

MANAGING WASTE ELIMINATION DATABASE IN LEAN MANUFACTURING: IMPROVE PROBLEM SOLVING CAPABILITY

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ABSTRACT

This study highlighted on managing the waste elimination database in lean manufacturing of the case study company. An application for managing the waste elimination database in lean manufacturing to improve the visual indicators and enhance the problem solving capabilities of the employees in the organization is introduced as the basic success factors to drive the process of continuous improvement culture forward. Ineffective database systems within the organization have caused the inaccurate, redundancy and inconsistency of data. Lean implementations are not successful because there is a lack of communication and involvement of all levels of employees. The study attempts to design an application in a personal database system to the employees at Lean department to keep track of the waste elimination database for analysis and evaluation purpose. Likewise, it's also examined the employees' problem solving capacity in waste eliminating project. Application in Microsoft Access is considered new in the case study company. The problems that faced are such as the human factors such as the fearful in changing and accepting IT systems and procedures. Application in Microsoft Access is considered new in the case study company. The employees in Lean department can easily keep track on the improvement projects and the management can monitor on the improvement task and problem solving capabilities of the employees. The visual indicators are improved because meaningful chart and reports are generated for visual and filling purpose. Besides, implementing the problem solving cycle in the designed application to improve the problem solving activities which is also an important element in creating continuous improvement culture. As the many factors such as human factors and skills in using the database application are affected the effectiveness of the designed application. The cost saving value after implementation the database application is difficult to obtain as some study subject are difficult to measure in term of cost.

Keywords: Improvement Plan, Database Management System, People Development System and Problem Solving Capabilities

1. INTRODUCTION

In Malaysia, manufacturers start to interpret the powerful and the essence of lean manufacturing. Most of the companies, especially the growing and established companies applied the lean manufacturing in the organization. Yet, many companies are not a success in lean implementation. This is because of lean implementation is not an easy job; it required culture

change within the organization. Besides, a lot of companies who implement lean are not realized how to measure the lean level in their company. Thus, performance measure of lean implementation is very important to match the lean result (Puvasvaran *et al*, 2009a). Likewise, other prospects such as lack of communication as well as because many companies are not successful in lean process (Puvasvaran *et al*, 2009b). The substance of the message has been transmitted, often quite distinctly.

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Only the direction in which the message has been presented always causes the trouble (Andrewartha, 2002).

The managers or leaders themselves did not possess a specific methodology and measurement for training people. The leaders treat lean as a tool kit but not a culture that have to acquire. They did not realize the importance of training people in lean manufacturing who can resolve problems and make daily improvement. The employees who are lack of basic skills in the daily management of their work teams are promoted because of their hard work and loyalty to the company (Liker and Meier, 2007). The simply implement tools, techniques and technology from lean manufacturing did not produce significant benefits to the organization (Repenning and Sterman, 2001). Thus, the lean culture must be developed within the organization.

The lean culture starts to build within the organization by some lean expert whether by internal employees or external consultant. They train the lean members the lean principles, concepts and lean tools and techniques to eliminating waste. The waste eliminating data are recorded in word file, table and graph, analysis and evaluate in the computer form. The data include all the facts and numbers. It means the useful and large source of data is maintained in a computer file. The data are recorded for either the reference of the project leader itself or the other employees. The data is important information for an improvement project.

The company claims to have implemented lean manufacturing for about 8 years. But until today, they did not have any system that can store their lean implementation, database in a systematic and organized manner. They always spend a lot of time for tracking the data and information that they are required. This is due to the difficulty in accessing the required data or file from the large source of database. Some databases involve just a few users and hundreds of rows of data in a few tables. These databases can be complex contain many files.

Besides, the same information is common to have duplicated copy in a computer because of database shared with more than one user. This may cause data redundancy and inconsistency. Moreover, data are dispersed in several files. The files may exist in different formats, so it is consuming more time to rectify the data for displaying purpose and retrieve the information. Therefore, a systematic and professional database management system must be developed. It is to help the employees to keep track the databases and performed some query from the databases in an easiest way and shorter time.

The main objective of this study is to design an application to manage the waste elimination database to

improve the visual indicators to help employees keep track of the database and problems solving capability of the employees in driving the organization to a continuous improvement culture. The improvement in the visual indicators through designing an application that helps to examine the problem solving capability of the employees in the organization. Thus drive the continuous improvement culture forward through applying the problem solving cycle in daily problem solving activities.

2. LITERATURE REVIEW

2.1. People Development System (PDS)

Toyota discovered the necessary to emphasize people development. People of development through new product development program, quality defect improvement and every Kaizen activities are crucial for the organization development (Liker and Meier, 2007). People need to have the thinking and problem solving capability during lean implementation. Lean production system required multi-skilled employees work with the single-piece flow process. Training is the right means for developed people instead of just orders the employees to follow the regulations. A most potential employee for the new system is the people who possess the capacity and desire to learn in the lean culture. People development will in turn give the benefits to the company.

Employees must possess an efficient method for determining the critical prerequisites of a job. They must clear with the purpose of the completed work instead of just based on personal preference. They must also have a standard way of doing work instead of perform the work differently from what has been prescribed. The effectiveness on transferring the knowledge to the employees must be considered during the lean implementation. Besides, the follow-up on verified the results of the improvement job are necessary to validate the result of the project (Liker and Meier, 2007).

PDS integrates key performance indicator, respect for people, skill and knowledge and team work which emphasis on people involvement and focuses on problem solving capability in Lean Process Management (LPM) (Puvanasvaran, 2010). Hoshin Kanri business methodology emphasizes that the total involvement of all levels of employees should incorporate into their daily routines in order to achieve the organization's objectives (Parmenter, 2010). The goal of knowledge management process to enable organizations to improve the quality of management decision making by ensuring that reliable and secure information and data is available throughout the service lifecycle where the organization needs to focus

on retrieving, sharing and utilizing their knowledge through problem solving, dynamic learning, strategic planning and decision making (Nabiollahi *et al.*, 2011). People Development System (PDS) is a system that aims to:

- To enhance problem solving capability among employees
- To get total commitment of employees from top to bottom
- To create lean behavior among employees and become change agents with the lean culture
- To enhance workers with skill and knowledge in using lean tools and techniques
- To increase continuous improvement activities and achieve sustainability
- To be self-directed and work as team in practicing lean concept

To work towards Vision and Mission of company and Integrate LPM in company strategy to achieve business goal.

Competitive advantages of an organization can be preserved and improved by performing performance measure (Hinrichs and Barke, 2008). The performance measure is an indicator used by management to measure, report and improve performance (Parmenter, 2010). The performance measure in lean involves top-to-bottom performance measure linking improvement initiatives to strategic goal (Bell, 2006). The performance measure can be varied as the change in marketing strategy, technology and the definition to measure and record the performance over time (Effendi *et al.*, 2008).

By referring to the performance measure framework proposed in Reference (Erickson, 2009), the lean level of an organization is measured in term of quality, cost delivery, accountability and continuous improvement (QCDAC). The measurement in QCDAC is then divided into 11 performance measurement metrics, which is scrap, customer complaint, attendance, Overall Equipment Efficiency (OEE), Work-In-Process (WIP), backlog, employees skills matrix, overtime, safety, number of ideas generated and number of projects done and cost saving.

2.2. Database Management

Information technology has been employed as a data management tool for handling the data, searching for required information and performing updating actions. The data for employees, products and equipment and so on are restructured in a table format for during database design stage. In manufacturing field, database system are usually

prepared for managing the supply chain and for tracking production item in factories, inventory level of the warehouse and orders for items (Silberschatz *et al.*, 2011).

The database system is designed to help people manage large source of information efficiently. In order to manage the large source of information, it involves two steps; which are defining structure for storage of information and providing a mechanism for the retrieving of the information. Also, the safety of the database system must be assured, despite the system been hacked by other unauthorized people, especially for the database that are shared by several users (Silberschatz *et al.*, 2011).

Database is a collection of related tables and other structures (Kroenke and Auer, 2011). Database arises from three sources; which the first database source is from the existing data from spreadsheets, data files and database extracts. Then, second database source is from new system development; which required data modelling and database design process. Third, database is arising from the need for redesigned an existing database to adapt the changing requirements.

Data is of course important in manufacturing, but place the greatest emphasis on facts. Right information that's delivered in the right format, to the right people, at the right time is useful for decision making. Raw data must be summarized, structured and presented as digestible information. Once information is combined with direct experience, then the incredible human mind can extract and develop useful knowledge. Over time, as knowledge is accumulated and combined with direct experience and judgment, wisdom develops (Bell, 2006).

The Database Management System (DBMS) as a computer program used to create, process and administer the database (Parmenter, 2010). The DBMS process the requests in encoded Structured Query Language (SQL) and translate the requests into the actions on the database. SQL is the standard Languages that can be read by all commercial DBMS products.

A Database Management System (DBMS) is a collection data and a set of programs to access those databases. The purpose of DBMS is to provide a way to store and retrieve database information conveniently and efficiently (Silberschatz *et al.*, 2011).

Database management system handles several critical tasks such as how the data is managed (input, processes, output and stored), basic security and replication/backup, among others (Erickson, 2009). A Database Management System (DBMS) is a software package designed to store and manage database (Ramkrishnan and Gehrke, 2003).

A database application is a set of one or more computer programs that serve as an intermediary between the user and the DBMS (Kroenke and Auer, 2011). Application program read the request by sending SQL to DBMS and present the query. The database application can be classified to the personal-database system and enterprise database system. The database application that is commonly used are such as Microsoft Access, Microsoft SQL Server, Oracle Database, or MySQL. The process of software development always requires to establish more and more effort in society to achieve the desired ends and attempt to simplify operations and reduce the time and effort in achieving the outcomes (Elmetwaly, 2011).

The first step of database design is the model conceptualisation. Database conceptualization described the data relationship of the organization. The entities or the interest of the object is employed in the functional operation of the organization and representation using tools such as an entity-relation chart. Next, storing locations of the data are determined. Then, functions can be organized by system to provide a blueprint for application development (Anjard, 1994).

3. MATERIALS AND METHODS

3.1. Conceptualization

Microsoft Access 2010 is selected as the database software due to its accessibility and easy to program. It is a personal database system which is suited for personal and small workgroups because it is easy to program. The primary advantages of Microsoft Access 2010 are the accessibility. Microsoft Access is in the package with Microsoft Office Suite, most companies have this software. It is software that combined with the DBMS and application generator. Microsoft Access can performed forms, report and query from the waste elimination. Besides, the performance of the employees can keep track and evaluate for people development.

Model conceptualization is a planning for developing the database program. It provides an understanding of the problem situation and the purpose of developing the database program, design the conceptual model, where the inputs and the outputs of the database system are determined so that the application designed is correct as the first time. Changing a data relationship after the database and applications have been constructed is more difficult and complex. The model conceptualisation is divided into two major sections, the project conceptualization and database application designing.

A set of data was input into the database application to check whether the required objectives were achieved or not through results interpretation. The database focused on the employees at Lean department in Company ABC. The inputs are then recorded in the database software-Microsoft Access for data managing and processing. Then, the expected output in this project is to create an application that generate forms, reports and query from user. The expected output is then used to evaluate to determine the achievement of the objectives.

In order to improve the problem solving capabilities of the employees, an application is designed to manage the waste elimination database. There are two phases in improving the visual indicators and problem solving capabilities through managing the waste elimination database. Phase 1-waste identification implements the problem solving steps and cycle defined by (Dennis, 2007). The four steps are proposed in problem solving, which are defining the current performance, prioritize the most causal areas, identifying the root cause of the problem and developing the action plan (Dennis, 2007). For phase 2-the monitoring of the problem solving capabilities through generated the reports such as type of waste elimination per year, lean tools and techniques used per year. Number of improvement plan per employee and total number of improvement activities per month.

3.2. Data Modelling

During the initial state, an interview with the employee at Lean department to collect the basic information such as the level of lean implementation, principles, tools and techniques that applied in the organization. Next, the waste elimination database such as the area of improvement project, the employees involved, the purpose of the project, the data collected in the improvement study, problem identification, analysis of the root cause, the countermeasure, duration of the project the implementation cost and so on will be collected. All the data required during the lean implementation project are gathered and fit into the database administrative software-Microsoft Access.

A user friendly form is created for the data and information entry so that the employees who just engage with the application can handle the application easily. After inserting the entire waste elimination database in the program, the output can be accessed and printed out for the tracking, displaying and analyzing and evaluation purpose.

Database model is created using the entity-relationship data model. The relationship between each waste elimination database is created in this modelling stage. This step is essential for the database design to ensure

the database application that will be design is correct. Changing a relationship after the database and applications have been constructed is more difficult and complex. In these steps, the output such as the type and pattern of forms, reports and data model are identified.

4. RESULTS

4.1. Database Implementation

Database is obtained from the Lean department at Company ABC. The improvement activities done in kitting department by the employees from Lean department is recorded for half year time period, which is from November of 2011 to May of 2012. The database is recorded in the application designed to test on the database processing of the application. The tables, queries, forms and reports designed are making sure to be generated when it is required.

In a database system, the application started with the master input form (**Fig. 1**) for data and data input for product A. After recorded the study product A and the date of data added, waste analysis form (**Fig. 2**) prompts out for the value added and non-value added activities analysis. The employee has to input the value added time and non-value added time based on the Value Stream Mapping (VSM). The non-value added time for each contributed categories are recorded into the table so that the main waste in a process is identified.

Prioritizing the waste (non-value added time) level for each process in a Pareto Chart is required. After the value time for all the process flow is input, a Pareto chart is generated to prioritize the process that has highest Non-Value Added time (NVA time). According to Pareto rule, the processes that cumulated 80% of the NVA time are critical to be solved. Hence, the processes need to be solved immediately are identified. It is important because the main problem area is defined and solving this problem area produce significantly reduces in waste level in process flow. Value added and non-value added pie chart is generated for overall waste level for the study product in **Fig. 3**. Besides, the NVA categories for the highest waste process are displayed in the bar chart in **Fig. 4**.

Root cause analysis in 5 Whys table in the highest priority process and highest waste categories. The main purpose of 5 Whys table is to brainstorm surface causes to the root cause of the problem. Developing the action or improvement plan to solve the problem. Improvement plans is the action on solving the root problem. The details description of the improvement project, tools and

techniques used, person in charge, priority, status of implementation, start date, due date, picture on before and after improvement are recorded.

The type of waste generated chart indicates that the employees are emphasized on the problem solving regarding time and defects wastes during the study period. Time waste is such as machine downtime, waiting time and so on. Defects waste is the major contributor to lose of sales and poor customer satisfaction so that the improvement departments put more effort to reduce the defects waste.

4.2. Improvement Plan

The improvements plan is recorded after the root cause analysis in 5 Whys Table. Then, the action plan on the essential problem is recorded. All the improvement plan details are stored in the database system and report is generated. A bar chart of the number improvement plan for each employee and the improvement plans details that done by each employee in Lean department (**Fig. 5**) are generated. The numbers of improvement plan represent the motivation of the employee's involvement in problem solving activities. The highest number of improvement plan is done by MohdNazri, which is 12 improvement plans, followed by Raja Saifullzuan, which on contributed 8 improvement plans. ShahrulBasha Abdullah contributed to 3 improvement plans for this six month study period. From **Fig. 6**, the numbers of improvement plan in kitting department from November, 2011 to May, 2012 is shown. Most of the improvement plan is done in February of 2012. Next, January, April and May have done the same number of improvement plan. November of 2011 have done the least number of improvement plans.

The scenarios for the number of improvement plan completed may due to the employees are motivated by the incentives and bonus on the brand new year. The productivity and performance of the employees are motivated by the rewarding plans either in yearly bonus or incentives from the employers (Hafiza *et al.*, 2011). The numbers of improvement plan done by each employee in Lean department do not show a good value because more ideas should be generated. Employees in Lean department should put more attention and actively contribute their ideas in problem solving activities.

4.3. Problem Solving Capabilities

The problem solving capability of the employees in Lean department is based on the results of the types of waste eliminated, lean tools and techniques used, improvement plan per employee and number of

improvement plan per month. In Lean department at Company ABC, the waste eliminated are focussed on the highest contributed in the waste Pareto chart, which is kitting department. From **Fig. 7**, the highest percentages of waste eliminated between the studied time period (from November of 2011 to May 2012) at Lean department is time waste, which is 25%, followed by the defects waste, which is 21%. Then, the lowest waste eliminated percentage is transportation waste is 2%.

For the number of lean tools and techniques used (**Fig. 8**), most improvement tasks are categorized by Kaizen activity, 49% and secondly is 5S improvement, 21%. The lowest percentage is 3% for the improvement plan that is Just-In-Time (JIT) related. The lean tools and techniques used by the employees indicates that the employee's knowledge and experience in Just-In-Time production are still lacking. Since, JIT is the core pillar in the lean manufacturing implementation, the employees' knowledge in JIT must be improved by providing training for them.

4.4. Benefits and Implication

The problem solving process in the organization becomes scientific and systematic. The employees perform critical improvement activities first by supporting data. They focused on the root cause of the problem before suggest an action plan. Besides, the management level able to monitor the improvement plan progress from the reports generated.

For visual indicators of the improvement projects, A3 report concept is implemented. The important data and information are compacted and printed for displaying purpose to improve the visual indicators hence the communication in the organization. Besides, the compact report is to reduce the bulk and excess data is presented on the shop floor. Now, a compact problem solving report in which the project identification, supporting data, root cause analysis and the details of the improvement plan are generated in a single paper so that the employees able to grasp the improvement details on the first glance. Good reporting framework can support timely decision making by accommodating it to all levels of employees in the organization and reporting frequency (Parmenter, 2010).

On the other hand, the problem solving capability able to be monitored through the number of improvement plans that done by the employees. The reports such as type of waste eliminated, lean tools and techniques and number of improvement activities have been done for each time period are used to monitor the problem solving level of the employees. The

employees' performance can be measured with a piece of important and useful information about the performance of a program expressed as a percentage, index, rate or other comparison which is monitored at regular intervals and is compared to one or more criterion (Jovan and Zorzut, 2006).

In terms of database performance, the designed application in Microsoft Access enables the employees to access vast quantities of data without being reliant on others to provide data. Employees can track back the past project in a shortest and organized way. Data redundancy and inconsistency is minimized compared to the previous condition. The database system reduced the possibility of inputting duplicated data.

Besides, this recording the data and information increase the transparency of analytical processes. The tables, queries, charts, forms and reports are well categorized. Others employee able to access and understand what is being done in the past projects. The rigidity in the application becomes benefits. This can solve the difficult to figure out the hidden calculation and scattered data and information in what is being done by Excel users. Moreover, the reports and forms generated are standard in format. Enforcing standards in the organization and structure of data files improve the efficiency in extracting data before decision making. Separation of data and presentation make the database in well managed.

Implications of the project are due to some uncertainty factors that should be further study. Factors such as human factors and skills in using the database application have affected the effectiveness of the designed application. Application in Microsoft Access is considered new in the case study company. The problems that faced are such as the human factors such as the fearful in changing and accepting IT systems and procedures. Since implementation the scientific problem solving process has seemed new to most of the employees, they are more focused on Lean implementation and did not want to be distracted by new technology. Besides, there are some misunderstanding in Lean and IT. Some employees viewed all IT intervention as synonymous with waste.

On the other side, the cost saving value after implementing the database application is difficult to obtain as some study subject is difficult to measure in term of cost. Then the effectiveness of the project implementation is difficult to measure such as the total time saving and the level of how well in managing database system.

Fig. 1. Master form for data and information input

ID	RecordID	Process	VA Time	NVA Time
1	1	Receiving	265	320
2	1	IOC	338	342
3	1	Warehouse	450	120
4	1	Kitting	492	10921
5	1	Layup	412	474
6	1	Cure	472	350
7	1	Demould	251	151
8	1	Trim	22	1463
9	1	NGIT	151	2423
10	1	Painting	8	1280
11	1	Final inspection	25	30
12	1	Stacking & Packing	140	45
13	1	Shipping	50	150

Fig. 2. Waste (value added and non-value added) analysis form

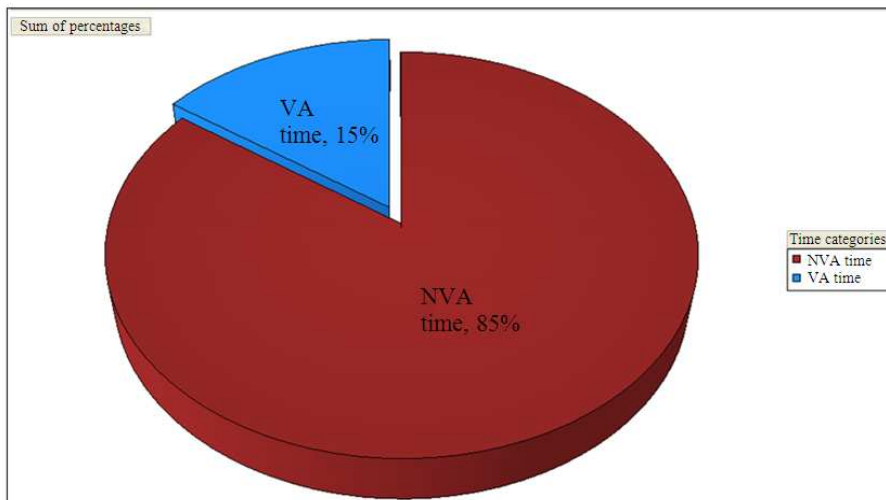


Fig. 3. Value added and non-value added pie chart

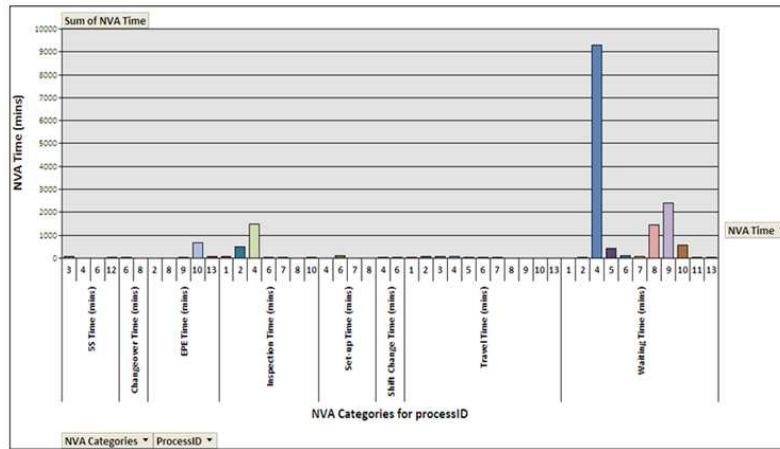


Fig. 4. The NVA categories in kitting process (highest waste contributed for product A)

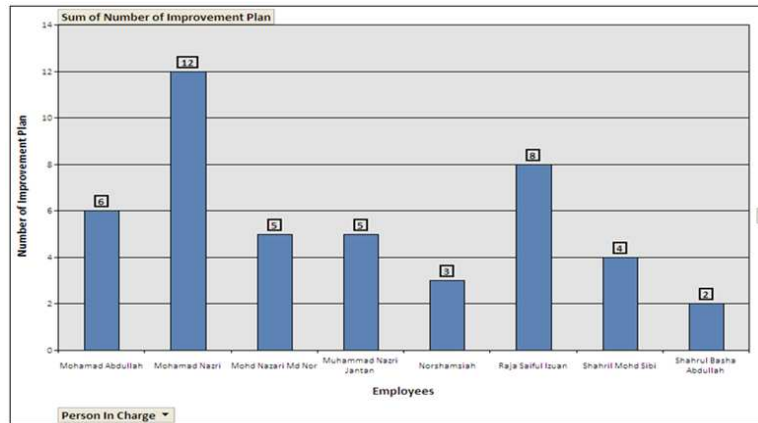


Fig. 5. Number of improvement plan per employees in Lean department

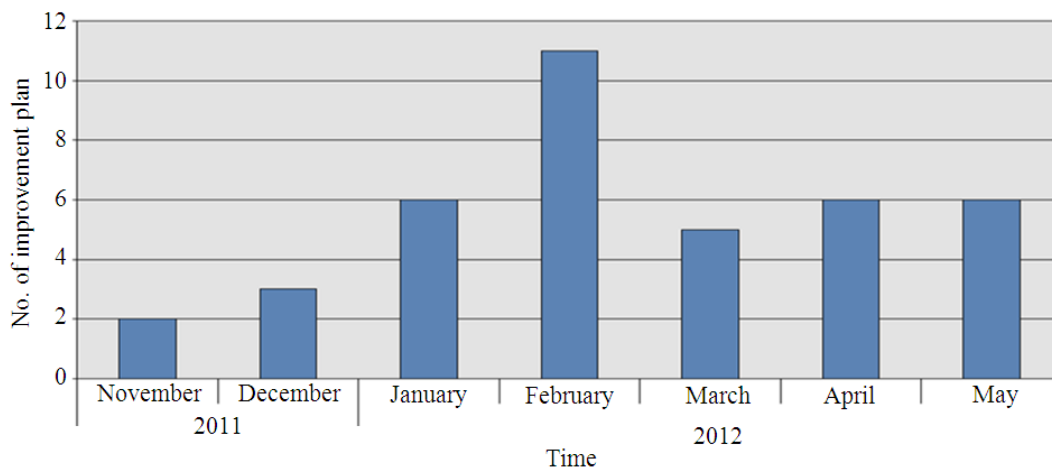


Fig. 6. Number of improvement plan from November, 2011 to May, 2012

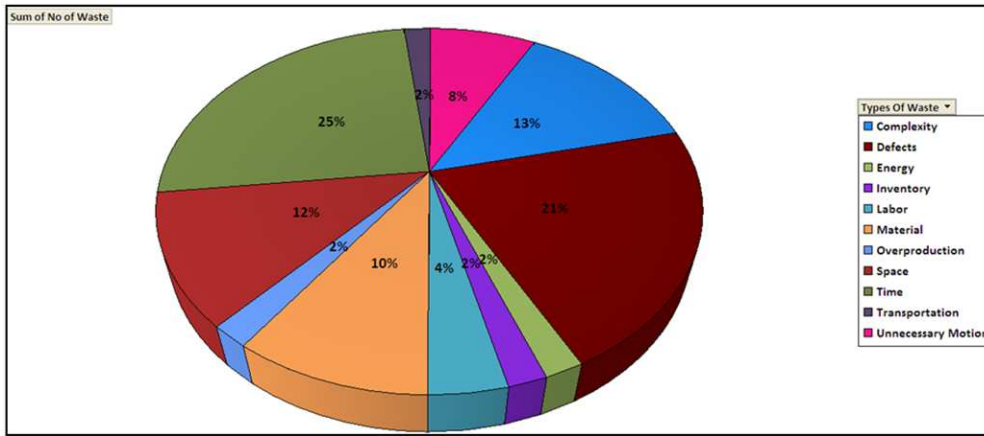


Fig. 7. Types of waste eliminated at kitting department from November, 2011 to May, 2012

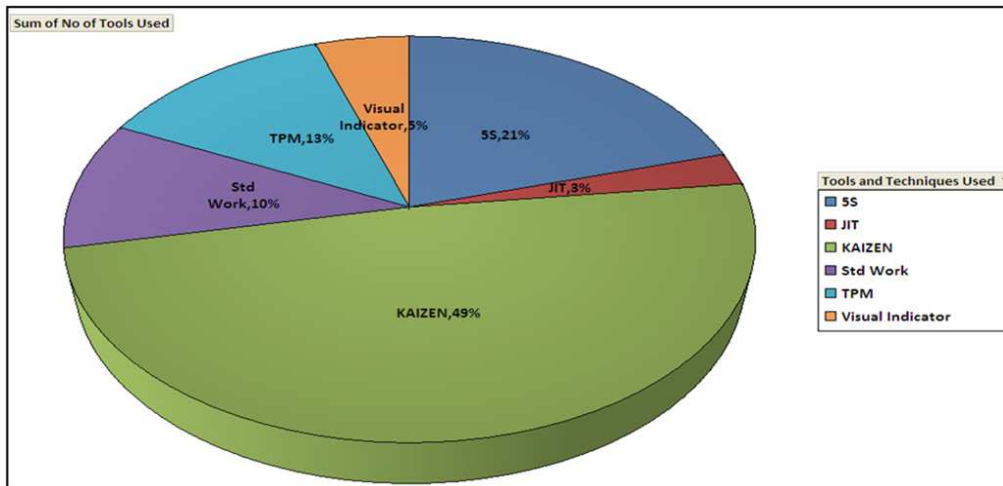


Fig. 8. Lean tools and techniques used for problem solving activities

5. CONCLUSION

The objectives of this study are achieved where an application is designed to manage the waste elimination database to improve the visual indicators and problems solving capability of the employees in driving the organization to a continuous improvement culture. The findings show on the data and information in problem solving activities are well-managed. The management are able to monitoring the improvement plans and the problem solving capability of the employees through the outputs generated by the designed application. Besides, the well managed database record of the improvement plans enables to manage to monitor on the progress of the plans so that it can completed within the planning period.

The novelty of this study is the capturing the lean culture implementation process in the information technology. The concepts such as problem solving cycle, lean tools and techniques, performance measure on the problem solving capability and A3 thinking report generated are implemented in the designed application. This has assisted the employees in focusing on cost reduction that eliminates non-value added activities during the problem solving activities. However, the effectiveness and impact of designed application after implementation are hard to measure, the database system are organized in a better manner for sure.

Based on the analysis after the data collected from the Lean department, some recommendations are

proposed for improving the lean implementation practices. Employees should be given more training on lean tools and techniques as some of the employees still not fully understand about it in lean manufacturing. Besides, a better rewarding system should be designed to motivate employees to involve more actively in the improvement work in the organization.

Moreover, the designed application should improve in more meaningful measurement such as the performance measure in term of Quality, Cost, Delivery, Accountability and Continuous improvement (QCDAC). As study from literature review, there are 11 performance metrics can be generated based to QCDAC aspects. The performance measure is very important to measure the lean level in the organization. These measurements will show how the improvement activities for all levels of the employees linking to the organizational goals. Future studies should be conducted on the implications proposed in the study, as the many factors such as human factors and skills in using the database application have affected the effectiveness of the designed application. The cost saving value after implementation the database application is difficult to obtain as some study subject are difficult to measure in term of cost.

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