UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS AND IMPROVEMENT OF LUBRICANT BLENDING CYCLE-TIME INCONSISTENCY USING QC TOOLS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) (Hons.)

by

LIM JIN TZEN

B051210077

920803-10-6071

FACULTY OF MANUFACTURING ENGINEERING

2016

ABSTRACT

This main concern of this project is to identify and remove the causes of inconsistent processing time during blending process in AsPac Lubricants (Malaysia) Sdn. Bhd., the lube oil manufacturing industry located at Port Klang. The objectives of this project are to identify the root cause of inconsistent blending cycle time using various quality tools and to propose solutions in addressing the root cause of inconsistent blending cycle time. Check sheet has reviewed that out of specification blend as major problem. Meanwhile, the moving chart showed that the blending process is in a state of control and focus to solve systematic issues. For the purpose of brainstorming, an interview and questionnaire were carried out. After eliminating the hypothesis that majority do not agree and verified by 5-Whys analysis, the major problem that has been confirmed is the inefficiency of blender to provide 100% of circulation in one cycle. To address the problem, electrical impedance tomography method is suggested to monitor the blending process. Besides, three methods are proposed to redesign and improve the performance of blending machine which are adding a more viscous material to less viscous material, add minor ingredients to the less viscous material and reduce the batch size. Furthermore, PDCA is recommended to maintain the sustainability of the proposed solutions.

ABSTRAK

Tujuan utama projek ini adalah untuk mengenal pasti dan menyelesaikan punca-punca disebabkan oleh proses pengadunan yang tidak konsisten di Aspac Lubricants (Malaysia) Sdn. Bhd. iaitu industri pembuatan minyak pelincir yang terletak di Pelabuhan Klang. Objektif pertama projek ini adalah untuk mengenal pasti punca kepada masa kitaran pengadunan yang tidak konsisten dengan menggunakan pelbagai alat kualiti. Objektif kedua adalah cadangan penyelesaian dalam menangani punca kepada ketidak konsisten masa kitaran pengadunan. Senarai semak telah mengenal pasti bahawa masalah pengadunan di luar spesifikasi adalah masalah utama. Sementara itu, carta bergerak menunjukkan bahawa proses pengadunan berada dalam keadaan terkawal dan tertumpu kepada penyelesaian isu-isu yang sistematik. Untuk mengenal pasti faktor-faktor yang terlibat, temu bual dan soal selidik telah dijalankan. Masalah utama yang dikenal pasti ialah ketidakcekapan mesin adunan yang juga telah disahkan oleh analysis “5-Whys”. Bagi menangani masalah ini, kaedah tomografi impedans elektrik dicadangkan untuk memantau proses pengadunan. Selain itu, tiga kaedah telah dicadangkan untuk merangka semula dan meningkatkan prestasi mesin pengadun. Pertama, menambah bahan yang lebih likat kepada bahan kurang likat. Kedua, menambah bahan-bahan kecil kepada bahan yang kurang likat. Akhir sekali mengurangkan saiz kumpulan yang berlaku di dalam campuran. “Plan, Do, Check and Act” turut dicadangkan untuk mengekalkan kemampanan penyelesaian yang telah dicadangkan.

DEDICATION

Dedicated to my parents and friends who giving me moral support, cooperation, encouragement and also understanding.

ACKNOWLEDGEMENT

First, I would like to express my utmost gratitude to both of my supervisors, Dr. Mohd Shukor Bin Salleh and Associate Prof. Dr. Md. Nizam bin Abd Rahman for their advices, valuable information and guidance which helped me in completing the Final Year Project.

Besides, special thanks also dedicated to my course mates Lorita Lawi Anak Balai and Chi Lai May because always provide me cheers, comments and sharing of knowledge.

Last but not least, I would like to show my deepest appreciation to my family members for their moral support, understanding and encouragement throughout this project.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

BCT	-	Blending Cycle Time
EIT	-	Electrical Impedance Tomography
FMEA	-	Failure Mode and Effects
HOQ	-	House of Quality
MRI	-	Magnetic Resonance Imaging
PDCA	-	Plan Do Check Act
QC	-	Quality Control
SKU	-	Stock Keeping Units
SPC	-	Statistical Process Control
VSM	-	Value Stream Mapping

CHAPTER 1
INTRODUCTION

This chapter includes the background of study, problem statement, objective and scope that related with this project.

1.1 Background

During the last two decades, manufacturing paradigms have evolved. The introduction of new paradigms is as a result from ever increasing customer expectations and competitions that requires manufacturing to deliver high quality products at low cost in the shortest period of time (Herron & Hicks, 2008). These challenges lead companies to implement various tools to improve their efficiency and productivity. The successful restructuring of company internal processes requires effective methods and tools. Staying competitive requires looking for new strategies of reducing costs and increase the quality of the company's product (Kovacheva, 2010) . Kovacheva (2010) also stated that lean thinking was believed to be one of the potential approaches for improving organizational performance.

The principles of lean manufacturing that aid in the elimination of waste have helped companies meeting ever increasing customer demands while preserving valuable resources for future generations (Miller et al, 2010). As waste is eliminated, operational control improves while production time and cost reduced. This change in manufacturing strategy is associated with increase in operational efficiency and effectiveness, which positively impacts firm performance (Shah, 2003).

The main concern of this paper is to identify and remove the causes of inconsistent processing time during blending process in AsPac Lubricants (Malaysia) Sdn. Bhd., the lube oil manufacturing industry located at Port Klang. Figure 1.1 shows the general process flow of the lube oil manufacturing plant.

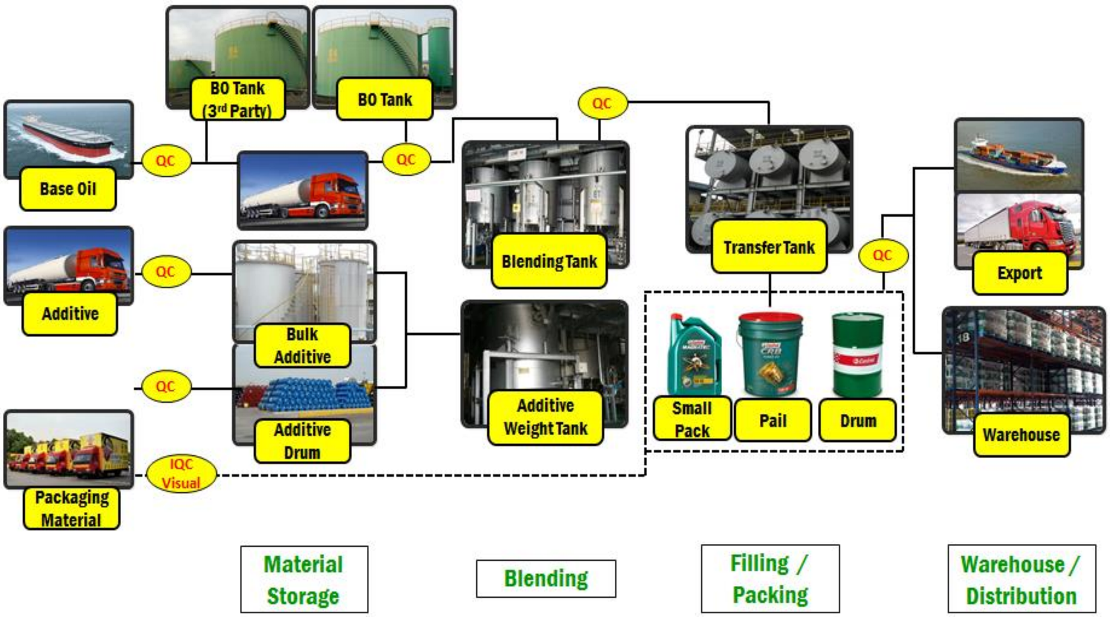

Figure 1.1: Process flow chart

Manufacturing of lube oil comprises of few main stages, but the scope of this study is limited to the blending production line. Blending cycle time (BCT) is the indicator used by the company to measure the consistency of blending cycle time. There are various sub-processes that comprised in blending process and the time taken for each sub-processes are included in BCT. Those sub-processes are charging time, mixing time, testing time and transfer time.

There are many potential causes that can contribute to the inconsistency of blending cycle, such as failure in measurement, inefficiency of blender, miscalculation of dispersion, environment factor and etc. In addressing the issue, the company has collected many operational data for each process. However, improvement made in addressing this issue is not significant. Thus, this study is proposed to investigate the root causes of the inconsistent blending cycle time and to propose solution to address that problem. The inconsistency in BCT creates difficulties to forecast team to plan the production planning.

1.2 Problem Statement

AsPac Lubricants (Malaysia) Sdn. Bhd. faces the difficulty in controlling blending cycle time. In order to trace the inconsistency in blending cycle time, time taken for each process has been recorded down by blending supervisor. Even though there are time records for each process, but no comprehensive investigation has been conducted. Therefore, the company is still facing this issue which causes difficulty for planning group to have an accurate production schedule.

1.3 Objective

The objectives of this project are:

a) To identify the root cause of inconsistent blending cycle time using various quality tools.
b) To propose solutions in addressing the root cause of inconsistent blending cycle time.

1.4 Scope

This project will be conducted at AsPac Lubricants (Malaysia) Sdn. Bhd. which located at Port Klang. The limitation of this project mainly concentrates on the investigation of inconsistency in blending cycle time. The investigation will be performed based on eight months of historical data collected by the company. The methodology that will be applied to analysis and evaluate these issues is 7 quality control tools and various tools. The Quality control tools involved are Check sheet, Control chart, Pareto chart, Ishikawa diagram, 5-Whys analysis and House of quality.

CHAPTER 2
LITERATURE REVIEW

This chapter describes literature review relates to this project. Topics covered in this review are the background of the company participates in this project, nature of its business and production, definition of quality, various quality control tools, and design approaches. The information included in this review is obtained from journals, books and company database.

2.1` Company Background

Figure 2.1: Logo of AsPac Lubricants (Malaysia) Sdn. Bhd.

AsPac Lubricants (Malaysia) Sdn. Bhd. is a lubricant blending plant located at Port Klang. This lubricant blending plant was commissioned in 1969 for bulk filling and lubes manufacturing. AsPac Lubricants (Malaysia) Sdn. Bhd's shareholder is BPAP/PNB and located on 18 acre site. The equipment by the company are predominantly manual machines. Despite manual operations, AsPac Lubricants (Malaysia) Sdn. Bhd. still manages to manufacture 620 types of Stock Keeping Units, (SKU).

AsPac Lubricants (Malaysia) Sdn. Bhd. offers lubricants for virtually all domestic, commercial and industry applications. These include automotive lubrication for motorcycle with 2-stroke and 4-stroke and both petrol and diesel car engines. The products produced by AsPac Lubricants (Malaysia) Sdn. Bhd. also comprised product for various applications such as manual and automotive transmission fluids, greases, cleaners and maintenance products, agricultural machinery, plant, general industry and marine engineering..

Based on Figure 2.2, AsPac Lubricants (Malaysia) has successively tripled their filled volume in a short period and has become the regional supply plant. As shown in Figure 2.3, AsPac Lubricants (Malaysia) is focusing on quality, service and cost. This is to ensure they remain competitive in the increasing production complexity.

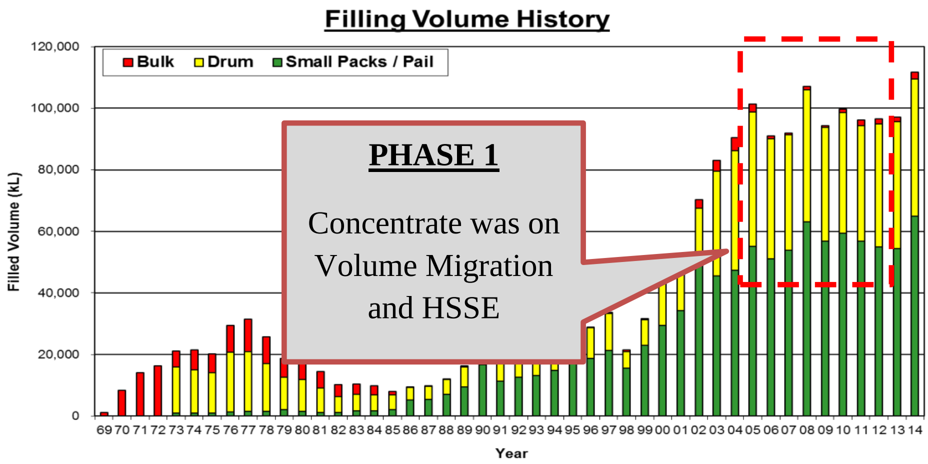

Figure 2.2: Journey (Phase 1)

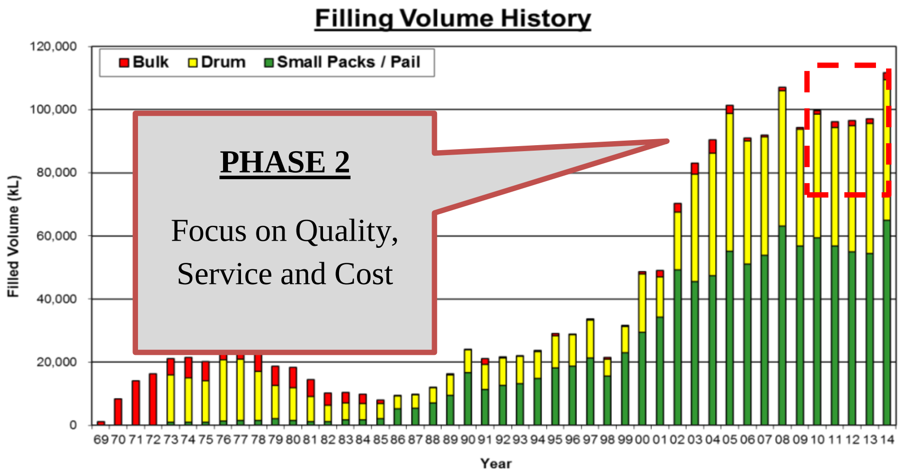

Figure 2.3: Journey (Phase 2)

2.2 Process Flow

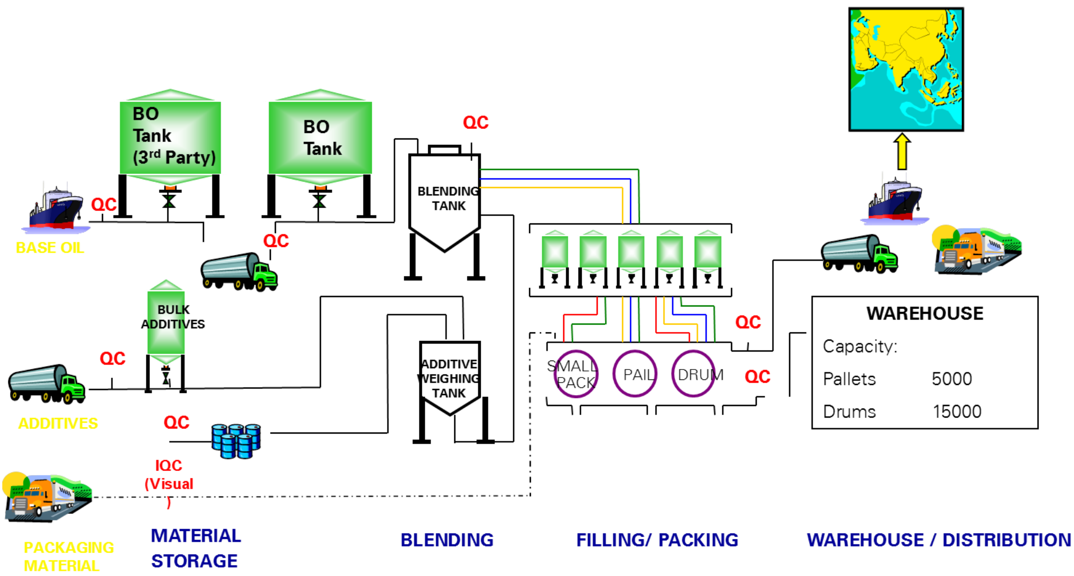

Figure 2.4: Process Flow Diagram

Figure 2.4 shows the process flow in lubricant manufacturing at AsPac Lubricants (Malaysia) Sdn. Bhd.. There are four distinct stages in this process, from initial reception of raw material to the eventual production of high performance lubricant.

At the first stage in the lubricant manufacturing process, base oil and additives obtain from the supplier. The samples of these raw materials are then sent to the company's laboratory for quality control (QC) test and the raw material is transported to specific storage tank. Next, the raw materials are delivered to the blending tank based on the specified weight. The raw materials are then mixed until it is homogeneous.

Stage three of the process involves SKU. The blended lubricant is filled either in small packs, pail or drum. The samples of these SKUs are then sent to the company's laboratory for QC test. Lastly, these SKU is sent to the warehouse and wait for the shipment.

2.3 Blending Process Detail

Different product has a different formulation and manufacturing process steps. Product PV EDGE 0W-40 A3/B4 is selected for this study because it contributes to the third-largest blended volume. This product is catered for application family 4B1. The process flow of this product is shown at Figure 2.5.

Flush blending vessel in accordance to the flushing matrix guidelines.
Flushing oil can be reused immediately as per flushing matrix guidelines.
Otherwise pump and completely drain out the flushing oil.

Heat R01758G in the blending vessel to at least 50C.tank.

Add-in R07699A and R11053A. Take care DO NOT heat these additives, as this may lead to the release of toxic gases if temperature >60C.

Concurrently, R05180A is dissolve in an additive weighing tank (AWT) equipped with heating coil. Procedure as follows:

a) Dissolve R05180A with a portion of the base oil in a separate vessel, heated until melted (70C-80C) to get a clear premix blend solution.

b) Transfer the premix into blending vessel via AWT.

(NOTE: The premix temperature MUST maintain at least 67C, as the R05180A will drop out of solution if cooled below 67C).

Circulate the mixture in the blending vessel until homogeneous (approx 45 - 60 min).

Charge-in R06275A, R10059A, and R07721A in sequence into the blending vessel via AWT.

Flush the AWT and pipelines with remaining R01761B and pump the oil into the main blend.

Send a representative sample to the laboratory for QC analysis.

Figure 2.5: PV EDGE 0W-40 A3/B4 Blending Procedure

Although the blending process is carried out by referring on standard procedure, the blending cycle time taken for each batch of this product is not consistent. Due to its inconsistency, the production planning group is having difficulties in accurately forecasting the production scheduling to meet customer delivery requirement. This is the motivation behind this project.

2.4 Cycle Time Study

Cycle time is a measure of how much time it takes for a particular operation, which normally expressed in term of similar units (time/piece) (Santos et al, 2015, p45). In the manufacturing process, cycle times help managers determine whether they are doing the right job, whether they are using resources effectively and whether they are improving (Bhat, 2015, p299).

Cycle time can also be defined as total workstation cycle time. This is applicable when more than one task is assigned to each workstation, the sum of process time of each one of the task determines the total cycle time assigned to the workstation (Santos et al, 2015, p45).

Because of the global competition, there is fear of losing the customers if the company does not reduce its overall cycle time in general (Sharma, 2013). Cycle time can be calculated using formula shown as below (Grubb, 1998).

$$\text{Cycle time} = \frac{\text{Work to be performed}}{\text{The capacity to do work}} \qquad (1)$$

In order to identify the wastes generated in various processes, ones needs to delineate the process in detail, and find out whether the steps add value or not (Ashok Sarkar et al, 2013). Based on the current processes, one needs to prioritize the sub-processes for improvement. This is essential because simultaneously improvement initiative for all sub-processes require immense effort and time (Ashok Sarkar et al, 2013).

2.4.1 Published Research on Reduction of Cycle Time

Venkataraman *et al*. (2014) described the implementation of lean manufacturing techniques in the crankshaft manufacturing system at an automotive manufacturing plant located in south India. The objective of the case industry was to improve the export sales. Lean manufacturing system was chosen as the approach to achieve the company's quality, cost and delivery targets. A crankshaft was manufactured in a single piece flow system with the low cost machine development. As a result, crankshafts have passed the testing, validation and approval by the consumer to produce any variant in the company. In this case, the author has applied value stream mapping so that to understand the flow of inventory and information required in eliminating waste of the manufacturing process. Next, the team implements Kaizen 1, the modified process by eliminating and combine operations. As a result, the cycle time reduced from 135 seconds to 70 seconds and the capital investment for the milling head was also eliminated, resulting in saving of Rs 0.15million.The following phase was the implementation of Kaizen 2 where the process parameters were optimized. The existing process parameters for each process were studied and optimized. As a result, the cycle time reduced from 140 seconds to 111 seconds and there was no side effect on the quality. In the third phase of improvement, Kaizen 3, the author improved the tooling used and introduce CNC lathe. The analytic hierarchical process in Kaizen 3 helps decision maker to gain confidence in the selection of suitable assembly processes.

A journal on cycle time reduction was studied by Lingam *et al*. (2015) for a manufacturing industry of a variety textile products using Lean Manufacturing approach. Initially, the different process in the manufacturing of T-Shirts was identified. Time study was taken for each process on a micro level such that each and every hand motion of the user was also recorded. In this case, two handed process chart was used to determine all possible movements and distinguish the Non-Value Adding movements from the Value Adding movements of the worker. Before the time study was conducted, a detailed process chart of the current process was made. A man machine chart is useful in analysing the times where the machine and man are idle. This tools help in effectively utilizing the resources thereby improving the production performance. In process improvement session, Kaizen and Poka Yoke's approach were implemented to reduce cycle times. A FMEA analysis was conducted and the corresponding failures were determined and addressed using the fool proof mechanisms. Value stream mapping was then used to identify how much the cycle time was reduced. For further improvement, line balancing was used to distribute even work load. This is used to predict the lead times after the list of Kaizen initiatives were implemented to the entire company. As a result, 20% reduction in cycle times, which equivalence to 1,500,000 INR saving monthly were realized (Dharun Lingam & Sakthi Ganesh, 2015).

A paper dealing with the implementation of lean principles in an automobile industry to reduce cycle time was discussed by (Kumar & Kumar, 2014). Takt time was used to determine available production time to meet customer demand. Second, line balancing technique was applied to minimize the cycle time in an automobile assembly plant, which comprises of many non-value added activities and work. Third, standardized work approach was used to study the operational steps and time consumed for the purpose of devising method to increase efficiency of workers. In addition to that the author also identified clear start and stop point for each process. Value stream mapping was then used to understand the flow of material and information, as a product makes its way through the value stream. This helped to determine the bottleneck conditions, the WIP inventory and processing time and production lead times. Tree diagram and prioritization were used to break down the broad categories into finer levels of details. It mapped detail tasks required to accomplish a particular process. It also prioritized the items and describes them in terms of weighted criteria. The combination of a tree and matrix diagramming techniques narrowed down options to the most desired one. The last approach conducted is lean manufacturing. The first phase of the lean implementation included a flexible works system and 5S. It was aimed at reducing the waiting time by dedicating groups of equipment for the production of specific families and coupling them close together. The second phase of lean manufacturing initiative improved and standardized the internal processes. Initially, the cycle time of the total assembly was 90 min, and the efficiency of the line was 17.5%. After balancing the line, the cycle time reduced to 37.5 min, and efficiency increased up to 30.09%.

Lin, Tsai *et al*. (2008) reported a study on cycle time improvement through Work-In-Process (WIP) Statistical Process Method in a semiconductor foundry located in Taiwan's Hsinchu Science Park. This study suggested the adoption of progressive bottleneck and WIP management improvement that can be divided into five steps. Firstly, estimate reasonable WIP level based on present cycle time level. Second, distribute WIP level to each machine group according to machine characteristics and utilization rate of productive capacity, and set standard WIP. Third, set WIP control line based on SPC concept, carry out automated processing of WIP balance behaviour by computers. Next, set monitoring mechanism, handle machine's variation, estimate and monitor the status of WIP, take remedial actions in time. When the line balance is under control and B/N has no capacity loss, reduce the WIP level gradually and repeat step. As a result, a formula for standard WIP and use statistical process control (SPC) concept to set WIP upper/lower limit level were developed. As WIP profile balances, the company doesn't need too much WIP. As a result, the WIP level was reduced and cycle time was also reduced.

Ashok Sarkar *et al*. (2013) reported study on improvement of claim cycle time through Lean Six Sigma methodology. The first step involved the identification of the process steps and reduction of critical time components. Once the process was identified, the next step is to find out the present status along with all the sub-processes. This is to prioritise the sub-processes for improvement. In order to assess the process performance, the distribution of cycle time has been explored. The process followed by plotting activity flowchart. The purpose of plotting is to obtain better comprehension. In improvement session, a risk analysis is to identify all identified solutions. Once no risk is found, propose an implementation plan with details of action plans, responsibilities assigned and the target date for completion. In order to maintain its sustainability, there is a modification in standard operating procedure.