Lean Manufacturing for Tsukiden Electronics Philippines, Inc.: a Six Sigma Approach

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ABSTRACT

To remain competitive, manufacturing organizations like Tsukiden Electronics Philippines, Inc. (TEPI) has addressed productivity and efficiency goals through manufacturing waste elimination. In this case-experimental research for TEPI, the paper proposes a process improvement technique for inventory management. Six Sigma methodology using Lean manufacturing tools were used to address the problem of TEPI in inventory management. Current state analysis and first level Pareto analysis revealed the highest contributor to the total loss of TEPI. Second level Pareto analysis showed that among the factors that contributed to losses, it was the missing/uncounted parts that contributed the highest to the total losses. The Ishikawa diagram and why-why analysis revealed that almost all the problems that arise in TEPI’s inventory activities were caused by the inability of the operator to do multitasking, lack of visual display and parts' sensitivity. Potential problems were identified using PFMEA and a control plan was made for inventory control using counter checker with proximity sensor and visual display to ensure the smooth flow of the processes.

Keywords: inventory management, lean manufacturing, six sigma, kaizen

I. Introduction

Tsukiden Electronics Philippines, Incorporated (TEPI) has been providing electronics manufacturing services (EMS) for more than 20 years. Incorporated in March of 1992 as a wholly owned subsidiary of Tsukiden Kogyo Co., Ltd of Japan, TEPI had started making floppy disk drives at first before they worked on hard disk drive assemblies. The growing demand of EMS products has directed the company to expand its operation and to add printed circuit boards, flexible printed circuits and electronic devices assembly in its line of priority. Despite its many years of existence as an organization, TEPI has not been spared of problems that affect its production, operation and profitability. These problems are found to be caused by the ineffective inventory system adopted by the company. These concerns include problems regarding inventory count, overproduction, and underproduction and scrap units. Based on the report, TEPI’s variation in inventory is too much that it is already beyond allowable error. These discrepancies have caused loss of time and money for a long time now and thus have to be addressed and resolved.

It was mentioned in the study of Thanki and Thakkar (2011) that to be competitive in the existing
global environment, it is necessary for the industries to accept the global and local market challenges and adopt the various tools and techniques to enhance their productivity, quality standards, and customer satisfaction. In the case of TEPI, two strategies which were proven to address inventory problems are the Lean Manufacturing and Six Sigma. Breyfogle III, F.W. (2003) affirmed the effectiveness of the combination of these two approaches. Since the implementation of Lean without Six Sigma may lead to an activity focus that is misdirected relative to the big picture. Companies that only choose to embrace lean manufacturing without six sigma concepts are missing out and can have problems like working on projects that cannot optimize the system or making the system worse. In this case-experimental research, the researcher has proposed a system for the inventory management of Tsukiden Electronics Philippines, Inc. (TEPI). Six Sigma approach using Lean manufacturing tools was used by the researcher to design and develop a system that can eliminate or reduce variation in inventory system and furthermore can resolve problems in inventory. Problems in inventory are being encountered in Tsukiden Electronics Philippines, Inc. and can be addressed and mitigated by evaluation of the current measures employed by the company and by preparing a strategy tailor fit to the inventory needs of TEPI.

The main purpose of this study was to formulate and evaluate a system that can address the issues of the inventory management of Tsukiden Electronics Philippines, Inc. using lean manufacturing and six sigma methodology integration. This study aimed to assess the current state of TEPI’s inventory management system, determine the root causes of the problems in the inventory management system, determine the potential solutions to the identified problem, and evaluate whether the proposed system will provide improvement to the inventory management system of TEPI.

II. Main Body

Applications of lean manufacturing tools and six sigma methodologies integration in addressing the issues of wastes in inventory is the focus of this research. Canel, Rosen, and Anderson (2000) defined waste as anything other than the minimum amount of equipment, materials, parts, space, and workers' time, which are absolutely essential to add value to the product or service. Costs incurred in inventory, set-up, scrap, and rework that do not add to the value of the product are also considered as wastes. It is anything that the customer is not willing to pay for. This means any type of wastes threaten many aspects of the company’s performance. The most common types of wastes are related to transport, waiting, motion, inventory, over-processing, overproduction and defects. According to Imai (1997), excess inventory tends to increase lead-time, prevents rapid identification of problems and increases space requirements. It is found that inventory influences other wastes. It affects over-production, defects, motion, and transportation wastes (Hines and Rich, 1997). Excess inventory represents cash tied up in the form of material, which is difficult to turn into cash quickly. It has to be managed, stored because it can become obsolete leading to scrap. The quality of inventory can deteriorate over a period of time. Finished goods inventory is generally the most expensive inventory as it has labor and other overhead attached to it along with the cost of material consumed during production. Reduction and elimination of these wasteful activities represents a significant opportunity for businesses to improve their performance.

In the study of Melton (2005), lean manufacturing is said to be a process that can improve the performance of the whole supply chain supporting increased business performance by improving manufacturing and service operations, reducing wastes, improving quality, and driving down costs. This concept was pioneered by Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company in Japan according to Womack, Jones, and Roos, (1991). According to Brett and Queen (2005),
it focuses on eliminating loss in process and reducing the complexity to bring out opportunities to increase performance. In the study of Hunter, Bullard, and Steele, (2004), it was mentioned that lean manufacturing is specifically designed to compete in today's highly competitive manufacturing arena. Lean system is considered "lean" because the manufacturing system uses less of everything compared to the traditional functional production manufacturing system design, less human effort, less manufacturing space, less tooling, and less engineering time required to develop a new product. It was also mentioned in the study of Womack, Jones, and Roos (1991) that with lean there is less than half of the work-in-process inventory on hand and there are fewer defects, while producing a greater variety of goods. In the study conducted by Diaz (2013), he stated to implement lean philosophy a big effort is required from the organization and its members to adapt themselves to new ways of performing, thinking and improving procedures. In this process there is a lot of knowledge sprouting out and changes provoked, and if it is not managed properly it can affect the development of Lean methodology and delay the positive results.

On the other hand, Six Sigma is also a methodology used to improve business processes. According to George (2002), the pattern of improvement that Motorola recognized was naturally divided into the five phases of problem solving, usually referred by the acronym DMAIC, which stands for Define-Measure-Analyze-Improve-Control. According to Brewer and Eighme (2005) it is commonly used for six sigma projects or big business project improvements. Estrada and Sinn (2012) mentioned in their study that Six sigma’s DMAIC approach was identified as a system that can bring measurable improvement to existing process. The DMAIC approach utilizes scientific method and statistics in process improvement (Linderman, Shroeder, Zaheer and Choo, 2003). Its objective is to define opportunities for improvement, measure the current process effectiveness to quantify the magnitude of the problems, analyze data to investigate the root causes of the problems, apply the necessary techniques to improve the process, and monitor techniques to sustain the process effectiveness and improvement (Gupta, 2004). According to Snee (2005), the broad use of DMAIC as an overall framework for improving existing processes adds predictability, discipline and repeatability to improvement projects. According to Berardinelli (2016), DMAIC is not an implementation method for best practices; it is a method to discover best practices. George (2002) mentioned that the principle of integrating Lean and Six Sigma is combining the best of both methodologies. It is focused on those activities that cause the customer’s critical-to-quality issues and create the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital, and lead time. Lean and six sigma integration directly attacks the manufacturing overhead and quality costs more effectively than any previous improvement methodology because it comprehends both quality and speed. Thus an obvious solution is to develop an integrated approach that will produce greater solutions in search of business and operational excellence, hence Lean and six sigma integration.

According to Smith (2013), when run separately, such programs will naturally collide with each other. In contrast, a combination of Lean and Six Sigma has a positive impact on employee morale, inspiring change in the workplace culture because teams see the results of their efforts put to work almost immediately. In the study of Timans (2014), he discussed how small and medium sized enterprises benefit from the basic principles underlying lean and six sigma integration.
the wastes in one of TEPI’s major contributor of variation, Client A’s process line, specifically in inventory management and to offer solution by implementing lean and six sigma as tools for positive results and benefits after optimization. Purposive sampling was used to gather relevant data. The supervisors and the employees assigned in Client A process line were chosen to be the target observes. The researcher conducted a document review and gemba walk. Gemba walk was done with the supervisor and planner of Client A. The researcher visited the production area, observed the process and interviewed the concerned personnel. These were done to observe who, where and how work is done (Lindquist, 2011). Consultation with IT specialists was done for the installation of the proximity sensor and visual display in the process line. Data before and after installation were obtained, recorded and statistically treated. Efficiency and cost savings calculations were also computed to determine the effectiveness of the proposed lean and six sigma integration.

To come up with a proposed lean and six sigma integration system that will help Tsukiden Electronics Philippines, Inc. optimize and improve their inventory management system, the researcher considered the following procedures:

A. Define

In this phase, the nature of the problem was identified using current state analysis, first level Pareto analysis, process map and flowchart. These tools were used in sequence to identify the pain area that needs improvement. The output directed the researcher to target the current issues in the company and suggest and implement improvements on the most important categories.

Current state analysis was used by Patel (2011) in his study to identify the current issues of Kishan, a plastic manufacturing in India. In this study current state analysis was also used to address the current issues at Tsukiden Electronics Philippines, Inc.

Tsukiden Electronics Philippines, Inc. have been providing electronics manufacturing services for more than 20 years. During research for TEPI it has been found the need to improve their inventory management system. TEPI has been serving different semiconductor companies as their clients. They are involved in printed circuit boards, flexible printed circuits and electronic devices assembly.

Currently the company’s raw materials, WIP, and finished goods were not tracked efficiently that causes too much variation in their inventory that result in losses in the company and their clients. Implementing
RFID and barcode system is not acceptable with their clients because of the size of the product and it will affect the quality of their product. Hiring additional manpower for product tracking is not acceptable with the management.

It is the problem with the inventory management system that becomes the focus within the DMAIC process in this research. The poor system affects the performance of TEPI. It is clear from the evidence that by improving the system, TEPI will reduce the variation in their inventory.

In parallel to the study of Talib, Rahman, and Qureshi (2010), Pareto analysis was used to identify and propose a list of “vital few” critical success factors. In this study, First level Pareto analysis revealed that among the seven clients of TEPI, Client A contributes 41.7% of the total loss which is the highest. It is an indication that focusing on Client A’s inventory issues will provide bigger improvement on TEPI’s inventory management system.

Since the problem now is localized, process map and process flow is used to have a clearer understanding of the flow of the system and identify the specific area where the problem exists. Below is the plant lay out showing the process map of Client A and its process flow chart.

Raw materials from the storage area was brought to the parts preparation area by an operator. Identification card was scanned before the raw materials were issued. Raw Materials will be brought to the parts preparation

| Client | Losses (in Quantity) | Percentage |
|--------|----------------------|------------|
| A      | 58,189               | 41.70%     |
| B      | 45,397               | 32.54%     |
| C      | 18,360               | 13.16%     |
| D      | 13,759               | 9.86%      |
| E      | 3,183                | 2.28%      |
| F      | 462                  | 0.33%      |
| G      | 177                  | 0.13%      |
| Total  | 139,528              |            |

**Table 1. Inventory Losses per Client**

**Figure 2. Plant Layout and Process Map**
To discuss the process in detail, below is the current flow chart of Client A showing the different tasks of the process line.

From parts preparation, items were received by an operator and forms containing the quantity of items were filled up manually. The items will then be brought to the process line. The process line starts with depaneling that was done manually. The throw-away parts were placed in the bin located near the operator. The useful parts were passed through the next process that is manual soldering. To prevent bottleneck manual soldering was divided into two stations those are manual soldering 1 and manual soldering 2. Visual inspection is the next process. If the item is good then it will be passed through the next process which is function testing but if the item is no good then it will be placed into a bin for rework. For items that categorized as good form the function testing it will pass through to the final visual inspection but if not it will be placed again on a bin for function analysis. There will an Out of Box Audit (OBA) for items that passed through the final visual inspection. Items that passed the OBA will be packed for shipment and items that are no

![Client A's Process Flow Chart](image-url)

*Figure 3. Client A's Process Flow Chart*
Table 2. Factors that Cause Inventory Losses for Client A

| Factors           | Quantity | Percentage |
|-------------------|----------|------------|
| Wrong count/ miscount | 24,511   | 42.12%     |
| Scrap units       | 15,472   | 26.59%     |
| Machine attrition | 11,575   | 19.89%     |
| Repaired units    | 6,631    | 11.40%     |
| Total             | 58,189   |            |

The quantity of items received from parts preparation does not undergo recounting or rechecking before depaneling and after final inspection. The record of data before depaneling did not match with the record of delivery/shipment area. If there is an underproduction, they need to produce the required quantity. They need to order again from the parts preparation area.
to finish the required quantity on time. These are done without tracing the parts or products if it is missing or miscounted only. After the delivery of products and they have found the missing product/part then there will be over-production. There occurs the variation in inventory control.

B. Measure

In this phase, the researcher identified the characteristics that influence the behavior of the process. This was accomplished by making measurements and collecting data from current state of the process line that causes the biggest problem in Tsukiden Electronics Philippines, Inc.

Since it was revealed in the first level Pareto analysis that it is Client A that needs to be the focus of study, a Second level Pareto analysis was conducted. This is used to better understand and quantify the extent of the problem.

The data above it shows the different factors that cause losses for Client A. It was the wrong counting/miscounting of parts that rank first having a 42.12% contribution to the total losses. Addressing the problem with missing or uncounted parts will provide solution for Client A process line inventory issues and for TEPI as well.

C. Analyze

In this phase, the objective is on determining the root cause of the problem. The data collected during the measure phase will be used to analyze the gap between the current and desired performance. Ishikawa diagram and Why-Why analysis is a useful technique to trigger ideas and to determine the factor to consider within a design of experiment. According to Kindlarski (1984), Ishikawa diagram is used to analyze the root cause of the problem by using causal connection of ordering things, events, or actions. The diagrams point from an effect toward the causes. After identifying the root cause, why-why analysis was also used to identify solutions to the problem and address its root causes (Deb, Chakraborty and Bhattacharya, 2010).

The Ishikawa diagram above shows that there are many reasons for poor inventory management system in TEPI that is variation in inventory count. Almost all the problems that often arise in TEPI’s inventory management activities are caused by the inability of the operator to do multitasking, lack of visual display and the sensitivity of parts. Operators are focused on the primary task assigned to them and additional tasks will only make them inefficient. Lack of visual display results to the operator’s lack of focus because he has no access to real-time monitoring of parts. Since parts are sensitive, manual counting is done that result to variation in inventory count.

Table 3 revealed that the major causes of variation in inventory count are lack of accountability, prolonged work routine, lack of visual display, manual recording of data and operators need to focus on single task. From these major causes of variation in inventory count the researcher proposed to install a counter checker. The counter checker is composed of a proximity sensor and a visual display that will help the operator to have an accurate count of parts, monitor the parts, and automatically record the data that do not require multitasking skills.

D. Improve

Ideas for process improvement were formulated and implemented in this stage. Gupta (2004) mentioned that improve phase consist of the development and selection of the optimal solutions for better results and higher performance. The researcher used design of experiment. Installation of proximity sensor and visual display was done in this phase.

Since the main issue in Client A’s process line is wrong count or miscount of items by their employees, the researcher added a device that will provide a real time monitoring of the items that passes through the process line. A counter checker that is composed of a proximity sensor and a visual display is placed before depaneling and after final inspection. The
Table 3. Why-Why Analysis for Client A

| Why 1                          | Why 2                          | Why 3                          | Why 4                          | Why 5                          | Root Cause                                                                 | Recurrence Prevention                                                                 |
|-------------------------------|-------------------------------|--------------------------------|--------------------------------|--------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Operators lack focus          | Operators unable to do multitasking | Operators focused on single task only |                                |                                | Every task are time constrained and needs attention.                       | Automate other tasks that requires accuracy.                                           |
| There is an error in data input | Data are manually recorded      |                                |                                |                                | No software program is available for each process line                    | Automatic data input                                                                |
| There is low frequency of counting | There is difficulty in counting | Parts manually counted by batch | Automated counter not available | RFID and barcoding is not allowed | Some parts are small and all parts are sensitive.                          | Use sensor that does not affect the quality of the product, and will provide accurate counting |
| There is poor documentation | There is a delay in recording data | Operators are unable to do multitasking | Operators focused on single task only |                                | Every task are time constrained and needs attention.                       | Automate other tasks that requires accuracy.                                           |
| Return and withdrawal of parts are undocumented | Located parts are not recorded | Operators are unable to do multitasking | Operators focused on single task only |                                | Every task are time constrained and needs attention.                       | Automate other tasks that requires accuracy.                                           |

Figure 6. Counter Checker (Proximity Sensor with Visual Display)
Figure 7. Improved Process Flow Chart

program was designed to have a 5 seconds delay after swiping. It displays a green background to signal the operator that the sensor is ready and a black background is displayed to signal the operator that it is in standby mode. The responsibility for the counter checker will be assigned to the operators assigned in depaneling and final inspection. The data will automatically be saved and can be printed.

1. Data Analysis

Since counter checker (proximity sensor with visual display) was installed and used in the process line of Client A, data analysis should be done to evaluate its effectiveness. The data provided below was retrieved from the process line of Client A before and after implementation of the project. It showed the planned production, the actual production and the variance which includes overproduction and underproduction.
Table 4. Production data before implementation

| Day | Plan | Actual | Variance | Day | Plan | Actual | Rework | Variance |
|-----|------|--------|----------|-----|------|--------|--------|----------|
|     | For  | For    |          | 16  | 360  | 355    | 4      | (1)      |
|     | Shipment | Rework |          | 17  | 180  | 180    | 0      | 0        |
| 1   | 360  | 287    | 20       | 18  | 360  | 359    | 0      | (1)      |
| 2   | 360  | 320    | 15       | 19  | 200  | 200    | 0      | 0        |
| 3   | 360  | 288    | 12       | 20  | 360  | 358    | 1      | (1)      |
| 4   | 360  | 412    | 0        | 21  | 720  | 710    | 10     | 0        |
| 5   | 360  | 297    | 3        | 22  | 540  | 530    | 10     | 0        |
| 6   | 360  | 288    | 15       | 23  | 540  | 520    | 18     | (2)      |
| 7   | 180  | 202    | 0        | 24  | 720  | 715    | 5      | 0        |
| 8   | 360  | 308    | 10       | 25  | 360  | 355    | 3      | (2)      |
| 9   | 360  | 435    | 0        | 26  | 360  | 360    | 0      | 0        |
| 10  | 360  | 360    | 0        | 27  | 360  | 355    | 4      | (1)      |
| 11  | 360  | 322    | 4        | 28  | 360  | 355    | 5      | 0        |
| 12  | 360  | 386    | 0        | 29  | 180  | 178    | 1      | (1)      |
| 13  | 360  | 315    | 5        | 30  | 180  | 175    | 4      | (1)      |
| 14  | 360  | 316    | 10       |      |      |        |        |          |
| 15  | 360  | 296    | 10       |      |      |        |        |          |

Table 5. Comparison of Data

|                  | Current State | Proposed System |
|------------------|---------------|-----------------|
| Planned          | 5220 units    | 5780            |
| Actual           | 4586 units    | 5770            |
| Overproduction   | 175 units     | 0               |
| Underproduction  | 459 units     | 10 units        |
| Total Variance   | 634 units     | 10 units        |
| Total Percentage | 12.15%        | 0.17%           |
| Total Losses in US dollars | $12,337.64 | $194.60 |
| Average Loss in US dollars | $822.51 | $12.97 |

Table 5 shows the comparison of data. There is a 12.15% loss in the current state. After implementation of the project it was reduced to 0.17% in the proposed system. It suggests a reduction of 11.98% in the inventory control variation. As compared to the study of Afzal, Ganapathi, and Kalathil (2012) after implementation of the improvement, their study brought more than 88% reduction in scrap cost for Sanmina-SCI.

E. Control

This is the final phase of the lean manufacturing and six sigma integration for Tsukiden Electronics Philippines, Inc.. According to Guitierrez and De la Vara (2006), it is the phase where the system which maintains the performance improvements at desired level is designed. In this study, the researcher used Process Failure Mode, Effects and Criticality Analysis to identify the potential problems in the new process. A control plan was developed to institutionalize the implementation of the new process.

In the study of Carlson (2014), he mentioned that failure mode and effects analysis can be used to anticipate and prevent problems, reduce costs, shorten product development times, and achieve safe and reliable products and processes. In this study, it was used to identify and analyze the potential failure modes within the system. It enabled the researcher to design those failures out of the system. For inventory control, the potential failures are wrong count/ miscount and malfunction of visual display. For wrong count/ miscount, it will require the repeat
Table 6. Potential Process Failure Mode, Effects and Criticality Analysis

| Process                                      | Potential Failure mode | SEV Potential cause(s) of failure | OCC Current Process Control | DET RPN Recommended actions |
|----------------------------------------------|------------------------|----------------------------------|----------------------------|-----------------------------|
| Inventory control (parts counting)           | wrong count/ miscount  | 8                                | Proximity sensor has been damaged, Dirt accumulation | Monthly preventive maintenance, Daily PM | 1 8 None |
| Line stop                                    | Power outage           | 8                                | Uninterrupted power supply, Standby generator | Display monitor, Daily PM | 1 8 None |
| Overproduction or underproduction            | Multiple swiping of parts | 8                                | 5 seconds delay | Counter checker after final inspection | 1 8 None |
| Malfunction of visual display                | Wrong display          | 8                                | Monthly preventive maintenance | Display monitor | 1 8 None |

Table 7. Control Plan

| Operation description | Characteristics | Process | Process specification/ Tolerance | Methods |
|-----------------------|----------------|---------|----------------------------------|---------|
|                      |                | Product |                                  | Evaluation/ measurement techniques | Control method | Responsible person | Reaction plan |
| Inventory control     | Count accuracy | Placed 18 inches away from the operator and 16 inches on top of the working table 5 seconds interval in parts scanning Color distinction for readiness and standby mode | Scanned parts registry in the database Zero variation in inventory count | Periodic inspection monthly basis | Technician | Repair tool Adjust and re-check |

action if proximity sensor has been damaged and it has accumulated dirt. It can be detected if there is no change in quantity in the display monitor and to prevent it there should be a preventive maintenance. Another potential cause is power outage that will make the line stop and fail to input data into the system. To avoid this, there should be a UPS and a standby generator. If multiple swiping of parts were done, there will be overproduction or underproduction.

To avoid this, the program is designed to have a 5-second delay before and after swiping. If the visual display fails, it will give wrong information that may be caused by a software bug; and to avoid this preventive maintenance should be done.

Inventory control will use counter checker composed of proximity sensor and display monitor for parts count accuracy. It was ergonomically placed 16 inches away from the operator and 18 inches on top of the working table. To avoid multiple scanning it was programmed to have a 5-second interval and color distinction in visual display, green background for ready to scan and black background for standby mode. Scanned parts should be registered in the database for printing. There should be zero variation in inventory count. Periodic inspection should be done by the technician. For the machine set-up, periodic maintenance
Table 8. Statistical treatment of data

|                        |          |          | t         | df | Sig. (2-tailed) |
|------------------------|----------|----------|-----------|----|----------------|
|                        | Mean     | Std. Dev. | Std. Error Mean | 95% Confidence Interval of the Difference |          |          |
| Paired Differences     |          |          |           | Lower | Upper          |
| Pair 1 before - after  | 41.60000 | 19.41575 | 5.01313   | 30.84791 | 52.35209       |

should be done as per preventive maintenance schedule, also by the technician.

1. Statistical Analysis

After the experimental results were obtained from Client A’s process line, the data were statistically treated using paired t-test to test the hypothesis that there is no significant difference between the current state and proposed system for Tsukiden Electronics Philippines, Inc.’s inventory management. It is used to compare the output of the process line before and after installation of the counter checker.

A paired-samples t-test showed a statistically significant decrease in the variances of client A’s process line output from \((M=42.27, SD=19.21)\) to \((M=0.67, SD=0.72)\); \(t(14)=8.298, p=0.00\) (two-tailed). The mean decrease in variation was 14.6 with a 95% confidence interval ranging from 30.85 to 52.35. The eta squared statistic (.50) indicated a large effect size. This means that there is a significant difference between the current state and proposed system for the inventory management of Tsukiden Electronics Philippines, Inc.

IV. Conclusions

A. Results

Using the current state analysis, the problem with inventory management system became the focus of this research. It was supported by first level Pareto analysis which revealed that Client A contributes 41.7% to the total loss. Process map and flow chart were used to show the different tasks in the process line. A second level Pareto analysis was also done for Client A which revealed that among the factor that contributes to losses, it is the wrong count/ miscount. This factor contributed 42.12% to the total losses. Ishikawa diagram and why-why analysis was used to analyze the reasons for variation in inventory count that result in inventory losses in TEPI. The major areas of focus are the lack of focus, poor documentation and difficulty in counting. To determine the potential solution to the problem, a DOE was conducted; a counter checker composed of proximity sensor and visual display was installed. Data gathering was done before and after implementation of the project. A reduction of 11.98% in the variation was observed. In the statistical analysis, paired t-test was used and revealed a t-computed value of -1.742 that is beyond the tabular value of -1.701 that suggests that there is a significant difference between the current state and proposed system for TEPI. A PFMECA was also done to identify and avoid the potential problems that may occur. A control plan for the inventory control using counter checker was also created to ensure that the processes will run smoothly.

B. Discussion

Current state analysis and first level Pareto analysis revealed that Client A contributes the 41.7% to the total loss which is the highest among the seven clients of TEPI. Therefore focusing on Client A’s issues will provide a big improvement for TEPI. In the second level Pareto analysis for Client A it revealed that missing/ uncounted parts contribute 42.12% of the total losses which is the highest among the four factors that cause losses. Therefore addressing this
problem will provide solution/improvement for Client A process line issues and for TEPI as well. Ishikawa diagram and Why-Why analysis was used to analyze the reasons for variation in inventory count in TEPI that results in inventory losses. Therefore, if lack of focus, poor documentation and difficulty in counting will be addressed there will be big improvement in TEPI. In the experiment conducted, a reduction of 11.98% in the variation was observed. Therefore installation of the proximity sensor and visual display before depaneling and after final inspection provided a big improvement in their inventory system. In the t-test for independent samples, it suggests to reject the null hypothesis that there is a significant difference between the current state and proposed system for TEPI. Therefore, the proposed system will provide a big improvement for TEPI. From the PFMECA, a control plan for the inventory control using counter checker was created to ensure that the processes will run smoothly.

C. Limitation

This study primarily focused on the integration of lean manufacturing and six sigma methodologies for the improvement of the inventory management system of Tsukiden Electronics Philippines, Incorporated. Only the inventory management system of TEPI was included in this study. Other departments of the said company and their extension plants was not considered for the study. The research sample included participants that are directly involved in the inventory management system of TEPI. A case in the inventory management system was used for the implementation of the Lean and Six Sigma integration.

Since the result of the experiment provided a huge improvement for Client A, therefore it can used as potential kaizen project for other clients and process lines of TEPI. Future researches using other lean tools may also be considered. Future researchers should also consider other potential application of Lean and Six Sigma Integration if optimization is their primary objective. Further studies on the manufacturing processes of TEPI are recommended in order to fully improve their system by reduction of time using lean six sigma implementation.

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