Elimination of Waste through Value Add/Non value Add Process Analysis to Improve Cost Productivity in Manufacturing - A Case Study

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Abstract – **Value Stream Mapping (VSM) is a very comprehensive tool to that allows an organization to identify sources of waste and implements process improvements. This paper describes the adoption of VSM in a semiconductor manufacturing company to improve personnel efficiency and optimize headcount in the production lines. Based on the future state of the value stream mapping a new production process flow was implemented. Non value added activities were reduced or removed by assigning butterfly operators to perform these tasks. The new system successfully resulted in the reduction of six headcounts in the taping process. This is equivalent to a saving of approximately eighty seven thousand Malaysian ringgits per annum. This systematic approach can be similarly employed by the lean practitioners to conduct lean activities in other manufacturing sectors.**

Keywords – **Value stream mapping (VSM), Productivity and Value added/Non Value Added Analysis, Semiconductor industry**

I. INTRODUCTION

The increase of operations and maintenance cost from year to year is of a great concern in most manufacturing firms today. In an effort to optimize and reduce operation and maintenance cost, the Total Preventive Maintenance programme has played a key role to increase equipment availability and hence reducing the needs for further investments [1]. In today's competitive environment, a manufacturing firm's success is very much dependent on its capability in incorporating cost reduction measures and productivity improvements in its daily operations [2]. Productivity can be expressed as a physical measurement of the rate at which outputs of goods or services are produced per unit of input. If a manufacturing firm is able to produce output beyond than desired with a given input, then higher productivity efficiency is achieved.

Lean manufacturing was developed based on the knowledge and know-how obtained from the Toyota Production System (TPS); where Toyota had successfully increased their world-wide market share by improving product lead-time, quality and employee productivity [3]. The fundamental principle behind lean manufacturing is to reduce non-value added process and reduced process lead-time. Non- value added activities refers to those activities which consume resources but produces nothing at the end of process [4]. The main objective of lean manufacturing practices are to improve overall productivity, personal cost, equipment performance and product quality [5].

II. LITERATURE REVIEW

According to Ohno [6], the Toyota Production System is a systematic approach to identify and eliminate production losses. TPS helps to reduce cost and product lead-time by challenging and analysing every single process step flow. It applies the "why-why analysis" by asking why an activity is performed and continues asking why after each answer and response [6]. By understanding each why, this will undoubtedly lead to the root-cause being identified so that the appropriate corrective action may be taken to address the situation [6].

Researchers such as McDonald et al. [7], Abdulmalek and Rajgopal [8] and Greasley [9] have explored and carried out study on the integration of value stream mapping (VSM) by using simulation. Simulation is one of the most appropriate tools that can be incorporated with the other practical methods such as business model and operation research [9].

Chitturi et al. [10] discussed and defined the method on how to calculate process time and how to continue process improvement activities in order to close the gap between the existing process flow and the future process flow steps. Chitturi et al. also pointed out that all detailed data and information must be collected from the beginning until the end of the process step during mapping the VSM process.

Chandradeep [11] pointed out that the lean approach and VSM methodology can by implemented and applied for a small company. He also ascertained that VSM is a comprehensive and powerful production tool to highlight the inefficiency and improvement areas of the identified future state of the process. Bhim Singh et al. [12] claimed that the implementation of lean manufacturing with the assistance of VSM methodology in the manufacturing industry resulted in a 83.14 percent decrease in the lead time, 12.62 percent decrease in the processing time and 89.47 percent decrease in the work-in-process inventory. In addition, they managed a 30 percent decrease in manpower requirement with productivity increasing to 42.86 percent per operator.

Another researcher, Ibon [13] claimed that the VSM is a comprehensive industry engineering tool to develop and design process flows through the identification of non-value added processes, removing these processes and to join or combine with other value-added process in order to cut down the cost of production and reduce product overall lead time. It is the production

tool used for re-designing and re-engineering the production system.

Based on a case study done by Belokar et al. [14], by adopting the VSM methodology, the production lead time improved from 18 days to 11 days and the processing lead time improved from 124.7 seconds to 107.2 seconds. In addition, in-process inventory was reduced from three days to one day. This translated to a 44% improvement in the value adding activities. As a result, the process flow became much simpler and less expensive to achieve operational excellence.

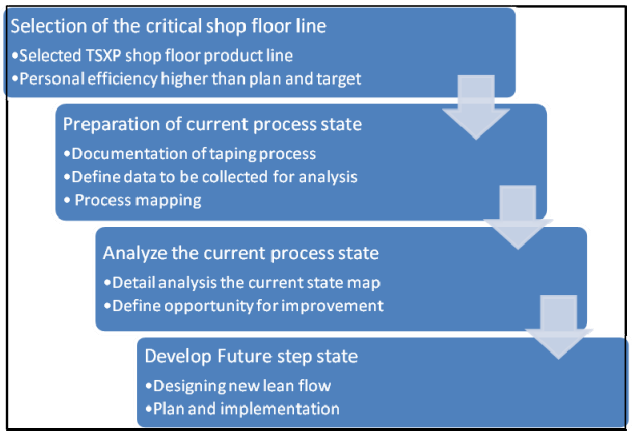
III. METHOD AND METHODOLOGY

The adoption of the value added and non value added analysis is demonstrated through a case study in a well known semiconductor. This case company is located in Malaysia and started to introduce lean manufacturing since 2012. The case company is actively involved in a market that is expected to grow at an average of 10 percent annually over the next few years. To achieve this, the company focuses on Quality and Productivity (Q&P) as its key thrust in attaining competitive advantage for the company.

To improve productivity, it is essential to identify the production waste and eliminate the waste by applying VSM principles and methodology in the production lines. For the case study, the Thin Small Leadless Package (TSXP) taping production line was chosen because the personnel efficiency level was above the Target Cost Roadmap (TCR). The various steps undertaken in the VSM implementation are illustrated in Figure 1.

The problem is clearly defined by using tools such as 12 dimensions approach and SIPOC. Issues on containment and actual performance were also carefully examined to ensure viability of the project. The problem description however does not contain the cause of the deficiency and likely actions or solution. At the first stage, the project team was able to identify non-conformity issues.

Figure 1: VSM Implementation Flow in the Case Company



For the purpose of validation measurement and evaluation against the baseline performance, tools such as trend charts, basic Pareto chart, process flow chart and process flow VA-NVA analysis were used. The team was able to identify potential root causes that can be used as levers for improvement for the problem under investigation.

In the next phase of the study, the team determined the type of non-conformity and the true root cause of these non-conformity. The team verified the hypotheses defined at earlier stage either by direct observation of by suitable statistical test. The hypotheses examines the relationships between NVA activities and low personnel efficiency; operator manual activities and low personnel efficiency; and high frequency of visual inspection processing time and low personnel efficiency.

In the improvement phase of the study the project team developed solutions to improve the process capability, implement and test the solutions. In this phase, after the process and its capability have been characterized, those process elements that need to be improved are identified and the improvement target has been defined, the next action is execution.

Finally, the proposed solution was implemented; process performances were monitored and acted upon on any deviation encountered. The project team also stabilized the process and measured the long term process capability.

IV. RESULTS AND DISCUSSION

The non-conformity for this case study is the Test Handler and Automation (THA) taping personnel efficiency which is above the planned target. The final problem statement developed was: TSxP THA taping personal efficiency is five cents above planned target which was three cents and headcount optimization is not optimized where the current man-machine-ratio is 1:2. The objective, background and scope of the case study were defined and shown in Figure 2.

Figure 2: Objective and scope of the case study

Project Background	TSxP THA Taping Personal Efficiency above Target Cost Roadmap
Scope	To improve personal efficiency and optimize headcount at TSxP THA Taping area
Objective	To improve personal efficiency by using VSM Approach To optimize MMO from 1:2 to 1:3
Resource	Timeline: 6 months. Target to complete by Feb 2013 Team Member : IE, Production, Maintenance, Test Process Engineering, Finance, Quality, HR
Benefit	Target annual saving: MYR87,000 (3 H/C)
Potential Constraint	Area Layout , Investment on Infrastructure
Project Metric	Multi-Machine-Operation

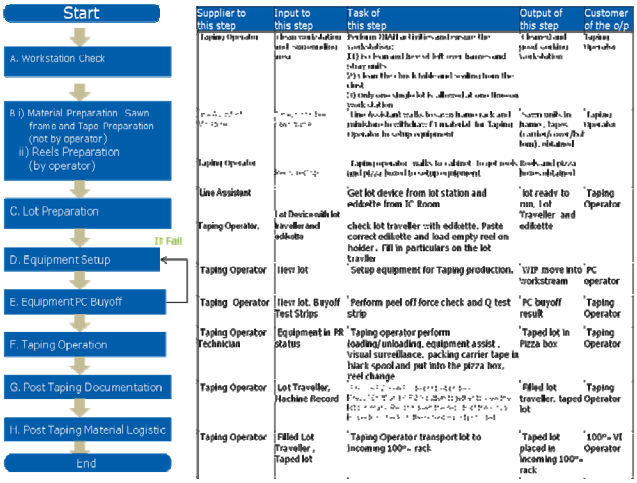
The problem statement was clearly developed by using the twelve dimension approaches. Figure 3 provides the details of the approach.

Figure 3: 12 Dimension Approach

No	Dimension	Is
1	Geographically where was the object when the nonconformity was noticed first?	TSXP taping process
2	Where is the nonconformity located on the object?	TSxP THA taping
3	At which time and date was the nonconformity first noticed	Since September 2012
4	What is the pattern of occurrences? (over time) What is the type of the nonconformity?	Pattern of occurrence: continuous trend. Type of nonconformity: No seasonal pattern
5	Where in the sequence of events (process steps) of the object was the nonconformity first noticed?	Taping process
6	Where in the sequence of events (process steps) of the object was the nonconformity first noticed?	All THA machine have the same nonconformity
7	How many faults are there on one object?	N.A.
8	What is the size of the nonconformity or how bad is the nonconformity?	Potential saving RM87,000 annually
9	Is the number of objects with the same nonconformity growing/ staying the same, stable / decreasing?	Stable
10	Is the nonconformity getting worse / stable / getting better?	stable

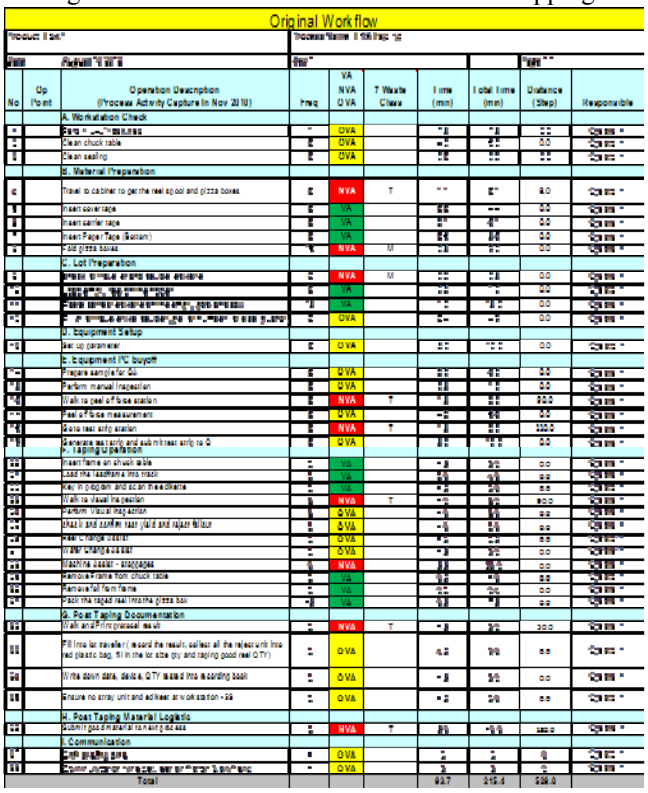
In the stage of the case study, process mapping was employed to identify the potential source of the low personnel efficiency at TSXP process. The actual process capability at the potential sources for this non-conformity was measure using the VA/NVA approach. The process mapping was based on the insights of more than one person and from different perspectives. Figure 4 shows the result for the taping process mapping.

Figure 4: Taping Process Mapping



After the process mapping has been completed, the team used value added and non-value added analysis to identify and eliminate production waste at the taping process. Figure 5 details the VA/NVA analysis for the TSXP taping.

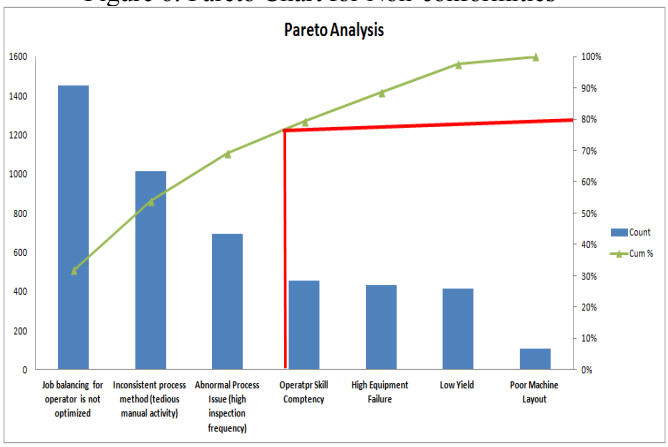
Figure 5: Value Added/Non Value Added Mapping



The analysis indicated that some tasks involved transportation and motion waste. Operation Value Add (OVA) and Non Value Add (NVA) contributed more than 70% and these revealed that there are some improvement opportunites at the taping process. Operation value add (OVA) is the activity that is not a value add to the customer's point of view, but it is necessary to keep the operation moving.

As a result, activities such as performing Jishu Hozen Autonomous Maintenance activities, travel and get the reels and pizza box, insert tap, fold pizza box, check lot traveler, fill in particulars on lot traveler, equipment set-up, traveler and perform peel off force measurement, traveler and perform test strip to quality check, travel and perform visual inspection check, reel changed and wafer change assist, machine assist, print material protocol and submit good material for next process were categorised as non value add activities. The use of the Cause and Effect Matrix helped to determine the relationship between non value add process elements and the non-conformity in taping process. The non-conformities identified were job balancing for operator is not optimize, inconsistent of process method, abnormal process issues, operator skill competency, high equipment downtime, high low yield material handling and poor machine layout. Based on the Pareto analysis, the top three of the non-conformities were job balancing, inconsistent process methods and abnormal process issue (high inspection frequency). Figure 6 shows the Pareto Chart of the non-conformities

Figure 6: Pareto Chart for Non-conformities



The three non conformities were then analyzed by using fish bone diagram to identify potential root-causes that contributed to the high non-value added activities. Figure 7 demonstrate the potential root-cause for the identified non-conformities.

Figure 7: Potential Root-causes for Non-conformities

Non-conformities	Potential Root-causes
Job balancing for Op is not optimized (operators)	High percentage of NVA activities in taping operation causing low personnel efficiency
Inconsistent manual activities process method among operators	Operator to operator manual activities processing time is not consistent resulting low personnel efficiency
Abnormal Process Issue (Visual Inspection process)	High frequency of Visual Inspection Processing Time causing low personnel efficiency

The three hypotheses were evaluated based on the non-conformities identified at the previous stage. Figure 8 shows the three hypotheses developed and the summary of findings

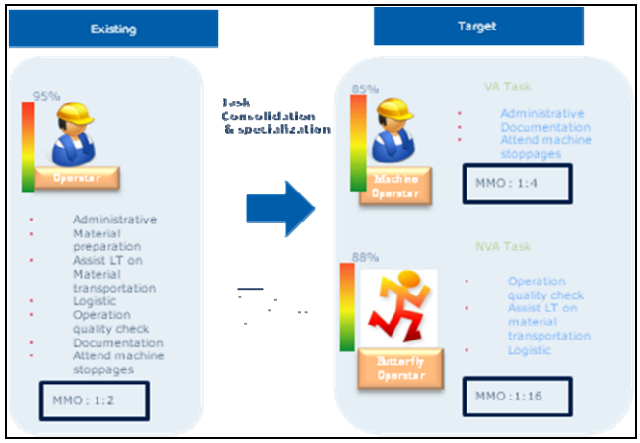
Figure 8: Hypotheses developed

Hypothesis	Hypothesis Test	Result
High percentage of NVA activities in Taping Operation causing low personnel efficiency	Ho: NVA activities cause no significant impact to low personnel efficiency H1: NVA activities cause significant impact to low personnel efficiency	Accept H1
Operator to operator manual activities processing time is not consistent resulting low personnel efficiency	Ho: No significant difference between operator manual activities processing time H1: Significant difference between operator manual activities processing time	Accept H0
High frequency of Visual Inspection Processing Time causing low personnel efficiency	Ho: High frequency of Visual Inspection Processing Time cause no significant impact to low personnel efficiency H1: High frequency of Visual Inspection Processing Time cause significant impact to low personnel efficiency	Accept H0

In order to analyse each hypothesis developed, propositional test method used to determine the p value. If p value smaller than 0.05, this revealed that there is a significant difference and the hypothesis accepted. Based on the proportion test carried out, p value obtained for high percentage of NVA activities in taping operation which cause low personnel efficiency was 0.025 and smaller than 0.05, this two proportion test indicate NVA contribution is significantly higher than the VA activity and therefore the NVA operator activities needed to be reduced.

A suggestion of regrouping and re-consolidating the value added and non-value added THA taping activities with the idea of removing the NVA task from the operator was proposed to improve multi-machine operations. Compared to the current state, the future state of process introduced "machine operator and "butterfly operator" concept by re-assigning the value added and non-value added task into two different groups of operators. Figure 9 illustrates the consolidation of value added and non value added tasks.

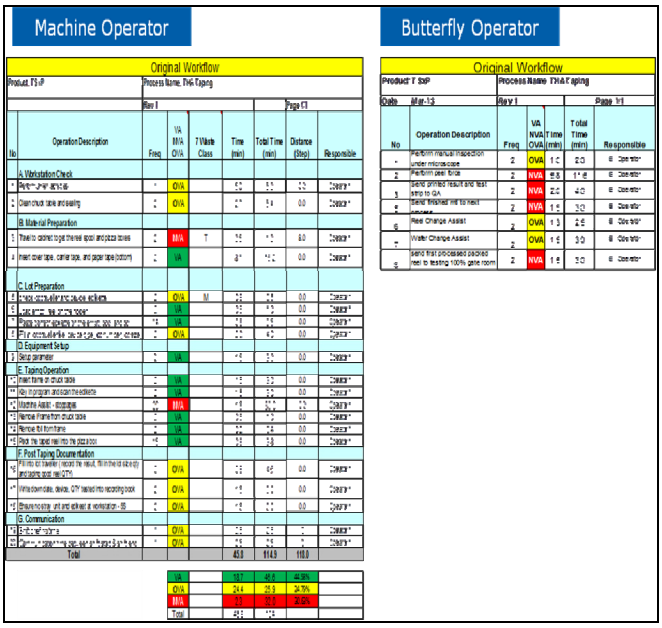
Figure 9: Consolidation of value add and non value add tasks



The new task allocation after the regrouping of value added and non value added process step after the improvement idea is demonstrated in Figure 10.

Based on the new future state of process steps, the workflow step for THA taping was divided into two separate parts. There are the "machine operator" activities and "butterfly operator" activities. The non value added activities of carried out by the machine operator was reduced by 31.5% compared with before improvement. By introducing butterfly operator, it shares some of the activities which original own by the machine operator. As a result, the machine operator was able to take-care additional equipment since the job load significant reduces compare to the initial state.

Figure 10: Improved process step by regroup VA and NVA activities



V. CONCLUSION

This study applies the lean concept of value added and non value added analysis to personnel efficiency of a semiconductor manufacturing company. Based on the case study, by re-assigning, re-grouping and re-arranging the value add and non value add activities, the organization is able to improve productivity such as improved headcount productivity and operation costs. This systematic approach can similarly assist and be applied by the lean practitioners to conduct lean activities in other manufacturing sectors.

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