Title:

Engen Refinery work process recalibration as an efficient maintenance strategy for oil and gas industries

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Declaration

I, **Mongezi Sokotshe,** hereby declare that this dissertation is my work and that:

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Glossary of acronyms

AMM - Assets maintenance management

AMMS – Asset Maintenance Management System

AMS - Asset Management System

AMS - Asset Management System

IAOGP - International Association of Oil and Gas producers

IEC - International electrotechnical commission's

ISO - International organisation for standardization

KPI – Key Performance Indicators

LPG - Liquefied Petroleum Gas

MMS – Maintenance Management System

MSS – Maintenance System Standards

MWP - Maintenance Work Processes

OIMS - Operation Integrity Management System

OSHACT – Occupational Safety and Health Act

PM – Preventative Maintenance

PMMS - Petronas Maintenance Management system

QMS – Quality Management System

RCM - Reliability Centred Maintenance

SA – South Africa

SAPIA – South African Petroleum Industry Association

UK - United Kingdom

USA- United States of America

Abstract

The quality of the final product is strongly associated with the quality and effectiveness of the plant machinery used to produce the product. The implementation of Maintenance work processes recalibration is what each refinery is willing to achieve as part of their routine maintenance process which will improve plant safety, reliability and efficiency which will highly contribute to plant profitability, competitiveness, and relevancy. This is because maintenance work processes bring benefits like troubleshooting of defects, empowering operations personnel to be able to execute less technical activities, planning and scheduling being the holding centre for these processes and improving efficiency by delivering materials to the field for execution. This study analyses work process recalibration as an efficient maintenance strategy for oil and gas industries. This study was aim was to investigate and understand maintenance work processes used in the refinery and seek to recalibrate seamless integration maintenance work process that will improve Safety, reliability and efficiency in the Engen refinery and other refineries at large.

A range of literature was reviewed which include, journals, articles, books, and conference empirical approved papers about effective maintenance management and work process recalibration in the oil and gas sector specifically in South Africa and other countries. Primary data was collected in a form of interviews which were later transcripted down for research analysis data processing. Twelve Engen refinery employees which include artisans, engineers, operators and maintenance managers who have been with the refinery for more than five years were selected from maintenance department within Engen refinery as participants of this study in order to get their views on work process recalibration as an efficient maintenance strategy in an oil and gas industry.

Four key findings on this study are that firstly there are plant maintenance gaps that exist within Engen refinery, and without addressing these gaps, maintenance is still going to be a challenge going forward. These gaps include being more reactive than proactive where operations escalate all defects jobs to priority one which is highly expensive, Manhours spent when artisans collecting the materials

from the warehouse, lack of seamless integration between operations and maintenance and the lack of integrated schedule tools. Secondly, the current hierarchical structure at Engen brings both advantages and disadvantages at the same time. This include lack transferring ideas from refinery floor to the management as hierarchical structure support management final decision. Thirdly, standardisation of maintenance work process was seen as the best method to be implemented by Engen as it helps level the work ground for all operators and artisans.

Some of the recommendations made by this study are that Engen use an integration of SAP and Primavera P6 where SAP is a database and planning tool, and Primavera is a scheduling tool. The study also recommended that an extensive training and development program should implemented to help all plant operators and artisans to perform their task effectively and efficiently.

Keywords: Maintenance Work process recalibration, Digital tools, Empowerment, Seamless integration

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1. Introduction

Maintenance is used to ensure that physical assets continue to do what their users want them to do (Moubray, 2007). Maintenance is the process of maintaining equipment in its operational state either by preventing it to fail or by restoring it to an operational state following a failure. Maintenance can be divided into parts, planned and unplanned maintenance activities. Planned Maintenance activities comprises of proactive and preventive maintenance which are planned and schedule in advance for execution based on their frequencies and availability of equipment's (Ahuja & Khamba, 2008). Unplanned maintenance activities are made up of defects, and breakdowns that caused either by aging of equipment's or unfavourable operating conditions (Blanchard, 1997). These are priorities based on their criticality and potential impact on people, health, environment, production, and equipment's. There are three maintenance strategies that are used in maintenance management or asset management which are preventive, predictive, or corrective maintenance (Labib, 2004).

For Maintenance activities to be effective and efficient it involves the following stakeholders, operations, planning, inspection, procurement, safety and process. If you want to improve effectiveness and efficiency of Maintenance, you need to develop work process that will create a seamless integration between these stakeholders. The key members of the process being Operate facility and Maintain facility teams. Operations team are the asset/equipment owners in the refinery context and maintenance team are responsible for plant/equipment reliability and availability all the time. Maintenance planning integrates the whole planning process from initiation by operations or from maintenance plan till the close out of the process. This study will evaluate the impact of maintenance management work processes on ineffectiveness of plant maintenance and the causes of these ineffectiveness. Engen refinery is currently using Petronas Maintenance Management System (PMMS) as a business strategy that includes asset management, work management and performance management.

1.1 Background of the study

Engen is an African energy company that focuses on the refining and marketing of petroleum, lubricants and functional fluids, chemicals, and retail convenience services through a large network of service stations in seven African countries and the Indian Ocean Islands (Engen, 2021). We have built our business from our beginnings in South Africa by using the experience of our people to include production plants, distribution networks, and retail service stations, with a history dating back to 1881 and trading as Engen since 1993 (Engen, 2021). The refining of crude oil, the distribution of our key refined petroleum products, and the provision of convenience services through our wide retail network are all core responsibilities of Engen (Engen, 2021).

1.2 Problem statement

The main aim of this study is to investigate and understand maintenance work processes used in the refinery and seek to recalibrate seamless integration maintenance work process that will improve safety, reliability and efficiency in the Engen refinery and other refineries at large. Maintenance is used in refineries to ensure plant is running safely, reliable within an optimum cost. Refineries like any industry are ran to be profitable, competitive, and relevant to attract investors. In any production lifecycle we are always faced by aging infrastructure asset which is always difficult to maintain or upgrade if they rich their maximum life span. This infrastructure asset plays a major role in high production and profitability. To keep the plant safe, reliable, and efficient world standard work processes need to be adopted by the refinery to avoid low profit margins, high incident, high cost, low reliability, and low availability of the plant.

This study seeks to intervene, resolve, and recalibrate poor asset maintenance management and maintenance work processes within the refineries focusing more on Engen refinery.

1.3 Aim of the study

The main aim of this study is to investigate and understand maintenance work processes used in the refinery and seek to recalibrate seamless integration maintenance work process that will improve safety, reliability and efficiency in the Engen refinery and other refineries at large.

1.3.1 Research objective

1.3.1.1 To examine profitability, competitiveness, and supplier development

1.3.1.2 To determine the world class standard priorities to attract investors.

1.3.1.3 To assess/evaluate/benchmark the standardize maintenance work process across the refineries in South Africa and abroad

1.3.1.4 To identify and ensure Seamless integration with various departments/functions within the refinery

1.3.2 Research questions

1.3.2.1 What strategies and work processes can enable the profitability and competitiveness of Engine Refinery?”

1.3.2.2 How to become a world class standard to attract future investors?

1.3.2.3 How can the refinery implement an appropriate standardised maintenance programme to ensure safety at the refinery?”

1.3.2.4 How is a seamless integration of maintenance work processes achieved within the various departments of the refinery?

1.4 Significance of the study

Maintenance is used in refineries to ensure plant is running safely, reliable within an optimum cost. Refineries like any industry are ran to be profitable, competitive, and relevant to attract investors. In any production lifecycle we are always faced by aging infrastructure asset which is always difficult to maintain or upgrade if they rich their maximum life span. This infrastructure asset plays a major role in high production and profitability. To keep the plant safe, reliable, and efficient world standard work processes need to be adopted by the refinery to avoid low profit margins, high incident, high cost, low reliability, and low availability of the plant.

This study seeks to intervene, resolve, and recalibrate poor asset maintenance management and maintenance work processes within the refineries focusing more on Engen refinery.

1.5 Structure of the dissertation

This paper is divided into five chapters which are briefly outlined below:

1.5.1 Chapter 1

This chapter introduces the research topic, discusses research background, research problem as well as research questions and objectives.

1.5.2 Chapter 2

This chapter reviews relevant literature that is related to the study conducted. In addition, it link theories and framework to be used to support the phenomena.

1.5.3 Chapter 3

This chapter outline the research methodology, research design, research approaches and paradigms to be used to conduct the study. It further outline the type of data collection method to be used when collecting primary data.

1.5.4 Chapter 4

This chapter outline the finding, presentation, and the results of the research objectives.

1.5.5 Chapter 5

This chapter provides a general conclusion, makes recommendations for the study, and provides an insight for future studies, within the scope of the findings.

1.6 Chapter summary

In summary the study is focusing on critically analysing safety, reliability and efficient petrochemical industry using the seamless integrated work processes. This study will also analyse the systems and tools used for Maintenance Management systems.

2. Literature review

2.1 Introduction and background

Asset maintenance management (AMM) and maintenance work processes (MWP) mostly used interchangeable to emphasize the importance of continuous maintenance of company of organisations machinery and assets (Vinnem, 2012). Most studies reveal that it is fundamentally important for oil and gas companies to ensure that they have AMM and MWP in place to ensure that they adhere to not only company health and safety measures but also adhere to the International Association of Oil and Gas Producers (IAOGP). According to Moubray (2007) Maintenance is the process of maintaining equipment in its operational state either by preventing it to fail or by restoring it to an operational state following a failure. In addition, Maintenance is used to ensure that physical assets continue to do what their users want them to do effectively and efficiently.

Having discussed the concept of Maintenance, the next step is clarifying the term Maintenance work process. According to Ahuja (2008) maintenance work process is a deep assessment of an organizations current work processes and reliability work processes in effort of ensuring safety and longevity of the plant. In addition, the process takes into consideration the current state of the plant, compare it with reliable best practices, and perform any needed maintenance process. This should be a continuous process for organizations to ensure adherence to international and local standards. On the other hand, AMM is merely a strategy used in MWP to manage solely the maintenance activities done inside organization. Furthermore, AMM involves all management systems for organisations assets, from technicians, operators, and decision makers.

According to Blanchard (2007) organisations with good asset management system and, maintenance management system likely to succeed because their assets are likely to live longer and perform much better. In addition, continuous recalibration of organization’s assets will give an organization an upper hand and save costs of breakdowns and unplanned maintenance which stops operations and cost organisations millions.

2.2 The international scope /Global Maintenance Management Systems

Empirical research shows that maintenance management systems are old and have been in place since the don of the 18th century. However, it was only after the discovery of oil and gas technologies and refinery machinery that these maintenance systems come to effect at refineries. For instance, Moubray (2007) reveals that, there are many challenges that are facing maintenance organization including improving plant reliability, improving effectiveness and efficiency of work processes, set-up time and cost reductions, reduced lead times, managing complex technology and innovation. In addition, all these challenges need time and money as well as training of personnel involved in these processes.

To overcome these challenges organisations, need to implement thorough strategies that support continuous recalibration of its assets. For example, Chevron in the United States of America (USA) embark on an annual routine safety and maintenance inspection at its 220 000 barrel per day in Texas refinery in efforts to ensure that all the plants and equipment are in good condition (Brelsford, 2021). Whereas Exxon Mobil in United Kingdom (UK) has implemented its Operation Integrity Management System (OIMS), this OIMS is a top to bottom review of its refinery sites, and it help Mobil to make informed decision in whatever they are planning to maintain. This system came after 1989 fire that entire destroyed Exon refinery in the northern UK (Brelsford, 2021). All these efforts not only help prevent aging of plants and equipment in refining companies but also work as daily schedule for employees to have confidence in their work processes.

The International Association of Oil and Gas require all refineries not only to take safety measure but also to be abide by the laws and regulations set by the association. For example, companies like Exon Mobil, Chevron and Petronas comply with all the laws and regulation and where laws do not exist, they are bound to use their high standards. The refineries commitment to integrity, ethical standards and legal compliance should always reflect on their global policies and procedure (Brelsford, 2021). In addition, these AMMS should be designed in such a way that they can measure and assess risk controls and procedures and mitigate concerns that may appear.

Figure 2.1 Asset management maintenance system of Paraguana Refinery

Source: Oil and Gas Journal, (2016:16)

According to (Figure 2.1), the asset management maintenance process begins on column 1 on inventory management. Paraguana Refinery in Venezuela, the third largest crude oil refinery develop this AMMS as a mean for ongoing maintenance of its subunits on continuous basis. According to Fernandez (2011) the process from preventative maintenance to work order management helps Paraguana to keep track of plants and machinery maintenance services and their dates of service. Furthermore, knowing the service history of each plant division gives Paraguana an upper hand, because every time the cycle come for service and maintenance. The service team knows exactly what was serviced and what might need to be serviced.

Refinery maintenance, for example, has the problem that, in today's global environment, average downtime in such firms can approach 10% of production time, and refineries are usually only used at 60% of capacity (Mondliwa, 2014). In addition, refinery turnarounds are large maintenance or overhaul activities that are the most critical and costly maintenance assignment for businesses. According to Quinton (2013), a turnaround is a large-scale maintenance procedure that involves the partial or complete shutdown of a plant and involves

either critical equipment that cannot be isolated during normal operation or equipment that has demonstrated difficulties or need frequent examination. Furthermore, the frequency of these operations varies by unit type, and they typically take 1–2 years to plan and prepare, and occasionally much longer when large capital equipment modifications are required.

2.2.1 Maintenance Management Systems

In theory, only the component of the plant that requires maintenance might be shut down, but the work is usually too disruptive to keep the plant running. Furthermore, manpower assets to undertake daily maintenance work in the plant's running component will be scarce. As a result, the maintenance outage usually entails a complete plant closure. Any significant refinery unit that undergoes a turnaround might have an impact on the output of finished products like gasoline or distillate (Paelo, 2017). When it comes to refinery turnarounds, safety is paramount. Refineries handle materials at high temperatures and pressures, and some of the ingredients are caustic or hazardous, requiring special handling (Rustomjee, 2017). To ensure safe operations, maintenance is essential, and turnarounds itself necessitate additional safety procedures.

The refinery provides a production system that ensures operational flexibility based on the crude oil used and the highest potential distillate yield. According to Brelsford (2021), it is a maintenance procedure that involves either essential equipment that cannot be isolated during normal plant operation, or equipment that has indicated difficulties or requires frequent inspection. Turnaround management is difficult since all interventions must be completed in a short amount of time (4 weeks at most), and all resources (human, material, technical, and financial) must be efficiently coordinated and planned. Plant management requires accurate data on both equipment performance and expenses to make well-informed decisions. As a result, it's critical to adapt to strategies that give accurate and fast data to make the maintenance function more useful and decrease unplanned plant outages.

During the life cycle of a project, maintenance is a collection of technical, administrative, and management procedures aimed at keeping it in or restoring it

to a state where it can perform the required function (Tribunal, 2014). Nowadays, maintenance is recognized as a significant contributor to a company's success and profitability. Maintenance managers, as a result, look for any way to improve profitability and performance while also saving money for the company. Quality improvement decreased lead times, set-up time and cost reductions, capacity growth, managing complicated technology and innovation, enhancing system reliability, and related environmental issues are all challenges that the maintenance organization faces (Corbett, 2011). In addition, Khan (2019) stated that to solve scheduling challenges in oil refineries using mixed-integer optimization models that use both continuous and discrete temporal representations. The optimal operation of crude oil unloading from pipelines, transfer to storage tanks, and the charging schedule for each crude oil distillation unit is articulated and solved as a problem in crude oil inventory management (Cooper, 2017). The paper will also discuss the creation and implementation of optimization models for short-term scheduling of a group of processes in refinery production and distribution in South Africa.

The fact that most Liquefied Petroleum Gas (LPG) and LPG by-products are exported from the Engen through pipeline creates the most scheduling challenges in this maintenance management system (Leedy, 2015). Because small amounts cannot be transmitted, vast volumes of each product must be accessible when pumping begins. In general, the refinery functions by practically exhausting its storage capacity before transporting most of the product, leaving only a little quantity behind. The demand for LPG in the local market, on the other hand, is nearly constant. According to (Sterman, 2016), the challenge is to make the best use of processing resources, raw materials, and storage space to meet product delivery deadlines and quantities. For the smallest number of spheres used, the objective function involves maximizing of product deliveries and available intermediate propane inventory.

According to Ronen (2015) for Engen to achieve analytic models that provide value by enhancing asset performance, significant efforts must be made. In most of today’s complex engineering assets, despite the existence of well-developed physical models for a component of a system, the complexity that arises from the

combination of elements, and often the changes in environmental and operational conditions, make it impractical to characterize a complete system through closed mathematical expressions. Stochastic models are frequently used to characterize this type of system as a solution.

2.2.2 International Organisation for Standardisation, quality, and risk management of petroleum products

International Organisation for Standardization (ISO) is an international body responsible for general national standard bodies to ensure that each country, governments, organisations either non-governmental or governmental organisation adhere to single and unified body of quality and standardization (Swanepoel, 2016). The main aim of ISO is to ensure and facilitate fair trade between the nations, ensure process improvements, ensure quality and safety in the workplace. Like any industry, refinery, petroleum, and gas have to adhere to ISO in order to be deemed safe and reliable to operate. The international standards are drafted in accordance and implemented by international committees responsible for world standards selected by all representing nations.

- **ISO 25457: 2008**

According to Habib (2021), ISO 25457 ensures that requirements and relevant guidance for maintenance, design, selection, and specifications related to mechanical failures in the refinery are address and in a formal way. In addition, this ISO is more relevant in evaluating the existing flares within an organisation as it provides a clear guidance of what is the next task to ensure that the plant and machinery are safeguarded. Furthermore, this ISO is used for the selection, specification, and mechanical aspects of flares, as well as the design, operation, and maintenance of flare combustion and related equipment, additional information and best practices are offered in sections of the ISO, 25457. This ISO provide organisation, guidelines, instructions and set of relevant data sheets for information recording.

2.2.3 The New Management Systems Standards for oil and gas

The new Management System Standards (MSS) that governs the petrochemical, petroleum and gas industry which work hand in hand with ISO 9001 is regarded

as a game changer in the refinery industry. According to Lamy (2011), this MSS replaced the previous ISO/TS, 29001 and work beyond its name in the management of the refinery and ensuring safety. In addition, it is perfectly aligned with the main body of international standards, ISO 9001 and outline the role that the refineries must play to ensure safety.

The aim of ISO/ TS 29001 is to ensure to promote and ensure the standardization of safety, quality and standard requirement in the refinery, petroleum, and petrochemical sector. Furthermore, ISO 9001 noted out that while certain components of the technical specification will be familiar to people who have used it before, some new elements were included when it was transformed into an International Standard. ISO 9001 committee also noted that the new International Standard was prompted by ISO 9001:2015's increasing focus on business objectives and risk management. Croft (2011) noted that in the petroleum, petrochemical, and natural gas industries, the new ISO 29001 introduces a risk-based approach to how businesses develop and apply Quality Management System QMS criteria. In addition, it also encourages sector-wide standardization by offering a framework for aligning requirements with complimentary MSS.

2.2.4 Risk Management in ISO 29000 series standards

Research shows that the international standardization community has developed several reports in efforts to minimize risks and dangers during calibrations and maintenance of refineries by different countries. Since it is the role of ISO and International Electro technical commission's (IEC) role to ensure safety, both these organizations join hands and publish hundreds of documents that can be useful to refineries that do continuous maintenance and calibrations of their respective refineries. In addition, Blind (2012), stated that, some national standards bodies and non-governmental groups have also helped to design and implement standardized risk management approaches.

ISO 29001 also suggests that each risk that an organization faces should be identified and assessed internally and document that risk to be used in future as a case situation to resolve any upcoming problems that will fact the refinery in the near future. Only minimal hazards with infrequent consequences are to be

controlled. Significant risks with serious implications should be managed in such a way that they are either fully eliminated or have their frequency and severity reduced. Organizations that have successfully implemented the ISO 14001 standards and are conducting ongoing analysis of their environmental management system, including significant environmental aspects such as air emissions, discharges into water, waste disposal, ground pollution, raw material and natural resource use, and other environmental issues. Stakeholders' expectations are typically met by such organizations' thinking and behavior According to Corbett (2011) Environmental risk management and loss prevention are two of the most important aspects of risk management during maintenance and calibration therefore it is vitally important for every refinery to consider those when setting up their local standards. Furthermore, refineries that successfully implement OHSAS 18001 and ISO 29000 identify hazards and conduct risk assessments for normal activities, as well as the danger of having subcontractors or visitors on the premises. The primary stakeholders are the people who work for the company, who help to foster a risk-management culture (Vanier, 2010).

At the end of 2008, a new edition of ISO 9001 was released. The introduction highlights for the first time that the construction of a quality management system (QMS) must consider the organization's operating environment, changes in that environment, and risks connected with that environment. In addition, this new ISO does not include criteria for other types of management, such as environmental management, health and safety management, financial management, or risk management (Corbett, 2011). Furthermore, these proposals, along with those of other stakeholders such as business, standardization, accreditation, certification bodies, and other ISO technical committees, should form the basis for the revision of ISO 9001's design definition in the future.

The first recommended concept has been identified as an opportunity and a requirement to incorporate risk management into the ISO 9001 standard. It was claimed that a separate allocation of subjects at risk is required, as well as a determination of which objects should be taken into consideration is production, organization, quality management system QMS compliance with business continuity, supply chain management, resources, and infrastructure (Lamy,

2011). To ensure that resources are available for future activities, the organization's management should identify and assess the risks of resource scarcity. The organization's management should examine concerns such as the risks associated with partner relationships while selecting and evaluating partners, as well as consistently upgrading their capabilities.

2.2.5 International Standards vs South African Local Standards

Empirical evidence reveal that South Africa (SA) own one of the best refineries in the world. This dates to 1954 when Mobil open the first refinery known as Enref Refineries then. According to Terblanche (2012), at the time, safety and international compliance was not a priority as South Africa was isolated due to its apartheid laws and regulations. In addition, SA took advantage of those laws and violated the international standard by following none of those laws. It was until 1962 after fire that killed more than 10 workers, which attracted an international media and attention, and SA decided to join the world and comply with all rules, QMS and international standards. Mondliwa (2014) argued that due to lack of resources, it took time for SA to meet the world standard in terms of risk management, safety and security and high standard of maintenance of their refineries. Today South Africa operates one of the best refineries in the world with 95% accident confidence. In addition, SA adopts and align its standards on ISO 9001.

ISO 9001 has become the acknowledged global standard for quality management. Since its debut in 1987, quality management systems based on the ISO 9000 family of International Standards have been implemented in over 70 countries. However, each country has a responsibility to develop its own refinery standard based on safety and security of its workers and these standards must be aligned with original ISO 9001.

Marquard (2016), stated that each SA refinery should produce an ISO certificate that shows all safety and security measures, Maintenance Management System processes and how they follow safety, procedures. Moreover, the role ISO 9001 on local level is to build client confidence in their ability to supply goods and services that fulfil their needs can then utilize The ISO 9000 certificates that the

registrars provide to these refineries. By the year 2000, the number of ISO 9000 certificates awarded in South African refineries reached 10 with other small refineries also applying for quality standards and asked to be monitored as well. While manufacturing has been the core market for ISO 9001, the standard is now being used in a wide range of industries, including software development, health care, security services, project management, and many more.

2.3 Maintenance Management Systems in South African Context

Engen refinery owned by Petronas, an international oil and gas corporation has to adhere to double standards, meaning, and South African and Malaysian standards. These standards do not differ much because all these organisations are both members of International Association of Gas and Oil Producers. In South Africa alone, refineries have to adhere to Mineral and Petroleum Resource Development Act, South African Petroleum Industry Association, Petroleum Agency of South Africa, Ministry of Minerals and Energy and many more. To develop a solid AMMS and MMS, Engen need to ensure these Maintenance systems are aligned with each of these laws.

According to South African Petroleum Industry Association (SAPIA), there are six refineries in South Africa alone, namely Sapref, Sasol, Chevref and Engen to mention few. They refine more than 400 000 barrels per day making them the third largest refineries in Africa. Engen Refinery is a South African based oil company focused mainly on the downstream-refined petroleum products. According to Petersie (2015) Engen refine more than 120 000 barrels per day and operates more than 1400 service stations in the Southern African hemisphere. To ensure smooth running of the refinery, it is vitally important for Engen to ensure that a maintenance management system is in place to ensure that its plants and machinery are not aging and breaking down. Furthermore, Engen has put into place many management systems as mean to curb any future breakdowns.

2.3.1 Maintenance Management Systems in South African refineries

The purpose of Maintenance Management Systems (MMS) is to ensure that organisations are reducing the impact of breakdowns and downtimes. According

to Hosskisson (2013) argues that in fact the objectives of MMS is to reduce breakdowns in the production facility. In addition, MMS in nowadays is considered more than calling people to do a service on regular basis but, to set a plan that will ensure that there is no breakdown or downtime in future. Furthermore, the author also emphasize that MMS is divided into two dimensions, namely preventative and proactive. Preventative, which looks deeper at inspection, scheduling, planning, alignment, lubricating and storage in the case of refinery whereas, often look at why plant and machinery breakdown and list down all the cause and come up with mitigating strategies to avoid those breakdowns.

For example, Sapref designed what they called Pipeline Supervision and anti-corrosion maintenance program. According to South African Petroleum Industry Association (SAPIA), this is to provide maintenance inspection strategy, which will continuously ensure that the integrity of their offshore pipeline is always up to standard. On the other hand, Chevron South Africa, which owns Caltex, has about three MMA in place that are always ready and assist during breakdowns.

2.3.2 Current Maintenance Management Systems at Engen Refinery

Over the years, Engen has implemented different MMS to make sure that it avoids breakdowns and downtimes. Moubray (2007) Stated that effective maintenance is doing the right maintenance at a right equipment at the right time with the main of not only extending the life of the plant or equipment but to bring high equipment reliability and lower operational risk. In addition, equipment that is properly maintained will yield quality, operability and reliability and will keep the employees safely from harm that may happen due to equipment that lacks service and proper maintenance.

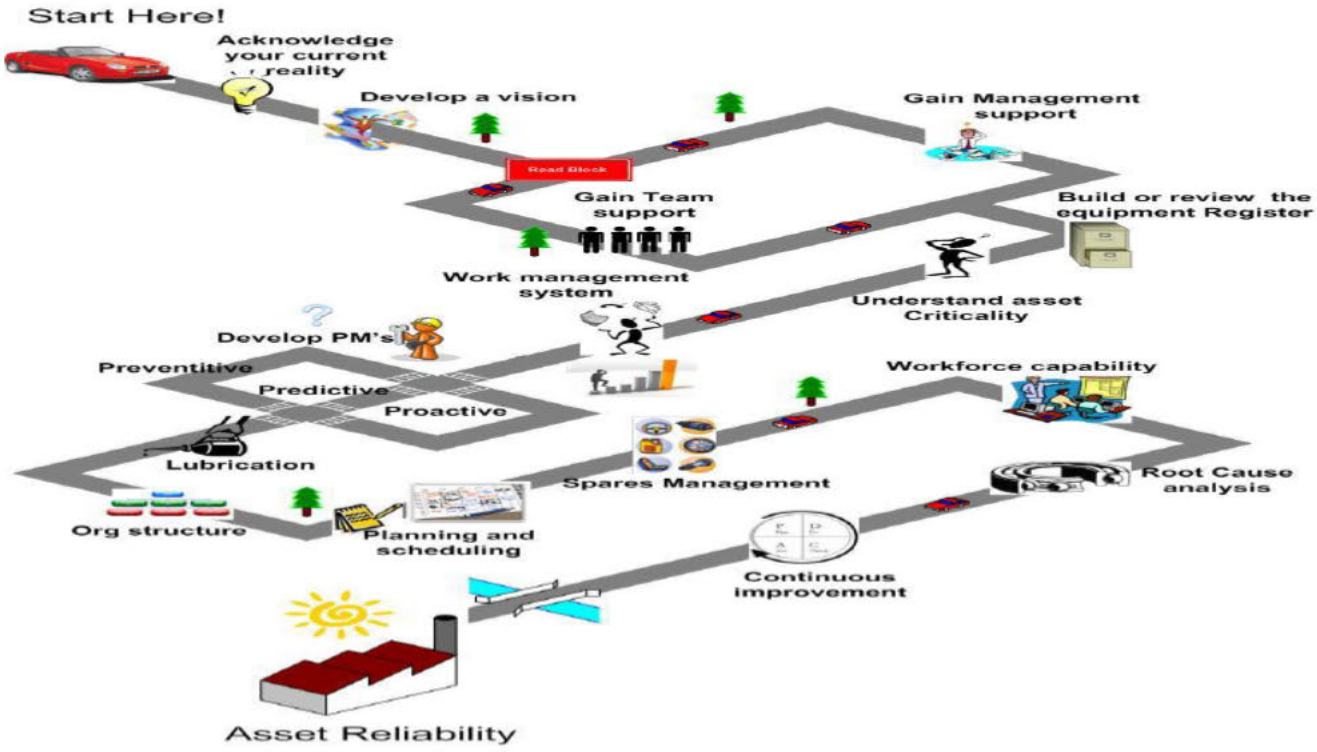


Figure 2.2 Engen's Assets Reliability Roadmap (2021:19)

Figure 2.2 above is showing the process followed by Engen refinery to ensure that all their equipment is always reliable and ready to operate at full capacity. Firstly, it starts by assessing and accepting the current realities at Engen. After acknowledgement of realities, the company develop a vision that will act as a guide for management and team leaders within the maintenance departments. Next step is to present the asset reliability plan to both teams and management to gain both team and management support. The most important step from there is to understand assets criticalities after reviewing equipment and undertake deep analysis. This is going to help the development team in designing a work management system that will support maintenance management three Ps, which are preventative, predictive and proactive. The next steps, which includes, planning and scheduling, spare management, workforce capability, root-cause analysis is all the role of the team that is given the responsibility of asset reliability development. The last step is to ensure continuous improvement, which is very common in most organisations.

2.3.3 Classification of Engen's Maintenance Strategies

According to Kause(2009) most refineries follow same and similar path when it comes to equipment maintenance strategy depending on the size of a refinery. Engen follow the three maintenance strategies to ensure that their equipment integrity and availability is optimal and equipment efficiency is not compromised.

These three Maintenance Strategies are:

- **Proactive Preventative Maintenance** – In this part, all damaged equipment is repaired and replaced before obvious problem occur. This is done through scheduling of maintenance activities that are generated by Engen systems.
- **Proactive Predictive Maintenance** – Engen also call it a pressure testing where equipment is run until they break. Work is only performed as the response to failure of equipment.
- **Proactive Predictive Maintenance** – here is where a work maintenance team will monitor an equipment condition and mitigate when need arise.

2.3.4 Engen's asset care maintenance, asset monitoring and asset improvement

Engen as a refinery knows that assets maintenance can deliver serious return on its investment because if there are no breakdowns and downtimes, it means company is making serious cash and paying off its investors. In addition, if plants and equipment are operating efficiently and effectively, there will be less risk and dangers to the Engen refinery employees.

2.3.5 Work processes, planning, schedule, execution, monitoring, and evaluation of Engen Refinery.

Since this study has look at different MMS used by other refineries across the world and in South Africa, in this part, the study will look at the viability, functionalities and how different MMS are executed as well as yielded results. Most studies that were reviewed shows that more and more refineries rely on MMS to recalibrate its plant and equipment in order to avoid breakdowns and down times. For example, Systems Analysis Programme (SAP) and Primavera (P6) tools are the most commonly used integration MMS system that deals with

planning and scheduling of complex scheduling of both maintenance and turnaround (shutdown) activities is still the most useful tools to date used by refineries. According to Shahin (2009), South African Petroleum Industry Association (MRO) Software Inc. SAP,PMMS and MMS, main role in the refinery is to help in planning and scheduling, ensuring that historical data or record of equipment maintenance plans and material management or inventory management for the entire plant is kept up to date and frequently revised for continuous improvement. This allow refineries to keep their records up to date with what might be needed for maintenance purposes of the plant and equipment.

According to Peters (2005) the main advantage of MMS is that they can use failures and problem codes found on the assets and record them in real time to assist the planning team of what exactly need to be monitored. In addition, refineries are one of the most dangerous and sensitive work areas, which can put hundreds, or thousands of employee's lives at risk. It is vitally important to make sure that every action, or every possible danger is planned, executed, and monitored by the risk team and employed trained on what to do in case of such event. In the case of good MMS, Magee (2008) stated that, refinery will save billions of rands in training and development expenses by just implementing a correct MMS that will recalibrate plant and equipment to remain safe and unharmful to refinery employees.

Engen refineries develop a very smart and early manual maintenance management system, which is progressive but still lacks latest technology and software support. Re-active proactive maintenance management system is a good example that was developed by Engen to curb a growing concern on their Wentworth refinery, this management support compares re-active maintenance system and use that date to develop a proactive system using a data gathered in the reactive system.

Table 2.1

Reactive/ Proactive Maintenance Management Schedule for Engen

Reactive MMS	**Proactive MMS**
Waiting for breakdowns to happen	Thinking about things before they happen, identifying small problem and record them.
Work until breakdowns are repaired	Scheduled maintenance using early detectors
Shut down when there is breakdowns	Planned schedule downtown for plant recalibrations
High stress	Low stress
Expediting spare parts	Planning and ordering spare parts in advance.

Source: Engen 10th Annual Conference (2012)

Table 2.1 above is a good example of Engen reactive/proactive MMS. Engineers use the technical data gathered during previous breakdowns, use the data to plan for future possible breakdowns, and made sure that all parts and spare parts that might be needed are available on standby. In addition, this does not only help Engen plans but gives its engineers enough time to plan and procure what might be required to the breakdown. According to Peters (2005) the replacement of manual maintenance management of assets and plants by MMS saves refineries money, time and resources. Furthermore, it also helps them to know exactly what need to be maintained and which plant that need more investment and continuous maintenance.

The implementation of MMS by Engen also helps assets and equipment to remain reliable. Reliable in this manner means, plants and equipment use by Engen must perform its intended duties without any glitches. Secondly, they must perform at any given condition and for a specified period. Vanier (2010) argues that this could only be achieved if proper MMS is in place and is working in favour of the refinery engineers. Therefore, it is vitally important for management and engineers' seat down and plan a viable MMS.

2.3.6 ISO 9001 in South African Refineries

Research shows that though South Africa operates one of the best refineries in the world, it is far from reaching first world countries like Malaysia, China, and Saudi Arabia in terms of safety standard. For example, Mondliwa (2014) revealed that one of the problems facing SA refineries is lack of continuous maintenance which led to more downtimes, breakdown and unnecessary fires that can be avoided if proper standards can be follows. Furthermore, the lack of government strict rules about Maintenance Management procedures also plays a major role in the downtimes that are continually experienced by refineries. Almost all of the electricity, processing, and manufacturing industries, in fact, are obliged to cut their overall costs while maintaining the value and reliability of their assets in the age of global competitiveness. Reliability Centred Maintenance (RCM) is very popular in the refinery sector. The implementation of an RCM and effective maintenance program is a key factor in lowering costs while maintaining the reliability of equipment and systems; in working environments such as refineries, the evaluation of component reliability and related maintenance actions must be made with the higher risk environment in mind.

2.4 International Standards vs Local refinery standards

Empirical evidence reveal that South Africa (SA) own one of the best refineries in the world. This dates to 1954 when Mobil open the first refinery known as Enref Refineries at that time. According to Terreblanche (2012), at the time, safety and international compliance was not a priority as South Africa was isolated due to its apartheid laws and regulations. In addition, SA took advantage of those laws and violated the international standard by following none of those laws. It was until 1962 after fire that killed more than 10 workers, which attracted an international media and attention, and SA decided to join the world and comply with all rules, QMS and international standards. Mondliwa (2014) argued that due to lack of resources, it took time for SA to meet the world standard in terms of risk management, safety and security and high standard of maintenance of their refineries. Today South Africa operates one of the best refineries in the world with 95% accident confidence. In addition, SA adopts and align its standards on ISO 9001.

ISO 9001 has become the acknowledged global standard for quality management. Since its debut in 1987, quality management systems based on the ISO 9000 family of International Standards have been implemented in over 70 countries. However, each country has a responsibility to develop its own refinery standard based on safety and security of its workers and these standards must be aligned with original ISO 9001.

Marquard (2016), stated that each SA refinery should produce an ISO certificate that shows all safety and security measures, Maintenance Management System processes and how they follow safety, procedures. Moreover, the role ISO 9001 on local level is to build client confidence in their ability to supply goods and services that fulfil their needs can then utilize The ISO 9000 certificates that the registrars provide to these refineries. By the year 2000, the number of ISO 9000 certificates awarded in South African refineries reached ten (10) with other small refineries also applying for quality standards and asked to be monitored as well. While manufacturing has been the core market for ISO 9001, the standard is now being used in a wide range of industries, including software development, health care, security services, project management, and many more.

2.4.1 Laws and Regulations abiding global and local refineries

Oil and gas refining sector like any other sector is regulated under strict rules and regulation set by different organisations like Organization of the Petroleum Exporting Nations (OPEC) or International Association of Oil and Gas producers (IAOGP) to ensure that all refineries operate smoothly without harm to the environment. The increase of price of oil in September 2005 caused by the hurricane's Katrina and Rita led to International Association of Outsourcing Professionals (IAOP), to implement strict laws governing refineries and well as companies that are transporting oil. It applies to South African refineries; they must adhere to strict and stringent rules and regulations when operating a refinery. In this part of this study, rules and regulations, governing oil refineries on global and local perspective is discussed extensively.

2.5 Global refineries laws and regulations

According to Oil and Gas Journal (2020) organisations like OPEC and IOAGP role is not only stabilizing oil and gas prices but to ensure that refineries adhere to good governance and follow rules and regulations set by these organisations. These laws are amended on continuous bases to make sure that they stay relevant. In addition, by regulating oil and gas sector, organisations like OPEC and IOAGP ensure that those that are following these rules are accident free as they show clearly, how to operate a refinery, and things that oil refineries should do to operate excellently. A good example is an Energy Policy Act of 2005 (EPAct) whose aim is to ensure that refineries follow sustainable development dream of free from dumping environment. Secondly to encourage refinery expansion and to increase capacity while not harming the environment.

2.5.1 Energy Policy Act (EPAct) of 2005

This policy main role is to ensure that refineries develop and implement cost effective energy conservation management plans. To reduce energy consumption while promoting renewable energy usage, procurement guidelines of correct energy products (Quinton, 2013). Furthermore, this policy is to ensure and combat growing international oil problems and to authorize loan guarantees and tax incentives to energy production companies on continuous bases.

2.6 Laws and regulations abiding South African refineries

Studies shows that oil and gas sector is highly regulated industry at all government levels. For example, Lowe (2014) stated that not only government is regulating the sector, but also environmental groups influence some of the laws and regulations that governs the sector. South Africa alone with its three sub refineries namely, Engen, Sapref and Sasol is regulated by 11 oil and gas regulations. These legislations include, South African Petroleum Industry Association (SAPIA), department of energy, Erratum, Petroleum product act of 1999, Petroleum and Diesel Act of 1998, Central energy regulation, National energy act, Mineral and petroleum resource development act and Occupational Safety and Health Administration (OSHA) to mention few. Any refinery operating into the borders of South Africa should always adhere to these rules and regulations. In this study, OSHA is discussed extensively.

2.6.1 Occupational Safety and Health Administration (OSHA)

Occupational Safety and Health Administration (OSHA) act of 1970 is the main act behind safety in all workplaces. Amended in 2017, the aim of the act is to ensure safe and healthful working conditions in the workplace. According to Freedlander (2008) refineries should create their own standardized rules developed under OSHA to ensure that men and women working are healthy and safety. In addition, OSHA is there to assist countries to ensure good working conditions, by giving refineries, training, development, and research in the field of occupational health and safety. Furthermore, this act serves as an education sector for health and safety of employees and to ensure that companies always adhere to OSHA.

OSHA Act also provide training and development on both employers and employees in the refining industry to prioritize health and safety. In addition, the act provides guidelines and procedures on how to conduct training and development. OSHA is divided into different subunits namely, workers' rights, right to safety and healthful workplace, employer's responsibility, self-employed or people that are not covered by OSHA. This information gives guidance and ways to run refineries without any safety and health concerned. Giving employees and employers a confidence when doing their jobs.

2.6.2 Employer Responsibility

The main responsibility according to OSH Act is to ensure a safe working environment for all employees. Employer must always follow OSHA act and provide employees with workplace that does not have any serious injuries. According to Hosskisson (2013), OSHA is there to ensure that employers reduce or eliminate any hazards by making feasible changes in the workplace that will suit their employees. In addition, some of the ways to reduce hazards in the workplace includes, proper ventilation system, safer chemicals, public and visible manuals on how to use dangerous machines, use of proper protective equipment that protect employees from hazardous situations. Furthermore, the employer must display permanent posters that describes rights and responsibility of the employees in the workplace. Employees must continuously provide employees with alarms and chemical sheets in case of hazardous situations.

2.6.3 Process Safety Management for Petroleum Refineries

Process Safety Management or PSM is there to curb unwanted hazardous situation in refineries such as unexpected fires, explosions, or toxic impacts (Journal, 2020). In simple terms, process safety is a safety management, which is concerned with safety, environmental damage, business losses and hazardous impacting. The main goal of the PSM is to develop and put into place systems and procures that can prevent unwanted explosions and fires. In addition, PSM is divided into many subgroups in order to protect petroleum companies and refineries, namely process safety standards, process safety programs, process hazards analysis (PHA), Management of Change (MOC), and operating procedures (Fernandez, 2011).

2.6.4 Process Hazards Analysis PHA

OSH Act shows that PHA is a systematic effort used to identify and analyze any potential hazard that are associated with handling in the refinery sector. In addition, PHA must always be in writing and identify any previous incidents and how were they overcome, administrative controls of hazards, and consequences of failure. A group of PHA must always make recommendations, to safeguards any possible hazards and how to mitigate them in a long run or in case, they happen again (Lowe, 2014).

2.6.5 Operating Procedures

Operating procedures of the refineries must always provide and show clear instructions of safe working, emergency days and normal operations to all employees that inside the boundaries of a refinery. Furthermore, these operating procedures must be in writing to be visible to the entire refinery team. OSHA has found out that on many occasions during inspections, some refineries do not have any written operating procedures, which in the end may lead to dangers that may be encountered by employees.

2.6.6 Mechanical Integrity (MI)

According to OSH Act, MI requires all refineries to create written manuals and procedures to maintain ongoing integrity of maintenance activities. Equipment integrity is key when it comes to MI as it plays as quality assurance act to keep

plant and equipment for long. In addition, piping systems, storage tanks, and pressure vessels are the main components that taken into considerations when doing integrity checking. It must be a continuous process by the employer to ensure a general integrity of all the work.

2.7 South African legislations governing Engen refinery

Like other countries, refineries operating in the borders of South Africa are governed by many acts and legislations that need to adhere to and make sure that they follow them according to set procedures. These legislations include, Petroleum Pipeline Act of 2003, Petroleum Pipeline Levies Act of 2004, the gas act of 2001, the Gas Regulatory Levies act 2002, the National Energy Regulator Act of 2004, the national environmental management act of 1999, and the Mineral and Petroleum Resource Development Act (MPRDA) of 2002, to mention few. Engen as the refinery must make sure that all these acts are part of their refining daily duties and are always adhere to.

2.7.1 Petroleum Pipeline Act of 2003

The petroleum pipeline act main function is to establish a proper national regulatory framework all petroleum pipelines in South Africa and its shores (Gazette, 2014). In addition, this act serves to ensure that the petroleum pipeline regulatory framework is the main enforcer of the national regulatory framework. Any matters related to petroleum pipeline are dealt with using this act.

2.7.2 The Gas Act of 2001

The gas act like pipeline act's main function is to promote a smooth development of piped gas industries within the South African borders and its shores. In addition, this act serves to establish a national regulatory framework that govern gas pipeline sector. Furthermore, ensure that the regulator is an enforcer of rules and regulations in the gas sector (Blanchard, 2007).

2.7.3 National Environmental Management Act of 1999,

This Act was amended in 2014, and its main function is to provide a proper environmental governance and co-operative. In addition, this Act establishes guidelines on matters and issues concerning environment. According to this act,

it is petroleum refinery's responsibility and obligation to make sure that they protect environment at whatever cost.

2.8 Theoretical framework informing the study.

The theoretical framework offers several benefits to a research work. It is linked to research problem and gives focus for the research (Dickson, et al., 2018). The theoretical framework guides and should resonate with every aspect of the research process from the definition of the problem, literature survey, methodology, presentation, and discussion of the findings as well as the conclusions that are drawn (Dickson, et al., 2018). In this study, we will be developing existing theories including but not limited to PMMS, Reliability-centred Maintenance (RCM), and Asset Management systems (AMS), Condition Monitoring System (CMS) as part of continuous improvement. In addition, this study will look, compare, and explore which theories fit well, and inform refining.

Research reveals that 30% of the revenue is spent on maintaining and malfunctioning plant and equipment as well as engineering systems. For instance, Peters (2005) emphasize that it is important to have in place a proper preventive maintenance program in an oil and gas industry. In addition, due to increase in cost of maintenance using old and traditional methods, it is vitally important to try latest technology that is going to fast-track maintenance programs in the refinery. In this part of the study, these existing theories at Engen with frameworks that have been in place and were used before. The main goal of PMMS is to ensure that no disasters happen during operations. In addition, safety must be a key element of oil and gas industry. Change need to be take place as a mean of mitigating all possible dangers.

2.9 Theories underpinning the study

2.9.1 Change Management Theory

According to Ntombana (2004) a change management need to take place in order for organisation to be profitable and increase revenue. Therefore, it is vitally important to review theories related to refinery and make informed decisions. The following existing theories help gives the study a view of how old systems operated before new systems and software for refineries. In addition, most

companies resist change because they always fear of failure. Research shows that some companies still prefer to use manual and traditional maintenance management procedures that are no longer perfect and can lead to deadly fires and explosion in the refinery.

2.9.2 Using Lewin's Theory of Change to Overcome Resistance to Change

Due to the ever-changing environment in which businesses operate, organizational change entails assessing and updating management structures and business processes. According to Chelsea (2015) changes in organization has involved numerous activities such as renewing organization direction, structure, and capabilities in order to serve the continued needs of the market, organization, and employees. Moreover, the petroleum industry's business environment has gotten more competitive as a result of significant modifications adopted during the last few decades. Globalization, information technology improvements, and a legislative framework that has put competitive pressure on the petroleum business in South Africa has driven strategic change decisions with the goal of distinguishing the sector from its competitors in a long-term manner (Darling, 2012).

The majority of humans, according to Lewin's theory, prefer and operate within defined zones of safety. The three primary steps of implementing change in Lewin's model are as follows:

1) **Unfreezing the present**- This entails diagnosing the need for change in an organization.

2) Moving from the present to the future by introducing intervention is the second step.

This is the point at which the parties concerned cease using the old and standard methods of running the company and start using the new and improved procedures.

3) **Refreezing**- According to the Levin's Model, this is the final stage of action, and it entails final review and stabilization of the change process. This is where

the organization's community has come to believe that the leadership's decision was the best, and that the results can even be felt.

South Africa's petroleum industry is continuously attempting to establish appropriate reaction strategies in order to propel it toward its organizational goal and stay up with these developments in order to remain competitive. Draft (2011), claimed that one of the environmental variables that drives business is competition, which puts pressure on businesses to be proactive and design successful strategies that enable proactive responses to perceived and actual changes in the competitive environment.

Due to the ever-changing environment in which businesses operate, organizational change entails assessing and updating management structures and business processes. Fine (2019) has established that the objective of organizational change is to create a market position capable of producing successful performance while establishing a sustained comparative and competitive advantage for the company to alter their plans to remain relevant in the ever-changing global market. Furthermore, the latter recommended that leaders should regard change as long-term methods for improving company performance, according to the recommended change framework. In order to compare the change between two momentums, the author suggested that a time dimension is necessary. The transition from time one to time, two should likewise be regarded a separate process.

Kurt Lewin devised one of the most important models for understanding organizational transformation in the 1940s, and it remains true today. Unfreezing, Change, and refreezing are three sequence approaches suggested by Lewin (Lewin, 1947). Therefore, it is important to understand these entire three stages perfect before implementing a change in an organization. Unfreezing is the most critical stage in the change management. Improving the readiness of the employees and willingness to change need to be monitored by management (Quinton, 2013). Transition, which is, also called a change itself or the implementation of change. In this stage, employees are accepting new ways of doing things at their workplace. Lastly, refreezing as the last stage of the change

management, where employees and their managers ultimately internalize their new ways of working using new methods. The necessity to respond to the ever-changing business environment that affects businesses has compelled strategic leaders to provide relevant guidance at all levels. No single firm can have a competitive edge, attain wealth maximization goals, or exist in the end, according to Fine (2011), unless it has a strong strategic direction and a clear strategic management process that allows it to meet its objectives. In addition, the latter mention that without the collaboration of several leaders, effective performance cannot be achieved.

These leaders in refinery sector dictate how the organization should adapt to the quick and discontinuous changes that emerge and re-emerge as the company progresses into the future. Moreover, it should be remembered, however, that when the sectors, industries such as refineries, or environments change, so should the essential competences. As a result, a strategic leader should be concerned about the key competences that will be required to achieve the organization's mission in the future, in order to create, preserve, and utilize them. Organizational leaders, on the other hand, are more focused on internal processes, leaving a company exposed to changes that could destabilize it in a hostile environment (Ahuja, 2008)

2.9.3 Corporate Communication and Organizational Change

Many business leaders choose a participatory and imposed strategy creation method. A participative method is one in which first-line supervisors design initiatives, and then communication is passed up the organizational ladder until the strategic leaders offer their approval. Decisions and plans are created at the top level and then communicated down to the lowest level in an enforced approach. Corporate Communication is intended to promote the organization's success and its response to change that may arise based on these two options. Faizah (2012), argues that about communication, it has been discovered that strategic leaders should possess knowledge, insight, skill, action, experience, and motivation. This will be useful in assisting the business in dealing with any size shift.

2.9.4 Engen's approach to Change Management

Lack of literature around Engen refinery regarding change management made it hard for this study to explore and discover how the refinery implemented its change from traditional methods adopted from Petronas to current Maintenance management systems within the company. The following diagram is a clear representation of how Engen approach the change while implementing it at the same time.

Figure 2.3 Engen Change Management Approach

Source: Engen 10th Annual Operations Conference (2012 :17)

Figure 2.3 shows how Engen refinery takes steps by steps to successfully implement the change management and implement the current MMS and PMMS that was discussed in this study. Starting from work process, the management has an obligation to seat down with engineers, discuss the new work processes, and suggest how these new work processes can be communicated to the employees. Secondly, empowering employees before any change takes place is the most vital part of any organization that want to make huge profits or want to adapt and succeed to the new processes. Empowered employees will always

bring their most knowledge and expertise when performing the tasks. The next step is to understand Engen's culture before making any change, some of the employees are Muslims some are Zulu and follow very strict rule, which needed to be taken into consideration. According to Friedlander (2008), organizations who tend to ignore people's cultures fail to exist. It is therefore, vitally important to make sure that the change is accommodative.

2.9.5 Benefits of Assets Maintenance Management in the refinery organisations

This is a very important part of this study as it shows the benefits brought in by implementing AMMS and MMS in the refinery company. In addition, it compares these benefits to different firms and help the researcher decides which are currently working better than others are before developing a new MMS for Engen. Different refinery companies use different AMMS and MMS depending on the size of the refinery, but they serve one purpose to bring safety into the refinery and to ensure that current plant and equipment live longer and perform better while being monitored for possible dangers.

- **Maintenance management systems reduce maintenance spending**

According to Brelsford (2021) AMMS reduce maintenance spending by 90% as most refineries will not worries of possible breakdowns as everything is under control. All plant is monitored, and engineers know exactly when the plant can break, down which they can mitigate by early service. In addition, refineries plan which plant, tools and spares that need to be always on standby so that during service or breakdown, work cannot be disturbed.

- **Maintenance management systems reduce probability of unplanned situations**

It is undoubtedly through that AMMS are there to inform the engineers about a possible event that may happen unplanned, and they know exactly which tools they need to perform those events. In addition, the MMS are designed in such a way that they give alert in advance. In that way, company will be able to plan any possible event and mitigate.

- **Maintenance management systems increase mechanical availability**

Research reveals that companies that knows who their problem might be are in future are likely to succeed because they put proper plans into place to curb any possible dangers. In this case, MMS will inform the management on how many engineers they need in order to solve a certain problem that may arise. Secondly, by employing or deploying the exact number of engineers, the company will also save costs of employing hundreds of engineers waiting for event can or may not happen.

2.9.6 Using John Kotter's Theory of Leading Change

The 8-Step Change Model, developed by John Kotter, is a widely used framework for successfully executing organizational change (Kotter, 1996). It was first mentioned in his book "Leading Change," which was based on years of study that found only a 30% possibility of successful organizational change implementation. However, it is not always relevant to emerging companies due to its complex processes design for big corporations, Kotter's theory in this study was compared with the existing systems at Engen. For example, Kotter's first step is about identifying any potential threats, which might disturb operations in the future and put plans into action. It is part of Engen's daily activity even before implementing the current system that were put into place in 2012.

This model aids strategic leadership and management by allowing an organization's vision and mission to be changed; it is feasible to change an organization's vision. Devising a sense of urgency, properly handling resistant groups, creating a plan of action, proper communication of change to the company, and suitable training that supports the new idea were all part of Kotter's eight model of change. In addition, Harrison (2014) stated that leadership and vision, establishing guiding coalitions, communicating, motivating, and empowering others, and anchoring innovative approaches in the firm's culture have all been stressed. In the short term, management should reward individuals who accepted the change while analysing and implementing the anticipated improvements and demonstrating the link between new behaviours and organizational transformation success by encouraging permanent change.

- **Creating an urgency for change plan**

Studies shows that open dialogues and discussions with employees around change as well as potential benefits that can be brought by change is vitally important to influence employees and see positives from the change. For instance, Vanier (2010), noted that employees became more optimistic about change if they are told their work will be more easier using the new systems that the company is about to implement. This is in agreement with Kotte (1996) because employees became more comfortable at work.

- **Developing a vision and a strategy to implement the change**

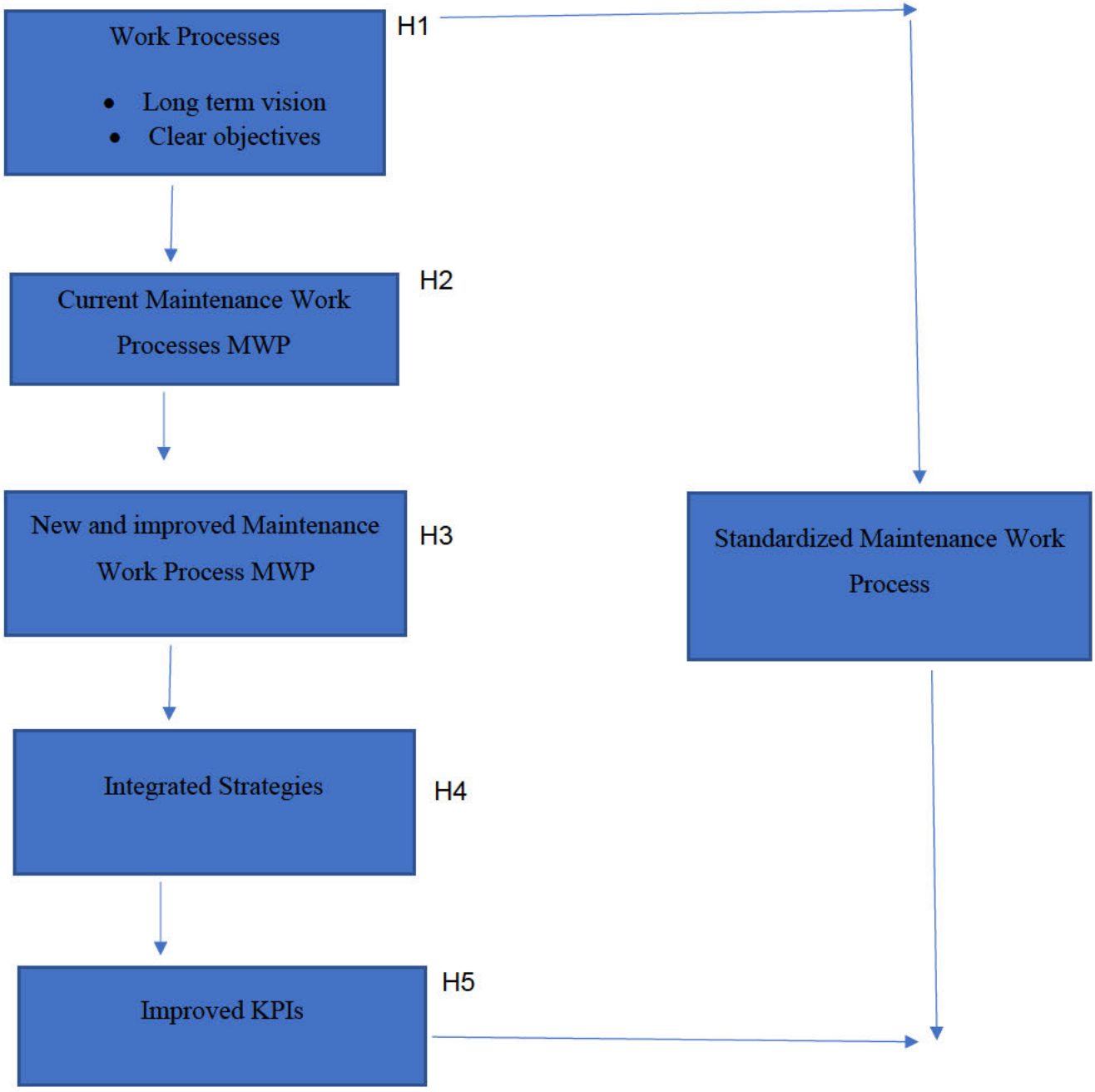
Refinery employees are very cautious people especially when it comes to their safety. Therefore, it is vitally important for management to have a strategy in place that will guide the change and inform all employees. Most companies or refineries put change leaders in change of communicating the change and ensuring people that it is not going to change their normal way of life rather; it will simplify their work processes. Implementing systems that will be responsible for recalibrating plant and equipment will save not only time and cost spent by engineers fixing plant but will allow employees to utilize the same systems to report any possible dangers or breakdowns that may happen in future.

2.9.7 Conceptual Framework

According to Johnson (2011), conceptual frameworks are made up of a collection of general ideas and theories that aid researchers in identifying the topic they are studying, determining the independent and dependent variables, framing their questions, and locating relevant literature. Conceptual framework is a type of structure that aims to explain the relationship between variables in a study by using diagrams to show the relationship. It is a model that identifies the concepts being studied and their relationships. In this study, the conceptual framework depicts the relationships between the study's variables, primarily the impact of Maintenance Management systems on Engen refinery. MMS, as measured by a streamlined cost structure, faster recalibration, and technological adoption during maintenance of refining plants, and aligned skills, is the dependent variable.

Figure 2.4

Independent Variable vs Dependent Variable



Proposed Conceptual Framework for the study

2.10 Chapter summary

The literature review informing this study has reveal clearly that there are MMS and AMMS that are in operational in most refineries, but more developments

need to be made to ensure that these systems are automated. This literature also reveals that most refineries still prefer old and manual maintenance systems as they feel more comfortable in implementing them but in a long run are not helping them at all. A good example is a 2020 drone attack at Saudi Aramco by rebel group. If Aramco like Sinopec in China employed drone interceptors, the damage was going to be zero as those drones were going to be intercepted before they hit the plant. Putting these measures into place not only helps organisations saves costs, but pre plan the future. The next chapter is research methodology where this study will look at methods that can be used to collect data and use it to develop a system to recalibrate maintenance at Engen.

3. Research methodology

3.1 Introduction

The previous chapter presented the conceptualisation of the present study whose main aim is to assess the work process calibration as an efficient maintenance strategy for oil and gas industry with Engen as a targeted organisation. Research acknowledge that South African refineries are facing poor maintenance of infrastructure which at times led to fires that can be avoided. This chapter discussed and looked deeper into the methodological decisions made in order to explore an effective work process calibration as an efficient maintenance strategy for oil and gas industries. Researched reveal that methodology is simple a general plan on how a researcher goes about answering research questions. For example, Thornhill (2016) stated that the most important part is to ensure that a decision is made around research design, sampling, and most importantly data collection and data analysis. In addition, the research methodology can be divided into the following easy categories namely research philosophy, research methods, the research approach, the research strategy, and research techniques.

3.2 Research design, methods and approach

3.2.1 Research paradigms

Many studies associate research paradigm with how the researcher reflect of global assumptions about methodological choices. For instance, Raymond (2018) defined research paradigm as the systems and beliefs involved in the development of research knowledge. In addition, the way the researcher perceives and understand the world is influenced by the chosen research paradigm. Furthermore, the research paradigm can influence a researcher's possible perception about problems and solutions to the problem. Moreover, Sekeran and Bougie (2016) simplify the research paradigm as a set of beliefs that guide the researcher about the world view and the relationships of one's individual with the world.

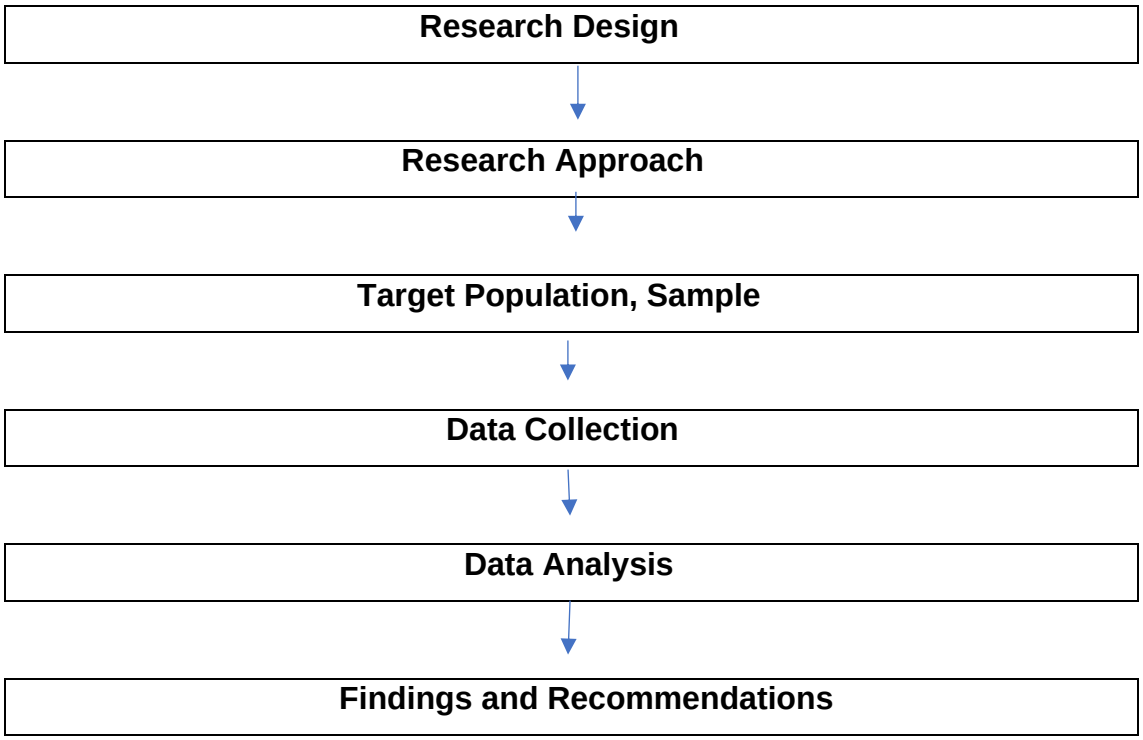
In research there are many paradigmatic categories but most popular are positivism, post positivism, critical theory, and constructivism (Leedy, 2015).

These categories can be distinguished from one another by their methodological ontological and epistemological assumptions.

According to Creswell (2013) critical theory and constructivism are of the view that the interpretation and construction of narratives and realities are mostly influenced by past events like history, positionality, and context, whereas positivism and post positivism implies that one's objectives reality can be known by using quantitative methods of research. Moreover, the ontology emphasise the nature of the reality of the situation, whereas epistemology explains the possibility of knowing that reality. Furthermore, the truth of such reality or credibility can only be achieved through methodology.

According to Tobi and Kampen (2017), the process of identifying, assessing and analysing the available data or the information needed to support research question for the research then develop and express the ideas is called research process. The main aim of the research process is to help establish the framework of the study being conducted and identify the research problem help set research design, the sample size, help collect and analyze available data and report the findings at the end (Bryman, 2015). Each study's research process consists of step-by-step process on how the researcher is going to collect data, how that data will be analysed in order to answer the research questions of the study. In addition, the research process, also consists of how data will be interpreted with an aim of answering research question.

Table 3.1. The research processes



Source: Adapted from Sekeran and Bougie (2016:48)

Table 3.1 is showing the six step-by-step processes that a researcher needs to follow in order to conduct the research effectively and efficiently. The research process begins with the researcher choosing the correct research design which is the technique use for collecting, analysing, interpreting, and reporting the data of the research study (Leedy, 2015). The process proceeds to research approach that the researcher will use to conduct the research namely, qualitative research, quantitative research method and mixed method approach will be discussed further in the upcoming topic of this research. Furthermore, the research process discusses the target population and sampling which is a group of people that the research will be targeting during data collection and those people that will be selected in a group respectively. Once these steps are finished, the researcher collect data using a selected researcher data collection method and analyse the available data. Finally, for the research process, the researcher discussed the findings and recommendations of the study.

3.3 Research designs

According to Boru (2018) research design is a technique used by researchers to collect, analyse interpret and report data in a research study that was conducted. In addition, research design is explained as an approach which explain how the researcher is going to conduct the study in order to solve or answer the questions. Furthermore, research design explains how the data is required to conduct the study is going to be collected by the researcher and also how it will be analysed (Saunders, 2016). Moreover, the research design helps the researcher to understand how required data will be utilized to answer intended question. Like Bryman (2015) stated that the exploratory research provides the researcher the understand that is deeper for the problem before the research can conduct the research. Moreover, the later also emphasize that the descriptive on the other hand is used by the researcher to describe the phenomena and some different characteristics that exists. In this specific study, the researcher used all the main research design namely descriptive, exploratory as well as causal study. For the subject of this study to be described accurately and correct, the descriptive research is relevant, whereas at the same time the researcher simplified and clarified the intended variables by showing the relationship between the study conducted and these research components, by using causal research. In addition, the researcher thoroughly observes by adding relevant and more important information in order to support the theoretical framework with available facts.

3.3.1 Research approach

According to Williams, Onsman and Brown (2015) a research approach is plan and procedure that describes the methods of data collection, analysis, and interpretation of results by the researcher. Moreover, chose of research approach depend on the nature of problem being address and is not static. In addition, some researchers use a certain approach because of available data. For example, Wartenweiler (2018) a researcher uses quantitative research because only numerical data that is available or qualitative data because the researcher have access to respondents that can seat for interviews or answer questionnaires.

3.4 Quantitative research

Quantitative research allows the research to use mathematical, numerical and measurements when conducting research (Daniel, 2016). In addition, quantitative research uses manipulative existing data, polls, questionnaires, and surveys to collect data for research. Furthermore, the quantitative research generalizes this collected data across a group of chosen people and explain the problem. Lastly the quantitative research approach allows the researcher to develop more or several concepts about the research phenomena in a free-flowing or unprompted manner.

3.5 Qualitative research

According to Leedy (2015) and Ormrod (2011) qualitative research as a holistic approach that investigate the social phenomena from the participant's viewpoint. In addition, qualitative purposefully describe, explain, and interpret data less structured than quantitative research method. Furthermore, qualitative formulate and build mostly, new theories. Moreover, for qualitative research, the researcher is more involved in the actual experience of the research like interviewing the participants or observing the actual study.

3.6 The method chosen for this study

For this study, the researcher finds it useful to use qualitative research method because the researcher has access to participants from inside the company Engen that can assist in answering questions related to work process calibration as an efficient maintenance strategy. Qualitative research method unlike quantitative, is not bound by limitation of available data or numeric but the researcher can capture the changing attitudes of participants within the targeted group (Creswell, 2013). In addition, the qualitative research allows the researcher to be more speculative in some instances especially with what areas of the research the researcher want to research.

3.7 Population and sample of the study

Target population in research simple means, a group of people that the study will be conducted around. Wilkinson and Bhandarkar (2019) describe target population as entire population the researcher is intended to conduct research or

interested to conduct research to. In addition, after the researcher has identify this target group, a sampling frame is then drawn from this group. Furthermore, target population can also be described as an entire population a researcher consider qualified for the research to be conducted to. In this research, the target population is Engen refinery employees in KwaZulu Natal, South Africa.

3.8 Sampling method

Sekeran and Bougie (2016) define sampling as subset of a targeted population a research study is going to be conducted to. Sampling has many advantages than conducting a research study on the entire population. Namely sampling saves time, as there is no need for the researcher to either interview thousands of participants or analyse thousands of questionnaires, rather only those sampled participants will be allowed to be interviewed or fill the questionnaires. In addition, sampling participants rather entire population likely to produce reliable results at the end. Sampling is made up of two types of sampling namely, probability sampling and non-probability sampling.

Different authors define probability sampling as a process whereby every member of the population has a chance or a probability of being sampled in order to participate in a research study. According to Collis and Hussey (2019) probability sampling suggested random sampling where every person in a chosen population has an equal chance of being selected to participate in a study. On the other side non-probability sampling implies that certain members of the targeted population are chose because of certain characteristics that are needed by the researcher. In addition, the non-probability sampling characterized by not being random as not everyone has equal chance of being selected by the researcher to be part of the research study. Moreover, in random sampling, a sample is selected on based on the judgement made by the researcher not on random bases like probability sampling (Creswell, 2013). The non-probability sampling uses many criteria like geographical proximity of the respondents or the targeted group, the availability of respondents or the expert knowledge of one's respondents. Non-probability sampling is divided into, different types of sampling methods namely quota sampling, snowball sampling, a convenience sampling and purposive sampling to mention few. A quota sampling is where a researcher

selects a predetermined number or what is called proposition (Chetty, 2016). In addition, the sample should be selected in a non-random manner.

A snowball sample is used mostly used by the researchers when it is extremely hard to reach the targeted population. In some cases, snowball sample is more relevant when there is little or no available database to help the researcher find the sample. According to Wartenweiler (2018) when a researcher conducts a snowballing, the researcher should start by sampling one respondent and use this selected sample to introduce the study to other. In this way, the selected sample is used to spread the word about the research, the phenomena, and the study as a whole. On the other hand, the convenient sampling is sometimes called the accidental sample by the researchers. This is because at some points, these samples can be selected because they are closer to the researcher and end up participating on the research study.

For this study a purposive sampling was used as the researcher was only interested in a specific population of a specific organisation which is 12 engineers within Engen refinery in KwaZulu Natal. This is for the purpose of collecting and obtaining a certain data from these Engineers. According to Rosenthal (2016) with purposive sampling, the researcher is only interested in specific population which possesses enough information with the study's aims and objectives. In addition, this population is where the researcher will necessary information, and they are also the ones who will answer the research question. Finally, interviewing these engineers that are directly involved in the day-to-day activities which includes calibration and recalibration, the researcher will get accurate data for this study.

3.9 Recruitment: inclusion and exclusion of participants in the study

Many research studies reveal that inclusion and exclusion criteria help by setting up the stage on who is going to participate in your data collection and who is not based on the qualities that a researcher need from those participants. In addition, researcher must firstly be clear on who is going to participant and what information or qualification the participant should possess in order to participate. Also, the participant must be clear on who is going to be excluded from the

participants and why. The aim of this study is to assess the work process calibration as efficient maintenance strategy for oil and gas industries. In that case, this study will only focus on Engen as a refinery in South Africa.

3.9.1 Inclusion

For the purpose of this study, the following participants were selected based on the criteria of research inclusion as well as aim of this research study.

- Selected Plant operators
- Selected Maintenance Managers
- Selected maintenance planners
- Selected maintenance engineers

3.9.2 Exclusion

For the purpose of this research study and the timeframe to complete the study and the criteria for research exclusion. The following participants were excluded to this study.

- Engen refinery process engineers
- Engen refinery warehouse team
- Engen's refinery inspection team
- Maintenance Artisans

In most cases, the inclusion criteria will also explain the age, the experience and the special needs or any qualities that researcher is looking for.

3.10 Data collection

For this study, the structured interviews were used a data collection method. The interviews were set up for each and every engineer of the 12 engineers where the researcher pose questions about the study. In addition, each engineer was given enough time in order prepare for interviews and answer at a maximum capacity. According to Leedy and Ormrod (2011) it is researcher responsibility to ensure that each interviewee or respondent is informed in advanced about the upcoming interviews and the tools to be used if necessary. For this study, all the

engineers were informed in advanced about interviews to prepare themselves about answering the research study questions

3.11 Qualitative data analysis

To analyse this studies data, a thematic method was used in order to analyse the available data and get accurate results. In addition, in thematic method, a researcher anticipates the responses from the respondents and design some kinds of themes with an aim of differentiating different responses from the respondents (Ganapathy, 2016). In addition, a researcher designs these themes under each and every category. As these responses come from the respondents, the researcher role is to make sure that the right response is under the right theme. Moreover, the researcher has to use the key findings from these respondents and use them as a topical category.

3.12 Thematic analysis

According to research, this is the most common research strategy in the academia. For instance, Gerring (2017) argue that action research is conduct by both the researcher and a participant which is a client in this case. The researcher and a client diagnose the problem and develop solution to the problem. In addition, the action research is more common in organisations where the organisation will call a collaborator to assist the researcher to diagnose the problem and then at the end, there should a solution to the problem. On the other hand, Boru (2018) describe grounded theory as a process whereby a researcher develops a theory about existing phenomena. Moreover, the grounded theory construct theory from the data that is collected with an aim of solving the phenomena. In addition, the grounded theory uses comparative analysis to construct a theory. In this study interviews will be a preferred us in order to gain more insight about the phenomena.

3.13 Ethical consideration

For this study, data were collected from reliable sources from engineers who are involved on the daily activities of work process calibration. Consent was also granted by the UKZN, and ethical considerations and gatekeepers' letter were approved.

3.14 Chapter summary

In this chapter, research paradigm, research design, research process, research approach, research strategy and sampling were dealt with accordingly. As the purpose of any research is to solve problem Walker (2017) and the method applied should always aim at solving that problem. The following chapter analyse and present the data that was obtained using the methodology that has just been discussed. In order to give a meaningful decision-making information for the research study, data analyses are fundamental.

4. Presentation, Discussion, and Analysis of Results

4.1 Introduction

The purpose of this qualitative study is to assess the work process calibration as an efficient maintenance strategy for oil and gas industries. In addition, it aimed to determine world class standard priorities to attract investors in an oil and gas industry. Furthermore, the purpose of this study is to identify and ensure seamless integration with various departments/ functions within the refinery. Moreover, this study aimed to assess, evaluate, and benchmark the standard maintenance work process across the refineries across South Africa and abroad. Lastly this study examines profitability, competitiveness, and supplier development.

4.2 Presentation of Findings

The data collected through interviews was coded into themes in order to categorize same and similar answers from participants and create necessary themes after. Henry (2018) mentioned that themes not only help the researcher to categorise the same and similar answers but also to simplify responses from the participants. For this study these themes were grouped together into categories of areas of improvements, C1 and C2 equipment, proactive preventative maintenance and reactive preventative maintenance of equipment, plant improvement programs, maintenance management process and risk management. These themes were reviewed numerous times in order to ensure that the participant feedback is captured correctly and allocation of titles in order to ensure and convey integration. Rowland (2016) argues this is done to ensure that no data from the participants is missed or remain unused for the study.

Research question one focused on strategies and work process in order for the refinery to be profitable, competitive, and relevant to the suppliers. Question two focused on how a refinery can become a world class standard to attract future investors. Question three focussed on how a refinery can standardize maintenance work process across refineries in South Africa. The last question focus on how a refinery can ensure seamless integration within various departments in the refinery. To ensure integrity, demographic data was also

analysed using nominal scale and the main results were presented in a form of a chart. In addition, in order to ensure anonymity, the participants real name were replaced with coded so as to not publish their real names.

4.2.1 Demographic Analysis

Data presented below represent all the participants demographic data like age, experience with Engen and their roles.

Figure 4.1: Age of Participants Interviewed

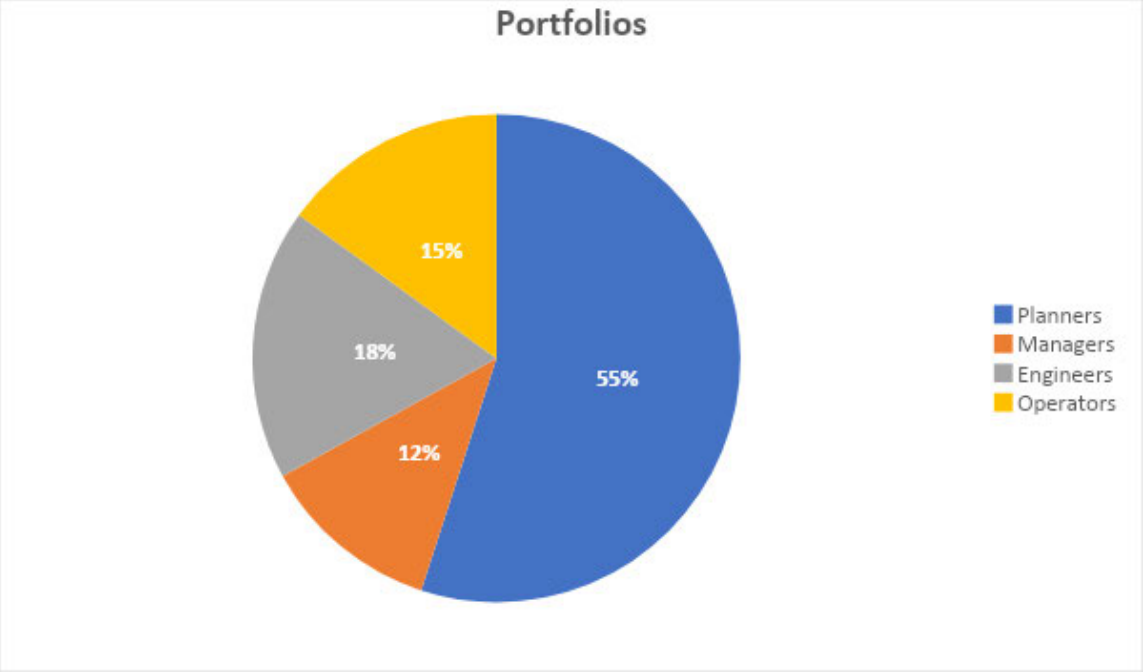


Figure 4.1 shows the age analysis of the managers, engineers and maintenance planners interviewed. 55% are more than age between the age of 45 and 50 and 18% are between the age of 35 and 40, whereas 15% are between the ages of 30 and 35 and finally 12% of them are between the ages of 40 and 45 years of age. It is also important to note that Engen employs mostly different grade of employees from C1 to C2 and their positions differs in terms of the specific department they work on. Furthermore, this analysis helps the researcher to balance different ages of participants and individuals who work at Engen.

Themes have been aligned with Four Objective that the study is earmarking to unlock and unpack in an effort to discuss all the findings from participants and well as ensuring that the theory development is executed within the inductive orientation of a qualitative methodology. The role of researcher is to structure the research objectives in a way that they also accommodate results and align feedback at the same time (Leedy, 2015). The themes are as follows, theme one understanding strategies and work processes, theme two plant maintenance gaps, theme three, plant maintenance strategies, theme four is benchmarking.

Figure 4.1: Themes discussed.

Dominant Themes	**Emerging Themes**
Strategies and work processes	Understanding Strategies and work processes
	Plant Maintenance gaps
	Integrate strategies to be profitable and competitive
World class standard and attract future investors	Benchmarking maintenance KPI
	Engen current maintenance hierarchical structure
	Plant Reliability and Availability to maximise production
Standardized Maintenance Work Processes across Refineries	Standardized Maintenance Work Processes across Refineries
	Leveraging resources across plants
	Use of digital tools to support the work processes
Seamless integration within various departments in the refinery	Ensuring Seamless integration within various departments in the refinery
	Leveraging resources across plants

	Use of digital tools to support the work processes

Source: Constructed by the researcher.

4.3 Presentation and Results of Objective One

To examine profitability, competitiveness, and supplier development:

4.3.1 Dominant Theme 1: Identify Strategies and work processes

4.3.1.1 Emerging Theme 1.1: Understanding strategies and work processes

For theme 1; 90% of the participants understood the strategies and work process that can be implemented in order for Engen to be profitable and competitive. In all the interviews conducted, all participants added their view on this question. Participant P05 mentioned that the safety, reliability and efficient is key if the company want to achieve operational excellence. On the other hand, other participants as well show a strong support of work process and strategies that can be implemented.

When asked about understanding of strategies and work processes, participant P02 viewpoint was:

"The maintenance strategies can be categorized into two streams or two groups. Group 1 deals with proactive maintenance Group 2 tackles reactive maintenance. Both maintenance strategies are then integrated." Participant P02 further narrated that "The proactive side is divided two components, which is preventive maintenance, which is a time-based maintenance with time intervals. Second type is predictive maintenance which is condition based, depending on the equipment economic life as it is being used in the production". Two types of proactive maintenance are preventative maintenance and predictive maintenance which are highly recommended in the refinery environment to keep your plant safe, reliable and available (Moubray, 2007).

Ten participants added more information which is a sign that they understand the need for these work processes to implement with an aim of making the plant more efficient. In addition, the participants added that these strategies will not only

maintain the plant but also ensure that the plant is safe reliable and efficient. Participant P01 stated that some condition monitoring inspections are conducted to measure the condition of the equipment which will assist in proactive maintenance.

In addition, Participant P011 viewpoint is that there is an understanding of strategies that can be implemented to support these work processes. Participant also quoted a previous employer which is a competitor of Engen that, the sometimes not wait for the plant to show signs of that it need maintenance, but maintenance was a continuous periodic measure, and their plants use to outlast the work and problems. In addition, on top of periodic services, the company would have monitoring managers, these manager with engineering background will now and again go around the site monitor any problem that may arise on daily bases.

4.3.1.2 Emerging Theme 1.2: Plant Maintenance gaps

All participants show a strong understanding of the gaps that exists in the current maintenance process that exist at Engen refinery. Closing these gaps by Engen was suggested by all participants as this will increase the efficiency of plant.

When asked about plant maintenance gaps, participant P04 viewpoint was:

The biggest gap is the culture to change and willing to change. Engen refinery is full of old employees who have been with the refinery for a while which are so hard to be influenced by newer managers or to change to new technological advancements. On the other hand, participant P0 12 stated that at some stage employees will utter to their managers that they are not ready to change to the new process and also ask the use of changing if the old processes are still working. In addition, the push their cultural existence more that work. This is becoming a major gap for Engen as these employees tend to drag the company backwards.

On the other hand, participant P03 also share the same viewpoint as P04 in stating the following:

I have experienced a situation where I suggested an easy and more reliable way to maintain plant and equipment, but other employees tend to oppose that because is going to either infringe their culture times of activities. I was not against anybody culture but also suggesting a more reliable and easy ways of calibrating the plant and equipment".

Another major gap that was brought up by Engen employees is the issue of skills level. These three Participants which is participant P07, P11 and P012 confirmed that refineries are faced with serious issue of skills shortage gap. Participants showed a very strong understanding of the important of a necessary skill not only to operate the plant and equipment but also a skill to maintain and service these plants. For example, participant P07 viewpoint was that some employees can be good at job execution but when it comes to reporting are not well equipped or empowered which affect the effectiveness of their reporting. In addition, these reports make a very huge impact on the entire reporting of the state of the plant. Participant P011 stated that currently Engen has more internal service engineers who are responsible for maintenance of plant and equipment than outsourcing. The participant also suggested that in most cases, external service engineers outsourced by the refinery usually do better job as compared to salaried engineers as they are also looking at opportunities of being called again.

Though some participants made a very informative argument that paperwork does not always reflect the experience, skill, and expertise the employee possess. For example, Participant P01 argue that most of the engineers who have been with Engen for over 3 decades always come up with solid solutions during breaks downs and downtimes. In addition, these engineers have no qualification of some sort, but their work ethic and skill is unprecedented. Participant P011 also support the participant P01 that it is important to understand that employees are different, and it is important to understand their role and value they add into the refinery as it may happen that their skill and expertise is unique and no one else possess that skill. So, the most important solution to close the skill gap is continuous training and development to all employees in Engen refinery.

Other gap that was brought by participants is work overlap which affect the effectiveness of their work in their specific role. Three participants mentioned this gap and discuss it deeper. Participant P04 stated that job rolling is not only affecting their productivity but makes them question, what exactly is their role in company as today they will be assigned as calibrators, tomorrow as maintenance manager and next day as engineers in a totally different department. Though many study studies reveal that job rolling is vitally important in all organisations as there will be no chance for employee shortage in an organisation. For instance,

Another gap identified by participants in this study is poor performance management by Engen. For example, participant P01 stated that a performance appraisals and Key Performance Indicator review (KPI) is done once per year at Engen unlike other companies who usually do it in every fortnight. Participants who discussed this gap also stated in most cases, performance management is a vitally important even in any company as it help employees to know exactly what their role is and what must be accomplished and when. In addition, the lack of KPI reviews help managers to exploit employees at Engen in such a way that they end up performing duties that are not theirs and will have a negative impact of their own duties. Moreover, performance management is able to determine the skill and expertise of every employee.

Participant P01 viewpoint was that "at some stage, there are no performance appraisals for more than six months which affect employee performance as employees like to know how they are doing so as to know where to improve as time goes on. Most employees like performance appraisal at Engen so as to gauge their work ability and reporting".

The final gap that was identified by participant P04 is lack of transition and mobility of Engen staff that work directly on the plant. This makes it hard for plant manager to assign key tasks when one of the specialist engineers is not around. Employing two or more engineers to avoid such cases is not only costing the Engen millions of rands but also increase a number of employees as more employees means more salary pay-outs. The participant emphasize that it is

vitally important to ensure that almost everyone who works as a plant maintenance or plant calibrator possess same and similar expertise so that in case of breakdown, anyone can pick up tools and assist. In addition, the participant emphasize that this can only be achieved through training and development. Engen should implement continuous training and development in order to level the skill set in all employees that work inside the Engen refinery.

4.3.1.3 Emerging Theme 1.3: Integrate strategies to be profitable and competitive

All twelve participants answered this question with confident and suggested as many strategies as possible. Five participants mentioned the importance of understanding organisations objectives before even setting up strategies that will help Engen to be competitive and profitable. For instance, participant P02 stated that, the value of aligning Engen plant objectives as well as the whole Petronas group is vitally important as everyone from top management in Malaysia and top management in South Africa will support any initiative implemented by Engen refinery. In addition, there must be no business units that operate in silos as this will affect the business process. There must be one objective, one reporting process and one strategy for the entire Engen group.

Regarding integrated strategies to be used by Engen in order to be profitable and competitive, participant P07 viewpoint was:

“Work processes kick in that address the planning, and execution of maintenance work. Maintenance is supporting production, hence there is a need for Operations work processes to tie up with Maintenance at all levels. Work process integration roles must be upskilled as needed so that there is not mismatch in Operations understanding maintenance requirements and vice versa.

More importantly none of the work processes would work efficiently if they were not empowered at the frontline level to make decisions that are aligned with their responsibility. Roles should be empowered to work in a team’s set up so that they achieve team goals rather than individual goals. What is the point of achieving an

individual goal if the team fails, it might not be felt by the customer? Team members can thus hold each other accountable, and leaders may then focus on strategic matters".

This explains the role of achieving group goals rather than individual goals as it hard to create a strategy based on three thousand goals under one umbrella organisation. Other participants also supported the issue of addressing objectives and aligning them first then develop a solid strategy for the organisation. Participant P011 also supported that each engineer must be given an opportunity to seat down with either plant manager or any senior and state his or her objectives about the progress of the refining plant. In doing so, Engen is not only giving these employees confidence but at the same time, Engen is creating an open communication where employees also have a say about anything that can help the organisation move forward. Moreover, employees know the job more than managers as they are involved in the refining process as well as inside the machines.

Participants clearly explained that this open communication strategy is going to help engineers to have a voice from machines and plants used during refining, or to anything that relates to maintenance of refining plants. Participant P05 stated the best way to address this is to set a communications office where it is accessible to everyone who is willing to suggest any improvement or anything that can be implemented by Engen with an aim of smoothing operations thus making employees not only effective but also productive. In addition, the open communication strategy will help planners to have enough data on what is happening inside the plant, what need to be done during the maintenance of plant, and also what can be done during breakdowns and downtimes. In addition, participant P02 also seconded the open communication strategy in such a way that the participant added that during downtimes, Engen can roll and rotate engineers to departments that are operational at the time. This should not be confused with job rotation, but this must be associated with helping out on other department within Engen plant during these downtimes.

Participants also identified that one of the problems that makes engineers not to report upcoming problems is the fact that most organisations like Engen have no proper communication structure and this make it hard for them to report in advance anything they are not sure about. So, by implementing open communication, the company is not only helping itself but opening opportunity for suggestion from internal engineers.

Another key strategy introduced by participants during interviews include employee empowerment strategy. Participant P012 mentioned that empowerment has nothing to do with training and development only by also it is vitally important to delegate engineers to even more senior roles in an organisation. This exposure will help them to even grow more on task performance as well as reporting at the same time. In addition, delegating tasks not only help the organisation alone but also will help if the one of more senior leaders is not available to perform the main task, and anyone can just carry on with the task, thus work process strategy. This strategy will open more opportunities for growth of internal employees to be fit for future managerial positions and to know what management expectations for senior managers are.

According to (Henry, 2018) employee empowerment has been found to yield positive results in any organisation as it is cheaper to look for employee of management replacement inside the organisation. In addition, these people are already familiar with work processes and procedures, and it became easy to adapt to any changes. Unlike an external person who need a thorough training and development, the whole interview process, screening, induction, placement and so forth. This comes at a massive cost as the company has to look for best candidate and the best candidate comes with a big fat salary. In this study most participant introduced this empowerment strategy as a mean to grow engineers to be ready for future management task and any future promotions.

Another important suggestion form participant P01 is that there must be collaboration and no department that should operate in silos. Collaboration means, each department within Engen refinery must be aware of activities happening at any other departments. This is to ensure that no department is

performing their own things when objectives and strategies point to a different direction.

On the other hand, Participant P01 viewpoint on the integrated strategies to make the refinery profitable and competitive is that, which “the *whole value chain starts with business objectives, from understanding what the business wants to achieve to meet customer needs, maintenance strategies could then be developed at site and facility level. No maintenance strategy must exist in a vacuum. And then the work processes kick in that address the planning, and execution of maintenance work. Maintenance is supporting production, hence there is a need for Operations work processes to tie up with Maintenance at all levels. Work process integration roles must be upskilled as needed so that there is not mismatch in Operations understanding maintenance requirements and vice versa. More importantly none of the work processes would work efficiently if they were not empowered at the frontline level to make decisions that are aligned with their responsibility. Roles should be empowered to work in a team’s set up so that they achieve team goals rather than individual goals. What is the point of achieving an individual goal if the team fails, it might not be felt by the customer? Team members can thus hold each other accountable, and leaders may then focus on strategic matters”.*

Understanding what other departments are doing helps simplify the work generally and most teams end up understanding exactly what is performed by different departments. For instance, maintenance as the most common department should always receive and understand the correct data performed by calibrating department. This will avoid unnecessary problems that occur due to carelessness or overlaps. Thus, unifying the work process of an organisation. In addition, the role of departmental managers is to seat down periodically e.g. every day or every week and report on their departmental progress, struggles, challenges, and future plans so that it will be easy for other departments to advise as well. Furthermore, these gatherings should always include all departmental heads of Engen refinery departments and at the end of these gatherings, they must go back to their teams and present other departments goals and findings. This will play a very vital role in understanding everyone scope of work and how other department can assist.

Another biggest strategy suggested by participants is to have constant plans that are not disturbed by any new jobs. For instance, participant P08 noted that as a planner in the planning office, they will plan for a schedule maintenance and all of a sudden, they will be told that the production was low the previous day and it will be hard to have a plant or equipment refining for more than an hour. This planned schedule is very important and need to be a continuous task for planning department with an aim of making sure that the plant is always operational. Forcing the plant to keep operating even if it's due for service not only kills its productivity but also delay production because it may happen in future that plant will stop working during the critical time. The participant supported technologically periodic checking and maintenance of plant and equipment with Engen refinery.

4.4 Presentation and Results of Objective Two

To determine the world class standard priorities to attract investors:

4.4.1 Dominant Theme 2: World class standard and attract future investors

4.4.1.1 Emerging Theme 2.1: Benchmarking maintenance KPI

All twelve participants had a great view on making Engen the best refining company in the Southern Hemisphere. In order to make Engen successfully and compete with big role players in oil and gas refining, it is vitally important to compare its business processes with those that are deemed best like Shell, BP, Sinopec, and Chevron. If Engen can meet all the standards that are placed by ISO 900 and achieved by these companies, then it can regard itself as a big role player in oil and gas refinery. In addition, benchmarking can take many forms in terms of these participants. For example, participant P02 claim that one of the problems that South African companies like Engen and Caltex feel hard to compete with major oil refineries, is because they do not have to compare themselves with big refineries like Saudi Aramco. In addition, they import more than they are supposed to export their production making it less know the first world countries and rating agencies.

According to participant P05, benchmarking maintenance KPIs will not only help Engen but will make employees and engineers know that they are no longer going to be appraised internally but their work will also have international standards.

Furthermore, meeting international standards will increase a potential number of customers that are also willing to buy the product. Benchmarking will ensure that the refinery is always on the eyes of international standard organisation ISO and follow its strict protocol. Participant P09 stated that, there is no need for Engen refinery to worry about producing exact product as major players but also just ensure that the refinery meet all ISO standards and keep up to dates with any international development that will keep the company up there. Same applies to the maintenance, during the scheduled maintenance, Engen should always ensure that plant and equipment are serviced as per ISO 900 and other standards in order to ensure the international safety and security standard are part of their scheduled maintenance plan.

Participant P012 viewpoint was, "I think what will help us is to increase on the planned maintenance as per ISO 900. That will mean our plant will be more reliable and will have less failures because we have increased our plan maintenance. We make sure that our equipment does not fail by complying to our planned maintenance and prevent failure before it happens. In our business is called PMR's (Preventative Maintenance Routine's). You do not let your equipment to run to failure, because when it fails it means you have unplanned downtime you are losing in production. So, if we stop our equipment, we stop our equipment just for two hours to make sure that we service. It's similar to servicing your car instead of waiting for it to fail, you service it before it fails. So, if we can improve the compliance on our PMR's, we improve the planned maintenance, then we'll have less failures. I cannot remember clearly, but I think our plan maintenance we need to achieve 90% of the plan maintenance and our reactive work. We try and minimize it. We don't want it to exceed 2% of our orders".

Furthermore, the participant emphasizes the need to ensure that plants and equipment used at Engen are not maintained whilst they are still in good condition in order to avoid downtimes and breakdowns. These breakdowns take longer to be resolved, that more cost to the company, and more cost means more money going out. Moreover, having a proper maintenance plan will not help plan the downtimes but will also plan in advance and have substitutes of what to be used in cases where the plant takes longer to be maintained or serviced. This will bring

a huge benefit to Engen at large as it become easy to anticipate plant breakdown and counter in advance.

Most participants also mentioned that thousands of maintenance report are available online or on the websites of major refineries around the world. Engen managers and plant calibration managers can take time off and visit those websites and download those maintenance manuals and use them to benchmark their maintenance strategies and that will yield positive results as those maintenance manuals are tried and tested.

4.4.1.2 Emerging Theme 2.2: Engen current maintenance hierarchical structure

All participants were so open in answering this question as it mostly affects the entire workforce. Most of participants have more disadvantages of this maintenance structure than advantages. For example, participant P08 reveals that the current maintenance structure is full of faults and gaps as sometimes stuff will be notified of unexpected downtimes that were not part of the plans. Thus, showing lack of planning and scheduling from plant and calibrating managers. In addition, participants added that the current maintenance structure only takes care of certain areas and not every part of the refinery is covered like unexpected breakdowns, periodic or planned quick check-ups.

According to most participants, the current maintenance structure needs to be revisited as only the superiors have power to comment of influence the decision about anything that need to be performed in an organisation. For instance, participant P011 stated that rigid structure's main weakness is that only the management can make key decision and their say is final. On the other hand, participant P05 argues that relying on the current hierarchical structure not only bring problems within maintenance schedule but also provide same and similar results as the previous calibration. In addition, they are lot of improvements that need to be followed which sometimes are unnecessary and has nothing to do with the work process of Engen. Some of the cons revealed by the participants is that some of the maintenance managers are not specialists which make hard for them to perform their intended tasks.

Regarding current hierarchical structure, participant P04 viewpoint was that "*the Maintenance Activity Coordinator (MAC) is the one person who has overseen the plant for a long time, understands the plant and has been technically involved in the plant. But OER2 changes the role of the MAC uses a technical team that services the entire organisation. Their technical team does not understand plant activities as much as the MAC. So, this may hinder solution development sometimes. The Maintenance Work Coordinator (MWC) also is now multi discipline. So, this person is expected to learn other disciplines and understand the technical scope for all disciplines while proper training and upskilling to other disciplines has not been conducted".*

Not all the participants notice the cons or disadvantages on the current maintenance hierarchical structure. Some were able to identify advantages like reporting and timeframes. For instance, participant P01 reveal that when it comes to reporting it is easy for engineers to report any possible danger that may occur within the plant. In addition, the current structure allows top managers time to plan and execute any future strategy they think it will operate successfully rather than listening to engineers' point of view. Furthermore, hierarchical structure makes it easier to report to your line manager about any progress of your work processes. Same applies to maintenance engineers, hierarchical structure helps them to know exactly who their line managers are as well who is supposed to give them tasks and duties related to maintenance work.

Whereas participant P010 viewpoint was that "In an organization that is hierarchical (many-layers) the speed of decision-making severely takes a knock. Nowadays the environment requires the business to be agile to customer needs. Generally speaking, in a hierarchical structure employees need to be risk averse as opposed to risk-takers within a given operating envelope. They wait for the boss to decide, or to concur with their thoughts – such that conformity and low accountable strives. In flatter structure there is accountability at all levels as employees are expected to make a fair amount of decision-making and to keep the leader informed of what is taking place".

One of the biggest disadvantages of hierarchical structure is the fact that engineers and plant managers have to wait from their bosses on what to do, how to do where to do and when to da a certain task. In addition, this can prevent an organisation to getting new and fresh ideas from the engineers who are directly involved in the refining process, who knows exactly how machines operate. Participant P08 even argue that these plant calibrators know more than managers and in hierarchical structure it is so hard to suggest any ideas that they think it can help managers to make key contributions to entire company or refinery strategy. In addition, the lack of employee involvement in the decision making also hinders and drag the organisation to succeed as they possess all form of knowledge. Furthermore, some top-level managers have no technical knowledge of the plant operations and maintenance but rely on manual and textbooks in order to create strategies for plant maintenance techniques.

4.4.1.3 Emerging Theme: Plant Reliability and Availability to maximise production

Participants show a strong understanding of ensuring plant reliability and availability in a refinery. All twelve participants mention the fact that planning and spending more time on proactive maintenance and routine maintenance to remain compliance to the plan of the refinery's maintenance department. In addition, these participants also reveal that this is the most important stage of the plant to remain operational, effective, and efficiently. For instance, Participant P06 revealed that one of the best options to make plant reliable and always available to produce is to have a properly plan of how to make the plant reliable by having space in between operational time, and a good example is to allow the plant to work for a certain period of time and then have plant break in between in order to allow the plant to cool down in order to come back stronger and more reliable thus increasing production.

Another challenge that was revealed by three participants is that downtimes even for an hour cost Engen millions of rand which is something that can be avoided or planned to ensure that plant is always on standby. This is because, the breakdown can last longer. The longer the breakdown of the plant the more costly it became. For example, participant P02 argues that the labour cost is increasing

regardless of whether the plant is operating or not. Furthermore, participant P08 and P09 agrees that indeed, the lack of maintenance of plant and equipment make it not to be reliable which can stop at any time. On the other side, participant P01 and P05 mentioned that sometimes one of the plant breakdown problems is that employees or engineers to come and work overtime in order cover the time wasted. Overtime means more money as some overtimes means double pay which is also costly to the refinery.

The other two participants mentioned the importance of budgeting as a mean to ensure safe zone for the unexpected breakdowns and downtowns. Sometimes maintenance can be planned and during the maintenance process, the plant needs more parts or process which comes at a cost. This budget helps to cover those costs and other variables that will make the plant available to produce again and then to be reliable at the same time. Part of maximizing this reliability is to also ensure that APIs are regular measured and evaluated. Another most important findings from participants are the case of waiting for future which will increase the cost of maintenance. For instance, participant P012 mentioned that it very important for refineries like Engen to check theories from other refineries around the country and then develop a solution based on those theories to prevent dangers that affected them. The participant made example of Sapref 2005 fire that led to the closure of the plant for over 7 months in efforts to bring it back to operational capacity again. If the company had a proper plan, the fire could have been avoided to avoid the spread or to destroy many more parts of the refinery. All in all, the participant emphasizes the importance of benchmarking and looking at what companies are doing right to operate reliable and always available.

4.5 Presentation and Results of Objectives Three

To assess/evaluate/benchmark the Standardize Maintenance work process across the refineries in South Africa:

4.5.1 Dominant Theme 3: Standardized Maintenance Work Processes across Refineries

4.5.1.1 Emerging Theme 3.1: Standardizing Maintenance Work Processes

Participants invested their time answering this question based on their experience from moving from one company to another and being exposed to different work processes with these different refineries. For example, participant P02 alluded that the hardest part was to leave SASOL which is a state-owned refining company and join Engen not knowing that operations and integration of process were completely different. The participant advises that standardisation not only simplifies work for all employees but also saves time and costs for new employees. These employees join the company very confident with an experience from other refineries not knowing that at Engen, calibration of plant and equipment is totally different.

On the issue of standardising maintenance work processes, participant P02 viewpoint was that "The documents and the training that is facilitated at one point and then you break the, the, the signals of the barriers between the divisions at the operational level because like now if you are maintenance manager, none of the tankage manager at the final, very rare, there's no session where they cross the borders and then you will find that they got session and discussing how do you do distinguish here once the possibility I've seen like. And I went. I worked in other divisions, loops, and refinery. The process of how they do tankage is totally different. One will start with the inspection and then after inspection we'll greet blast. After Greek blasting, you repair when you repair, then you got more failures".

According to most participant the best way to master maintenance work process is to start with a proper planning. Total productive maintenance is vitally important for refineries whose aims is to standardize their maintenance work processes. According to participant P07, the role of total productive maintenance is to involve equipment operators in the maintenance activities with an aim of holding them accountable for the performance of their equipment. In addition, this maintenance model is ensuring that machinery and plant operate at a maximum level with zero defects, zero accidents and zero losses and flaws at the same time. Furthermore,

the participant P04 suggested an autonomous maintenance which was discussed in the literature of this study. According to this participant, autonomous maintenance promotes and ensure a total involvement and participation of all operators in activities that are basic about their plant they operate in a refinery. This will ensure that each operator be more responsible for their own plant and equipment.

4.5.1.2 Emerging Theme 3.2: Leveraging resources across plants

Participants showed a very strong understanding of this question in such a way that they also provided examples of how Engen as a refinery can leverage resources. For example, participant P012 reveal that introducing digital platforms where plant performance data and maintenance schedule can be stored, managed and documented. This information will not only help the plant maintenance managers but also the plant operators to make decisions like knowing when to stop the plant and when to start it to operate efficiently.

The main advantage of these digital software's is that everyone within the refinery who is involved can have access to this data and can also use it at the benefit of plant and its operators to smoothness the operations. Operators can have a good relationship with their plant which in term benefit the refinery positively. Another suggestion to leverage resources was ongoing session between plant operators and plant maintenance managers. According to participant P07, this can be in a form of weekly meetings between them with an aim of advising one another. This discussion cannot only help leverage resources but spread the information from one operator to another on how they usually keep their plant up to standard by also advising one another.

On the other hand, participant P01 and P08 reveal that leveraging resources could mean centralizing plant maintenance to a single team that will monitor it on computer 24 hours a day and report any unusual changes and act from that data. Participants believe this instant monitoring will minimize the number of breakdowns in such a way that they will no longer have to do interval service, but plant will be service as soon as these monitors detect a problem that might occur

in future. In addition, these participants believe that this form of monitoring will prolong the life of the plant to even longer that it supposed to live.

Participant P08 viewpoint on leveraging resources was that "everyone should be equipped with a digital tool to report what is doing and to create is to send information anywhere in the plant or as late as possible. Therefore, that that will help people to understand or to see the challenge and then if the if one got the interesting thing that is happening, you will use that tool to share information immediately to the team. Let's say you are an artisan, you can share, send with other artisans"

Last two participants believe that another best way of leveraging resources is rotating plant and equipment across divisions of Engen. Participant P012 and participant P07 believe that if the plant is operated by two or more people, one of them is definitely going to notice the changes of the plant during operations and inform the maintenance department to look after the equipment in order to avoid further damage of the vehicle. In addition, rotation plant and equipment will also save costs for the refinery as there will be no need to operate or buy many plants for different divisions.

4.5.1.3 Emerging Theme: Use of digital tools to support the work processes

Participants believed that digital tools bring more benefits to the refinery more especially the maintenance department. For instance, participant P011 revealed that there are hundreds of software's that companies can leverage with an aim of solving manual monitoring and maintenance. The participant like SAP is not only capable of storing data but also can be linked with scheduling and help remind the operators and the maintenance department at large to check up with plant and equipment. In addition, integration SAP with P6 can bring amazing results for the plant efficiency and it produce real time data for the operators. Furthermore, the aim of these software is to ensure that resources are used effectively with zero defects, flaws and mistakes. Another biggest advantage and benefit of the digital tools according to participant P012 is that they always suggest ad on, as well areas that needs improvement from the plant and

equipment as well the entire maintenance team. In addition, these digital tools can pull reports which can be used by management to make future decisions related to operations and maintenance of the plant. Moreover, these digital tools help to make it easier to know which resources within a refinery are overloaded or underloaded. Last the digital tools can be linked with one another in order to provide efficient data that can be used by different teams to work collaboratively.

4.6 Presentation and Results of Objective Four

To Identify and ensure seamless integration with various departments/functions within the refinery:

4.6.1 Dominant Theme: Seamless integration within various departments in the refinery

4.6.1.1 Emerging Theme: Ensuring seamless integration within various departments in the refinery

All participants believe that operations and maintenance department are two key departments that need to be involved in the roll out of the work process. For example, participant P03 believe that these two departments are the heart of refinery operations, and the entire refinery cannot operate if they are not operational. In addition, these two departments need to work hand in hand in efforts to ensure synergy and integration thus effective calibration at the end. Participants believe that if both operations and maintenance department can be involved in the rollout of the work process, the plant and equipment can operate effectively and efficiently. One of the advantages of starting with these two departments is that they are interlinking other departments and also are directly involved in the production and refining of oil and gas.

Participants also discovered that organisation that has strong leadership who put more resources and funds in these department tend to yield positive results. For instance, participant P010 argues that the more money invested in plant and equipment and the more positive results an organisation will benefit. In addition, if operators who are involved in work process rollout are well equipped, there will

be no need for management to worry about anything as these employees are also taking responsibility of their machinery and plant.

4.6.1.2 Emerging Theme: What systems/process can be used to close the gap

About system and processes used to close the gap, participant P11 viewpoint was “Give proper training on system. Keep on reminding and motivating the team”. On the other hand, participant P10 viewpoint was “Gap analysis is either a tool or a process to identify where gaps are and what differences exist between an organization’s current situation and “what ought to be” in place. These can include a management system such as human resources or resource planning, excel spreadsheet, a diagram model, and so forth.

Essentially, gap analysis should consist of four steps:

(i) identifying an organization’s key needs of the present situation,
(ii) determining the ideal future or desired situation of organization,
(iii) highlighting the gaps that exist and need to be filled, and
(iv) modifying and implementing organizational plans to fill the gaps.

4.6.1.3 Emerging Theme: Monitoring tools to be used to ensure seamless integration

Participants of this study suggested many tools that can be used to ensure seamless integration but continuously mentioned the system that is currently used by Engen to monitor its maintenance processes namely SAP. All participants believed that this tool is not used to its entirety as it consists of more features that Engen is not using which can bring positive results during maintenance and tracing work process of Engen refinery. Some of these benefits includes its ability to track and trace plant faults in advance, its ability to provide real time data and its ability to collaborate with as many users as possible. Participants believe that if Engen can invest heavily on this software, it will be easier not only to report to the management but also for operators to receive real-time data that can be used to make future decisions.

4.7 Unexpected findings

Almost all participants that were interviewed in this study were very excited to voice out their opinions about operations within Engen refinery. The unexpected findings that came from this study was that, all the participants made time to discuss these findings and were also happy to recommend anything that they believe it will simplify their work as engineers, maintenance managers and plant operators. These participants understand the value of introduction and development of new process that can simplify and make their work easy in such a way that they recommended more and more ways to roll out work processes. In addition, the participants showed strong understanding of what they are doing and believed that investment in their skill can also play a huge part in the Engen refinery because the more skilled an operator the more effective a plant or machinery it can operate the more profit Engen as well as a refinery will be.

Another unexpected finding was that all participants are flexible and willing and happy to adapt to any changes that the refinery is willing to introduce. They even willing to listen to any processes that their superiors are suggesting given that they contribute positively to their everyday work. Moreover, participants revealed that the continuous downtimes and breakdowns of machinery can lead to shorter hours which in turn lead to shorter salaries at the same time. So, all in all, participants were so happy about the research study as they believe it is going to solve this problem. Participants also believed that if work process can be rolled out correctly, it will not only be a win for themselves but also for the organisation as a whole as production and refinery will increase as plant productivity increase.

4.8 Chapter summary

This study aims to assess work process calibration as an efficient maintenance strategy for oil and gas industries specifically targeting Engen as a refinery based in KwaZulu Natal. This study further aimed to assess if the standardisation of maintenance work processes across all refineries can indeed yield positive results for the refinery. Finally, the study aimed to establish how to ensure seamless integration between various departments of Engen refinery. The following conclusions were drawn from these findings.

- The refinery should use both proactive maintenance strategy and reactive maintenance strategy as each of these maintenance strategies bring their own benefits during the work process calibration. If the refinery can master both of them, maintenance will be seamless and simple.
- Participants recommended that the refinery should have a policy of at least 1% breakdowns so that they cannot fall at more than that percentage. If that can be attained, it will be easier to manage the operations and maintenance at large.
- On the part of closing the existing gaps in the maintenance department, participants recommended that operators must be given more freedom and also each plant operator must be given its own machinery so that there will be more accountability which will avoid blame game. In addition, assigning each machine to each operator will make life easier for maintenance managers as they know exactly who is responsible for which machinery.
- On the case of attracting future investors and meeting KPI. Participants recommended that each operator must be assign to a certain maintenance manager who is going to monitor the operator plant relationship and count the intervals these machines are services. That will help them to know exactly who are these operators that still need a training.

Participants show a strong support or hierarchical structure of reporting as they fear that vertical will cause those with more experience to be reluctant to be rated by people of managers that have less experience that them. All of them also supported the performance management as a process of keeping them aligned to what they are doing. Another important issue that the participants mentioned is training and development. They believed that the more they have skills and expertise to operate the machinery the more the machines last. In addition, the development of their skill will make them more responsible for what they are doing on daily basis. The following chapter will discuss the recommendation from the findings and literature. It will also discuss limitation of this study. Finally, it will also suggest some areas that were not covered by this study but still need research by future researchers.

5. Recommendations, Limitations of the Study and Conclusions

5.1 Introduction

In the previous chapter of the study looked at findings of this study. This chapter present the conclusion of the study conducted. Conclusion and recommendation in this chapter are based on findings of the previous chapter. The aim of this study was to assess the work process calibration as an efficient maintenance strategy for oil and gas industries. The study was motivated by the growing concerns breakdowns and aging refining plant and machinery at a refining oil and gas company called Engen in KwaZulu Natal. This chapter conclude the study and a whole. In addition, this chapter also summarize the previous discussed chapters, revisiting the objectives that were outlined in the first chapter. Finally, this chapter will provide recommendations for any future studies that might be conducted related to work process calibration as an efficient maintenance strategy.

5.2 Summary of research findings and recommendations

5.2.1 Dominant Theme 1: Findings: Strategies and work processes

The findings revealed that the refinery is predominantly focussing more on reactive preventative maintenance which is shifting focus and prioritisation on

proactive maintenance. Breakdown/Reactive work is categorised into Priority 1 (P1) which is an emergent work that need to be started immediately and completed within 24hrs, Priority 2 (P2) which can commence within 36hrs and completed soonest, and Priority 3 (P3) is the normal reactive work which can be planned accordingly. Since all the units/plants want their work to be prioritise they would rank them as P1/P2 without considering the cost effect and resource constraints caused by this habit and this hugely impact the execution of proactive maintenance. Therefore, this reactive measure ended up costing the refinery not only time to fix or repair the damage but also increase costs of unplanned maintenance and breakdowns.

- **Recommendations:**

As part of recalibrating work processes Engen should ensure that all the work requests are value adding and have been scrutinize and correctly categorised in terms of them prioritise such that no work should be treated as a P1 whilst it is a normal P3 work.

- More efforts and time should be spent on planning and scheduling work processes to reduce unplanned work which is costly and impacting the proactive maintenance
- Empower Operations team to be able to do troubleshooting of defects and to extent such that can carry out basic maintenance work instead and reduce call outs and schedule breakers.
- Engen should enforce and improve a proactive preventative maintenance which will automatically reduce the unplanned downtimes, plant failures, and breakdowns. If these failures can be avoided, the operators can become productive at what they are doing. In addition, the maintenance managers will also have enough time to plan for future on next maintenance phase instead of monitoring plant and machinery for unexpected breakdowns.
- Invest time and resources in proactive maintenance strategies. This can be done by ensuring that operators are informed about way to report any

unusual occurrences to their plant the operate and report in order for the maintenance team can attend that problem before it escalates further.

- Use technological tools and software's to implement proactive preventative maintenance. Tool like SAP can provide real time data that can help both plant operators and maintenance managers to monitor their machinery at a distance and get real time data that can also help them to make decision.

The refinery must determine the root cause of plant and equipment failures before they spread and cause more damages to the plant and the entire production. These causes can be documented in order to be used in future maintenance activities or used as cases to solve problems. One of the biggest advantages of the proactive preventative maintenance is that equipment is always at optimum performance which lead to effective operations with no unscheduled breakdowns and interrupt.

5.2.1.1 **Emerging Theme 1.1 Maintenance Work process strategies**

- Implementation of the new maintenance work processes will alleviate the maintenance crisis of fighting fires and spending more time on reactive more than the proactive work
- Maintain Facility work process 1 which is Create Value add work order deals more basics in terms of identifying, troubleshooting defect before creating a notification. Currently notification is just raised without proper troubleshooting and in many cases, there is a lot of data missing which impacts the scoping, planning and execution of the job.
- Maintain Facility Work process 2 which is planning, and scheduling work processes holds the centre of the entire maintenance work process as more work is done at this stage starting from work scope, work planning, work scheduling and work distribution.
- Work scoping deals more with site walk and identifying all the hazards related to the work to be executed, identifying materials required, resources required, services required etc.

- Work planning includes sequence of activities, assigning durations and resources and relationships within one work order
- Work scheduling – This is where work exact date, day and time is assigned for execution of the job depending on resource availability. This is necessary for integrating all the unit/plants plans into one refinery schedule which gives a clear picture of our resource effectiveness and efficiency. This will assist improve from being reactive to being proactive
- Execution phase – This work process is where the actual work is done and compliance to schedule need to be enforce, any deviations from the schedule need to be accounted for and there will be consequence management related to deviation if the justification is not making business sense. At this stage monitoring, control and reporting is taking place and we will be able to ascertain if we complying to schedule and reducing scope creep.

5.2.1.2 **Emerging theme 1.2 Plant maintenance gaps**

The findings reveals that some employees were not skilled enough and end up relying more on older and more experienced engineers and operators. This not only affect the job of others but consume time trying to show them how to operate plant and machinery. This led to delay and incomplete jobs by the main engineers and main operators.

- Training and development of both plant operators and maintenance managers. This will help close the gap between new and old operators as well as levelling the playing ground between inexperienced and experienced operators.
- Continuous training and workshops to all operators can also help level the skill set. In addition, on top of workshops and trainings, the experienced operator should mentor the less experienced operators and maintenance managers.
- Any future planned chained should be communicated as early as possible with an aim of giving the unfreezing operators and maintenance managers

time to think about the positive benefits of new changes in the maintenance processes.

- In closing the gaps on lack specialized skills gap, Engen can now and again outsource from outside companies that specialized on some maintenance services.

5.2.1.3 Emerging theme 1.3 Integrate strategies to be profitability and competitiveness

Findings reveals that the most important action that Engen has to undertake as a first stop is to align objective of local and a parent company Petronas in order to work towards same and similar objectives which is to make Engen a global refinery adhering to and meeting international standards. In addition, findings reveal that some of Engen departments operate in silos which is against Petronas objectives of unit and collaborations in all their refinery subsidiaries.

- Engen should ensure that no sub departments within the refinery that operate in silos. This will create unnecessary divisions within the refinery.
- Engen should ensure that they implement and follow all international standard organisations for big and successful refinery companies like ISO 9001 which is an international standard for quality management. ISO 14001 which is an international standard for environmental management systems. ISO 22301 which is an international organisation for business continuity management systems and PAS 2060 which is the only international standard for carbon neutrality.
- To ensure that there is no mismatch between operations and maintenance department, work process integration roles must be upskilled to a high a level.
- Engen should ensure that they promote teamwork in order to achieve team goals and objectives rather than individual goals.
- Create open communication to ideas from operators and engineers that can save the organisations costs to make it profitable and competitive.

5.2.1.4 Emerging theme 2.1 Benchmarking maintenance KPI

Research findings reveals that Engen's current maintenance KPI is 70% proactive preventative maintenance and 30% reactive maintenance. The company is doing everything it takes to improve the 70/30 rule to even more focusing on increasing the proactive side with even more percentage. This is because Engen has discovered more advantages on the proactive maintenance compared to reactive maintenance.

- Current maintenance KPI is 70% proactive maintenance work and 30% reactive maintenance work.
- The main aim it to move to 80% proactive maintenance work and 20% reactive work.
- Breakdowns (P1/P2) target should be 2% of the total reactive work; Currently P1/P2 is about 10% of the total reactive work which are the signs of an unhealthy plant.

5.2.1.5 Emerging 2.2 current maintenance hierarchical structure

Findings revealed that in most cases, the only people with superior power are superiors and management and operators, engineers and maintenance managers always take order on what to do, when to do and how to do it. In addition, the findings also reveal that though the current maintenance structure is working, it has its shortcomings and challenges. Moreover, the findings suggested that a flatter structure can be the right structure for Engen given its nature of open communication and open to suggestions.

- The current refinery structure is hierarchical which has an impact on decision making as there are many layers of Level of Authorities (LOA)
- Recommend a flat structure for improved efficiency and decision making
- Flat structure also supports more open communication between the management, operators, and engineers. This will help the organisation to be open to new ideas and innovations.

5.2.1.6 Emerging 2.3 plant reliability and availability

Findings revealed that planning and spending more time on proactive maintenance and routine maintenance to remain compliance to the plan of the refinery's maintenance department. In addition, the findings also reveal that proper plan of how to make the plant reliable by avoiding unplanned downtimes and maintain the plant between the planned downtimes/shutdowns.

The following recommendation are formulated.

- Implement Maintenance work processes to ensure compliance maintenance schedule which will reduce breakdowns and unplanned shutdowns.
- Seamless integration between operations and maintenance teams

5.2.1.7 Dominant theme 3.0 standardizing maintenance work processes

Findings revealed standardisation not only simplifies work for all employees but also saves time and costs for new employees. In addition, the total productive maintenance is vitally important for refineries whose aims is to standardize their maintenance work processes.

- These work processes need to be standardized across the Engen plants which can be further adopted by other refineries in South Africa.
- This will assist in ensuring that when a person replaces another one hits the ground running with or without handover.

5.2.1.8 Emerging 3.2 leverage resources across plants

Research findings for this study revealed that resources are assigned to a specific plant, and they become specialists for those plants/units without understanding the plant holistically. This poses a high risk when people start leaving the organisation either due greener pastures or retirement as they have become irreplaceable, and the organisations loses experience and expertise. Maintenance artisans also specialises on their own trades/disciplines which also is making the organisation vulnerable to skillset loss.

The following recommendations were drafted from the findings.

- Rotation of resources across different plants, units or areas is key for upskilling the resources such that they can easily fit in should someone leaves the organisation. This will be beneficial to both the organisation and individuals.
- Retooling and Reskilling of resources is very crucial to improves resources skillset as a mechanical person will be empowered to be able not to execute mechanical activities only but to be able to do other trades as well. This will benefit both individual and an organisation and will improve efficiency as there will be no waiting period for other resources.

5.2.1.9 Emerging 3.3 use of digital tools to support the work process

Findings revealed that digital tools bring more benefits to the refinery more especially the maintenance department. In addition, digital tools always suggest ad on, as well areas that needs improvement from the plant and equipment as well the entire maintenance team. Moreover, these digital tools can integrate the plans and schedules across the refinery plants and can pull reports which can be used by management to make future decisions related to operations and maintenance of the plant.

- Currently maintenance work is planned only on SAP.
- This limits an opportunity of having a refinery wide integrated schedule and full plant resource utilization overview
- Engen to use an integration of SAP and Primavera P6 where SAP is a database and planning tool, and Primavera is a scheduling tool
- Primavera scheduling will assist to integrated the schedule and achieve the resource leveraging strategy as it will level the resources across the plants.
- Many reports can be pulled out of Primavera like barchart, histograms, Scurves etc which assist in analysing the resource utilization and effectiveness.

5.3 **Limitations to the study**

Conducting a study during the post COVID period was not only challenging in terms of meeting the participants but also to try other means of conducting interviews rather than face to face. One of the disadvantages of doing e-interviews is the data and computer signal. Some participants were cut by Microsoft teams in between the interviews which affect the quality of interviews and transcription. Below are some of the limitations and shortcomings of this study.

- Load shedding – the interviews of this study were conducted to the height of load shedding in South Africa which ended some participants to reschedule their interviews for later dates or even later hours.
- Time constraints – the interviews were conducted either during the weekends or during break times with artisans and maintenance managers. Some of these participant's weekends are very tight which allow a very short period for interviews.
- Sampling technique – though the researcher wanted much higher number of interviewees, due to nature of Engen refinery, the researcher has to go with available artisans and maintenance managers in order to not only save time but to cater the chosen sampling technique.
- Engen Conversion from refinery to terminal: This research happened during a very challenging time for Engen employees as the organisation had made a decision to change from being refinery due to high costs of operating and maintaining the refinery.
- Engen structural change – Because of the conversion this called for a structural change and threats of people losing their jobs and this had even a more impact on the study as people were so uncertain and do not really have time to assist.

5.4 **Recommendations for future research**

During the study, some of the research spaces and gaps that need to be researched for future research purposes were identified. The following are some of them.

- A study around refinery manpower/ resource utilization can be conducted to determine and assess the efficiency of artisans in their respective disciplines.
- Another possible study can be conducted around the importance of digital tools and their usability in a refinery.

5.5 Conclusion

This study investigated work process calibration as an efficient maintenance strategy for oil and gas industries. The main objective of this study was to examine profitability, competitiveness, and supplier development. To determine the world class standard priorities to attract investors as well as to identify and ensure seamless integration with various departments. The findings and recommendations presented on this study by various participants will not only help Engen as an organisation, but also any refinery across the world who is willing to improve its maintenance strategies.

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Appendix A: Gate keepers' letter

With us you are Number one | ENGEN

18 October 2021

To whom it may concern

Engen Petroleum Limited
Engen Refinery, [illegible] Tara Road, Wentworth, Durban
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CONFIDENTIALITY AGREEMENT BETWEEN MONGEZI SOKOTSHE AND ENGEN PETROLEUM LTD

This letter serves to acknowledge that Mongezi Sokotshe (Company number 78250) is hereby given permission to conduct research within Engen Petroleum Ltd (Engen Refinery Division) for the purpose of obtaining his Master's in Business Administration (MBA) degree at the University of KwaZulu Natal. The following topic has been approved and supported by the organization for an employee to continue and investigate within the premises of the company:

Engen Refinery work process recalibration as an efficient maintenance strategy for oil and gas industries.

The above approval is given provided Mr. Sokotshe adheres to the following conditions of access:

- Maintains the privacy and confidentiality of all accessible project data and understands that unauthorized disclosure of confidential data may result in disciplinary, civil and/or criminal actions against him.
- May not disclose data or information to anyone other than those to whom he is authorized to do so.
- Should his employment be terminated or his work in relation to the project discontinues for any reasons, he will continue to be bound by his signed Confidentiality Agreement.

Requested by: Mongezi Sokotshe

Signed: [redacted] Date 20 October 2021

Designation: Maintenance Planning Manager – Engen Refinery

Approved by: Thabani Zondi

Signed: [redacted] Date 20 October 2021

Designation: HR Manager – Engen Refinery

Appendix B: Informed consent letter

Informed Consent Letter

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Dear Respondent,

Research Article
Researcher: Mongezi Sokotshe ([redacted]
Research Office: HSSREC (031) 260 8350/3587
Email:hssrec@ukzn.ac.za

Researcher, who is a student at the University of KwaZulu Natal, Graduate School of Business and Leadership (GSB&L), Mongezi Sokotshe inviting you to participate in the research project entitled: **Engen Refinery work process recalibration as an efficient** maintenance strategy for oil and gas industries

---

This study seeks to intervene, resolve, and recalibrate poor asset maintenance management and maintenance work processes within the refineries focusing more on Engen refinery.

You may opt to discontinue participating or withdraw from the study at any time with no negative consequence. There will be no monetary gain from participating in this research. Confidentiality and anonymity of records identifying you as a participant will be maintained by the researchers undertaking this research project who are from the Graduate School of Business and Leadership, UKZN.

If you have any clarity seeking and queries, questions or concerns about completing the research instrument or about participating in this study, you may contact one of the researcher.

The data collection will be conducted via Online questionnaire and should take you approximately 20-30 minutes to complete. I hope you will take the time to complete this survey.

Sincerely

Mr M. Sokotshe Date :16/08/2021

Investigator's signature_[redacted]_____

Appendix C: Interview questions / schedule

Appendix A: Interview Schedule

1. Critically identify strategies and work process to become a profitable, competitive, and relevant supplier?
    a. Define the maintenance strategies and identify areas of improvement for operational excellence.
    b. What are the gaps on the current maintenance work processes and how to close them?
    c. How do we integrate strategies and work processes to become profitable, competitive and competitive supplier?
2. How to become a world class standard to attract future investors?
    a. How to benchmark our Maintenance KPI's in order to meet the world class standard?
    b. Do you think the current hierarchical structure will assist to achieve our objectives?
    c. How do we ensure that the plant is reliable and available to maximise our production?
3. How to Standardize Maintenance work process across the refineries in South Africa?
    a. How do we standardize work processes across the different divisions and plants?
    b. How do we leverage resources across the plants and refineries?
    c. How do use digital tools to support the work processes?
4. How to ensure Seamless integration within various departments in the refinery?
    a. Which departments need to be involved in the roll out of the work process and why?
    b. What systems/process can be used to close the gap?
    c. What are the monitoring tools to be used to ensure seamless integration?

Appendix D: Ethical clearance approval letter

HSSREC application (Engen Refinery work process recalibration as an efficient maintenance strategy for oil and gas industries ,HSSREC/00003481/2021) Sokotshe, Mongezi (218087914)

NB:
Please click on **Edit** on the top right of the screen to view the full information and make changes to the application. If there is no edit button visible to you, you may be unable to edit the application as it is may be with someone else at the moment.
However, you can view the application by clicking on Ethics Applications on the left menu. If there are many applications displayed, you can filter for the application you are looking for.

If you require more help, you can find Ethics User Guides here. OR you can contact the Ethics Office here OR using the Ethics Office contact details here.

Type of ethics review: HSSREC application

Title: Engen Refinery work process recalibration as an efficient maintenance strategy for oil and gas industries

Date of approval: 06/12/2021

Principal Investigator:

Sokotshe, Mongezi (218087914) - Grad School Of Bus &Leadership (Active)

List all sites in which the project will be carried out i.e. geographic location (e.g. KwaZulu-Natal) and type of place (e.g. name of hospital, clinic, schools, community, animal research facility, conservation areas etc). the project will be carried out i.e. geographic location (e.g. KwaZulu-Natal) and type of place (e.g. name of hospital, clinic, schools, community, conservation areas etc).:

UKZN: Engen Refinery

Appendix E: Turnitin report

Dissertation Submission

ORIGINALITY REPORT

9%	7%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ir.jkuat.ac.ke Internet Source	2%
2	mafiadoc.com Internet Source	1%
3	researchspace.ukzn.ac.za Internet Source	1%
4	Submitted to University of KwaZulu-Natal Student Paper	1%
5	www.scielo.br Internet Source	<1%
6	Submitted to University of Johannsburg Student Paper	<1%
7	res.mdpi.com Internet Source	<1%
8	onlinelibrary.wiley.com Internet Source	<1%
9	Submitted to University of the Philippines - Main Library Student Paper	<1%