Faktor-faktor yang menyebabkan aktiviti tidak menambah nilai dan tidak diperlukan seperti proses NCR, penyemakan kuantiti, membuat laporan, kerosakan bahagian dan lain-lain lagi faktor dikenal pasti. Analisis kualitatif dicapai melalui temu bual dengan kakitangan pemasangan dan ketua bahagian pemasangan untuk mengenalpasti punca-punca bagi faktor-faktor di atas. Cadangan untuk memperbaiki atau menghapuskan aktivititidak menambah nilai dan tidak diperlukan dicadangkan berdasarkan pendekatan Lean.

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CHAPTER 1

INTRODUCTION

1.1 Background

In this project, manufacturing process of a test handler in a semiconductor equipment manufacturer is being studied. A test handler is a pick and place machine that test and sort semiconductor devices. A specific tester is hooked to the test handler according to different test requirement. Subject test handler in this project is named as MX handler. A MX test handler is capable of testing semiconductor devices at 16,000 UPH (Unit Per Hour).

Company A in this project is a semiconductor equipment manufacturer which is the global leader for test handling, thermal subsystems, package inspection, contactors and Micro Electro Mechanical Systems (MEMS) test solutions for semiconductor industry. It has development centers in the United States and Europe, and handler manufacturing in Malaysia and the Philippines. Two major tooling operations in the Philippines and China provide customers in Asia with short cycle-time design and manufacturing of handler kits. Initially, the plant is planned with capacity of one shift (office hours). Currently it operates two shifts per day, seven days per week in order to cater business ramping time. The issue will be detailed and explained in the problem statement. Company A has a total of 231 employees. Figure 1.1 shows the MX handler.

Figure 1.1: Photo of a MX semiconductor test handler

Semiconductor market is a high flexible and aggressive market. All semiconductor manufacturers are working with three simple directions, smaller, faster and cheaper. Analyst from United States, Gartner published an article in 2014 states that the 2015 market is still growing and expected to increase 5.4% from 2014 (Van der Meulen and Rivera, 2014). In order to be able to be profitable and cater the market trends, semiconductor equipment manufacturer is using business model of High Mix Low Volume (HMLV) to operate. HMLV business model is used to bring product to market quickly and adapt to the quick change of market trends especially smart phones and Tablets.

The test handler is currently being manufactured with a lead-time of 14 days (around 112 hours). In the manufacturing, MX handler is assembled as below flowchart in Figure 1.2. There are five main modules; the modules are base frame, upper frame, Pick and Place (PNP) head, Test site and chamber. These five modules are outsourced to individual contract manufacturers for assembly and test. The activities for assembly starts with sub- assemblies, there are options and configurable to be sub-assembled. The list of options and configurable are listed in Table 1.1 and Table 1.2. Next, the options and configurable are assembled into main modules in the process called Pre-assembly. WS1 integration is the next activity of combining Base Frame, Test site and Chamber. Upon WS1 integration, Upper frame and Pick and Place head is installed in WS2 integration. Finally, some options and configurable are assembled to the handler in final assembly process.

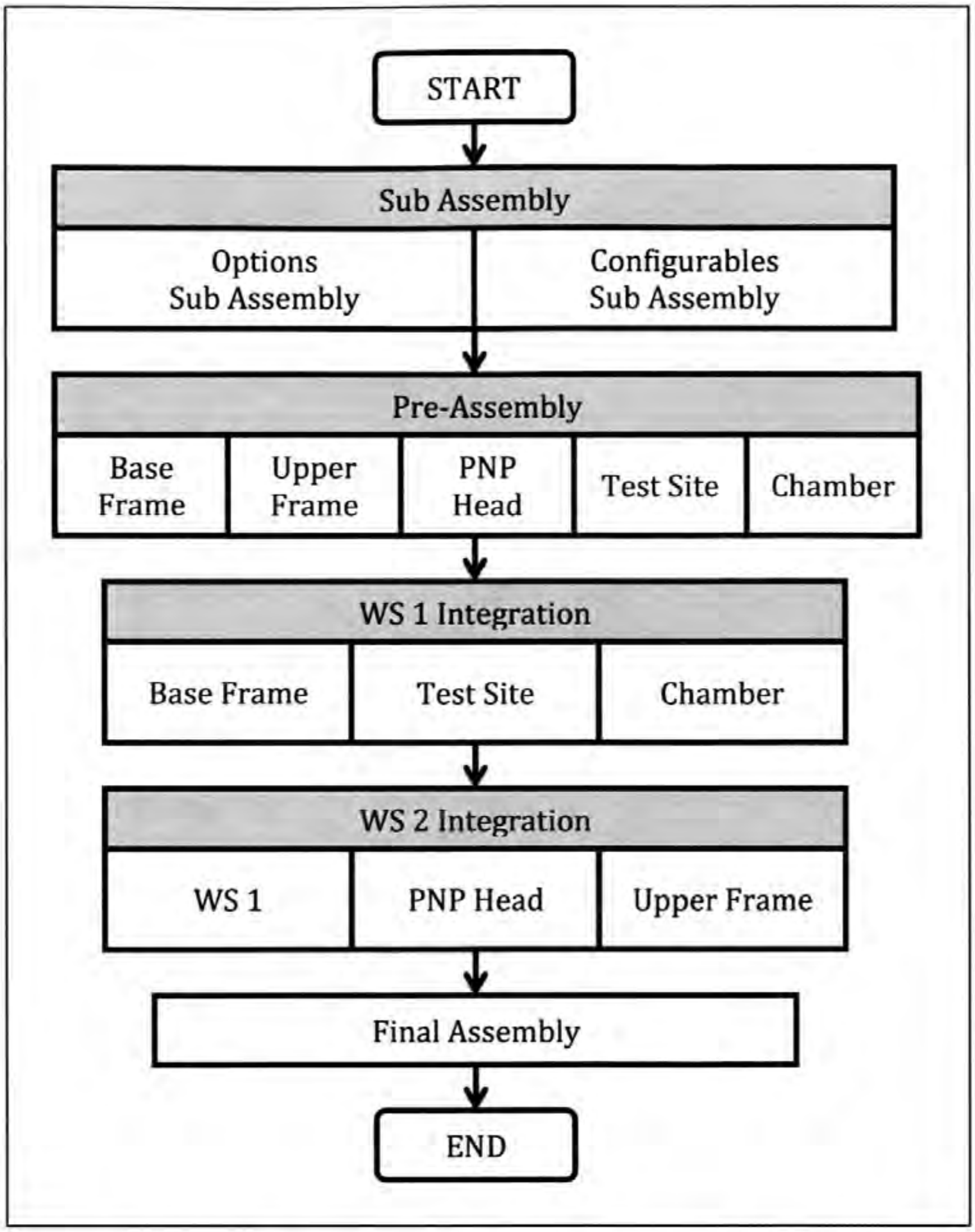

Figure 1.2: Process flowchart of MX assembly process

Table 1.1: List of options in MX test handler and the processes where each options is installed

Options	Assembly process
Manual Tray drawer	Base Frame Pre-assembly
Vacuum Pump	
Leg cold option	Chamber Pre-assembly
WS2 cold option	Final Assembly
Ionizer option	
16K option	
X16 test site option	Test Site Pre-assembly
Cold Z-link	
Cold Manifold	
WS4 cold option	Final Assembly
TS contactor regulator	Upper Frame Pre-assembly
TS shuttle regulator	
TS PPC contactor regulator	

Table 1.2: List of configurable in MX handler and the processes where each options is installed

Configurables		Assembly process
Family	**List of configurables**	
Chucks	2.5" X4 Chucks	Test Site Pre-assembly
	3" X4 Chucks	
	40mm X4 Chucks	
	50mm X4 Chucks	
	60mm X4 Chucks	
Test force config	500lb force	Final Assembly
	1000lb force	
	1250lb force	
	2000lb force	
Lift kit	3.25" lift kit	Final Assembly
	5" lift kit	
	7" lift kit	
TS X pitch	22mm X-pitch	Test Site Pre-assembly
	30mm X-pitch	
	35mm X-pitch	
	40mm X-pitch	
Blowoff configuration	Low pressure blowoff 10k	PNP head Pre-assembly
	Low pressure blowoff 16k	
	Standard pressure blowoff 10k	
	Standard pressure blowoff 16k	
Chuck frames	500lbs frame	Test Site Pre-assembly
	1000lbs frame	
	1250lbs frame	
	2000lbs frame	
Shuttles	Hot-ambient shuttles	Final Assembly
	Cold shuttles	

1.2 Problem statement

Current lead-time required to complete assembly of a semiconductor test handler is 14 days (112 hours). Options and Configurable sub-assembly are done in parallel and all Pre-assembly are done parallel. In current situation, the maximum output per month of the semiconductor equipment manufacturer is two handlers per month for eight hours working day. Currently, the semiconductor equipment manufacturer is receiving orders of five to six handlers per month from customers. Unable to keep up with customer demands is causing the manufacturer to lose business or profits. Competitors that are able to deliver handler in shorter lead-time will eventually get the business.

In order to cater to this increasing order, the Company A hired temporary or contract workers to sustain the assembly and testing process. This practice is not a good long-term solution for the problem. It is the nature of semiconductor industry to fluctuate every year and it is unpredictable. The revenue data is shown in Figure 1.3. As can be seen the annual semiconductor revenue is inconsistent and unpredictable throughout the year 1991 to year 2013. Therefore, it is not a good practice for a semiconductor equipment manufacturer to hire extra headcounts for ramp up and fire during ramp down, as human capital needs to be developed and trained. In this case, the top management have to develop alternative ways to improve efficiency without the needs of hiring extra permanent headcounts. Engineers should start to look into processes to improve and subsequently improve the manufacturing lead times and capacity. Table 1.3 shows the current standard time MX handler in assembly activities. Figure 1.4 shows the current critical path of MX handler assembly process

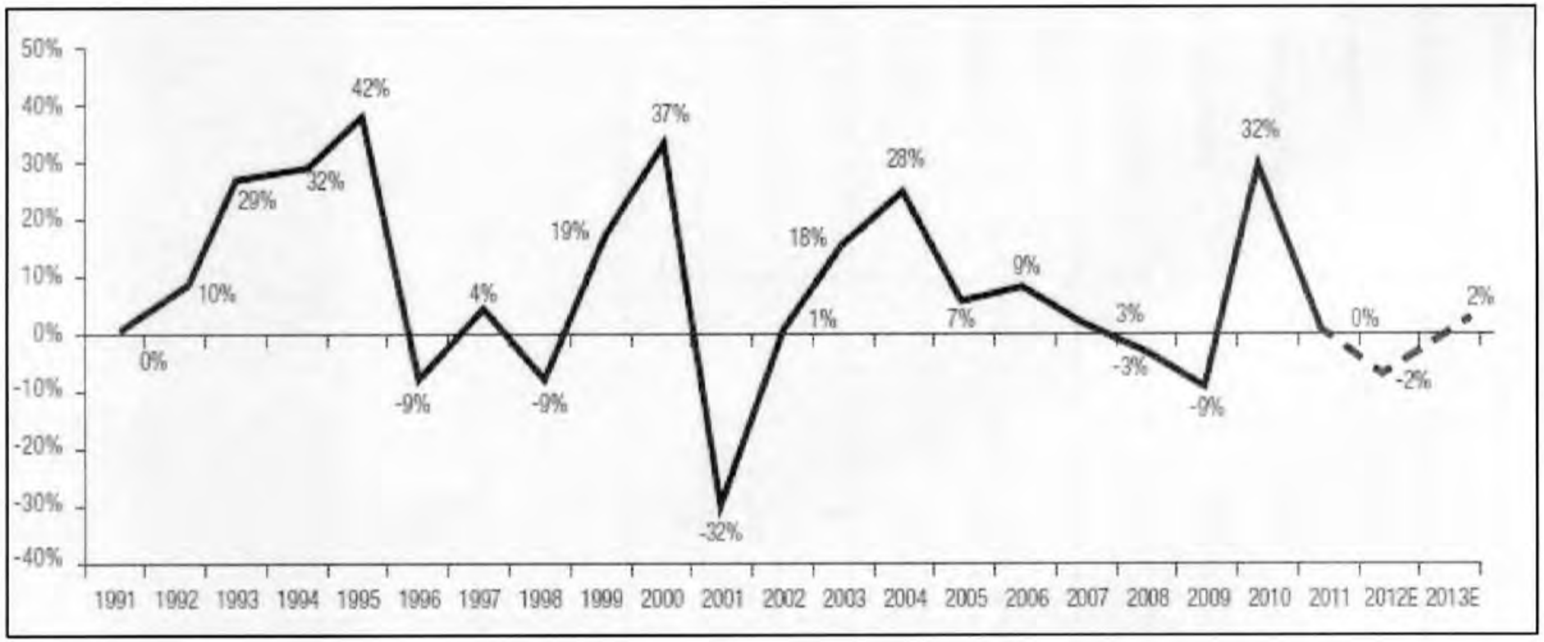

Figure 1.3: Annual semiconductor revenue growth 1991 to 2013

Source: SIA partners and Alix partners analysis (2013)