ORGANIZATIONAL VERTICAL & VIRTUAL INTEGRATION MODEL IN IMPLEMENTING LEAN MANUFACTURING TRANSFORMATION

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ABSTRACT

At present-day, organizations face increasing global competitiveness and demands of the information and technological age, the need arises for integration of organizational structure and application system in order to achieve Lean manufacturing transformation. A broader set of skills, creative and innovative approaches to analysis, using up-to-date tools and design through the implementation of Lean manufacturing methodology are therefore important. The purpose of this paper is to integrate the organizational vertical and the virtual application in the conceptual framework from Lean manufacturing perspective through sensory modalities. This is to reduce some gaps that have been pointed out to Lean manufacturing transformation, namely, lack of ability to understand organizational structure and behavior, potentially negative impact on innovation capability and inability to eliminate waste in Lean manufacturing management. An integration Lean model is proposed in implementing Lean manufacturing transformation, thus enhancing problem solving capabilities and continuing improvement. The novelty of Organization Vertical and Virtual Integration model (OVVI) has parallels input values with other lean disciplines that providing quality information and effective information systems with special reference to Lean manufacturing in achieving organizational efficiency and accomplishment of application programs. The five sensory modalities applied to suite the real-time Lean process environment.

KEYWORDS: *Organizational Vertical and Virtual Integration, Lean Manufacturing Transformation, Five Sensory Modalities, Lean Process Management.*

1.0 INTRODUCTION

In today's age of integration, companies start to apply Lean and other improvement methods beyond the factory floor to office administration department, supply chain, customers and all different status levels in the organization. Many manufacturing industries discovered that Lean manufacturing transformation and techniques could produce significant results. Lean manufacturing is a variation on the theme of efficiency based on optimizing flow, increasing efficiency, decreasing waste, and using empirical methods and real-time lean application program to decide what matters, rather than uncritically accepting pre-existing ideas. Lean manufacturing is important to enable the organization to reach beyond business alignment toward fundamental integration. Top level and low level management comprise the different status levels in the organization will have easy and convenience access to the real-time oriented application program for Lean manufacturing transformation. The advancement of information technology (IT) tool and practice enable and sustain Lean process management. According to Steven C. Bell and Micheal A. Orzen (2011), Lean IT is much more than just a set of tools and practices. It is deep behavioral and cultural transformation that encourages everyone in the organization to think differently about the role of quality information in the creation and delivery of value to customer.

The scope is mainly focuses on the Lean manufacturing transformation through vertical organization and Lean software development. Lean software development views all Agile methods as valid, proven applications of Lean thinking to software as stated by Jeff Sutherland (2007). In fact, Lean emphasizes seeing the whole through the eyes of customer, not its component parts through the eyes of designer or developer. Five sensory modalities applied to suite the real-time Lean process environment. By integrating PC and many handheld devices with real-time lean application programs to provide flexibility, efficiency and features for better functions. By developing this real-time lean application programs that incorporate OVVI should provide a highly versatile and practical tool. Since almost all manufacturers and customers today receive some IT experience and have access to PCs or embedded systems as they particularly need this. Such real-time Lean application programs and techniques will naturally be much more effective if it takes advantages of OVVI model in lean manufacturing transformation.

2.0 LITERATURE REVIEW

Many manufacturing and production industries in today's competitive and fast moving companies have successfully adopted lean manufacturing practices and principles. Despite its general acceptance and usage, some of its gaps have been pointed out throughout its development. Those gaps include the lack of ability to understand customer value, Hines, P., Holweg, M., & Rich, N. (2004) and its potentially negative impact on innovation capability, Chen, H. Y., & Taylor, R. (2009). But, most of these companies are not considered fully lean since of their wastages of valuable resources that affected their productivity and profit. In order to become fully lean, in whatsoever a company must understand lean as a long term continuing and developing tool to right processes, right results and added value to organization (A.P. Puvanasvaran, 2008). The use of classical Lean management tools, namely of Value Stream Mapping (VSM), can result in overlooking major waste that occurs in small processes, Wilson, L. (2010). In Creating a Lean Culture, organizational psychologist David Mann (2005) suggests that as organization changes the way work is done, it must also fundamentally change the way it manages that work. He describes the behavior necessary to create an effective lean management system through visual control-the sensory modalities. Spear and Bowen (1999) argues that these are necessary for a successful Lean implementation due to people or the employees of the organization are the main appreciating asset after products and services. But, at the same time, they are also the most under-utilized resources in many organizations due to organizational vertical scenarios.

Many researchers, experts, authors have discussed the Lean manufacturing as part of organization centric issues but still failed to provide a complete or optimal structured Lean system that can give guide lines in enhancing problem solving competence. Some of the reasons and problem statements are to be considered as: (i) The business is unable to Learn and change its organizational behavior (Emiliani, 1998) and he defined the repeated mistakes as another primary type of waste and argues that, " no doubt, risk the future existence of their entire enterprise as currently governed", (ii) A lack of direction of planning and adequate project sequencing. (Bhasin and Burcher, 2006) for application program execution, (iii) Lean concept was viewed as a counter-intuitive alternative to traditional manufacturing model proposal (Wolmack et al., 1990), (vi) Need to improve the productivity of a manufacturing organization with respect to different market and product mixes, (Hilmola, 2005); customer value and market segments (Setjono and Dahlgaard, 2007), and (v) Absence of practical and detailed model to follow in pursuit excellence within manufacturing (Gilgeous and Gilgeos, 1999), holistic logic and management system (Holweg, 2007), and the outcome of dynamic learning process that adopted the practice (Cusumano, 1992). This new go Lean OVVI model supports Lean planning and execution of manufacturing operations all the way from forecasting demand, supplier chains, customer scheduling, and leveling production to setting line rates and pulling parts using Kanban signals with integrated quality management, Kaizen costing and elimination of waste.

Although many suggests that "what" and "why" an organization should incorporate the Lean manufacturing system into functioning, but fails to clearly explaining "how" and "where" it should improve the Lean manufacturing transformation. Therefore, this aims to identify the research statements and the manufactures' problems, hence, providing the solutions to "what", "why", "where" and "how" for an organization incorporate the Lean principles and practices. Lean manufacturing transformation engages people, using a framework of Lean principles, system and tools, to integrate, align, and synchronize the organization with the business to provide quality information and effective information systems, enabling and sustaining the continuing improvement and innovation of process. Organizational vertical and virtual integration is therefore important for enhancing problem solving capabilities and continuing improvement. Lean manufacturing is important to enable the organization to reach beyond business alignment toward fundamental integration. The advancement of IT tool and practice enable and sustain Lean manufacturing transformation. By linking five sensory modalities, OVVI model has parallels input values with other Lean disciplines with a connection to Lean principles, process and tools. The OVVI plays the important rule in the effort to implement Lean manufacturing in an organization. Therefore it is important to measure progress or changes made in an effort to become Lean. The principle implanted is one of the determinants of Lean manufacturing system (Karlsson *et.al.*, 1996). Table 1 shows that principles are the determinants that are able to reflect changes in an effort to become Lean (Karlsson *et.al.*, 1996, Worley *et.al.*, 2006, and Bhasin *et.al.*, 2006).

Table 1: The Integration of OVVI and the Principles of Lean Manufacturing

Integration Model	Principles of Lean manufacturing	Author	Description
Organizational Vertical : - top level - middle level - low level - manufacturer - supplier - consumer - end user - director - manager - supervisor - employee - employer	Elimination of waste	Rawabdeh (2005)	Waste can be defined as anything than the minimum amount of resources which are absolutely essential to add value to a product.
		Nicholas (1998)	7 type of waste (inventory, defect, transportation, overproduction, waiting time, processing & motion.) identified by Toyota, first described by Taiichi Ohno.
		Karlsson *et.al.* (1996)	The goal of Lean manufacturing is to lower costs and can be done through the elimination of waste.
	Continuous improvement (Kaizen)	Karlsson *et.al.* (1996)	The constant strive for perfection is the overriding concept behind good management, in which the production system is being constantly improved; perfection is the only goal.
		Sánchez *et.al.* (2001)	Involving everyone in the work of improvement is often accomplished through quality circles.
		Karlsson *et.al.* (1996)	Activities where operators gather in groups to come up with suggestions on possible improvements.
		Nicholas (1998)	A company's survival and success now depend on its ability to continuously improve products and services to meet and exceed customer expectations.

Integration Model	Principles of Lean manufacturing	Author	Description
Virtual Applications : -Database -DBMS -RDMS -SQL -Lean IT -VR -VSM	Zero defects	Karlsson *et.al.* (1996)	Defects are prevented through discovering errors that can Lead to defects.
		Basu *et.al.* (1999)	Identification and adjusting of defective parts are responsibility of workers.
	Just-in-time (JTM)	Basu *et.al.* (1999)	The goal of JTM is that every process should be provided with one part at a time, exactly when needed
		Karlsson *et.al.* (1996)	To achieve the goal, some interrelated determinants have to make that is reducing lot sizes, reduction of buffer sizes and reduce order lead time.
		Nicholas (1998)	Just-in-time is management that focuses the organization on continuously identifying and removing sources of waste so that processes are continuously improved.
	Pull instead of push	Ohno (1988)	The more inventories a company has … the less likely they will have what they need.
		Liker (2004)	Ohno recognized that individual departments building products to a schedule using a push system would naturally overproduce create large banks of inventory.
	Multifunctional teams	Karlsson *et.al.* (1996)	The most important feature of the organizational set-up of the Lean manufacturing system is the extensive use of multifunctional teams, which are groups of workers able to perform many different works.
		Sánchez *et.al.* (2001)	Work organization in multifunctional teams greatly facilitates task rotation and flexibility to accommodate changes in production levels.
	Decentralized responsibilities	Karlsson *et.al.* (1996)	The multifunctional team is expected to perform supervisory tasks with rotations of team leadership among workers.
		Sánchez *et.al.* (2001)	Result of this is reducing the number of hierarchical levels in the organizations.
	Integrated functions	Karlsson *et.al.* (1996)	Tasks previously performed by indirect departments are integrated into the team. Thus, the number of tasks performed by the team increases, and consequently the number of indirect employees can be reduced.
	Vertical information system	Karlsson *et.al.* (1996)	Information is important in order for the multifunctional teams to be able to work efficient. Two types of information: 1. Strategic information about the overall performances and plans of the organization. 2. Operational information about performances of the teams, quality productivity, lead times and other factors in the production process.
		Sánchez *et.al.* (2001)	The objective is to deliver timely and useful information down to the production line.

To eliminate waste, it is important to recognize it firstly. This can be done by using five sensory modalities to indentify the nature of industries for consumable and non-consumable products. Since waste is anything that does not add value, the first step to eliminating waste is to develop a keen sense of what value really is (Poppendieck *et.al.*, 2006). From a practical perspective, waste can be categorized into seven categories: waste from overproducing; processing; inventory; transporting; producing defects; time waiting; and motion waste (Shingo, 1992; Imai, 1997; Emiliani, 2001; Flinchbaugh, 2001). Bodek (2006) identifies eleven wastages that are simplified in the Table 2.

Table 2: Eleven type of wastages & Sensory Modalities

Sensory Modalities	Type of Wastages	Description
Visual (see) – Auditory (hear) Heptic (touch) Olfactory (smell) Gustatory (taste)	Motion	Any wasted motion during the course of work, such as reaching for, stacking parts or walking are waste.
	Transportation	Carrying work in process (WIP) long distances, creating inefficient transport, moving materials, parts, finished goods into or out of storage or between processes.
	Producing defects, creating scrap	Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.
	Machines not functioning properly	Producing defects and adds extra time to the process of the part.
	Inventory	Excess raw material, WIP, finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs & delay. Extra inventory hides problems like production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
	Improper design of the process and the equipment	Taking unneeded steps to process the parts. Inefficiently processing due to poor tool & product design, causing unnecessary motion producing defects. Waste is generated when providing higher-quality products than is necessary.
	Waiting Time	Workers merely serving to watch an automated machine or having to stand around waiting for the next processing step, tool, supply, part or just plain having no work because of stockouts, lot processing delays, equipment downtime, and capacity bottlenecks.
	Inspection	Process involves the measurements, tests, and gauges applied to certain characteristics in regards to an object or activity. The process of measuring or checking materials, workmanship, or methods for conformance with quality controls, specifications, and/or standards.
	Extra time to set up a new product	An incurred cost that does not add any value to the product.
	Not utilizing the inherent talent of your workers	Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees.
	Not managing correctly	Producing items for which there are no orders, which generates such wastes as overstaffing and storage and transportation costs because of excess inventory.

3.0 RESEARCH METHODOLOGY

This paper focuses on an overall methodology for the planning process using Lean principles and practices approach as a tool and integrating with organizational vertical and application programs to meet the commitment for problem solving capabilities and continual improvement in Lean manufacturing transformation. By conducting a background literature review and identifying the problem statements, fields and case study and a series of data collection will create a source of database collection for the input to Lean process management and planning. A case study at an aerospace composites manufacturing plant as named ABC Company which participated in Lean project has also been presented. The result of the case study was reviewed and found has parallels input values of Lean manufacturing perspectives with a connection to People Development System (PDS) in organizational vertical aspect. By using the PDS database, ABC Company can enhance the problem solving capability among employees and get commitment from various level of management as what the OVVI model is delivered to fit well with the investigation of PDS implementation in an organizational vertical-virtual application relationship.

4.0 THEORY

The basic structure of Lean manufacturing feedback simulation, design and concept is shown in Figure 1. Human operator (user) typically holds the PC or embedded system device while interacting with the virtual application programs. The interaction is processed by the built-in hardware with system instruction algorithms. The transducers convert visual and audio signals from computer into a form that the operator will perceive. The key feature here is that the audio and visual channels carry information unidirectional. The OVVI application program is to simulate the real-time environment through Lean manufacturing simulation algorithms and display the virtual reality environment in PC or embedded device.

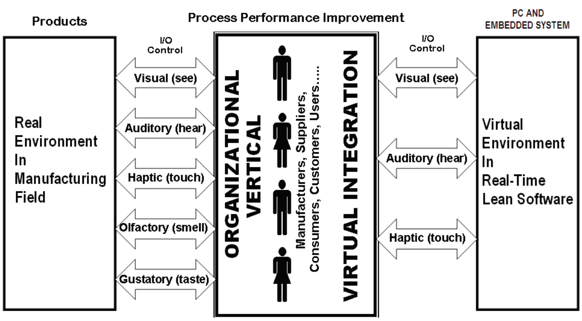

Figure 1: Organizational Vertical & Virtual Integration Conceptual Model

The controller part of a Lean manufacturing system is mostly realized in real-time Lean application programs. Embedded control systems are hard real-time systems and the reliable operation of such systems is crucial for reliable operation of the lean system as a whole as shown in Figure 2.

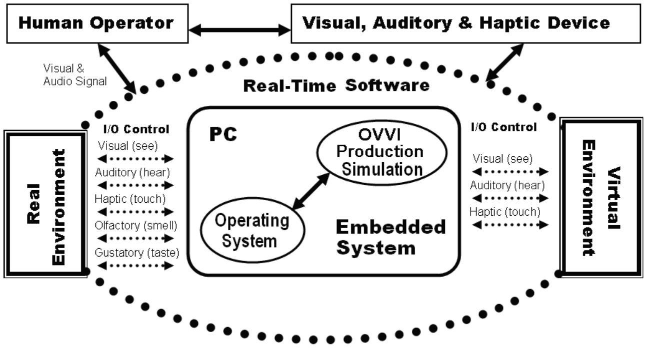

Figure 2: Real-Time OVVI Application Program Design Concept

Developing Lean manufacturing simulation application program that incorporates both methods production analogy and numerical computation of differential equation practical tool, being free from the limitations of either method used alone. In order to create numerical computation application program on an embedded system device, one must be capable of synthesizing knowledge from various scientific and engineering disciplines. Moreover, simulation programs may provide a better path into the production field for OVVI model in particular, since almost all production staffs today receive some computer training and have access to PCs. Such simulation techniques will naturally be much more effective if it takes advantage of the PC's virtual environment.

5.0 TESTING AND ANALYSIS

Success in Lean manufacturing transformation directly correlates to how an organization handles global competition. Cost effective solutions and practices are essential to stay competitive in the market. OVVI Model integrates Value Stream Map (VSM) with the cost aspects for testing and analysis purposes. VSM provides a blueprint for implementing Lean manufacturing concepts by illustrating information and materials flow in a value stream. Researchers define the VSM as the process of visually mapping the flow of information and material. It helps to visualize the station cycle times, inventory at each stage, manpower and information flow across the supply chain (Womack and Jones, 1996). VSM can serve as a good starting point for any company that wants to be Lean and describe value stream as a collection of all value added and non-value added activities which are required to bring a product or a group of products using the same resources through the main flows, from raw material to the hands of customers. The objective of Value Stream Map Future Status is to match the production rate with TAKT time and to achieve the target cost as the manufacturing cost. For the present study

TAKT time is taken as the benchmark for process pace and target cost was set as the benchmark for the manufacturing cost.

They are various steps in implementation of VSM. The process analyses is carried out by collecting data from various enquiries with shop floor experts and directly participates in measuring the time involved in various processes (Sahoo et al, 2008). Data collection and analysis of computer and Lean manufacturing in simulation using a didactic approach, is the art or science of learning. Didactics is a field of lean manufacturing studies mostly referring to research aimed at investigating what is unique with a particular subject and how this subject ought to be taught and processed. From the analysis at Figure 3, a conclusion can be made that Lean manufacturing has a thematic identity and a functional legitimacy.

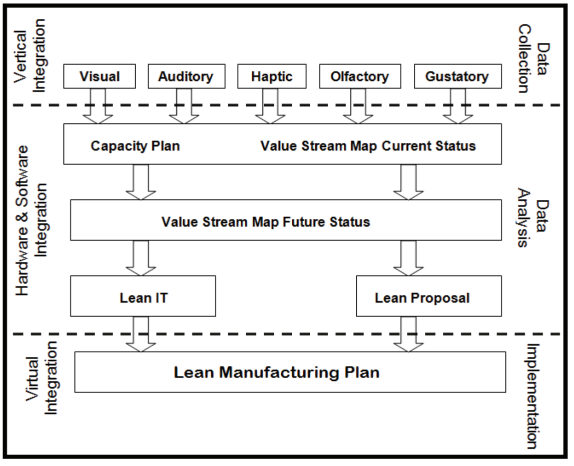

Figure 3: OVVI Lean Manufacturing Implementation Framework

Although lean principles can be implemented manually, a lean manufacturing software solution such as OVVI application model can make any lean initiative even more successful. OVVI applications complement lean manufacturing with improved data visibility, speeding information flow for problem resolution, design changes, quality issues, and changing customer demand. The OVVI model applications support lean initiatives in three main functional areas: (i) Manufacturing Performance Management, (ii) Production Planning and Execution, and (iii) Waste Reduction.

The Lean Scoreboard is designed to assess the current level of maturity in lean implementation. It can put together an orderly step-by-step implementation plan and easily measure the progress at any time during the implementation. The Scoreboard is a starting point from which to generate awareness and understanding in the workplace of specific concepts and techniques. It is a tool that helps to integrate people and processes. OVVI model application supports planning and execution with functionality for demand leveling, supplier chains and delivery, Kanban planning and execution, vendor-managed inventory, repetitive production and etc. A variety of techniques are available for reducing or eliminating waste which include the Value Stream Mapping analysis, Total Quality Management, Total Productive Maintenance, Kaizen Costing and cost analysis, People Development System, engineering and change management, administration excessive staffs and document management.

The study case focused at the Kitting Department at ABC Company with all level of staffs. Currently, the numbers of employees work in Kitting Department are 40 person included from top level to bottom level of management. The processes of kitting are involve cutting, labeling, stacking, packing and thawing. The sequences of this process are shown below Figure 4.

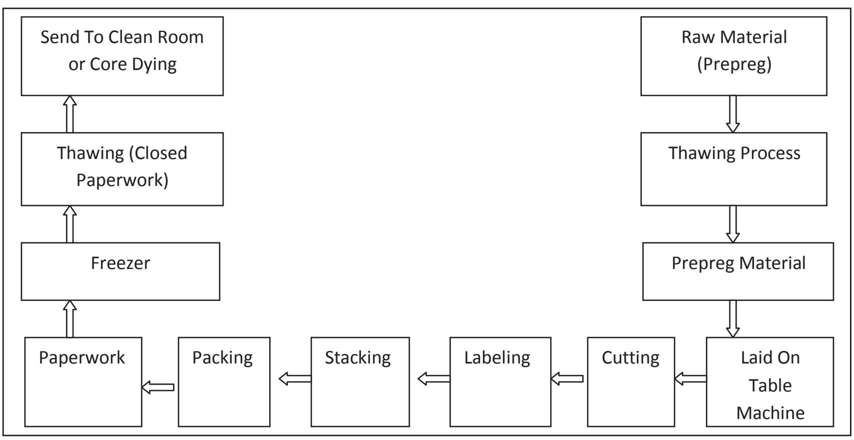

Figure 4: Process Sequence of Kitting Department At ABC Company

6.0 RESULTS AND DISCUSSIONS

Using the PDS database, company can enhance the problem solving capability among employees and get commitment from various level of management as reflected in organizational vertical and virtual integration. According to Puvanasvaran *et.al* (2009), PDS places emphasis on people involvement and focuses on problem solving capability in Lean Process Management (LPM). LPM then, is to assist any types of organization with a desire to improve the company's operations and become more competitive by focusing on cost reduction that eliminates non-value added activities. Some of the results of the case study are elaborated in this section. It consists of tables and graphs from the PDS database which integrated with OVVI model. From the Table 3: Total Of Level Involvement, it can be seen that Middle-Bottom has the higher percentage, 36.69%, followed by bottom with 27.34%, Top-Middle with 25.18%, 8.63% for Middle and Top level with a percentage of 1.44%. Top-Bottom level is the lowest with a percentage of 0.72%. The highest percentage of the wastages eliminates as shown in figure above is time that is 20.92% and followed by space with a percentage of 15.90%. Overproduction is the least wastages eliminate with the percentage of only 1.67%. From the Table of Total Tools Used, it can be seen that Total Productive Maintenance (TPM) is the most lean tools and techniques used by the employees to solve problems with a percentage of 32.80%. Just-in-Time (JIT) is the less lean tools and technique used by the employees at th kitting department that is only 2 times or percentage of 1.06%. The total of monthly cost is how much cost managed to save by the department after certain lean tools and techniques applied to reduce the wastages usually KAIZEN. From above figure, the highest cost manage to save by the employees is in June that is RM 188,037.38, followed by December RM 187,910.68. Thus, other month have same cost saving that is RM 157,667.08.

Table 3: Result of Case Study at Company ABC In Year 2007
(A.P. Puvanasvaran *et.al*, 2009)

Total Of Level Involvement

Level Involvement	No. of Idea	Percentage (%)
Top	2	1.44
Middle	12	8.63
Bottom	38	27.34
Top-Bottom	1	0.72
Top-Middle	35	25.18
Middle-Bottom	51	36.69
Total	**139**	**100**

Total Of Monthly Cost

Month	Cost (RM)
January	157667.08
February	157667.08
March	157667.08
April	157667.08
May	157667.08
June	188037.38
July	157667.08
August	157667.08
September	157667.08
October	157667.08
November	157667.08
December	187910.68
Total	**1952617.86**

Total Of Wastages

Type of Waste	Sum of Waste	Percentage (%)
Complexity	25	10.46
Defects	29	12.13
Energy	17	7.11
Inventory	6	2.51
Labor	30	12.55
Material	29	12.13
Overproduction	4	1.67
Space	38	15.90
Time	50	20.92
Transportation	5	2.09
Unnecessary Motion	6	2.51
Total	239	99.98

Total Of Tools Used

Lean Tools	No. of Time Use	Percentage (%)
5S	55	29.10
TPM	62	32.80
KAIZEN	27	14.29
VSM	4	2.12
TQA	8	4.23
SMT	11	5.82
Visual Indicator	12	6.35
JIT	2	1.06
Std Work	8	4.23
Total	189	100

From the result of the case study, the objectives was accomplished as using the OVVI database, management can easily monitor the teamwork among level of management and problem solving capability of its employees. From Table 3: Level Of Employees Involvement for Year 2007 Graph, it can be seen that there is a teamwork among the various level of management as certain problems need to be solved in a group. However, there were large range of differences between top management and bottom level compare with between top management and middle management and between middle management and bottom management. So, it can be conclude that the top management lack commitment and communication with the bottom management. The organizational vertical is must to be fulfilled. According to Nalini and Bonnie (2004), goals of an organization should be communicated frequently so the employees know what is expected to accomplish the goal.

Problem solving capability can be monitored through how many idea generated by the employees to solve problems that occurred during work activities or ideas to improve the process of activities. Based on Table 3: Total Of Wastages and the Total Of Tools Used, most of the workers generate an idea to solve problems using various kinds of Lean tools and technique. By eliminating or reducing the wastages that occurred during the working activities, the company manages to reduce the cost of operation. This can be seen from Total of Monthly Cost result, as every month there is cost save by the Kitting Department. This is obtained through eliminating or reducing the wastages occurred in Total of Monthly Cost result. Using the PDS database, ABC Company can enhance the problem solving capability among employees and get commitment from various level of management in which the OVVI model is reviewed.

7.0 CONCLUSION

Lean integration has become a major field of research worldwide especially in manufacturing and production. Possibilities offered by modern analogue and digital electronics and software enable that Lean manufacturing plan get more functionality, better accuracy and flexibility and can be produced cheaper while keeping the performance at the same level. This paper shows that OVVI model is an ideal tool to expose the waste in value stream and identify improvement areas. It substantiates the effectiveness of lean principle in a systematic manner with the help of various tools, such as cost analysis in value stream mapping, OVVI model and so on. It enables the companies to move towards their ultimate goal leading to, sustainability, profitability in Lean manufacturing transformation. The novelty of 5 sensory modalities in OVVI model and Lean Process Management revolution software for implementing Lean manufacturing transformation and enhancing problem solving capabilities and continuing improvement. Besides, it helps in solving difficulties of integration that depends on a number of factors in addition to cost, expertise, availability of resources, etc. These factors include complexity of the company (single / multiple sites, national / multinational, small / large), the nature of the business, whether management is looking for alignment of few standards or full integration of all management systems and the nature of operations of the organization. All these are solved by the OVVI model and the revolution real-time lean software. As for future work, potential applications can improve the effectiveness of OVVI model as lean tool by connecting its continual improvement activities to larger financial drivers for manufacturing industries (consumable and non-consumable products) and Small & Medium Industries (SMIs).

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