Factors Affecting in Improving Quality in Production:

A Study on O&G Manufacturing Company - Cameron Malaysia Sdn Bhd

Ahmad Rizal Bin Bahrom Azhar

Project Paper Submitted in Partial Fulfillment of the Requirements

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DECLARATION

I'm declaring that:

(1) My case study for this paper is fully resulting from my own works with all the acknowledgements given in the references from all the sources taken.

(2) This is my original research study that I submitted and none of it submitted to or use by any other degree's holder or any qualification for any other university or institution of learning.

Signature :

Name : Ahmad Rizal Bin Bahrom Azhar

Student ID : M19711012

Date :

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This humble work is especially dedicated to:

PROF. SAPOWAN BIN SANUSI, my project supervisor,

All the respondents

And

To my family and all my loved ones,

Thank you for being my guidance and support.

TABLE OF CONTENTS

LIST OF FIGURES

Abstract of the project paper submitted to the Senate of Universiti Tun Abdul Razak in partial fulfilment of the requirements for the Master of Business Administration.

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By
Ahmad Rizal Bin Bahrom Azhar

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This research study will focus in detail on the factors that affecting in Improving quality in production and focusing on O&G Manufacturing Company - Cameron Malaysia Sdn Bhd. The aim of this study is to find the real root causes that affecting the quality improvement in production for Cameron Malaysia based on all the non-conformance issues from previous years and find effective ways to reduce or eliminate to improve the production line performance. Various technique and tools to be used to investigate and solve the problem. By using the data analysis and observing the actual process that already implemented and ongoing in Cameron Malaysia, it hopes to show what's went wrong and what the problem with current improvement process which currently inefficiently to solve the problem. This research will focus more deeper to see the hidden issues might untapped before that causing the non-conformance issue still high in 2021 even though the improvement process already implemented from the non-conformance problem-solving process and actions was taken. The earlier judgement, when the overall process involves with humans, it required continuous follow-up, regular assessment to be conducted, support with the guidance, do the observation, and intervention and the most important the continuous improvement cannot be stopped at certain period or level. The system either used by Cameron, or any other manufacturing company will always change with the times. As a company, it is good to ensure all workers ready to that changes and they must be equipped with the latest knowledge, skills, competency so that all the process will continuously flow without any major interruption. The outcome from this study is expected to show the real problem to the issues that become a factor that affecting the journey in improving quality in Cameron Malaysia Sdn Bhd. All the problem-solving method and process taken must be used, continuously until the issues solve. Good problem-solving method and actions taken will help to eliminate the repeated non-conformance. If current practices not efficient enough, there are thousand other what to solve the issue.

"There is no solution because there is no problem" - Marcel Duchamp (An Author).

CHAPTER 1

INTRODUCTION

1.0 Introduction

Non-conformances are the output that not meeting customer expectation or the deviation from the engineering drawing, quality specification or a failure to meet the specific requirement in any processes, service, product, or system that has been establish earlier. Non-conformances also can be said a product, process, service that does not follow the company standards.

Non-conformance can be ended with reworks which can increase manufacturing lead time, cost, operation cost, decrease productivity, efficiency, and utilization. Worst-case, the product can be recalled. Corrective actions should be activated immediately once the non-conformance issue detected, and corrective action identified. Root cause action should provide permanent solution to avoid reoccurrence and if possible, eliminating the issues in future.

Non-conformance in a manufacturing environment can fall into one of two buckets - major and minor non-conformance. Manufactures differentiate between these two non-conformance categories depending on the impact to the issues and to the production and the organization. Furthermore, these two groups are identified upon examining the ease of detection and rate of recurrence. Differentiation also involves exploring the scope and difficulty of the recommended rectification measures.

Minor Non-conformance – A minor failures can lead to major non-conformance or consequences. If minor failures not being address correctly or solve earlier, it can escalate to major nonconformance. Examples of minor non-conformance in Cameron Malaysia is wrong stamping, missed one digit identification number, surface did not meet the RMS required by the drawing but still within rework capabilities, missed to update dimension in dimension report etc. However, if all that issues escape from our final QC inspection and detected by the customer at customer warehouse, storage or in any customer properties, it will be changed to major non-conformance which might also become a catastrophic level even the defect looks small and can be rework on the spot.

Major Non-conformance – Major or minor have the similar meaning where both not meeting the specific requirement. However, major non-conformance normally ended with major rework process that causing high rework cost, long rework lead time and deviating a lot from the design, process or service from the company standards or international standard such as ISO 9001. Examples of the major nonconformance are wrong profile machined, dented on sealing areas, wrong testing pressurize being used, wrong assembly, wrong procedures used, parts broken, sealing damaged and few others.

Non-conformances constitute a significant issue for manufacturing businesses across every industry. When workers utilize non-standard practices, they're bound to create finished products that does not meet the specifications as per drawing and Bill of Material - B.O.M documents. As a results, manufacturing companies will face significant setbacks in their operation. For instance, the brands can damage its public reputation for making and distributing defective products to its customers. In addition, the cost of non-conformance can increase more when go fines levied by regulatory bodies that can make the manufacturing business or company bankrupt. Not only that but the product recalls and rectification measures will increase production costs and take up valuable production time.

In other manufacturing company, non-conformance might also be categories in few other levels. Majority categories set to Major and Minor nonconformance. However, for Cameron Malaysia Sdn Bhd, non-conformance has been categories to five level which is.

a. Light
b. Near-Miss
c. Serious
d. Major
e. Catastrophic.

Only Serious, Major and Catastrophic required problem-solving process based on Cameron Malaysia Quality procedures. Light, Near-Miss was not counted to be follow-up with problem-solving report due to the defect can be solved immediately. A lot of it has been accepted by the Engineering which not required rework process. If the defect still required rework process with high operation hours and long lead time, it would change to serious or Major non-conformance. However, a lot of minor non-conformances just need a minor rework that can be solve immediately such as dirty,

no document attached with the products that flow to next work center, stamping error (identification), minor scratches etc.

The difference in problem-solving is how many corrective measures needed to bring back the quality level back to the quality standard and meet the requirements. Two things that need to be address is the type of non-conformances. When non-conformance detected, react immediately.

- Addressing non-conformance immediately once detected.
- Light, near-miss non-conformance can become serious, major, and catastrophic non-conformances. So, all nonconformances cannot be hiding, hold, or waiting and cannot be brushes away.

The effective ways to study all non-conformance issues for the improvement is by looking the frequency of the defects, how the detection done, and what are the impact from it.

- Can the problem / nonconformance be repeated?
- Can the system detect the problem / nonconformance earlier?
- Can the problem / nonconformance be corrected?

These deviations can be identified through follow-up on nonconformance trends. Internal audit can be done quarterly to identify the potential nonconformance issues in the process while external audits depend to the outsider auditor to check the internal process. This can be arranged to avoid bias in the audit except the auditing done by Government quality agency such as SIRIM, API (America Petroleum Institute) which any finding from these agencies is not a good report for the company. Customer complaints is part of the survey that can be done to measure the quality status from the eye of customers. Other than audit, the internal team can do process confirmation through material inspection or routine testing. A report can be prepared from these audit and assessment and nonconformance report can be generated from the results. The purpose of the report is to document the details of all the deviation found that not meeting the expectations. The report will help to define the problem clearly, logically, and concise way and from there management can take actions to do or implement the improvement or changes. Even in ISO 9001:2015 no longer requires a documented procedures, but to monitor the trends these nonconformity should be recorded and follow-up to corrected it.

Quality Management Important to Manufacturing Company?

Quality Management important to meet all the requirement or standard which also a customer-focused process and this will drive the continual improvement in the organization operation or business. Quality Management will ensure all employees continuously work together to meet the same quality goals to improve products and services produced and provided by the organization. By establishing the standard quality process flow, the organization can maintain their quality target / goals with the support and cooperation from their employees. Many manufacturing industries implemented Quality Management System in their business not only to meeting the ISO9001:2015 standard but also to ensure the quality objective is achieved. Quality objectives must be measurable and help to increase the organization values in their process, products produce, and the service provided. Nowadays, establishing a quality management system become a basic in any business line and quality is not only a senior management responsibility but also all employees in the organization. Senior management are responsible to ensure the effectiveness of the quality management systems in the organization process flow and ready for accomplishing the quality objectives.

The establishment of Quality Management System is required by ISO 9001 at all relevant organizational levels and functions. The objectives must be created and implemented in the organization and all functional team are able to manage it and know what the impact to their overall performances. Once the quality objective is functioning well in the organization, the improvements process will become a normal process across the entire organization. Finally, it will increase the prominence of the quality management system in the company. There are few Quality Objectives for a Manufacturing Company which are.

- Accuracy of a Process or Service.
- Product Completeness.
- Customer Service Objective.
- Increased Service Levels.
- Continual Improvement.
- Ensuring Effective Supply Chain.

Quality control is important everywhere especially in the manufacturing industry. Why it is important to produce the highest-quality products? And why is it essential to have a system in place to ensure this happens?

Customer Expectations

As a customer, they always expecting manufacturing company to deliver the best quality products. They can simply turn to look to other alternatives if the quality required not meeting their needs and expectations. Satisfying customer is a critical to retain their loyalty and continuously doing business with the same company in the future. Quality always one of the criteria contributes for a long-term business that with extended the revenue and profitability. The other good thing it give the opportunities to increase the charges higher prices or maintain it.

Below is the others customer expectation to the organization that matter to them that help to retain the business in future:

a. Take immediate action for any complaint and given quick solution for their inquiries
b. Customers always preferred organization providing optional services
c. Providing proper quick channel or help center for any of their inquiries
d. They tend to have personal experience with the organization
e. Good data protection and privacy from the organization

Reputation

Quality influences company's reputation. In whatever industry of manufacturing company customer involved in, they not easily choose becuase of the interested price offered but the most important is quality. Customers willing to pay more if the company can provide high quality products or services if they found the quality produced exceeding the quality standard. This is a normal customers expectation to receive a quality product.

Social media playing biggest roles in promoting or criticism a product in the markets which cannot be ignored where it can easily affect the product and company reputation. Your product quality can easily being review in a discussion in social media, in a forum which means it can become a favourable product or being and criticize by them as what you can see nowadays happened in product review sites, social networking sites, such as Facebook and Twitter. To become a strong competitor in open markets, good quality product can give a big impact and poor-quality product resulting product recall campaign can create a negative publicity where it will damage company reputation.

Meeting the Standards

Product certification often involves a series of evaluation activities, such as the inspection of manufacturing processes, tests on samples taken by the certification body and, on occasion, auditing of the quality system, depending on the product being certified.

Accreditation from recognized international quality standard such as API (America Petroleum Institute) for Oils & Gas company is important to penetrate O&G markets. ISO 9001"2015 accreditation is a must as an essential and when the company dealing or have a contract with the certain customers that also complying with the accreditation. Three are few public sectors, government companies and agencies required ISO 9001:2015 as standard accreditation to be comply. Accreditation help to protect company or organization when they comply with the standard which also designed to protect customers / consumers. Accreditation playing crucial roles and complying with international standards will help to ease the process and ways wining the contract especially new customers and entering new markets. It gives better independent prospects as a confirmation to customers about the company's ability supplying a quality product.

Costs

All the cost incurred, used to produce a product will be counted as product cost. The overall cost including direct and indirect labour, materials and all consumables supplies that used in the production, and factory overhead costs. The shipping cost, land transportation, air freight cost needs to be considered under indirect labour cost or factory or company overhead costs.

Poor quality products will increase overall product costs. Without an effective quality management system in place, investigation and analysing nonconforming issues might require extra or high cost when rework activity required and to determine the root causes also will having the difficulty. In other cases, some of the defective product need to be scrapped and required additional costs to purchase new material to replace the scrapped product. If the defective products slipped from QC final detection and reach customers, not only reputation affected but also required huge cost when the product need to be recalled and make the replacement immediately. Worst case, it will incur legislative costs due to the failures in complying customer contract related to completion dateline and quality standard.

1.1 Background

All countries in the world using Oil and Gas that can give direct and indirect impact to their domestic economy. whether it large or small becuase these are the main materials used in the life of a country's society. The prices movement for Oil and Gas will always give big impact and affecting their country's economy health. The important of Oil and Gas industry not only to individuals and businesses but also to certain countries in the world who supplying it to over half of the world energy. Even though the renewable and the sustainable energy initiatives available, none of it able to replace the number of Oils and Gas supplied to the world. The new energy not only expensive but also difficult to get the sources and unreliable to cover or replace the energy markets or demand. Country in the world and the world itself is under oil and natural gas controlled. Many countries having problem to sustain without this energy sources in their daily operations.

The domination of oils in vehicle industries expanded to Asians including developing countries where vehicle market has rapidly increased. Around 1.2 billion vehicles used in Asian countries and 98% from them rely on oils. It was expected to increase until 2 billion by end 2035 and will increase to 3 billion by end 2050. This supported by the increasing of Asians people incomes. Around 89 million vehicles were sold by year end 2021 and the sales starting to increase from 2005 which covered 37% increments. Around 1.5 million gallons gasoline was used every single minute which around 24-million-barrel drums of gasoline and around 27-million-barrel drums of diesel fuel in everyday usage. Rich countries (OECD nations) using 50% which about 1.6 gallons a day Oils from 17% their population while the poor only used 0.32 gallons a day.

Jet fuel will be the new emerging oil markets to monitor after the vehicles. Based on Boeing statement, commercial aircraft will double up to 40,000 and this will increase the oil consumptions which target by 2032 and Asia region will be the focal point of new changes in the increase in aviation capacity. The Jet fuel demands increased double to over 2-million-barrel drums since 2000 in Asian's region.

It has been thousand years oil used to lighting up living house and places. The oil was found in shallow of reservoirs from the seeps of crude oil gas which may naturally develops. And some of the oil was simply collected from seepage or tar ponds. It was stated that in 500 B.C., in the China, Chinese people boil their water using natural gas.

In 1859 "Colonel" Edwin Drake (Refer **Figure 1**) was trying to find oil sole and successfully found it. He has drilled the first well in that year. The Drake Well was found in the middle of a quiet farm in the country and located in the north-western Pennsylvania and that was the beginning of his international searching the oil for an industrial use of petroleum.

Refer **Figure 2.** Oil and Gas was produced from 100 to 4000 barrels a day and the production were done almost in every part of the worlds. The cost from 10 thousand to 10-billion-dollar offshore development and from 20 meters deep of reservoirs to 300-meter-deep of wells.

Refer **Figure 3.** The most important pieces of oil and gas equipment's is a well head and Christmas tree or namely X-mas tree. The X-mas tree will be rested on the wellhead equipment which is how the production oil done**.** On the X-mas tree, it was fitted with few fittings, valves, and spools. This section will help oil and gas flow to be controlled. In production process, this will allow surface regulation controlled and monitoring. The Oil and Gas was separated as part of the separation process in the production system. This process also called Gas Oil Separation Plant (GOSP). In this process, the well was flow directly into a clean marketable product which is oil, a natural gas, and a condensate. This is the purpose of GOSP processes.

API 6A was used to certified wellhead and x-tree equipment manufacturer. Without API 6A, the equipment cannot be used to produce the oil and gas. This not only to ensure the equipment's meet the quality required but the main purpose to ensure this equipment's safe to be used in production of oil and gas. Quality is crucial things need to be managed properly not only for oil and gas industry but also for other businesses. To maintain customer satisfaction, producing quality products will help to achieve it. With positive reviews or comments from customers, it will end-up with continuous order and loyalty to the company and at the same time will reduce the risk of the high cost when the faulty equipment's' or arts need to be replaced with new equipment's.

In the beginning of Cameron Malaysia, Cameron International Corporation which was formerly known as Cooper Cameron Corporation (CCC) Cooper Oil Tool under Cameron Iron Works. And after more than 100 years, Cameron now operating under Schlumberger Company. Schlumberger is one of the global company providers of pressure control manufacture under Cameron, production which previously a core business for Schlumberger. Other than that, is processing process, and manufacturer flow control systems as well as the project management and aftermarket services.

Cameron was acquired by the Schlumberger (SLB) in 2016, and now operates as Cameron, a Schlumberger Company. It was starting in year 2015 for the acquisition and Cameron employees was approximately around 23,000 people at that time which was a huge oil & gas company in the worlds and delivered USD9.8 billion in yearly revenue.

Cameron worldwide has few other manufacturing divisions all over the world focusing to manufacture different type of oil and gas equipment from surface, sub-sea, drilling etc. All Cameron Plant sharing the same target in-term of quality where Cameron is committed to continuously improving the quality in all their services and product produced while at the same time protecting people and environment. This is the best commitment and the interest of Cameron's customers, their own employees and contractor, stockholders and all not forgotten with all the communities in which Cameron employees live and work.

Cameron quality policy including the commitment to reduce and eliminating all non-conformances issues related to quality to meet customer requirements specifically and to ensure our customer satisfaction will continuously happen. The setting of quality objective as part of the company and department KPIs will be happen with the action stake to always measure the results, assessing all the process, and improve it when needed, provide good services, and deliver product quality, by using an effective management system that has been established earlier. Cameron always plans for any quality emergency cases and to respond, recover for any business disruption. The technical skills to be apply in all design and engineering of all Cameron Malaysia products following with the improving of the performance on any issues relevant to the stakeholder on which can impact the business performance.

Cameron Malaysia Sdn Bhd, is under surface division located in Lot 843, Jalan Subang 7, Taman Perindustrian Subang, 47500, Subang Jaya, Selangor. **Figure 4** showing the transition of Cameron Malaysia from Ingram Cactus until now Cameron, a Schlumberger Company. Cameron Malaysia focusing to produce well head equipment's and one of the main suppliers for oil and gas equipment's in Malaysia. The main customers for Cameron Malaysia Petronas, Shell Sarawak, PTEP Malaysia, ExxonMobil, Repsol etc. Cameron Malaysia also supporting to produce a product for Asian country and middle East such as ENI Vietnam, Shell Brunei, PTEP Thailand, PDO Oman, Aramco, ADCO and few others.

Maintaining the good quality products from the beginning until it's reaches customers required a consistent and full commitment from all employees, section,

department and from top management teams to general workers. It is important to eliminate any potential sources that can generate errors or real defect. The defect will not only impact the overall lead time, delaying the on-time delivery but also impacting the overall production cost. Rework process and the overall time taken to produce the product will increase the total manufacturing costs. Eliminating the correct potential sources will avoid reoccurrences for the same defects. Therefore, this case study is important to improve quality in production for Cameron Malaysia Sdn Bhd. Refer **Figure 5**.

The study for this paper will focus detail on the factors that affecting quality improving in production of Cameron Malaysia Sdn Bhd Plants where the product is produced from the raw material to the finished products and ship to customers. Any quality failure or quality escape at this stage will end-up with major quality issue to the company. For any quality failures at end user, especially on the rig during exploration activities, it will end up with major catastrophic severity. The failures that causing the activities to be stopped called NPT - Non-Productive Time. It's not only just delaying the process but it also very costly.

The exploration on the offshore is an expensive investment and the cost is very high for every single of hour. Exploration cost is very critical as a factor in determining the overall financial returns. The focus to eliminate any Non-Productive Time (NPT) or downtime by ensuring all the equipment quality always on the top. Downtime should be avoided in any operation and the undesirable outcome should be eliminated as much as possible. The NPT very costly in onshore operation. The longer NPT time, the more expensive the drilling costs will be.

Figure 6 showing the various product produced by Cameron Malaysia Sdn Bhd. Each Plant in the worlds have different capabilities in producing Oil and Gas products and it will refer to the equipment's available at each plant.

1.2 Problem Statement

In 2021, quality has become a major topic being discussed in Management Meeting for Cameron Malaysia. The non-conformance records in 2021 for production is the highest in 3 years. **Figure 7** showing the non-conformance segregation based on 3 main department which is Production, Quality and Others (Eng, Buyer, Purchasing). The trend of non-conformance increasing from 2019 to 2021 for production department. **Figure 8** showing on how the non-conformance data being

track and collected using SAP (Systems Applications and Products in data processing) that used by Cameron Plants all over the worlds.

Figure 9 showing the non-conformance trend from 2019 to 2021 where the trend is increased. 2020 non-conformance is lower due to low production affecting from Convid-19 pandemic rules and regulation that implemented and forced by the government. The increased trend has signalled Cameron top management to Cameron Malaysia during MRM - Management Review Meeting which conducted in January 2022. In earlier stage, it was highlighted in Management Goal Setting Meeting conducted in December 2021. During MRM, few top managements commented on the issues and reminded Cameron Malaysia team to treat and solve the non-conformance issues seriously. Cameron Malaysia needs to start the improvement plan to mitigate these issues in 2022. This high non-conformance reports are not a good trend for business continuity and it's affecting Cameron reputation in the eyes of customers.

All the non-conformance details selected from Annex 12 CRP-83 "Control of non-conforming products" document. Refer **Figure 10**. The main cause for the higher non-conformance in 2021 is Processing Error, Operator Error, Product Engineering Error followed by Routing Error, Storage Shipping Error, Maintenance Error. Quality Procedure Error, Quotation / Sales Error, Planning Error, Vendor Error, Purchasing Error, Engineering Change in Requirement, Tooling Error, NC Program Error, Machine Malfunction, Misuse in Service / Environment, Alternative Material and Shelf Life. Once the main "Cause" selected, the main cause need to details down by selecting another cause from "Cause Text" as per stated in the document - Annex 12 CRP-83 "Control of non-conforming products". This is to ensure the defect root causes being investigate and selected correctly to ensure the improvement to be done will also correct. The investigation to be conducted once the non-conformance raised. This to ensure important evidence collected from the fresh scenario that just happened. The investigation process should not be delay avoiding data missing from the scenes or forgotten by those who involve with that nonconformances.

Any new root causes detected from the investigation that not available in the Annex 12 CRP-83 "Control of non-conforming products" document, supervisor or those who updating the non-conformance report can use the number with empty detail. All this info will be collected by QA- Quality Assurance department who will review first and advice if the info can be inserted in current main "cause" and "Cause Text" list. If the new root cause is valid, QA can request to add more info as part of the improvement for this document. The main reason this Annex 12 CRP-83 "Control of

non-conforming products" document released is to ensure all the non-conformance info update systematically. This will ease to those who collected the info either for his research or department who want to do the improvement or just for a report.

Figure 11 showing the variables root causes selected for the non-conformance in 2021. From all the non-conformance data collected, 3 top main root causes issue is the highest defect that contributed to overall top NCR in 2021 and 2 of the root causes came from the production.

CONC - Cost of non-conformance. The cost of non-conformance was continuously exceeded the target which was set at 0.32% in 2021. Based on below chart in **Figure 12,** total internal rework cost for 2021 is around USD125K and total cost for defects under Engineering due to Engineering error, Standardization, Customer request and Plant request is around USD18K. This amount was charged to the rework process and material replacement when the non-conformance materials disposed scrapped. The rework process considers as non-value-added activity that need to be done to ensure the same order / products complete and ship or deliver to customer. All this extra cost affecting the overall Cameron Subang quality performance and decreasing the profit versus target.

First Pass Yield in **Figure 13** was monitored based on total job or order released to production versus total order that having defects as updated in **Figure 14** and defect percentage in **Figure 15**. The FPY target for 2021 not meeting where the results are below 98%.

1.3 Research Objectives

The objective of this case or research study is to find the real factors from the data collected that's affecting the quality improvement in production in Cameron Malaysia Sdn Bhd. In problem statement, all the non-conformance and root causes has been identified. However, this study to focus more deeper into the problem to know what causing nonconformance increasing and repeated even the problem-solving activities conducted the whole years with several actions taken. Several questions related to the issues to be answered in this case study.

a. What is the reason non-conformances issues keep increasing and repeated?
b. Why the action taken unable to solve the issues?
c. Does the action taken to mitigate the non-conformance issues incorrect?
d. Does the non-conformance investigation do wrongly?

e. What kind of investigation method used?
f. Does the info collect ineffective, and not enough?

The research study will analyse all the existing data available in the Cameron Malaysia system and it will be discussed / brainstorming with few problem-solving analyses to find what is the real issues happened before and importantly, does previous root cause identified earlier is the correct root causes. Once the real root causes identified, the solution or improvement to prevent the same nonconformance can be generated and all the causes can be eliminated permanently. Few works center under production which is Warehouse, Machine Shop, Weld Shop, Assembly and Testing. Other than QC which under "Others" is planning, buyer and engineering.

This research is important to ensure Cameron Malaysia business continuously achieved the quality standards to meeting customer expectation. Maintaining the quality of product to the satisfactory uniform, to preventing the product failure and out from the specification. With the market open widely, the market full of the new competitive which given an opportunity for the new player / new competitors to join the same industry. This will be a challenge for Cameron Malaysia as O&G supplier not only for Asian region but also for few other countries in the world. To continue competitive in this business line, Cameron Malaysia must improve from current condition to be more reliable in term producing of quality product. It's required an efficient quality management system and implies all the opportunity to continuous make the improvement in daily operation. The improvement might start from the small process to the bigger processes. From production area to sales department and from production level to management level.

All the journey to achieve high quality product manufacturer required full commitment and discipline from all people and levels. The growing effort by everyone involved in the organization from production process that must be supported of management and the administration. With structured organization, establish quality policies and programs, supported by measuring customers satisfaction for better understanding on the customers' needs and improvement needed, it can be achieved.

1.4 Research Questions

Research Question will be varies based on few independent variables highlighted in Conceptual Framework. The independent variables were given to 6 core categories in conceptual framework. These 6 core categories were taken from Fish Bone diagram which one of the problem-solving methods to find the real root causes.

The fish bone analysis to find the potential root causes and can be used for any issue and not just focusing on the defect or nonconformance alone. Few points to be asked during the survey as update below.

H1 - Humans - Skills, Competency, Training, Knowledge etc.

H2 - Materials - Correct material supplied, Document, Equipment, Tools etc.

H3 - Measures - Measuring the equipment, KPIs, Performance. Productivity etc.

H4 - Machines - Break Down, PM Schedule, Ageing, Calibration etc.

H5 - Methods - Work Instruction, Safe Work Procedure, Process Flow, Routing etc.

H6 - Environments - Storage, Space, Weather, Lighting etc.

The set of question can be referred in **Appendix B**. From all 6 core Independent Variables, the focal point should be selected from the highest data captured from the surveys, interviews, observations and from the system that used to keep all the defect records. From the analysis results, 3 highest pointers can be selected to use and focus for the improvement.

1.5 Significance of the Study

Manufacturing company key driver in move forward consistently is from their improving quality process. Eliminating non-conformance in the fabrication, manufacturing or in all process to produce a product is vital. To unveils the problem, require proper study from the beginning where the process started and where the non-conformance report raised or started. The data collection is important and the beginning of the process by looking all the possibility based on the independent variables that created earlier through a proper process to avoid wrong process or data collected which bring the wrong outcome from the study.

Manufacturer's will be in risk if the quality standards not met during manufacturing process where it will give implication to their overall costs. Every improvement process in any manufacturing company, the root causes on their nonconformance need to be identified. Using new technology will help to analyse data faster and deeper and help to untapped areas of improvement. And this will unlock levels of efficiency and quality control in operation area and embrace lean manufacturing. This study is expected to be significant to the Cameron Malaysia Sdn Bhd as it will outline all factors that affecting in improving quality in Cameron Malaysia

as a manufacturing company. The study will be useful to alleviate the problems of high nonconformance in Cameron Malaysia Sdn Bhd.

1.6 Summary

In Chapter 1, the introduction started focusing on the important of the quality to the manufacturing company. Keys driver for the successful for manufacturing company is quality. Quality issue not only will be impacting company performance but also increasing overall operation cost, decreasing company reputation, not meeting standard but the most important is customer satisfaction. Continue with the integration of Cameron Malaysia and International. The latest when Cameron International merging with Schlumberger and now Cameron known as a Cameron, A Schlumberger Company where the Cameron name remain as a products brand.

Problem statement explaining details on the issue happened in Cameron Malaysia Sdn Bhd which is the main reason this subject selected to become a topic for this research study. Non-conformance has become a major issue to the company and need to be solved to aligning back Cameron journey to meet the quality target. And to achieve that target, all the factors that affecting the quality improvement journey planned by Cameron Malaysia Sdn Bhd need to be eliminated. All the factors required further study in detail to know why it's occurred. All non-conformance detail to be collected, analyses, discuss on the outcome, looks for any opportunities improvement that can be implemented immediately or implemented in the long run of Cameron manufacturing process.

The data will not only collect for Cameron system but also through the survey where the employees performing their work and who creating the non-conformance or where the non-conformance raised. A set of question was created and to be used during the interview survey. The significant of this study conducted is to look deeper on the issues. Even with Quality Management System in place, problem-solving programs conducted, raised but the issue still high and impacting the organization every year.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Quality control in manufacturing is important for several reasons. First, quality production is a sign that a company's processes are designed and working as planned. An optimized process will include the production of quality products. A drop in quality may indicate a broken process somewhere along the line. Second, quality control is essential to cost. Lost material due to poor quality not only threatens the supply chain and purchasing system, but it drives up waste disposal costs and can impact a company's compliance with various environmental regulations. These costs due to quality fallout increase as each value-added step in the form of labor or material alteration are added to the produced units. A completed unit rejected for quality will cost a company more than the materials at the start of production. Finally, quality control is vital to a company's brand reputation. Excess quality fallout can result in missed delivery times, threatening customer satisfaction and creating the risk of loyal customers jumping ship (Stephanie Watson, 2016).

In chapter one, nonconformance segregation / classification and the important of quality objective was explained clearly. Together with quality management to the organization from meeting customer expectation, maintaining company reputation, meeting the standard requirement, and controlling the overall production or manufacturing costs. The reduction of global oil prices has impacted Oil & Gas industry and company that involve with. With this new current condition, not only impacting their annual revenue but also impacting to their overall process when Oil & Gas supplier requesting all the manufacturer company those produce oil & gas equipment's to lower down their prices to win their contract. With this situation, all manufacturer company need to do major improvement to reduce the overall manufacturing cost and removing or eliminating non-value-added activity in their manufacturing process. Nonconformance is one of it and eliminating or reducing all the factors that affecting the process in improving the quality in the production area help to reduce indirect cost in the production for Cameron Malaysia Sdn Bhd.

This chapter also will discuss on the past studies done by other researcher in improve quality in manufacturing company and what their approach and action taken from the result of their case studies; their methodology used and how they are developing the foundation for their research. And in this chapter, the discussion will

touch on the dependent and independent variables which highlighted in in conceptual framework. At the end of this chapter, the discussion will focus on the proposed hypotheses and explaining the framework path.

Product quality are key priorities for all the customers. Any failure of product quality could result in customer complaints and products recalls. To ensure customers are satisfied with the products delivered, every production area needs a reliable manufacturing and quality control systems. Regardless on how well a quality system set or planned, monitoring, assessment, audit still required to ensure an effectiveness of the quality system program are met and resulting in the finished products that to meet the client's specifications and needs.

2.2 Underpinning Theory

Linda Ogbevoen -- Oden Technologies - Based on his study, operation department exploring and managing their own equipment's / tools to meet specific quality goals and all challenges in their process. Their Plant managers has shown his consideration to buy in the improvement for the plug-and-play technology tools because these tools offering the fastest time in the process that have value in term of expediating the operation flow that will reduce the cost. However, he not 100% sure if a plug-and-play technology system that introduced by his team in production can be integrated or customized. That was to meet the specific needs in the operation. The goal for this process is to implement the available and latest technology that can improves quality and at the time can maximizing the efficiency in their operation.

Shiau Wei Chan, Md Fauzi Ahmad, Mei Wan Kong - IOI Publishing - Soft factors was the subject of the research that was found become the key factors of the success in the quality improvement of an organization. In their research they also found that many organizations neglected the importance of soft factors, and this may and have influence the overall organizational performance. By using six hypotheses which were examined and at the same time they considering six dimensions of soft factors. These including management commitment, customer focus, supplier relationship, employee involvement, training and education, and reward and recognition that resulted a positive impact on quality improvement to the organization process.

Bwisa (2018) has assessing all the factors that affecting the Quality of Inputs in the Manufacturing Organizations. The research was carried out in one of the companies in Kenya. Nampak Kenya Limited was a food packaging company that supplying both local and internationally of its raw materials. Selecting the supplier and

developing the new supplier is among the other factors that plays a vital role in ensuring that manufacturing organizations get an acceptable quality of inputs from their suppliers. By using a questionnaire, an interview guides and observation guide was used to collect all the required data. 92% rate responded was obtained from the survey. From the research conducted, the findings were showed 89% of the respondents indicated that supplier selection criterion affected the quality of input in manufacturing organizations and 61% from its saying that the supplier development was greatly affecting the quality of inputs in manufacturing organizations. The study also concluded that the manufacturing organizations in Kenya need to be improved on their supplier selection criteria, reducing their supply base and they need to develop or improve their existing suppliers rather than develop or getting new ones all the time.

Sajjan (2019) was examining all the factors that affecting product quality, overall development cost and time in the automotive products development organizations. Sajjan was using qualitative research for this case study it was performed at a major automotive manufacturer company in Sweden. A semi structured interviews was used to collect as much information as possible from all the respondents at two automotive product development companies. All the collected data were analysed by using the pattern matching techniques and the theoretical model has been tested against the observed or actual models. By getting supports from his members to do the checking and reviews to further enhance the credibility of this study. It was found that the outcome of study is that product quality can be improved by using government quality agencies, the cross-functional teams, work force with knowledge in multiple fields and by integrating previous product knowledge during the product development. The knowledge of creation and the sharing method are the fundamental in innovation of the product development.

The knowledge sharing and knowledge creation process should be facilitated and developed by the organization. Lack of previous product knowledge was found affecting the effectiveness the integration of the information during the innovative product development process. Both cross functional teams and the knowledge integration was seeming appears having strong influence on the product quality and improving the development cost. The flexibility of the knowledge however not fully supported to the development of the innovative products. Government quality agencies need to be more proactive in developing the innovation to improve more the quality. Sajjan recommended to have one multiple skills project leaders that will help to improve to make the correct and timely decision making and at the same time integrated with the government quality agencies ass a cross functional teams views

which will lead the improvement process to improved product quality and lower down the development cost and time.

Odhiambo (2017) was investigating all the factors that affecting the quality of the products in a printing firm in Kenya. His reference is to the Euro Packaging Limited company. The focus of the objectives is on the training, their technologies, the quality agencies, and raw materials. Odhiambo highlighted that the case study he conducted has significant to the organization especially the management team and any other company that have similar business line and in future for the new researcher. 120 respondents selected from the organization based on descriptive research design which suit to the case study conducted. This based on stratified random sampling design used to divide the population of the employees in the organization. Primary and secondary data gathered for the collection method was used and pie charts and tables were used to analyse the data depending on the techniques.

The technology used in other private company has affecting the quality of the products produce in the production. This was the finding from the study which this private printing firms represented 70% of the production. 87% was due to the training that affected the quality of the product. 79% due to quality agencies and 11 raw material was affected covered 83% of the quality products based on respondents respond during the interview.

The organization should be adopted the new modern technology to increase efficiency and performance of duties as recommended from the results of the study. All employees should be well trained to increase their skills throughout the seminars to perform their daily duties and all that need to be arranged and supported by the organization. Quality rules and all the regulations should be implemented and followed and monitor by the quality agencies to ensure that quality of the production maintained. The last recommendation to the organization is to be sourcing their own raw materials and to ensure the sourcing from the approved suppliers.

Crosby (2016) focusing on the issue where the purchasing of the proportion of all the purchased parts increased and at the same time the company reducing their vertical range of product. The company was being force by the international market competition to focus on the exclusively their core competencies. The paper named “The art of making quality certain” has asserted that growing in the international competition and it has forcing them to reduce the other vertical ranges of their products. The reduction leads to the consequent of the increasing the dependency on the suppliers. Crosby was found that the succession of the company was determined by

the abilities of its suppliers. Most organizations depend on their suppliers. Choosing wrong supplier will impacting the overall company performance. Based on the performance of the company and purchasing strategies key element to the profitability of supply chain it depends on the decision of the supplier selection and their capability to support the company needs and requirements.

Vonderembse and Tracey (2016) focusing on the investigation to know what the criteria and the involvement needed or to be used and done by the manufacturer to select the supplier to their organization. The evidence showing the organization using empirical studies to make the selection based on the evidence showing the positive impact on performance. Previously it was based on the price offered rather than quality and lastly on the delivery timing or speed. Previous study done by Poler in 2019 was carried with the title "the effectiveness of supplier selection on product quality". By using the questionaries structured survey, data was collected. From the 98 respondents involved, the final findings and indicated that the quality final product can be achieved when material receive from supplier also is good. When the company selecting the supplier, quality should become the priority because it also will give impact to the quality product produced.

2.3 Independent Variables Factors

Independent's variables factors that selected for this study to Cameron Malaysia Sdn Bhd covered all the main root causes of nonconformance issues as explained below. Understanding all the factors that causing the nonconformance product very important in any problem-solving process. It is a key controller to all the improvements process that to be developed based on the actual result finding.

H1: Human

The first independents variables are humans. Human error is the most common root causes selected or choose in any problem-solving process. This due to fast judgement based on easy justification where every movement, acts is from the human selection and decision. Human has been selected for the job / task based on their competency, skills, capability that being measured earlier during interviewed or justify from the observation on the process of work. When "Human" pick as a nonconformance root cause, it must come with proper justification. It is advisable to investigate in detail to ensure the real root cause identify. Humans tend to make mistake based on few principles. Humans' error referring to the something that was

done but "the action done was not intended by the person; also, not required by observer or any rules; or led the task outside the acceptable limits".

Human's tendencies make a mistake when they work under stress or when they work with short lead time to complete the task or job which also can be said work under time pressure. Human" fallibility" is often the result of conditions that when workers work exceeding their limitations of human nature. Error also can happen when people work within a complex system. The other thing is people or human normally overestimated their own capability when try to maintain the control under difficult working conditions.

This case study will look in detail on all the causes to ensure the results collected is correct so that the improvement plans can be draws to mitigate or solve the issues. Refer below 5 principle of human performance factors.

1. **People make mistakes** - The best workers also make mistake. When we start to accept the mistake that done by the peoples, it is the first step to constructing a bigger mistake. The important here is to look what are the real root causes that these peoples make mistake. Understanding on how and why the unsafe acts occurs is the essential first step to make the improvement in the error management. If the first step we already start blaming the people who make the mistake, it will be hard to get the support to collect the important information to find the real root causes.

2. **Error in managing the situations** - To know everything is a battle for everyone. Knowing the condition or the present of the condition that might provoke error is something that everyone wants where the control, barriers, safeguards can be provided before error happens or occurs. In manufacturing, digital technologies can help to ease the process also known as manufacturing industry 4.0 which creating a smart factory.

3. **Importance of culture in the working environment –** the engagement between management and team, worker is important to have better connection not only from boss to their employee but also as a friend, guidance, mentoring that will help to ease the process in the management systems. People will feel important and will try to avoid mistake to maintain the good relationship. Directing employees will not help to improve people behaviours and building a culture of respects will be harder.

And to avoids the risk also become something that difficult to achieve especially when we focusing to minimize the error.

4. **Workers respond to encouragement and reinforcement – Coaching, guidance, mentoring, supervision, assessment to maintain the** cultural once the positive identified and implemented and not only depend on the enforcement. Yes, changes don't happen overnight, but the positive changes will maintain with recognition and encouragement culture.

5. **Progress follows when mistakes become lessons - Proving mistake is** the keys to achieving the value fast. All the mistakes should be recorded, analysis, brainstorming to make the improvement and avoid reoccurrence.

Any other improvement journey, not matter how good equipment's you have, how efficiently and good it functions, how good the training conducted, how efficient your supervision, good procedures; having best worker, best engineer, or manager when they are performing their duties, all of them cannot perform better if company or organization not supporting them.

There are few techniques can be used to collect the information to analyse human error issues based on the target people in the production line. It is important for the researcher to at least understand on how the workflow and what are the information needed by the people, workers to performance their works. What is the experience they should have, the skills they should hold, the capability on them to perform the work? **Figure 16** showing total Operator Error in 2021 related to Human Error which cover 80% of the Error - **Figure 17**.

There are too many questions can be used for this research or to be used for the survey or 5 Why in problem-solving session. The question almost similar when you do the auditing because at this point, the important is to collect as much as possible all the info to find the real the root cause to the non-conformance issues.

H2: Material

Second is "Material" where it normally focuses to the set of material / job / load employees or workers received and used to completing their daily work task. Material For production workers in Cameron Malaysia, they normally work with few materials such as metal, B.O.M (Bill of Material) documents, tools, machines. All that to be received to complete the machining on the metal and some are depends on the area

they work. The documents such as Bill of Material B.O.M involves a drawing - body drawing or assembly drawing, work order - with all the information required for the task including the hours to be claim for each task and measuring form records. Each task has specific hours that workers or employees needed to complete their task and work. If the workers or employees can perform the work within the time given it mean their productivity and efficiency at 100%.

H3: Measuring

The third is Measuring which one of the important points in maintaining the quality in the production area during the manufacturing process. However, measuring not only about measuring the length, size, weight, diameter but also measuring the performance of individual or group, work center or department, the process involves, KPIs so that the potential defect can be detected earlier before it escalates to real nonconformance. It is important to have standard measuring process to ensure the process continuously done and update to the team. From the measurement results, the action can be taken immediately with A4, CPAR, Kaizen, even JDI - Just Do It and CI - continuous Improvement.

H4: Machines

The fourth factors are machine. In Cameron Malaysia, there is a lot of machines used to perform daily work. For Machine Shop, there are few milling machines, turning machines. For Weld Shop, welding machine - SAW, GMAW, Pre-heat machine, Furnace machine, Suction portable machine, TIG machine etc. For Quality, Harness machine, NDE machine, Scissor lift table machine etc. For Assembly - hydraulic torque machine, stamping machine etc. Testing - Pressure pump machine, test bunker etc. All this equipment must in good condition before they can continue and perform their work. They have been given a "Stop Work Obligation" regulation / procedure if they found an error on their machines or the machine not safe to proceed the work. Employees are required to perform daily inspection before running their machine. The Autonomous Maintenance report called "Preventive Maintenance Check-list" which provided you the list to inspect and this process is a minimum process under preventive maintenance. "Stop Obligation" is one of the methods / safety procedures used to stop the process before it escalates to major issue.

H5: Methods

The fifth is Methods which related to Procedures, Standard Operation Procedures, Process Flow etc. All employees required to work with the procedure's scopes. If the defect found because current procedure not meeting the quality standard, that the time the procedure needs to be revised. Below are few questions can be used.

H6: Environments.

The last factor is environment. Environment normally used for defect issue related to weather - rusty, seal damaged, paint damaged etc. Defect under environment that affecting human is lighting, glares, blackout, too hot, noisy that affecting human concentration to the task. It is very rare to have defects caused by environment unless the storage area is not effectively containing or securing the products from environment factors such as raining, flooded, heat temperature causing by the open storage etc.

2.4 Theoretical Foundation

A theoretical foundation is an explanation based on ideas that are related to the research subject. It is a way on how to evaluate the research problem and research questions. It also a guidance to the research itself, and it informs every aspect of it. And to have clearer and a viable research proposal, it is important to have well-constructed and built theoretical foundation to serve as a the basic of the research.

Theoretical foundation will evaluate all research problem and question. The theoretical framework required for the quantitative studies and conceptual framework qualitative studies. Every research needs to have both theoretical foundation and theoretical framework or conceptual framework. Once the theory or theories identified, the information used is important to be included in the discussion. It can be defined with 3 steps:

Identify the key concepts. Select the important keys points from problem statement and research questions.

Problem: Quality defects still a major issue in production line.

Objective: To achieve > 90% quality product produce and deliver to customer versus the orders released to production.

Question: What are the main factors affecting the product quality in the production and what is the solutions to improve it. Evaluate that info and suggest back using the relevant theories to overcome the problems. Look through literature review to see how other researcher defining the same or similar issues and drawn all the connection of all key's concepts given. Show how the research fits in. Other than referring others researcher theories, the theoretical framework can use few ideas by aiming to do below test:

- Using few theories to see if it holds any specific context
- Use again theory to interpret or see the results
- Criticize and challenge that theory
- Use other combination or different of theories in a new or unique way
- If the test is relevant, theoretical framework can be used to develop hypotheses.
- Theoretical or Conceptual framework can explain the relationship between variables.
- Variables that used are relevant to the topic and can be study.
- It was developed from the literature review of existing studies on the selected topic.
- Each path in the conceptual framework is firm and relevant.
- The frameworks are to make research findings more meaningful, acceptable to the theoretical constructed.
- The structure can hold and support the research to study further deeper to see from the root causes before the solutions can be establish and implement.

2.5 Empirical Research

Empirical research using empirical evidence. The information collected and received based on the set of observation, opinion and suggestion from the participants and the senses to the situation. All that need to be documented to see the pattern of behaviour, movement, process through the experimental that conducted by the researcher. The evidence data also can get from both quantitative and qualitative research methods. This because both data somethings have connection each other through the researcher observation and measurement where he directly experienced it at the actual process. The data can be used to make the comparison with the hypothesis.

1. Qualitative research is empirical research which using data that did not come from the format of numbers. The example qualitative data is from 5 Whys analysis in A4 problem solving which using ideas, opinion, suggestion, and

action that nor form from the numbers data. For the research that not using numbers should be used qualitative research. The survey can be conducted using survey, interview using unstructured or semi structured method questions. The info collected more to know the reason from participants statement from the survey and not to collect the number of the answer given but to the info itself.

2. Quantitative research is empirical research which using numbers from the data collected. The number will be used to analyse the quantify of opinions, the behaviours or other defined variables. The data collected is something that already predetermined and in good formatting or more structured. The method used in quantitative research for this case study is survey.

2.6 Proposed Conceptual Framework

A conceptual framework (**Figure 19**) presented visually to show the connection between the variables or expected to have relationship with the variables. All the variables selected is the variables that have characteristic, properties that to be study. It was developed from the study and literature review based on theoretical logical and study that conducted before updated in conceptual framework. The conceptual framework below explains roughly on the relationship between the independent variables and the dependent variables. In independent variables, there are Manpower or Human, Material, Measures, Machines, Methods or Procedures and Environments. Dependent variable of this study is quality in production is improved and Customer satisfaction.

2.7 Hypothesis Development

Hypotheses using predictions in a specific way to predict what will happen based on the study or research data used either it is accurate or not. The development of the hypothesis from the consideration of the evidence gathered and collected during the research study and using reasonable justification with the specific context of the interest. Hypotheses can be derived from or using theories but need to be supporting by the sets of observation before it can be developed. A hypothesis should be explained in specific ways, must be cleared, should be able to be tested and most important the outcome can be predicted. Theories itself broad in nature, too wider and will required larger data to explain. So, in this research not only to using question to collect data but also to observe the actual process.

For a good hypothesis, there are three characteristics. As updated in first paragraph, hypothesis should be able be tested and a good hypothesis not only can be tested but also can be falsifiable. To test the hypothesis, we must be able to test it using science as a method and when talk about falsifiability, it also should be tested to see if it indeed false. One of the methods is using Popper's falsifiability criterion to confirm it false. Second, a good hypothesis must be logical. Logical is the second good criteria for the hypothesis. Not only a random guess but a good hypothesis should be able to be informed by previous theories or from the observations with the logic reasons.

The last good hypothesis positive. In hypothesis, the statement be made in positive statement that can show the existence of a connection or relationship and not to say no relationship or no effect. If we are the scientists, we will not be showing something that does not exist especially in relationship of the experiment because it doesn't worthen rather than showing something that can be visualize, show or that have evidence. In science natures, all are existed and can be prove. Science will try to show and find the evidence to prove their statement or experiment. Assuming something does not exist is not in their dictionary. They will seek the evidence to prove it wrong to show that really it does exist.

- Hypothesis 1: Humans factors is one of the factors contributed to non-conformance. Hypothesis based on predictions on Human's judgement to decide in all his/her actions. They who operating the machines, using the tools, following the method / procedures, who make the decision to when to start and stop, where to go, what to do and don't, how to work, which to select, etc.

- Hypothesis 2: Material factors is one of the factors contributed to non-conformance. Material used to perform work can be incomplete, not suitable to the process and can be wrongly supplied. Material also can be defective during usage, counterfeit or do not meet the requirements.

- Hypothesis 3: Measures factors is one of the factors contributed to non-conformance. Measures include tooling or gauges use for measuring the equipment can be out of calibration, wrong sizes or type that not suitable to the measuring parts, blueprint mistake, incorrect quantity, incorrect time, wrong estimation of time etc.

- Hypothesis 4: Machine factors is one of the factors contributed to non-conformance. Machine can be malfunction, centricity out, alignment out, vibration

in term of machine position, stand causing the machining not stable, backlash on X, Y, Z axis, machine calibration did not meet the original position and condition, etc.

- Hypothesis 5: Method factors is one of the factors contributed to non-conformance. Method is how the process use to complete the task / job. Using incomplete procedure, procedure for the process not suitable, wrong procedure used, wrong routing, wrong work sequences, wrong procedures revision used, etc.

- Hypothesis 6: Environment factors is one of the factors contributed to non-conformance. Predictions on environments factors due to storage method which not suitable for the equipment's. Rusty equipment's due to store at open area which not able to avoid from hit by raining, heat from the sun, aircon malfunction for elastomer storage in a room that can cause the elastomer damaged, rusty due to open storage, limited space, etc.

All these factors can be tested, data can be collected and be falsifiable just by changing the info.

2.8 Summary

In Literature review chapter, the conceptual framework was developed that use to evaluate the research problem and research question. This is important to begin the research study. Without identifying the real problem for the research study on the selected problem, it is difficult to continue with other process.

The empirical research is a cycle on how the evidence collected through the survey and data collected from the system. The independent variables can be the main contributor to the issue and all that potential solution to solve it stated in mediating variables. All can be identified before the dependent variables can be achieved. The last for this chapter is the hypothesis development which is the prediction about what happens and what will happen, and development based on the information collected. All the hypothesis to be evaluated, can be tested to see whether it is correct or not. The hypothesis factors also can be falsifiable just by changing the info collected.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

For this case study, there are few Research Methodology used to collect all the data / information. The techniques were used to identify, select, process, and analyse to find the real root causes. The research methodology allows to evaluate the overall validity and reliability. Data may be grouped into few categories. This research methodology contains every information's needed that explaining in detail on the issues which also feasible and useful. The explanation methods can easily be understandable by all.

One of the Research Methodology used is Quantitative Research. Quantitative research is the process of collecting and analysing numerical data. It's used to find patterns and averages, make predictions, test causal relationships, and generalize results to wider populations. For this research some of the data collected for 3 year which from 2019, 2020 and 2021. However, some of the info collected just for one year which is in 2021 and segregated by months to see the trends.

For the survey method used for this case study, all the answers of all respondents were recorded through questionnaires forms. Questionaries that used in the survey focusing on all 6 factors. Questionaries also can be varies based on the answer given which some of it will have continuous questionary until the real root causes identified. The second set of questionaries provided in this research is a sample questions that used to get more detail on the issues and can be selected as the potential root causes to the overall process. The example focusing on machine shop and weld shop department. The question for survey can be referred to **Appendix B**.

Quantitative Research Method.

- **Structured tools:** Structured tools such as surveys are used to gather the quantitative data for this survey. Using such structure methods helps in collecting in-depth and actionable data from the survey respondents.

- **Sample size:** Quantitative research is conducted on a significant sample size of 15 respondent's that represents the target people from few departments.

Appropriate sampling methods is used to drive the sample to fortify the research objective.

- **Close-ended questions:** Closed-ended questions are created per the objective of the research. These questions help collect quantitative data and hence, are extensively used in quantitative research.

- **Prior studies:** Various factors related to the research topic are studied before collecting feedback from respondents.

- **Quantitative data:** Quantitative data represented by charts and graphs. This makes it easy to understand the data that has been collected as well as prove the validity of the market research.

- **Generalization of results:** Results of this research method generalized to an entire population and to take appropriate actions for improvement.

Observation - this method based on qualitative method. The observation was based on the defect trend data collected from 2019 to 2021. The info not only the numbers of defect created but also from which department and section the defect happened. All the info can be referred in **Figure 7**. For this Case Study, all the data collected from the Cameron system SAP - Systems Application as shown in **Figure 29 & 30** and Microsoft Teams as shown in **Figure 31**.

3.2 Research Design

Research design shown in **Figure 20** is the overall approach on how this research done and how this research connected between theory and concepts and the development of research questions, the design of data collection and the analysis methods for the analysis or study. This research design is based on an integration of the theories, concepts, goals, contexts, beliefs, and sets of relationships that shape a specific topic. In addition, it is shaped by responding to the realities and perspectives of participants and contexts of a study. In a solid qualitative research design, framing theory and key constructs are clearly explicated, and methods are built out of theory in ways that reflect prior learning. This theoretical examination of core concepts/constructs in the study sets the stage for a rigorous, systematic process of gathering and analysing data. Every aspect of a study, from early development of guiding research questions to selection of setting and participants to the micro and

macro contexts that shape all of this, interacts in dynamic ways that reflect the lived complexity and intersectionality of human beings in the working environments especially in Cameron Malaysia Sdn Bhd.

As illustrated in **Figure 20**, the qualitative research design process begins with research topic - problems. The problem was selected based on nonconformance issues happened in Cameron Malaysia which what I'm as a researcher interested in this case study. The issues, however, already explained detail in the problem statement.

The research questions were created based on the independent variables listed. This fish bone diagram normally used in A4 Problem-Solving fishbone diagram focusing on 6 main potential root causes that covered all areas from human, material, tools, machine method and environment. A4 problem-solving method was a simplified from A3 Problem-Solving which were used by Toyota Industries as a structured problem-solving and continuous improvement approach.

As a researcher, I need to be responsive to the phenomena, realities, and contexts of a study, research questions which can be refined over time. This requires a mindset that allows researcher to not only work hard to refine a set of research questions but also to matching it with research design.

The research questions and the overall research design process is inductive so that data collection and analysis processes can evolve to reflect real-time situation. This including making a change to the data collection methods. As data are collected and analysed, aspects of the research design may change.

3.3 Study Population and Sampling Procedures

Sampling taken for the Survey conducted at Machine Shop, Warehouse, Weld Shop and Assembly & Testing using "Probability Sampling Methods". 15 respondents were selected from 50 total employees in production - **Figure 21**.

There are varies sampling method in research study:

1. **Simple random sampling -** Simple random sampling is a type of probability sampling in which the researcher randomly selects a subset of participants from a population. Each member of the population has an equal chance of being selected.

Data is then collected from as large a percentage as possible of this random subset.

2. **Systematic sampling -** Systematic sampling is a probability sampling method where researchers select members of the population at a regular interval – for example, by selecting every 15th person on a list of the population. If the population is in a random order, this can imitate the benefits of simple random sampling.

3. **Stratified sampling -** In stratified sampling, researchers divide subjects into subgroups called strata based on characteristics that they share (Team in Cameron all are male from a different department). Once divided, each subgroup is randomly sampled using another probability sampling method.

4. **Clustered sampling -** Cluster sampling is a probability sampling technique where researchers divide the population into multiple groups (clusters) for research. Researchers then select random groups with a simple random or systematic random sampling technique for data collection and data analysis.

Non-Probability Sampling Methods

1. **Convenience sampling -** A convenience sample is a type of non-probability sampling method where the sample is taken from a group of people easy to contact or to reach. For example, standing at a mall or a grocery store and asking people to answer questions would be an example of a convenience sample.

2. **Quota sampling -** Quota sampling is defined as a non-probability sampling method in which researchers create a sample involving individuals that represent a population. Researchers choose these individuals according to specific traits or qualities.

3. **Judgement (or Purposive) Sampling -** Purposive sampling, also known as judgmental, selective, or subjective sampling, is a form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their surveys.

4. **Snowball sampling -** Snowball sampling or chain-referral sampling is defined as a non-probability sampling technique in which the samples have traits that are rare

to find. This is a sampling technique, in which existing subjects provide referrals to recruit samples required for a research study.

Bias in sampling - There are five important potential sources of bias that should be considered when selecting a sample, irrespective of the method used. Sampling bias may be introduced when:

- Any pre-agreed sampling rules are deviated from.
- People in hard-to-reach groups are omitted.
- Selected individuals are replaced with others, for example if they are difficult to contact.
- There are low response rates.

An out-of-date list is used as the sample frame (for example, if it excludes people who have recently moved to an area)

For this case study, Simple Random Sampling was used. 15 respondents were from total 50 workers were selected. All 15 respondent's representing the whole group of production team than can help to avoid any bias in the data collected. However, there must be room for error represented by plus and minus variances.

While simple random samples are easy to use, they do come with key disadvantages that can render he data useless.

Advantages - Ease of use represents the biggest advantages of simple random sampling. Unlike more complicated sampling methods, such a stratified random sampling and probability sampling, no need exists to divide the population into sub-population or take any other additional steps before selecting members of the population at random. A simple random sample is meant to be unbiased representation of a group. It is considering a fair way to select a sample from a larger population since every member of the population has an equal chance of getting selected.

Disadvantages - A sampling error can occur with a simple random if the sample does not end up accurately reflecting the population it is supposed to represent. For example, in a simple random sample of 25 employees, it would be possible to draw 25 men even if the population consisted of 125 women, 125 men, and 125 nonbinary people.

For this reason, simple random sampling is more commonly used when the researcher knows little about the population. If the researcher knew more, it would be better to use a different sampling technique, such as stratified random sampling, which helps to account for the differences within the population, such as age, race, or gender. Other disadvantages include the fact that for sampling from large populations, the process can be time-consuming and costly compared to other methods.

3.4 Data Collection Method.

Qualitative Data Collection.

Qualitative Data Collection based on the questionary survey's conducted in Warehouse, Machine Shop, Weld Shop and Assy & Test employees.

Quantitative Data Collection.

Quantitative Data Collection in this case study are from all the SAP - NCR, Microsoft Team - A4, CPAR and Kaizen reports.

SAP - Systems Application and Products.

SAP (**Figure 29 / Figure 30**) used in all operation related to data collection and records from Attendances of employees, Information of all Cameron Products including product drawing, product new design, Purchase Order, Invoice, Sales, Engineering Information, Inspection Data, Procedures, Quality report, including nonconformance report or NCR, maintenance, labour confirmation etc. This system also has good connection with all Cameron Company in the worlds where all the data can be achieved in seconds even the report pull from USA.

All the transaction required specific codes and these codes limited depends on the level you are in the organization. This to avoid sensitive info being pull out by unauthorize person that does not require for the info.

Microsoft Team.

Second method for data collection from Microsoft Teams (**Figure 31, Figure 32, Figure 33, Figure 34, Figure 35 & Figure 36**). This is not only a communication apps but also medium to keeps all the reports, records for Cameron Malaysia Sdn Bhd including all the improvement and meetings. The communication can be done through this apps including phone calls to any location in Malaysia and worldwide, chatting, sending pictures, sending reports which safer from WhatsApp, Google Meet or Skype.

Each department can generate group or team in this apps and can limited the access based on creator needs.

Some of the data was collected from this Apps / Software used by Cameron Malaysia. Total NCRs from 2019 to 2021 raised in Production - refer to **Figure 33**.

3.5 Operationalization and Measurement

Independent Variables

SURVEY - Interviews

The interviews were conducted using structured questionnaires and focusing to productions team where the high nonconformance detected. This survey conducted to collect the data and to know on the respondents' views on the factors that can cause nonconformance especially in their daily task and what are the main criteria from each independent factors that can cause or potential cause to the high nonconformance in production area. That is why for this case study, the survey was conducted physically to the specific group in Machine Shop, Weld Shop, Warehouse and Assembly & Testing department so that not only to collect the data but also to see directly the actual process happened in the shop floor.

Survey results plotted in Bar Chart and high selection to low highlighted below.

H1: Manpower (**Figure 23**) – Quality defect caused by human due to lack of skills, incompetent, less knowledge, improper training, inexperience etc.

Highlighted Points:

- Training is the highest selection to avoid nonconformance for employees based on 15 respondents under Human factor.
  - Training is important to maintain the skills and competency of the employees. Humas tend to forget the correct process if they are using the same method for so long. Skills, knowledges are required to perform the daily task.
- Skills and Competency required to improve nonconformance in humans' factor for second highest selection.
- Earlier preparation before start work can avoid nonconformance issues during the process as a third highest selected.
- Based on the data collected in 2021, Operator Error is the second highest contributed to non-conformance which matching with this survey results.

H2: Material (**Figure 24**) – Quality defect caused by material due to wrong material specification used, wrong document used, wrong programs, data incomplete, documentation error etc.

Highlighted Points:

- Incomplete, deviation, checking is the highest factors under Material that if not done will cause nonconformance the highest selection from the respondents.
- Material must be in good condition and are safe to use for second highest selection. If not meeting the requirement, the task should stop.
- The third selection is the completeness of the material to use in the process from the jobs itself, tools, documents, program, WI/SOP etc.
- Based on data collected in 2021, Design/Engineering Error can be added in material where employee receiving wrong data due to engineering error, NC Program Error, Major revision, and few others that can be categories under material that use to perform the process. It meets the results that Material is one of the factors contributed to the non-conformance.

H3: Measuring (**Figure 25**) – Quality defect caused by measuring - measuring process was not establish correctly to measure not only the equipment's but also KPIs, performance, capability of team and department to certain task and process, etc.

Highlighted Points:

- Measuring the process and performance is important to avoid any nonconformance due to improper process conducted and performance which might not meeting the target to be done in correct manner and time based on 15 respondents' selection.
- Verification is important and lack to check can cause nonconformance as a second factors selected.
- The third is lack of measuring process that can cause nonconformance and unable to justify the results of the process which end up with unpredictable outcome.
- Based on data collected in 2021, Processing Error is part of the measuring factors that one of the root causes contributed to the non-conformance. However, Processing Error was not a solid root causes to the non-conformance. Processing Error need further analysis where the real root cause may vary that can be segregate to other factors. If refer to " Annex 12 CRP-83 "Control of Non-conformance product", Wrong Inspection Method Used and Missing Receiving Inspection is the root causes under Measuring factors. It's meeting the survey

where measuring factors one of the root causes contributed to the non-conformance.

H4: Machines (**Figure 26**) – Quality defect caused by machine due to machine not in good condition, ageing, vibration, out of centricity, power cut off due to machine part malfunction etc

Highlighted Points:

- Machine condition and competency is the highest selected by 15 respondents that important to look before starting any task.
- Abnormal condition if happen during operation must be stopped immediately before it escalates to nonconformance.
- Machine should be checked before starting daily task to avoid any issue that can cause issue as selected in second highest factors.
- Based on data collected in 2021, 16 under Machine Malfunction which one of the various factors contributed to the non-conformance where it is meeting the survey results conducted for this case study.

H5: Methods (**Figure 27**) – Quality defect caused by methods due to improper methods used to produce the parts, wrong procedures used, incomplete workflow, wrong machining sequences etc.

Highlighted Points:

- Correct method and training are important to avoid any nonconformance under method issue based on 15 respondents' selection.
- Any abnormality found during performing the process need to stop and get clarification before continuing.
- All must be trained before allowing to perform the tasks.
- Based on data collected in 2021, Quality Procedure Error, Routing Error is one of the factors contributed to non-conformance that meeting the surveys results conducted in for this case study.

H6: Environment (**Figure 28**) – Quality defect caused by environment due to hot working environment, raining, flooded, storage in open space etc.

Highlighted Points:

- Storage is important to maintain the quality to avoid nonconformance issue from the environment's aspect.

- All the environments issue should be counted or consider when make any decision to perform any works.
- Yes. Environment can cause nonconformance due to raining, too hot, flooded, electrical breakdown, lighting, open storage, etc.
- Based on data collected in 2021, Shelf life, Storage Shipping Error is one of the factors that contributed to the non-conformance and meeting the survey results conducted for this case study.

Mediating Variable

Mediating variable is the process to meet the dependent variable which is all the improvement process that affecting to the dependent variables. All the process improvement based on the issues happened or occur on all the independent variables as listed. Examples.

- Training, competency test, skills assessment etc. - All the improvement focusing on the defects, nonconformance caused by human factor etc.
- 6S for tooling storage, standardize the tooling for each process, specified tooling for specified work or task. for each department, work centre and form a method to inspect, measure, assess, verify before used - All the defect or nonconformance caused by tooling error. Specified tooling for specified work or task.
- Measuring method need to be establish correctly to avoid improper measuring method being used in daily process. Not only to measure length, diameter, weight but also measuring the process, KPIs, performance etc.
- 6S for material areas, Kanban Lane, Complete material to be used for all the task assigned to employees, Bill of Material - BOM, drawing, correct material with correct part number, heat number for the machining process etc. - All defect or nonconformance issue related to material.
- 6S on machine body, areas, Preventive Maintenance with proper schedule, Autonomous maintenance done by the employees as the ownership of the machine, daily, weekly, monthly, and yearly inspection, providing extra spare parts for fast running part that need to change regularly - this to avoid any defect or nonconformance due to machine defect or malfunction.
- Work Instruction, Standard operation Procedure for all activity in the company including for general works, correct machining sequences - this to avoid any defect due to method issues.
- 6S also can help to avoid any defect issue related to environment.

Dependant Variable - Improvement.

Dependent variables are the target for this case study which is Quality in production will improves and at the same time customer will satisfied with the quality products they receive.

A4 problem-solving report.

For the problem-solving, A4 Problem-Solving report is the method used by Cameron Malaysia and in this thesis. Not only Cameron Malaysia, but A4 was used widely in Cameron company worldwide. A4 Problem-Solving was raised to mitigate the defect / nonconformance issues as parts of the improvement process involving the owner of the process and those who creating the non-conformances. The highest in 2021 is form Machine Shop and Assembly & Test. Based on earlier data analysis, processing error is the highest non-conformance recorded for both departments.

To use this A4, all the section must be updated. At the first section, all the problem needs to be updated in Section 1 (**Figure 37**). In these A4 Problem-Solving reports, there is a fishbone diagram. In fishbone diagram the potential root cause to the problems need to be identify. That where 5 Why process that need to be determine first. Followed by why-why questionaries until the real root cause reveal, intermediate action to be taken to contain the issue and permanent solution which is the root cause actions. The discussion will focus more to the fish bone diagram analysis to find the potential root cause to the problem based on independents variables that has been explained earlier. This discussion advisable to be conducted in group from those who have relation to the nonconformance issues and the expert team so that all the ideas can be generated from many peoples and from the expert team itself. The combination of group is better to avoid bias to the process owner.

Example of New and Completed A4 Problem-Solving Report - refer **Figure 37, Figure 38, Figure 39, Figure 40, Figure 41, Figure 42, Figure 43, Figure 44, Figure 45, Figure 46, Figure 47 & Figure 48**.

Example of completed A4 Problem-Solving - **Figure 49 & Figure 50.**

CPAR

The second method is using CPAR - "Corrective Prevention Action Request" reports which is higher than A4 Problem-Solving - refer **Figure 51**. CPAR will be issue by QA - Quality department if the nonconformance repeated more than three times for the same root causes. CPAR is more effective but rarely use because this CPAR only raised by QA. However, there is no restriction for other department or HOD to issue CPAR but need to update to QA on the issuances, but it still needs to be monitored by QA for all the process conducted. QA will do the assessment direct to the defective area after the improvement done to measure the sustainability of the improvement. Once the improvement verification done by QA which might take few weeks, this CPAR can be closed. CPAR problem solving not much different from A4. CPAR not only update in Cameron Malaysia but to high level until Director of the Surface division located in Houston. This to show how serious the issues when CPAR raised to the respective department to complete the action from the issues being raised. However, if the issue keeps repeating until the affect from it getting bigger, Kaizen event will be used.

KAIZEN - Improvement

Kaizen is the last Problem Solving used to focus on bigger issues. All issues under SPQDC - Safety, People, Quality, Delivery and Cost which the focus of Cameron, can used Kaizen Event as a problem-solving method which is covered more wider and details on the issue.

Kaizen was introduced by Masaaki Imai 30 years ago in Toyota factory. There are 5 principles under Kaizen which is: Know your customer, let it flow, go to Gemba, empower people and be transparent - **Figure 52**.

Kaizen Rules.

a. Eliminating the 3 waste categories - Mura - Unevenness, Muri - overburden and unreasonableness and Muda - totally useless actions.
b. Deliver significant (>50% metrics) improvements.
c. Complete multiple Rapid PDCA cycles
d. Think creatively before spending money and waiting
e. Have fun.

Kaizen can be implemented successfully with below supports.

a. Supportive Management (e.g., kick-off event, daily recaps, participation in events)
b. Engaged Cross Functional Teams (including operators, off shift employees, and support functions)
c. Skilled Facilitator who pushes a team to think “Narrow and Deep” vs. “Wide and Shallow”
d. A structured format
e. Significant metric improvement (> 50%)
f. Implemented improvements with limited follow-up actions
g. A robust control process, where completed kaizens include Leader Standard Work & Process Confirmations. Thus, ensuring that the “Gains and Maintained”

When the problem identified, Kaizen can be conducted as a continuous improvement process flow - **Figure 53**.

This systematic method on the Event days includes the following steps:

- **Get employees from all the department involved.** This will help to wider the ideas during brainstorming session. Organized as specific groups of individuals to gathering all the information needed.
- Team kick-of and introduction the Kaizen event. Conduct briefing on the process flow. **Find root causes to the main title of Kaizen.** To do this GO & See is the recommended method to see on the exact issues. If the issues can be pull from the system, the data can direct be discussed to find the root causes. Using widespread feedback from all employees, gather a list of potential root causes and potential opportunities to solve the issues. List all the wastes. Identify value added and non-value-added activity. Records all the movement using spaghetti diagram, records the timing and activities.
- **Create a solution after brainstorming on the potential root causes to the issues.** Encourage employees to offer creative solutions, with all manner of ideas encouraged. Pick a winning solution or solutions from the ideas presented.
- **Test the solution.** Implement the winning solution chosen above, with everyone participating in the rollout. Perform the ideas physically so that everyone can see the result or if using system need a time before the results can be detected.
- **Analyse the results.** At various intervals, check progress, with specific plans for who will be the point of contact and how best to keep ground-level workers engaged. Determine how successful the change has been.

- If results are positive, adopt the solution throughout the organization.
- If the result still below the target, new kaizen can be conducted to detail down the process.
- Conduct the close out meeting - **Figure 54**.

3.6 Data Analysis Techniques

There is a lot of analysis method that can be used to analysis the data collected. As explained earlier, the data collected by using apps and system used by Cameron which is SAP (Systems Applications and Products) and Microsoft teams. Cameron. All this data can be analysed to defining the real root causes which also part of the factors that affecting in improving quality in production.

DMAIC

DMAIC have the similarity from other data collection methodology. **Define** the issues by collecting all the information needed, **measure** all the information, and selected at least 3 root causes for each process and **Analysis** it. During analysis the data or information, Fishbone can be used to detail down the issues to see the real root cause. Once the real root cause found, discuss to come out with the Improvement plan. The outcome maybe varies with few improvements planning. Before the improvement can be proceeds, SWOT method can be used to see if the improvement can be implemented without any issue or less barriers. Once the improvement method defines, proceed with the improvement, and monitor the process using PDCA. The last is **Control.** All the improvement needs to have proper control to all the improvement to sustain it.

1. **Define** the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
    a. Project charter to define the focus, scope, direction, and motivation for the improvement team
    b. Voice of the customer to understand feedback from current and future customers indicating offerings that satisfy, delight, and dissatisfy them
    c. Value stream map to provide an overview of an entire process, starting and finishing at the customer, and analysing what is required to meet customer needs

Note: Factors Affecting in Improving Quality in Production.

2. **Measure** process performance.
    a. Process map for recording the activities performed as part of a process
    b. Capability analysis to assess the ability of a process to meet specifications
    c. Pareto chart to analyse the frequency of problems or causes

    Note: All NCR data collected from SAP and Microsoft Teams.

3. **Analyse** the process to determine root causes of variation and poor performance (defects).
    a. Root cause analysis (RCA) to uncover causes
    b. Failure mode and effects analysis (FMEA) for identifying possible product, service, and process failures
    c. Multi-various chart to detect different types of variation within a process

    Note: Analysis the data using Fishbone diagram, Survey, 5 Whys, Why-Why question.

4. **Improve** process performance by addressing and eliminating the root causes.
    a. Design of experiments (DOE) to solve problems from complex processes or systems where there are many factors influencing the outcome and where it is impossible to isolate one factor or variable from the others
    b. Kaizen event to introduce rapid change by focusing on a narrow project and using the ideas and motivation of the people who do the work

    Note: A4 Problem-Solving, CPAR - Corrective Prevention Action Request, Kaizen - Improvement Event.

5. **Control** the improved process and future process performance.
    a. Quality control plan to document what is needed to keep an improved process at its current level
    b. Statistical process control (SPC) for monitoring process behaviour
    c. 5S to create a workplace suited for visual control
    d. Mistake proofing (poka-yoke) to make errors impossible or immediately detectable.

    Note: Audit Quarterly and Yearly. NCR Weekly Meeting, Quality assessment during weekly HSE and Quality Plant Walk, QMS - Quality Management System Audit, Sirim Audit, Shell Audit, API- American Petroleum Institute Audit, ISO 9001:2015 Audit

Fishbone Diagram

Fishbone diagram used to find the potential root causes to the problem as updated in **Figure 57**. All the potential root causes should come from updated to be discussed among the team with the involvement of expertise team to the process to ensure all the improvement ideas being filter correctly during the discussion. The selection should not less than 3 but also not advisable to use all. If the time permitted, all potential root causes can still use but must not to over commit to avoid the improvement cannot be monitor and follow-up. All other potential root causes can be done in next process.

Brainstorming process (5 Whys / Why-Why)

Brainstorming process is the process to detail down all the potential root cause identified in the Fishbone diagram. If the potential root cause list too many, identify the main root cause to be discuss in 5 Whys analysis. PICK chart (**Figure 63**) can be used to identify which root cause to be discussed or to proceed with the 5 Whys analysis. PICK Chart also can be used to measure if the action can be done or not. However, if the team have sufficient time, all the lists can be discussed in 5 Whys analysis.

PICK Chart

Pick Chart is a Lean Sigma tool for organizing process improvement ideas and categorizing them during the identify and prioritize opportunities phase of a lean Six Sigma project.

P - Possible (The ideas can proceed without any issue)

I - Impossible (The ideas maybe can and maybe cannot proceed)

C - Challenge (The ideas can proceed but have challenges)

K - Kill (The ideas totally cannot proceed)

SWOT

SWOT analysis can be used to verify the improvement from the root cause actions either it will work or not or can the improvement sustain, suitable to proceed or need to reject. All the selected ideas, improvement should be filter using SWOT to see the Strengths of the ideas, what is the Weaknesses from it, the weakness will cause the improvement will not last longer. We also need to look if the ideas, improvement

we want to implement have other Opportunities to be consider as new input to improve the ideas more. The last we need to see the treats. Can this treat be removed? Is the treat to big, we need to look back the ideas and if too small, we can ignore it? From this analysis, we will select the high potential will low treat to proceed and implement.

- **Strengths**:
  a. Improvement program well established
  b. Records and data recorded systematically
  c. Good follow-up on the implementation of problem solving

- **Weaknesses**:
  a. Less participant from other departments.
  b. Required to much access to pull the data.
  c. Low usage on the problem-solving compared to the issues.

- **Opportunities**:
  a. Add employees to be competent to use A4 problem-solving.
  b. Add A4 submission as department KPIs per month.
  c. Celebrate the completion of any improvement events.

- **Threats**:
  a. More access to company data.
  b. More time taken to increase employee's competency.
  c. Reduce the production time when too many involve in improvement event.
  d.

PDCA (Figure 61)

PDCA help to monitor the root cause actions flow from the beginning until the end. PDCA have timing that need to follow as a monitoring process on the implementation. Without timing frame or lead time, the implementation might stop halfway. This is the main reason why all HOD must get involve monitoring the process and follow-up with the assigned person. Some improvement event used PDCA just to update the date when the action planned, which at "PLAN". Once the action started, the date update at "DO". Once completed the date will change to "CHECK". "ACT" normally used once the action take fully completed and has been verify through the assessment.

Below the normal justification for each PDCA.

1. Plan - First identify and understand the problem or opportunity. If the standard of a finished product is not that high enough or an aspect of company marketing process should be getting better results. Explore the information available in full. Generate and screen the ideas and developed a robust implementation plan. Be sure to state all success criteria and make them as measurable as possible. Return all of them in the check stage.

2. Do - Once the potential solution has being identified, test it safely with a small-scale pilot project. This will show whether the proposed changes achieve the desired outcome - with minimal disruption to the rest of your operation if they don't. For example, you could organize a trial within a department, in a limited geographical area, or with a demographic. As the pilot running, gather the data to show whether the changes have worked or not. Use this in the next stage.

3. Check - analyse pilot project's results against the expectation that defined in step 1, to assess whether if the ideas were a success. If it wasn't, return to Step 1. If it was, advance to Step 4. The trial can be done for other changes. Repeat the Do and Check phases but if the original plan didn't work, all need to return to Step 1. 4. Act - This is where the time to implement the solution selected. Remember that PDCA is a loop, not a process with the beginning and end. Improved the process or product to becomes the new baseline and continue to look to ways to make it even better.

3.7 Descriptive Analysis Techniques

Descriptive analysis normally works with smaller data set. The process also a simple process to do and results obtained represent the entire data set. Error for descriptive analysis usually less. What the data telling us as a researcher?

Descriptive: What is happening to the business? The issues must be clear based on the data or information collected which must be comprehensive, accurate. A live data also should be able to show the issues and all that must be effective and visualized.

Diagnostic: What is it happening? The researcher must be able to drill down the issues until the root cause. This to ensure the follow-up especially improvement can be done to the correct issues. Otherwise, the issue remains the same if the

improvement not done to the real root causes. The researcher also should be able to isolate all confounding the information.

Predictive: What's likely to happen? The researcher should be able to predict what will happen once the real root causes to the issues removed or solved. With the data collected, it can be used to predict the outcome by using algorithms and technology.

Perspective: What do I need to do? All the actions should reflect from the finding result and what has been suggested to outcome the issues in future. The action should have been discussed earlier after applying advanced analytical techniques to make the specific recommendations.

The survey conducted to see what respondents' feedback on all 6 independent variables that can contributes more to nonconformance issues in production. Based on the data shows in **Figure 62.**

Highlighted Points:

- Major respondents selecting machines as a factor to nonconformance which is the highest (47%).
- Human and tools having the same results to contribute to nonconformance (20%)
- Method is the third selection that can contribute to the nonconformance (13%).
- No respondent selects environment as a factor of nonconformance (0%)
- No respondent selects Material as a factor for nonconformance issue (0%).

3.8 Summary

This chapter describes and explains the research methodology method used to collect and analyse the data required to address the research question and to test hypothesized relationships developed in this case study. This chapter begins with the discussion of the research design, followed by the population from which data collected and the approach used in the sample selection. The chapter then continue with the description of the questions design, data measurement and scaling.

From the surveys conducted through the structured questionaries shows that the results meeting the analysis done from the data collected from the Cameron Malaysia systems. It's proved that all the Independent Factors contributed to the non-conformance for Cameron Malaysia Sdn Bhd which affecting in improving quality in the production. All the data was analyse using few methods such as A4, CPAR, Kaizen

etc. to detail down the root causes and defining the real root causes before the improvement can be triggered, arranged, and proceeded. The improvement for all the root causes is vary based on the factors being analysed.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

The research results that's gained from this case study based on the few analysis methods conducted such as FISHBONE diagram and 5 WHY analysis through A4 Problem-Solving report, CPAR and Kaizen then was being filtered using DMAIC, PDCA and SWOT. This analysis to ensure the improvement can be done without any major disruption in-term of difficulties. The other method which not highlighted in this case study is JDI - Just Do It process and CI - Continuous Improvement program where it drives by the employees itself with the support from their superior and HOD - Head of Department. This was monitored closely by Black Belt Lean Sigma team as their final approval.

4.2 Sample and characteristics

15 samples taken in the survey as part of the data collection method used for this case study. Based on earlier analysis, all independent factors contributed to factors that affecting in improving the quality in production for Cameron Malaysian Sdn Bhd.

4.3 Factor analysis

All the factors highlighted in Independent Variables contributed to the factors affecting in improving the quality in production for Cameron Malaysia Sdn Bhd. From there, the improvement can be developed, arranged, and proceeded. However, few other points need to be considered to avoid reoccurrences. All this required full commitment from all levels to achieve the target. All the points highlighted has been discussed, studies by other researcher which useful to support the quality improvement journey by Cameron Malaysia Sdn Bhd.

Few points to be consider:

a) **Soft Factors -** When discuss about factors, factors itself bring huge prediction and justification especially when it relates to human management which is soft factors. Soft factors are related to the creation of the customer consciousness and human resources management. The soft factors are the characteristic aspects of management such as leadership, human resource management (HRM), employee involvement and authorization, and so on. The beneficial use of these soft quality factors (example: Executive commitment, employee involvement, customer focus, and employee focus), can bring quality improvement in an organization.

Based on the case study " The Impact of Soft Factors on Quality Improvement in Manufacturing Industry", done by **Shiau Wei Chan, Md Fauzi Ahmad** and **Mei Wan Kong**, all these three authors agreed that soft factors have correlation to all the quality improvements in the organization. However, based on the regression analysis they performed shows that supplier relationship and employee involvement has more significant impact to the quality improvement compared to other soft factors. They also suggested to new researcher to investigate the possible inclusion of several other soft factors such as communication, quality culture, and teamwork that are related to quality improvement.

b) **Management Commitment -** Top management commitment is displayed by creating the elements of quality management structure. The impact of top management in leadership commitment influences other quality attributes. When top management is committed to the quality improvement, an adequate resource will be allocated to the quality improvement efforts. Hence, this effort can be one for top management commitment performance to quality. Furthermore, customers looking a customer relationship practice, proper organizational procedures, systems, and always focusing on what customer needs. "Customer focus" can be the starting point of any quality initiative. The product quality should be focused on customer wants and demands basis rather than theoretical standards. Hence, qualities that have been recognized and defined from the customer's viewpoint have always achieved the most successful quality improvement plans.

Kate Eby in her journal "Quality Improvement Processes: The Basics and Beyond" said, empower your people to go above and beyond with a flexible platform designed to match the needs of your team and adapt as those needs changes. This will help team to be more effective and get more to be done.

W. Edwards Deming in his journal focusing on the business owner commitment to achieve the quality required. 5 steps to be taken to ensure the quality journey can be achieved. 1.Make a commitment - The commitment must come from the top and to be reinforced over and over. 2. Track the mistakes - Tracking the quality issues by using a statical quality control and set the standard to be achieve will help to improve overall quality in the organization. 3. Invest in training - Train all worker at all levels to looks for a way to improve quality and to ameliorate problems. 4. Organize quality circles - organizing employees into quality circles can be effective way to identify and address problems and 5. Have the right attitude - this attitude is not necessarily easy to adopt

and runs afoul of some of the basic management practices that might take for granted. Rather than pointing out inadequacy wherever it might be found, Deming believe that the job of manager was to frame the pursuit of quality as an interesting, noble, and worthwhile goal.

c) **Supplier Relationship -** Supplier relationship refers to chances to build on the success of strategic sourcing and traditional procurement initiatives. It consists of developing supplier relationships with key suppliers to reduce costs, innovate with new products, and create value for both parties, based on a mutual commitment to long-term collaboration and shared success. Developing and maintaining a supply relationship can be achieved either by collaboration or agreement. Specifically, trust provides a basis for achieving collaboration, while power acts as a mechanism for achieving an agreement. Poor quality of supplier products causes extra costs that need to be purchased more.

Dr. Sean De Burca in his journal / Study "The Impact of Buyer-Supplier Relationships on Quality Practices and Quality Performance" developing trust and commitment, adapting each other needs and improving communication and co-operation, a stronger relationship should emerge which ultimately will create a closer bonding between supplier and customer. With stronger relationships ultimately improve customer satisfaction and it is also will affecting the quality of the product purchased.

d) **Employees -** Moreover, employee involvement is defined as the level at which employees have a sense of control over their work. Employee involvement provides chances for employees to enhance their skills and provide direction in their jobs and enjoy their work. The successfulness to have better quality in the organization is with the employee's involvement on quality improvement practices. This was not fully utilized in the problem-solving sessions where only certain employees being invited especially in A4 Problem-Solving. However, Kaizen events is one of the examples of good participations from the employees happens in Cameron Malaysia

Danica Bakotic & Andrijana Rogosic in their journal "Employee involvement as a key determinant of core quality management practices" focusing on 8 quality management which is customer focus, leadership, involvement of people, process approach, system approach to management, continual improvement, factual approach to decision-making and mutually beneficial supplier relationships which required

employees involvement to support the overall process to achieve the quality target for the organization.

e) **Training -** Training is an effort to develop knowledge and skills of an employee in performing a particular job. Training is best supplemented with practical and hands-on experience. Providing more training in all aspect from process, product knowledge, including managing personal work behavior is a good activity to developing employee knowledge, skills, improve moral values, and increase their understanding in all aspect that they required in their life rather than just having knowledge and skill relating to a limited field of activity.

f) **Recognition -** On the other hand, reward and recognition are consistently recognized by organizations and managers as an important part in motivating an individual employee. Employee of the month schemes, profit sharing, and monetary payment for higher productivity or commission on sales revenue are widely used. Reward and recognition can be used to improve relationships by encouraging cooperation and working towards achieving common goals. Reward and recognition strategies can also encourage development and learning by encouraging risk taking and trying new initiatives.

g) **Quality Improvement -** Quality improvement is defined as all activities that contribute to defining, evaluating, monitoring, and improving quality. Quality improvement can be measured by using 11 scales, which are customer involvement, feedback, inter-functional design process, new product quality, process control, process management, quality improvement rewards, quality leadership, supplier involvement, selection for teamwork potential, and teamwork. Customer involvement is their feedback that is important for offering quality products and services, sample survey, opinion polls, or by soliciting individual customer's opinion on the preferred product quality and service dimensions. Feedback is defined as sharing information with co-workers about the impact of their behavior on the team's process, results, or relationships. It can build trust, remove interpersonal barriers, and guide people in the team to improve performances by giving and receiving feedbacks. Inter-functional is a different approach such as management, marketing, logistics or information technology science. Inter-functional can be found by managing it in the present business conditions.

Ciric, Neb in his journal "5 ways to increase product quality" focusing to understanding product quality that will allow for all to be able t create more informed decision about how to develop a product from start to finish. A lot of experts have different opinion and Ciric advised to create strategy, implement a QMS, embed quality in everyone or organization culture, performed regular product and market tests. By doing this, all are well on their wat towards creating high-quality products which also will delight customers.

h) **Design Process -** Design process means a multidisciplinary process of creating new products and the involvement of different functional units. New product quality was found to have a significant impact on the market success and profitability of a new product and therefore, firms are increasingly using cross-functional teams to improve product quality in product development process. Factors that influence a new product's market success and profitability are its quality, in the dimension of appearance, performance, workmanship, life or durability, features, conformance, reliability, serviceability, aesthetics, and customer-perceived quality.

i) **Process Control -** Process control is significant because it could improve process performance by reducing product changeability and improves production efficiency by decreasing waste and rework. Data are collected and appropriate action is taken to control the quality process and the product through the basis of analysis measurements in process control. Process management is a part of managing the whole organization. Process management is a set of tools and techniques for improving processes and a method for integrating the whole organization.

j) **Quality Leadership -** Quality leadership is where quality principles become a basis for guiding, empowering, and supporting the constant pursuit of excellence by the employees throughout the organization. Leadership styles such as transformational and transactional leadership have a positive correlation with quality management practices.

C Bliersbach in his journal "Quality leadership: the key to quality management" Quality leadership is a precondition for implementing quality management. How organizational leaders structure and direct an organization as well as how they behave within an organization are critical elements to the success of an effective quality management process.

k) **Supplier Involvement -** Supplier involvement refers to the resources, (i.e., capabilities, investments, information, knowledge, and ideas that are provided by the suppliers), the tasks they accomplish, and the responsibilities they assume regarding the development of a part, process, or service for the benefit of a buyer 's current or future product development projects. Supplier involvement has contributed to short-term project performance by improving product quality and reducing development time and in development and product costs. Selection is often presented as a planned rational activity, comprising certain sequentially linked phases within a process of employee resourcing. Teamwork involves functional cooperation, which is working together towards a practical purpose. While for potential team, there is an important and incremental performance need, and it tries to improve its performance, it requires more clarity about purpose, goals, or work products, and more discipline in hammering out a common working approach. Besides that, teamwork is also defined as a cooperative process that allows ordinary people to achieve extraordinary results.

4.4 Prevent or minimize non-conformance:

1. Management Review

Management review is required under ISO9001:2015 requirement and part of Quality Management System process and to review and finalize all the Goal Setting program, KPIs, opportunity that has been discussed and finalized. Since Management reviews are conducted once a year, this is the best timing to review all the opportunity with top management for their approval and comments. Other than that, all other issue will be discuss such as new policy include quality to minimizing nonconformance, product changes, new requirements, new processes, new management approach etc. The management review process can identify and correct any current or incipient deficiencies before they might be revealed by an audit or incident. Routinely reviewing the organization's process helps spur continuous improvement. A system should be in place for implementing any resulting plans for improvement or corrective action and verifying their effectiveness.

2. Review

A review is usually a 'senior management' exercise. It's important to conduct a similar exercise with the actual employees who are involved in the day-to-day process. These employees have an in-depth understanding of various processes and how they are related. They have vast knowledge about the product and more importantly about past non-conformance issues. They very well could have been first to respond to a

crisis and would have played a crucial role in analyzing the situation and solving an issue. On the flip side, this discussion could reveal a knowledge gap crucial to fixing non- conformance. An end-to-end understanding is crucial in setting up new objectives to minimize non-conformance. Also, understanding the process followed by lower-level employees could highlight pain points and provide key insight into potential areas of non- conformance, those which cannot be identified in a management review or audit.

3.Internal Audit

Internal audit is normal process to form a testing on the implementation of quality system effectiveness that has been used in the company. Internal Audits need to be scheduled at regular intervals to check the quality system conforms to requirements and to ensure the system's efficacy. Unlike an external audit, all the processes need not be audited at the same. Internal audits can be conducted as a series of smaller audits, with different processes audited at different times. The frequency of audit can also be set depending on the process in question. With changing internal and external dynamics, the criteria for the audit can be decided prior to the audit rather than the planning stage. Any previous findings, past audit conclusions, and pre-defined questions all become valuable data. Observations raised during internal audits could be classed as preventive actions as they can suggest improvements within the system to prevent non-conformances from occurring in the future.

4.Feedback

While all customer complaints are recorded and must be actioned, customer feedback also plays a role in minimizing non-conformance. Feedback from customers helps to understand potential non-conformance issues and is an opportunity for improvement. Customer suggestions may prevent any issues from being raised in the future. Negative as well as positive feedback is valuable data. Spending time to analyze could help spot trends and patterns. Feedbacks help to dig into the root cause of the issue which may not always be obvious (else it would have been picked up in audit testing). Understanding the root cause can help differentiate a temporary lapse from a process flaw.

No system is perfect, therefore problems with the system i.e. non- conformance will occur. The aim is to resolve the non-conformance as quickly as possible and prevent any recurrence. Recording non-conformities helps analyze negative trends,

examine root cause, and eliminate the cause of the problems. Corrective actions should also include the longer-term actions to ensure the problem will not occur again.

While corrective actions are reactive, preventive actions are pro-active. A preventive action can prevent the occurrence of an issue or stop it from becoming too severe. A preventive mindset helps to reanalyze the product and process, get a different perspective and help improve the system as a whole in a timely manner. Prevention can also be thought of as risks and opportunities. Identifying the potential source of problems, their effects and the likelihood of occurrence is the first step in risk management. This is followed by analyzing whether the associated costs with reducing the risk are worth it. Mitigating risks and avoiding unnecessary costs are some of the biggest and obvious reasons to minimize non-conformance.

Effectively managing non conformances and preventive actions is an integral part of an organization's continuous improvement plan. This should result in fewer defective products and processes and more satisfied customers.

Quality management systems have compliance, content, and collaboration management initiatives and strategies at their core. A good nonconformance management should assist everyone, from management to the day-to-day employee, in the common goal of better quality.

4.5 Summary

In this chapter described and explains more on how the improvement can be done supporting with the suggestion from other researcher for the similar issues resulting from their journal, study that can be adopted and implemented in Cameron Malaysia Sdn Bhd. Focusing more on the human factors from all levels, department, organization that have connection to Cameron Malaysia direct and indirect will help to improve the quality journey. The problem-solving method that was established well in the organization can be more affective with the implementation that can be added on in the improvement process. The most important the quality enforcement to activate all the improvement process which was found not enough.

Based on the A4 raised, Kaizen event records that conducted focusing on the non-conformance is too far from the target. CPAR was not a key to the issue because its overlapping with the A4 Problem-Solving. However, CPAR can be used to improve the A4 Problem-solving process if the assessment on CPAR issuances can be done

in correct ways especially to the A4 problem-solving which not effectively solve the issues. The management can continuously support the improvement process that already established well but need to add another supporting program to achieve better results that will help to improve the quality products for Cameron Malaysia Sdn Bhd.

CHAPTER 5

CONCLUSION

5.1 Recap of Major Findings

- Based on the nonconformance data from 2021, it was found that the selection of the root causes was not being discussed properly during problem solving process. This was not given much impact to overall nonconformance issue in 2021. This because only 74 A4 raise in 2021 for 489 NCR raised.

- CPAR was raised for the same nonconformance issues which overlapping with the A4 raised. However, CPAR can help to improve the A4 issuance as a tool to verify the effectiveness of the A4.

- Only 8 Kaizen conducted in 2021 and only 2 focus on Quality issues. Kaizen was an improvement tool for major or catastrophic non-conformance issues. These tools focusing on issues that give big impact to Cameron Malaysia Sdn Bhd. Minor non-conformance normally used A4 problem-Solving or CPAR.

- The problem-solving method was established perfectly in Cameron Malaysia, but the problem-solving tools was not fully running as per planned or use to tackle the issues.

- The root causes analysis was not involving employees much based on the A4 problem-solving records except for Kaizen events. Employees should be included as part of the team in the discussion and brainstorming session. Employees who involve direct in the process might have better ideas to improve the process which this can be consider as a failure.

5.2 Implication of the study

a) The study was focusing on the factors that impacting the improving quality process in Cameron Malaysia Sdn Bhd.

b) The study can be continued further to be focussing more details on nonconformance root causes which was not done in this study.

c) This study shows that the process flow to solve the problems is established well but the implementation or execution too low.

5.3 Management Involvement

a) It is important that management especially Head of Department driving the process to ensure the process continuously running non-stop.

b) Based on the survey, the selection of the root causes chosen from the person who involve with the process which is good to be used in the discussion.

c) The expert involvement to process is important so that the direction flow of the problem solving is correct.

d) The appreciation event can help to encourage all team to get involve more in the problem-solving process in future and to let them know the important of the process to them.

5.4 Limitation of the study

The study was limited in the following ways:

a) Data collected might not fully update to cover the whole problems in the company.

b) Info from the survey might inaccurate and not matching with the question and problems.

c) Each department teams might have different answer for the same question.

To overcome this challenge, the objective of the research has been explained by the support of other Head of Department - HOD and supervisor since the topic selected will help to improve company performance that contributed to the overall company profit.

5.5 Recommendation for future research

a) Future researcher can narrow down the issue and focus topic by topic to be more specify on the issues. Specification important in defining the issues to avoid any data losses or missed during the case study.

b) Focusing in one major, highest, or critical topic can help to reduce the variables input that causing less focus to the case study topic. Even it will not help to eliminate full the issues, but it will help to reduce the non-conformance records. Once the first issues done, it then can be follow-up with others based on the priority and criticality of the issues. This will help researcher to detailing overall process for better results.

c) Using more analytical methods is good to have better output from the research study. More analytical method might show better results that help to provide better improvement process.

d) It is good if the researcher does not have connection to the case study to avoid any biases to the info and outcome from the study. Those who have relationship with the process tend to make conclusion to the topic based on his or her experiences. Even it looks a good opportunity, but the study might not run correctly if the data being concluded too fast.

5.5 Conclusion

It was confirmed that all six independent variables are valid and proven as the factors that contributing impacting in improving quality in Cameron Malaysia Sdn Bhd. The problem-solving method that already established not managed to reduce the issues and was found inconsistently conducted or implemented in 2021. However, it was a good tool to be used and the current improvement process and tools can be added with other method that already suggested or recommended by other researcher in their similar case studies or journal.

The Management can support to reinforce the problem-solving process by setting the rules and regulation, given the guidance's, providing the supporting tools and equipment's required, training and manpower, timing and budged to ensure the improvement process consistently implemented all the time until the issues can be reduced until reach the excepted level.

The improvement journey is a continuously journey that should not have end date. Based on the findings, it shows that the improvement process must be done on time, as soon as possible, and to be raise, conducted for all catastrophic, major, serious defects, and required as many employees as possible to be involved in the improvement process for better results. Non-conformance issues will not stop but can be reduce and control and quality target can achieve to gain back the company reputation and improve customer satisfaction.

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APPENDICES

APPENDIX A

***Figure 1**: Drake Well Museum Collection, Titusville, PA.*

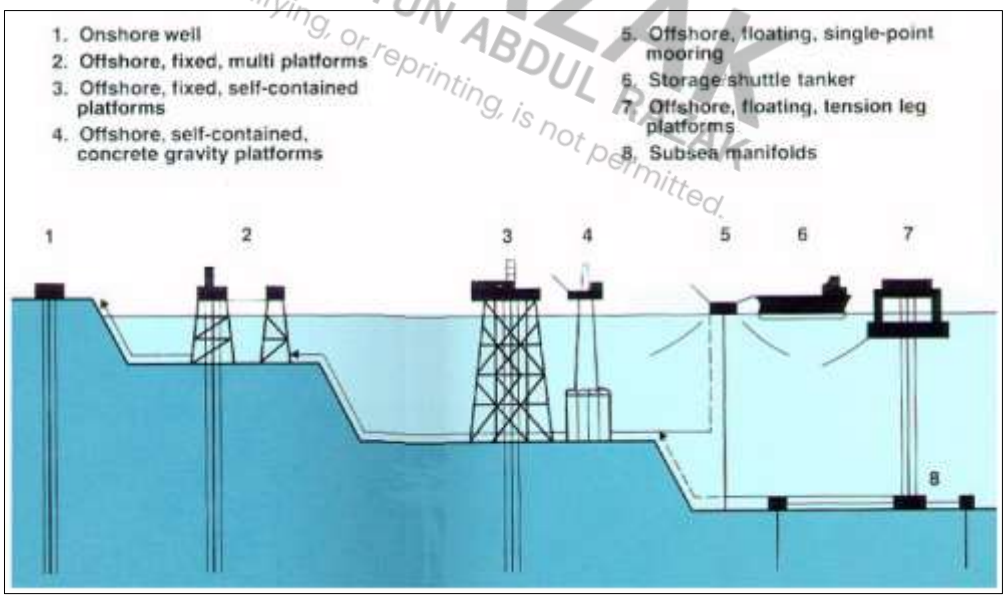


***Figure 2**: Oil and Gas production facilities.*

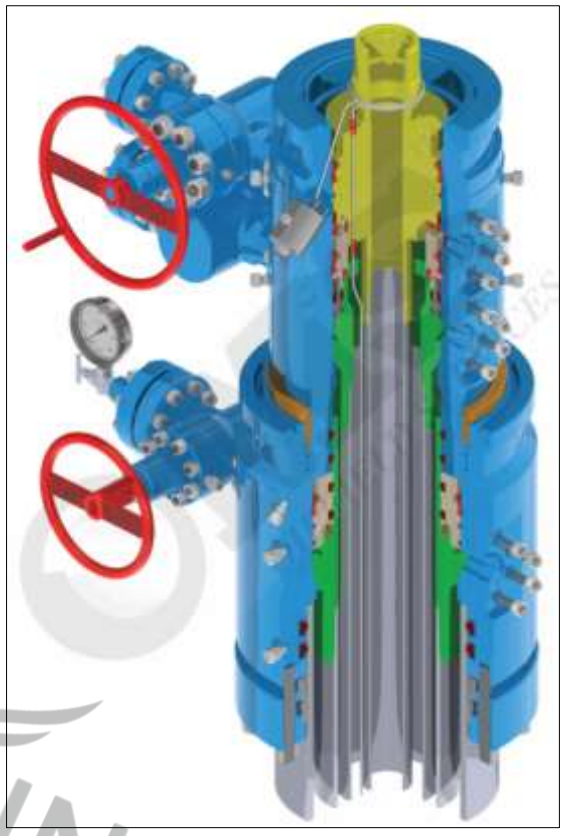


***Figure 3**: Wellhead Equipment's.*

Cactus	**1988** Started as **Ingram Cactus**, JV with Wembley Industries
COOPER CAMERON	**1997** **Cooper Cameron** acquired Ingram Cactus
CAMERON	**2008** Known as **Cameron (Malaysia)**
CAMERON	**2012 – 2014** **4 CNC Machines** transferred from Singapore
CAMERON A Schlumberger Company	**2016** Integration to **Schlumberger**
CAMERON A Schlumberger Company	**2018** Cameron Manufacturing System fully implemented
CAMERON A Schlumberger Company	**2019** New **Digital Hydrostatic** Test bunker investment
CAMERON A Schlumberger Company	**2020 (Covid-19 Pandemic)** New **SOLIDrill** Wellhead Manufacturing capability & Stocking Plan Achieved historically the **highest Revenue** and **Production Hours**
CAMERON A Schlumberger Company	**2021 (Covid-19 Pandemic)** **New Fontus Wellhead** Manufacturing capability first in ASIA. **TIG Cladding** investment.

***Figure 4**: Cameron Malaysia Sdn Bhd*

***Figure 5**: Quality Product Target*

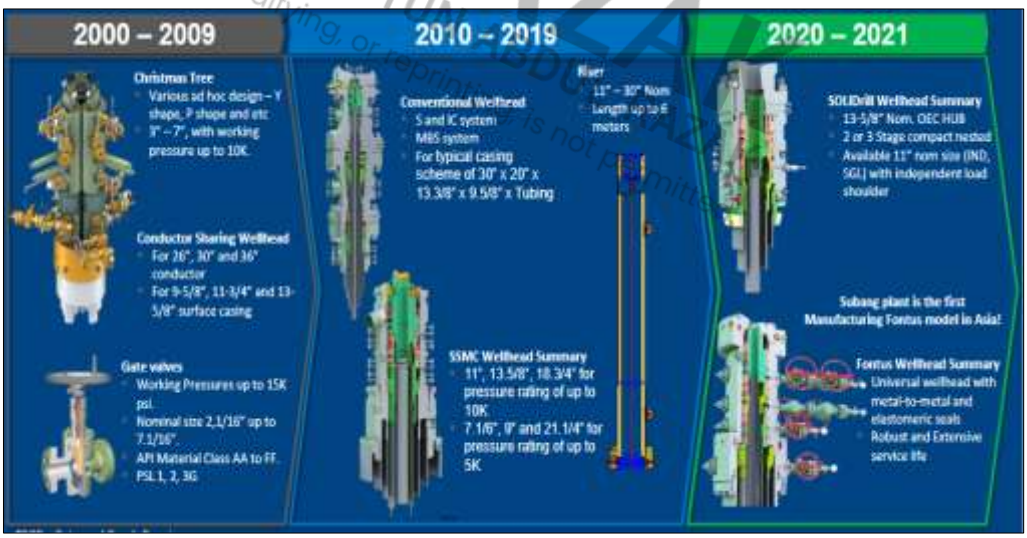


***Figure 6**: Plant Capabilities*

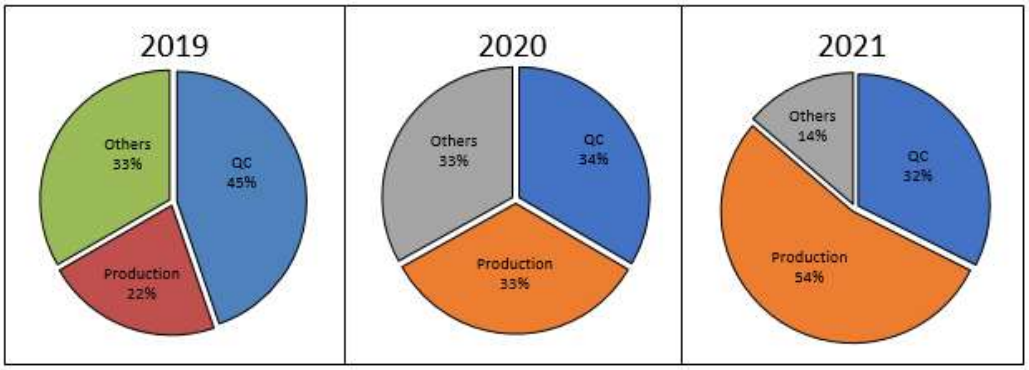


***Figure 7**: Total defect by department for 3 years*

Notificati	Created (	Comp. da	Prod. ord	Material	Description	Cause code text
210417678	01/04/2021	01/11/2021		2388832-12	ASSY, CSG HGR RT 13-5/8 X 7 VT	Vendor Error
210417764	01/04/2021	01/11/2021	121625864	141551-31-68-03	GV HWO FLS 02.06 05K FG PU DDNL 3 2"	Storage Shipping Error
210417917	01/04/2021	01/12/2021	121625865	141551-31-68-03	GV HWO FLS 02.06 05K FG PU DDNL 3 2"	Storage Shipping Error
210417920	01/04/2021	01/12/2021	121633154	141551-31-97-03	GVA HWO FLS 2.06 5K FG PU-DD-PSL3-PR2	Storage Shipping Error
210418142	01/06/2021	01/11/2021	121607718	140863-01-70-26	BDY FLS 4.06 5K FG U EENL 3 "	Operator Error
210418152	01/06/2021	01/13/2021		2388814-30-06-03	ASSY, TBG HGR, SOLIDrill, 13-5/8 X 4-1/2	Processing Error
210418153	01/06/2021	01/12/2021		2388814-30-06-03	ASSY, TBG HGR, SOLIDrill, 13-5/8 X 4-1/2	Processing Error
210418154	01/06/2021	01/12/2021		2388814-30-06-03	ASSY, TBG HGR, SOLIDrill, 13-5/8 X 4-1/2	Processing Error
210418155	01/06/2021	01/12/2021		2388814-30-06-03	ASSY, TBG HGR, SOLIDrill, 13-5/8 X 4-1/2	Processing Error
210418342	01/07/2021	01/09/2021	121581803	2235421-11-02	BODY, SSSBTV, 'FH' STYLE, W/ THREE FLS	Operator Error
210418449	01/08/2021	01/18/2021	121638141	2205124-01	ASSEMBLY, SEAL, PACKOFF,	Engineering Change in Requirements

***Figure 8**: NCR Reports*

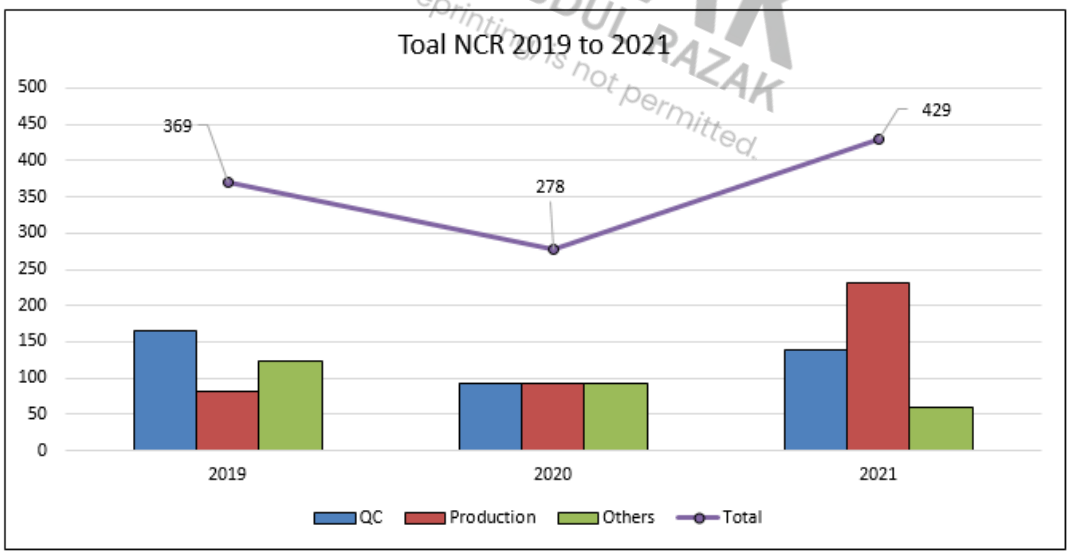


***Figure 9**: Total NCR & Operator Error for 3 years*

Annex 12 rev 01 at CRP-83 "Control of nonconforming products"

CAUSE CODES LEVEL 2 FOR PRODUCTS NONCONFORMITIES

Cause code from SAP	Cause name from SAP	Cause code Level 2	Cause name Level 2
In field "Cause"		In field "Cause text"	
1	Operator Error	101	Ineffectiveness of Training
		102	Missing Training
		103	Wrong Interpretation of Drawing
		104	Wrong Measurement
		105	Wrong Measuring Equipment Used
		106	Inspection Error
		107	Inconsistency (due to routine)
		108	Wrong Reading on Measuring Equipment
		109	Indiscipline
		110	Wrong Correction
		111	Wrong Setting of Part (positioning)
		112	Wrong Torch Preparation (Welding)
		113	Wrong Inter-pass Temperature (Welding)
		114	Use of Damaged tool
		115	Wrong Documentation
		116	Inappropriate Self-Inspection
		117	Operator Tool Crib Error
		118	Use of Worn Insert
		119	Used of Non-validated CNC program
		120	Inappropriate Deburring
		121	Incorrect Program Used by Master Machinist
		122	
2	Product Engineering Error	201	-
		202	Incomplete Specification / Drawing / Marking Instruction / ...
		203	Wrong Specification / Drawing / Marking Instruction / ...
		204	Missing Specification / Drawing / Marking Instruction / ... in BOM
		205	PN Not Revised
		206	
3	Routing Error	301	Missing Manufacturing Operation
		302	Missing Routing Verification
		303	Pour Verification of Routing
		304	Missing Inspection Operation
		305	Wrong Sequence in Routing

Cause code from SAP	Cause name from SAP	Cause code Level 2	Cause name Level 2
In field "Cause"		In field "Cause text"	
		306	
4	Storage Shipping Error	401	Wrong Protection
		402	Wrong Storage Condition
		403	Missing or Wrong Shipping Instructions
		404	Mixed Parts in Warehouse
		405	
5	Maintenance Error	501	Poor Maintenance
		502	Missing Maintenance
		503	
6	Quality Procedure Error	601	Unclear or Incomplete Procedure / Work Instruction
		602	Missing Procedure / Work Instruction
		603	
7	Quotation / Sales Error	701	Poor or Incomplete Customer Requirements Review at Quotation Stage
		702	Missing Customer Requirements Review at Order Stage
		703	Customer Requirements Not-transferred from Customer Order / Contract to SO
		704	
8	Planning Error	801	Customer Requirements Not-transferred from SO to WO
		802	
9	Vendor Error	901	Vendor Error
		902	
12	Purchasing Error	1201	Poor Management of CDR
		1202	Poor Management of NFI
14	Engineering Change in Requirements	1401	Major Revision
		1402	
15	Tooling Error	1501	Incorrect Tool Assembly
		1502	Broken Tap
		1503	Missing Maintenance of Tool

Cause code from SAP	Cause name from SAP	Cause code Level 2	Cause name Level 2
In field "Cause"		In field "Cause text"	
		306	
4	Storage Shipping Error	401	Wrong Protection
		402	Wrong Storage Condition
		403	Missing or Wrong Shipping Instructions
		404	Mixed Parts in Warehouse
		405	
5	Maintenance Error	501	Poor Maintenance
		502	Missing Maintenance
		503	
6	Quality Procedure Error	601	Unclear or Incomplete Procedure / Work Instruction
		602	Missing Procedure / Work Instruction
		603	
7	Quotation / Sales Error	701	Poor or Incomplete Customer Requirements Review at Quotation Stage
		702	Missing Customer Requirements Review at Order Stage
		703	Customer Requirements Not-transferred from Customer Order / Contract to SO
		704	
8	Planning Error	801	Customer Requirements Not-transferred from SO to WO
		802	
9	Vendor Error	901	Vendor Error
		902	
12	Purchasing Error	1201	Poor Management of CDR
		1202	Poor Management of NFI
14	Engineering Change in Requirements	1401	Major Revision
		1402	
15	Tooling Error	1501	Incorrect Tool Assembly
		1502	Broken Tap
		1503	Missing Maintenance of Tool

***Figure 10**: Annex 12 CRP-83 "Control of non-conforming product"*

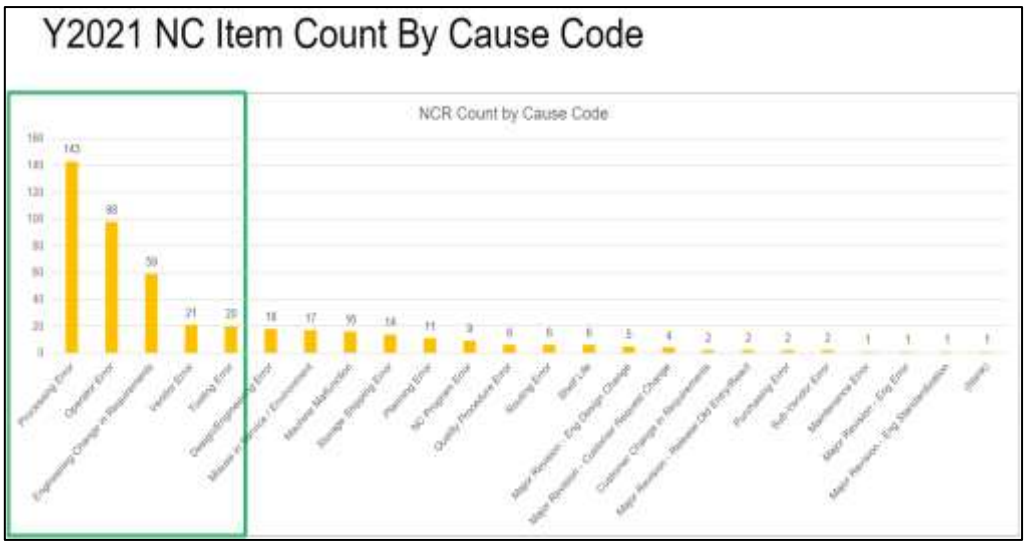


***Figure 11**: Nonconformance item by Cause Code*

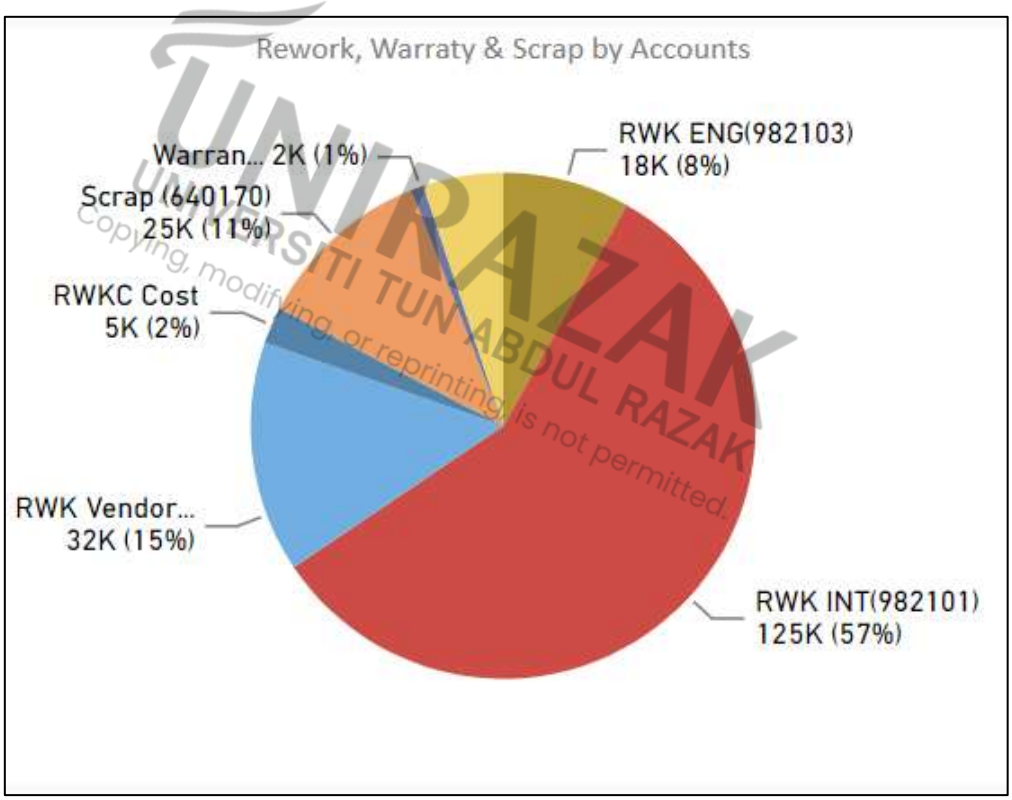


***Figure 12**: Cost of Non-Conformance*

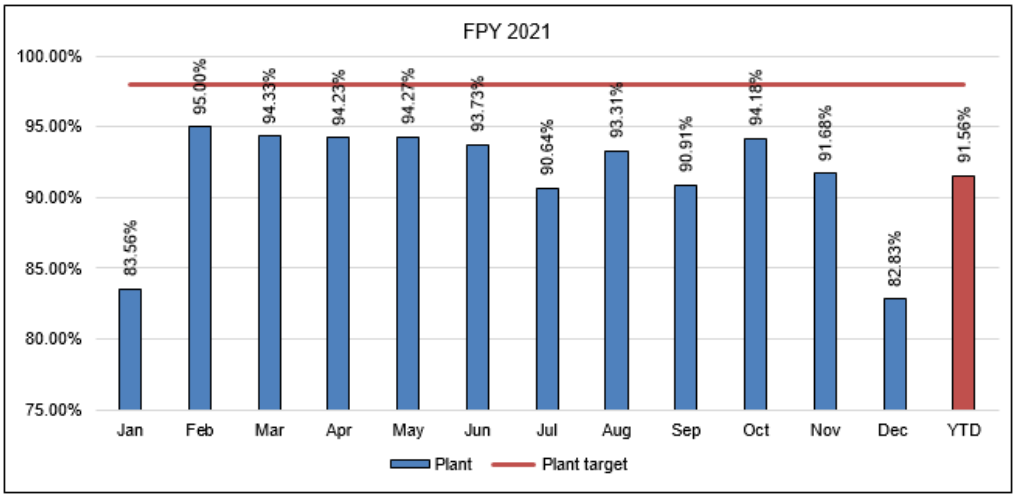


Figure 13: *First Pass Yield (FPY)*

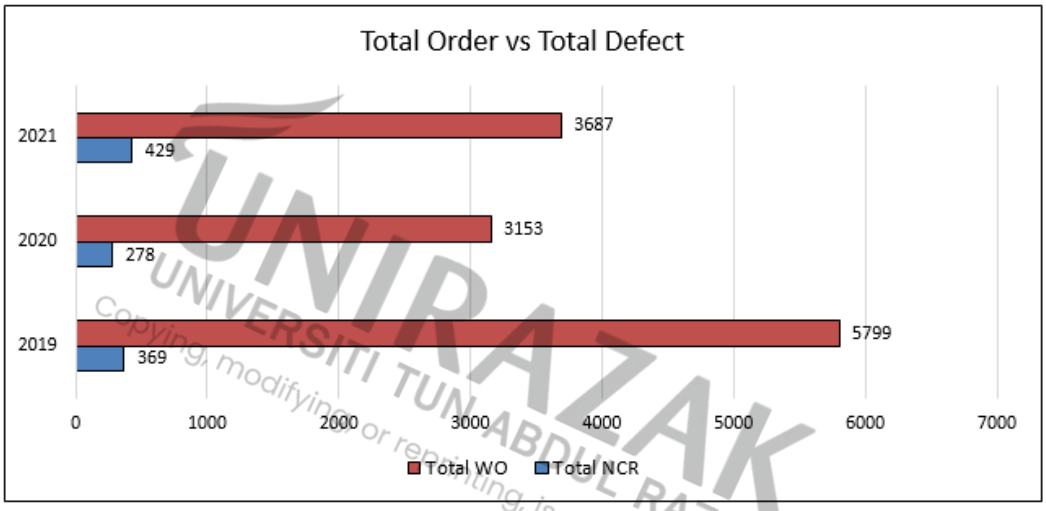


Figure 14*: Total order released to production vs total defect.*

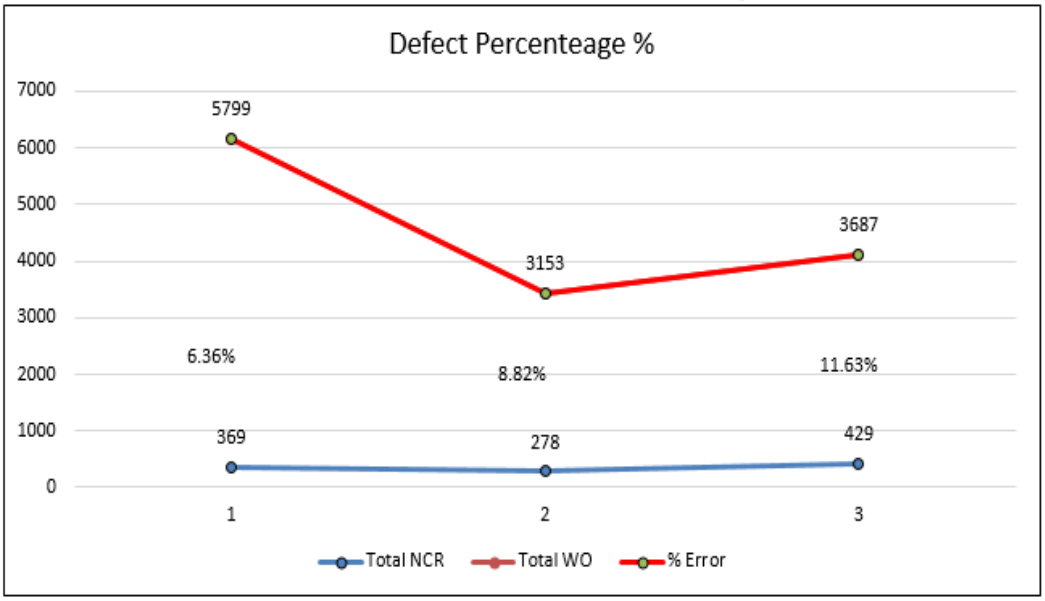


Figure 15*: Defect Percentage %.*

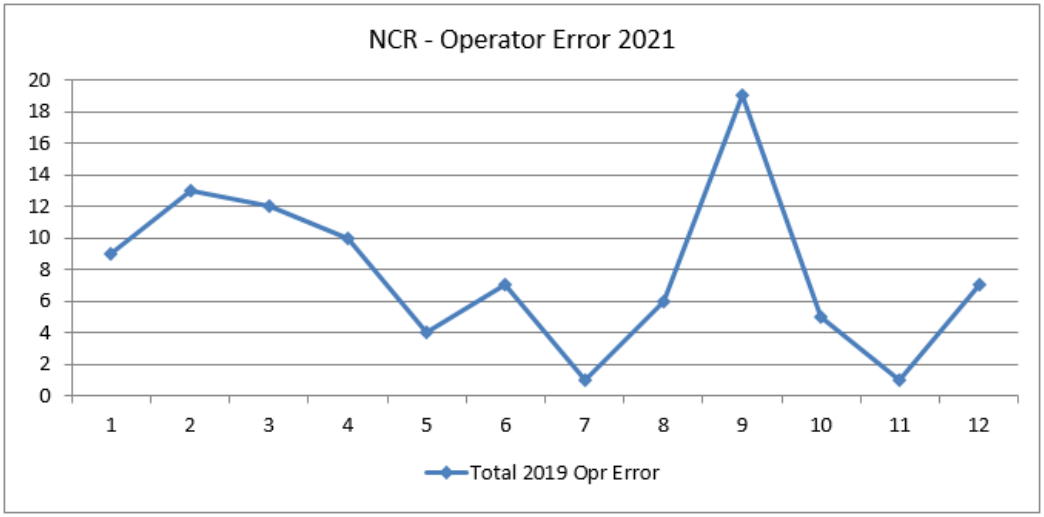


***Figure 16**: Total Operator Errors*

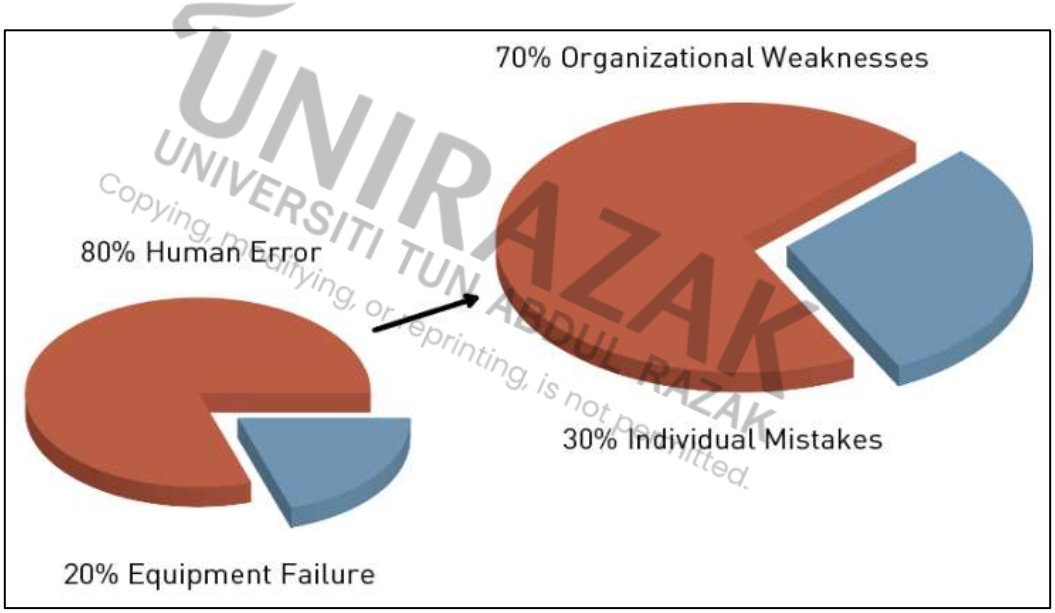


***Figure 17**: The Errors*

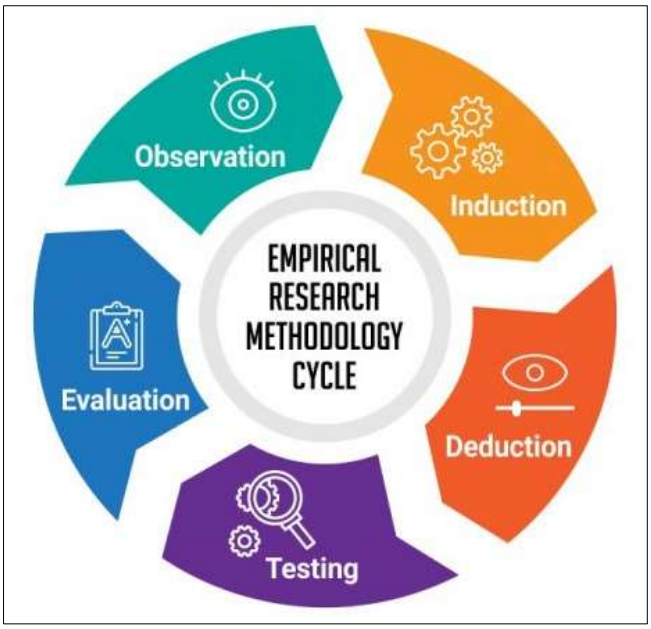


***Figure 18**: Empirical Research Methodology Cycle*

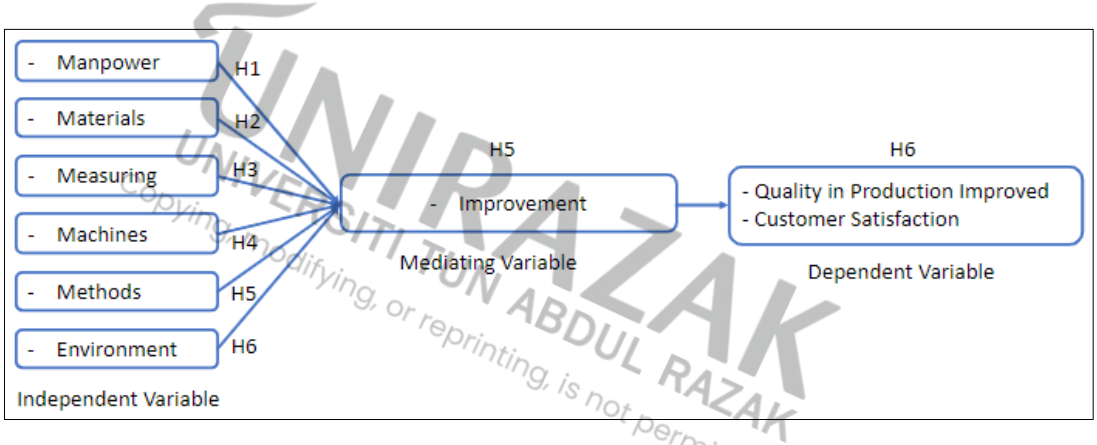


***Figure 19:** Conceptual Framework*

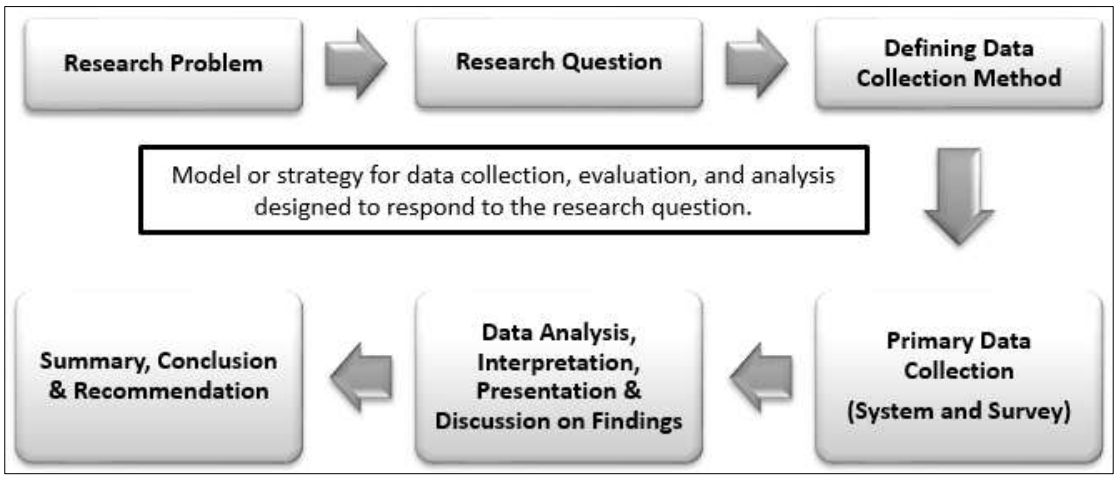


***Figure 20:** Research Design*

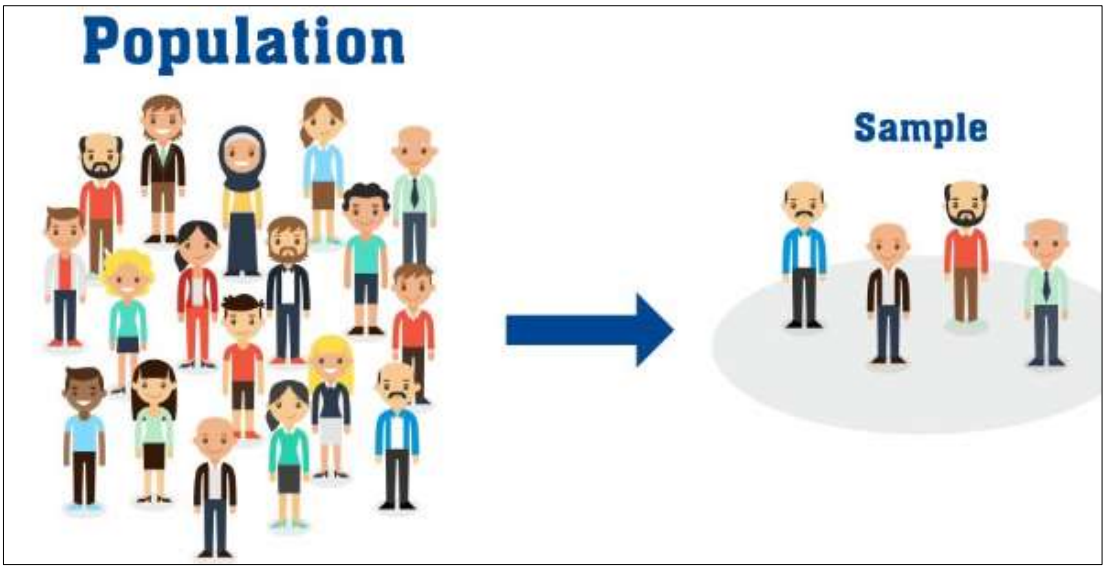


***Figure 21**: Probability Sampling Methods*

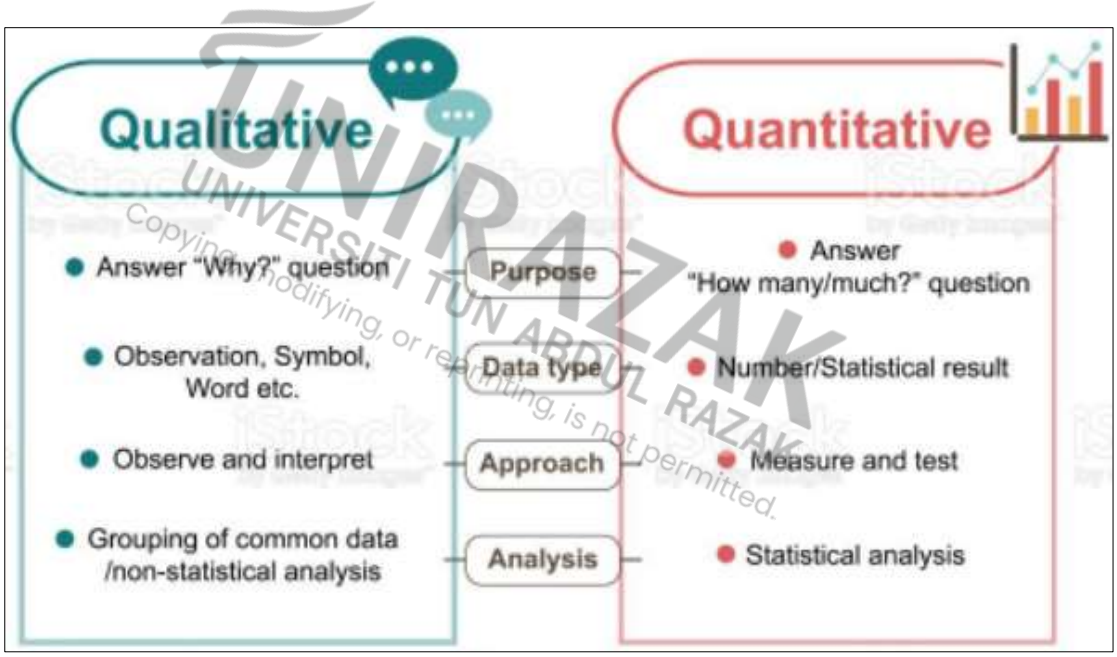


***Figure 22**: Quantitative Data Collection*

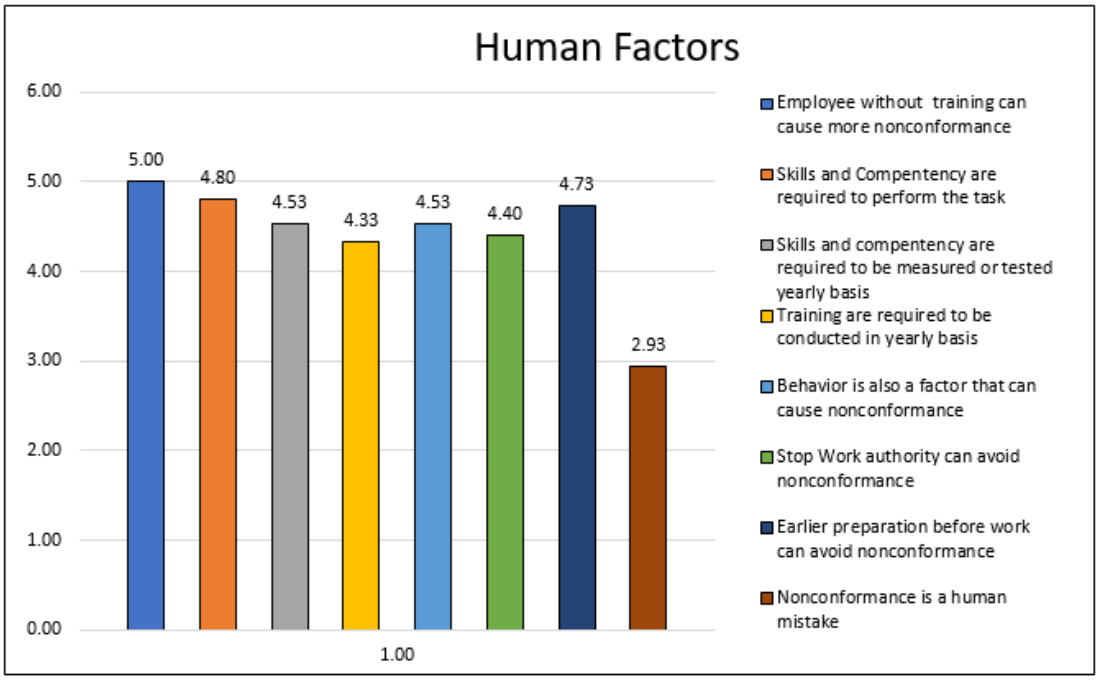


***Figure 23**: Survey data to Human Factors*

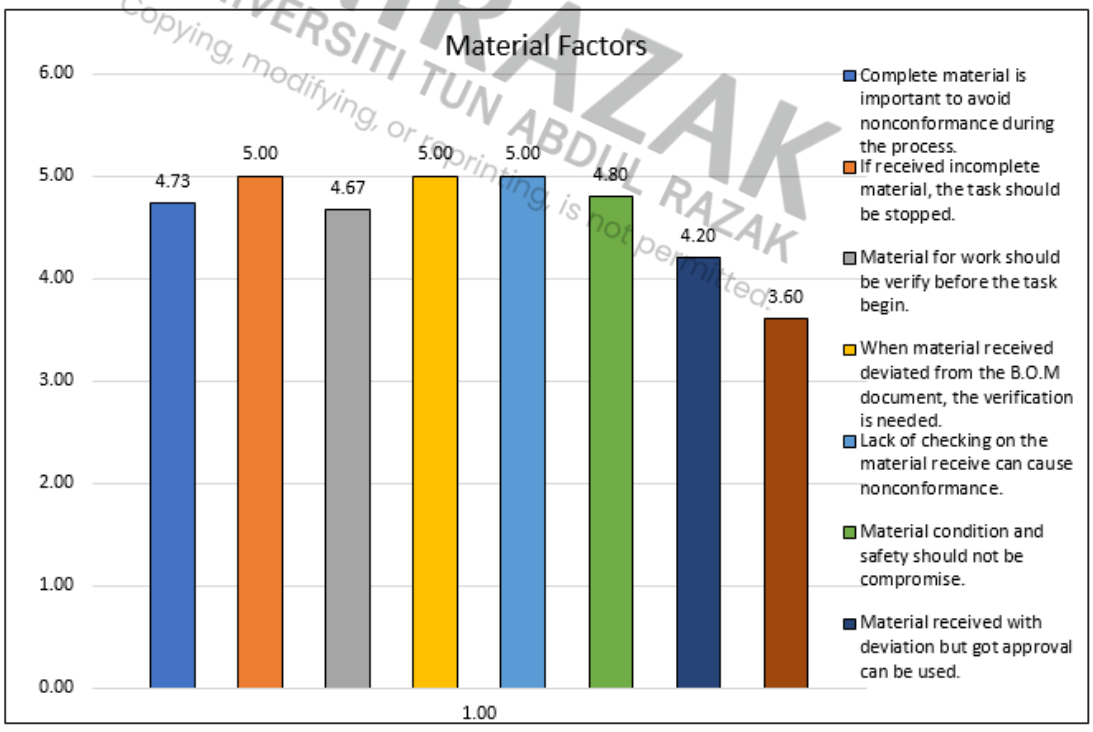


***Figure 24**: Survey data to Material Factors*

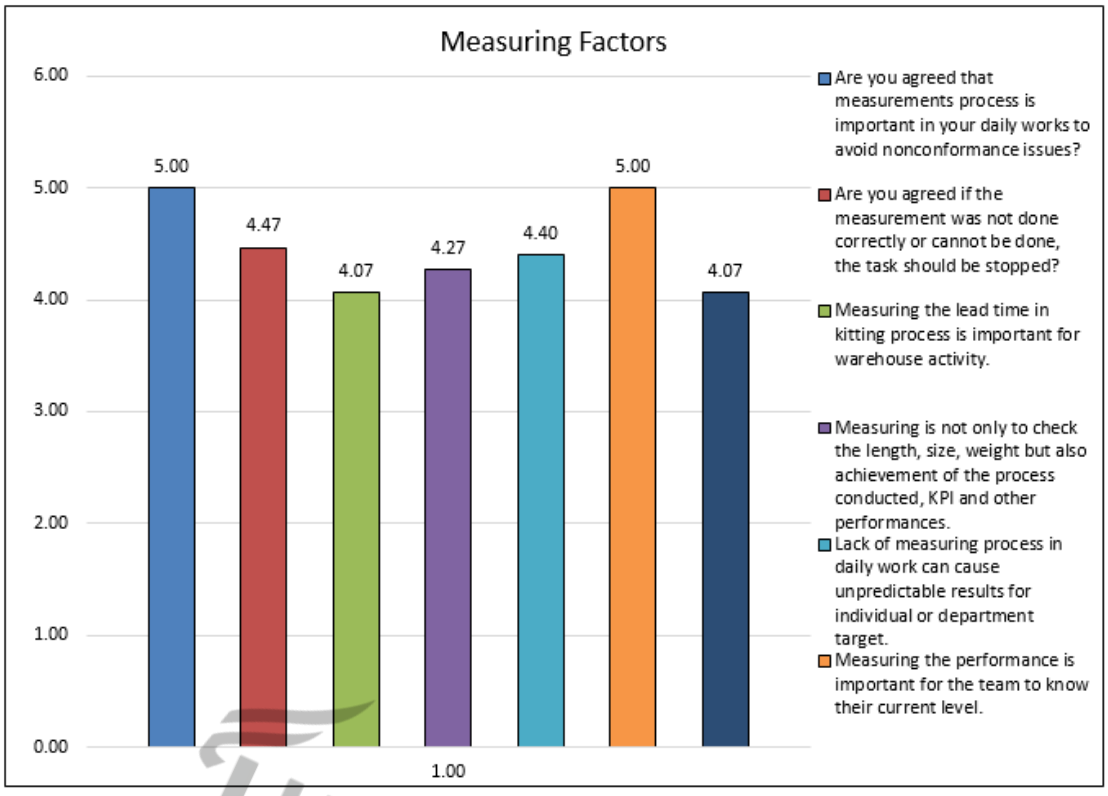


***Figure 25**: Survey data to Tools Factors*

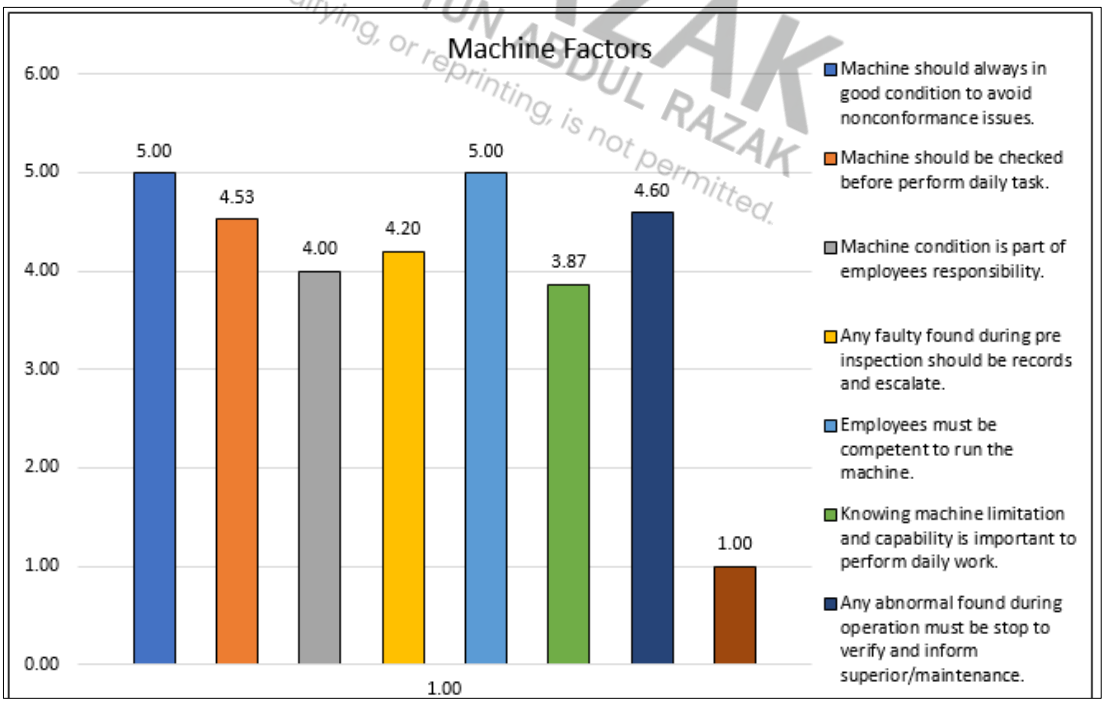


***Figure 26**: Survey data to Machines Factors*

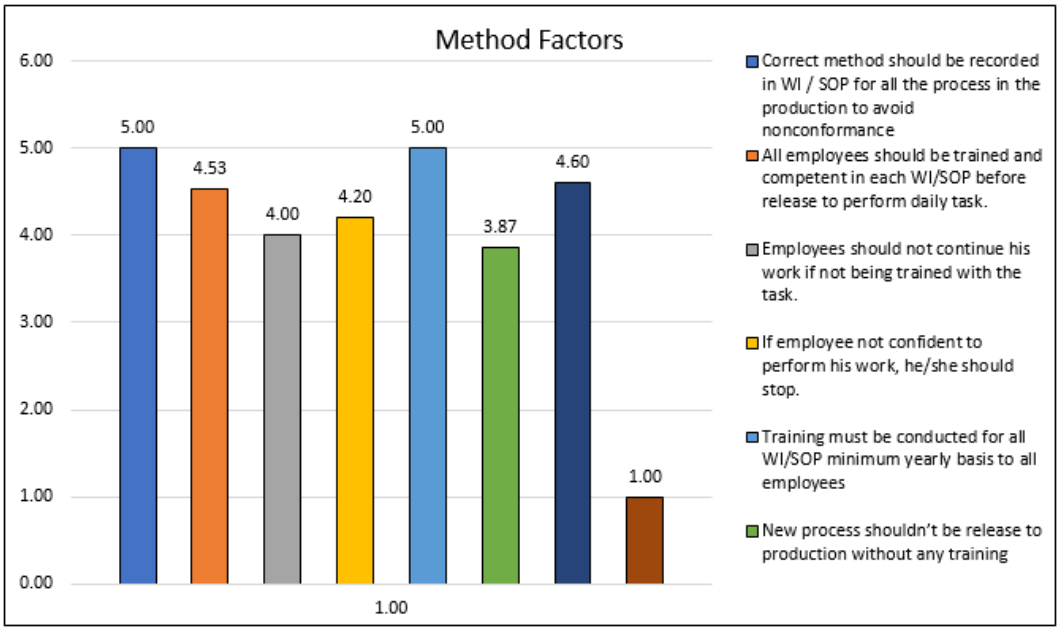


***Figure 27**: Survey data to Method Factors*

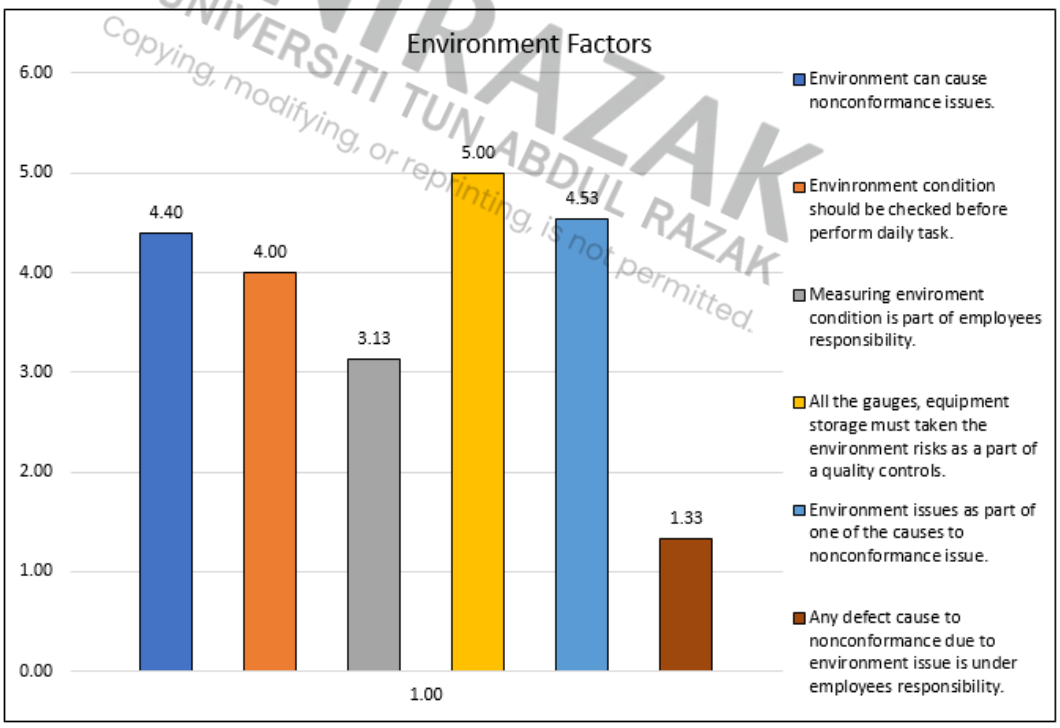


***Figure 28**: Survey data to Environment Factors*

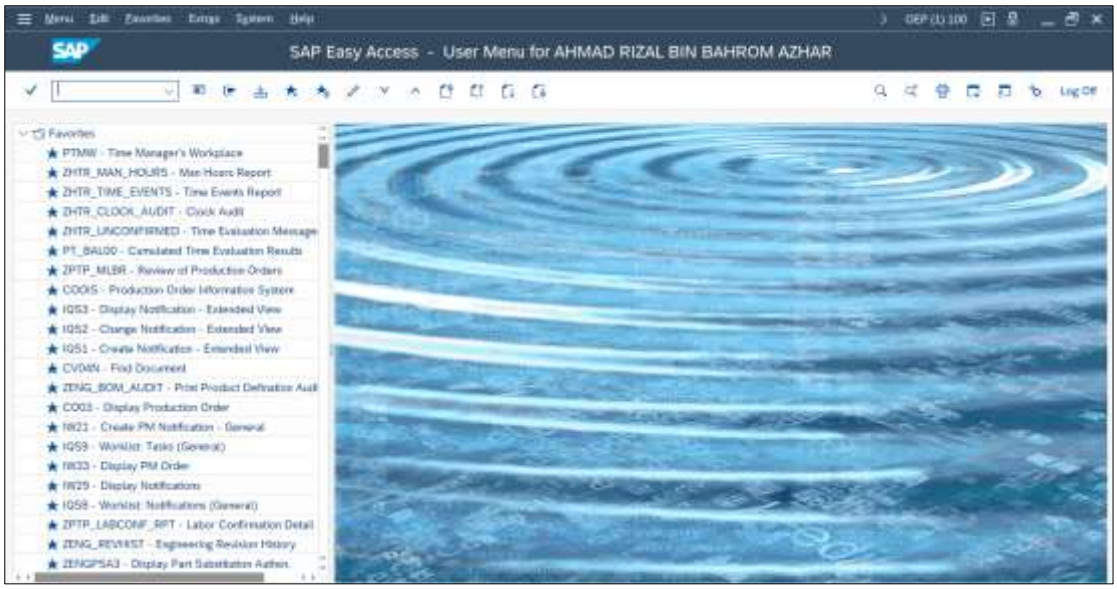


***Figure 29**: SAP - Front Pages*

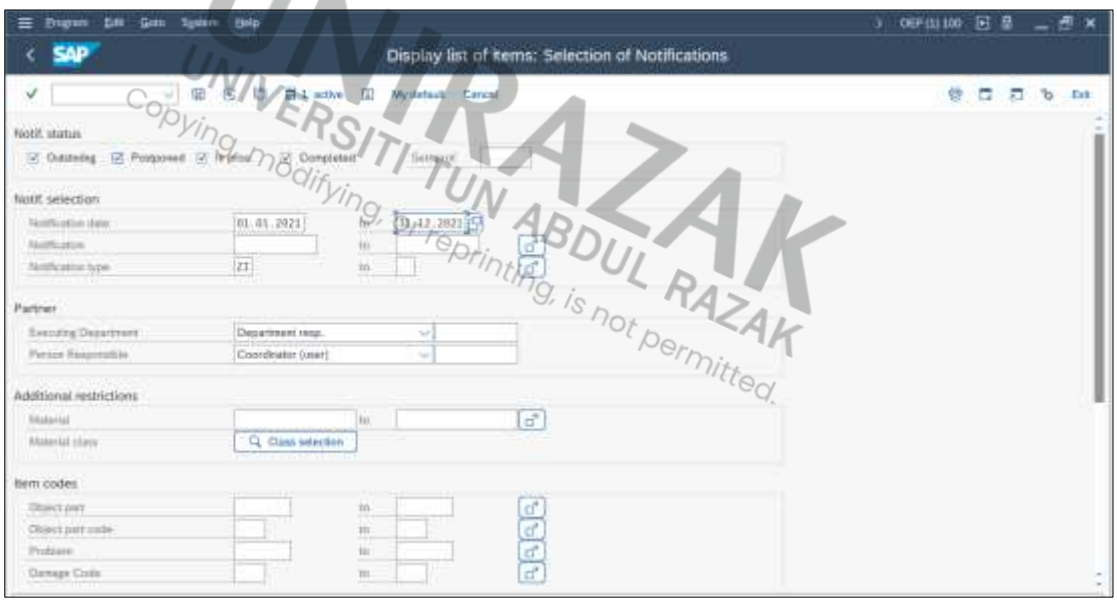


***Figure 30:** SAP- Transaction pages*

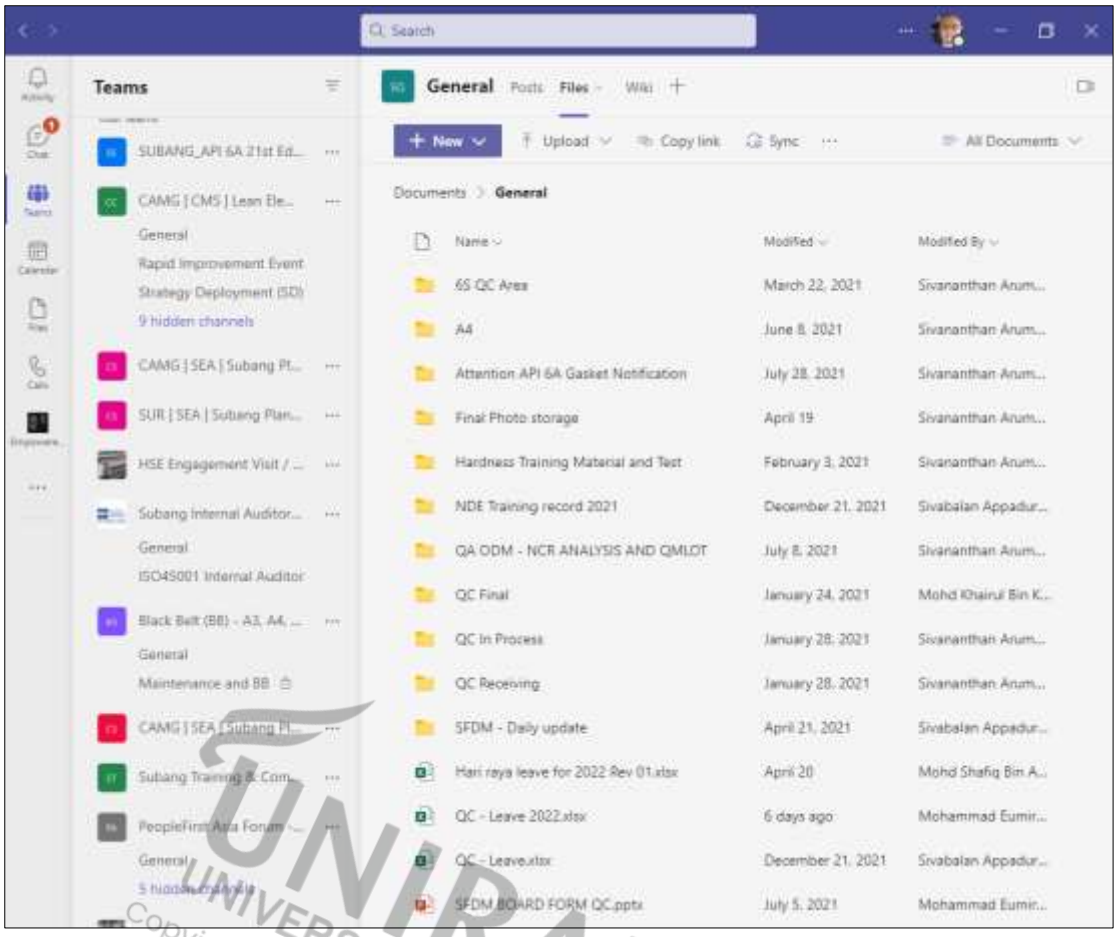


Figure 31: *Microsoft Team*

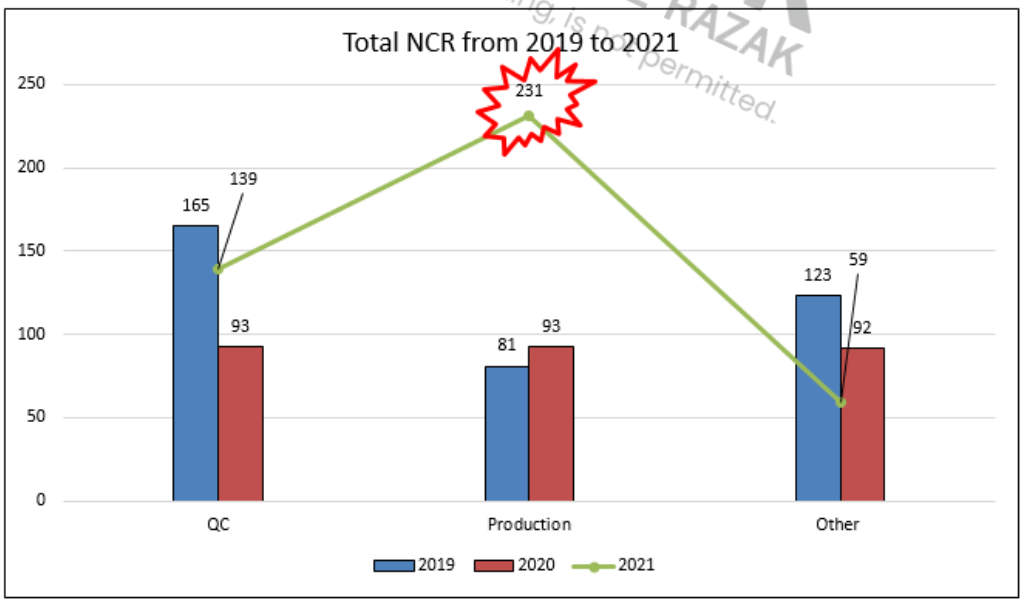


Figure 32*: Total NCRs in Production*

Row Labels	Sum of Count
Processing Error	143
Operator Error	98
Engineering Change in Requirements	59
VOID Notification	24
Vendor Error	21
Tooling Error	20
Design/Engineering Error	18
Misuse in Service / Environment	17
Machine Malfunction	16
Storage Shipping Error	14
Planning Error	11
NC Program Error	9
Quality Procedure Error	6
Routing Error	6
Shelf Life	6
Major Revision - Eng Design Change	5
Major Revision - Customer Request Change	4
Customer Change in Requirements	2
Major Revision - Release Old Entry/React	2
Purchasing Error	2
Sub-Vendor Error	2
Maintenance Error	1
Major Revision - Eng Error	1
Major Revision - Eng Standardization	1
(blank)	1
Grand Total	489

***Figure 33**: Total NCRs in Cameron Malaysia Sdn Bhd*

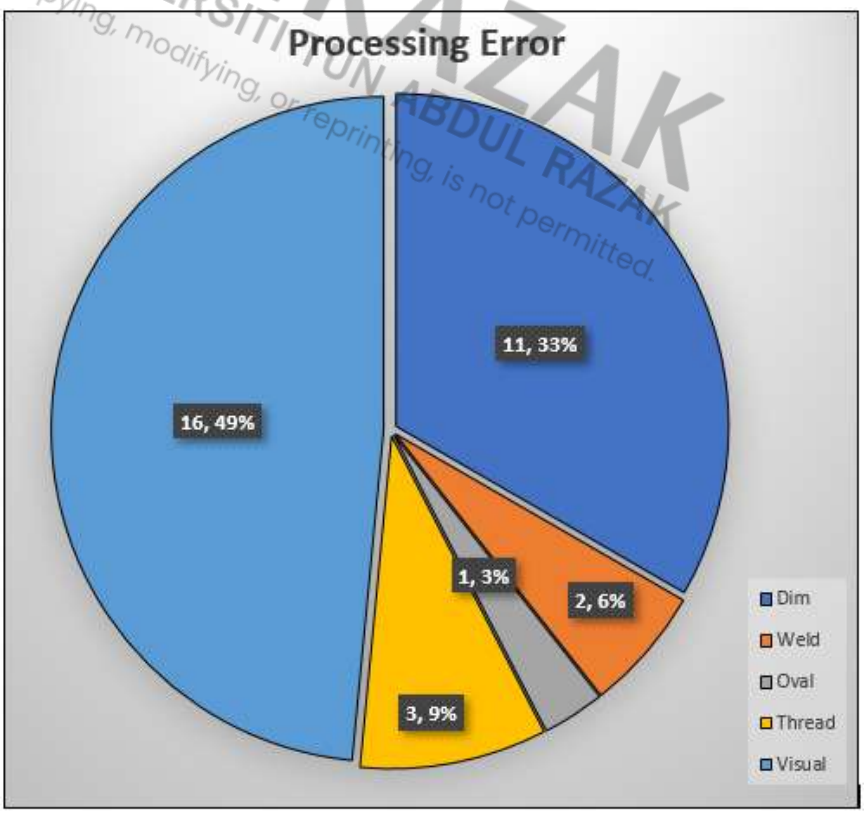


***Figure 34**: Processing Error vs Issue*

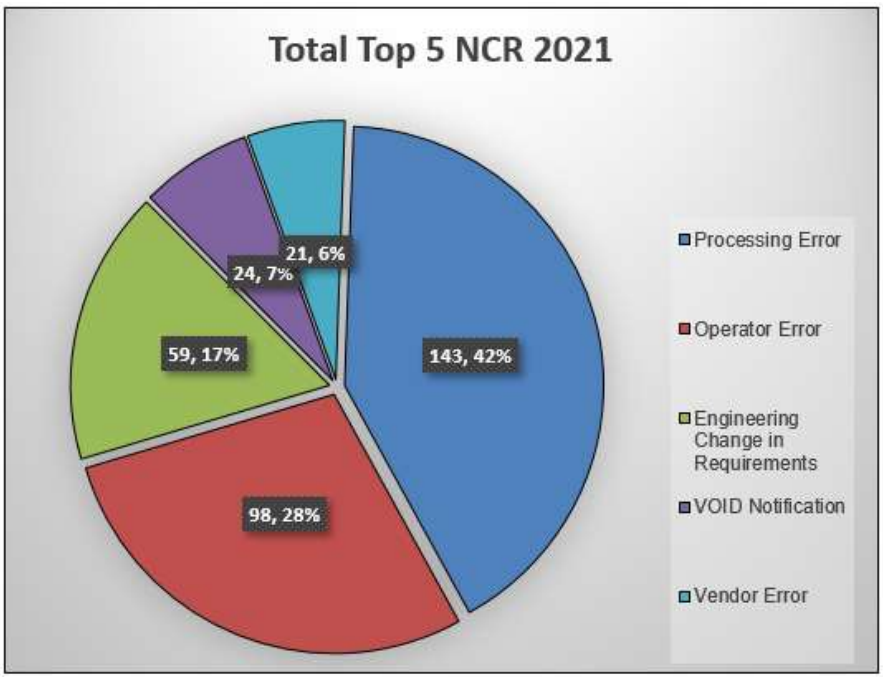


***Figure 35**: Top 5 NCRs in 2021 vs Issues*

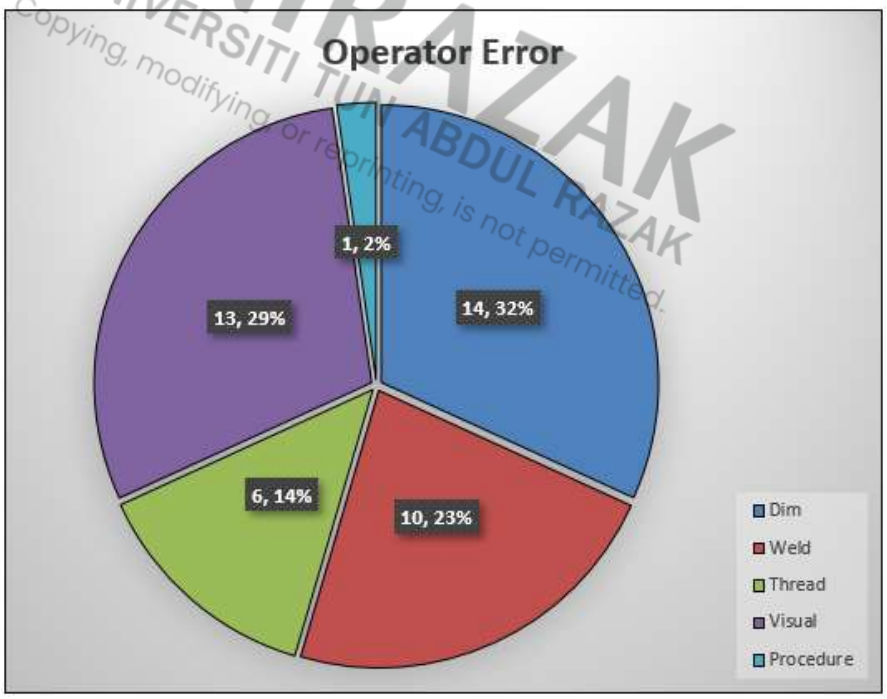


***Figure 36**: Total Operator Error vs Issues*

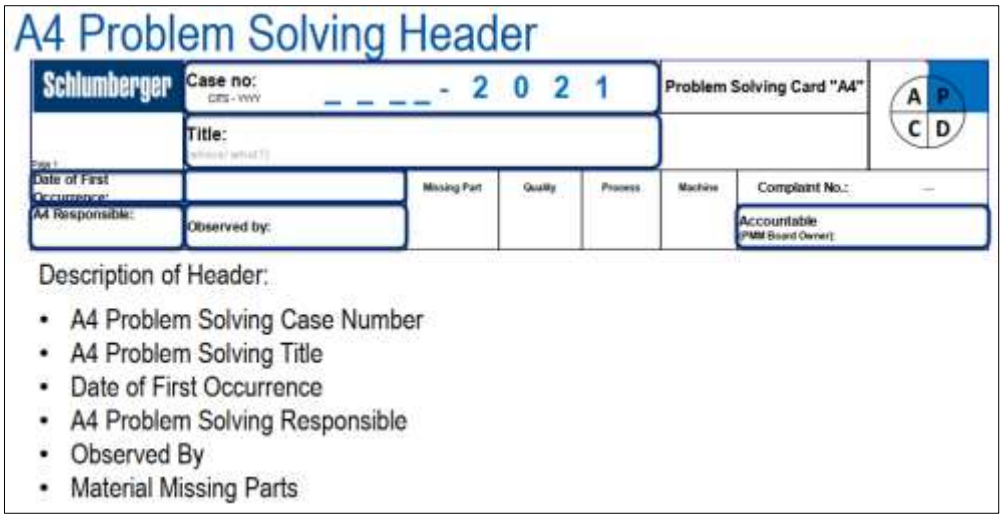


***Figure 37**: A4 - Header*

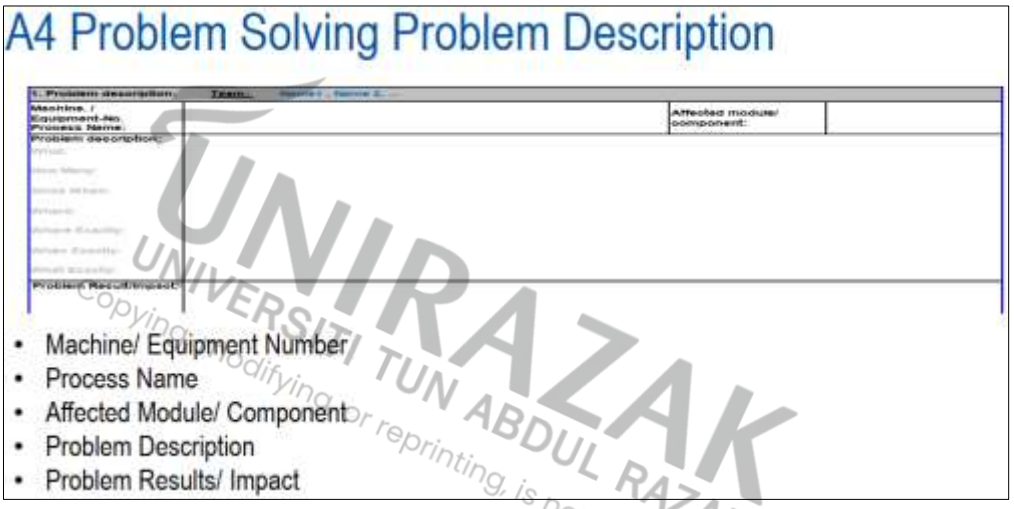


***Figure 38**: A4 - Description*

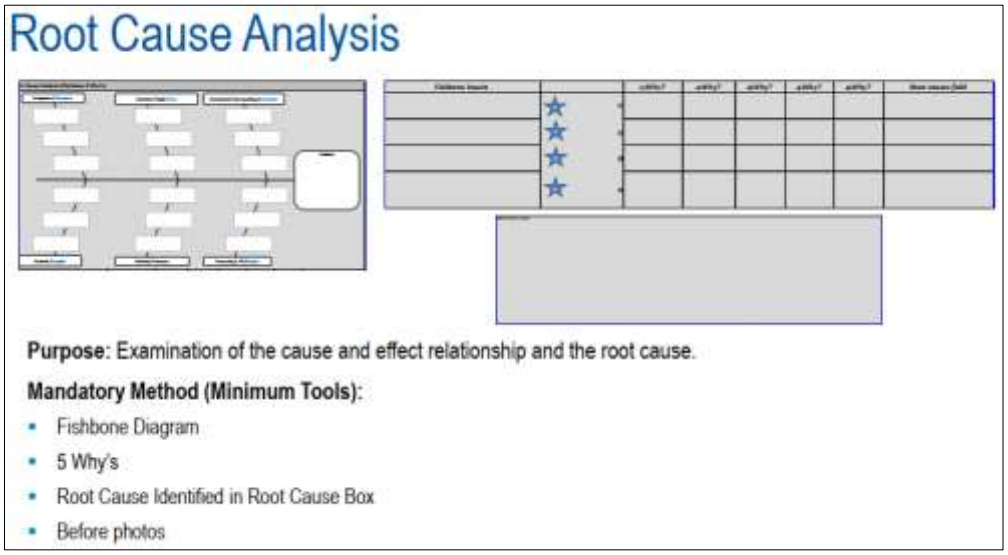


***Figure 39:** A4 - Root Cause Analysis*

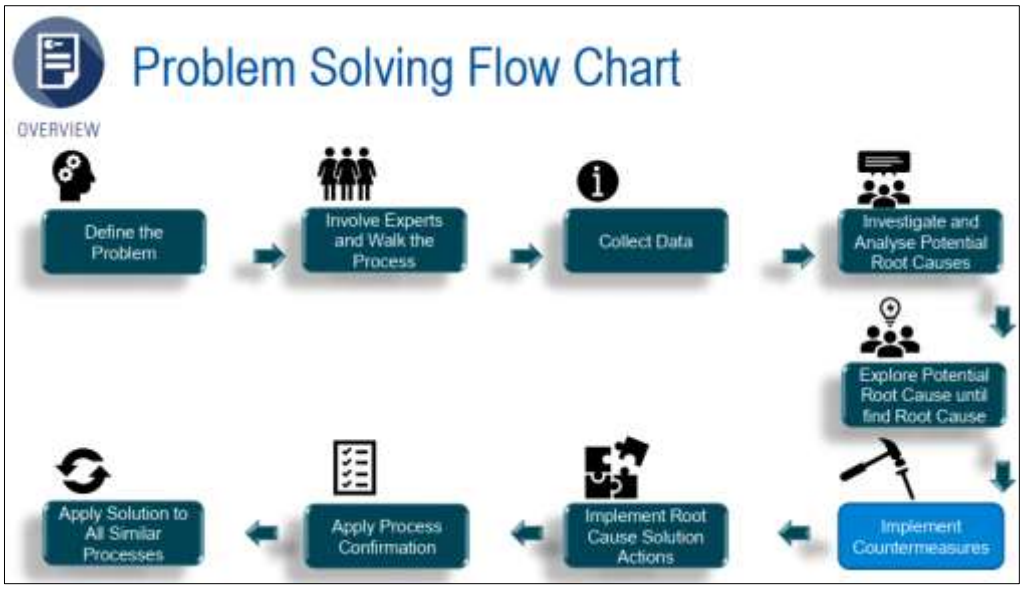


***Figure 40**: A4 - Counter Measure Flow Chart*

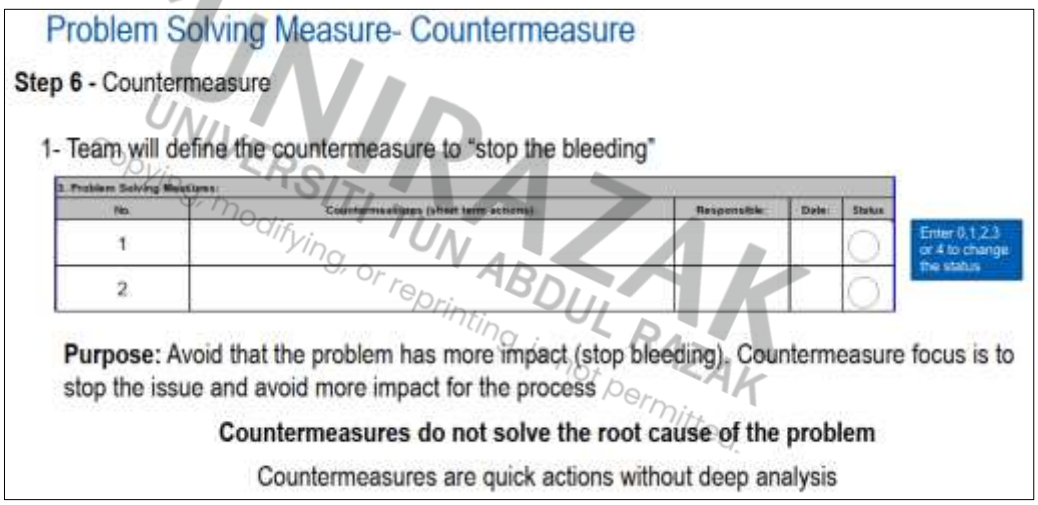


***Figure 41**: A4 - Counter Measure Actions*

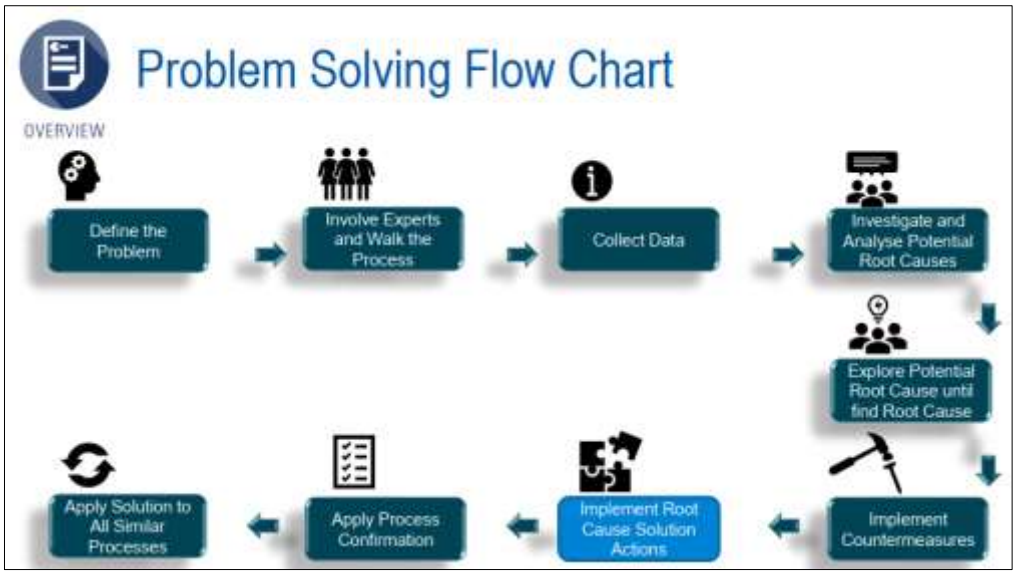


***Figure 42**: A4 - Root Cause Action Flow Chart*

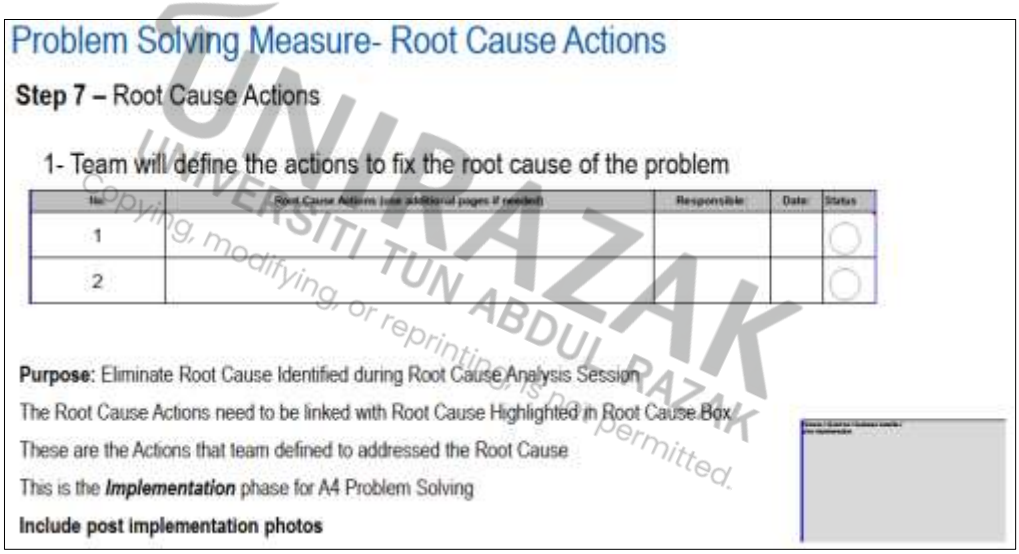


***Figure 43**: A4 - Root Cause Actions*

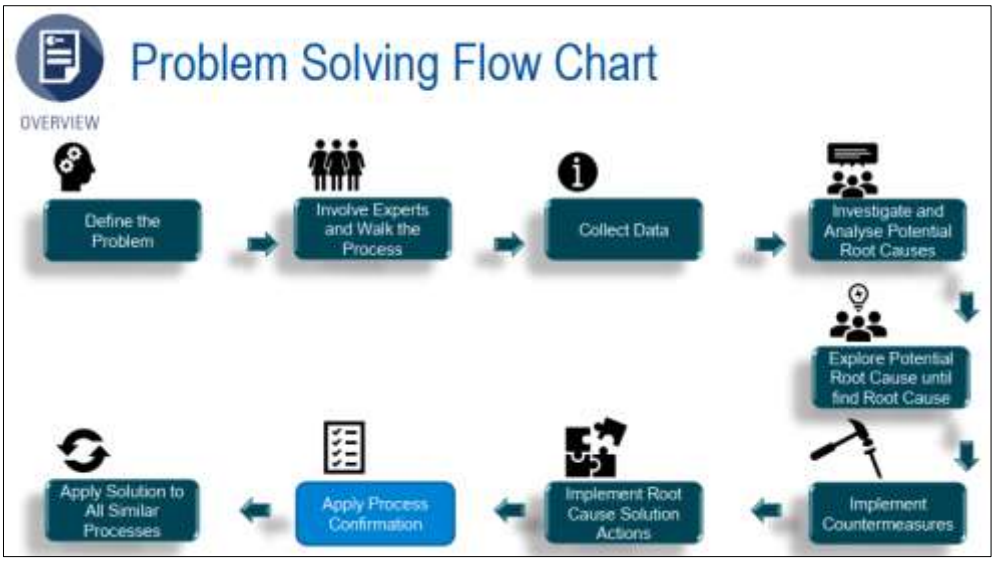


***Figure 44**: A4 - Process Confirmation Flow Chart*

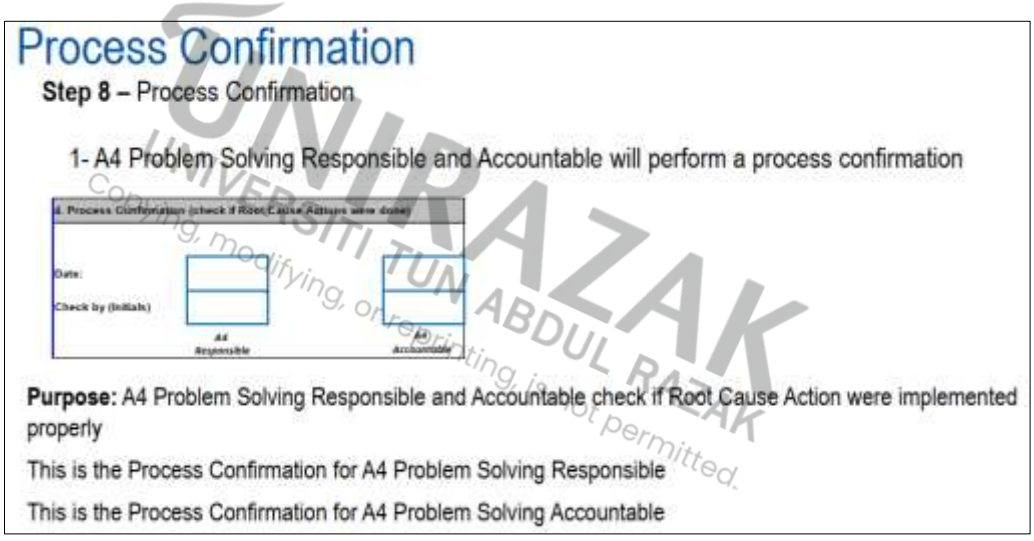


***Figure 45**: A4 - Process Confirmation*

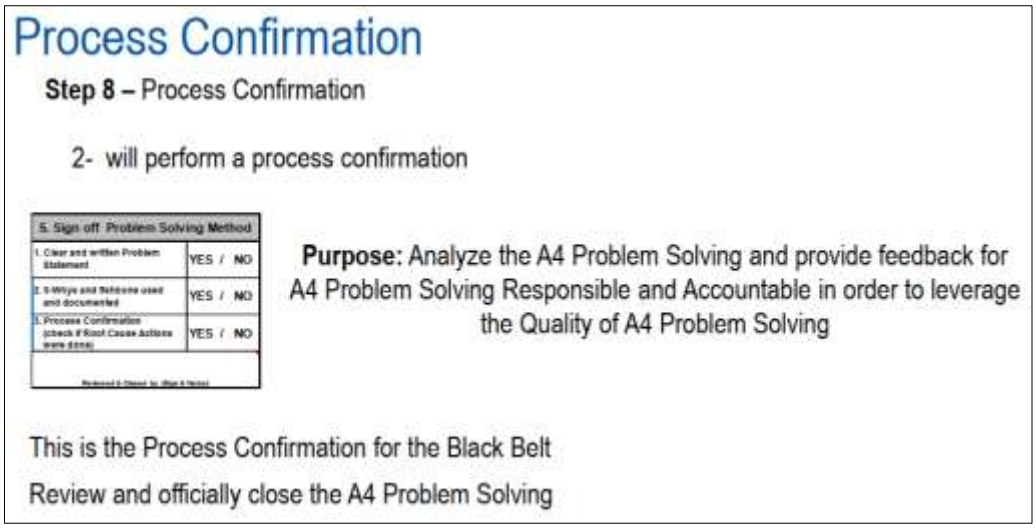


***Figure 46**: A4 - Process Confirmation by Black Belt (Lean Sigma Team)*

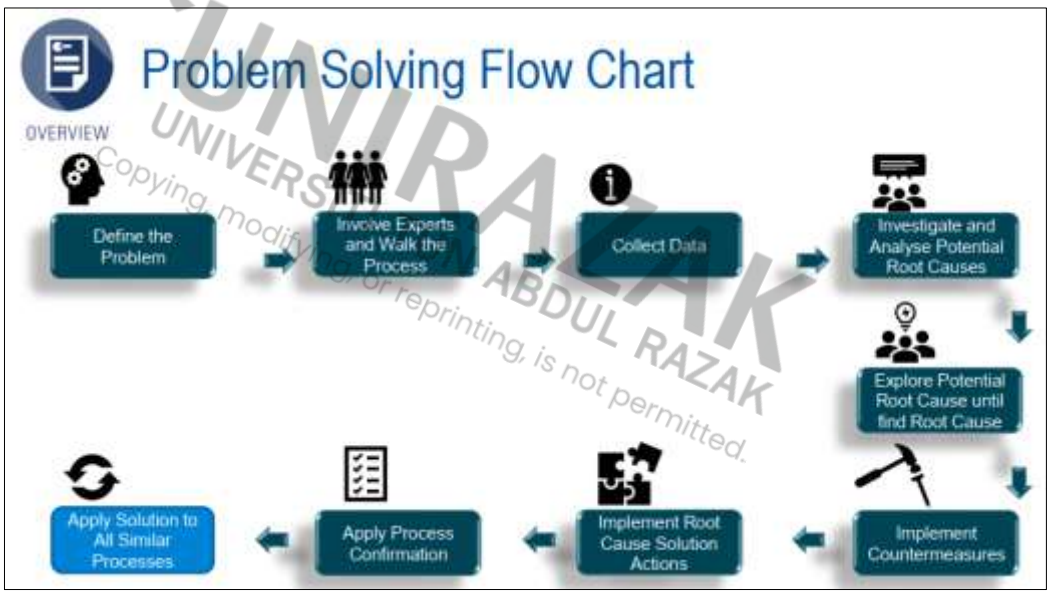
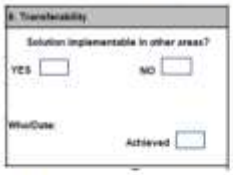


***Figure 47**: A4 - Apply Solution to All Similar Processes Flow Chart*

Solution is Applied in Other Areas?

Step 9 – Applying Solution to Similar Processes

1- A4 Problem Solving Accountable will check if solutions used for the Problem Solved is applicable to other processes



Purpose: A4 Problem Solving Accountable evaluates if Root Cause Actions defined could be implemented in difference process

- If it is not the case, no more actions are needed and ready to close
- If Problem Solving solution is "Transferable" (checked "Yes"), Problem Solving Accountable assigns Responsible Person, defines due date and tracks the progress on the transferred area's Countermeasure section
  - A new A4 Problem Solving is not needed to be created because all analyze was already done

***Figure 48**: A4 - Apply to Other Areas Confirmation*

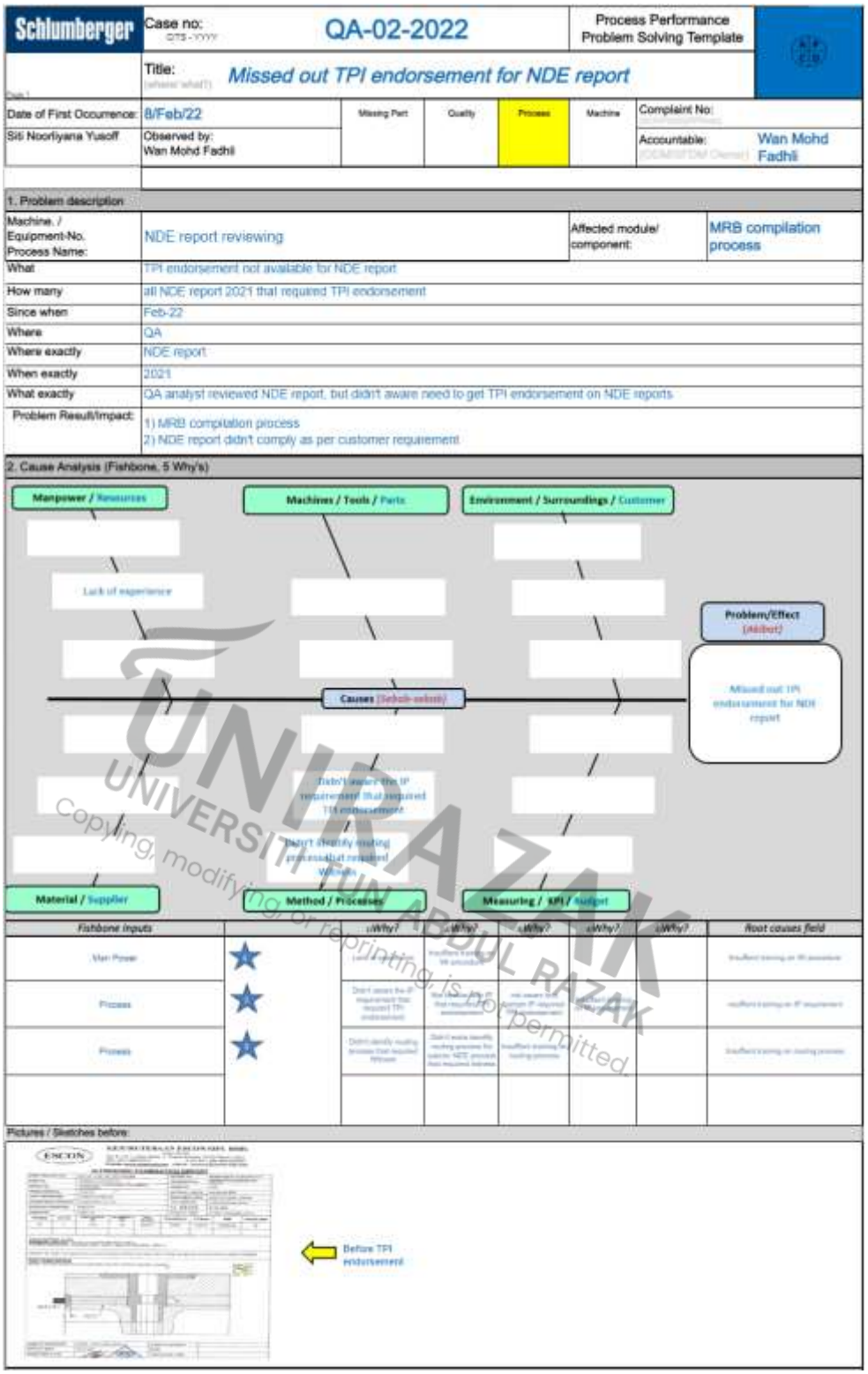


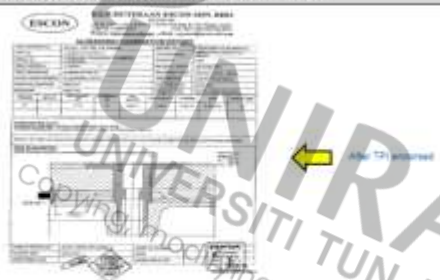
Figure 49: *Completed A4 - Section 1 & 2*

3. Problem Solving Measures:

No.	Countermeasures (short term actions):	Responsible:	Date:	Status
1	Print out all NDE report that required witnesses & approach TPI to endorse the reports	QA Analyst	11/02	
2	To identify IP requirement that required TPI endorsement.	QA Analyst	11/02	
3	To identify routing process that required witnesses for next NDE report review	QA Analyst	11/02	
4				
5				
6				

No.	Root Cause Actions (use additional pages if needed)	Responsible:	Date:	Status
1	QA responsibility print out the NDE report that required witnesses for TPI endorse the report	Yana QA Analyst	11/02	
2	To conduct refresher training on WI procedure, IP requirement & routing process to QA Analyst for awareness	AZMI, QA Engineer	2/Mar/22	
3				
4				
5				
6				

Pictures / Sketches / Business benefits / After implementation



4. Process Confirmation (check if Root Cause Actions were done)

Date: 18-Feb-22

Check by (Initials): Siti Noorliyana

Responsible

22-Feb-22

Wan Mohd Fadhli

Accountable

5. Sign off Problem Solving Method

1. Clear and written Problem Statement YES / NO

2. 5-Whys and fishbone used and documented YES / NO

3. Process Confirmation (check if Root Cause Actions were done) YES / NO

6. Transferability

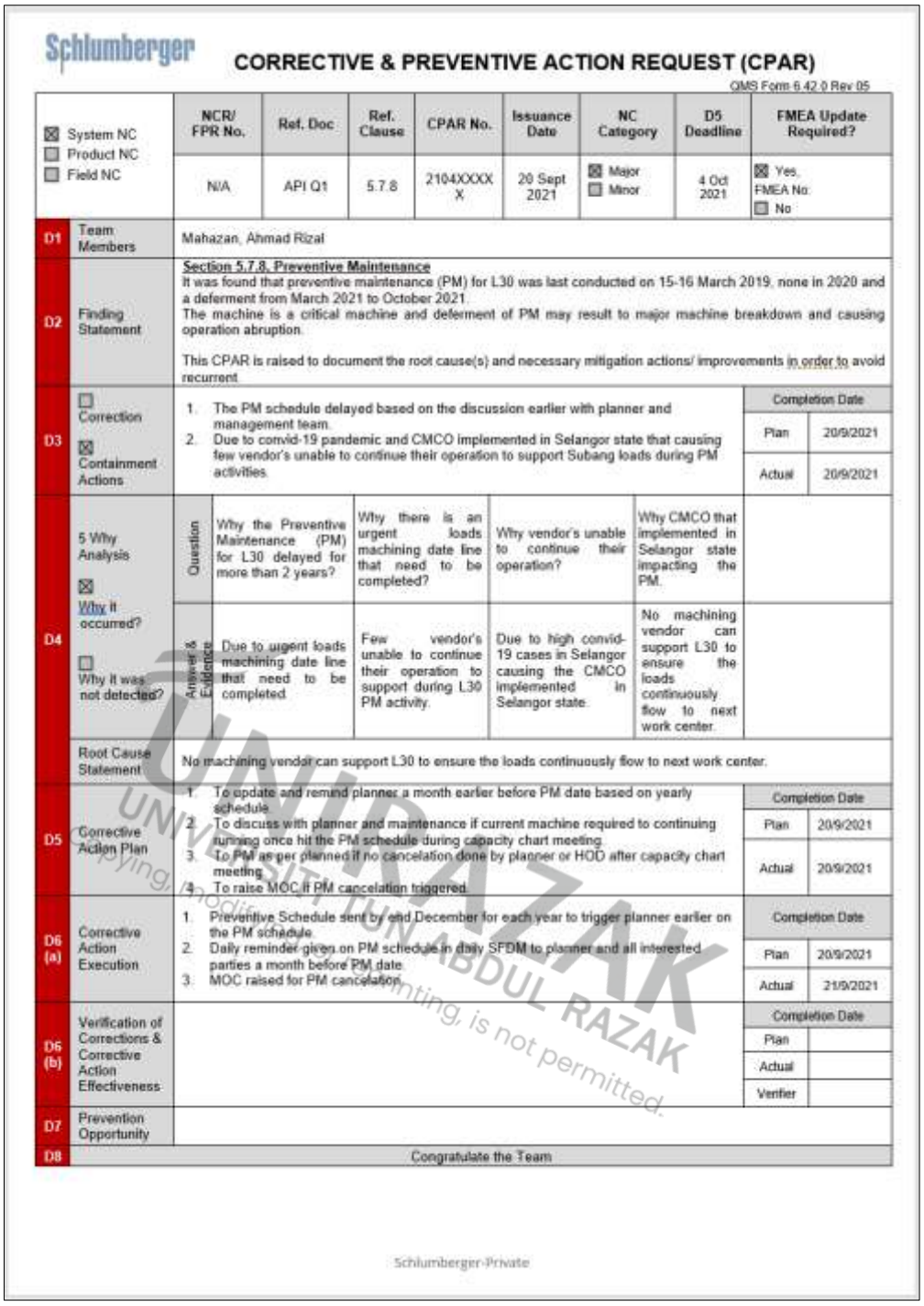
Solution implementable in other areas?

YES [ ] No [ ]

Who / Date:

Achieved [ ]

Figure 50: *A4 - Section 3 & 4*



Schlumberger

CORRECTIVE & PREVENTIVE ACTION REQUEST (CPAR)

QMS Form 6.42.0 Rev 05

☒ System NC ☐ Product NC ☐ Field NC	NCR/ FPR No.	Ref. Doc	Ref. Clause	CPAR No.	Issuance Date	NC Category	D5 Deadline	FMEA Update Required?
	N/A	API Q1	5.7.8	2104XXXX X	20 Sept 2021	☒ Major ☐ Minor	4 Oct 2021	☒ Yes, FMEA No: ☐ No

D1 Team Members: Mahazan, Ahmad Rizal

D2 Finding Statement:

Section 5.7.8, Preventive Maintenance

It was found that preventive maintenance (PM) for L30 was last conducted on 15-16 March 2019, none in 2020 and a deferment from March 2021 to October 2021.

The machine is a critical machine and deferment of PM may result to major machine breakdown and causing operation abruption.

This CPAR is raised to document the root cause(s) and necessary mitigation actions/ improvements in order to avoid recurrent.

D3 ☐ Correction ☒ Containment Actions

1. The PM schedule delayed based on the discussion earlier with planner and management team.
2. Due to convid-19 pandemic and CMCO implemented in Selangor state that causing few vendor's unable to continue their operation to support Subang loads during PM activities.

Completion Date	
Plan	20/9/2021
Actual	20/9/2021

D4 5 Why Analysis ☒ Why it occurred? ☐ Why it was not detected?

Question	Why the Preventive Maintenance (PM) for L30 delayed for more than 2 years?	Why there is an urgent loads machining date line that need to be completed?	Why vendor's unable to continue their operation?	Why CMCO that implemented in Selangor state impacting the PM.	
Answer & Evidence	Due to urgent loads machining date line that need to be completed.	Few vendor's unable to continue their operation to support during L30 PM activity.	Due to high convid-19 cases in Selangor causing the CMCO implemented in Selangor state.	No machining vendor can support L30 to ensure the loads continuously flow to next work center.	

Root Cause Statement: No machining vendor can support L30 to ensure the loads continuously flow to next work center.

D5 Corrective Action Plan:

1. To update and remind planner a month earlier before PM date based on yearly schedule.
2. To discuss with planner and maintenance if current machine required to continuing running once hit the PM schedule during capacity chart meeting.
3. To PM as per planned if no cancelation done by planner or HOD after capacity chart meeting.
4. To raise MOC if PM cancelation triggered.

Completion Date	
Plan	20/9/2021
Actual	20/9/2021

D6 (a) Corrective Action Execution:

1. Preventive Schedule sent by end December for each year to trigger planner earlier on the PM schedule.
2. Daily reminder given on PM schedule in daily SFDM to planner and all interested parties a month before PM date.
3. MOC raised for PM cancelation.

Completion Date	
Plan	20/9/2021
Actual	21/9/2021

D6 (b) Verification of Corrections & Corrective Action Effectiveness:

Completion Date	
Plan	
Actual	
Verifier	

D7 Prevention Opportunity:

D8 Congratulate the Team

Figure 51: *CPAR Form*

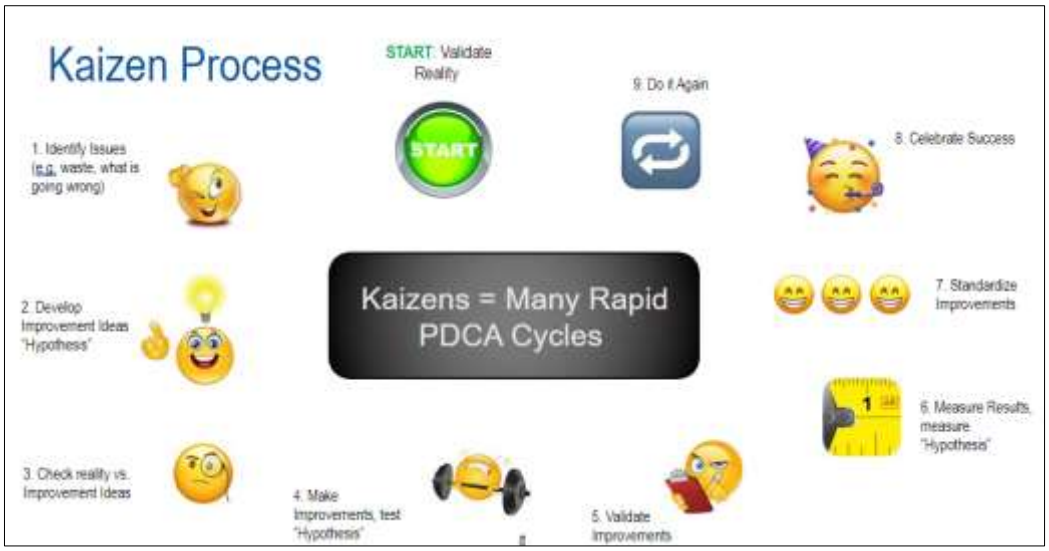


***Figure 52**: Kaizen Flow (1)*

***Figure 53**: Kaizen Flow (2)*

***Figure 54:** Summary of Kaizen Events*

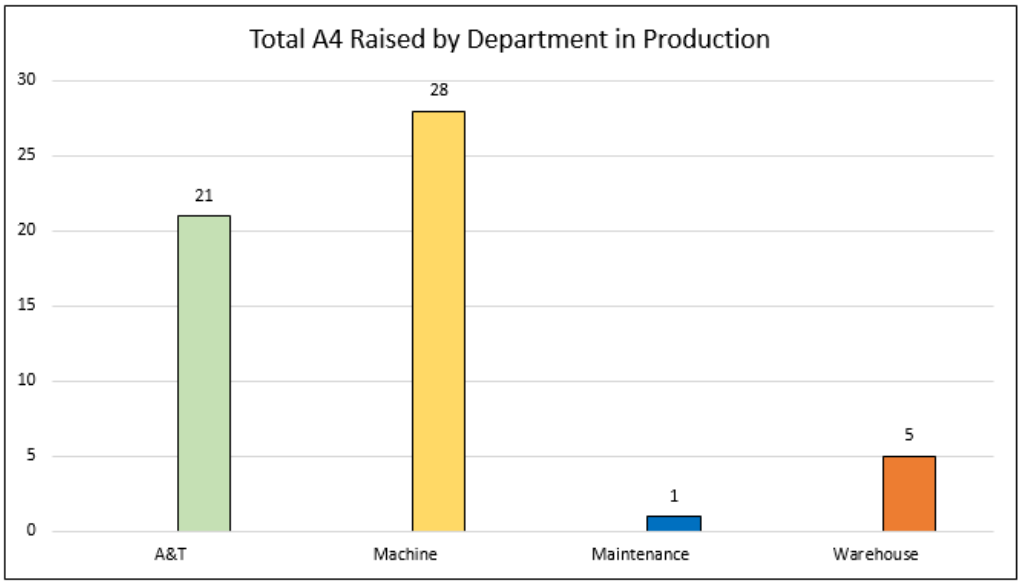


***Figure 55**: Total A4 raised in 2021*

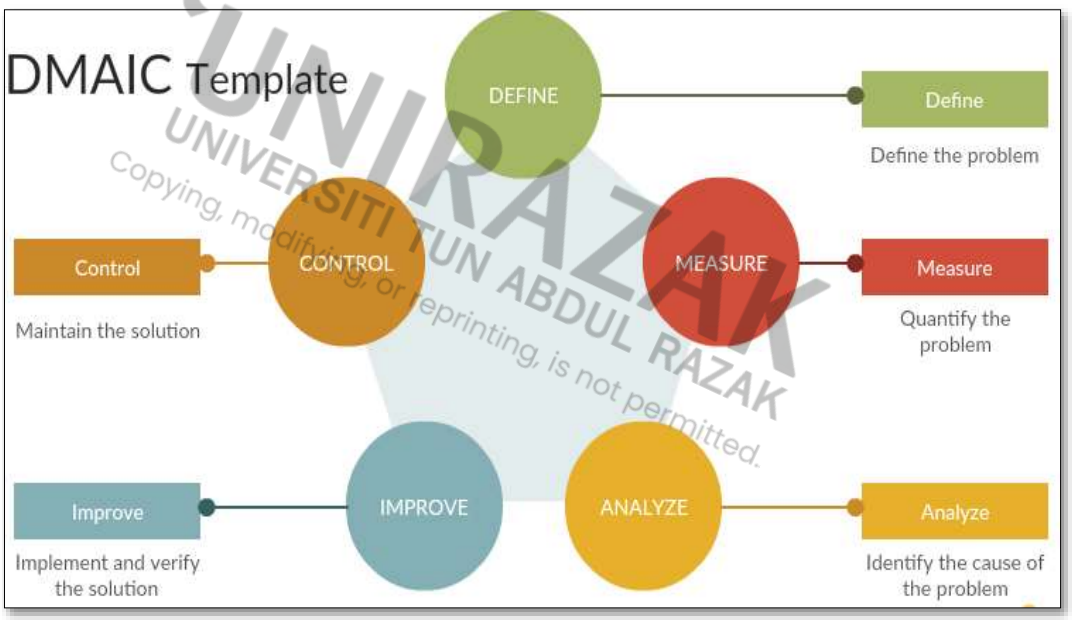


***Figure 56**: DMAIC - Define, Measure, Analyse, Improve & Control*

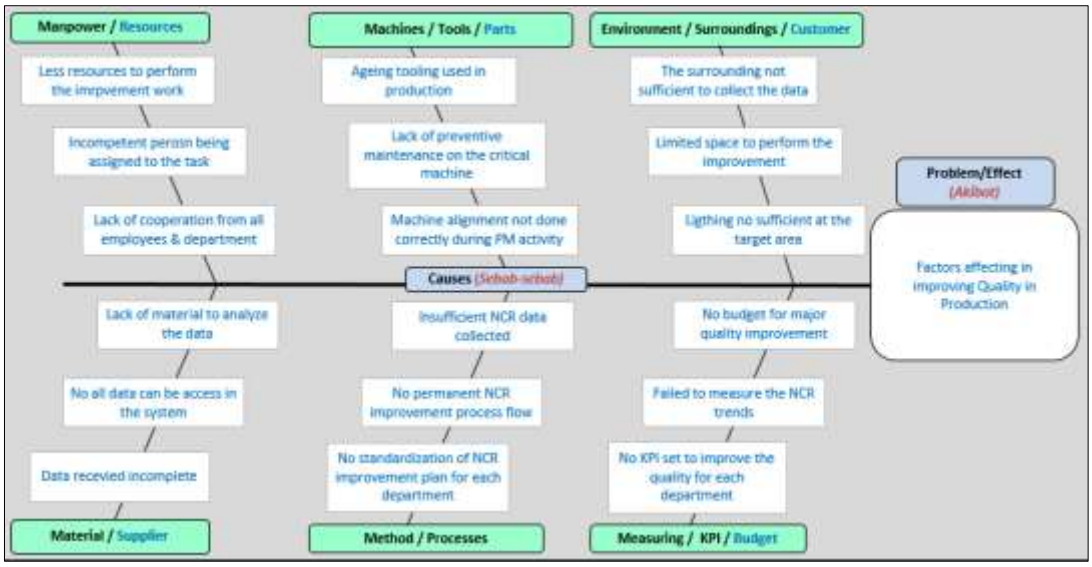


Figure 57: *Fishbone diagram and independent variables factors.*

Fishbone Inputs		1) Why?	2) Why?	3) Why?	4) Why?	5) Why?	Root causes field
No KPI set to improve the quality for each department	1	Each department having different KPI based on Goal setting target	No instruction for each Department to set quality as their KPIs target	Not all having the high nonconformance records	This allow them to skip the Quality KPIs from their Goal Setting target		KPIs should bea standard KPIs for all department
Insufficient NCR data collection	2	Not all data can be access through SAP	Each employees having limited access to SAP transaction code	To secure the sensitive data fromunauthorize person	The data can be used by the competitor		Need to request the access and HOD will justify the needs
Lack of cooperation from all employees & department	3	Not all willing to participate in the improvement circle event	Less manpower in the department with high workload	Focusing on fast running process which affecting bigger KPIs for the company			Required HOD supports
No standardization of NCR improvement plan for each department	4	Not all department required to conduct improvement event	Not all competent to conduct the improvement event	Al has assigned to Lean Sigma Black Belt	Lean Sigma Black Belt will triggered the improvement events	As part of his/her schedule and work scope	BB will triggered the event and HOD will notify their team

Figure 58: *Brainstorming Process.*

No.	Root Cause Actions (use additional pages if needed)	Responsible:	Date:	Status
1	Request to each HOD (Head of Departm,ent) to update Quality as part of department KPIs target	All HOD	30/6/2022	
2	Request access through SAP and rquired approval from HOD.	All Dept. Supervisor	30/6/2022	
3	Request HOD to get their team support for any improvement session conducted in Cameron Subang	Black Belt	30/6/2022	
4	Black Belt to discuss with all HOD on any potential improvement process can be conducted under their department.	Black Belt	30/6/2022	

Figure 59: *Root Cause Actions.*

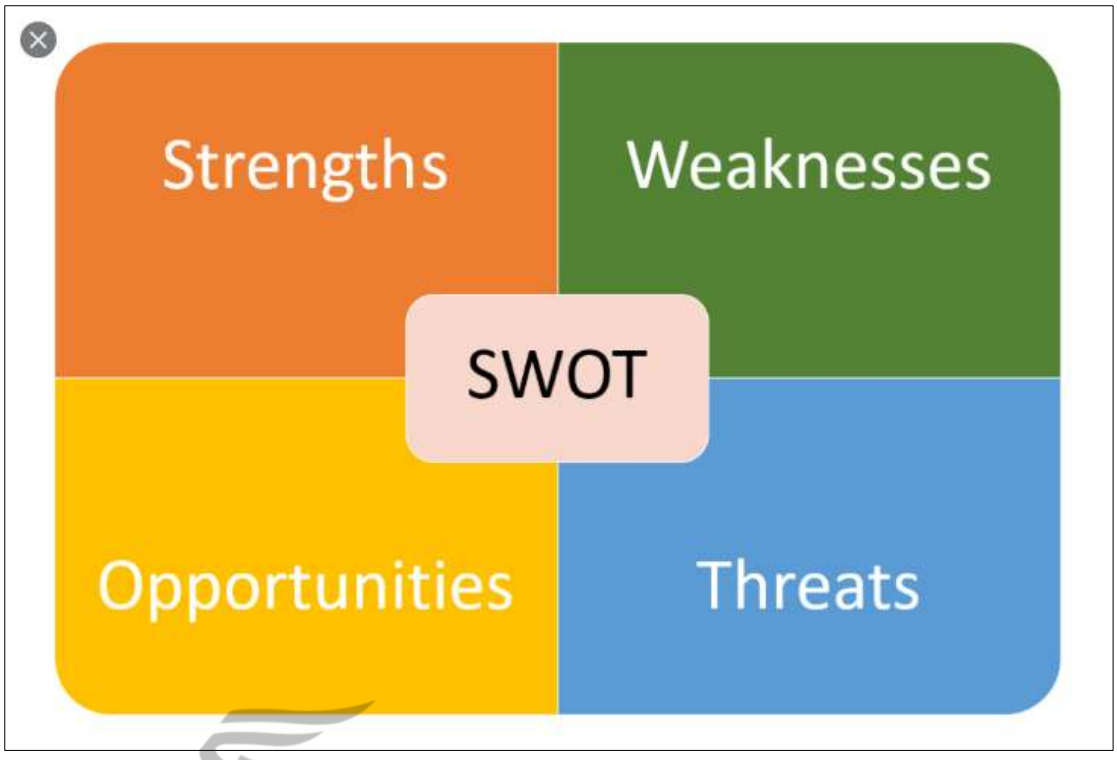


***Figure 60**: SWOT - Strength, Weakness, Opportunities & Treats.*

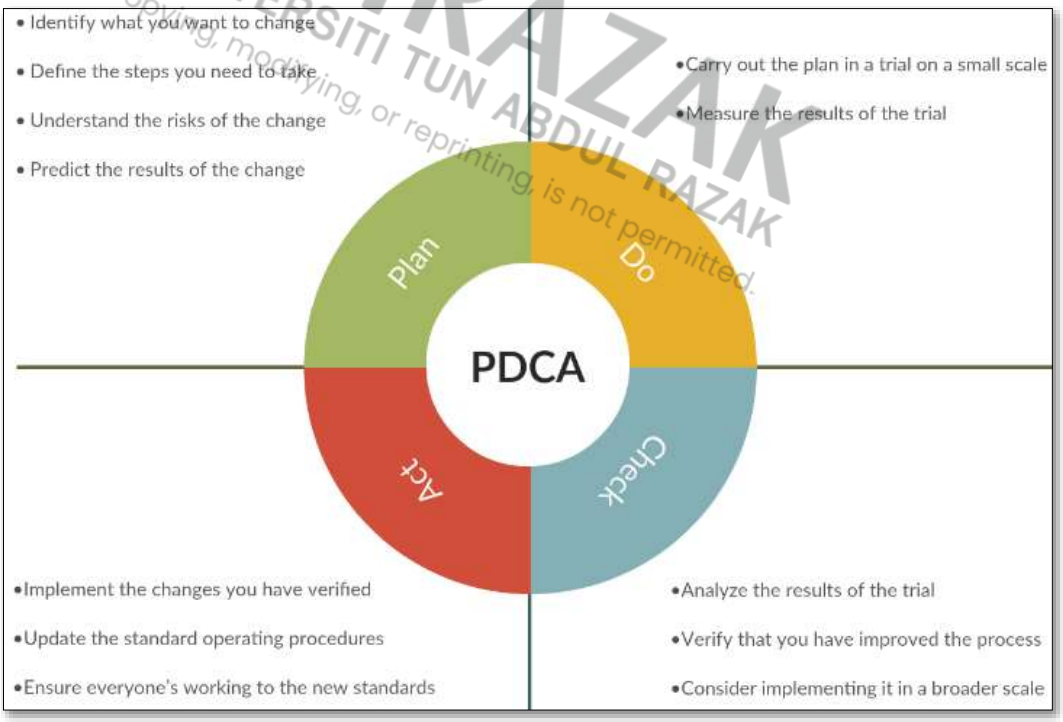


***Figure 61**: PDCA - Plan, Do, Check and Action.*

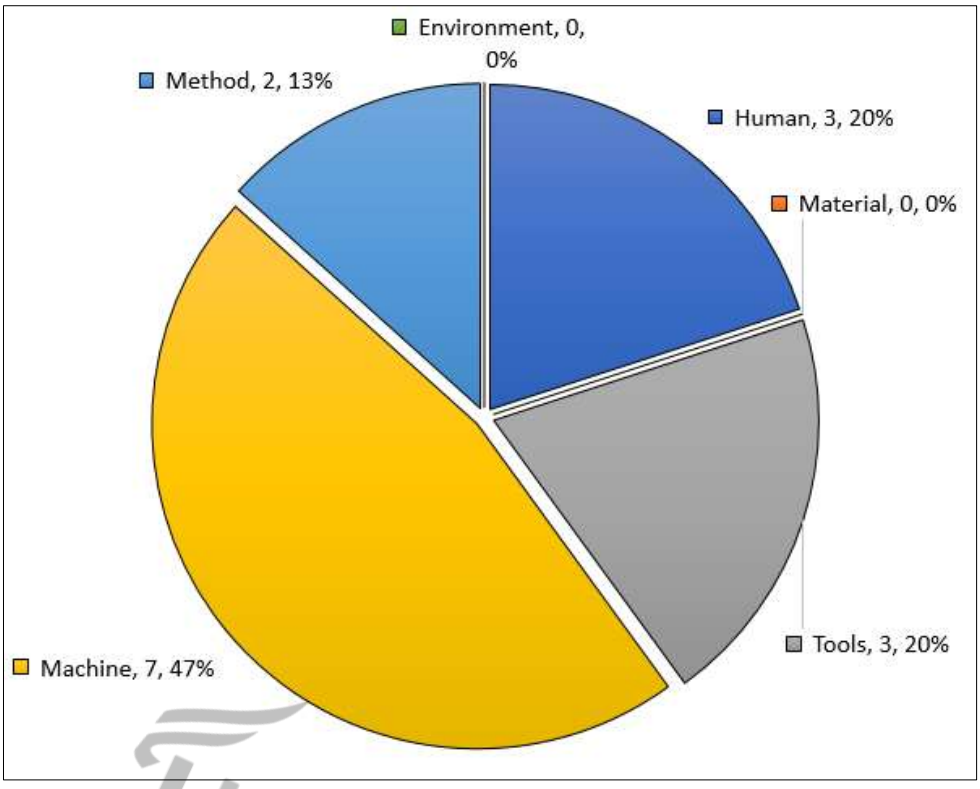


Figure 62: *Employees Survey on Independent Variables Lists*

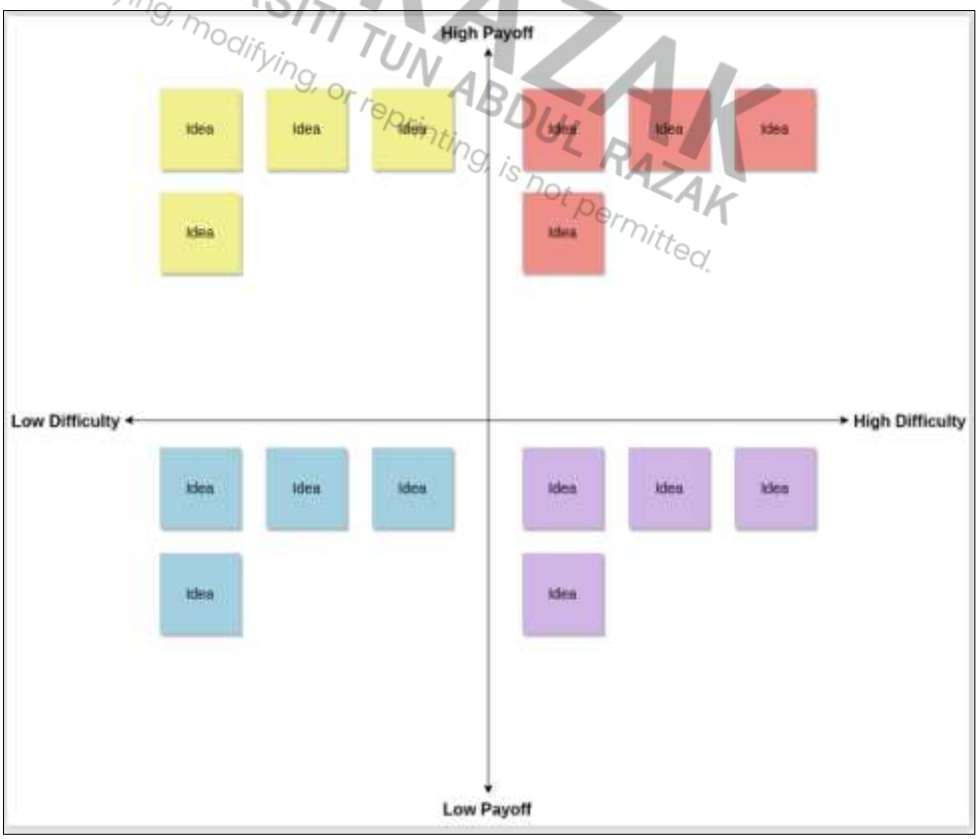


Figure 63*: PICK Chart*

APPENDIX B

Example and Survey Question

H1: Questionaries under Human factors.

a) Have you attended the training before you being allowed to perform the task?
b) What are the skills and competency required to perform the task?
c) How's your skills and competency being measured?
d) What is the acceptance result required from the training before you can be released to perform your task?
e) How frequent the training, skill and competency test needed?
f) What kind of training you receive to improve your knowledge that also will improve your skills and competency?
g) What is the issue that you know based on your experience in your daily task that can contribute to the defect or potential issue that can become a defect in your daily task?
h) What do you think, or you can suggest to avoiding the defect from occur?
i) What kind of the attitude needed to ensure the work can be done in safe way and correct ways to avoid defect due to behaviour issue?
j) What is your suggestion to avoid human error in any non-conformance issues related to human?

Question for the survey.

a) Employee without training can cause more nonconformance.
b) Skills and Competency are required to perform the task.
c) Skills and competency are required to be measured or tested yearly basis.
d) Training is required to be conducted in yearly basis.
e) Behaviour is also a factor that can cause nonconformance.
f) Stop Work authority can avoid nonconformance.
g) Earlier preparation before work can avoid nonconformance.
h) Nonconformance is a human mistake.

H2: Questionaries under Material factors.

a) What material needed to perform your daily task?
b) What will you do if material not supply or available to perform your task?

c) What to do if the material deviates from the Bill of Material - B.O.M standard?
d) What to check on the material you received?
e) What measuring method use to ensure all material meets all the requirement?
f) What are the other causes that you think can cause non-conformance issue due to material issue and what is your suggestion to improve it?

Question for the survey.

a) Complete material is important to avoid nonconformance during the process.
b) If received incomplete material, the task should be stopped.
c) Material for work should be verify before the task begins.
d) When material received deviated from the B.O.M document, the verification is needed.
e) Lack of checking on the material receive can cause nonconformance.
f) Material completeness, condition and safe should not be compromise.
g) Material received with deviation but got approval can be used.
h) Failed to check material receive is under "human error" issue?

H3: Questionaries under Measuring factors.

a) What is the quality measurement to product produce in your daily task?
b) How you know what kind of measurement you need for the task?
c) How to ensure the measurement equipment selected is correct for the task?
d) What is the area you need to measure on the parts you produce?
e) What is the measurement of quality standard in your daily process?
f) If the measurement standard not achieved, what you need to do?
g) What kind of measurement other than length, size, weight that you can tell me?

Question for the survey.

a) Are you agreed that measurements process is important in your daily works to avoid nonconformance issues?
b) Are you agreed if the measurement was not done correctly or cannot be done, the task should be stopped?
c) Measuring the lead time in kitting process is important for warehouse activity.
d) Measuring is not only to check the length, size, weight but also achievement of the process conducted, KPI and other performances.

e) Lack of measuring process in daily work can cause unpredictable results for individual or department target.
f) Measuring the performance is important for the team to know their current level.
g) Quality performance should be measure daily, weekly, monthly, and yearly basis to consistently monitor the achievement or issues.

H4: Questionaries under Machines factors.

a) Before machine can be operated, what you need to check?
b) What is the critical area or parts on machine that must in good condition before it's can be operated?
c) What is the measuring method to perform the inspection?
d) If you found any faulty during your inspection, what do you need to do?
e) Do you still running that machine if the faulty remain the same?
f) How to confirm if the faulty not affecting your task or job you running?
g) What is the procedure to running the machine?
h) What are the competent criteria on machinist to run the machine?
i) How's the verification done to measure employees' skills and competency to run the machine?
j) What are the criteria or condition on the machine that will cause non-conformance?
k) What is the abnormal condition that might only happen during running the machine that can cause non-conformance?
l) Do you know your machine capability and limitation?

Question for the survey.

a) Machine should always in good condition to avoid nonconformance issues.
b) Machine should be checked before performing daily task.
c) Machine condition is part of employee's responsibility.
d) Any faulty found during pre-inspection should be records and escalate.
e) Employees must be competent to run the machine.
f) Knowing machine limitation and capability is important to perform daily work.
g) Any abnormal found during operation must be stopped to verify and inform superior/maintenance.
h) Machine faulty that cause nonconformance is under "human error" issue?

H5: Methods

a) What is the WI - work instruction or SOP - standard operation procedure for the process you will perform?
b) Do you familiar with the WI / SOP for the process you will perform?
c) If you are not familiar with the WI / SOP, will you continue the task?
d) If WI / SOP not available, do you continue the task? If no, what you need to do?
e) Do you still remember the WI / SOP details to perform the task?
f) When is the last you've being trained with the WI / SOP?
g) How frequent you need to be trained with the WI / SOP?
h) How supervisor measure your competency for this WI / SOP?
i) What is the other issue under this method that can cause non-conformance?
j) What is your improvement suggestion under "Method" to avoid non-conformance issue?

Question for the survey.

a) Correct method should be recorded in WI / SOP for all the process in the production to avoid nonconformance
b) All employees should be trained and competent in each WI/SOP before release to perform daily task.
c) Employees should not continue his work if not being trained with the task.
d) If employee not confident to perform his work, he/she should stop.
e) Training must be conducted for all WI/SOP minimum yearly basis to all employee's
f) New process shouldn't be release to production without any training.
g) Any abnormality in the process found during the process should be stop and ask for clarification.
h) Wrong method used after being trained that cause nonconformance is under "human error" issue?

H6: Environments.

a) What is the environment condition suitable to perform the task?
b) What will you do when the environment did not meet the requirement to perform the task?
c) How to ensure all environment surrounding meet the requirement to perform the task?

d) What inspection needed or standard requirement of the environment that meet the requirement?
e) How frequent you need to inspect in your daily task?
f) What is the precaution to be taken earlier to ensure the part will not damage or have defect related to environment?
g) What the PPE given to protect employees when they working under hot weather?
h) What are the safety rules for employees to follow when they working outside to ensure their safeness and not to jeopardize the quality of the equipment they work on?
i) What is the precaution taken to ensure the job not rusty when the company closed for one week?

Question for the survey.

a) Correct method should be recorded in WI / SOP for all the process in the production to avoid nonconformance
b) All employees should be trained and competent in each WI/SOP before release to perform daily task.
c) Employees should not continue his work if not being trained with the task.
d) If employee not confident to perform his work, he/she should stop.
e) Training must be conducted for all WI/SOP minimum yearly basis to all employee's
f) New process shouldn't be release to production without any training.
g) Any abnormality in the process found during the process should be stop and ask for clarification.
h) Wrong method used after being trained that cause nonconformance is under "human error" issue?

Few examples of question to verify Weld Shop process flow.

1. Have you check the LPG Gas flame heating torch, hose, pressure regulator and non-return for ant damage, loose-joints, and gas leakage before start work?
2. Have you check heating pads, cables for any damage and loose joints?
3. Have you verified Production Order number from the job matches with the Shop Packet?
4. Have you ensured Pre-weld NDE operation have been signed off?
5. Have you verified if TPI witness is required for the welding operation?

6. Have you verified traceability (Air-Sheet) requirement (Check Physical job PO#, Serial#, Part #, Rev etc.)?
7. Have you verified suitability of WPS provided in routing for the welding operation?
8. Have you verified the condition and validity (calibration) of welding machine, gauges, and inspection tools?
9. Have you ensured gas flow is as per WPS requirement (FCAW/GMAW/TIG)?
10. Have you verified the type of parent material is as per WPS/BOM?
11. Have you verified weld preparation surfaces and its adjacent sides 3" all around are free from any visual, defect, rust, oil, moisture, and any contamination?
12. Have you verified residual magnetism left in the part that should not exceed 3-Gauss?
13. Have you verified the welding consumables selected is as per WPS in term of size, physical condition, traceability - Heat or Lot#?
14. Have you verified baking and holding temperature that should maintained within 100°C - 120°C?
15. Have you ensured the electrodes not stacked more than 4 layers?
16. Have you check seals areas / critical dimension that should in good condition before starting the welding operation?
17. Have you verified pre-heat temperature before start welding based on WPS range?
18. Have you ensured no air draft directly to the job during welding?
19. Have you ensured air draft protection and temperature controlling method on the job are in place (Shielding ring - for all jobs, seat pocket cover - for Block and fire blanket - for Block / Housing?
20. Have you verify fit up dimension, orientation and the joint mismatch are as per drawing / procedure requirements?
21. Have you verified welding parameters are maintained within WPS range during welding?
22. Have you ensured welding parameters are promptly documented in weld logbook before welding, followed by record in to into WDS system?
23. Have you verified inter-pass temperature during welding that shall be within WPS range and check adjacent to the weld bead?
24. Have you verified inter-layer cleaning is done during welding (Grinding off slag, porosity, inclusions, improper fusion, crack and improper weld bead for manual welding and SS wire brush / Buff / Grind for overlay)?
25. Have you ensured the weld size including weld capping (for manual welding) and final weld dimensions (for both manual and overlay) are complying with drawing / procedure requirement?

26. Have you visually checked the completion weld (ensure no spatters, p0rosity, under-cut, arc strike, burn through, sharp dent or chipping mark, crack, improper weld bead and insufficient weld)?
27. Have you ensured to heat up the butt weld joint within pre-heat temperature range after welding completion and wrap up with thermal cloth before moving to PWHT?

Example Question for Machine Shop.

1. Have you performed daily checklist before starting the operation, including preventive maintenance inspection, updating operator board?
2. Have you check CNC program, part number, routing, drawing number and revision are correct and complete in shop packet before start work?
3. Have you referred setup sheet before performed the setup?
4. Have you recorded tool offset value and double check before machining?
5. Have you check the length & diameter of tools before proceeding the machining?
6. Before chucking workpiece, have you adjusted chucking pressure?
7. Have you done precision checking after clamping, clocking workpiece OD and ID and end face by indicator, ensure within tolerance and machining allowance?
8. Have you ensured type of thread required BEFORE proceeding with the thread cutting?
9. Have you referred the table for confirming thread cutting procedure by tool position and spindle rotation?
10. Have you bolting down the clamping nut and performed it in equally manner to clamp block and ensured it is flat with table surface?
11. Have you ensured no gap left between chain adapter and clamping block which indicate improper clamping?
12. Have you ensured to follow the correct machining sequence for Work Order with high quantity to ensure all have same Heat Number?
13. Have you marking each work piece for WO with high quantity upon finish machining process?
14. Have you check after machining, the part traceability in shop packet and VOD form, before close the operation in system?
15. Have you completed update and check all dimension and records before unload job from machine?

APPENDIX C

APPROVAL PAGE

TITLE OF PROJECT PAPER:	**FACTORS AFFECTING IN IMPROVING QUALITY IN PRODUCTION: A STUDY ON O&G MANUFACTURING COMPANY - CAMERON MALAYSIA SDN BHD**
NAME OF AUTHOR:	**AHMAD RIZAL BIN BAHROM AZHAR**

The undersigned certify that the above candidate has fulfilled the condition of the project paper prepared in partial fulfillment for the degree of Master of Business Administration.

SUPERVISOR

Signature : _____

Name :

Date :

ENDORSED BY

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Dean

Graduate School of Business