UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI CAMPUS

QUALITY ASSURANCE PROCEDURES IN AUTOMOBILE WORKSHOP: A CASE STUDY IN THE J.A. PLANTPOOL GHANA LIMITED IN ACCRA

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CHARLES BRAINOO MENSAH

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M. TECH. MECHANICAL TECHNOLOGY-OPTION

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A Thesis in the Department of Mechanical Technology Education, Faculty of Technical Education, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for award of the Master of Technology in Mechanical Technology of the University of Education-Winneba, Kumasi

AUGUST, 2014

STUDENT'S DECLARATION

I, **CHARLES BRAINOO MENSAH**, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …….

DATE: …….....……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Thesis / Dissertation / Project as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: **DR. JOSHUA AMPOFO**

SIGNATURE: …….

DATE: …….

ACKNOWLEDGEMENTS

All thanks go to God Almighty for his guidance and grace that has enabled me to do this research.

I express my profound gratitude to my supervisor **Dr. Joshua Ampofo** for his guidance, comments, positive criticism and patience that has helped me complete this research.

I am also thankful to my family for their encouragement and support through thick and thin to and grateful to **J. A. PLANTPOOL GHANA LIMITED** for the opportunity given me to use their facility for this work.

DEDICATION

I dedicate this thesis first and foremost to the **Almighty God** for seeing me through in my educational ladder this far and making this master's programme a reality.

I also dedicate this thesis to my daughter Aba Brainoowa Mensah.

ABSTRACT

A common discussion is that the in automobile workshop lacks efficiency, quality is poor, budgets are unreliable and prices are excessive. Better management would result in increased efficiency with reduced quality failures while saving tremendous amount of money. This study was on quality assurance procedures in automobile workshop: A case study in the J. A. Plantpool Ghana Limited. The objectives of the study was to increase knowledge and awareness of quality related matters in quality assurance procedures in automobile repair workshop, to shed light on automobile repair workshop in relation to quality and quality related matters, to identify the current quality assurance procedures used in J. A. Plantpool Ghana Limited workshop and measure the current process.

100 respondents were chosen through convenience sampling technique from J. A. Plantpool Ghana Limited to answer the questionnaire. Data obtained was anaylsed using Statistical Product for Service Solutions (SPSS 22).

The research strongly suggests that quality is a problem for the automobile workshop. The research revealed that there is a scope for improving quality and it is possible. This conclusion is both supported with literature research and the research results. The research revealed that quality professionals saw clear improvements in organisational operations after having implemented quality assurance procedures in the automobile workshop. Furthermore the general employee had a very positive view towards applying and using the system on his work. However the research suggests that there is a gap in the use and implementation of quality assurance procedures in automobile workshop and that knowledge needs to be improved.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is the introductory section of the study which presents the general background of the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitations and limitations of the study and the organisational plan of the study.

1.1 Background to the study

Quality Assurance procedures (QA) is way of preventing mistakes return job in repairs services or defects in manufactured products and avoiding problems when delivering solutions or services to customers and avoid wastage in a system. Quality assurance procedures is applied to providing repair services to customers or physical products in pre-production to verify what will be made meets specifications and requirements, and during manufacturing production runs by validating lot samples meet specified quality controls. Quality assurance procedures is also applied to software to verify that features and functionality met business objectives, and that code of conduct is relatively bug free prior to shipping or releasing new software products and versions.

Quality assurance procedures refer to administrative and procedural activities implemented in a quality system so that requirements and goals for a product, service or activity will be fulfilled (Majcen & Taylor, 2010). It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention (Pyzdek, 2003). This can be contrasted with quality control, which is focused on process output.

Two principles included in Quality Assurance are: "Fit for purpose", the product should be suitable for the intended purpose; and "Right first time", mistakes should be eliminated. QA includes management of the quality of raw materials, assemblies, products and components, services related to production, management, production and inspection processes.

Suitable quality is determined by product users, clients or customers, not by society in general. It is not related to cost, and adjectives or descriptors such as "high" and "poor" are not applicable. For example, a low priced product may be viewed as having high quality because it is disposable, where another may be viewed as having poor quality because it is not disposable.

1.2 History quality assurance procedures.

During the middle Ages, guilds adopted responsibility for quality control of their members, setting and maintaining certain standards for guild membership.

Royal governments purchasing material were interested in quality control as customers. For this reason, King John of England appointed William Wrotham to report about the construction and repair of ships. Centuries later, Samuel Pepys, Secretary to the British Admiralty, appointed multiple such overseers.

Prior to the extensive division of labor and mechanization resulting from the Industrial Revolution, it was possible for workers to control the quality of their own products. The Industrial Revolution led to a system in which large groups of people performing a specialised type of work were grouped together under the supervision of a foreman who was appointed to control the quality of work manufactured.

During the time of the First World War, manufacturing processes typically became more complex with larger numbers of workers being supervised. This period saw the widespread introduction of mass production and piece work, which created problems as workmen could now earn more money by the production of extra products, which in turn occasionally led to poor quality workmanship being passed on to the assembly lines. To counter bad workmanship, full-time inspectors were introduced to identify quarantine and ideally correct product quality failures. Quality control by inspection in the 1920s and 1930s led to the growth of quality inspection functions, separately organized from production and large enough to be headed by superintendents.

The systematic approach to quality started in industrial manufacturing during the 1930s, mostly in the U.S., when some attention was given to the cost of scrap and rework. The impact of mass production required during the Second World War made it necessary to introduce an improved form of quality control known as Statistical Quality Control, or SQC. Some of the initial work for SQC is credited to Walter A. Shewhart of Bell Labs, starting with his famous one-page memorandum of 1924.

Statistical Quality Control includes the concept that every production piece cannot be fully inspected into acceptable and non-acceptable batches. By extending the inspection phase and making inspection organisations more efficient, it provides inspectors with control tools such as sampling and control charts, even where 100 percent inspection is not practicable. Standard statistical techniques allow the producer to sample and test a certain proportion of the products for quality to achieve the desired level of confidence in the quality of the entire batch or production run.

Automobile repair workshops that are independently owned and operated businesses and J. A. Plantpool Ghana Limited is one of such business that operates in Ghana. J. A. Plantpool Ghana Limited is into sales and service of Sinotruck trucks, Youtong buses and earth moving equipment from china to customer across the length and breadth of Ghana and neighboring countries in the sub-Sahara countries. In Ghana and like the United States, these automobile repairs shops are commonly certified by their respective manufacturer to perform warranty and recall repairs by that manufacturer or distributor.

Independent automobile repair shops in the US may also achieve certification through manufacturer sponsored programs. In the European Union a recent law (The EC Block Exemption Regulation 1400/2002) allows motorists more flexibility in selecting where they can get their car or heavy equipment serviced. Due to this legislation, maintenance and service work does not have to be done by the main dealer as long as the garage uses Original Equipment 'Matching Quality' parts, and are recorded as such, and the garage follow the manufacturer's service schedules. The Block Exemption Regulation (BER) covers service and maintenance during the warranty period and prohibits vehicle manufacturers' warranties from including conditions that require normal maintenance to be provided within the vehicle manufacturer's network or that all parts used must be the manufacturer's original spare parts. This means that motorists benefit from open market competition in aftermarket parts, repairs and services thus reducing the cost of servicing through better labour rates and competitively priced parts.

In Ghana, the legislation for automobile repairs and establishment of automobile garages is same as in Europe and America. They are certified by their respective manufacturer to perform warranty and recall repairs by that manufacturer or distributor. Motorist and

owners of heavy equipment have the flexibility in selecting where they can get their car or heavy equipment serviced.

Specialty automobile repair shops are shops specializing in certain parts such as brakes, mufflers and exhaust systems, transmissions, under carriage body parts, tires, electrical, automotive air conditioner repairs, automotive glass repairs and installation, and wheel alignment or those who only work on certain brands of vehicle or vehicles from certain continents of the world.

There are also automotive repair shops that specialize in vehicle modifications and customisation. Oftentimes, various specialised auto repair shops will have varied infrastructure and facilities (for specific jobs or vehicles), as well as technicians and mechanics with different qualifications.

1.3 Statement of the problem

J. A. Plantpool Ghana limited workshop provides repairs services of trucks, buses and earth moving equipment to the general public. The workshop offers such services through the Accra branch of the company which offer repair services of buses, trucks and earth moving equipment sold to all customer across the nation and the neighboring countries like Togo, Nigeria Côte d'Ivoire, Burkina Faso, Mali, etc. Also J. A. Plantpool Ghana Limited Ghana workshop provides repair services to the construction and mining sector across the country and the sub- region of Africa the company.

The main workshop is based in Accra with service vans across the nation to provide repairs services to its customers with the country and the sub region. Owners of this vehicles and equipment sold and services by J. A. Plantpool Ghana Limited have a vested

interest in insuring that it is properly used, maintained, and managed and that give room for poor repair service delivery. Owners of these said vehicles and heavy earthmoving equipment fall into three major categories: transport, mining companies and construction companies. Although the applications these machines perform within these two types of companies may seem similar, the conditions are very different. Owners of vehicles and heavy equipment relied on our support in maintenance and repairs to enable their equipment and vehicles to operate smoothly with minimal or no downtime of their equipment or vehicles. Quality services is the most desired services expected by customer for total utilisation of their equipment and vehicle for economic benefits and growth of Ghana, and to reduce cost of repairs and operation to J. A. Plantpool Ghana limited. Over time, there have been much complaints about poor quality of services, by the J. A. Plantpool Ghana Limited workshop in areas of;

i. High rates of returns jobs.
ii. Complaints of defected other vehicle systems which were not defected before vehicle where brought in J. A. Plantpool Ghana Limited workshop for repairs or maintenance.
iii. Frequent breakdown of vehicle and equipment after service by the J. A. Plantpool Ghana Limited.
iv. Delay in service and repairs by J. A. Plantpool Ghana Limited.
v. Increase in cost and time of repair services.
vi. High down time of customer's vehicles and equipment.
vii. Loss of customer to company due to poor quality repair service to clients.

These complains have negative effect on the operation of the customers in the transport, mining and construction sector of the Ghana and is having negative effect on service rendering leading to poor production. Again the company is losing customer to competitors particular those in the informal sector of the industry is affecting the growth of the company in terms of growth hence the need to research into quality assurance procedures of the company.

1.4 Aim and objectives

Few studies in Ghana have focused on the quality and the use of quality assurance systems (QAS) within the Ghana automobile sector. These studies have mostly been directly focused on the use of QAS in the automobile repair industries particularly J. A. Plantpool Ghana Limited workshop with regards to client satisfaction and system benefits. No study has yet been performed on the importance of quality assurance procedures and workshop process in the automobile.

1.4.1 The aim of this research is to increase knowledge and awareness of quality related matters in quality assurance procedures in automobile repair workshop. The research aims to identify the main problems the automobile repair industry is having with quality. In addition, the research aim is to examine where the scope lies for improving and identifying barriers that might be standing in the way of quality improvements.

1.4.2 The research focuses on shedding light on automobile repair workshop in relation to quality and quality related matters. This involves analysing the quality status theoretically as well as catching a glimpse at automobile repair workshop experience and views on quality related matters and their use of QAS. It is crucial

to map the magnitude of quality problems as well as mapping the human aspects. Analysing how well the two aforementioned items converge is of importance as well. In order to see the big picture, it is helpful to compare Ghana to other countries in relations to quality assurance procedures in automobile repair workshop related topics. This should give a better understanding of what needs to be done to raise the quality bar.

1.4.3 Also the research is aimed at identifying the current quality assurance procedures used in J. A. Plantpool Ghana Limited workshop and measure the current process if it marches standards, if not find ways of institute, develop or improving quality assurances processes that will improve repair service delivery in the J. A. Plantpool Ghana Limited workshop for good customer satisfaction, smooth operation of customer vehicle/equipment, increase productivity for economic growth of Ghana.

In order to form the research direction and set the research demarcation, research questions were formed. The research questions marked the strategy chosen for this research. This research is a triangulation of methods. In addition, it will involve sending out a questionnaire, interviews will be conduct with quality managers in the case study company which will be participating in the study. The purpose of the interviews is to gain a deeper understanding of questionnaire results.

The research questions that will be kept in mind during the research are the following:

1) Is quality a problem for the automobile repair workshop?

a. What are the main problems and to what extent are they occurring?

b. Is it possible to improve the quality?

c. What meaning does the industry put in quality?

2) Do quality management systems increase quality?

3) By what means is the application of quality management systems conducted?

a. What is the employers' experience of working with the quality management system?

b. Are there any gaps in the use of the quality management system?

1.5 Significance of the study

The research study is significant because it could provide solution to the frequent breakdown of customer's equipment, vehicles, poor quality service of J. A. Plantpool Ghana Limited and to develop quality assurance process that could be used by others in the automobile repair industry. The following are some of the benefits that this research could bring forth if the recommendations are adhered to:

1. The Significance of the Study is to achieve consistent and predictable repair results every day in production while increasing over all through-put. In-Process Quality Assurance will improve on time deliveries, production flow, and cycle times by reducing and eliminating internal redo's and come-backs thereby simultaneously driving internal costs down.
2. It could help increase productivity of clients. This is because client's vehicles and equipment are the back bone of their operation being construction, mining, or transports business that makes it the pivot of productivity in country of operation. Hence anything that would affect these clients' vehicles and equipment could automatically influence productivity in Ghana or the country of operation.
3. The study could narrow down the causes of poor quality repairs and, quality assurance procedures services for an onward resolution of the problem.

1.6 Limitations of the study

Despite the numerous benefits that would be derived from this research, I anticipate real challenges that would attempt to bedevil this study. The following are some of the anticipated limitations that are likely to slow down the progress of this study.

1. Getting access to vehicle and equipment owners who are scattered all over Ghana and the neighboring countries in the sub- Sahara Africa.
2. Willingness of J. A. Plantpool Ghana Limited staff to volunteer information.
3. Getting enough finance to travel the length and breadth of Ghana to administer and retrieve questionnaires from respondents.
4. The findings of this study should not be generalised to all J. A. Plantpool Ghana Limited including satellite workshops across the country as the respondents involved were workers J. A. Plantpool Ghana Limited.

1.7 Delimitations of the study

The study was delimited to only J. A. Plantpool Ghana Limited workers at Ghana which include technical managers, store managers, technicians, drivers and clients (owners of vehicles and equipment). The study did not include the administrative staff of the non-technical department.

1.8 Thesis outline

The thesis has five chapters:

In the first chapter the background of the research is presented, aims and objectives are described and the research method is presented. The second chapter presents the theoretical background of the study. Firstly, it discusses quality in general. Secondly, it

discusses the special characteristics of the industry and quality barriers within the industry. Thirdly, it discusses quality management systems in relation to their use and implementation. Finally, it discusses quality problems and their costs.

The third chapter goes into full detail on the methodology and methods used in this study. Furthermore, it describes how the questionnaire and interviews were designed and carried out.

Chapter four presents the research findings, both from the questionnaire and the interviews conducted. The result was presented with supportive data such as graphs, tables and text.

Chapter five discusses the research findings with regards to the research questions and previous findings. This chapter also analyses and discusses the results in a broader context and provides a final conclusion on the research and recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Quality Assurance refers to any process by which quality requirements are ensured either prior to or during the production process. In auto repair this would equate to definition of quality standards and communication of those requirements to technicians (pre-production). Secondly it would refer to the process by which technicians ensure that quality requirements are met during the performance of repair work. If the standards are clearly defined and the processes by which the standards are applied are sound, then desired quality levels should be achieved. The application of quality assurance can be viewed as building quality into the product at the point of production. Quality Control refers to the process by which all aspects of the production process are reviewed and examined to ensure that quality standards are met. Probably the most important element of quality control is the inspection process. In auto repair, the quality control inspection process is performed after work is completed on a vehicle to make sure that all required repairs were performed and that they meet quality requirements. Inspections are performed post production and are focused on identifying problems before vehicle delivery. Quality assurance focuses on improving and stabilisng processes by which service is delivered thus minimising quality problems during the repair process. Quality control focuses on identifying and correcting problems after repair work is performed and ensuring that it is corrected before the vehicle is returned to the customer. Both areas are critical to delivering quality auto repair service. Quality assurance and control principles can be applied to all areas of a business. In the auto repair business, the repair process

receives the most focus but quality management principles can also be applied to parts procurement, points of customer interaction and other areas of the business. Applying quality principles in this manner can be referred to as Total Quality Management. Quality assurance is an integral part of any business. Delivering quality service is essential to business success. Most quality problems are the result of poorly defined business processes. If procedures are defined so that quality assurance is included the product delivered will have quality built into it. Quality problems occur at the point of production however the underlying cause may not be production related. Production is fed from various sources such as work requirements definition and parts to be used. Superior quality is ensured by building quality checks into all processes that are part of service delivery.

2.2 Quality assurance

It is a way of preventing mistakes or defects in manufactured products and avoiding problems when delivering solutions or services to customers. ISO 9000 defines quality assurance as "A part of quality management focused on providing confidence that quality requirements will be fulfilled". It thus differs subtly from quality control. QA is applied to physical products in pre-production to verify what will be made meets specifications and requirements, and during manufacturing production runs by validating lot samples meet specified quality controls. QA is also applied to software to verify that features and functionality meet business objectives, and that code is relatively bug free prior to shipping or releasing new software products and versions. Quality Assurance refers to administrative and procedural activities implemented in a quality system so that

requirements and goals for a product, service or activity will be fulfilled. It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. This can be contrasted with quality control, which is focused on process output. Two principles included in Quality Assurance are: "Fit for purpose" (the product should be suitable for the intended purpose); and "Right first time" (mistakes should be eliminated). QA includes management of the quality of raw materials, assemblies, products and components, services related to production, and management, production and inspection processes.

Suitable quality is determined by product users, clients or customers, not by society in general. It is not related to cost, and adjectives or descriptors such as "high" and "poor" are not applicable. For example, a low priced product may be viewed as having high quality because it is disposable, where another may be viewed as having poor quality because it is not disposable.

2.3 Initial efforts to control the quality of production.

During the middle Ages, guilds adopted responsibility for the quality of goods and services offered by their members, setting and maintaining certain standards for guild membership.

Royal governments purchasing material were interested in quality control as customers. For this reason, King John of England appointed William Wrotham to report about the construction and repair of ships. Centuries later, Samuel Pepys, Secretary to the British Admiralty, appointed multiple such overseers. Prior to the extensive division of labor and mechanization resulting from the Industrial Revolution, it was possible for workers to

control the quality of their own products. The Industrial Revolution led to a system in which large groups of people performing a specialised type of work were grouped together under the supervision of a foreman who was appointed to control the quality of work manufactured.

2.4 Wartime production

During the time of the First World War, manufacturing processes typically became more complex with larger numbers of workers being supervised. This period saw the widespread introduction of mass production and piece work, which created problems as workmen could now earn more money by the production of extra products, which in turn occasionally led to poor quality workmanship being passed on to the assembly lines. To counter bad workmanship, full-time inspectors were introduced to identify quarantine and ideally correct product quality failures. Quality control by inspection in the 1920s and 1930s led to the growth of quality inspection functions, separately organized from production and large enough to be headed by superintendents. The systematic approach to quality started in industrial manufacturing during the 1930s, mostly in the U.S., when some attention was given to the cost of scrap and rework. The impact of mass production required during the Second World War made it necessary to introduce an improved form of quality control known as Statistical Quality Control, or SQC. Some of the initial work for SQC is credited to Walter A. Shewhart of Bell Labs, starting with his famous one-page memorandum of 1924. SQC includes the concept that every production piece cannot be fully inspected into acceptable and non-acceptable batches. By extending the inspection phase and making inspection organisations more efficient, it provides inspectors with control tools such as sampling and control charts, even where 100 percent

inspection is not practicable. Standard statistical techniques allow the producer to sample and test a certain proportion of the products for quality to achieve the desired level of confidence in the quality of the entire batch or production run.

2.5 Postwar

In the period following World War II, many countries' manufacturing capabilities that had been destroyed during the war were rebuilt. General Douglas MacArthur oversaw the re-building of Japan. During this time, General MacArthur involved two key individuals in the development of modern quality concepts: W. Edwards Deming and Joseph Juran. Both individuals promoted the collaborative concepts of quality to Japanese business and technical groups, and these groups utilised these concepts in the redevelopment of the Japanese economy. Although there were many individuals trying to lead United States industries towards a more comprehensive approach to quality, the U.S. continued to apply the Quality Control (QC) concepts of inspection and sampling to remove defective product from production lines, essentially ignoring advances in QA for decades.

2.6 Failure testing

A valuable process to perform on a whole consumer product is failure testing or stress testing. In mechanical terms this is the operation of a product until it fails, often under stresses such as increasing vibration, temperature, and humidity. This exposes many unanticipated weaknesses in a product, and the data is used to drive engineering and manufacturing process improvements. Often quite simple changes can dramatically improve product service, such as changing to mold-resistant paint or adding lock-washer placement to the training for new assembly per **Statistical control.**

Statistical control is based on analyses of objective and subjective data. Many organisations use statistical process control as a tool in any quality improvement effort to track quality data. Any product can be statistically charted as long as they have a common cause variance or special cause variance to track.

Walter Shewart of Bell Telephone Laboratories recognized that when a product is made, data can be taken from scrutinised areas of a sample lot of the part and statistical variances are then analysed and charted. Control can then be implemented on the part in the form of rework or scrap, or control can be implemented on the process that made the part, ideally eliminating the defect before more parts can be made like it.

2.7 Total quality management

The quality of products is dependent upon that of the participating constituents, some of which are sustainable and effectively controlled while others are not. The process(es) which are managed with QA pertain to Total Quality Management.

If the specification does not reflect the true quality requirements, the product's quality cannot be guaranteed. For instance, the parameters for a pressure vessel should cover not only the material and dimensions but operating, environmental, safety, reliability and maintainability requirements.

2.8 QA in medical industry

QA is very important in the medical field because it helps to identify the standards of medical equipment and services. Hospitals and laboratories make use of external agencies in order to ensure standards for equipment such as X-ray machines, Diagnostic Radiology and AERB.

2.8.1 QA in software development

Software Quality Assurance consists of a means of monitoring the software engineering processes and methods used to ensure quality. The methods by which this is accomplished are many and varied, and may include ensuring conformance to one or more standards, such as ISO 9000 or a model such as CMMI.

2.8.2 Models and standards

ISO 17025 is an international standard that specifies the general requirements for the competence to carry out tests and or calibrations. There are 15 management requirements and 10 technical requirements. These requirements outline what a laboratory must do to become accredited. Management system refers to the organisation's structure for managing its processes or activities that transform inputs of resources into a product or service which meets the organisation's objectives, such as satisfying the customer's quality requirements, complying with regulations, or meeting environmental objectives. The CMMI (Capability Maturity Model Integration) model is widely used to implement Process and Product Quality Assurance (PPQA) in an organisation. The CMMI maturity levels can be divided into 5 steps, which a company can achieve by performing specific activities within the organisation.

2.8.3 Company quality

During the 1980s, the concept of "company quality" with the focus on management and people came to the fore. It was realised that, if all departments approached quality with

an open mind, success was possible if the management led the quality improvement process.

The company-wide quality approach places an emphasis on four aspects:

1. Elements such as controls, job management, adequate processes, performance and integrity criteria and identification of records
2. Competence such as knowledge, skills, experiences, qualifications
3. Soft elements, such as personnel integrity, confidence, organisational culture, motivation, team spirit and quality relationships.
4. Infrastructure (as it enhances or limits functionality)

The quality of the outputs is at risk if any of these aspects is deficient.

QA is not limited to the manufacturing, and can be applied to any business or non-business activity:

i. Automobile /equipment repairs
ii. Design
iii. Consulting
iv. Banking
v. Insurance
vi. Computer software development
vii. Retailing
viii. Investment
ix. Transportation

x. Education

xi. Translation

It comprises a quality improvement process, which is generic in the sense that it can be applied to any of these activities and it establishes a behavior pattern, which supports the achievement of quality.

This in turn is supported by quality management practices which can include a number of business systems and which are usually specific to the activities of the business unit concerned.

In manufacturing and construction activities, these business practices can be equated to the models for quality assurance defined by the International Standards contained in the ISO 9000 series and the specifications for quality systems. In the system of Company Quality, the work being carried out was shop floor inspection which did not reveal the major quality problems. This led to quality assurance or total quality control, which has come into being recently.

2.8.4 Using contractors and/or consultants.

Consultants and contractors are sometimes employed when introducing new quality practices and methods, particularly where the relevant skills and expertise are not available within the organisation or when allocating the available internal resources are not available. Consultants and contractors will often employ Quality Management Systems (QMS), auditing and procedural documentation writing CMMI, Six Sigma,

Measurement Systems Analysis (MSA), Quality Function Deployment (QFD), Failure Mode and Effects Analysis (FMEA), and Advance Product Quality Planning (APQP).

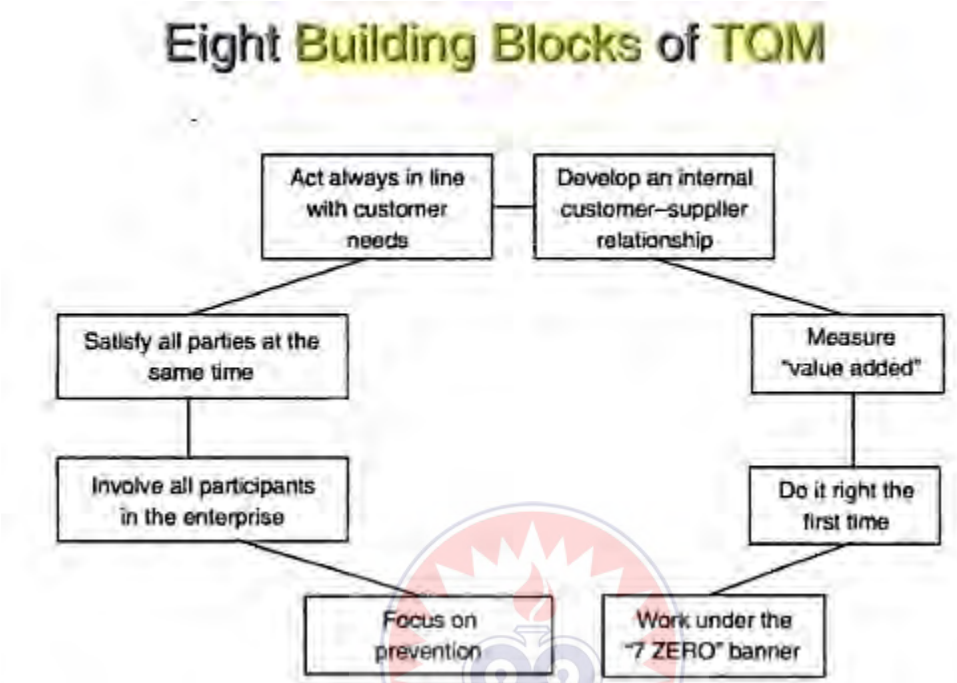

Figure 2.1: TQM and its building blocks (Mukherjee & Kachwalka, 2010)

Market excellence is achieved through customer satisfaction. The customer's needs and wants serve as the guiding principle for all of the company's goals. Global competition will not allow the organisation's survival, if it is not focused on fulfilling customer needs. The development of an internal customer supplier relationship, as the interface into the subsequent process for each process, is regarded under a customer relations perspective, entailing the appropriate ramifications, which are derived from a need to satisfy the customer. Measurement is an important pre-requisite for improvements in TQM. The value of each process or step must be measurable, and measurements should be conducted regularly. By analysing the value of the product before and after the process, the created surplus of the process can be measured. This maxim is expressed with the

TQM motto, “Do it right the first time.” This perception tries to minimise the waste of resources, which goes in hand with a focus on prevention. Repetition of mistakes is not acceptable, and quality is only assured if the root cause of problems or defects is found and eliminated. The building block of the eight zeros, as illustrated in the Figure 1.1, refers to the eight mudas, a Japanese term meaning waste, derived from the Toyota Production System. For TQM, muda, or waste, must be eliminated on several levels: negative thinking refers to the whole company culture; removing excessive inventory and achieving zero delays, zero paper are directed towards improving organisational processes, while zero downtime, zero defects and zero accident are the goals to be achieved. Involving all participants is a recurring theme in quality management, pervading all quality systems. Satisfying all parties at the same time refers to expectations to excel in all relations with the customer, the employees, the suppliers, and moreover with the shareholders as well as society as a whole. The following list highlights the principles of TQM:

i. Organisations need a vision and a goal, clearly defined with a mission.

ii. The quality paradigm is customer centered.

iii. The employee is an asset and is the driving force for success.

iv. The organisation’s processes are directed towards continually improving the quality.

v. Tools and techniques must be available to support improvements.

Benchmarking as a tool for quality improvements.

Customer Market Evaluation as a crucial tool supporting the customer-driven approach.

Reiterating the importance of people, processes, and systems for quality initiatives to succeed, the building blocks of TQM (Department of Trade and Industry, n.d.) are illustrated in Figure 2.2 as processes, people, management systems, and performance measurement. The responsibility of implementing process quality lies with the people who will be the decisive success factor. People carry out the processes and by focusing on quality measures, combining improvement activities with commitment and recognition from the leaders, the prerequisite climate is prepared to facilitate the success of Quality Management Systems. Once the strategic direction for the organisation's quality journey has been set, it needs Performance Measures to monitor and control the quality standards in order to sustain the quality strategy.

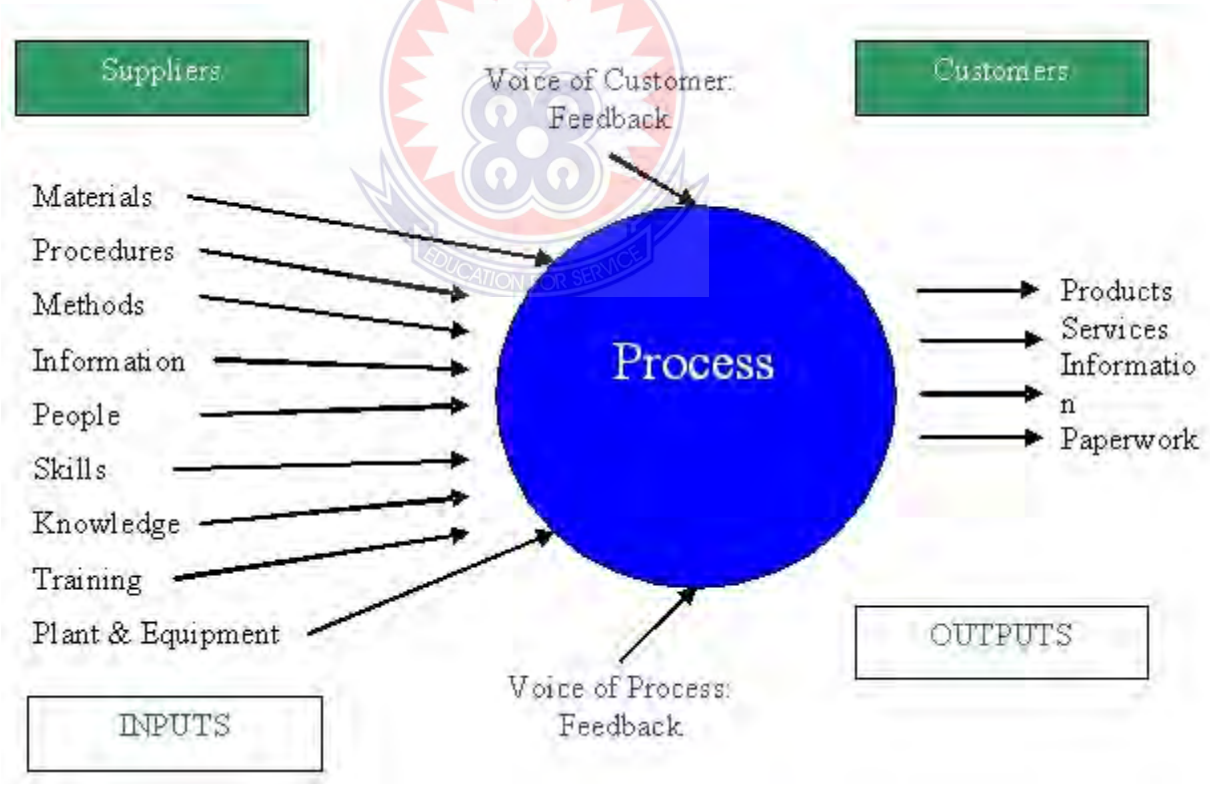

FIGURE 2.2: A view on TQM accentuating people, processes, and systems (Department of Trade and Industry, 2002)

The effect of TQM on business value, product innovation, and organisational excellence is a controversial topic among scholars, and several research studies have been conducted to examine the interdependence of quality on business results. A major review and seminal study on TQM and its effect on business excellence was conducted by Powell in 1995. The study evaluated a vast amount of data available at that time, and it concluded that there is no obvious correlation between the pure application of TQM frameworks and an improved operational performance. TQM has the potential to improve performance, but it is by no means a self-selling item. Powell suggests that for consistent operational excellence, companies must focus their efforts in creating a company culture based on quality principles, rather than imitating TQM methodologies (1995). A more recent empirical study by Liang-Hung, & Iuan-Yuan (2006) examines the effect of product quality on product innovation at various automakers in Asia, the USA and Europe. The study determined a strong relationship between product quality and the effective innovation capabilities of the automakers. When applying the issued patents as indicator of product innovation, and the problems-per-100 vehicles (PP100) metric as indicator for quality, Figure 2.3 indicates a resulting linear regression function. The linearity of the regression plot displays an equivalence of all quality systems, since product quality is achieved by various quality system approaches. Further-more, the study does not make assumptions about the type of specific quality system, such as Six Sigma, TQM, or simply the adherence to quality standards such as ISO 9001. Thus, the result demonstrates the need for one quality system, if an automaker aims to stay at the front of innovation. It is interesting to note that geographical origin affects innovation more than anything else, as displayed by the higher value function for Asian producers compared to

Western ones. The authors attribute the cause to a different company culture but not to quality systems per se. Further research is required to verify this analysis, since one factor could be a higher quality maturity due to the longer and more consequent implementation of quality systems in Japan, where Toyota began applying its TPS as early as the 1950s.

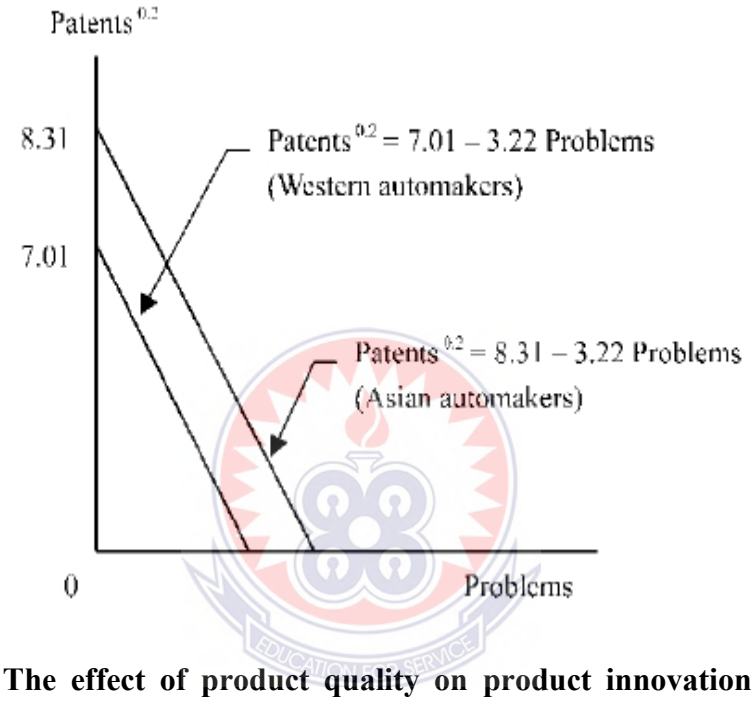

Figure 2.3: The effect of product quality on product innovation (Liang-Hung & Iuan-Yuan, 2006)

Relationship and compatibility among different quality approaches.

Several scholars have pursued the question of compatibility between different quality approaches, which can be concurrently prevalent within organisations. While quality management systems, such as ISO 9001 and their derivates, are basically goal oriented quality frameworks, which do not prescribe processes but require the organisations to achieve standards, questions arise as to what degree they are consistent with full quality management systems. These full quality management, such as Six Sigma systems, on the other hand, prescribe specific techniques and approaches. Several studies have been

conducted, such as a research paper by Chin-Hung (2009), elaborating on the compatibility of Six Sigma with the quality management system ISO/TS 16949, which is a globally accepted substandard for the automobile was derived from (ISO 9001). The ISO/TS framework focuses on continuous improvement and improving customer satisfaction. Six Sigma is the collection of processes that utilise statistical quality tools to achieve better results in terms of quality. The goal is to eliminate defects below the limit of 3.4 parts per million and reduce variability in process outcomes. By comparing this definition of TQM with the ultimate objectives of the lean producers as described above, it is obvious there are no contradictions between the two objectives. This is not a coincidence, because the roots of TQM can be traced back to the Japanese quality evolution in which Toyota was one of the pioneering companies.

2.9 The Toyota quality approach.

Toyota practiced the philosophy and principles of TQM as early as the 1950s. Toyota pioneered many quality business principles, such as Just-In-Time and Lean Management, which today are essential core principles of almost any production system in all industries worldwide. Toyota managed to convince critics with the perseverance of its long-term strategy, eventually surpassing most of its peers and becoming the most profitable mass automotive producer in the world in just a few decades.

To understand the system underlying Toyota's lean production approach, the Toyota Production System (TPS) requires the acceptance of a totally new perspective on production systems and quality concepts. It is not sufficient to learn the lean tools and techniques. In order to succeed, all stakeholders in the company from the manager down to the last worker on the production line need to grasp the philosophy. TPS is a culture

rather than a set of tools and techniques. Companies have tried to adopt quality approaches and tools devised by Toyota, such as Kanban (used for managing the flow and production of materials), Andon (a control device in the production area enabling workers to stop processes if defects occur), and failed to improve their production systems. Continuous improvement of the production system and a focus on the people who stand behind the system requires active participation and communication by all participants. The system needs to be designed in a way to support the employees in improving the system. It enables the workers to participate by emphasising the necessary education, training, and rewards. The lean tool of 5S (sort, stabilise, shine, standardise, and sustain) is a prime example of Toyota's philosophy, in which "sustain" stands for the long-term alignment of all activities.

The 14 Principles of the Toyota Way, assembled as an executive summary by Jeffrey Liker, characterizes its specificities and illuminates the cultural approach behind TPS (2003, pp.37-41). The principles are divided into the four major pillars sustaining the system, which are determined as long-term strategy, goal orientation of TPS tools, value creation by empowering the employee, and continuously solving root problems:

i. Principle 1 Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.

ii. Principle 2. Create a continuous process flow to bring problems to the surface.

iii. Principle 3. Use "pull" systems to avoid overproduction.

iv. Principle 4. Level out the workload (heijunka). (Work like the tortoise, no the hare.)

v. Principle 5. Build a culture of stopping to fix problems, to get quality right

the first time.

vi. Principle 6. Standardised tasks and processes are the foundation for continuous improvement and employee empowerment.

vii. Principle 7. Use visual control so no problems are hidden.

viii. Principle 8. Use only reliable, thoroughly tested technology that serves your people and processes.

ix. Principle 9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.

x. Principle 10. Develop exceptional people and teams who follow your company's philosophy.

xi. Principle 11. Respect your extended network of partners and suppliers by challenging them and helping them improve

xii. Principle 12. Go and see for yourself to thoroughly understand the situation (gen-chi genbutsu).

xiii. Principle 13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (nemawashi).

xiv. Principle 14. Become a learning organisation through relentless reflection (han-sei) and continuous improvement (kaizen).

Several studies were conducted, evaluating the Toyota approach as driver for quality improvements. Most of them identify many of Toyota's principles in influencing product quality as well as customer satisfaction. Lightle, Rosenweig, and Talbott (2003) highlight employment empowerment and management commitment as two outstanding basic catalysts providing Toyota with a competitive edge over its U.S. peers. A larger study

executed by Regassa and Ahmadian (2007) uncovered several principles based on the TPS as a driver for efficiency, putting Toyota well ahead of the big three U.S. car manufacturers. The TPS was identified as supporting Toyota's business excellence on the basis of the Kaizen principle, Toyota's philosophy of continuous improvement, which is incessantly focused on eliminating inefficiencies, coined as muda (waste). As a second major factor pushing Toyota ahead of its competition, the authors identified the Just-In-Time Production, which helps the company gain efficiency and facilitates the early detection of quality defects. As a consequence of this quality approach to business performance, comes the increased financial performance of Toyota compared to GM as well an increase in U.S. market share development, which is highlighted with Figures 2.4.

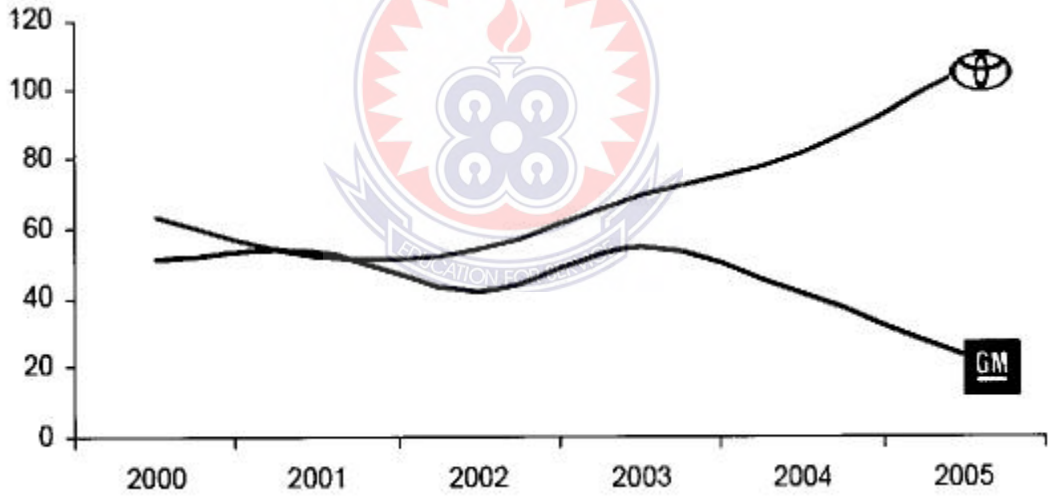

Figure 2.4: Financial performance between Toyota and GM (Regassa, & Ahmadian, 2007)

2.9.1 Toyota's recent troubles

Recently, the image of Toyota suffered from several setbacks, casting doubts on the once so successful Toyota Way. Car accidents, the recall of millions of cars, and even an interrupted production process for one week uncovered unprecedented quality

deficiencies in the current Toyota Process (Wharton University of Pennsylvania, February, 2010). Analysing the problem in depth revealed a shift from its focus on quality improvements according to their own TPS, towards cost reductions and the implementation of a tremendous expansion plan, which exceeded the capabilities of TPS. The growth coupled with the cost cutting measures itself was not the only cause, rather internal factors such as increased production lines, new production facilities, and a greater model variety contributed to the growing complexity as did outside factors in the form of social pressure and market demand (Wharton University of Pennsylvania, March, 2010).

Although Toyota did not try to hide the problems, the passive approach was perceived negatively in the U.S. It took a slowly adopted learning process for the company to encounter the negative publicity. Consequently, the media reaction vastly exaggerated the situation, trying to malign the company processes as a whole. Liker (2010) points out that most of the public reaction is based on emotions without substantive facts and emphasizes the underlying strength of the Toyota's quality model. According to Liker, Toyota survived the recession without layoffs and took ad-vantage of the current economic slowdown to improve on quality and safety. Workers who were not needed in the production process were reeducated in the quality production system (2010). Due to the offset between the current quality improvements and its effect on customer market and ensuing quality perception, Liker points further out that Toyota might have the quality problems already under control.

2.10 Quality prizes as drivers for business quality.

Primus inter pares among quality awards, the Japanese Deming Prize (DP), was already introduced in the 1950s in Japan as the very first award of this kind, thus indicating the relevance of quality for business improvements in Japan. The prize, named in honor of Deming's achievements to the Japanese industry, is awarded to companies that accomplish outstanding achievements in the field of quality. It took until the 1980s for both the U.S industry and politics to realise the importance of quality management on product improvement, and this came only after Japanese imports displayed a superior product designs. As a consequence, the Malcolm Baldrige National Quality Award (MBNQA) was established in 1987 as a concerted response by the U.S. government to raise the general awareness for quality in the U.S. industry. Since then, the MBNQA is given to U.S. companies, which satisfy certain quality criteria. It is devised as a competition, in which each year one company per category wins.

According to Kumar (2007), both the Deming and the MBNQA quality awards base their scope on TQM concepts with an emphasis on their country's socio-cultural conditions. The awards are arranged around the seven fundamental management principles of leadership, strategic planning, customer and market focus, information and analysis, human resource focus, process management, and business results. The differentiating elements can be explained predominantly by the diverse cultural backgrounds of the countries as taken from Hsien and Kay (2003): The DP is more process-oriented and puts less emphasis on managerial practices and decisions. Leadership by example, for instance, is a quality element which is deeply rooted in the Japanese tradition. The focus of the MBNQA is directed toward business results, as illustrated in Figure 7 taken from

the National Institute of Standards and Technology [NIST] (2010). In order to win, organisations must present outstanding achievements in financial performance, customer satisfaction, customer retention, product performance, service performance, productivity, supplier performance, or public citizenship. The performance levels must be achieved consistently and must be among the best of their peers. The fact that the award is result driven is underpinned by the relative weight of 25 to 45% of the total score.

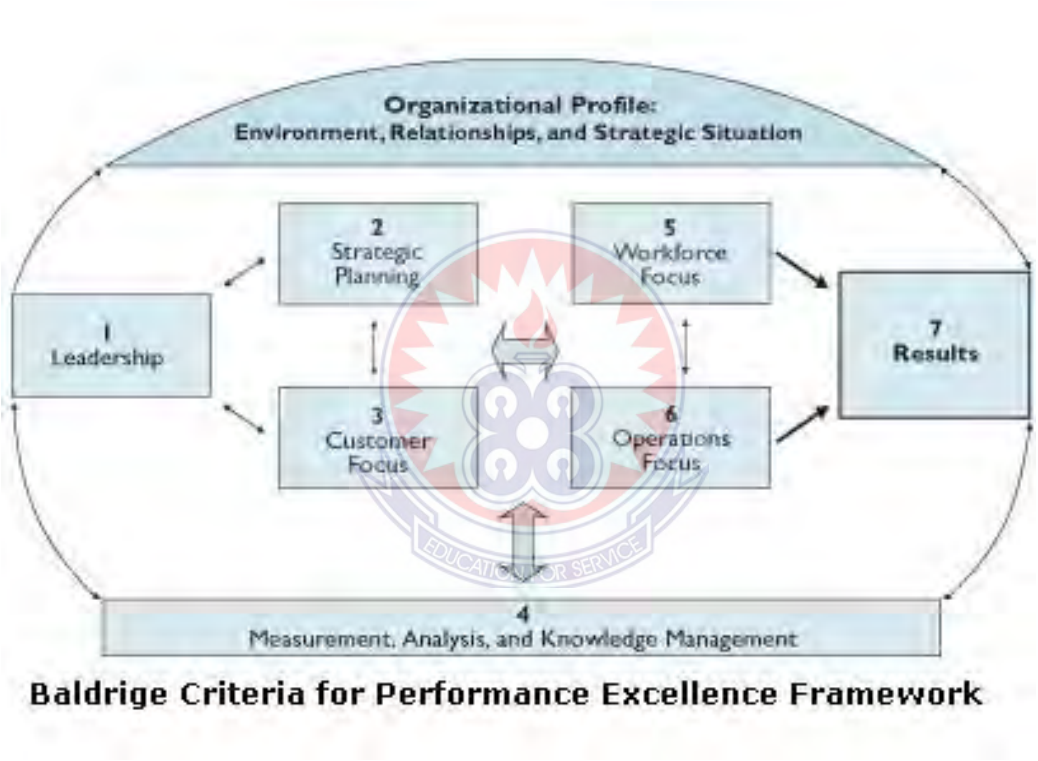

Figure 2.5: Result driven performance criteria of the MBNQA (NIST, 2010)

The criteria of the award are non-prescriptive and adaptable. The criteria do not predetermine which tools, techniques, or process the organisations should use to reach their goals (NIST, 2010). Baldridge criteria focus on the alignment of goals and processes, which should encompass the entire organisation. The companies should incorporate strategic processes and measures that are focused on attaining the company

goals. Consistency of purpose should be harmonised with innovation support. The fundamental learning paradigm should be a cohesive element in aligning strategic objectives with implementations on the operation level. Goal driven diagnosis is a fundamental criterion. Among the assessment dimensions are the approach, deployment, and results categories. These three categories define the methods for identifying performance objectives, implementing them, and assessing the outcomes. This approach allows the company to evaluate its strength and identify areas for improvement. Finally, the MBNQA focuses strongly on the results of the company processes. The prize categorizes four different areas of results, such as customer-focused results; financial and market results; human resource results; and organisational effectiveness results.

2.11 The influence of quality awards on organisation performance.

The elevated publicity of quality prizes, triggering a large number of companies to compete for quality awards, have induced a large array of research, focusing predominantly on the impact of quality prizes on organisational performance. The researchers are trying to determine a correlation between winning a quality prize and certain quality criteria. The crucial question behind the research is if the widespread support and public focus is really justified and a competitive advantage in terms of business attributes is generated, which will be sustained for long-term periods. One significant research project was conducted by Iaquinto, which evaluated the long-term performance of Japanese DP winners, of which one third consisted of automobile suppliers participating to the Toyota Production System (1999). Interestingly, the study concluded a predominantly negative effect of winning the award on long-term business performance. At first glance this seems contradictory to common quality understanding

and would undermine the support by many governments for similar programs in order to foster national industrial competitiveness. Analysing the findings in more detail, the result shows failure stemming from management immaturity and lack of quality culture. Companies, who won the DP without having implemented pervasive quality framework, such as TQM, and focusing too narrowly on the DP competition, harmed their company by deviating vital resources from the ongoing business processes, thus put-ting the employees even more under pressure, while diluting the approach to truly integrate quality aspects into business practices (Iaquinto, 1999). The conclusions can only be to generate definite guidelines for companies, which must focus on a genuine pursuit of quality management rather than following unsustainable goals such as one-time quality prize competitions.

2.12 Six sigma as a quality approach.

"Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services" (GE.com, 2010). This definition of Six Sigma by one of its fore-most promoters, General Electric (GE), illustrates the whole philosophy behind it. As a response to the increasing awareness by the U.S. public and industry, triggered by the Japanese quality superiority over the U.S industry, quality moved into the focus of business strategists. The book *Quality is Free* by Philip Crosby marked an important step of the development process, presenting a 14 step approach aimed at quality improvements with the ultimate goal of zero defects (Crosby, 1979). Motorola adopted the idea in the late 1980s and advanced it, creating the concept of Six Sigma. Motorola devised Six Sigma as an aggregation of statistical tools, based on the principles of process capability and product specifications, which evolved into the

statistical concept of defects per million opportunities (DPMO) and was aimed at finding inefficiencies in product development processes (Folaron, 2003). The name was derived from the goal to allow six standard deviations between the process mean and the specification limit, thus reaching less than 3.4 defects per million parts. GE, under the helm of Jack Welch, went a step further to establish Six Sigma as the company's mandatory and all pervasive company culture. The concept of continuous quality improvements focused on driving down defects both in production and design and was refined with the underlying principle of DMAIC (Define, Measure, Analyse, Improve, and Control). The concept provided an effective quality management approach, and it was due to the famous success stories of Motorola and GE, which both claimed to have increased quality and process efficiency drastically. Motorola, for instance, claims to have saved $17 billion from 1986 to 2004, (Motorola University, 2005). Six Sigma was also eventually adopted in the automobile industry, with Ford as the most prominent example. Ford, which had previous experience in TQM approaches, was able to profit from Six Sigma after it experienced increasing issues with quality management approaches.

2.13 Assessing the quality approach by ford.

Ford is a prime example in reflecting the quality approach of the U.S. automotive industry. Ford introduced TQM in the 1980s as a response to the superior Japanese car imports. TQM was focused on quality processes at all company levels, which had to be strictly followed, constantly improved, and evaluated via customer quality satisfaction surveys, emphasising a customer driven approach. The results were huge quality improvements, and in 1986 Ford became the most profitable U.S. automotive company

(Gabor, 2001). After Ford had received a substantive success with its TQM program by the mid-1980s, business focus shifted once again towards cost savings. The leading perception was that with the positive achievements from the applied TQM pro-grams, the quality problems had been solved and the programs could be concluded. Consequently, quality levels declined, and Ford experienced major quality setbacks. Customer satisfaction lagged the competition during the 1990s again. The lesson from these experiences could be identified with lack of continuity as the major obstacle to attaining sustainable elevated quality standards. As Subir Chowdhury, a quality strategy expert had stated, “U.S. automakers had so much confidence, they felt they had achieved quality and didn't need to focus on it anymore," (Gabor, 2001).

To overcome these deficiencies, Ford decided beginning with 1999 to overhaul its quality process, this time adopting Six Sigma as an enhancement to their former TQM philosophy (Gabor, 2001). Six Sigma was seen as a good way to integrate innovation with marketing needs, while keeping the focus on costumer orientation. By adding a customer driven Six Sigma Process, quality was taken a step further, strengthening the design and engineering analysis process (Scheid, 2010). With the DMAIC process, as explained above, problems can be detected and corrected early on, which is further supported by newly developed virtual tools. The success, quantified by Ford with a decrease in 60% of the warranty repair rate, is based on several premises. Among the foremost factors is that if processes do not undergo radical changes, utilizing the tools of Six Sigma is not sufficient. Ford pursued an overall strategy which is founded on two irrevocable pillars: achieving consistency in the process improvements as the basis for change and focusing intensely on customer satisfaction. Six Sigma implementation was

furthermore dependent on the establishment of cross-functional groups of engineers, plant management, and production specialists, with the emphasis on problem solving, predominantly based on skills gained through Six Sigma training. The selection of Six Sigma projects is based on their relevance in regard to customer satisfaction, their expected quality improvements to achieve at least a reduction in defects by at least 70 percent, and a cost-reduction goal averaging more than $250,000 (Scheid, 2001). The Ford DMAIC cycle, to be followed by Six Sigma quality experts, Black Belts, consists of the following steps (Paton, 2001):

Defining the scope of the project and identifying the customer involvement and what matters to them.

Measuring involves the development of process measures facilitating the performance evaluation of the process. Current process characteristics need to be collected to enable assessment of the desired process performance. The Black Belts need to know what the process is, including the entire dependencies. Common tools used for this process are process mapping, cause-and-affect diagrams, failure mode and effects analysis, gage R&R, and graphical techniques. Analysing requires the determination of the root causes of process variation by prioritising the input variables according to their impact on process deviation. Process mapping, graphical techniques, multivariate studies, hypothesis testing, and correlation and regression analysis are among the used tools for this approach. Improving the processes relates to the identification of solutions to best address the problems, which utilises process mapping, design of experiments, simulation, and optimization to generate cost-benefit analysis, validation of problem solutions, and

the implementation plan. Controlling, as the final stage, completes the improvement process and includes controls, which assure a sustainable gain in the processes.

Based on the principle of quality improvement, Six Sigma is furthermore focused on improving customer satisfaction by applying methods such as the process of Quality Function Deployment (QFD) and Taguchi's method of Design of Experiments (DOE), encompassing product design and robust design (Foster, 2010). Figure 8 illustrates the applicability of Six Sigma to the global supply chains of the U.S. automakers, highlighting the pervasive application of Six Sigma throughout the entire supply chain. The focus on reducing the process variation, based on customer needs and expectation surveys, will need to extend the approach of preliminary design, prototyping, and field-testing with each tier of suppliers (Bandyopadhyay, & Jenicke, 2007).

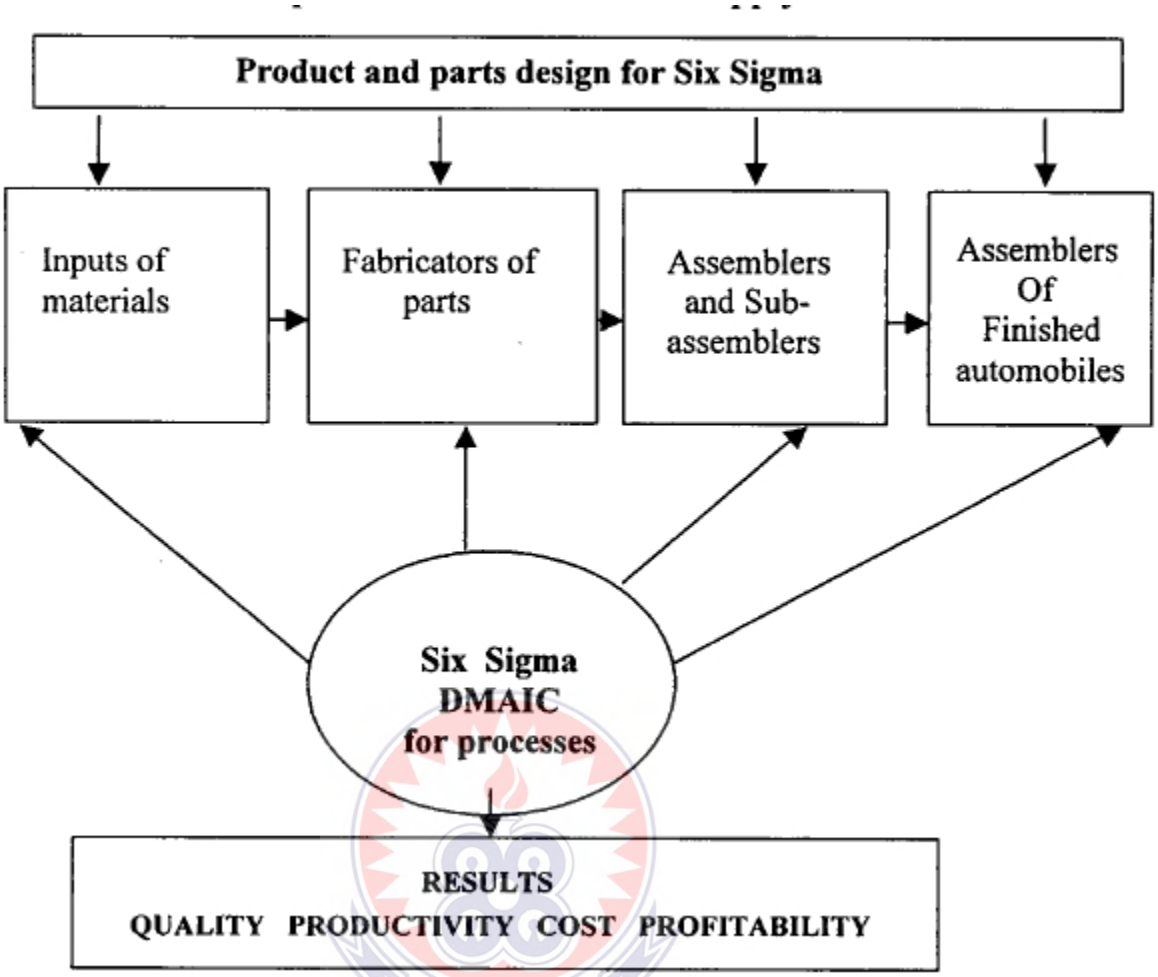

Figure 2.6: A model for six sigma approach to design and process improvement in automotive supply chains (Bandyopadhyay & Jenicke, 2007)

2.14 Quality assurance matrix in automotive industry.

Quality Assurance Matrix is an identification tool of the problems, and it isn't another problem solving tool. "Quality Assurance Matrix is a standardised process that takes potential or actual Quality concerns, ranks their importance to customer satisfaction and evaluates the robustness of the manufacturing and inspection processes against the potential or actual seriousness of the concern". Quality Assurance Matrix (QM) helps to achieve the goal of meeting Customer Quality Expectations such as:

1. QM enables control of all critical, significant and / or important items on the vehicle;

2. QM is a useful problem identification tool.

This tool is used for:

1. New Model Process Planning;

2. Current Model Quality Concerns.

Quality Mapping uses some of the Failure Modes and Effects Analysis (FMEA) thought processes – Risk Assessment. Ultimate aims of this tool are:

- Robust products and design;

- Robust manufacturing processes delivered through In-Station Process Control;

- Operator interface with process and product which assures quality of output;

- Engaging the intelligence of the total organisation in pursuit of Customer Satisfaction.

2.15 Utilisation of the quality assurance matrix.

The quality assurance matrix is used (1), (3), (4):

a) As part of the new mechanical projects (new products and new industrialization)

In a way it synthesises the default risk product / process taken into account during the construction of the control plan of the product for a manufacturing line.

It is part of the results expected in the borne of the project "Manufacturing Agreement". Its failure to achieve or incomplete implementation, and the value is not reached the level of guarantee, will be an unfavorable opinion from quality.

b) For serial production line

QM will be used, either in continuity with the implementation of a new product / process to the manufacturing agreement; or either to reduce the failure of a current manufacturing process. It will be chosen to implement a QM in the production line the most.

2.15.1 Realisation of the quality assurance matrix.

The matrix QM is established around the PDCA cycle:

P - Assign goals and definition of lines to work.

D - Carry out the analysis.

A - Implementation of the corrective actions for the operations that do not guarantee the quality level established.

C - Check the reliability of the controls established.

To realise the Quality Assurance Matrix, we must work according to the following:

1. Selection of the working line.

   Fill in the header of the QM sheet by indicating the date of the first realisation or its renewal.

2. Division of the process into operations.

   Based on the synoptic manufacturing, we have to document all the numbers of operations and their designations.

3. Definition of the causes of the failure and the influential parameters of each operation.

   For each of the operations described, identify the causes of the possible failure that could cause non-quality in the columns by separating the causes of product from the process causes called “influential parameters”. For this, we must rely on the experience of group members and QM existing historical data.

4. Evaluation of the importance level of the failure causes and the influential parameters

   Each of the failure causes and the influential parameters associated can be valued on the following basis:

5. Documentation of the column IR / PVG

Document the values of RI (Risk Index) according to the influential parameters.

6. Search a history of failures.

To build a complete QA matrix, look for, if possible, the existing information on the last 3 years for defects as similar products made in other processes.

7. Identification of the controls in the various operations of the process

It has to be identified for each workstation of the line analysed the cause of failure and influential parameters, the type of control used (visual, manual, automatic, anti-error etc.).

Setting the level of guarantee quality of product failure causes and each influent parameter

Enhance the quality assurance of each control for each product and cause of failure for each influential parameter.

9. Calculation the value of guaranteed quality of each cause of failure and influent parameter.

10. Documentation columns identifying defects (proven)

These are identified by a black point or a value, the number of defects recorded between two matrix QA reviews:

- Defects detected in the previous three months in the service network;
- Defects detected in the previous month in the process of assembling;
- Defects detected in the previous month in the process where we use the matrix QA.

11. Documentation of the column for observations

Noted in this column, all elements that can help improve the quality assurance process (e.g. for an incomplete weld defect, we can note: Beware of welding parameters).

12. Evaluation of the overall level of guaranteed quality of each cause of failure.

    The evaluation of each cause of failure will be on the following mode:

    - OK for a level considered good;
    - NG (not guaranteed) for a level considered bad.

13. Calculation of the overall level of quality assurance of the line analysed.

    The overall percentage will be calculated using the following formula:

    % Overall Level Guarantee Product/Process (values all OK causes failure) Example of a Quality Assurance Matrix is presented in the figure 2 for a mechanical part from automotive industry.

2.16 Eight (8) points on quality assurance

1. **Define the Scope of Quality Assurance** – In order to be effective in quality assurance the extent of requirements must be laid out. For instance, if a vehicle requires a minor repair the extent of quality assurance requirements may not be that great. But some repairs may require testing and confirmation in more than one affected area based on inter-relationships.
2. **Balance the Cost with Profit Requirements** – Time spent on quality assurance has a cost associated with it. Parameters must be set to ensure that time spent on quality doesn't result in losses. However, the cost of poor quality far outweighs the cost of ensuring good quality on delivery.
3. **Be Process Oriented** – Most quality problems are the result of poorly defined processes. Quality at the point of production is always the most effective. If processes are clearly defined and followed quality will be built into the end

product as work is performed and assurance processes will serve as confirmation.

4. **Define Procedures** – Quality assurance procedures enacted at the point of production or as an inspection function should be defined and followed. Check lists outlining tests and expected results are the most reliable tools to use in quality assurance. Test plans make sure that nothing is missed.
5. **Utilise Constructive and Destructive Testing** – Constructive testing makes sure that something works the way it's supposed to. Destructive testing involves attempting to make something malfunction. Both forms of testing should be employed for the best results.
6. **Keep Audit Trails** – It's important to know who performed inspections and how they did the inspection. Thus weaknesses in the inspection process can be overcome. The objective should be to identify flaws in the process – not to assign blame.
7. **Focus on Prevention** – Quality assurance should be about preventing problems from having to be corrected not about finding problems. Quality issues originate during the processes of work specification, production and delivery thus designing processes that prevent problems from occurring are the strongest factors in ensuring quality.
8. **Strive for Customer Satisfaction** – The entire purpose of providing products and services is earning and retaining business. At the heart of quality assurance is the customer. The goal should always be customer satisfaction.

2.17 Repair operation - Quality assurance manual

Scope and Purpose:

This quality assurance manual covers the basic procedures for quality control and inspection of regulated repair. These procedures provide the necessary guidance to ensure that each regulated repair meets the minimum safety standards adopted by the state and any specific requirements established by the repair operation.

General Information:

This quality assurance manual may be used in its current form or may be reprinted by the repair operation. If this quality assurance manual is reprinted by the repair operation, certain minimum information must be included. The required information that must be included in marked with an asterisk (*).

Quality Assurance Procedures:

To ensure that regulated repairs meet minimum codes, standards, and are performed at acceptable quality level, the following quality control procedures must be implemented by the repair operation:

1. The owner and/or service manager/foreman have complete control and responsibility over the work performed within this facility.
2. Every regulated repair performed must be inspected by an approved quality assurance technician during and/or at final completion of the repair.
3. Follow-up inspections must be made of unsatisfactory work by the approved quality assurance technician to ensure an acceptable quality level has been obtained.
4. Quality assurance technicians must use a quality control checklist for all regulated repairs.

The quality control checklist is used to ensure conformance with the minimum safety codes and standards.

5. All appropriate tests must be performed and verified through the quality assurance procedures.
6. Upon satisfactory completion of regulated repairs, the quality assurance technician must affix an Oregon Insignia of Compliance to the vehicle and record the label number and corresponding work performed in the repair work order. The insignia of compliance may be placed near the repair or may be placed on the exterior near the main entry into the vehicle.
7. The Insignia of Compliance must reference the work/repair order number assigned to the vehicle being repaired and the registration number of the repair facility.

2.18 Uses of quality assurance in identifying and providing adequate resources in automobile repair workshops.

The standard requires that the supplier identify resource requirements for management, performance of work, and verification activities and provide adequate resources and equipment (Sroufe & Curkovic, 2008).

The term resource is often used to imply only human resources when there are in fact other types of resources. The standard is not specific although resources would normally include time, manpower, machines, materials, finance, plant, and facilities: in fact, any means available to the supplier for implementing the quality system. So when ISO 9001 requires that one provide adequate resources it requires that you provide all the human, finance, and material resources necessary to implement your quality system, including the allocation of sufficient time.

Resource management is a common feature of all organisations and while it may be known by different titles, the determination and control of the resources to meet customer needs is a fundamental requirement and fundamental to the achievement of all other requirements.

There are two types of resource requirements: those needed to run the business and those needed to execute particular contracts or sales. The standard is not specific, but a glance at ISO 9004-1 revealed that it is more than those needed for a particular contract and less than needed to run the business. ISO 9004-1 limits the resources to those needed to implement the quality policy and meet quality objectives. It will be very difficult for companies to distinguish between those resources which serve quality and those which serve other objectives. There may be some departments that can be eliminated, such as the legal, insurance, catering, medical, or publicity departments, but in a company-wide quality culture all departments etc. will be included.

The way many companies identify resource requirements is to solicit resource budgets from each department covering a 1 to 5-year period (Sroufe and Curkovic, 2008). However, before the managers can prepare budgets they need to know what requirements they will have to meet. They will need access to the corporate plans, sales forecasts, new product development plans, marketing plans, production plans, etc. as well as the quality policies, objectives, and procedures needed in repair workshops.

A practical way of ensuring that you have adequate resources to implement the quality system in automobile workshop is to assign cost codes to each category of work and include the management and verification activities among these (Sutton, 2007). Quality system management activities are often deemed as an overhead, but the costs may be

difficult to identify among all the other overheads. Unless you can identify what you spent on internal audits, for instance, how can you allocate sufficient resources for future programs? Allocating and collecting costs does not inhibit you from moving resources around to resolve immediate problems and gives you more effective control of the business. Providing a means for staff to charge their time is often a practical way of overcoming resistance to the policies and procedures (Sutton, 2007).

2.19 Quality performance at repair workshop.

The concept of performance may take on different meanings depending on the context in which it is used. At the global level, performance represents the results of activities. Traditionally effectiveness has been measured (doing the right things) as well as efficiency (doing them right). Performance has been attributed numerous dimensions, such as quality, productivity, profitability, safety, timeliness, growth, attendance and satisfaction. To add to the complexity of performance the before listed functions can also be interpreted as functions of each other's. In general, the framework for the performance in any given context requires (Yasamis, Arditi & Mohammadi, 2002):

1. A combination of criteria (not a single measurement)
2. A level of analysis (such as end-users, employees, etc.)
3. A certain focus (kind of performance desired).
4. A time frame (short or long range)
5. A measurement system (quantitative versus qualitative, objective versus subjective).

Quality performance is result oriented and seeks evidence of quality awareness within the operations and outputs of a contractor. The quality performance is defined over the long-term for the effects to be permanent (Yasamis et al., 2002).

2.19.1 Equipment, tools and spare quality at automobile repair workshop.

Equipment, tools and spare parts quality can be viewed as one part of a triangle as seen in Figure 2:7. The contractor must attain the cost level as planned; meet the schedule deadlines while achieving the required quality level. There must be a balance amongst those three aspects because they define the project scope. However, quality may be the first of those components to be disregarded in favor of increased cost savings and time reductions (Chini & Valdez, 2003).

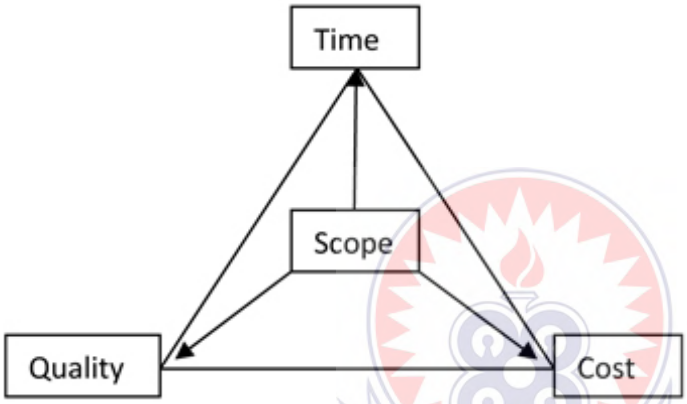

Figure 2.7: Quality is involved in every stage (Chini & Valdez, 2003).

Quality is involved in every stage and every aspect of tools and spare acquisition and usage. Workshop process and quality are inseparable parts of each other. Quality in automobile repair workshop cannot exist without a project and a workshop repair procedure cannot exist without quality**.** The modern automobile market requires automobile companies to guaranty the quality of their service to their clients. Harris, McCaffer, and Edum-Fotwe (2006) show various concepts that are considered to influence the quality of the service that can be associated with quality in automobile repair workshops. The figure reflects the service features, processes of production and

organisation, as well as company business/industry issues (Harris, McCaffer & Edum-Fotwe, 2006).

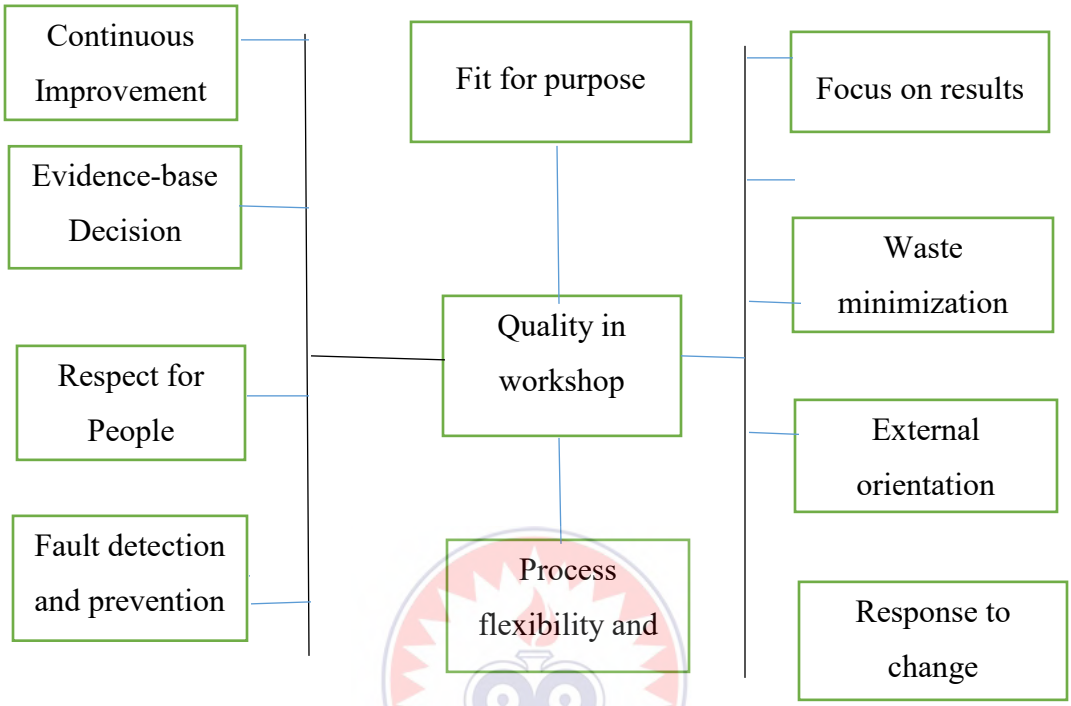

Figure 2.8: The figure shows aspects involved in the concept of automobile repair quality (Harris et al., 2006)

2.19.2 Measuring equipment, spare parts and tools quality.

It can be difficult to define and put a measure on quality in spare part and tools. But nevertheless it is necessary. The term 'quality' should not be used as an expression of degree of excellence, as may be implied by a dictionary definition, but how well it is fit for its purpose (Chini & Valdez, 2003). Pheng and Teo (2004) define quality as the total features and characteristics of a product or service that satisfy the personalised need of the customer. Arditi and Gunaydin (1997) define quality as meeting the legal, aesthetic and functional requirements of a project. The quality requirements may be simple or complex or they may be stated in terms of the end result (Arditi & Gunaydin, 1997). The

bottom line is that quality is only obtained if the stated requirements are adequate and the completed project fulfills the requirements. According to an American Society of Civil Engineers (ASCE) study, quality can be characterised as follows (Arditi & Gunaydin, 1997):

1. Meeting the requirements of the owner as to functional adequacy; completion of work on time and within budget; lifecycle cost; and operation and maintenance.
2. Meeting the requirements of the design professionals as to provision of well-defined scope of work; budget to assemble and use a qualified, trained and experienced staff; budget to obtain adequate field information prior to design; provisions for timely decisions by owner and design professionals; and contract to perform necessary work at a fair fee with adequate time allowance.
3. Meeting the requirements of the customer as to provision of plans, specifications, and other documents prepared in sufficient detail to permit the user to prepare priced proposal or competitive bid; timely decision by the owner and design professional on authorization and processing of change orders; fair and timely interpretation of contract requirements from field design and inspection staff; and contract for performance of work on a reasonable schedule which emits a reasonable profit.
4. Meeting the requirements of regulatory agencies (the public) as to public safety and health; environmental considerations; protection of public property including utilities; and conformance with applicable laws, regulations, codes and policies.

In a U.S. case study by Hoonakker (2006), the results showed that it was hard to define and put a measure on quality in the automobile industry. Automobile users had an attitude of: “looks good, feels good” which is a measure that is hard to quantify.

Hoonakkers's main results were that it was hard to find a quantifiable outcome measure of quality in automobile repair workshops (Hoonakker, 2006).

Measurements play an important role in identifying and tracking progress against organisational goals and identifying opportunities for improvement. It can prove hard to manage what cannot be measured. Not being able to put a measure on quality therefore results in a problem of not knowing where things stand. When there is knowledge on what can be improved, appropriate direction of strategy can be formulated. Without the right strategy for improving it is hard to head for the right direction where the proper results can be achieved. The fact that it has proven hard to put a measure on quality in construction could be an indication that organisations do not know where they stand when it comes to quality and quality defects, and therefore do not realise their potential for cost efficient quality improvements.

2.19.3 Quality requirements

Establishing quality requirements for the automobile repair workshops begins at the automobile repair workshops inception. During the design stage the requirements of the client are identified. Furthermore, the standards of quality are defined. This is done through procedures, drawings and technical specifications. This stage aims at achieving an adequate balance between the owner's requirements with regards to project cost and schedule while achieving desired operating characteristics, materials of automobile repair workshops and giving the design professional adequate time and budget to execute his work (Arditi & Gunaydin, 1997).

The work in the design phase is usually split into several temporary sequences and then delivered to different specialists for its execution. The design professional is obligated to

fulfill all necessary legal requirements such as public health and safety in the context of the final completed project. The user of an equipment or automobile is responsible for the methods, techniques, sequences, and procedures of equipment or automobile use, as well as safety precautions and programs during the workshop process (Arditi & Gunaydin, 1997). Problems arising from this work sequence have been discussed for many years. The main problems are caused by the little iteration between parties involved in the design and automobile repair workshop process phase (Alarcón & Mardones, 1998). The problems caused in the design phase, are not discovered or revealed until the automobile repair workshop phase is reached. Those problems can be incomplete designs, change orders, rework, workshop process delays, etc. Moreover, the impacts of change are not fully understood and rarely recognized, in terms of costs and schedule (Alarcón & Mardones, 1998).

To begin with, Ghanaian government agencies executed their projects by themselves, either by hiring labor groups or employees. Now, almost all of their work is being executed by the hands of independent automobile and equipment dealers. The competitive bid began being used in Ghana around 1980, a little later than abroad and is now a frequently used bidding form in automobile and equipment (Frímannsson, 1997). For government agencies, it is now required by law and in accordance with government procurement policy to seek for competitive bids for all major equipment, both for the design and workshop process phases (Arditi, Akan & Gurdamar, 1985). However, there has been a growing concern among parties within the automobile equipment industry over the “competitive bidding” arrangement. Each bid aims at being as low as possible, in order to get the work which can results in choosing as low quality as possible since it is

sought to push the price down by choosing cheap material, equipment parts and resources to achieve higher margins.

2.19.4 Quality assurance in purchasing scope of requirements in automobile workshop.

Most organisations need to purchase items in order to conduct their business (Bailey, Ruyter, Jonathan & Tyler, 2010). The purchasing requirements of the standard apply only to items needed to design, manufacture, install, maintain, or operate the products and services which it supplies to its customers. Other items are needed to sustain the business such as stationery, catering supplies, furniture, etc. and may be used in design, manufacture, installation operations, etc. but do not contribute to the quality of the products and services which are supplied to customers (Bailey et al., 2010). The term purchasing involves the payment of money or an equivalent but the requirements still apply if items are obtained without any payment being made, at least by the organisation which is to use the item. A more suitable term would be procurement, which does not need to involve payment. Although the principles are common sense, the detail requirements of the standard would be too onerous to apply to everything you acquire in connection with business; son one need a means of classifying purchases so as to apply controls on the basis of their risk to the quality of the products and service supplied to customers (Bailey et al., 2010).

In addition to products and service which are incorporated or which form part of the products and service supplied to customers, there are tools, test equipment, contract labor, facilities, calibration services, computer services, and many other items which, if not of

adequate quality, may adversely affect the quality of the products and service you supply. These items are also governed by these requirements.

Even though one may not have designed or manufactured the purchased items, one have a responsibility to ensure that such items are fit for their purpose if you sell them on to your customer either directly or as part of another product, because you selected them (Boehm & Ulmer, 2008).

2.19.5 Spare parts inventory control.

Spare parts inventories are different from other types of inventories in companies. Cohen and Lee (1990), Cohen, Zheng and Agrawal (1997), Muckstadt (2004), Kumar (2005) and Rego (2006) have pointed out some important factors in the management of these inventories:

Customers have rising expectations concerning quality of associated products and services. The occurrence of failure is already a concern and the delay in repairing due to lack of spare parts worsens clients' negative perception; Some items have high demand (parts with great wearing and those related to preventive maintenance), but the great majority has intermittent demand and; The increasing complexity of products and the life cycles reduction generate an increase on the amount of active codes and risk of obsolescence.

Initially, it is important to distinguish disposable parts from repairable ones. Spare parts are extremely expensive in some segments, and their repair (instead of discard) is feasible; damaged units can be replaced either by new units or by repaired ones. In this case the inventory control models should also consider the costs and repair time. Sherbrooke (2004) discusses the case of repairable parts.

2.19.6 Demand forecasting for spare parts.

Most spare parts present intermittent demand, that is, occur at given moments followed by long and variable periods without demand. Intermittent demands are particularly difficult to predict and shortage may result in extremely high costs (Hua et al., 2007). According to Love (1979), demand forecasts are absolutely necessary for the inventory levels planning. Although forecasts are subject to errors, the knowledge of these errors enables the definition of the necessary safety stocks. Makridakis, Wheelwright and Hyndman (1998) constitute a classical reference in demand forecasting.

One point that is not often discussed in the literature is the choice of the time bucket that characterizes the demands. A more accurate approach for intermittent demands was developed by Krever et al. (2005) to compute the mean and variance of demand during the lead time. In their approach, known as Single Demand Approach (SDA), as opposed to the more traditional Periodic Demand Approach (PDA) with time buckets, three random variables are used: amounts demanded during the lead-time, time intervals between demand occurrences, and the lead-time itself.

The pioneer work by Croston (1972) demonstrates that the use of classical methods of exponential smoothing on intermittent demand items generates high forecasting errors and, as a consequence, unnecessarily high safety inventories. Croston (1972) proposes an alternative method which separates the estimation of intervals between demands of the amounts demanded in each occurrence. Johnston and Boylan (1996) compared forecasting made through exponential smoothing to the ones made through Croston's method, and concluded that the latter is superior when the average interval between demands is greater than 1.25 time periods (time bucket). Syntetos and Boylan (2001)

pointed out a bias in the original Croston's model and proposed a correction that gave rise to the SBA (Syntetos-Boylan Approximation) model.

Ghobbar et al. (2003) compared 13 forecasting techniques to aircraft parts demand and proved the superiority of the techniques: weighted moving average, double exponential smoothing (Holt), and Croston's method. Similar results were presented by Regattieri et al. (2005). Eaves and Kingsman (2004) evaluated spare parts demand forecasting techniques in the case of British air-force (RAF), including SBA and Croston's method, and demonstrated the superiority of the SBA method to a certain service level.

Willemain, Smart and Schwarz (2004) developed forecasting models for intermittent demands, using the bootstrapping technique to assess the demand distribution during lead-time, considering autocorrelation and introducing small demand variations to the original series (jittering). Comparing the new model to Croston's method and exponential smoothing, they concluded that the first provides better results, especially for small historical series. Hua et al. (2007) used bootstrapping together with regression analysis in demand forecasting of parts in the petrochemical industry and showed the advantages of the proposed model.

2.19.7 Classification of spare parts.

According to Huiskonen (2001) and Boylan, Syntetos and Karakostas (2008), the items classification is an essential part of the inventory management systems, in order to: i) determine the adequate level of managerial attention; ii) allow the choice of demand forecasting and inventory control methods; and iii) establish different performance goals at the inventory turnover and service levels between categories. However, most of the

surveyed works use the classification of parts only to choose the demand forecasting model instead of the inventory control method.

The organisations which keep inventory of spare parts commonly classify these items through different criteria, setting different service levels for each category

(Syntetos; Keyes & Babai, 2009). It is recommended that spare parts of the industrial maintenance to be classified according to criticality in the categories: Vital,

Essential, and Desirable - Ved (Gajpal, Ganesh & Rajendran, 1994), whereas consumer goods are usually classified in Pareto's graphs in the categories ABC - high, medium and low values (Silver, Pyke & Petterson, 1998).

Williams (1984) proposed the partition of the demand variance during lead-time into three components: variability in the interval between demands, in the amount demanded per order, and in the replenishment lead-time. From preset sections, items are divided in three categories: intermittent, slow moving and smooth.

2.19.8 Decision to stock or not to stock.

One alternative for the reduction of spare parts inventory levels is the critical revision of the need to maintain or not each one of the items active. Models developed under the premise that all items must be stored should be reconsidered. Is it worth bearing the costs of storage, even for only one unit, or would it be better to acquire the item under demand? This section discusses the question of whether or not to stock a given item.

Silver, Pyke and Petterson (1998) approached the specific problem of whether or not to stock, citing Tavares and Almeida (1983). Johnson (1962) proposes two criteria: one to start storing an item currently purchased upon demand, and another to stop stocking an item purchased to stock. Popp (1965) compared the costs of the alternatives to currently

purchased upon demand (zero inventories), purchased to stock, and hybrid strategies. The model disregards the costs to add the item to management system; treats demand as continuous; and considers storage and order costs constant for the three strategies. Shorrock (1978) proposed an operational decision model based on the formulation proposed by Popp (1965).

Croston (1974) elaborated a similar criterion in periodic review systems with maximum inventory, negligible lead-time, maximum of one demand occurrence for each revision interval, and normal distribution of the amount demanded by occurrence.

Tavares and Almeida (1983) considered the case of demand following Poisson distribution and inventory options of zero or one. The model evaluates these options through the comparison of their costs: for inventory of "one", it considers regular costs of holding and ordering; for "zero" inventory, it eliminates the holding costs and increases the ordering cost because it comprises emergency purchases (they will occur only when there is already one order on hold). The option for "zero" inventory will take place when the average demand of the item is greater than a lower bound demand calculated by the specific formulation.

Olthof and Dekker (1994) presented a storage decision rule for spare parts where at least one unit should be kept in inventory if its unit annual holding cost is greater than the expected annual shortage cost (emergency purchase and penalties for downtime). Silver, Pyke and Petterson (1998) modified the original model by Popp (1965) to consider the existence of the cost to include the item in the inventory control system. Alternative formulations for decision in two conditions are obtained: i) keeping other Popp's

premises; and ii) changing the premises of similar costs for regular and emergency orders.

Botter and Fortuin (2000) applied the AHP method in a case study performed in the electronic industry. The study uses the VED classification of criticality of items together with a demand classification (high, medium or low) to take or not the decision to store the item. The AHP methodology was also adopted by Suryadi (2003) in a similar decision model applied to the inventory of maintenance pieces at the petrochemical industry.

2.19.9 Initial orders of spare parts.

When new products are launched on the market, spare parts managers may decide to anticipate the occurrence of demand, creating an initial inventory of parts, or let the demand occur and, only then, trigger the orders. Even though errors in the initial order may be corrected in future orders, it is difficult to set the initial order due to lack of historical demand. Often, in the automobile industry, this initial inventory is arbitrarily determined by the product manufacturer

(REGO, 2006).

Walker (1996) elaborated graphs to aid the initial purchase decision for reparable items, based on a limited number of products in the market and under the assumption that the time between failures is exponentially distributed. Such premise is quite restrictive, since it does not consider the different rates of failure of spare parts during its life cycle, namely, the phases of early mortality (when the failure rate is decreasing) and further aging of components (when the failure rate is increasing).

Haneveld and Teunter (1997) dealt with storage strategies for slow moving and high cost parts based on the concept of remaining lifetime (V), which determines when not to store (order only upon demand) is the best alternative. If remaining lifetime is longer than "V", the optimal solution is to keep one unit in inventory. They then developed a formulation which optimizes the amount for sizing the initial order of parts (n). The model is a case where the decision to store or not to store is a result of the inventory control policy itself, also involving the matter of the initial order, in this case, supposedly made at a lower cost, because it is made simultaneously to the order of the equipment that will use the spare part.

Peres and Grenouilleau (2002) developed a model for dimensioning the initial order of spare parts for the International Space Station project, aiming to minimise the probability of delaying any maintenance operation subject to budget limitations.

Syntetos, Keyes and Babai (2009) proposed an additional category of items D, in the ABC classification, composed of the critical parts of just launched products, defined subjectively, which should be kept in inventory and in this category for the first six months of their "lifetime".

2.20 Workshop layout of J. A. Plantpool Ghana Limited

Automobile Repair Shop of J. A. Plantpool Ghana Limited

The company is into sales and servicing of duty equipment namely tipper trucks, excavators, wheel loaders, bulldozers, truck cranes, etc. The company has various departments playing their various roles to ensure the growth of the company as well as the satisfaction of the customer during sales, servicing or repairs. Servicing and repairs are handled by the workshop department which is also broken down into various sections.

Sections

There are six (6) sections under the workshop department. Each specialised in a particular area of the vehicle.

General Servicing Section

This section does the general servicing of all heavy duty equipment, that is, changing of fuel filters and oil filters; draining of dirty engine oil; servicing or replacement of air cleaner element, etc. Equipment is due for servicing when it has covered a distance of 5000km, if it's a tipper truck or 200 working hours, if it's earthmoving equipment. During servicing, parts like the air cleaner element is serviced by blowing out dust with a compressed air; manpower tools such as spanners, screw drivers, hollow round bars, Allen keys, and others are used.

Electrical Department Section

This section has its technicians specialised in the electrical and electronics of the equipment and so the technician does repairs and maintains the equipment that has electrical or electronic problems using electrical gadgets such as the multimeter, testers, ammeter, etc., as well as the electric/electronic diagrams of the equipment. The section is not equipped with electronic diagnostic tools.

Component Rebuilding Section:

This section does the rebuilding of component such as the transmission, torque converters, etc. when the customer has some of his/her equipment component parts damaged and the customer finds it cost-saving to rebuild rather than buy brand new one.

The technicians in this section have been equipped with the necessary tools and the technical know-how to rebuild any of the components of the equipment. This section has various component stands for various component rebuilding.

Engine Rebuilding Section

This section has its technicians specialised only in engine rebuilding. There are several engine rebuilding stands and so more than one engine rebuilding can be done at the same time. The section has been equipped with manpower tools as well as power-tools such as electrical nut tightener and slacker to make the job of the technician easier. This section lacks engine testing equipment.

Spare-Parts & Stores Section

This sections stores and supplies all the various sections with needed parts for the servicing and repairs. They are also in-charge of sourcing for unavailable parts needed in the repairs and servicing of customer equipment from automobile spare parts shops outside the company that deals in the company's brand of equipment. When parts aren't obtained from other dealers, the needed parts are airlifted to ensure completion of the technician's task. This takes time and delays the job.

Quality Control Section

After pre-delivery inspection, servicing or repairs of equipment is completed, the equipment is moved to this section for all the necessary checks to be done by technicians specially trained and have experience in repairs and maintenance of the company's

equipment. The equipment is delivered to the customer after the technicians in this section are satisfied with the job done.

General Servicing Procedure at J. A. Plantpool Ghana Limited

When equipment is brought to the company for servicing, the equipment goes through the following procedure:

1. The service adviser or administrator takes all complaints made by the customer concerning the equipment.
2. A company driver is made to drive equipment to the workshop for servicing.
3. The workshop supervisor opens a job-card for the equipment and assigns a team of technicians to the equipment.
4. The team leader takes the part numbers on the parts that they will need for servicing and then makes a request for the needed parts.
5. Whiles the team of technicians awaits parts, they do visual inspection of the equipment to check for other unnoticed faults.
6. Servicing is then conducted as soon as the technicians receive the parts; and if other faults aside what customer complained about noticed, they are reported to service advisor who informs the customer about them and asks for the customer's consent to fix the other problems. If the customer agrees, the other noticed faults are added to that on the job card for repairs; if not the technicians do the assigned job.
7. After completion of equipment servicing, the equipment is moved to the quality control section for final checks to ensure that the assigned job has been properly.

8. After quality control checks, the equipment is delivered to the customer by the company driver. The next date of servicing is pasted on the windscreen of the equipment.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents a description of the methodology that was employed in the study. It spells out the techniques and methods of sampling, data collection, processing, analysis, and the area in which the study is carried out. The chapter also highlights the following: research design, quantitative research, sample of respondents and data processing and analysis.

3.2 Research design

This research is a triangulation of research methods. Triangulation is a term used to explain the combination of different methods in dealing with particular subject matter. This research approach is chosen in a single study to gain a broader and more complete understanding of the phenomenon. This means checking the results of qualitative method with those of a quantitative method or vice versa (Robson, 2002).

The fundamental principle of triangulation is to use complimentary methods to enhance interpretability. This research was primarily based on quantitative study where the interpretation of statistical analysis was enhanced by a qualitative narrative account. Conversely, a qualitative account may be the major outcome of the study, but it can be enhanced by supportive quantitative evidence used to buttress and clarify the results. This chapter describes the research study and the methods used. A quantitative questionnaire was prepared and qualitative interviews were used. The chapter is divided in two main subchapters, the first of which discusses the quantitative part of the research, and the second discussed the qualitative part of the research.

3.3 Quantitative research

A survey is an appropriate tool for this research since it is a system for collecting information to describe, compare and predict attitudes, opinions, values, knowledge and behaviors. Designs for survey studies can be categorised as experimental or descriptive (Fink, 2002). The questionnaires in this research were descriptive. The descriptive design produces information on groups and phenomena that exist.

The survey gives information collected from a group of participants in a standardised form. An appropriate sample of people is formed and respondents are asked to give their answers in a standardised form. However, there is always a limitation in survey case studies, since people evaluations and opinions vary. But it is expected that the questionnaires as a whole gave a good indication and information regarding the subject and could therefore provide meaningful results on the subject. The questionnaires designs were as result of information that had been collected during the literature research and its goal was to shed further light on the research topic and the research questions asked. This involves getting answers to how well the data collected by literature research will comply with data collection using the questionnaires and the learning that can be drawn. Respondents were chosen from engineering firms and equipment operators that had been selected for the research. The questionnaires were divided to four sectors: 1. Respondents backgrounds 2. Quality assurance systems 3. Quality assurance aspects

3.4 Population

According to Esterberg (2002), population refers to the complete set of individuals (subjects or events) having common characteristics in which the researcher is interested. For the purpose of this study, the target population constitutes of the employees of J. A.

Plantpool Ghana Limited in Accra. The total staff strength of J. A. Plantpool Ghana Limited is three hundred and eighty (380). It was chosen because of time, availability of data and resources.

3.5 Sample of respondents

The sample was based on convenience sampling. This involves the sample being drawn from that part of population which is selected because it is easily available and convenient. This approach to sampling was considered the most appropriate for this research. The advantages for this type of sample are the following:

i. Convenience sampling is very easy to carry out with few rules governing how the sample should be collected.
ii. The relative cost and time required to carry out the sample is less in comparison to probability sampling.
iii. This sampling method is appropriate to achieve the research goals since it is focused on a few individual organisations within a certain sector and comparing them.

The disadvantages for this type of sampling is that convenience sampling often suffers from a number of biases so it is unlikely to be representative of the population and undermines the research ability to make generalisations from the sample to the population studied.

With the convenience sample, in most cases the respondents were handpicked from accessible employee list. When choosing a sample for each organisation, it will seek to obtain a certain breadth that could reflect the whole organisation. The sample included CEOs and general employees and they came from different departments of the

organisations with a breadth of education that was considered to reflect the organisation as a whole. Only employees linked directly to workshop process and equipment management were chosen. Support department staff obviously were not appropriate as respondents. The sample size of 100 representing 26% of the population was chosen from staff of J. A. Plantpool Ghana Limited data.

3.6 Data collection procedure

An initial pilot study was conducted to determine the suitability of the items for this study. This initial study helped determine whether the items are meaningful and also reliable. A sample of 10 participants was selected for this purpose. The distribution of the questionnaires and the interviews were carried out between the months of April and May 2014. By the end of the period, the researcher had been able to retrieve all the 100 questionnaires distributed, representing 100%.

3.7 Data processing and analysis

Analysing data involved reducing and arranging the data, synthesizing searching for significant patterns and discovering what was important. Ary et al. (2002: p12) has noted three steps involved in analysing data: organising, interpreting and summarizing data. Statistical tools such as tables, bar graphs and pie chart was used. The analysis was done with the help of Statistical Product and Service Solutions (SPSS 22) and Microsoft Excel. The closed ended questions were given numerical codes which were done in a varying scale depending on the responses. Data were analysed in the form of reliability analysis, descriptive statistics and multiple regression analysis. The results of data analyse were present in the form of tables and charts.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter focuses on analysing the data collected. The data was analysed for frequencies of the responses which were presented using pie charts, bar charts and frequency distribution tables.

4.2 Respondents' background

Respondents were asked about their background. These questions included participants' gender, age, length of work experience in the construction industry, educational background as well as asking about their field of work.

Age distribution of respondents

In addition, in determining the age category of the respondents, 19% of the respondents are within the age group of 26-35years, 9% are within the age group of 36-45 years and 21% are within the age group of 46-55 years. In addition, 8% and 3% of the respondents are between 56-65 years and 66 or older respectively. The majority of the respondents were between 46-55 years. This implies that the respondents are matured enough to understand and respond accordingly to the questions asked.

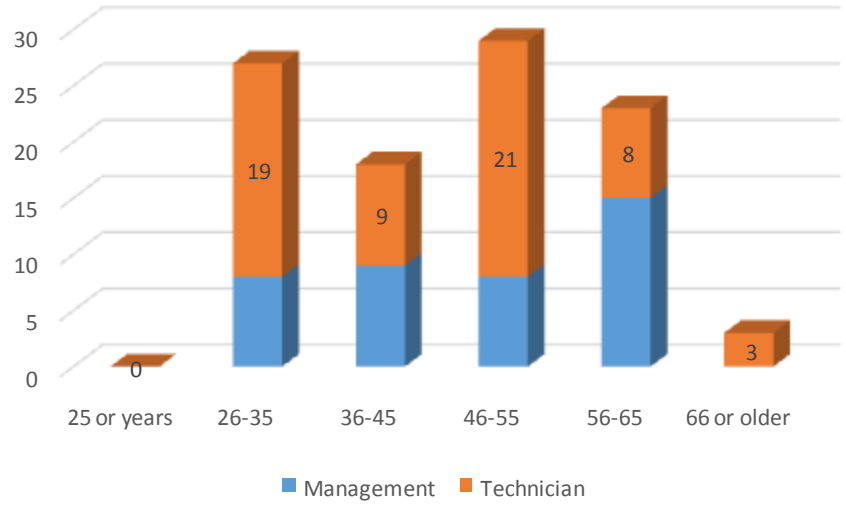

Figure 4.1: Age distribution

Source: Field data, 2014

Work experience within industry

In determining how long the respondents have been working with J. A. Plant Pool, it was found that 6% management and 7% technician of the respondents have been in company 5 or less years, 16% management and 7% technician have work with J. A. Plant Pool between 6 – 10 years, 5% management and 6% technician have been working with the company between 11-15 years while 3% management and 5% technician have been working with J. A. Plant Pool for between 16-20 years. Finally 20% management and 25% technician have work with company for 21 years or more. Majority of the sampled respondents have been working with J. A. Plant Pool for 21 years or more. This implies that staff and management are well experienced and very familiar with the activities of the organisation.

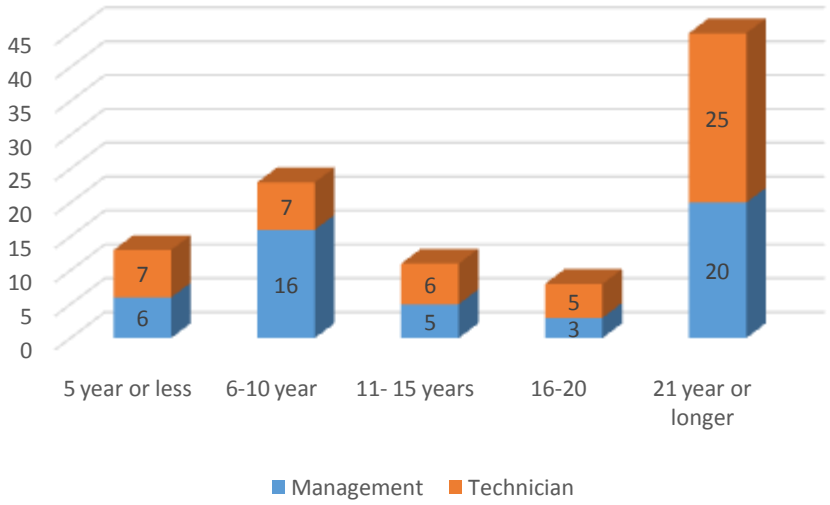

Figure 4.2: Length of work experience within the industry

Source: Field data, 2014

Educational Background of Respondents

Participants were asked about their educational background, by indicating their highest educational level. Engineers with a master's degree were those who mainly submitted the survey at 42% with those who had a bachelor's degree in engineering at 29%. Whilst 8% and 16% had structure mechanic and technical study respectively. It implies that educational background of the respondents indicates that they are highly knowledgeable therefore reflecting their knowledge on the topic.

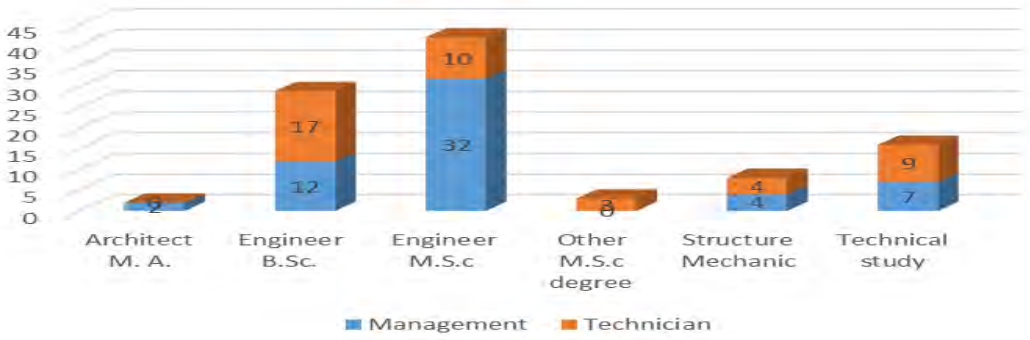

Figure 4.3: Respondents' educational background

Source: Field data, 2014

4.3 Quality assurance procedures

This part of the research aims to identify respondents' views towards the quality assurance procedures. In this part, respondents were asked whether or not there were quality assurance procedures within their organisation. If they replied there was, they were sent to a new page containing questions regarding the quality assurance procedures, if they replied there was none, they were sent to a different page containing questions regarding the absence of the system. The participants who answered 'I don't know' skipped both of the above mentioned pages.

The participants were asked what type of quality assurance procedures was in place in their organisation, a certified ISO system or other. Almost all of the respondents knew what type of system was in place in their organisation, but there was some confusion amongst respondents. The management has a quality system within the organisation, but 30% of the respondents responded that the quality management system was an ISO 9000 certified quality system. It was the other way round with the technician, where two thirds knew rightfully that the organisation is following a certified ISO 9000 quality assurance systems but one third thought they were following a quality system within the organisation.

Participants were asked how much training they had received from their employer to learn to implement the quality system in their work. They were asked to answer on a scale from 1 (No training) to 5 (Comprehensive Training). The average rating was 3.4 (with a standard deviation of 1.05), which can be interpreted as an overall positive response to the question (>3). However, as seen on Figure 4.4, the results show that a total of 20% of participants and 2% participants making 22% were negative towards the

amount of training they had received on implementing the quality management system, 32% were neutral. 28% and 18 making 46% were positive towards the amount of training they had received. This means that more than half of the participants answered this question either on a negative or a neutral scale. This could indicate that the organisations that were part of this research are not putting enough emphasis on teaching their staff to use the system. But majority of the respondents were positive towards the amount of training they had received.

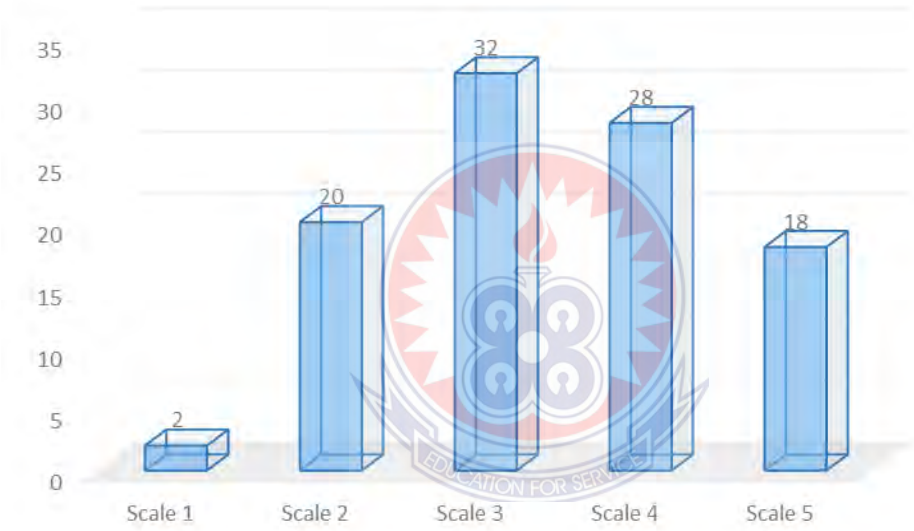

Figure 4.4: Participants views on the amount of training received on implementing the QMS.

Source: Field data, 2014

The degree of top management commitment towards the quality assurance procedures

Participants were asked to what extent they would agree to the statement that the top management were committed to following the quality assurance procedures. The average rating was 3.94 (with a standard deviation of 0.80). As can be seen in Figure 4.5, a total of 47% of participants and 23% participants were positive towards the statement, 27%

were neutral and 3% disagreed with the statement. As seen in Figure 4.6 and Figure 4.7, there are indications that the top management among the technician holds higher degrees than in the management. 55% and 21% making 76% are positive towards the statement among the technicians, compared with 27% and 32% making 59% in the management. Despite this, the overall response can be interpreted as positive. This implies that top management was commitment towards the quality assurance procedures.

Figure 4.5: Technicians' views on the degree of top management commitment towards the quality assurance procedures.

Source: Field data, 2014

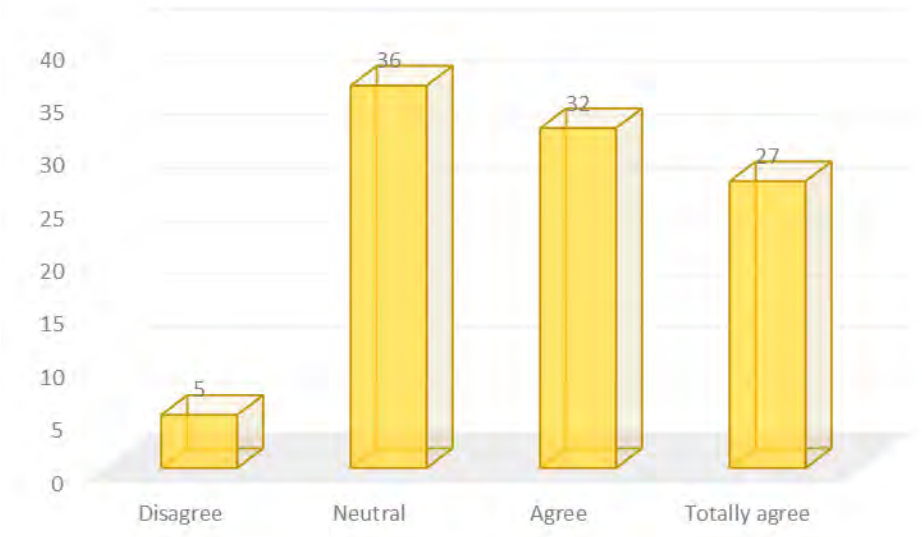

Figure 4.6: Customers' views on the degree of top management commitment towards the quality assurance procedures.

Source: Field data, 2014

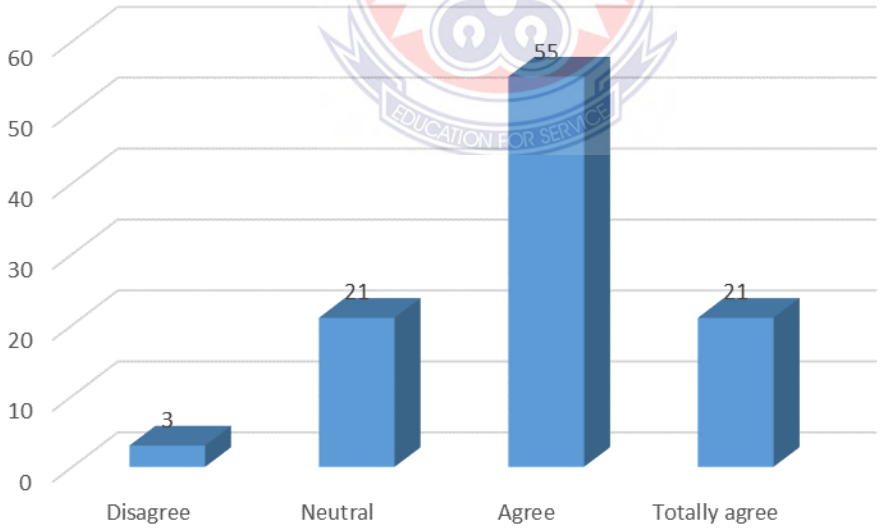

Figure 4.7: Customers' views on the degree of top management commitment towards the quality assurance procedures.

Source: Field data, 2014

Quality Assurance Procedures - Useful to work

Participants were asked about the extent to which they would agree to the statement that the quality system was useful for their work. The average rating was 4.23 (with a standard deviation of 0.61). As seen in Figure 4.8, all the participants were either positive or neutral towards the statement. 59% of the respondents totally agree that quality system was useful for their work. 31% of the respondents agree that quality system was useful for their work while 10% were neutral. The result implies that majority agree that quality system was useful for their work.

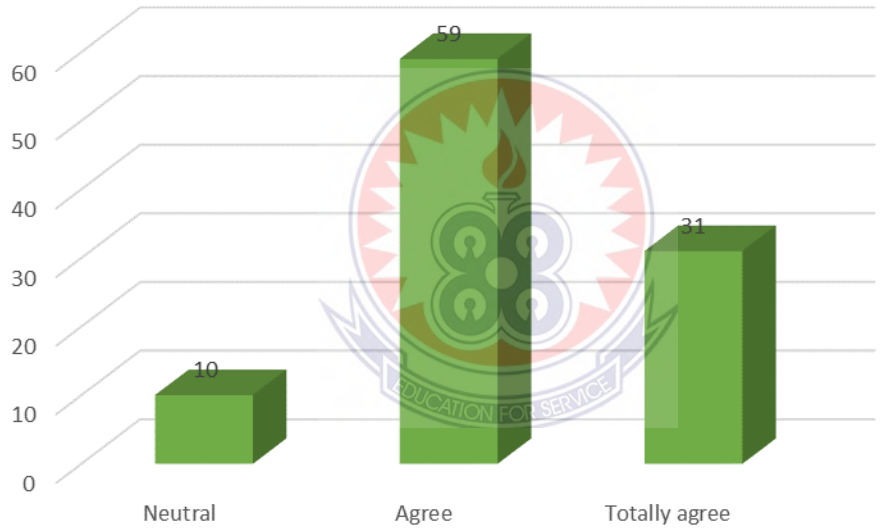

Figure 4.8: Participants' views on usefulness of the quality assurance procedures

Source: Field data, 2014.

The easy it is to use the quality assurance procedures

Participants were asked to what extent they would agree to the statement that the quality assurance procedures were easy to use in their work. The average rating was 3.69 (with a standard deviation of 0.73). As seen in Figure 4.9, a total of 65% that is 8% and 57%

were positive towards the statement, 28% were neutral and 7% were negative. This means the workers agree that use the quality assurance procedures was easy.

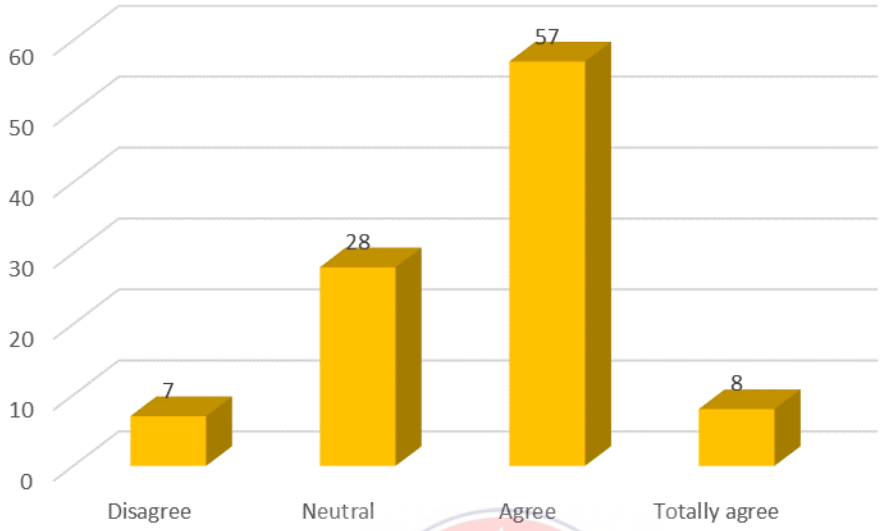

Figure 4.9: Participants' views of how easy it is to use the quality assurance procedures.

Source: Field data, 2014

It seems that the participants are, overall, positive towards the amount of training received, system usefulness, system ease of use and top management commitment towards following the system although there are some negative responses. Pearson's correlation coefficient was calculated between the amount of training and mentioned factors. There was a positive correlation in all cases. The correlation was 0.28 between training and usefulness. Between training and ease of use, the correlation was 0.34 and between training and top management commitment the correlation was 0.35. Though it is not possible to generalise from such a small sample, as in this case, the positive correlation, could be an indication of (a) that the amount of training personnel is receiving on implementation influences their experience of using the quality assurance

procedures and (b) the amount of training provided could possible reflect top management commitment to the system.

4.4 Quality assurance procedures in general.

This part aims to identify aspects to quality in general. Respondents were asked to grade a list of eleven factors on how well they indicated good quality performance. The factors that were identified as being most important were (1) repeat business from the client with an average rating of 4.1; the factors that came next were (2) management commitment to quality, (3) skilled work force, (4) certified quality program and (5) customer satisfaction. The lowest rated factors were (11) quality awards, (10) the length of warranty and (9) amount of rework due to errors. The ratings can be seen in Table 4.1. From these results, it can be interpreted that participants have a positive view towards almost all of the factors, except for quality awards.

Table 4.1 Quality assurance procedures indicators ranking.

Rank	Quality indicator	Rating	Std. dev.
1	Repeat business from the client	4.1	0.94
2	Management commitment to quality spare parts	3.9	0.87
3	Skilled work force	3.8	0.91
4	Certified quality programs such as ISO 9000 series	3.8	0.99
5	Customer satisfaction	3.8	0.94
6	Regular inspections	3.7	0.91
7	Training and education	3.7	0.89
8	Use of Standards tools and spare parts	3.6	0.89
9	The amount of rework due to errors	3.3	1.22
10	The length of warranty for spare parts and equipment	3.1	0.97
11	Quality awarding of contracts	2.8	0.97

Source: Field data, 2014

Participants were asked to define quality. They were given some options, but they could also type in their own definition. All of the respondents checked a given option. As seen in Figure 4.10, a majority (66%) of respondents said that quality could be defined as meeting all the customers' expectations or demands for the finished product. 24% defined quality as being able to guarantee that the finished product will not fail or have problems. 6% of respondents said that quality could be defined as 'looks good, works good, or proud to put the company's name on the finished product. 4% said either that quality was non-applicable to their work or they did not use a definition of quality. The results general suggest that quality could be defined as meeting all the customers' expectations or demands for the finished product.

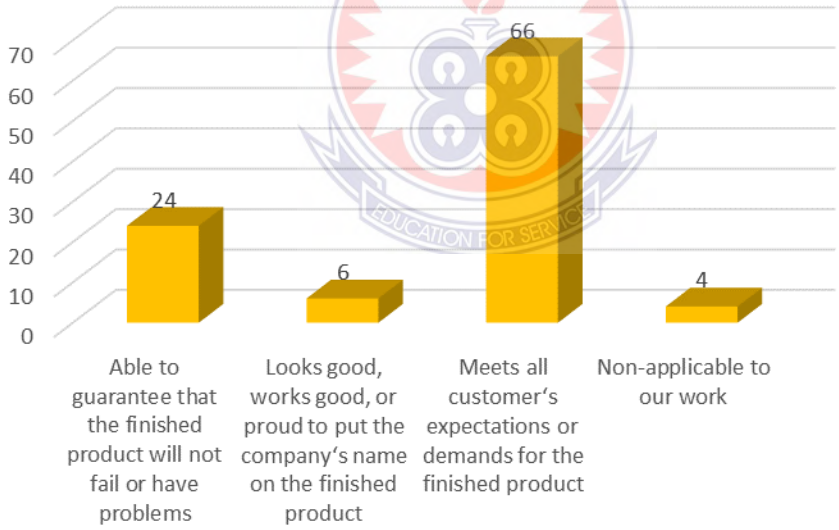

Figure 4.10: Participants' definition of quality

Source: Field data, 2014

In the next question, respondents were asked whether or not quality cost was being collected at their work place. As seen in Figure 4.11, 30% said 'yes' to this questions, 70% either did not know whether or not the quality cost was being collected or answered

that this was not the case. The result implies that quality cost has not being collected at the work place.

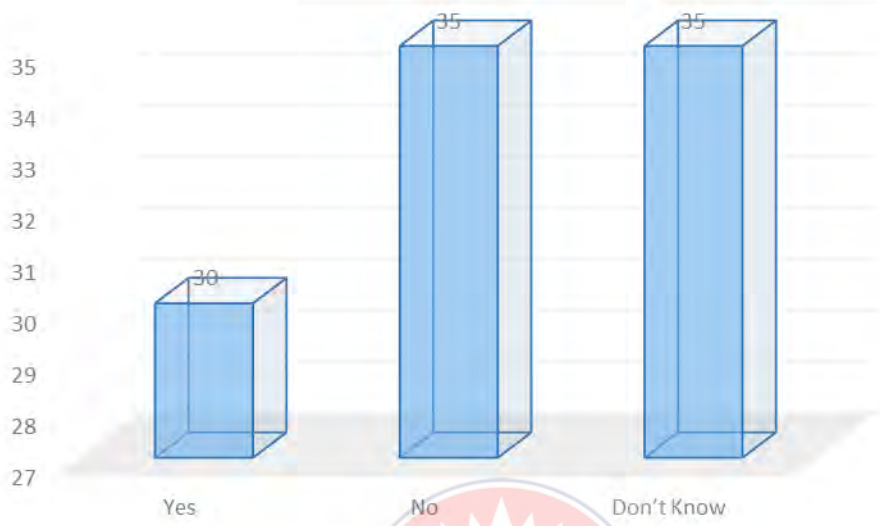

Figure 4.11: Quality cost collection

Source: Field data, 2014

Participants were asked about their perception of what was involved in the term "Quality cost" in quality assurance procedures. Several options were given and they were able to select as many as they felt applied to the term as well as writing in their own explanation. All respondents answered this question. Figure 4.12 shows how the respondents answered to the question. The majority of respondents (69%) said quality cost involved prevention cost, almost half of them (45%) said that appraisal cost was a part of the term, then came cost of quality assurance, cost of repairing defects (29%) and cost of repairing defects after handover (26%). Only a small number of respondents (13%) indicated that they did not know what was involved in the term quality cost. This means that quality cost involved prevention cost.

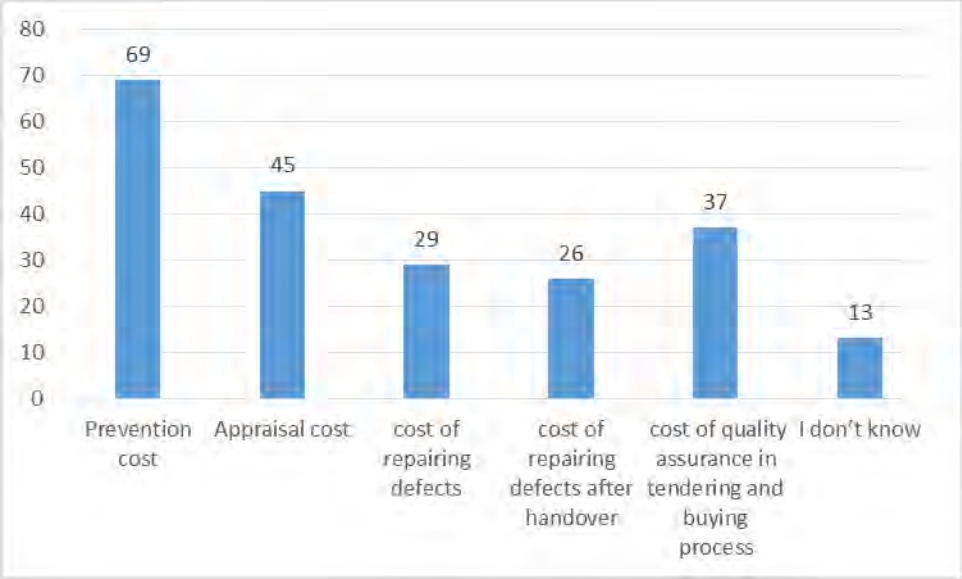

Figure 4.12: Participants' perception of quality cost

Source: Field data, 2014

4.5 Discussion of findings

100 respondents answered the questionnaire to increase knowledge and awareness of quality related matters in quality assurance procedures in automobile repair workshop, to shed light on automobile repair workshop in relation to quality and quality related matters, to identify the current quality assurance procedures used in J. A. Plantpool Ghana Limited workshop and measure the current process. The following findings were arrived after the analysis of data in accordance with the objectives of the study. The study was on quality assurance procedures in automobile workshop: A case study in the J. A. Plantpool Ghana Limited.

The study revealed that more than half of the participants they have not received training on implementing the quality management systems. These findings support the prior studies of Anderson et al. (1994) and Aoieong et al. (2002).

It was also observed after the research that top management was commitment towards the quality assurance procedures. This finding validates the claim by Bandyopadhyay and Jenicke (2007).

It also came to light that quality system was useful for their work. This confirms the assertion by Boehm and Ulmer (2008).

The study unveiled that the workers agree that use the quality assurance procedures was easy. This is corroborated by Chini and Valdez (2003).

The study also revealed that participants have a positive view towards almost all of the factors, except for quality awards. This finding corroborates the findings of Douglas and Ransom (2006).

The study shows that quality could be defined as meeting all the customers' expectations or demands for the finished product. This finding confirms the findings of Foster (2010).

The study disclosed that quality cost has not being collected at the work place. This finding validates the claim by Gabor (2001).

The study also revealed that quality cost involved prevention cost. This finding corroborates the findings of Gunnarsdóttir and Ingason (2007).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study. It covers the major findings, conclusions arrived at and the recommendations made.

5.2 Summary of findings

This study was on quality assurance procedures in automobile workshop: A case study in the J. A. Plantpool Ghana Limited in Accra. The objectives of the study were to increase knowledge and awareness of quality related matters in quality assurance procedures in automobile repair workshop, to shed light on automobile repair workshop in relation to quality and quality related matters, to identify the current quality assurance procedures used in J. A. Plantpool Ghana Limited workshop and measure the current process.

In order to attain the needed results, the researcher used convenience sampling technique to sample workers of J. A. Plantpool Ghana Limited in Accra, who answered the questionnaires The quantitative data collected was analysed using the Statistical Product and Service Solutions (SPSS 22) and Microsoft Excel to run basic descriptive statistics such as frequencies, percentages and means of the main variables of investigation.

With the objectives of the study for this research work as a guide, the researcher was able to come out with findings based on the research problems. In addition to the main objectives, other relevant issues on quality assurance procedures in automobile workshop were discovered. The summaries of the findings are therefore elaborated below.

The study suggests that quality assurance procedures were a problem for the automobile workshop. Quality could be improved. The study furthermore suggests that there is a gap in the use and knowledge of quality management and quality management systems.

The research revealed that there is scope for improving quality assurance procedures. The research participants found quality assurance procedures to be inadequate. The research revealed that respondents rated the quality assurance procedures status in a positive manner.

Former studies presented in the literature research support the research results. There has been increasing emphasis amongst automobile workshop professionals on the necessity of quality assurance procedures improvement. On the one hand, the automobile workshop has been lagging behind other industries when it comes to efficiency. On the other hand, projects are getting bigger and more complex that has led owners to increasingly demanding higher standards for their delivery.

This research indicated that the automobile workshop stakeholders see quality to be inadequate. Therefore, there must be a scope for improvement. The research revealed that quality professionals in J. A. Plantpool Ghana Limited saw clear improvements of their organisational operations after having implemented new work methods based on quality management. Their experience replicates the findings of other research presented in the literature research such as [(Deming, 1986) work on quality, productivity and competitive position in Cambridge, (Douglas & Ransom, 2006) work on understanding building failures in Routledge and (Ortega & Bigaard, 2000) work on quality improvement in the

automobile industry in Brazil] where there were clear improvements in project performance (cost, time and quality) after having challenged existing working practices.

Some researchers have pointed out similarities between quality and safety. The research revealed that participants rated the overall safety status higher than the quality status. It is the author's impression that a change for the better has been ongoing with regards to safety culture over recent years. The increased knowledge and improved safety culture that the company have adopted there seems to be slowly transferring to the external environment and on to other projects.

5.3 Conclusion

The research discussed the use of quality assurance procedures in terms of effectiveness and utility to organisations within the industry automobile of workshops identified clear improvements in the organisation operation and effectiveness implementation. Furthermore, personnel working with the company were seen to have a positive attitude towards the company and its application. However, the research indicated that employers training on implementing automobile workshop could be improved. Merely half of participants were satisfied with the training received on implementing the quality assurance procedures. Furthermore, the study suggests that there is a gap in the use and implementation of quality assurance procedures and that knowledge about quality assurance procedures.

Most of participants in the research correctly connected the term quality assurance procedures with prevention cost. Almost, half of the respondents connected it to appraisal cost, but less than one-third realised that deviation cost was a part of the term.

Furthermore, many participants connected the term quality assurance procedures with quality. This supports the theory that knowledge on quality related matters needs to be improved.

The main problem that the automobile workshop is having with quality and improvements of quality is that the quality culture seems to be underdeveloped. The peculiar characteristics of the automobile workshop seem to make it harder than in some other industries to adapt to changes. If more emphasis would be put on raising quality, increasing quality demands and increasing the use of quality management systems, the knowledge on these matters would improve and the quality culture and quality status would slowly begin to change for the better.

5.4 Recommendations

From the questionnaire administered and data analysed as well as a careful scrutiny of the findings, the researcher puts forward the following recommendations: -

Management must put in place a clear corporate philosophy and policy on quality assurance procedures. Such policy would inevitably guide and propel the organisation towards an effective quality assurance practice and curb or improve the problem of quality assurance.

Workshops and seminars should be organised for the workers regularly to reduce the gap between the use of knowledge in quality management and quality management systems.

A strong safety culture should be put in place by J. A. Plantpool Ghana Limited; this will assist the company in quality assurance procedures.

To ensure sound and efficient quality assurance procedures there must be a quality assurance management department or committee which would ensure quality assurance in the organisation.

All quality assurance policy must be well communicated to all employees. This would ensure strict and proper compliance to quality assurance policy.

Where there is a quality assurance department, the position of the quality assurance manager must be an executive one to ensure that effective quality assurance management decisions and policies are fully implemented in the organisation.

5.5 Recommendations for further studies.

This study was an exploratory and descriptive one to evaluate the quality assurance procedures in automobile workshop: A case study in the J.A. Plant Pool Ghana Limited in Accra. At the end of this study, the researcher finds the need to recommend for further studies should be conducted on the extent of quality failures and non-conformance in automobile workshop. A study should also be conducted on whether or not implementing quality assurance procedures proves to be cost effective for automobile workshop. Both these studies would be worthy research topics for researchers and of value to the automobile workshop.

REFERENCES

Alarcón, L. F., & Mardones, D. A. (1998). Improving the design-construction inter face. *Proceedings of the 6th Annual Meeting of the International Group for Lean Construction*.

Allen, I. E., & Seaman, C. A. (2007). Likert scales and data analyses. *Quality Progress*, *40*(7), 64–65.

Anderson, J. C., Rungtusanatham, M., & Schroeder, R. G. (1994). A theory of quality management underlying the Deming management method. *The Academy of Management Review*, *19*(3), 472–509.

Aoieong, R. T., Tang, S. L., & Ahmed, S. M. (2002). A process approach in measuring quality costs of construction projects: model development. *Construction Management and Economics*, *20*(2), 179–192.

Arditi, D., & Gunaydin, H. M. (1997). Total quality management in the construction process. *International Journal of Project Management*, *15*(4), 235–243.

Bailey, F., Ruyter, D., Jonathan, L., & Tyler, P. (2010). The moderating effect of supply chain role on the relationship between supply chain practices and performance: An empirical analysis. *International Journal of Physical Distribution & Logistics Management*, *41*(2), 104 – 134.

Bandyopadhyay, T., & Jenicke, G. (2007). A quality monitoring and decision-making

scheme for automated production processes. *International Journal of Quality and Reliability Management, 16*(2), 148-157.

Boehm, T., & Ulmer, P. (2008). Strategic technology adoption: extending ERP across the supply chain. *Journal of Enterprise Information Management*, *18*(4), 427 – 440.

Chini, A. R., & Valdez, H. E. (2003). ISO 9000 and the U.S. Construction Industry. *Journal of Management in Engineering*, *19*(2), 69.

Crosby, P. B. (1979). *Quality is still free: making quality certain in uncertain times.* New Jersey, NJ: McGraw-Hill.

Deming, W. E. (1986). *Out of the crisis: quality, productivity and competitive position*. Cambridge, UK: Cambridge University Press.

Denzin, N. K. (1989). *Interpretive biography*. New Jersey, NJ:: Sage.

Department of Trade and Industry (2002). Experiences of implementing statistical methods in small enterprises. The *TQM Magazine*, 11(5), pp.341-350.

Douglas, J., & Ransom, B. (2006). *Understanding building failures*. London, UK: Routledge.

Eaves, S., & Kingsman, B. (2004). Mapping the re-engagement of CRM with relationship marketing. *European Journal of Marketing, 40*(5), 572 – 589.

Egan, J. (1998). *Rethinking construction*. London, UK: Department of the Environment, Transport and the Regions.

Esterberg, K. G. (2002). *Qualitative methods in social research*. New Jersey, NJ: McGraw-Hill.

Fink, A. (2002). *How to design survey studies* (2nd ed.). New Jersey, NJ: Sage Publications, Inc.

Folaron, R. (2003). Critical success factors for implementing quality engineering in Malaysian's and Indonesian's automotive industries: A proposed model. *International Journal of Automotive Industry and Management, 2*(2), 1 – 16.

Foster, M. (2010). Modeling of a quality control information system for small to medium-sized enterprise. *Integrated Manufacturing Systems*, *13*(4), 222-236.

Frímannsson, J. (1997). *Er maðkur í mysunni? mbl.is.* New York, NY: Basic Books.

Gabor, M. (2001). *Identifying some management approaches to total quality management (TQM) within industerial organizations*. New York, NY: University of Wisconsin-Stout

Gunnarsdóttir, A. H., & Ingason, H. P. (2007). Identifying root causes of construction accidents, *Journal of Construction Engineering and Management*, *2*(6), 52-60.

Harris, F., McCaffer, R., & Edum-Fotwe, F. (2006). *Modern construction management*.

Oxford; Malden, MA: Blackwell.

Hsien, F., & Kay, N. (2003). Statistical process control in machining, a case study for machine tool capability and process capability. *Materials and Design*, *2*(7), 364- 372.

Hoonakker, P. (2006). Quality management in construction industry. *ASQ World Conference on Quality and Improvement, Milwaukee, 8*(9) 1–3.

Hua, C., Fuxiang, L., & Yuhui, Y. (2007). Study and explores on CRM based on the supply chain integration. *Management Science and Engineering,* 5(1), 01-09.

Iaquinto, S. (1999). *Statistical Quality Control* (5th ed.). New York, NY: John Wiley.

Josephson, P. E., & Hammarlund, Y. (1999). The causes and costs of defects in construction: A study of seven building projects. *Automation in Construction*, *8*(6), 681–687.

Juran, J. (2005). The quality trilogy. *Joseph M. Juran: critical evaluations in business and management*, *19*, 54-67.

Karim, K., Marosszeky, M., & Davis, S. (2006). Managing subcontractor supply chain for quality in construction. *Engineering, Construction and Architectural Management*, *13*(1), 27–42.

Kärnä, S. (2009). Analysing customer satisfaction and quality in construction – the case

of public and private customers. *Nordic Journal of Surveying and Real Estate Research*, *2*(8), 89 – 99.

Krever, T., Hendricks, K.B., Singhal, V. R., & Stratman, J. K. (2005). An operation management perspective on adopting customer-relations management (CRM) software. *International Journal of Production Research*, *50*(4), 3974-3987.

Kumar, G. (2007). Statistical process control: an essential ingredient for improving service and manufacturing quality. *Managing Service Quality*, *10*(4), 233-238.

Liang-Hung, T., & Iuan-Yuan, N. (2006). The use of statistical process control in food packing: Preliminary findings and future research agenda. *British Food Journal*, *101*(10), 763-784.

Lightle, E., Rosenweig, N., & Talbott, B. (2003). The design for real-time paper perforation quality control. *Journal on Engineering and Computer Science. 8*(11), 49-51

Liker, R. (2010). Confluence of six sigma, simulation and software development. *Managerial Auditing Journal*, *20*(7), 739-762.

Loushine, T. W., Hoonakker, P. L. T., Carayon, P., & Smith, M. J. (2006). Quality and safety management in construction. *Total Quality Management & Business Excellence*, *17*(9), 1171–1212.

Love, P., & Irani, Z. (2003). A project management quality cost information system

for the construction industry. *Information & management*, *40*(7), 649–661.

Love, P., & Li, H. (2000). Quantifying the causes and costs of rework in construction. *Construction Management and Economics*, *18*(4), 479–490.

Love, P., & Smith, J. (2003). Benchmarking, Benchaction, and Bench learning: Rework Mitigation in Projects. *Journal of Management in Engineering*, *19*(4), 147–159.

Makridakis, E., Wheelwright, D., & Hyndman, R. (1998). Customer focus, supply-chain relational capabilities and performance: Evidence from US manufacturing industries. *The International Journal of Logistics Management, 22*(2), 202 – 221.

MBNQA (NIST, 2010). *Statistical process control*, (5th ed.). Oxford, UK: Butterworth-Heinemann.

McIntyre, C., & Kirschenman, M. (2000). Survey of TQM in construction industry in Upper Midwest. *Journal of Management in Engineering*, *16*(5), 67–70.

Mukherjee, H., & Kachwalka, T. (2010). Quality management tools and techniques: An overview. In Dale, B. G. (ed): *Managing Quality* (4th ed.). Oxford, UK: Blackwell.

Ortega, I., & Bisgaard, S. (2000). Quality improvement in the construction industry: Three systematic approaches. *Total Quality Management*, *11*(4-6), 383–392.

Pheng, L. S., & Teo, J. A. (2004). Implementing total quality management in

construction firms. *Journal of management in Engineering*, *20*(12), 8-25.

Powell, R. (1995). Quality control procedures to determine staff allocation in a bank. *International Journal of Quality & Reliability Management*, 11(1), 6-21.

Regassa, F., & Ahmadian, M. (2007). Output *confirmation test system for cigarette paper perforation quality measurement,* New York, NY: Plenum.

Robson, C. (2002). *Real world research: a resource for social scientists and practitioner-researchers*. Oxford, UK: Blackwell Publishers.

Scheid, E. (2010). Sampling for quality assurance of grading decisions in diabetic retinopathy screening: Designing the system to detect errors. *International Journal of Health Care Quality Assurance*, 18(2), 113-122.

Sroufe, J., & Curkovic, L. (2008). PDCA cycle *vs.* DMAIC and DFSS. *Journal of Mechanical Engineering, 53*(27), 369-378.

Stanley, L., & Sclove, P. D. (2001). *Notes on likert scales.* New York, NY: Plenum.

Sutton, M. (2007). *Assessing business excellence.* Boston, USA: Elsevier.

Teddlie, C., & Tashakkori, A. (2008). *Foundations of mixed methods research: integrating quantitative and qualitative techniques in the social and behavioral sciences*. Thousand Oaks, California: SAGE.

Tim, V. W., & Le, K. N. (2007). Quality improvement in construction by using a

Vandermonde interpolation technique - ICE. *International Journal of Project Management*, *25*(8), 815–823.

Wharton University of Pennsylvania (2010). Statistical process control in plastic packaging manufacturing: A case study. *2009 International Conference on Electrical Engineering and Informatics, 5-7*,199-203.

Yasamis, F., Arditi, D., & Mohammadi, J. (2002). Assessing contractor quality performance. *Construction Management and Economics*, *20*(3), 211–223.

APPENDICES

APPENDIX A

UNNIVERSITY OF EDUCATION

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF MECHANICAL TECHNOLOGY EDUCATION

TOPIC

QUALITY ASSURANCE PROCEDURES IN AUTOMOBILE WORKSHOP: A CASE STUDY IN THE J. A. PLANTPOOL GHANA LIMITED IN ACCRA

QUESTIONNAIRE

This questionnaire is designed with the purpose of finding out quality assurance procedures in automobile workshop: a case study in the J. A. Plantpool Ghana Limited in Accra with references to respondents' educational background, gender, age, and experience with quality assurance procedures in automobile workshop.

The researcher is a Master of Technology Education in Mechanical Technology student of the above named institution and would be very grateful if you could give your views by responding to the following questions as they may be applicable to you in order to help him contribute his quota to the body of knowledge.

Please, be fully assured that all information given will be treated with much confidentiality.

INSTRUCTION FOR FILLING OUT THE QUESTIONNAIRE

Please Endeavour to answer all questions as applicable to you. Read carefully before answering any of the questions. Please tick [√] the most appropriate answer.

SECTION A

BIO- DATA OF RESPONDENTS

1) Please; indicate your Gender:

   a. Male [ ] b. Female [ ]

2) Indicate your Age Group (in years):

   a. Below 18 [ ]

   b. 18-24 [ ]

   c. 25-31 [ ]

   d. 32-37 [ ]

   e. 38-43 [ ]

   f. 44 and above [ ]

3) Marital Status:

   a. Single [ ]

   b. Married [ ]

   c. Separated [ ]

   d. Divorced [ ]

   e. Widowed [ ]

4) Place of Residence: ……..

5. What is Your Level of Education?

   a. Non–Formal education [ ]

   b. Basic Education [ ]

   c. Secondary Education [ ]

   d. Technical Education [ ]

   e. Tertiary Education [ ]

6. What is your occupation?

   a. Mechanic [ ]

   b. Driver [ ]

   c. Trader [ ]

   d. Teacher [ ]

   e. Businessman [ ]

   f. Others, please specify…….

SECTION B

CUSTOMERS OF J. A. PLANTPOOL

7. Are you a regular customers of J. A. Plantpool workshop?

   a. YES [ ]

   b. NO [ ]

8. If the answer to question 7 is yes, how long have you been customers of J A plant pool workshop?

   a. 1 yr [ ]

   b. 2 yrs [ ]

c. 3 yrs [ ]

d. 4 yrs and above [ ]

9. Why do you choose J. A. Plantpool workshop?

a. Because of Corrective & Preventative Actions [ ]
b. In-Process Inspection [ ]

c. Because it is faster [ ]

d. No other option [ ]

10. Do you like Preservation, Packaging, & Shipping procedures of J. A. Plantpool?
a. YES [ ] b. NO [ ]

11. Have you ever experience breakdown of J. A. Plantpool workshop before?

a. YES [ ] b. NO [ ]

12. If yes, what would you attribute the breakdown to?

a. Lack of maintenance [ ]

b. Overloading [ ]

c. Bad road [ ]

d. Careless driving [ ]

13. Have you ever experience problem with the company Purchasing & Contracting procedures workshop before?
a. YES [ ] b. NO [ ]

14. If the answer to question 13 is yes, will you say the problem was as a failure of quality assurance procedures?

a. YES [ ] b. NO [ ]

15. What is your take on corrective & preventative actions of J. A. Plantpool workshop process?
a. Very Good [ ]

b. Good [ ]

c. Bad [ ]

d. Very Bad [ ]

16. How do you assess their Inspection Status of J. A. Plantpool Ghana Limited process?

a. Very Good [ ]

b. Good [ ]

c. Bad [ ]

d. Very bad [ ]

17. What is your take on Document Control of J. A. Plantpool Ghana Limited process?

a. Very Good [ ]

b. Good [ ]

c. Bad [ ]

d. Very bad [ ]

18. Do you think the company use the best spare parts for your work?

a. YES [ ] b. NO [ ]

19 How do you rate the company workshop process?

a. Very Good [ ]

b. Good [ ]

c. Bad [ ]

d. Very bad [ ]

20. Was there an instance when you compromise on quality spare parts?

a. YES [ ] b. NO [ ]

21. What are your recommendation and suggestion on quality assurance procedures in the company work shop?

……

……

……

APPENDIX B

UNNIVERSITY OF EDUCATION

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF MECHANICAL TECHNOLOGY EDUCATION

TOPIC

QUALITY ASSURANCE PROCEDURES IN AUTOMOBILE WORKSHOP: A CASE STUDY IN THE J. A. PLANTPOOL GHANA LIMITED IN ACCRA

QUESTIONNAIRE

This questionnaire is designed with the purpose of finding out quality assurance procedures in automobile workshop: a case study in the J. A. Plantpool Ghana Limited in Accra with references to respondents' educational background, gender, age, and experience with quality assurance procedures in automobile workshop.

The researcher is a Master of Technology Education in Mechanical Technology student of the above named institution and would be very grateful if you could give your views by responding to the following questions as they may be applicable to you in order to help him contribute his quota to the body of knowledge.

Please, be fully assured that all information given will be treated with much confidentiality.

INSTRUCTION FOR FILLING OUT THE QUESTIONNAIRE

Please Endeavour to answer all questions as applicable to you. Read carefully before answering any of the questions. Please tick [√] the most appropriate answer.

SECTION A

BIO- DATA OF RESPONDENTS

5) Please; indicate your Gender:

   b. Male [ ] b. Female [ ]

6) Indicate your Age Group (in years):

   g. Below 18 [ ]

   h. 18-24 [ ]

   i. 25-31 [ ]

   j. 32-37 [ ]

   k. 38-43 [ ]

   l. 44 and above [ ]

7) Marital Status:

   f. Single [ ]

   g. Married [ ]

   h. Separated [ ]

   i. Divorced [ ]

   j. Widowed [ ]

8) Place of Residence: ……..

18. What is Your Level of Education?

   f. Non–Formal education [ ]

g. Basic Education [ ]

h. Secondary Education [ ]

i. Technical Education [ ]

j. Tertiary Education [ ]

19. What is your position in the company?

……

SECTION B

Management of JA Plant

20. Does your company practice quality assurance procedures in automobile workshop?

a. YES [ ] b. NO [ ]

21. Does your company have corrective and preventative measure in the workshop?

a. YES [ ] b. NO [ ]

22. If the answer to question 8 is yes, what are the measures in place?

……

23. Does your company have document control measure in the workshop?

a. YES [ ] b. NO [ ]

24. If the answer to question 10 is yes, how long have this been done?

a. 2-5 years [ ]

b. 6-9 years [ ]

c. 10-13 years [ ]

d. 14 years and above [ ]

25. Does the company comply with quality assurance processes in purchasing and contracting tools and spare part for the company?

a. YES [ ] b. NO [ ]

26. If the answer to question 12 is yes, is this procedure still effective in the company?

a. YES [ ] b. NO [ ]

27. How do u assess quality assurance procedures J. A. Plantpool Ghana Limited?

……..

28. Does the company workshop practice in-process inspection and final inspection of spare part and engines before they are taken out from the workshops?

a. YES [ ] b. NO [ ]

29. How will you grade the company stance on in-process inspection and final inspection of spare part and engines?

a. Very good [ ]

b. Good [ ]

c. Very bad [ ]

d. Bad [ ]

30. Does the company apply quality assurance in preservation, packaging, & shipping equipment form the to and fro of the workshop?

a. YES [ ] b. NO [ ]

31. Would you attribute the failure of the workshop to the failure of quality assurance procedures?

a. YES [ ] b. NO [ ]

32. If the answer to question 18 is NO, what would you attribute the failure to?

……

33. Do you take part in drafting quality assurance procedures of the automobile workshop?

a. YES [ ] b. NO [ ]

34. If the answer to question 20 is yes, would you agree that the quality assurance procedures in automobile workshop is maintain**?**

    a. YES [ ] b. NO [ ]

35. Are you always satisfied with the level of maintenance carried out at the workshop?

    a. YES [ ] b. NO [ ]

36. Does the company made it a point buy quality product into the workshop?

    a. YES [ ] b. NO [ ]

37. If the answer to question 23 is yes, what is your level of satisfaction on applying quality assurance purchasing?

    a. Very satisfied [ ]

    b. Satisfied [ ]

    c. Neutral [ ]

    d. Unsatisfied [ ]

    e. Very unsatisfied [ ]

38. Does J. A. Plantpool Ghana Limited gives periodic training on quality assurance procedures in automobile workshop?

    a. YES [ ] b. NO [ ]

39. If the answer to question 24 is yes, how often do you receive the training?

    a. Every 3 months [ ]

    b. Every 6 months [ ]

    c. Every 12 months [ ]

    d. 14 months and above [ ]

40. Give your suggestion and recommendation on the subject matter

……

……

APPENDIX C

UNNIVERSITY OF EDUCATION

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF MECHANICAL TECHNOLOGY EDUCATION

TOPIC

QUALITY ASSURANCE PROCEDURES IN AUTOMOBILE WORKSHOP: A CASE STUDY IN THE J. A. PLANTPOOL GHANA LIMITED IN ACCRA

QUESTIONNAIRE

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INSTRUCTION FOR FILLING OUT THE QUESTIONNAIRE

Please Endeavour to answer all questions as applicable to you. Read carefully before answering any of the questions. Please tick [√] the most appropriate answer.

SECTION A

BIO- DATA OF RESPONDENTS

9) Please; indicate your Gender:

c. Male [ ] b. Female [ ]

10) Indicate your Age Group (in years):

m. Below 18 [ ]

n. 18-24 [ ]

o. 25-31 [ ]

p. 32-37 [ ]

q. 38-43 [ ]

r. 44 and above [ ]

11) Marital Status:

k. Single [ ]

l. Married [ ]

m. Separated [ ]

n. Divorced [ ]

o. Widowed [ ]

12) Place of Residence: ……..

41. What is Your Level of Education?

k. Non–Formal education [ ]

l. Basic Education [ ]

m. Secondary Education [ ]

n. Technical Education [ ]

o. Tertiary Education [ ]

SECTION B

WORKSHOP TECHNICIANS

How long have you worked with J. A. PLANT POOL as a Technician?

a. 1 year [ ]

b. 2 years [ ]

c. 3 years [ ]

d. 4 years and more [ ]

42. Were you having working experience from a different company before **J. A. PLANT POOL workshop**?

a. YES [ ] b. NO [ ]

43. How many years working experience were you having before joining **J. A. PLANT POOL workshop**?

a. 1 year [ ]

b. 2 years [ ]

c. 3 years and more [ ]

d. No working experience before coming to **J. A. PLANT POOL** [ ]

44. As the plants and equipment are aging does management review maintenance plan to suit the current condition of the, parts?

a. YES [ ] b. NO [ ]

45. If the answer to question 11 is yes, how often do they review your quality maintenance plan in the workshop?

a. Once in a year [ ]

b. Twice in a year [ ]

c. 3 times in a year or more [ ]

46. Do you have a maintenance schedule in the workshop?

a. YES [ ] b. NO [ ]

47. If the answer to question 10 is yes, do you follow the maintenance schedule to the core?

a. YES [ ] b. NO [ ]

48. What type of quality maintenance do you carried out in the workshop?

a. Preventive maintenance [ ]

b. Predictive maintenance [ ]

c. Corrective/breakdown maintenance [ ]

49. Indicate your level of agreement or disagreement by ticking [√] the components of the equipment which frequently is repair or change in the workshop.

NO.	Item	Strongly Agree	Agree	Disagree	Strongly Disagree
1.	Hub				

2.	Hydraulic Pump				
3.	Centre Bearing				
4.	Clutch				
5.	Tyre				
6.	Brake Pad				
7.	Steering Pot				
8.	Engine				
9.	Radiator				
10	Propeller Shaft				
11	Fuel Tank				
12	Differential Rear				
13	Gears Box				
14	Windscreen				
15	Shaft				

50. Does the company apply quality assurance in preservation, packaging, & shipping equipment form to and from of the workshop?

a. YES [ ] b. NO [ ]

51. Would you attribute the failure of the workshop to the failure of quality assurance procedures?

b. YES [ ] b. NO [ ]

52. If the answer to question 18 is NO, what would you attribute the failure to?

……

53. Do you take part in drafting quality assurance procedures of the automobile workshop?

b. YES [ ] b. NO [ ]

54. If the answer to question 20 is yes, would you agree that the quality assurance procedures in automobile workshop is maintain**?**

b. YES [ ] b. NO [ ]

55. Are you always satisfied with the level of maintenance carried out at the workshop?

b. YES [ ] b. NO [ ]

56. Does the company made it a point buy quality product into the workshop?

b. YES [ ] b. NO [ ]

57. If the answer to question 20 is yes, what is your level of satisfaction on applying quality assurance purchasing?

f. Very satisfied [ ]

g. Satisfied [ ]

h. Neutral [ ]

i. Unsatisfied [ ]

j. Very unsatisfied [ ]

58. Does J. A. Plant Pool Ghana Limited gives periodic training on quality assurance procedures in automobile workshop?

b. YES [ ] b. NO [ ]

59. If the answer to question 24 is yes, how often do you receive the training?

e. Every 3 months [ ]

f. Every 6 months [ ]

g. Every 12 months [ ]

h. 14 months and above [ ]

60. Do you have difficulties in ensuring that the best spare part is used for the spoilt one?

a. YES [ ] b. NO [ ]

61. Give your suggestion and recommendation on the subject matter

……

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