Cape Peninsula University of Technology

REDUCING NON-CONFORMANCE FROM FOUNDRY PRODUCTS THROUGH SUPPLIER QUALITY MANAGEMENT

by

VELAPHI HENRY MABILETSA

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Supervisor: Dr Stephen Bosman

Bellville

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DECLARATION

“I hereby declare that this research report submitted for the degree (Magister of Engineering: Industrial and Systems - Quality) at the Cape Peninsula University of Technology, is my own original unaided work and has not previously been submitted for any other institution of higher education. I further declare that all sources cited or quoted indicated or acknowledge by means of a comprehensive list of references"

Name: Velaphi Henry Mabiletsa

Signatu 

Date: 04 November 2021

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GLOSSARY OF TERMS

Continual Quality improvement techniques:	A philosophy of quality management that inspires all company staff including the board, employees, and volunteers to ask continuously what is be performed better. McFadden, K.L., Stock, G.N. and Gowen (2015)
Control of non-conforming products:	Any precluded incoming procured products or services arriving from the vendor; group of or part, final or subassembly assembly that is forbidden in the course of the final or in-process inspection. Natarajan (2017)
Cost of Poor Quality (CoPQ):	Costs linked to offering poor quality services or products. Prashar (2014)
External failure costs:	External failure costs mean costs the company incurs in remedying defects the customer has discovered. Teli, Majali, Bhushi and Surange (2014)
Internal failure costs:	Internal failure costs mean the costs the company incurs in remedying defects it discovers before delivery of the service or product to the client. Modhiya and Desai (2016)
OEM	Original equipment manufacturer
Prevention costs:	The development, preparation, and maintenance of programs (Quality assurance) are also part of prevention costs. Olayinka, Suresh & Chinyio (2015).
The Supplier Quality Assurance process (SQA):	A process meant to guarantee that the supplier consistently supplies the services or goods satisfying the needs of the customer. Amanipour, Jamshidvand and Tabatabaei (2015)

ABSTRACT

Supplier Quality Assurance is an important aspect of Total Quality Management where organisations dedicate an element of their operations within the businesses to the development and continuous improvement of their suppliers which then form part of the organisations extended supply chain. An Original Equipment Manufacturer (OEM) in the mining and minerals space was selected based on its challenges with parts that end up in their manufacturing processes from foundry suppliers and deemed not to meet the quality requirements for its manufacturing processes. The objectives of the research were: to determine "Why" detectable defects reach the end –user; To determine the quality improvement medium required to ensure better performance of suppliers to the OEM, to determine the effect of Supplier Quality Assurance in the improvement of supplier performance, to evaluate the suppliers Total Quality Management (TQM) and control of non-conforming products. The following notable findings that formed the premise of this research were that: The visually detectable defects can be prevented by suppliers from reaching the end-user. Findings from the literature review showed that the industry is facing challenges with high energy costs, lack of skills and development, low labour productivity, import leakages, lack of technologically sophisticated machinery, colossal transport costs, environmental rules and regulations as well as capital constraints. It was also realised that organizations should streamline their process costs to ensure that quality is achieved. A mixed research methodology was used in the research. Target population consisted of OEM company managers and employees handling Supplier Quality Assurance and Quality managers or representatives in foundries in South Africa. A total of ten respondents were purposively sampled. From the primary research findings it was discovered that internal audits and awareness training, heat treatment, spectrographic management, inspector checking are some of the supplier quality management mechanisms used.

CHAPTER 1: INTRODUCTION AND MOTIVATION

1.1. INTRODUCTION

This study analysed what entails the supplier quality management approach for foundries in preventing non-conformances from reaching the end-user. In the attempt to convey a background to the problem studied, the study availed a research motivation and background; stated the research problem, questions and objectives. The study defined the main terms used throughout the project in order to give meaning and avoid misinterpretation. The research constraints and the research timetable was presented in this chapter as well. This research also outlined the included chapters to the study project.

1.2. MOTIVATION

Globally organisations strive to produce quality products. This is because cutthroat competition is a driving force. Apart from that, companies aim to gain a large market share and maximise on a colossal customer base which brings more revenue. Anilchandra *et al.* (2017) posited that, well developed nations generally have companies that offer excellent products particularly in the foundry industry. This is because such companies are well established and have the financial resources to devote towards total quality implementation. This has also benefited these companies in meeting consumer needs and realisation of large profits. The motivation of this empirical study is derived from the gap identified from the global, regional and local approach.

Regionally, that is within the African context, several companies provide foundry products to local and international markets. Fesehaie & Rustomjee (2018) posted that the stumbling block has been poor quality as compared to the products from the developed economies. This in turn implies that the foundry products will be difficult to sell since some of them do not meet the client expectations. From that perspective it follows that such organisations have a lot to do with regards to quality management

of foundry products. Phele et *al* (2004) posted that the need for quality foundry products in the African context cannot be underestimated since there is a general increase in demand for such products. However, the influx of cheap products that are substandard affects the industry at large. As such companies should ensure that they have total quality management approaches in place that ensures that quality foundry products are produced.

Locally, the South African foundry industry has few participants and the quality of foundry products is a matter of concern. Although there are certain quality benchmarks as shall be explored further, there is a strong need for the concerned companies in the South African context to ensure that they achieve an excellent quality on their foundry products. This empirical research is therefore hinged on the idea to find a suitable quality management approach that will reduce non-conformance from foundry products. This is very important since product quality should satisfy client needs. Apart from that, this will also help the organisations to make profits as well as securing more clients and to be able to compete on the global market. This of course in the long run has a positive effect on the economy of South Africa as foreign currency will be realised.

This research finds motivation in the difference between the chosen company and the international or global SQA (Supplier Quality Assurance) Policy. The international or global SQA (Supplier Quality Assurance) policy entails the following fundamental parts; the purchasing documents, classification of suppliers, monitoring and assessment, selection of supplier, activities of Supplier quality and responsibility. Every commercial and purchasing agreement must be in English with an option of translation into the domestic language. The process of monitoring and assessment consists of several diverse procedures first with the collection of supplier data to self-certification of the best performing suppliers. Supplier classification is settled by the capacity of classification to back the company's purchasing policy; that is, the capacity to realize the company targets on the delivery, environment, cost, quality, and engineering amongst others. There is internal communication of such kind of classification and use of the classification as a supply-sourcing tool.

1.3 BACKGROUND TO THE RESEARCH PROBLEM

Organisations are faced with non-negotiable demands for high-quality products. The subject organisation in this research is a manufacturing entity in the mining and minerals industry and is classified as an original equipment manufacturer (OEM) of slurry pump products. The products manufactured by the company provide variety of integrated solutions (product plus service to ensure optimum performance) for the mining and minerals industry. The purpose of the research was to gauge the effect of Supplier Quality Assurance (SQA) and management process in preventing non-conforming products from reaching the end user or customers. Figure 1.1 illustrates what is regarded as the end user in the ambit of this research paper.

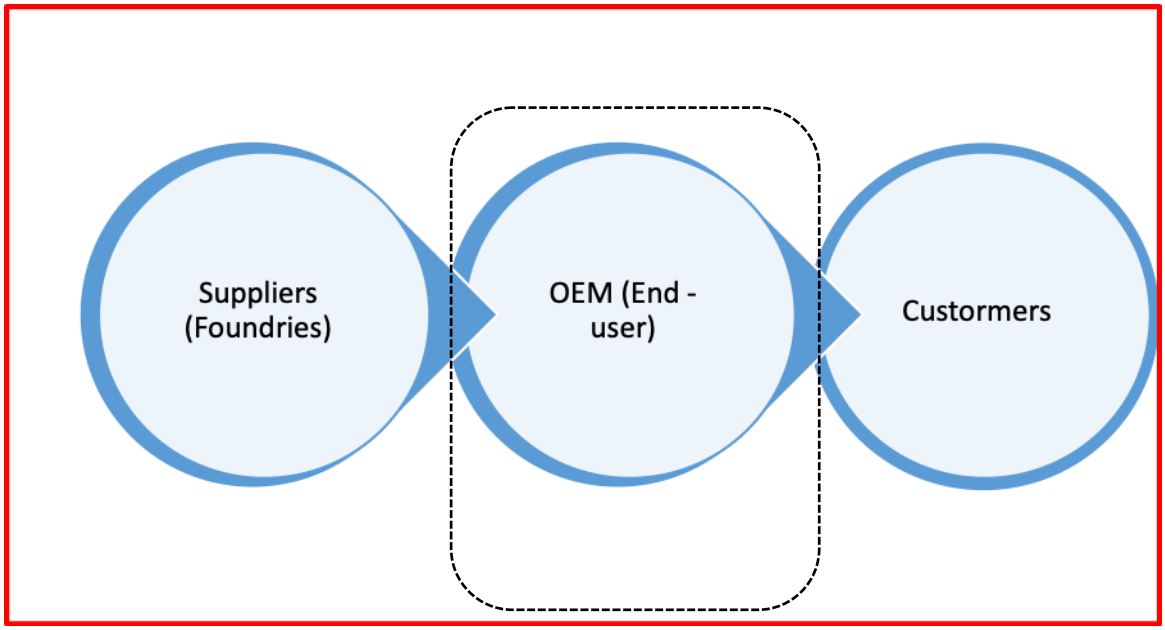

Figure 1-1: The Macro business process showing supplier and end user

(Source: Own)

The company manufactures its components and supplies them to clients in Africa and the Middle East as an Original Equipment Manufacturer (OEM). In 2018, the organisation experienced production losses in terms of the lead time to supply their customers due to non-conforming products from foundry suppliers permeating their

manufacturing processes. This is internally at the customer premises where detectable defects were found during the customer's input and value-adding process. These losses in production lead times have led to the drive by the organisation to focus on supplier quality assurance (SQA) processes as a method to prevent defective products that end up reaching its manufacturing processes as an end-user to foundry suppliers.

The organisation uses an SQA process for the management of its 27 listed or approved suppliers for efficient communication between the company and the suppliers (see figure 1.2). The SQA engineers distribute information from the OEM to the suppliers on the required product key characteristics. These engineers are the custodians of the SQA process, compliance for suppliers and are drivers for the problem-solving initiative resulting from customer complaints, in this case, the OEM in this case through the Non-Conformance Reports (NCRs). The information from the OEM then triggers a problem-solving process where the products are rejected and the SQA engineers become the champions in the process.

The methodologies used in the problem-solving process as adopted by the organisation are aligned to LEAN manufacturing methodologies which include quick solutions like the Plan Do Check Act method (PDCA), to intensive and in-depth problem-solving methods like the A3 Practical problem solving to the 8D method which are both problem-solving methodologies used in the Automotive industry for root cause analysis and problem solving where repetitive issues are experienced by organisations. These methods requires a cross-functional collaboration between the user and the supplier of the product to come together and solve the issue at hand thus resulting in clear preventative actions to stop the problem from occurring again.

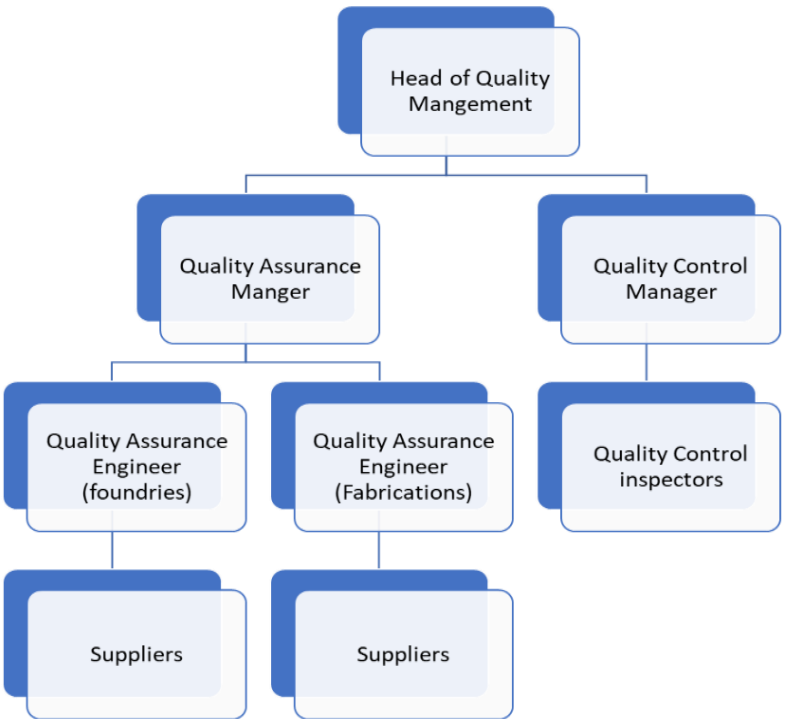

Figure 1-2: Supplier Quality Assurance hierarchy within the OEM

Source: (Own)

1.4 RESEARCH PROBLEM STATEMENT

In translating the customer requirements for a unique product, foundries face the challenge of ensuring that each component manufactures meets the stringent intended application of the component which in many cases can be for multiple uses. In creating and designing the quality management system, foundries emphasize the following elements:

- Company identification,
- Continuous training of personnel,
- Casting modelling,
- Process documentation & description of the procedures,
- Previous lessons learned from similar cast components,

- The analysis, measurement & improvement of the processes.

These elements described above, often for matured organisations are stated in the quality manual which is the guiding document for the operations of the organizations and it's TQM (Total Quality Management). The foundry quality policy is the company's strategic factor covering the cast production followed by the clients' demands and requirements.

Regardless of the recommended international SQA policy structure, all companies and their employees accept and understand that the foundry quality policy for each company is unique to the following:

- The product which the y supply,
- The chosen cast method or process and
- The unique customer requirements for each product supplied.

The OEMs (Original Equipment Manufacturers) in South Africa remain under serious pressure to meet policies like the BBBEE (Broad-based Black Economic Empowerment) and the South African government charters on giving suppliers equal tender opportunities. However, due to the historical disadvantages, several suppliers, experience various problems including the BBBEE suppliers that make it hard for them to get tenders like:

- shortage in finances,
- tender opportunities,
- business and
- management skills as well as capacity and quality problems.

Unless adequate training is offered to the potential suppliers and company employees, OEMs companies and supply shall stay in the few hands of prevailing recognized suppliers with so little revolution in the industry Thus presenting the current challenge on how to improve the quality of products supplied and to prevent the visually detectable defects that are the premise of this research.

Any company with the aim of satisfying needs of the customer and gets maximum profit must procure the right quality requirements in the correct amounts at the right price and time. Strong competition, globalisation, progressively stringent requirements on quality and revolution of technological characterise the conditions of the modern commercial world. The result is that such trends shorten the products' life cycle, make a selection of the correct OEM supplier for organizations an intimidating challenge to supply and purchasing management. To obscure the purchasing and selection procedure further, the modern international trend focuses on the closer relationships that, implies fewer chosen suppliers, e-procurement as well as long-term contracts.

There is a lot of pressure from a regulatory perspective in South Africa for OEM companies to, a greater extent, procure from the previously disadvantaged or BEE suppliers yet such suppliers experience several challenges which include:

- JIT (Just in Time) supply
- Skills required to produce the intended product and
- Meeting of the quality requirements for the product.

This study examined practical difficulties experienced by the OEM and its suppliers, the impact of such problems on complexity and risk in the industry as well as offer policies which address the SQA problems or even help the OEM and its suppliers to become South Africa's A-regarded foundry suppliers.

1.5 RESEARCH QUESTION

For this research, the focal point was "what is the supplier quality management approach for reducing non-conformance from foundry products". This will exclude macro-value chains such as outbound logistics. To achieve this, the following research questions were used in this empirical study.

- What SQM mechanisms can foundries use to prevent non-conforming products from reaching the end-user?
- What are the effects of non-conforming products?
- What are the Quality (SQA) management tools and methods available or adopted by OEMs in the prevention of non-conforming products from foundry suppliers?
- What are the recommendations for reducing non-conformance from foundry products through supplier quality management?

1.6 PRIMARY RESEARCH OBJECTIVES

The objective of this research is to identify the supplier quality management approach suitable for preventing non-conformance from foundry products reaching the end-user. The following objectives are going to be used in this study:

- To determine the Quality (SQA) tools and methods adopted by OEMs in the prevention of non-conforming products from foundry suppliers.
- To ascertain the SQM mechanisms foundries can use to prevent non-conforming products from reaching the end-user.
- To determine the effects of non-conforming products.
- To offer recommendations on reducing non-conformance from foundry products through supplier quality management.

1.7 RESEARCH CONSTRAINTS

Due to confidentiality, the research subject did not make any notations of Intellectual Property Data from the OEM and its Suppliers.
Estimated figures were used as a proxy in that case, and they were well-motivated.
Aside from that, the field of quality and defect prevention in the foundry industry is under-researched and under-publicized, so the scope of this study was based on agile methods for literature reviews used in similar industries.

The study was limited to foundries who are suppliers to the described OEM described at introduction. Lastly, the sample was concentrated only to the suppliers mentioned above thus may not be representative of the industry due to geographical and scope limitations.

1.8 CONCLUSION

All in all, this chapter presented key aspects behind the need of having a supplier quality management approach ideal for preventing non-conformance from foundry products reaching the end-user. To achieve this, key research objectives and questions were outlined. From the entire discussion it is clear that a supplier management approach is a panacea to the identified research problem. The next chapter is going to be based on the overall view of the research environment.

CHAPTER 2: AN OVERALL VIEW OF THE RESEARCH ENVIRONMENT

2.1 INTRODUCTION

The chapter focuses on presenting the environment in which the research was conducted. All aspects that directly and indirectly, influenced the research were outlined. A general overview of the sectors serviced by The South African Foundry Industry were presented. Apart from that, a short discussion on the current challenges and opportunities facing The South African Foundry Industry at large were looked at in this chapter. These are some of the key features that characterise the research environment. In addition to that, some of the key principles that relate to research integrity were explored in this chapter.

2.2 SOUTH AFRICAN FOUNDRY INDUSTRY

The South African Foundry Industry (SAFI) has a limited number of key players. The South African foundry industry service a number of sectors in the economy as is shows by the table 2.1 below.

Sector	**Percentage %**
Mining	**32**
Manufacturing	**24**
Infrastructure	**2**
Agriculture	**3**
Railways	**9**
Automotive	**25**

Other	**5**

Table 2.1: Sectors Serviced by The South African Foundry Industry (SAFI)

Source: Madzivhandila (2015)

Table 2.1 shows that the mining sector, manufacturing sector as well as the automotive sector have the largest percentages in terms of the service derived from the South African Foundry Industry. On the other hand, the agricultural sector and the railways sector have smallest proportions with regards to the products supplied by the South African Foundry Industries.

From such statistics it shows that the need for high quality products cannot be undermined since all the above sector are critical for economic development of the South African economy. In this chapter, the focus was to give an analysis of the research environment. As such it was essential to have an overview of some of the challenges and opportunities the industry is facing at large. However, the aim of this research was to determine supplier quality management approach reducing non-conformance from foundry products.

2.3 CHALLENGES FACED BY THE SOUTH AFRICAN FOUNDRY INDUSTRY

Madzivhandila (2015) posted that the industry is facing challenges with high energy costs, lack of skills and development, low labour productivity, import leakages, lack of technologically sophisticated machinery, colossal transport costs, environmental rules and regulations as well as capital constraints. In as much as there are obstacles being faced by the industry at large, a need for high quality foundry products is very important for the clients, Davies (2015).

Madzivhandila (2015) further avers that the industry has more opportunities especially with regards to abundant raw materials, government funding as well as some training and development programs offered by the National Foundry Technology Network (NFTN). As it was posted earlier on that capital constraints

affect the company and on the part of the current opportunities there is some form of funding from the government, it can be concluded that the government funding is insufficient to the meet the industry needs. Given the opportunities presented in this discussion, the drive for quality products in the industry should be a key priority for all the concerned companies. When high quality is achieved in the foundry sector or industry, it can be very helpful to improve product competitiveness as was posted by Calvin (2016). Product competitiveness will help to satisfy the needs of the clients in foreign markets and this will generate foreign currency for the South African economy. From this overview it is essential to explore some of the key principles behind a research environment. In this context the focus is on the foundry products quality as was postulated earlier on.

2.4 RESEARCH ENVIRONMENT PRINCIPLES

There were a number of research principles that were adhered to or observed to ensure that there is value addition to any research carried out. Some of these principles were presented as is below and they are: pellucid policies to support researchers, appropriate mentoring support, monitoring systems to ensure that policies are adhered to and researcher awareness of the expected standards.

With regards to policies that support the researcher, it implies that the university has to offer enough support to a researcher to ensure that the thesis is completed as per university guidelines, Kretser (2019). Furthermore, there was a need for sound monitoring systems that ensures that the research is done in an appropriate manner.

2.5 CONCLUSION

This chapter was based on an overall view of The South African Foundry Industry. Some of the challenges and opportunities being faced by the industry were explored. The South African Foundry Industry services a number of sectors in the economy of South Africa. It was realised although there are challenges being faced, there need for quality foundry products is of great value. Some of the research principles were

explored also. Such principles enabled the researcher to carry out the research in the environment that has been described with some obstacles and opportunities. All the research principles were adhered to in the research environment. Some of the principles relate to the ethical standards which were articulated in subsequent chapters of this empirical study.

CHAPTER 3: LITERATURE REVIEW

3.1 INTRODUCTION

This chapter was based on the review of recent literature that relates to the topic under investigation. Both theoretical and empirical literature review was analysed. Theoretically, all related theories were presented. From an empirical perspective, relevant recent empirical research from diverse scholars were critically analysed in this chapter.

3.2 COST OF POOR QUALITY

Prashar (2014:126) defines Cost of poor quality (COPQ) as costs linked to offering poor quality services or products. Cost of poor quality has four key categories including costs of internal failure, costs of external failure, appraisal costs and prevention costs. Costs of internal failure are the costs linked to defects discovered prior to the customer receiving the service or product. Costs of external failure are the costs linked to defects discovered after the client receives the service or product.

Appraisal costs are costing the company incurs in the attempt to determine the conformance degree to the requirements of quality. On the other hand, prevention costs are the costs the company incurs to retain to reduce or minimize the number of defects (Teli, Majali, Bhushi & Surange, 2014:41). Cost of quality is thereby the methodology which permits the company capacity to define the extent its resources will be used for undertakings of preventing the poor quality, appraise the services or products quality and spring from external and internal failures (Noshad & Awasthi, 2015:487). Such data offer the company capacity to define the possible savings that can be gained from implementing improvements in the company process (Bolcar, 2014:60). Figure 3.4 summarises the total cost of quality concept.

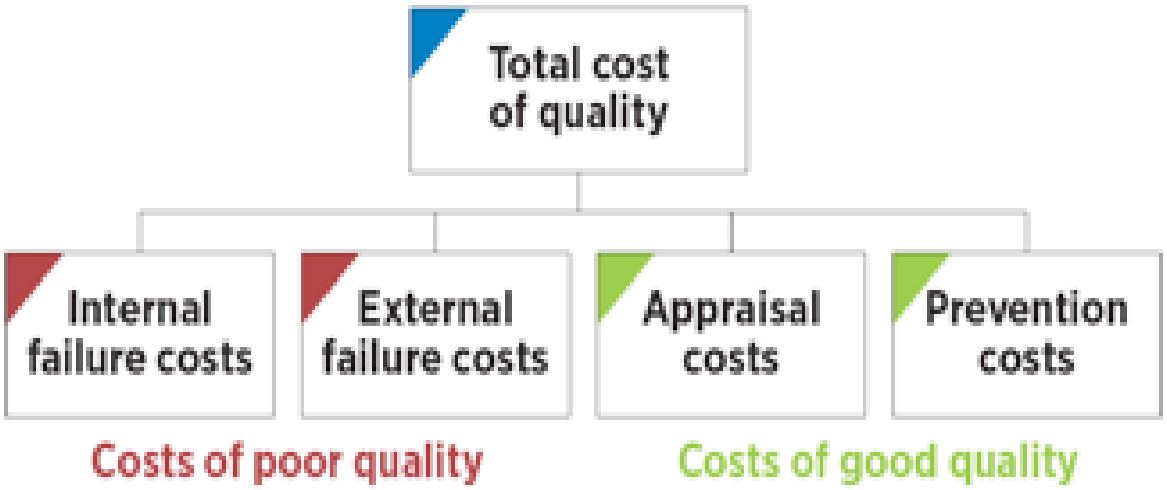

Figure 3-3: Cost of Quality

Source: (Duffy, 2013: 65)

In short, Figure 3.1 depicts that total cost of quality is made up of internal, external, appraisal and prevention costs. Prevention costs are going to be looked at next.

3.2.1 Prevention costs

Since the incurrence of prevention costs is intended to avoid or prevent quality complications, prevention costs remain linked to quality management system designing, maintenance and implementation. Moica & Radulescu (2014) posted that the prevention costs include establishing specifications for the incoming materials, processes, finished products, and services (service or product requirements). Prevention costs include creating reliability, quality, operations, inspection, and production plans. The costs also cover quality system maintenance and creation. The development, preparation, and maintenance of programs forms part of prevention costs (Olayinka, Suresh & Chinyio, 2015:188).

Mahmood, Ahmed, Panthi and Kureshi, (2014:311) state that appraisal costs relate to evaluation by the suppliers and customers of the materials, products, services and processes purchased to guarantee conformity with specifications. The costs include an examination of the incoming materials, process arrangement and the products as

against the approved specifications. Pujiyanto *et al.* (2019) posted that appraisal costs also include the validation that the correct functioning of the quality system. The costs also include supplier ratings; that is, assessing and approving product and service suppliers. Internal failure costs are going to be looked at next.

3.2.2 Internal failure costs

Modhiya and Desai (2016:94) contend that internal failure costs mean the costs the company incurs in remedying defects it discovers before delivery of the service or product to the client. The costs include the undertaking of needless work and or stock holding because of poor communication, or organization and errors. Internal failure costs also include defective material or product that is unrepairable, sold or usable as well as rectification or rework; that is, rectification of faulty materials or faults. Internal failure costs also include failure examination, that is, activities needed to find the reasons for internal service or product failure (Mulay & Khanna, 2017:72). The next discussion is going to be centred on external failure costs.

3.2.3External failure costs

Teli *et al* (2014:21) states that external failure costs refer to costs the company incurs in remedying defects the customer has discovered. Vysochynska (2017) posted that external failure costs include the servicing and repairs of returned merchandises and the products in the field. In addition to that, claims of warranty (failed and replaced products or the re-performed services under the guarantee); complaints (all the costs and work linked to servicing and handling complaints from customers) as well as the returns (investigation and handling of recalled or rejected merchandises, including the costs of transport). The next analysis or discussion is going to be centred on the control of non –conforming products.

3.2.4 Control of non-conforming products

Natarajan (2017:12) defines non-conforming products to include any precluded incoming procured products or services arriving from the vendor; group of or part, final or subassembly that is forbidden in the course of the final or in-process inspection. Non-conforming products do not include such identified concern that can be resolved to comply with the minor dispensation and finalised within an hour. The procedure for controlling non-conforming products entails identifying, documenting, evaluating, and disposing of the non-conforming merchandises. The process applies to every received (purchased), finished, and in-process service or product (Natarajan, 2017: 23).

Under clause 8.3, the ISO 9001:2008 as revised by ISO 9001:2015 offers the requirements for control of non-conforming products stating that:

- There must be identification and control of Non-conforming products if the company is to avoid unintended delivery or use.
- For Companies to control non-conforming products, they must offer documented procedures that define the controls, authority and responsibility.
- Upon correction of the non-conforming product, the company must re-verify the product to establish conformity.
- The three fundamental ways a company has to solve non-conforming products include concession and precluding original intended application or use as well as assuming action suitable for the impact upon detection of non-conformity after product delivery
- The company must maintain the non-conformity records and the succeeding action the company took to solve the nature of nonconformity.

ISO (2018) indicates that regardless of the way the company resolves non-conformance, it has to keep accounts for each non-conformance as well as the way the company resolved the non-conformity. The company must periodically review the records on the conformity of a product to determine the existence of a chronic fault with the process of production. It is all about constant improvement of the company and products according to ISO 9001:2008 as revised by ISO 9001:2015.

In keeping the non-conformities records, it becomes easier for the company to identify the negative tendencies, inspect the original cause and remove the causes to that problem. In return, the company registers fewer faulty merchandises and contented customs.

There must be no deviation in the company from such non-conformity measures because there will also be lesser processes in the company that will require rigid devotion to actions like controlling the non-conforming merchandises. Controlling the non-conformances also applies to company services many tangible merchandises that reports, information, test outcomes and IP (intellectual property) can be hypothetically non-conforming. Either way, all process disciplines apply. From this perspective, it follows that continual quality improvement techniques are essential to ensure a desirable benchmark of quality is achieved. The next discussion is going to be centred on the continual quality improvement techniques.

3.3 Continual quality improvement techniques

McFadden *et al* (2015:34) defines continual quality improvement as a philosophy of quality management that inspires all company staff including the board, employees, and volunteers to ask continuously what is be performed better. Continuous quality improvement (CQI) finds the foundation on the existing approaches of quality management like Total Quality Management (TQM), Six Sigma, and Lean; however, Continuous quality improvement (CQI) emphasizes that external and internal consumer satisfaction is dominant (van Assen, 2021). Continuous quality improvement (CQI) also maintains that it is the processes that cause problems, not the people. The key to all continuous quality improvement initiatives is the use of a structured scheduling approach that evaluates the prevailing practice measures and improves the processes and systems with a goal of achieving the anticipated vision and outcome of the desired imminent state. The Lean technique is going to be discussed in depth as is below.

3.3.1 The Lean Technique

Balaji *et al.* (2014) posted that Lean technique denotes the continuous improvement strategy that focuses on reducing the nonvalue-added undertakings, mistake-proofing responsibilities and persistently focusing on waste reduction to improve delivery of service, care or product. Lean assist in operationalizing the transformation to generate handoffs, workflow and procedures that work in the long-term as is shown on Figure 3.5. The main focus on change in this strategy is enhancing efficiency as well as eliminating or reducing the seven types of waste including; Overproduction, Waiting time in queuing, Transportation, Non-value-adding procedures, Inventory, Motion, Costs of quality, inspection, scrap and rework.

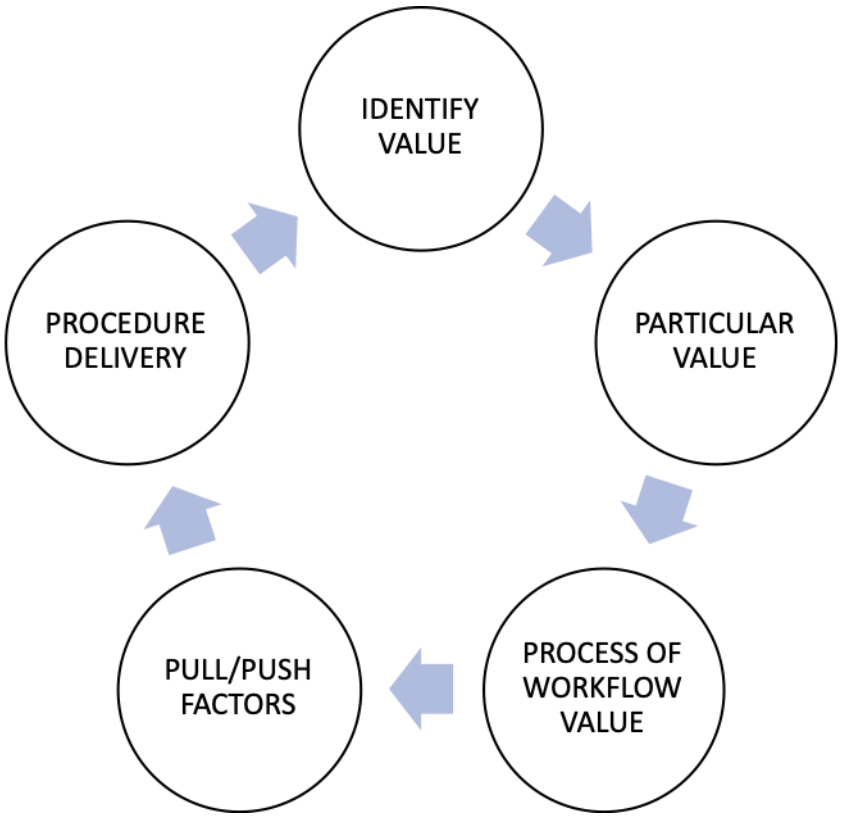

Figure 3-4:Lean strategy

Source: (Own)

Assen (2018) postulated that a Continuous quality improvement (CQI) initiative using the lean strategy adheres to principles of: identifying the features that generate value, Identify the key care activities, Improving flow for information and activities to move in an efficient procedure, test the administrative process and perfect the process. All these principles are going to be discussed in great depth as is below.

- ***Identifying the features that generate value***

The company's external and internal perspectives help determine the identification of value. For instance, clients may value lesser call on hold time yet the providers or company values having every information available in making orders or appointments. Such particular values are dependent on the streamlining of the process.

- ***Identify the key care activities (the value stream).***

Upon determination of value, the company leaders must identify the activities contributing to value. The value stream is the whole sequence of activities. Waste are activities falling outside the realm and require streamlining.

- ***Improving flow for information and activities to move in an efficient procedure.***

After the identification of the value-added actions and essential non-value events, the company leaders must guarantee that the efforts of improvement are focused on making a smooth flow of the activities. However, for this to be achieved, there is need for effective communication between the management and the concerned departments.

- ***Test the administrative and/or clinical process.***

The company must test the modified flow upon identification and documentation. Testing includes piloting the few clients or a day's test in areas of using the new process during the course of practice.

- ***Perfecting the process.***

There can be identification and change of all learned lessons and strains arising from the process before the rollout of the final process.

3.3.2 The Six Sigma technique

Da Silver *et al.* (2017) posted that the Six Sigma technique is a commercial administration and continuous quality improvement strategy that focuses on improving efficiency through the identification and eradication of the error causes and decreasing variability in processes of manufacturing and commerce as is depicted by Figure 3.6. The Six Sigma term originated from the jargon linked to statistical process modelling. Therefore, this continuous quality improvement strategy joins methods of quality management with the statistical examination. The Six Sigma technique also forms an exceptional people infrastructure within the company. There is always a combination of the Six Sigma and Lean techniques in the attempt to lessen error and waste.

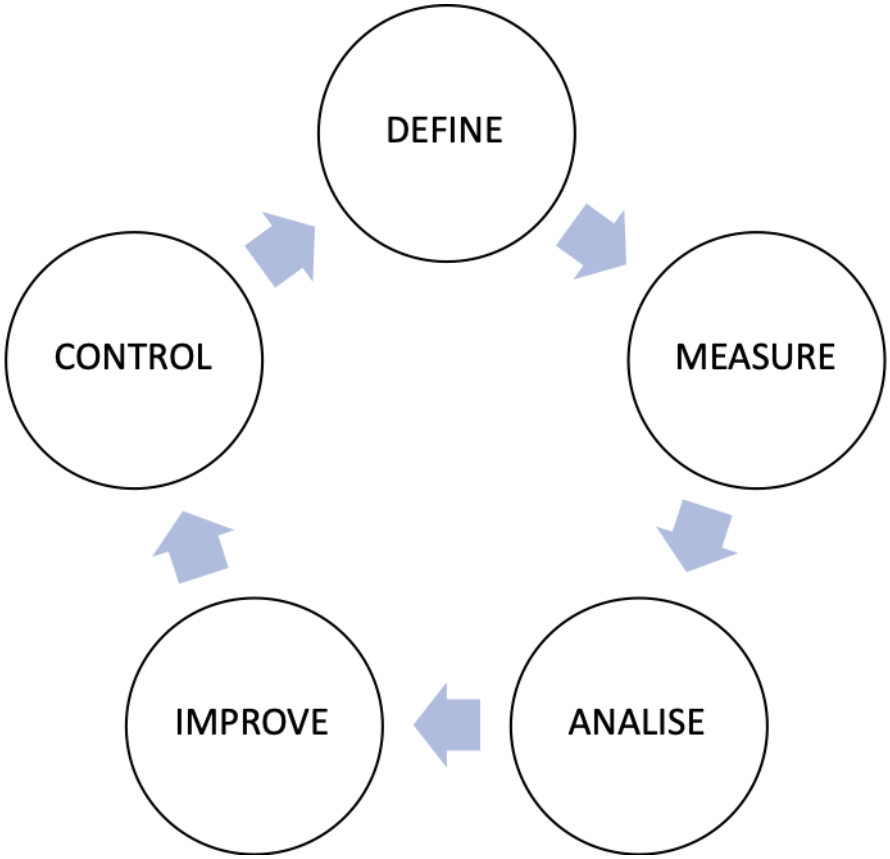

Figure 3-5: Sigma strategy

Source: (Own)

Figure 3.6 shows that the Six Sigma is hinged on key concepts which are define, measure, analyse, improve and control. The Six Sigma technique is dependent on the company's ability to attain statistics and measures of outcome and process. Any company using this Six Sigma technique observes five key principles that include Defining the outcome and process in need of improvement; defining outcome and processes key features and mapping the pertinent inputs into such process that shall occasion the outcomes and outputs desired. This stage also covers defining the Continuous quality improvement (CQI) project's boundary. Measuring entails tracking performance by a collection of data after defining the outcome and process in need of improvement. Measures of performance are capturable through surveys and structured observations. Analysis entails determining the performance of practice after setting up measures, and collection of data. Preferably, the collection of baseline information comes before implementing the new procedures at

systematic intervals. A company can review the information as part of its process appraisal to define the problem causes.

Improving entails using the analysis results to formulate improvements. For instance, there is a need for adjustments if the process modifications occasion workarounds. In the same way, the company must examine the required alternative or extra changes to enhance the process if the quality measures show no improvement upon implementation of a change. Control entails ongoing improvement and monitoring as required. The Baldrige Quality Award Criteria Technique is going to be looked at next.

3.3.3 The Baldrige Quality Award Criteria technique

The Baldrige Quality Award is evolving from a quality recognition honour to a methodology and approach enabling continued brilliance by self-assessment. The continuous quality improvement (CQI) technique concentrates on total company improvement as well as instituting the Continuous quality improvement (CQI) culture. The technique promotes strategic goal achievement by aligning resources with improved productivity, communication, and efficiency in seven criteria classes of leadership, strategic planning, client focus, measurement, knowledge, and analysis management, workforce focus, operations focus and results.

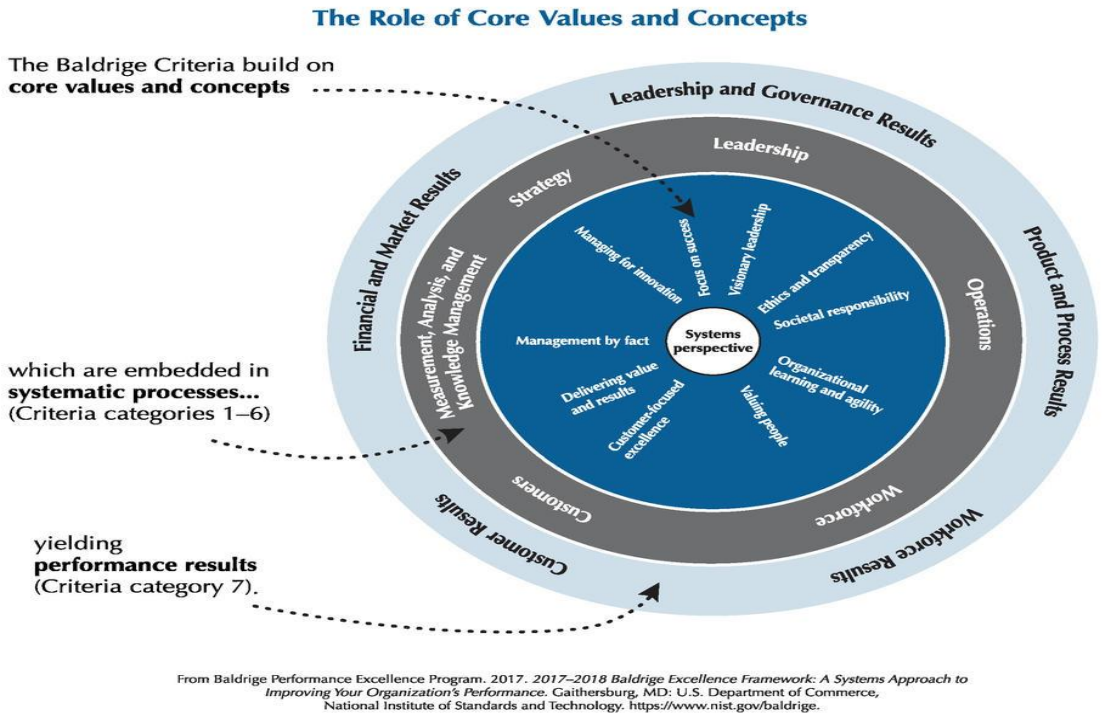

Figure 3-6: The Baldrige Technique

Source: (NIST, 2018)

Huang & Sather (2018) posted that the Baldrige criteria technique helps the company identify the opportunities and strengths for development. The company using this Baldrige Award technique follows, identifying the self-assessment scope or boundaries. The assessment is of the whole practice and/or the particular role (process, outcome, or structure) in the practice. Selection of champions since Baldrige covers company change. Selection of interdisciplinary teams for every champion with the aim of the champion to carry out self-assessment and representing multiple stakeholders, (Leonidou, Christofi, Vrontis, & Thrassou, 2020). The collection of data to resolve questions in this technique helps Champions prepare the company profile to describe their practice as well as the involved challenges. Creating and communicating the action plan to employees for advancement or improvement helps teams ascertain opportunities and strengths, set primacies and create action plans. The practice helps company staff in evaluating the process of self-assessment and identifying possible improvements (Eriksson, 2016:1405).

The motivation behind this study is identifying the supplier quality management approach that will improve OEM or foundry processes and systems. The Supplier Quality Assurance Process is going to be discussed next.

3.4 The Supplier Quality Assurance process

Amanipour *et al* (2015: 15) state that the famous evangelist of quality management Joseph Juran Moses offers the supplier quality assurance process with nine steps. Supplier Quality Assurance (SQA) is a process meant to guarantee that the supplier consistently supplies the services or goods satisfying the needs of the customer. The Supplier Quality Assurance process must be collaborative if it is to guarantee the offerings of the supplier that meet the agreed requirements with less modification or inspection. The first step in the definition of product or service's requirements of quality. Demirel *et al.* (2018) posted that the next step in the process is identifying and evaluating the suppliers available for needed parts. The third step in the process is choosing the suppliers that are most reliable to fit in the needs of production. The company, staff and suppliers must then carry out joint planning on quality. With joint planning, the company and suppliers establish collaboration and cooperation during the period of relationships. Validation of compliance to the regulations and requirements is the next step in the six-step in the Supplier Quality Assurance process. The seventh step is the company certifying the qualified business suppliers while the eighth step is conducting plans for quality improvements. The last step in the Supplier Quality Assurance process is developing and implementing scorecards for supplier ratings.

All these theories are useful in explaining how quality can be achieved. The next discussion is going to be centered on the analysis of previous empirical work that was done by other researchers who examined a similar topic.

3.5 EMPIRICAL LITERATURE REVIEW

Bhero & Dhlamini (2016) carried out a research on the cost of quality. Bhero & Dhlamini (2016) discovered that organizations should streamline their process costs to ensure that quality is achieved. Apart from that, lean manufacturing techniques were observed as essential in ensuring that quality is achieved that satisfy the clientele needs. From these findings it follows that quality for foundry products can be improved through quality techniques such as the use of lean production methods.

Sajjan & Peterson (2014) carried out a research on the success factors needed for product development. Interviews were used for data collection for the empirical qualitative study. Sajjan & Peterson (2014) discovered that cross-functional teams and knowledge integration through quality processes are key essentials that are needed for achieving the desired quality.

Sajjan & Peterson (2014) and Bhero & Dhlamini (2016) shares similar sentiments on how quality can be achieved with regards to foundry products. From their researches it is pellucid that organizations need to ensure that they reduce costs of poor-quality products through the use of quality management techniques. Their research findings conform to the theoretical literature review that was discussed earlier on.

Toga (2017) also examined a research on the relationship between total quality management and innovation in the South African foundry industry. The research was quantitative in nature and data was collected through questionnaires. Toga (2017) discovered that a positive relationship between clientele focus, leadership as well as people management and product quality. From this research it is clear that organizational leadership is at the core of total quality management. This is so since it remains the duty of management to ensure that proper quality techniques are employed in the production process so as to satisfy the clientele needs. Product and process innovations as well as quality performance were seen as important aspects that should be taken into consideration by organizations to ensure high quality is achieved in the South African foundry industry.

Gustafsson (2016) carried out a research that focused on quality management. From this empirical study, Gustafsson (2016) discovered that organizations should ensure that they abide to quality benchmarks set by the International Organizations for Standardization (ISO) as well as internal quality standards. This implies that organizations should be driven by quality motives to fulfill the clientele needs and to keep pace with the dynamic environment with cutthroat competition. From this research it follows that the organizations should invest enough resources towards quality management. This is so since with enough resources quality can be compromised and this especially in the foundry industry can have ruinous effects especially to the clients.

To add more, Donauer (2014) investigated the quality management strategies and tools that can be used in the manufacturing sector. Donauer (2014) found out that manufacturing process require effective cost modelling. Apart from that, it was also discovered that quality on products should be achieved using cost effective methods. From this research it can be deduced that organizations should continually review their quality techniques as well as their manufacturing process. This will ensure that quality products are produced that meets the client expectation.

Gustafsson (2016) and Donauer (2014) share similar sentiments with regards to quality management. The former emphasized on the need for having quality benchmarks adhered to and the later emphasized the need for having cost effective strategies for achieving high quality. From these assertions it follows that the internal environment, that is the quality techniques used by organizations plays a key role and should complement the external environment. The external environment in this case relates to the quality benchmarks prescribed by organizations such as the International Organizations for Standardization as was postulated by Gustafsson (2016).

Juanzon & Neyestani (2016) carried out a research on variables required to ensure that total quality management is achieved. Juanzon & Neyestani (2016) discovered that product quality can be achieved through employee involvement, supplier quality management, clientele focus, sound leadership as well as process management. From these results it can be deduced that quality management requires a holistic and comprehensive approach to ensure that organizations produce quality products.

Gustafsson (2016), Juanzon & Neyestani (2016 and Donauer (2014) both outlined key factors that help the production of quality products. From their research it can be concluded that international quality benchmarks as well as internal quality mechanism should be well monitored and the need to meet client needs should be promise.

3.6 CONCLUSION

This chapter was based on the critical analysis of the various literature centred on quality management with respect to foundry products. From a theoretical perspective it was realised that the Lean technique, Sigma approach and the Baldrige technique are essential methods that can be used for ensuring quality is achieved for foundry products. Apart from that, a clear analysis on the internal and external costs that relates to quality where explored in great depth. Also, the need for cost effective quality process was emphasized in this chapter. From an empirical perspective it was established that organisations should abide to international quality standards. The need for internal quality control mechanisms as well as ensuring a client driven approach was emphasized. For this empirical study it is yet to be determined on the supplier quality management approach that can be used to reduce non-conformance from foundry products.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The key aspects of this chapter are the research design, sampling techniques, target population and the research design. Apart from that, data collection methods were discussed as well as the diverse ethical aspects that will be observed in the entire empirical study. The research methodology was looked at first.

Saunders, Lewis and Thornhill (2012:108) posited that for proper researches to be carried out in any field it is desirable to reflect on the research onion. This is illustrated under Figure 4.8 below. Figure 4.8 summarizes some of the key aspects that will be discussed in this chapter as was posted earlier on. In short these are research strategies, research philosophies and data collection methods.

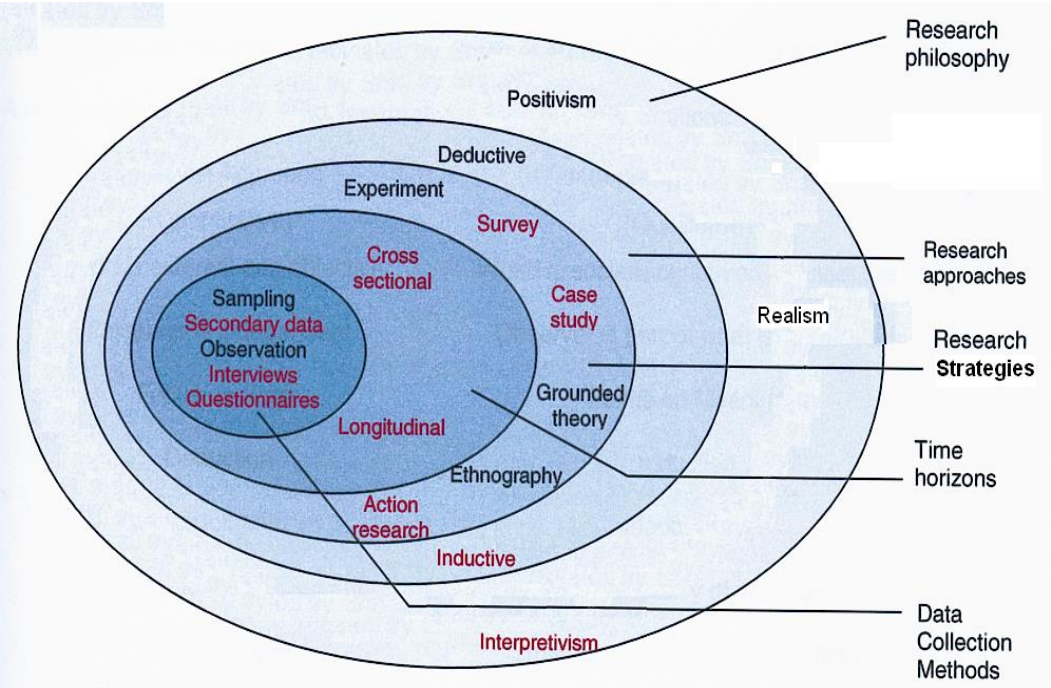

Figure 4-7: Research Onion

Source: Saunders et al. (2012:108).

This study was carried out in accordance to the below research methodology framework.

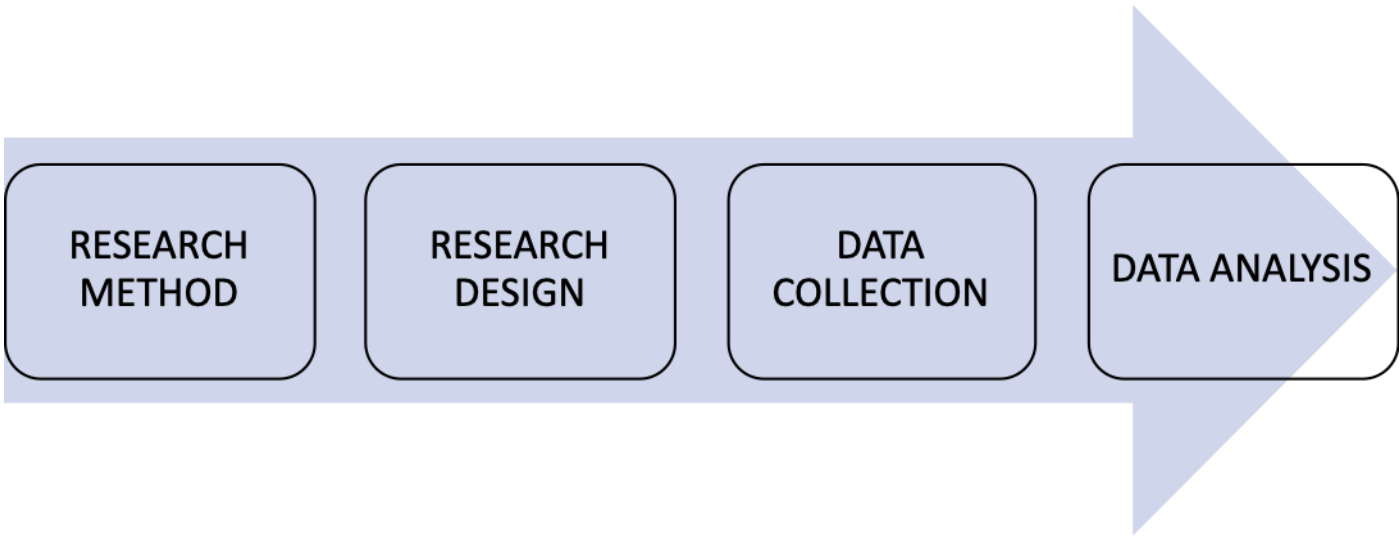

Figure 4-8: Research Method Framework

Source : Own

Figure 4.9 shows that the research methods will be looked at first and the research design will follow. Data collection techniques and related concepts will be discussed after and an overview of the data analysis method to be used will be presented.

4.2 RESEARCH METHODOLOGY

Brannen (2017: 37) defines research methodology as the specific technique or procedure the researcher uses in selecting, analysing, identifying, and processing information on the preferred topic. For this study, the research methodology enables the reader and researcher to critically analyse the overall reliability as well as the validity of the research. Steen *et al*. (2018:17) state that quantitative, mixed research and qualitative research methods are the main key types of research methodology used. Schoonenboom (2017) posted that a quantitative methodology focuses on the classification of features, computation and creation of statistical depictions to explain the observations as well as test hypotheses. On the other hand, Gaile (2018) postulated that the qualitative methodology focuses on the details and total

observation explanations, like the settings and background. Tariq (2013) posted that a mixed research methodology can be seen as a hybrid research methodology that incorporates the features of qualitative and quantitative research.

Quantitative research is useful for addressing hypothetical aspects in studies and it helps to reduce bias since the research strategy allows results verification through the aid of computational means, Rahman, (2017). However, a quantitative research has a demerit in that it is not useful for explaining social phenomena. Apart from that, some quantitative researches are based on the use statistical software such as SPSS, E-Views just to mention a few and such software cannot be used for data analysis unless one has the software knowledge, Regnault & Willgoss, (2017).

A qualitative research can be advantageous in research since it allows content to be generated and insights can be provided to case studies and it gives allowance of human experience, Oltmann, (2016). However, this research method can be disadvantageous since the degree of bias of may be high. The researcher can manipulate the research results to meet the desired outcomes. This empirical research is going to be based on a mixed research methodology. The justification for choosing this research methodology is given below.

4.2.1 Justification for the Chosen Research Methodology

McKim (2015) posted that a mixed research methodology is advantageous in researches since it minimises the limitations of both the qualitative and quantitative research methods. Apart from that, the methodology may allow the use of more than one data collection instrument. This becomes advantageous because high quality data can be collected, and it enables meaningful research outcomes to be produced. Furthermore, since the researcher may have the capacity to use more than one research instrument it follows that, a mixed research methodology may have a limited degree of bias, Bilau *et al.* (2017). Lastly, the technique can be useful for reaching out a remote population through the use of electronically distributed questionnaires. This therefore becomes advantageous to researchers on cutting travelling costs for data collection. Given the above discussion, this empirical

research will pursue a mixed research methodology. The research design is going to be looked at next.

4.3 RESEARCH DESIGN

Research design is the outline created to pursuit answers to the research questions. Creswell and Creswell (2017: 14) define research design as the methods and procedures the researcher uses to gather and evaluate variables the research problem specifies. Figure 4.10 below shows some of the research designs commonly used in researches.

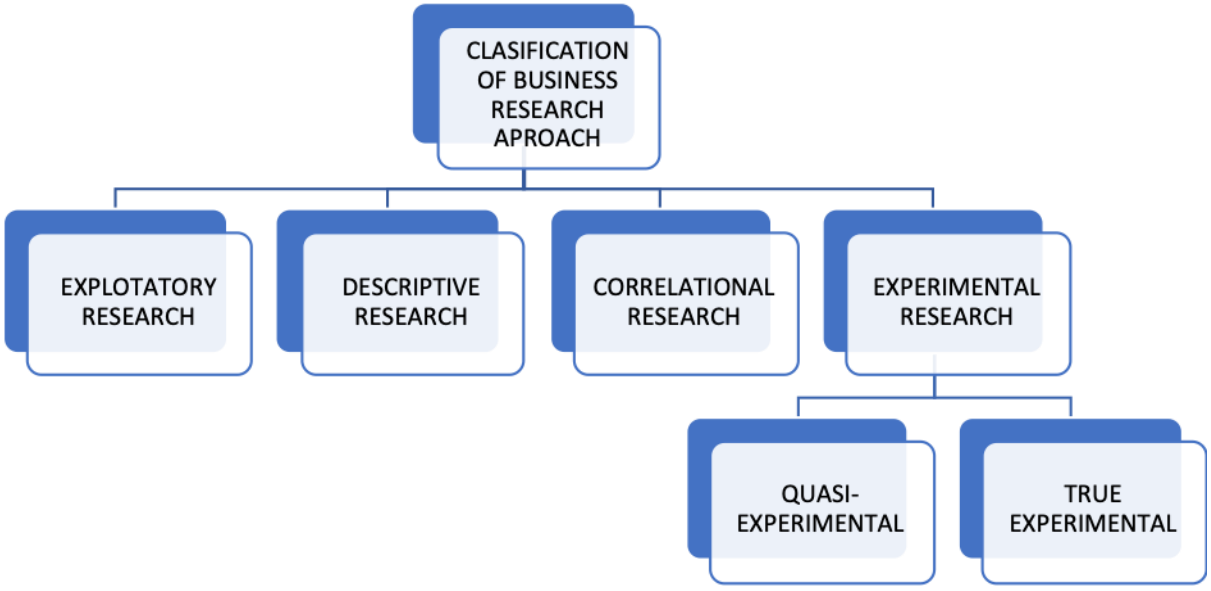

Figure 4-9: Research Approaches

Source : Greener and Martelli, 2015:47

Research can be exploratory, descriptive, correlational or experimental as is shown on Figure 4.3. Abutabenjeh & Jarat (2018) posited that explanatory research is used

to justify why patterns or relationships exist in researches. Long (2014) posted that descriptive research is based on the collection of data that can be used to connect factors or variables. It is also useful for explaining existing phenomena. On the other hand, correlational research is useful for investigative purposes especially on previously conducted researches. Correlational research is usually used to explain the different changes between factors or variables.

The key types of quantitative research design include ethnographic, Grounded theory, narrative study, historical, phenomenology, and case studies (Creswell & Creswell, 2017: 16). Phenomenology is hinged on the study of structures of consciousness as observed or from the first person's opinion as was posted by, (Flynn and Korcuska, 2018). This implies that using such an approach entails the capturing of views or opinions of the chosen participants. This research shall adopt the Phenomenology design; a research design used in identifying phenomena as well as focusing on the subjective understanding and experiences of such construction of experiences.

4.3.1 Justification for Selecting Phenomenological Paradigm

Lombardo (2017) posited that the use of phenomenological paradigm is of advantageous to researchers since they can gather high quality data from the participants through the use of the designed research instrument. To add more, the paradigm allows easy comprehension of the participant's views, Lombardo (2017). This is justified by the fact that if data collection is based on interviews, the researcher has an opportunity to collect more valuable data through probing of questions. Lastly, the use of phenomenological paradigm does not only allow quality of data collection but is also very prolific in closing research gaps. This paradigm is going to be used in this empirical study to meet the research demands as well as maximising the benefits of this approach. The target population is going to be discussed next as is below.

4.4 TARGET POPULATION

Yin (2017: 68) states that the study population is the people or subject-of- interest on whom such research is conducted. For this research, OEM company managers and employees handling Supplier Quality Assurance and Quality managers or representatives in foundries in South Africa will form the target population. The total number of foundries in South Africa is estimated at fifty. The target population entailed a total of fifty as it is the sum total of the existing population. The next discussion was centred on sampling techniques. This entire target population is in the South African economy and this is so since the foundry industry has few players.

4.5 SAMPLING STRATEGY

Sampling is a technique of selecting or choosing a representative subset of the target population, Showkat (2017). Yin (2017: 69) states that the sample frame is the entire catalogue of every sampling unit that has the capacity to represent adequately the entire population. The researcher has developed a sample frame with the intent of producing a symbolic sample of the population with projected characteristics. The Sample size is the observations in a statistical setting, like public-opinion surveys (Creswell and Creswell, 2017:35). For this research, the targeted sample is ten correspondents. Figure: 4.4 below shows the overview of sampling strategies.

Figure: 4.4 Overview of Sampling Strategies

Surbhi (2016), posted that probability and non-probability sampling are the main sampling techniques.

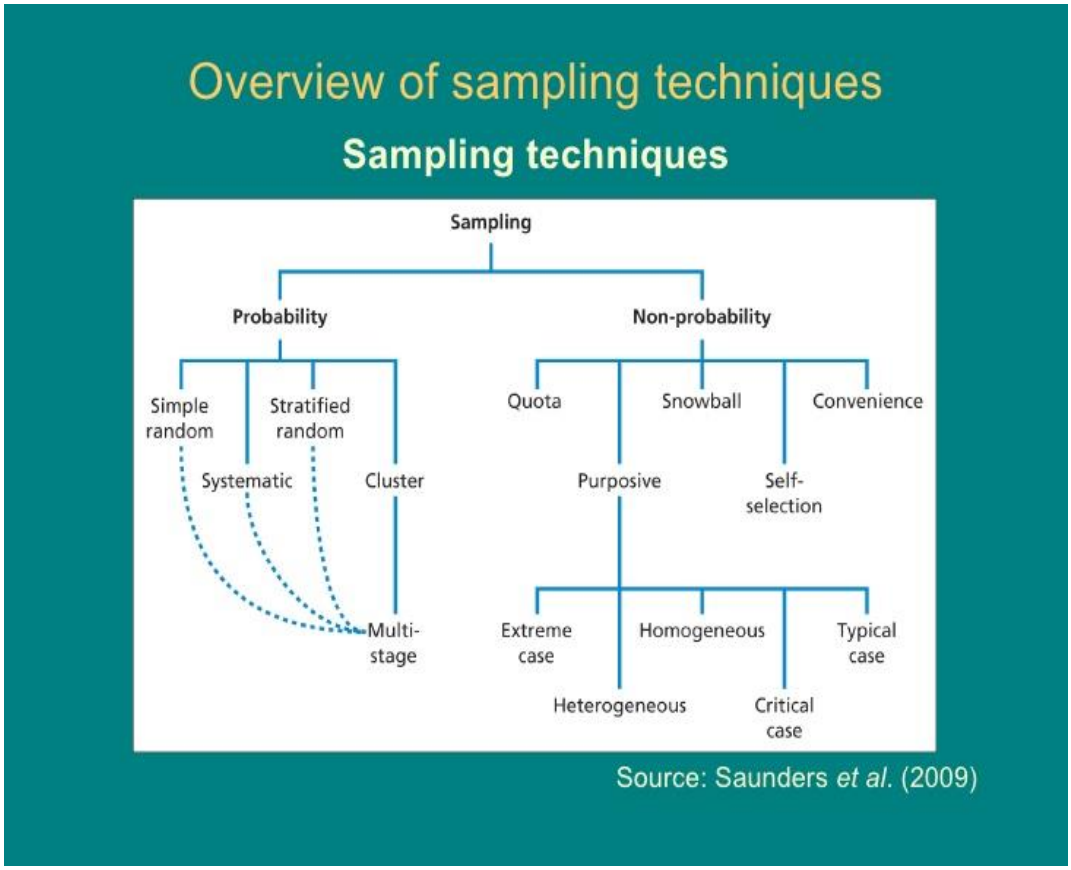

Figure 4-10: Sampling Techniques

Source: Saunders et al (2009)

4.5.1 Sampling Techniques

There are different sampling techniques that are used in the field of research**.** A discussion on some of these sampling techniques was presented and stated below. Probability sampling was looked at first. Other sampling techniques that fall under probability sampling were explored. Non- probability sampling and the related sampling techniques that fall under this sampling strategy were discussed in depth as well.

4.5.2 Probability Sampling

Probability sampling is a technique, whereby the subjects of a target population get an equal chance to be chosen to form a representative sample. Below are some of the sampling techniques to be looked at.

- Simple random sampling
- Cluster sampling
- Stratified sampling
- Systematic sampling

4.5.2.1 Simple random sampling

This sampling strategy can be called random sampling. Random sampling involves use of random basis for selecting the desired sample. This is carried out with the aid of random number tables, random number tables and online random number generator as was posted by (Elfil, 2017).

4.5.2.2 Systematic sampling

This is when a researcher systematically chooses a sample from an ordered sampling frame and it can be seen as a regular technique of choosing a sample size, (Alvi, 2016).This means that, the units that makeup the target population of a particular research must be listed, and every k^{-th} element must be selected. "k", or the sampling interval, will therefore represent the number with each element to be selected, for example, every 12th person, and It calculated by dividing target population by sample size, (Raina, 2015).

4.5.2.3 Stratified sampling

Stratified random sampling as the method of sampling that consists of apportioning the population studied into smaller groups (Cekim & Kadilar, 2017:301). Lone, Tailor and Singh (2016: 3309) state that such smaller groups in stratified random sampling remain based on the mutual attributes.

4.5.2.3.4 Cluster sampling

Cluster sampling is applicable if there are “natural” and non-heterogeneous sub categories in a particular population for use in a research study, Tipton (2016).The sample must be split into clusters or categories.

4.5.3 Non- Probability Sampling

Nonprobability sampling is a method of sampling in which the chances of selecting a respondent or individual is unknown.
Surbhi (2016) posted the following types of non-probability sampling:

- Snowball sampling
- Quota sampling
- Purposive sampling

4.5.3.1 Quota Sampling

Quota sampling technique usable on a wide population that is inclusive of sub-groups. Apart from that, quota sampling requires two basic conditions to be met that are: The first condition is that the categories must have a numerically estimable distribution in a target population, Yang (2014). Secondly, the variable used in setting up each category should be of great value with respect demands of the research.

4.5.3.2 Snowball Sampling

This sampling technique can be used in researches or in contexts where there is a hidden population, Kirchherr (2018). For example, one can look for an Ethiopian in South Africa, and make use of referrals on how and where to locate other Ethiopians. This is justified by the fact that Ethiopians appear to be a hidden population in the nation of South Africa.

4.5.3.3 Purposive sampling

Purposive sampling technique refers to any sample that is deliberately selected by a researcher in accordance with predetermined non-probability criteria as was postulated by, Eitikan (2016). This research used purposive sampling to choose the 10 participants: OEM company managers and staff handling SQA. The rationale for choosing purposive sampling is that it allows one to select the respondents based on personal judgement and in a way that will allow data to be collected to answer the research questions, Showkat (2017). The merits of using purpose sampling in this research is that it is less costly since data collection can be done through the use of electronically distributed questionnaires and interviews, which is more convenient, Showkat (2017).

4.6 DATA COLLECTION DESIGN AND METHODOLOGY

Data collection in research can be done through questionnaires, interviews, observation or databases as is summarised by figure 4.12

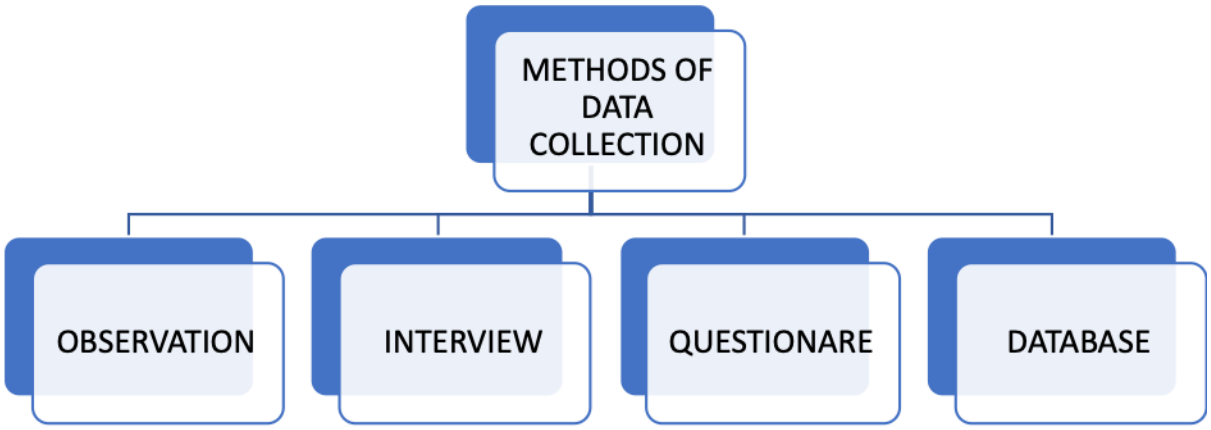

Figure 4-11: Data Collection Techniques

Source: Own

In-depth interviews are the main method of data collection for this paper. Creswell and Creswell (2017:34) state that In-depth interviews involving the carrying out of intensive personal discussions with small respondent numbers to discover their outlooks on the particular program, situation, or idea. Since this research was carried out using a mixed research technique, questionnaires were used also for data collection. Questionnaires were distributed electronically to the selected respondents.

The main advantage of in-depth interviewing was that the interviews offer more comprehensive data than is accessible through the methods of data collection, like surveys. The In-depth interviews also offer a more informal atmosphere for collecting information. Questionnaires will also give more privacy to the respondents to provide the detailed information.

4.6.1 Procedure for collection of data

The investigator consulted the research supervisor throughout the process of presenting to the administration of university for letters of approval and OEM company managers for consent as well as permission to collect data as exhibited in the university portal for prior approval to conduct research. The researcher has, on attaining the approval, scheduled interviews to the selected employees and managers after attaining their individual consent and corresponding workplace consent. The interviews were naturally one-on-one telephonically where there were limitations due to time, geographic disposition and financial resources or in person with the participants. For questionnaires, their distribution was based on electronically means that is through the use of emails to selected respondents.

4.6.2 Design of Research Instruments

An interview guide was designed that contain biographical questions. To be more specific, questions on age, occupation just to mention a few were asked to the respondents. Apart from that, questions were designed in line with the research questions and objectives. See Appendix A with the interview guide for detailed information. With regards to the questionnaire, it contained biographical information as well and the formulated questions were “open ended” approach to enable high quality data collection for meaningful analysis and subsequent conclusion. See Appendix B for the questionnaire.

4.7 Pilot Study

A pilot study is described as the process of data collection usually small-scale basis with an aim of ascertaining research feasibility, research or any possible adverse

events before to the actual data collection, Kistin & Silverstein (2015). A pilot study was conducted with the use of two questionnaires and two interviews. The data from the pilot study was analysed and the results were used for ascertaining if there is need of making adjustments on the research instruments.

4.8 Data Analysis

Data analysis refers to the systematic process of deducing sense from the collected data which must be consolidated, reduced and interpreted as was posted by (Sutton, 2015). Thematic data analysis was used in this this research. This technique is used widely in data analysis to identify patterned meaning across a dataset, Nowel (2017). A six-step technique will be employed to carry out thematic analysis, Nowell (2017). There are six key steps to be used in this mixed empirical research which are:

- Familiarisation with the data,
- coding,
- searching for themes,
- reviewing of themes,
- defining and naming themes and
- writing up.

4.9 ETHICS

Bryman et al (2012) citing Diener & Crandall (1978) when noting that “Discussion about ethical principles and how they can be transgressed and classified into four main areas”:

- Whether there is harm to participants.
- Whether there is a lack of informed consent.
- Whether there is an invasion of privacy.
- Whether permission was obtained.

All the above key principles are discussed briefly below.

Nyeboer & Page (2017) posted that research ethics is based on the analysis of the aspects or values that must be observed to the participants or respondents who are involved in a data collection process. Informed consent is going to be looked at next.

4.9.1 Ensuring Participants Have Given Informed Consent

Any empirical study should be carried out in accordance with the academic guiding frameworks and ethical standards, Borwn, *et al.* (2018). Formal consent will be obtained from all the participants or respondents in this empirical study. The next ethical aspect to be looked at is of ensuring that there is no harm to participants.

4.9.2 Ensuring No Harm Comes to Participants

Gray & Mcknenna (2018) posted that respondents should not be exposed to pain, distress, discomfort or any form of embarrassment through any action during and after data collection. This ethical value will be achieved by ensuring that all the participants have equal and fair treatment. Confidentiality and anonymity is going to be looked at next.

4.9.3 Ensuring Confidentiality and Anonymity

Kara & Pickering (2017) postulated that all the participants or respondents have full rights to anonymity in academic research. Personal and confidential details such as, next of kin, names, postal address, cell phone numbers, emails will not be requested from the respondents to guarantee their privacy. And the data collected will be used for this research only.

4.9.4 Ensuring That Permission Is Obtained

The concept of “Full information about the aim and purpose of the empirical study as well as the researcher’s status and role must be revealed” (Yip, 2016) Permission to collect data will be obtained from the responsible officials of the companies concerned in South Africa. The conclusion of the entire chapter is going to be presented below.

4.10 CONCLUSION

The chapter outlines a mixed research methodology was used for the study. Apart from that, it was explained that a phenomenological paradigm was going to be employed in this study. Questionnaires and interviews are the main research instruments used in this study and data analysis is going to be done using the thematic approach. A pilot study will be carried before the actual data collection. The target population were the officials in the foundry industry in South Africa and purposive sampling is going to be used to obtain a maximum of ten participants. All the data collection processes were done in line with the well-articulated ethical values.

CHAPTER 5: DATA ANALYSIS AND PRESENTATION

5.1 INTRODUCTION

This chapter focuses on data analysis and presentation. Themes were extracted from the data. Results from the pilot study were presented in brief and apart from that, the presentation will be done using appropriate tables or graphs. Extracts from the respondents views were also be used to substantiate the research findings. Lastly, a conclusion was given at the end.

5.2 DATA ANALYSIS

In this section, data was analysed thematically, however, there is a need to recapitulate on the main research objectives or questions of this empirical qualitative research.

Research Objectives

- To determine the Quality (SQA) tools and methods adopted by OEMs in the prevention of non-conforming products from foundry suppliers;
- To ascertain the SQM mechanisms foundries can use to prevent non-conforming products from reaching the end-user.
- To determine the effects of non-conforming products.
- To offer recommendations on reducing non-conformance from foundry products through supplier quality management.

Research Questions

A total of 11 questions were asked to the respondents as this research was seeking to answer the main question of Preventing detectable defects from reaching the end-user. The questions were asked as follows:

- Briefly outline the type of foundry products you supply?
- Explain the type of clients or markets you supply the above-mentioned foundry products.
- What quality standards do you have in place to ensure that high quality foundry products are produced?
- Briefly explain if your company is facing a challenge with non-conforming or substandard foundry products?
- What Supplier Quality Management Mechanism does your organisation has in place to reduce non-conforming products?
- In your opinion, what other Supplier Quality Management Mechanisms should be employed by your organisation to reduce non-conforming products?
- What are the effects of non-conforming products?
- How have you dealt with these negative effects in the past?
- What panaceas can you recommend minimising the effects of non-conforming products in your organisation?
- What are the Supplier Quality Assurance (SQA) tools and methods available or adopted by Original Equipment Manufacturer (OEMs) in the prevention of non-conforming products from foundry suppliers?
- Overall, what policy recommendations can you offer to solve the problem of non-conforming products in your organisation?

5.2.1 Response Rate

The response rate was 100%. All the respondents participated in the interview.

5.2.2 Pilot Study Results

A pilot study was carried out before the actual data collection for the sake of assessing the research feasibility. A total of two respondents were identified for the pilot study and these respondents were not used in the actual data collection.

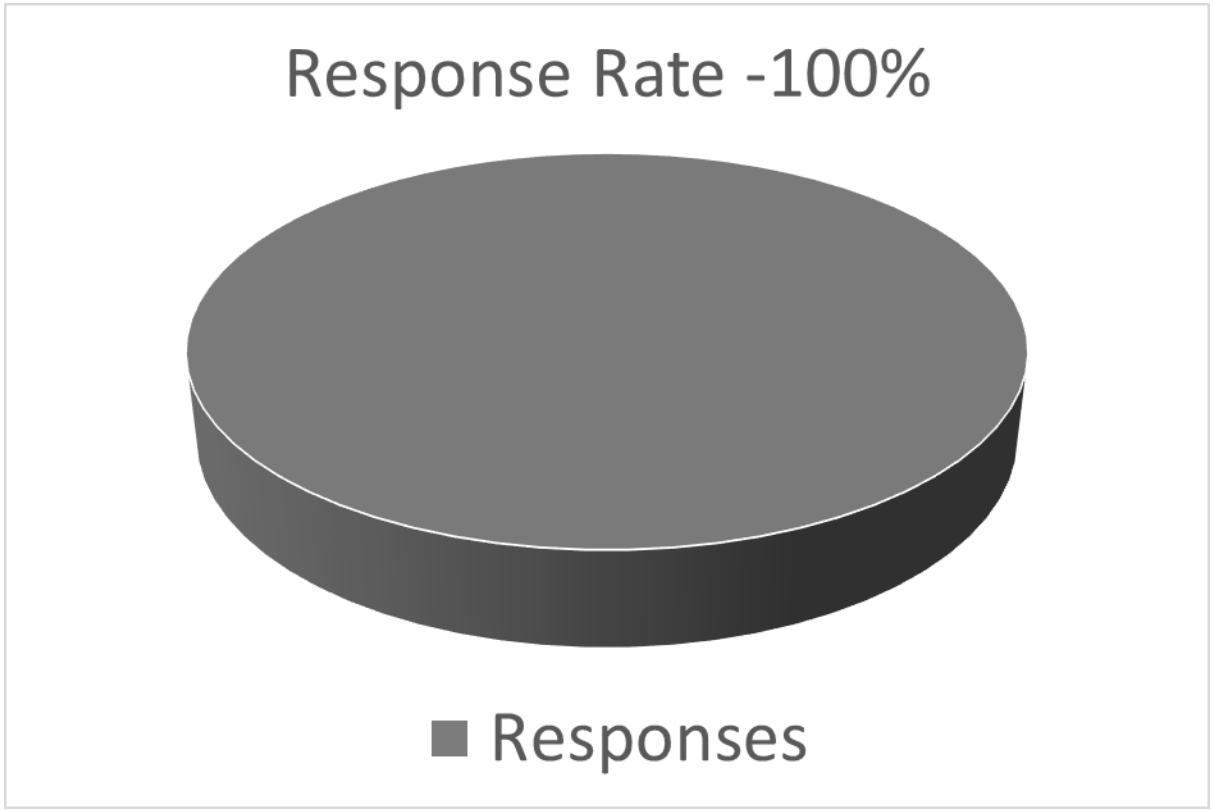

Figure 5-1: Pilot Study Response Rate

(**Source: Own)**

5.2.2.1 Analysis of Pilot Study

The two participants revealed that generally quality is a key aspect that their companies aim to provide to their clients. However, foundry products tend to be sub-standard although some of the companies apply some quality benchmarks. Below is an extract of the common themes from their responses.

Respondent 1 said that, “we have ISO900-2015 but quality of our products is a concern”

Respondent 2 said that, “we use our quality managers to check every stage, but we suffer financial costs when we remake some of the products”

From these responses it was clear that quality management is very important with regards to foundry products. Financial costs are incurred in remaking the products and this also affects clients in that they can get delayed in getting the right product and the right quality.

5.3 ANALYSIS OF DEMOGRAPHIC DATA

The following demographic factors were analysed and presented below.

Age – The minimum age and the maximum age for the respondents who took part in this study was 32 and 58 respectively. All the participants had adequate level of experience in the foundry industry as seasoned professionals with at least 5-year experience in the Foundry industry.

Gender – A total number of 7 males and 3 females took part in the study. The industry is more male dominant hence more males than females made part of this sample.

Occupation- all the respondents who took part in this study were all from the foundry industry. They held different positions such as quality engineers, quality assurance managers and chief quality inspectors.

5.4 THEME EXTRACTION

The following themes were extracted from the data collected.

5.4.1 Foundry Products

The respondents posited that they supply different products to their clients. These are presented below.

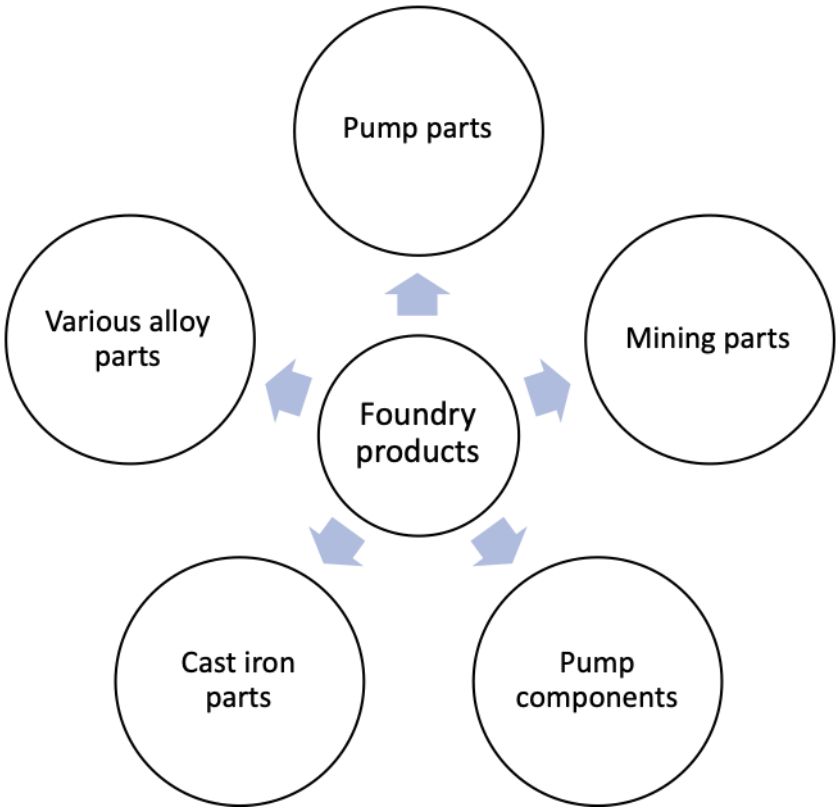

Figure 5.2: Foundry Products

Source: Own

Figure 5.2 shows that some of the foundry products that are supplied to clients are: mining products, cast iron, pump components.

5.4.2 Types of Clients

The companies serve clients in the different industries. Below is an extract of the responses from which the following 3 themes were a common thread:

Theme 1, “we supply products to the Pump and valve industry”

Theme 2, “our key clients are in the mining industry and pump industry”

Theme 3, “we major with the automotive industry and the export market”

From the responses above it shows that the clients of foundry products are in the Pump and valve industry, mining industry and the automotive industry and the export market.

5.4.3 Quality Standards of Foundry Products

Quality standards of foundry products are a very important aspect, and this is where this research is hinged on. Common responses were extracted from the respondents and are presented below in four themes:

Theme 1, “we use ISO9001-2015 for Quality Assurance Purpose”

Theme 2, “We make use of internal audits, ISO9001-2015 as well as quality inspectors”

Theme 3, “in our company we check prescribed specifications, quality assurance process as well as ISO9001-2015”

Theme 4, “mainly we use quality inspectors, quality standards such as ISO 9001-2015”

From these responses it was pellucid that the main quality standards used are: ISO9001-2015, internal audits and quality inspectors. These responses suffice the answer for the research objective. These are the quality standards the companies use in the prevention of non-conforming products from foundry suppliers. From this perspective it follows that the first research objective was successfully met.

5.4.4 Challenges of Non-Conforming Sub-Standard Foundry Products

Although from the previous themes it was clear that there are some quality standards being used to prevent non-conformance from foundry products through supplier quality management there remain some challenges with the quality of the foundry products. Below are some of the extracted responses that showed three common themes:

Theme 1, "fit-for-use issues are affecting us as a business though we have some quality assurance plans in place.

Theme 2, "of late we have been suffering from dimensional issues on our foundry products, high internal scrap rate"

Theme 3, "We are suffering from incapacitation to meet the client needs**"**

From the above responses was clear that the key challenges being faced with regards to challenges of non-conforming sub-standard foundry products are fit-for-use (meaning component meets minimum requirements) issues, dimensional issues, high internal scrap rate, and the inability to meet customer specifications. All these challenges affect the quality of foundry products and such challenges should be addressed.

5.4.5 Types of Supplier Quality Management Mechanism

Supplier Quality Management Mechanisms can be used to prevent non-conforming products from reaching the end-user. Below are common extracts of the responses from the respondents who took part in the research consolidated to four themes:

Theme 1, 'we use internal audits and awareness trainings"

Theme 2, "we use heat treatment, spectrographic management, awareness training"

Theme 3, "in our company we make use of inspector checking, audit trainings"

Theme 4, "we do not have proper supplier quality management mechanism in place as such, but our quality department do some quality checks to ensure the products meet the desired quality"

From the above responses it was clear that internal audits and awareness training, heat treatment, spectrographic management, inspector checking of parts and processes are some of the supplier quality management mechanisms used. However, it is also pellucid that some of the companies do not have proper supplier quality management mechanism in place. This research aim was to examine on what can be done to ensure that the quality of foundry products improve.

5.4.6 Alternative Supplier Quality Management Mechanism

There are alternative supplier quality management mechanisms that can be used by companies in the foundries industries to improve the quality of foundry products. Respondents' views were extracted, and they are presented below in five common themes:

Theme 1, "it can be good if we use 3 D scanning to improve the quality of the products we produce."

Theme 2, "manual inspection and 3D scanning can be very prolific supplier quality management mechanisms"

Theme 3, 'quality meetings, trial processes, quality checks on prototypes and employing skilled experts on quality can help to improve the quality of our foundry products"

Theme 4, "The use of 3 D scanning, training and development of quality personnel can be very useful measures of supplier quality management mechanisms.

Theme 5, "manual inspections, hiring skilled quality assurance personnel, acquisition of modern technology to improve quality of foundry products."

From the above responses was concluded that the alternative supplier quality management mechanisms that can be used by companies in the foundry industry

are: manual inspections, hiring skilled quality assurance personnel, acquisition of modern technology to improve quality of foundry products, use of 3 D scanning, training and development of quality personnel, continuous monitoring of quality at each level and quality meetings. This answers the first and the third research question of the empirical qualitative study.

5.4.7 Effects of Non-Conforming Products

There are several effects being experienced in the foundry industry. Below is an extract of the participant's views which constituted five themes.

Theme 1, "there are financial implications we suffer when we re-make the foundry products"

Theme 2, "loss of goodwill and reputation in the market"

Theme 3, "resources are wasted when clients return sub-standard products and we suffer transportation costs"

Theme 4, "we often experience delivery delays, and this affect us as competitors gain mileage over us"

Theme 5, "loss of clients and good reputation, it also affects our sales volume"

From the above responses it was clear that the effects of of non-conforming products are loss of clients and good reputation, reduction in the sales volume, loss of clients, delivery delays, resource wastage as well as financial costs. All these challenges imply that quality of foundry products must be improved. These effects in the long run can give other competitors mileage in the industry and tis promote the growth of monopolies. Such monopolies can in turn affect clients since monopolies tend to supply their products at a higher price. These responses suffice the second research question of this empirical study.

5.4.8 Measures Used in the Past for Reduction of Effects

There are measures that were used by different companies in the past to solve quality issues on the foundry products. Below are the common 4 themes of the responses that were extracted from the participants:

Theme 1, “We used to have quality re-checks and Root Cause Analysis”

Theme 2, “in the past we involved all workers in the quality assurance process.”

Theme 3, “to correct quality issues we ensured that proper measurements are followed, review of production process and Scrap analysis”

Theme 4, “internal and external control mechanisms, Root Cause Analysis and using quality assurance experts”

From these responses it was concluded that companies used measures such as internal and external control mechanisms, Root Cause Analysis and using quality assurance experts, Root Cause Analysis as well as involvement of all workers in the quality assurance process. These responses also answer the third research question of this study. Indeed, quality issues with regards to the foundry products are a cause a concern and a solution is required to solve such anomalies in the foundries industry.

5.4.9 Solutions to Minimise Effects of Non-Conforming Products

The respondents who took part in this study had diverse views on what can be done to solve the sub-standard quality of foundry standards. These panaceas are useful to ensure that a supplier quality management approach is prescribed to ensure that prevention of non-conformance from foundry products reaching the end-user is achieved. Below is an extract on the common themes or the views they shared with regards to the solutions needed to minimise the effects of non-conforming products.

5.4.10 Supplier Quality Assurance Tools and Methods of Preventing Non-Conforming Products

There are diverse supplier quality assurance tools and methods of preventing non-conforming products that can be used. The respondents shared the following views with regards to this theme. These responses are presented below in four respective themes:

Theme 1, "use of improved production techniques and inspection reports can be very helpful."

Theme 2, "there is need to set up customer support system."

Theme 3, "one solution is to have modern production equipment put in place to improve quality and supplier audits."

Theme 4, "more research and development is needed to improve quality of foundry products"

From the above responses it was clear that the Quality (SQA) tools and methods available or adopted by OEMs in the prevention of non-conforming products from foundry suppliers are:

- using modern production techniques,
- supplier audits,
- inspection reports,
- setting up customer support system as well as
- research and development.

These measures are available or can be adopted by companies to ensure that quality foundry products are produced. This implies that companies in the foundries sector should ensure that they have deep pockets to finance modern production equipment to ensure that quality of foundry products is maximised. After all, have been said and done it was essential to discuss the key policy recommendations that

can be used to ensure that high quality is achieved on all foundry products for both the domestic and export market.

5.5 POLICY RECOMMENDATIONS

From the above discussions quality for foundry products cannot be compromised further and it is essential to examine some of the ways that can be used to improve the quality of foundry products so as to satisfy the end-user needs. These policy recommendations were extracted from the responses of the participants in five key themes:

Theme 1, "training cycles can be used to improve quality of foundry products."

Theme 2, "Quality controls and quality checks are useful policies"

Theme 3, "tests must be carried out in the production process,"

Theme 4, "we need to have departmental quality standards in place"

Theme 5, "we need to have international quality benchmarks"

Key polices that can be drawn from the above responses are:

- **Training cycles –** there is need for foundry companies to ensure that they offer training to all employees to ensure that quality is achieved at all levels.
- **Quality controls and quality checks-** quality personnel need to ensure that they put quality controls and checks in place. This will improve the quality of foundry products and it will help the clients to have their needs met.
- **Departmental standards-** companies need to ensure that they have departmental standards that are pro-quality. This will assist in reducing the sub-standard goods reaching the need user.
- **International quality benchmarks-** companies need to invest sufficient financial resources to acquire modern technology and international quality standards that will be useful in achieving the required quality.

5.6 CONCLUSION

All in all, in this chapter the results from the pilot study were analysed and were used for assessing the suitability of the research instrument. From the research, it was established that companies in the foundry industry have certain quality benchmarks and they still lag behind in providing quality products to the clients. Key policy recommendations that can be used to solve the anomalies in the foundry industry have been presented. These recommendations are useful in reducing the effects of sub-standard goods reaching the end users. All the research questions and objectives were thus successfully met in this study.

CHAPTER 6: SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.0 INTRODUCTION

This chapter seeks to present the summary of the research findings. A number of policy recommendations were presented as well to ensure that high quality is achieved in the foundry industry. Directions for future research was discussed as well in this chapter. A research conclusion was presented as well, and a chapter conclusion was provided at the end of this chapter.

6.1 SUMMARY OF FINDINGS

The research showed that the foundry products that are supplied to clients are:

- mining products,
- cast iron,
- pump components.

The main quality standards used were:

- ISO9001-2015,
- internal audits and
- quality inspectors.

The key challenges faced with regards to challenges of non-conforming sub-standard foundry products were:

- Fit-for-use issues,
- dimensional issues,
- high internal scrap rate and

- the inability to meet customer specifications.

From the data analysed it was discovered that internal audits and awareness training, heat treatment, spectrographic management, inspector checking are some of the supplier quality management mechanisms used.

Furthermore, the alternative supplier quality management mechanisms that can be used by companies in the foundry industry were manual inspections, hiring skilled quality assurance personnel, acquisition of modern technology to improve quality of foundry products, use of 3 D scanning, training and development of quality personnel, continuous monitoring of quality at each level and quality meetings.

Several effects experienced in the foundry industry were loss of clients and good reputation, reduction in the sales volume, loss of clients, delivery delays, resource wastage as well as financial costs.

Companies in the foundry industry tried to use different measures to solve quality issues on foundry products as exhibited by the themes discussed on the research findings above.

It can be concluded that companies used measures such as internal and external control mechanisms, Root Cause Analysis and using quality assurance experts, Root Cause Analysis as well as involvement of all workers in the quality assurance process.

To add more, diverse solutions for prevention of non-conforming products from foundry suppliers were:

- using modern production techniques,
- supplier audits,
- inspection reports,
- setting up customer support system as well as
- research and development.

These research findings showed that quality in the foundry products must be achieved.

6.2 RECOMMENDATIONS

- **Training cycles –** there is need for foundry companies to ensure that they offer training to all employees to ensure that quality is achieved at all levels of its processes and continuous improvement.
- **Quality controls and quality checks-** quality personnel need to ensure that they put quality controls and checks in place. This will improve the quality of foundry products and it will help the clients to have their needs met.
- **Departmental standards-** companies need to ensure that they have departmental standards that are pro-quality. This will assist in reducing the sub-standard goods reaching the need user.
- **International quality benchmarks-** companies need to invest sufficient financial resources to acquire modern technology and international quality standards that will be useful in achieving the required quality.
- **Recruitment of quality assurance experts**- there is need for companies in the foundry industry to recruit quality experts. This may be costly in terms of wages and salaries but the benefits far outweigh the costs as this will be counter reversed by lower Cost of Poor Quality (CoPQ). The companies will enjoy more profits from supplying quality standards to different clients. It is therefore highly recommended that companies recruit quality assurance experts in the fields to eliminate non-confirming foundry products.
- **Research and Development –** more is required to set up research and development units in the foundry sector to ensure that quality products are produced. It is recommended that companies must invest more financial resources in research and development.

6.3 DIRECTIONS FOR FUTURE RESEARCH

This empirical research focused on the quality products in the foundry products with a specific focus on South African economy. For future research it can be prolific for other researchers to focus on quality aspects in the African or Sub-Saharan context. This will allows more research findings to be unearthed. To add more, it can be useful for other future researches to be conducted using mixed or quantitative research. This is so since this research was based on a qualitative technique and some of the inherent demerits of qualitative research could not have been avoided. Lastly, this research was carried out on a limited time due to academic needs. Future research it can be beneficial to carry similar researches on a long period of time to get more detail on the subject matter.

6.4 LIMITATIONS OF THE STUDY

This research was limited to foundry companies in South Africa. Apart from that some unavoidable demerits of qualitative research technique were encountered in the study. Lastly, the study focused on a limited sample since the target population is also small. The foundry small has a countable number of players.

6.5 CONCLUSION

This empirical qualitative research examined the quality effects of foundry products. All the research objectives and questions were successfully met. The data collected was successfully analysed. The research findings showed that companies in the foundry industry need to ensure that quality is achieved. Different measures to improve quality standards for foundry products were successfully discussed. The identified research gap has been closed and the overall aim of the study has been met.

This chapter presented the summary of the study. The key research findings were presented, and all the research objectives were successfully met. Key policy

recommendations to address quality aspects in the foundry industry were presented. Apart from that, the suggestions for future research were also discussed. Lastly, the research limitations were also presented, and the research gap has been successfully closed.

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Appendix A: Interview Guide

I am A Masters Student (**STUDENT NUMBER: 211281131**) at the above-mentioned educational institution carrying out an empirical research entitled**: Reducing Non-Conformance from Foundry Products through Supplier Quality Management** to full the Masters of Engineering requirements. All data collection or information is solely for the academic purposes only. **Privacy and Confidentiality is guaranteed**.

Name of Field Worker: **VELAPHI HENRY MABILETSA**
Contacts: **0714004783**

Estimated Interview Time: 10-15 Minutes

Section A: Biographic Information

1. Gender…… Male Female

2. Age……. Years

3. Occupation……..

Section B

4(a). Briefly outline the type of **foundry products** you supply?

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(b) Explain the **type of clients or markets** you supply the above mentioned foundry products.

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(c) What **quality standards** do you have in place to ensure that high **quality foundry products** are produced?

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5. (a) briefly explain if your company is facing a challenge with **non-conforming or substandard foundry products?**

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(b) What **Supplier Quality Management Mechanism** does your organisation has in place to **reduce** non-conforming products?

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(c) In your opinion, what other **Supplier Quality Management Mechanisms** should be employed by your organisation to **reduce non-conforming products?**

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6(a). What are **the effects of non-conforming products**?

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(b) How have you **dealt** with these **negative effects** in the past?

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(c) What **panacea**s can you recommend to **minimise the effects of non-conforming products** in your organisation?

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7 (a) What are **the Supplier Quality Assurance (SQA) tools and methods** available or adopted by **Original Equipment Manufacturer (OEMs) in the prevention** of non-conforming products from foundry suppliers?

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(b) Overally, **what policy recommendations can you offer to solve the problem of non-conforming products** in your organisation?

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THE END THE END THE END

Appendix B: Questionnaire

I am A Masters Student (**STUDENT NUMBER: 211281131**) at the above-mentioned educational institution carrying out an empirical research entitled**: Reducing Non-Conformance from Foundry Products through Supplier Quality Management** to full the Masters of Engineering requirements. All data collection or information is solely for the academic purposes only. **Privacy and Confidentiality is guaranteed**.

Instruction

Answer all questions in the spaces provided.

Name of Field Worker: **VELAPHI HENRY MABILETSA**
Contacts: **0714004783**

Estimated Time: 10-15 Minutes

Section A: Biographic Information

1. Gender…… Male ☐ Female ☐

2. Age……. Years

3. Occupation……..

Section B

4(a). Briefly outline the type of **foundry products** you supply?

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(b) Explain the **type of clients or markets** you supply the above mentioned foundry products.

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(c) What **quality standards** do you have in place to ensure that high **quality foundry products** are produced?

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(b) What **Supplier Quality Management Mechanism** does your organisation has in place to **reduce** non-conforming products?

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(c) In your opinion, what other **Supplier Quality Management Mechanisms** should be employed by your organisation to **reduce non-conforming products?**

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6(a). What are **the effects of non-conforming products**?

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(b) How have you **dealt** with these **negative effects** in the past?

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(c) What **panacea**s can you recommend to **minimise the effects of non-conforming products** in your organisation?

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(b) Overally, **what policy recommendations can you offer to solve the problem of non-conforming products** in your organisation?

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