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LEAN SIX SIGMA APPROACH FOR LABOR PRODUCTIVITY IMPROVEMENT AT FINAL TEST SEMICONDUCTOR MANUFACTURING

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ABSTRACT : Labor productivity improvement is all about getting more units out with the same or lesser amount of labor. Due to the economic challenges, the semiconductor company under study wanted to determine the ideal number of operators to be employed especially at the critical operations in order to minimize the labor cost and improve labor productivity. Thus, the main focus of the study is to perform analysis at the bottleneck area which is the Final Test in order to determine the labor utilization and also to identify the ideal man to machine ratio. The lean work study analysis using Man Machine Ratio (M2M) Technique enabled the authors to unveil the various types of wastes occurring at the final test area in order to propose lean improvement activities. Six Sigma Define, Measure, Analyze, Improve and Control (DMAIC) approach was employed during the project implementation. The results of the final test area Lean Six Sigma study showed significant improvements could be made on the labor utilization and man to machine ratio. With the knowledge of how to improve the labor productivity, the semiconductor company will be on the right track towards achieving a leaner and more cost effective operation.

KEYWORDS: Labor productivity, Lean Six Sigma, MOST, Work Study

1.0 INTRODUCTION

Productivity has become an important issue in a business organization because high productivity means higher profit margin. According to Stevenson [1], productivity can be defined as a ratio of a measure of output to a measure of resources used for the input. Productivity is important as it is used to benchmark the standard of the organization. A more productive organization is able to produce high number of output from a minimum input count. Hence, productivity is improved if the productivity index or ratio is increased.

Labor productivity can be measured in terms of either employee number or labor costs and is a key factor to achieve project goals [2]. Thus, it is paramount to understand the main determinants of labor productivity in an organization as it contributes to the organization or company's performance. Greater labor productivity enables firms to produce a given amount of goods and services with smaller number of labor hours [3].

An established semiconductor company was faced with labor productivity issue due to high labor turn over. The company policy did not allow for hiring of foreign worker to work as the manufacturing operator thus making the hiring process more difficult since the potential candidates often will select company that is able to offer better salary. The existing practice to hire manufacturing operator was by the manufacturing supervisors determining the number of operators required. Unfortunately, the management had no appropriate method to check whether this quantity was higher than the actual requirement or not. Therefore, the management had to find an accurate way to determine the actual number of operators required especially for the critical processes. In addition, the management also wanted to focus on identifying opportunities to reduce or eliminate waste in the production line and improve labor productivity. Consequently, these issues have become the basis of this paper where a work study technique called Man to Machine (M2M) ratio was used to measure the existing labor utilization and to suggest an ideal man to machine ratio [4]. A systematic Lean six sigma DMAIC (Define, Measure, Analyze, Improve, and Control) methodology was employed to conduct the study.

2.0 LEAN SIX SIGMA

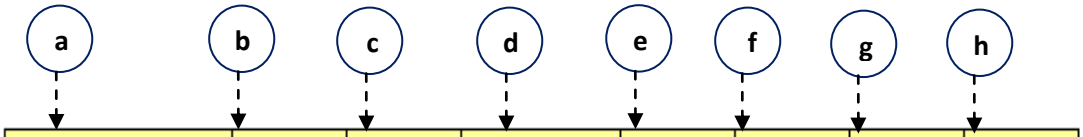
Lean manufacturing is known as the most influential manufacturing paradigm of recent times that can be considered as multi-dimensional approach that encompasses a wide variety of management practices in an integrated system that produces finished products at the pace of customer demand with little or no waste [5]. Lean is a term coined by the Americans originating from the famous Toyota Production System [6]. The Lean productivity improvement effort is solely on waste elimination. Svensson explained that in terms of cost, waste refers to any incurred cost such as inventory, set-up, scrap, and rework that do not add to the value of the product [7].

The outcomes of lean manufacturing include significant reduction in inventory and lead times, improved delivery performance, better space and resource utilization and enhanced productivity and quality [8]. Abdulmalek and Rajgopal [9] mentioned that the lean manufacturing tools and techniques such as Just-In-Time (JIT), cellular manufacturing, total productive maintenance, single-minute exchange of dies, and production smoothing have been widely used in discrete manufacturing which spanned in many sectors including automotive, electronics and consumer products manufacturing.

Table 1.0: M2M Study Lot Cycle Time

Cell	Product	Lot Cycle Time (min)
Cell 3	SMA/SMB	251.83
Cell 4	SMB/C/SOD	146.8
Cell 7	Powermite	164.93

Table 1.0: Man to Machine (M2M) Calculation Example



Activities	Time (min)	Frequency / lot	Lot cycle time (min)	M2M(1)	M2M(2)	M2M(3)	M2M(4)
1. Wafer Preparation	0.3	1	15	0.020	0.040	0.060	0.080
2. Wafer Mount	0.5	1	15	0.033	0.067	0.100	0.133
3. Machine Set-up	3	1	15	0.200	0.400	0.600	0.800
M2M utilization (%)				25.33	50.67	76.00	101.33

Table 2.0: Summary of the Final Test M2M result

Cell	Product	M2M(1)	M2M(2)	M2M(3)	M2M(4)	M2M(5)
3	NT 16 SMA/SMB	29.32%	54.97%	80.61%	106.26%	
4	NT 16 SMB/SMC/SOD	24.65%	45.12%	65.59%	86.06%	106.53%
7	NT 16 Powermite	30.57%	56.95%	83.34%	109.73%	

However, it is quite common for companies to combine Lean Manufacturing and Six Sigma in what is called Lean Six Sigma. The two are quite complimentary since Six Sigma is a powerful tool for helping to make the company leaner. Likewise, some of the processes often used in Lean Manufacturing may be the solutions to problems addressed in a Six Sigma projects [10]. Both Six Sigma and Lean Manufacturing have unique strengths and they integrate well together. Lean is broader in nature since it sets a broad objective of eliminating all waste, and recommends certain processes for achieving that. Six Sigma is more focused in nature since it is a set of tools for achieving clearly defined improvements, which are likely to result in a leaner company.

Harry et.al. [11] defined Six Sigma as a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction. The standard approach to Six Sigma projects is the Define, Measure, Analyse, Improve and Control or DMAIC methodology developed by General Electric which is central to Six Sigma process improvement projects. The DMAIC phases provide a problem solving process in which specific tools are employed to turn a practical problem into a statistical problem, generate a statistical solution and then convert that back into a practical solution [12].

3.0 MAN TO MACHINE (M2M) RATIO TECHNIQUE

M2M ratio technique was developed based on the evaluation of the common work study tools such as Process Mapping and Multi Machine Chart. The important elements that contribute to the labor productivity determination such as the operator's activity time, the number of time each activities is repeated (frequency) and the machine lot processing time are factored into the M2M equation.

$$\mathrm{M2M}(\%) = \sum_{i=1}^{n} \frac{Activity\ time_i\ x\ Frequency_i}{Lot\ Cycle\ Time} x\ 100 \quad \textbf{(1)}$$

Where,

i = number of activity time and the frequency

n = total number of activity time and the frequency

Table 1.0 is a Microsoft excel template designed to conduct the Final Test Lean Six Sigma work study. Column (a) indicates the activity element of the operator and column (b), (c) and (d) is the time for the activity element, frequency and lot cycle time respectively. The M2M (1) in column (e) is obtained using Equation 1. Whenever a new machine, M2M (2) is added, the M2M utilization (%) increases from 25.33% to 50.67%. The International Labor Standard (ILO) of 85% labor utilization is observed and thus, the ideal man machine ratio of 1 operator to 3 machines is set for this operation.

4.0 FINAL TEST LEAN SIX SIGMA

The Final Test was the area selected as the back-end semiconductor that the Lean Six Sigma study was conducted since this operation was identified as the bottleneck area for the production line. This process is where each device is tested for the electrical performance based on customer's specification. In addition, each unit will be marked using the same machine with company's logo, device number and production date for traceability purposes. Each completed unit will automatically be inserted into a reel and sealed before being packed.

The focus for this area was to determine the existing labor utilization, to identify the ideal man to machine ratio and to find the opportunities to reduce or eliminate any non-value added activities or wastes. Six Sigma DMAIC was used to conduct the study.

4.1 Define

The final test area is where the units are separated from the lead frame and the legs of the units are shaped to the customer's specification using the trim and form equipment. The same equipment also is used to mark the units with the company logo and to test the units to meet the customer's electrical requirements.

The first step is to define the product and equipment allocation at the final test area before detail capacity study can be done to define the unit per hour (UPH) and the lot cycle time to be used in the M2M study. From Table 2.0, the final test area consists of seven cells containing two different types of final test equipment; Ismeca T-16 which is very old technology final test equipment and Ismeca NT-16 which is the newer technology final test equipment. However, there is already a plan to phase out all the Ismeca T-16 and thus, for the purpose of the M2M study, the author is asked by the management to only focus on the NT-16 equipment.

The labor configuration in each cell at final test area is 1 operator handling 2 machines. The operators are designated to load and unload the materials, operate the machines, perform machine assist whenever minor stoppages occur, product inspection, transport materials and prepare required documentations.

4.2 Measure

The product and equipment information in the final test area such as the lot size and the units per hour (UPH) are then used to calculate the lot cycle time using the formula defined during the M2M method development. Since the equipment efficiency information is not available at the time of study, the management has agreed to standardize the use of 70% equipment efficiency for the purpose of calculating the lot cycle time. The summary of the lot cycle time used for the three M2M studies done at the final test area is presented in Table 1.0

4.3 Analyse

Based on the analysis of the M2M result, the summary of the operator's utilization and man to machine ratio for the final test area is summarized in Table 2.0 below.

Referring to Table 2.0, the cell 3 operator's utilization who is only handling two machines is 54.97% and can be improved to 80.61% if another machine is allocated to the operator. Similarly, two more machines can be handled by the cell 4 operator and the utilization of the operator can be improved further to 86.06%. In addition, the operator handling the Powermite products can also take care of another equipment to improve the utilization to 83.34%.

The existing allocation of operators is three operators per each cell. However, if one operator has to handle 3 machines, there will be only 2 operators handling a cell and this will create a problem when one of the operators go for break or had to attend to some other personal delays. This will result in 1 operator handling 6 machines and the operator's utilization will increase to beyond 100% and risking potential loss of valuable outputs if the operator is unable to perform critical functions such as machine assist, reel change and start new lot. Consequently, the alternative to reduce one operator from each cell will need to be delayed until waste elimination activities are implemented in the final test area.

4.4 Improve

From the three cells Final Test M2M study, the top three major wastes in the final test area are the machine assist, reel change and start new lot activities. Machine assist is the activity of the operator needs to perform whenever the equipment suddenly come to a stop to reset the test program, units pick up problem or laser not marking issues. As a result from the M2M study, the IT group has agreed to install another workstation in every cell to improve the machine assist time. For the rell change issue, the inspection activity has taken most of the time to change the reel, thus changing the inspection from every reel to the first and last reel has proven to improve the operator activity time by more than 50%. The third issue of starting new lot requires too many steps in operator's activities and requires the process engineers to relook at the standard operating procedures to reduce non-value added activities.

4.5 Control

The final test improvement team was required to report the progress of the implementation during the monthly team review and quarterly management review. This was to ensure that the lean efforts are given appropriate attention in order to continuously increase the productivity of the final test production line.

5.0 CONCLUSION

Focusing on labor inputs provides the opportunity for a company to efficiently utilize the manpower needed especially at the critical operation to gain maximum output with minimum labor hours. Lean Six Sigma is a systematic technique that can be used to uncover the various types of wastes in the operator's activities in order to increase the efficiency of the workers.

The Man to Machine ratio (M2M) technique is an alternative technique that can be used to provide any work study practitioner with easy, fast, accurate, economic and flexible tool. By utilizing the M2M method, current and ideal labor utilization can be determined and various wastes can be uncovered to further improve labor productivity and reduce manufacturing cost.

The result of the improvement of the cycle time will contribute to the increase in the speed of delivery to the customers. Thus, the company will be able to confidently identify the actual number of employees they need to employ and can concentrate on the training to ensure each employee they hire provides high productivity and performance to the company.

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