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MAINTENANCE OF MODERN ELECTRONIC FUEL INJECTION VEHICLES

A CASE STUDY AT SUAME MAGAZINE - KUMASI

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CHAPTER ONE

INTRODUCTION

1.0 Overview of Introduction Chapter

The chapter looks at the background to the study, problem statement and justification of the research need. It further outlines the research objectives and the scope of the study. Limitations to the study are also presented as well as overview of the research methodology and the general organization of this thesis.

1.1 Background of the Study

Transportation is defined as the movement of people and goods from one location to another (Meyer, 2009). According to Meyer (2009), it is usually classified by the medium in which the movement occurs, such as by land, air, water, or pipeline. Within each of the first three media, many different methods are used to convey people and goods from place to place. Pipelines are used mainly to transport liquids or gases over long distances. Transportation systems and the routes they use have greatly influenced both how and where people live (Meyer, 2009). Reliable transportation allows a population to expand throughout a country's territory and to live comfortably in remote areas far from factories and farms. Meyer (2009) reported that, the growth and expansion of the United States were directly related to the means of transportation available at the time.

Throughout history, the economic wealth and military power of a people or a nation have been closely tied to efficient methods of transportation. Kevin (2008) emphasized that transportation provides access to natural resources and promotes trade, allowing a nation to accumulate wealth and power. It also allows the movement of soldiers, equipment, and supplies so that a nation can wage war with accurate ease. Accordingly, the history of transportation is largely one of technological innovation. Advances in technology have allowed people to travel farther, explore more territory, and expand their influence over larger and better areas. Innovation continues today, and transportation researchers are working to find new ways to reduce costs and increase transportation efficiency, and this must be met with equal expertise and knowledge by the servicing industry (mechanics), but this has not been the case of developing countries such as Ghana. Recent innovations in technology have been driven by a desire to find safer, faster, and more reliable means of moving from place to place.

In the 17th century, Ferdinand Verbiest, a member of a Jesuit mission in China, built the first steam-powered vehicle around 1672 as a toy for the Chinese Emperor. It was of small scale that it could not carry a driver but it was, quite possibly, the first working steam-powered vehicle ('auto-mobile') a tiller, rather than a wheel for steering (Setright, 2004). Consequently, Eckermann (2001) revealed that the history of the automobile began as early as 1769, with the creation of steam engine automobiles capable of human transport. Automobiles were powered on kerosene, coal oil, vegetable and animal oils were also used as lubricants. With the development of technology to produce gasoline (replacing kerosene and coal oil) and improvements in heat-tolerant mineral oil lubricants (replacing vegetable and animal oils), vehicles became more efficient (Csere, 1988). In 1896, William Jennings Bryan became the first presidential candidate to campaign in a car (a donated Mueller), in Decatur, Illinois (Lewis, 1988).

By 1900, it was possible to talk about a national automotive industry in many countries, including Belgium (home to Vincke, which copied Benz; German, a pseudo-Panhard; and Linon and Nagant, both based on the Gobron-Brillié); Switzerland (led by Fritz Henriod, Rudolf Egg, Saurer, Johann Weber, and Lorenz Popp); Vagnfabrik AB in Sweden; Denmark (by A. F. Hammel and H. U. Johansen at Copenhagen, which only built one car in 1886); Irgens (starting in Bergen, Norway, in 1883, but without success) [Buchanan, 1958]; Italy (where FIAT started in 1899); and as far afield as Australia (where Pioneer set up shop in 1898, with an already archaic paraffin-fuelled centre-pivot-steered wagon) [Georgano, 1985]. Consequently, Georgano (1985) emphasized that the export trade had begun to be global, with Koch exporting cars and trucks from Paris to Tunisia, Egypt, Iran, and the Dutch East Indies in the early 1900s. The first use of gasoline direct injection (i.e. injection of gasoline, also known as petrol) was on the Hesselman engine invented by Swedish engineer Jonas Hesselman in 1925 (Christer, 1990; Björn-Eric, 1992). Hesselman engines use the ultra lean burn principle; fuel is injected toward the end of the compression stroke, and then ignited with a spark plug. They are often started on gasoline and then switched to diesel or kerosene (HybridKingdom.com, 2012).

Fuel injection is a system for admitting fuel into an internal combustion engine. It has become the primary fuel delivery system used in automotive engines, having replaced carburetors during the 1980s and 1990s. A variety of injection systems have existed since the earliest usage of the internal combustion engine. Modern fuel injection systems are designed specifically for the type of fuel being used. Some systems are designed for multiple grades of fuel (using sensors to adapt the tuning for the fuel currently used). Most fuel injection systems are for gasoline or diesel applications. The functional objectives for fuel injection systems can vary. All share the central task of supplying fuel to the combustion process, but it is a design decision on how a particular system is optimized. There are several competing objectives such as: power output, fuel efficiency, emissions performance, ability to accommodate alternative fuels, reliability, driveability and smooth operation, initial cost, maintenance cost, diagnostic capability, range of environment operation and engine tuning (HybridKingdom.com,2012). Alfa Romeo tested one of the very first electronic injection systems (Caproni-Fuscaldo) in Alfa Romeo 6C2500 with "Ala spessa" body in 1940 Mille Miglia (HybridKingdom.com, 2012). The engines had six electrically operated injectors and were fed by a semi-high pressure circulating fuel pump system.

In 1980, Motorola introduced the first electronic engine control unit, the EEC III (www.motorolla.com, 2011). Its integrated control of engine functions (such as fuel injection and spark timing) and is now the standard approach for fuel injection systems. The open loop fuel injection systems had already improved cylinder-to-cylinder fuel distribution and engine operation over a wide temperature range, but did not offer further scope to sufficient control fuel/air mixtures, in order to further reduce exhaust emissions. Later Closed loop fuel injection systems improved the air/fuel mixture control with an exhaust gas oxygen sensor and began incorporating a catalytic converter to further reduce exhaust emissions. Fuel injection was phased in through the latter '70s and '80s at an accelerating rate, with the US, French and German markets leading and the UK and Commonwealth markets lagging somewhat. Since the early 1990s, almost all gasoline passenger cars sold in first world markets are equipped with electronic fuel injection (EFI). The carburetor remains in use in developing countries where vehicle emissions are unregulated and diagnostic and repair infrastructure is sparse. Fuel injection is gradually replacing carburetors in these nations too as they adopt emission regulations conceptually similar to those in force in Europe, Japan, Australia and North America. Many motorcycles still utilize carburetored engines, though all current high-performance designs have switched to fuel injection system

NASCAR finally replaced carburetors with fuel-injection, starting at the beginning of the 2012 NASCAR Sprint Cup Series season (NASCAR). According to Lindh (1992), experimental engines have been made and tested that have no camshaft, but have full electronic control of the intake and exhaust valve opening, valve closing and area of the valve opening. Such engines can be started and run without a starter motor for certain multi-cylinder engines (Ian, 2003). Equipped with precision timed electronic ignition and fuel injection. Such a *static-start* engine would provide the efficiency and pollution-reduction improvements of a mild hybrid-electric drive, but without the expense and complexity of an oversized starter motor (Kassakian, 1996). General Motors' first ECUs had small application of hybrid digital ECUs as a pilot program in 1979; by 1980, all active programs were using microprocessor based systems. Due to large ramp up of volume of ECUs that were produced to meet the US Clean Air Act requirements for 1981, only one ECU model could be built for the 1981 model year (http://history.gmheritagecenter.com/wiki/index.php/GM_Emission_Control_Project_Center_-_I_Was_There). The high volume ECU that was installed in GM vehicles from the first high volume year, 1981, onward was a modern microprocessor based system. GM moved rapidly to replace carburetor based systems to fuel injection type systems starting in 1980/1981 Cadillac engines, following in 1982 with the Pontiac 2.5L "GM Iron Duke engine" and the Corvette Chevrolet L83 "Cross-Fire" engine. In just a few years all GM carburetor based engines had been replaced by throttle body injection (TBI) or intake manifold injection systems of various types. In 1988 Delco Electronics, Subsidiary of GM Hughes Electronics, produced more than 28,000 ECUs per day, the world's largest producer of on-board digital control computers at the time. Fuel pressure is similar to a single-point injection system. CPFI (used from 1992 to 1995) is a batch-fire system, while CSFI (from 1996) is a sequential system (Chevrolet Truck Service Manual, 1997).

Fuel injection introduces potential hazards in engine maintenance due to the high fuel pressures used. Residual pressure can remain in the fuel lines long after an injection-equipped engine has been shut down. This residual pressure must be relieved, and if it is done so by external bleed-off, the fuel must be safely contained. If a high-pressure diesel fuel injector is removed from its seat and operated in open air, there is a risk to the operator of injury by hypodermic jet-injection, even with only 100 psi (6.9 bar) pressure (Agha, 1978). The first known such injury occurred in 1937 during a diesel engine maintenance operation (Rees, 1937).

Several technologies that are shaping society in a variety of ways will likely characterize the future of transportation. Intelligent transportation systems apply the latest advances in computers and electronics to better control vehicle operations. Computerized road maps used with the Global Positioning System (GPS) help drivers to navigate. Companies that use fleets of vehicles, such as delivery companies, can use satellite technology to monitor the location of their vehicles at all times and improve efficiency (Kevin, 2008). The improvement of materials used for transportation vehicles and infrastructure is an area of current active research (Kevin, 2008). Composite material, which is a hybrid consisting of many different component materials, can provide lightweight, extremely strong, and highly durable material for vehicle construction (Kevin, 2008).

The costs to society of using automobile, which may include those of maintaining roads, land-use, pollution, public health, health care, and of disposing off vehicles at the end of their service lives, can be balanced against the value of the benefits to society that automobile use generates. The societal benefits may include direct economic benefits, such as job and wealth creation (from automobile production and maintenance), transportation provision, society well being (derived from leisure and travel opportunities), and revenue generation from the tax opportunities. The ability for humans to move flexibly from place to place has far reaching implications for the nature of societies (US EPA, 2011).

Despite the importance of transportation to humankind they do pose several significant threats to welfare, especially in terms of heath and ecosystem stability. Thus, Ball (2009) asserted that transportation is a major contributor to air pollution in most industrialized nations. According to Ball (2009), the American Surface Transportation Policy Project reported that nearly half of all Americans are breathing unhealthy air. The researcher further revealed that air quality in dozens of metropolitan areas has worsened over the last decade. In the United States the average passenger car emits 11,450 pounds (5,190 kg) of the greenhouse gas, carbon dioxide annually, along with smaller amounts of carbon monoxide, hydrocarbons, and nitrogen. Fuel taxes may act as an incentive for the production of more efficient, hence less polluting, car designs (e.g. hybrid vehicles) and the development of alternative fuels. High fuel taxes may provide a strong incentive for consumers to purchase lighter, smaller, more fuel-efficient cars, or to not drive. On average, today's automobiles are about 75 percent recyclable, and using recycled steel helps reduce energy use and pollution (Hogg, 2009).

In Ghana, artisans with little or no educational background occupy such a central and vital position in the maintenance and servicing of vehicles that have been of paramount interest, not only to the government and to the public as a whole, but also many researchers. To solve the world's global warming and many other problems, there have been continuous innovations of new models of vehicles which have resulted in diverse combinations of mechanics. The carburetor remains in use in developing countries where vehicle emissions are unregulated and diagnostic and repair infrastructure is sparse. This has resulted in continuous pressure on the maintenance industry at "Suame Magazine" (the largest auto mechanic workshop in the West African sub region), to maintain and service these vehicles on which little are known. Thus, the researcher looks at the documentation of these challenges, critical analysis and appropriate recommendation that would help curtail the problems that ensue in the servicing of modern vehicles in Ghana, by the Suame Magazine.

1.2 Problem Statement

Transportation is one of the important tools for the development of a nation (Kevin 2008). Artisans occupy such a central and vital position in the maintenance and servicing of vehicles that have been of paramount interest not only to the government and the public as a whole but also many researchers. Continuous innovations of new models of vehicles have resulted in diverse combinations of mechanics. This has resulted in continuous pressure on the maintenance industry, to maintain and service these vehicles in all their complexities. The maintenance and servicing of modern vehicles have become a major problem for the artisans of the country in recent years, more especially at the Suame-Magazine. Many modern cars are seen packed at many garages at Suame magazine unattended to. The general perception is that artisans find it difficult to determine problems faced by such modern vehicles because the artisans are ill-informed, under-educated, lack requisite up-to-date training and continue to use old methods of diagnosing vehicle faults, thus trial and error. Due to the use of try and error, methods in determining faults artisans sometimes make things worse or condemn the vehicles. The modern fuel injection vehicles need modern diagnostic equipment in determining problems of vehicles and this cannot be done without having knowledge of such equipment.

Suame magazine is one of the important sectors that help in the rapid economic development of the country. Thus, the study of problems facing the artisans assumes an added importance and relevance to the researcher. Therefore, the researcher looks at the documentation of these challenges, critical analysis and appropriate recommendation that would help curtail the problems that ensue.

1.3 Justification

The significance of the study in question cannot be over emphasized. There is the need at the moment to help improve the sinking image of artisans in the maintenance of modern vehicles, to enable the sector prevail against poor servicing rendered. Poor servicing is perceived to be a result of lack of proper equipment, inadequate training of artisans and poor attitude towards work by the artisans. The study will therefore assume an added importance and relevance. The study is bound to contribute to effective maintenance culture in the country by first identifying the problems faced by the artisans, diagnosis and design of possible solutions and the development of remedies through appropriate technology that would solve the problems that have been militating against the sector for the past years. The findings would bring to fore the gap left between artisans and authorities, make authorities aware of what artisans need and expect authorities to do to improve their levels of conditions of service and job satisfaction. This study will definitely serve as a source of knowledge to future researchers.

1.4 Main Objective

The main objective is to determine the difficulties faced by artisan/technician in the field of servicing and maintaining of modern electronic automobile vehicles.

1.4.1 Specific objectives

The specific objectives of the study are to:

1. determine the difficulties encountered by artisans at Suame-Magazine in the servicing of modern vehicles
2. examine the general equipment used in servicing modern vehicles by the artisans and how they impact on job satisfaction
3. determine the type of training needed by the artisans
4. give recommendations on how the conditions of service of the artisans can be improved to enhance job satisfaction.

1.4.2 Research Questions

In the light of the effect of proper maintenance culture and effective work done the following questions are deemed important:

1. What are some of the difficulties you encounter in servicing of modern vehicles?
2. What tools are used in your workshop for determining faults on fuel injection vehicles?

3 Why are artisans not interested in using the diagnostic fuel equipment.

3. What type of training do you give to your employees and how does it impact on job satisfaction?

4. What kind of training or help would the artisans need from government and NGOs?

1.5 Scope of the Study

The study was done in the Kumasi Metropolis. The Suame-magazine, Kumasi and its environs were specifically studied to enable the researcher do a thorough research of the problems at stake. The study was defined within the boundary of modern vehicles only. Samples respondents comprised randomly selected senior mechanics and electricians based on the administrative zonation of The Kumasi Association of the Garages.

1.6 Limitation of the Study

The major constraint encountered during the study were scant documented information on the Suame Magazine and inadequate of funds. In addition, time available for the research was limited to one (1) year, hence the limitation of the work to only the Suame Magazine in the Kumasi Metropolis. The study was further limited by scant information relating to the problems identified (due to unavailability of previous research works), hence inadequate and ineffective literature review. Refusal to reveal some information on the part of respondents for fear of victimization and uncertainty was another problem that significantly hampered the progress of this research.

1.7 Overview of Research Methodology

In order to achieve the objectives set out, the researcher adopted case study as a research methodology. Based on the administrative zonation of The Kumasi Association of the Garages, a total of 200 workshops, made up of 100 senior electricians and 100 senior mechanics, were selected at random for the study. Both primary and secondary sources of data were used to gather enough and appropriate information for both literature review and discussion. Questionnaires were administered to only senior artisans. Finally, data extracted from the study were cleaned, evaluated and analyzed using both qualitative and quantitative techniques. Quantitative analyses were done through the use of the Statistical Package for Social Sciences (SPSS), whiles qualitative data was analyzed by using tables and percentages in Microsoft (2010) Excel spreadsheet.

1.8 Organization of the Study

The study comprises five chapters. The first chapter is a general introduction, which deals with the background of the study, the statement of problem, objectives, significance, scope, overview of research methodology, limitation and organization of the study. The second chapter provides a theoretical framework within which the study is located and some related research findings; this chapter deals specially with the literature review. Chapter three highlights methodology, i.e. the procedures adopted to collect information for study. It involves detailed discussion of the methods of data collection and analysis. Chapter four provides the results of the data analysis and discussion of the result. Chapter five contains the summary, conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter looks at the theoretical framework within which this study is carried out. Thus, literatures in the field of auto-mechanics relevant to the research are sampled and organised in this chapter.

2.1 History of Automobile Production

The introduction of the automobile production dated back to 15th Century when the famous Italian genius, Leonardo da Vinci suggested the possibilities for power-driven vehicles. Later in 17th Century, Eckermann (2001) revealed that the history of the automobile began as early as 1769, with the creation of steam engine automobiles capable of human transport. Consequently, the famous English physicist Sir Isaac Newton proposed the concept of a steam carriage which was brought to reality in the late 18th Century by French Army Captain Nicholas- Joseph Cugnot. During the mid-1800s, the attention had shifted to internal-combustion engines which were safer and easy to operate than the steam-driven engines. The first successful version of the internal-combustion engine was built by Jean-Joseph Etienne Lenoir in 1859 (http://www.edmunds.com/advice/specialreports/articles/101677/article.html).

This model was revised by a German shop clerk, Nikolaus August Otto in 1876 and hence came to be known as the Otto engine. His compatriots Gottlieb Daimler and Karl Benz used this model to build the first modern cars, which were launched in 1886. In the US, George Baldwin Selden, made further improvements to the engine, by reducing its weight thereby, making it compatible for light vehicles. The first automobile company was founded in 1896 by Charles Edgar Duryea and his brother Frank and this initiative paved the way for the emergence of an automobile production.

The automobiles manufactured in the 1890s were called as 'horseless carriages.' This marked the beginning of craft production as all the manufacturing was done by craftsmen employed in metal and machine tool industries. Each car was tailor-made to suit the needs of wealthy customers. But this craft-based production structure demanded skilled workers and resulted in very low production volume. By early 20th Century, the craft-based system was replaced by mass production techniques (http://www.ucsusa.org/clean_vehicles/cars_pickups_suvs/hybridelectric-vehicles.html), popularized by Henry Ford. In 1913-14, he upgraded the existing push and move assembly line to a conveyor belt line, which reduced assembly time considerably. His famous Model T was assembled in 93 minute (http://www.free-essays.us/dbase/b1/utv237.shtml). The main advantage of mass production technique over craft-production was the ability to manufacture several products simultaneously rather than one at a time. The other features like inter-changeability of standard parts, standardized product design, and centralized hierarchy of tasks helped to realize economies of scale. This increased labor productivity by leaps and bounds but also brought about a reduction of skilled labors. Each worker performed identical tasks using identical tools which were always kept within hand-reach. It was found that the Ford assembler's average task cycle declined from 514 minutes in 1908 to 1.19 minutes with the introduction of moving assembly line in 1913 (Sako, 2006). The enormous success of mass production resulted in the global sector being dominated by the American car manufacturers. In 1955, North America accounted for 75% of global motor vehicle production. The Big Three, Ford, GM and Chrysler accounted for 95% of all American car sales.

In Europe, mass production was widely adopted in the 1950s through the initiatives of Volkswagen, Renault and Fiat. But rather than production efficiency, the emphasis was more on product differentiation and technical innovation (Sako, 2006). Their product offerings included compact cars (VW Beetle), sporty cars (MG) and luxury cars. Front-wheel drive, fuel injection, unitized bodies, and five-speed transmissions were some of their innovations in the technical front. Thus with focus on product strategy, the European automobile industry contributed more than the US to the global automobile production during 1960s and early 1970s.

Japanese auto-makers emerged as a force to reckon with in the global scenario with the oil crisis in 1973, and subsequent price increases in 1979 (Kathy, 2006). The crisis had resulted in a shift in consumer demand for energy efficient cars, a segment hitherto dominated by the Japanese automakers. By 1980s, the Japanese auto-makers were benefited from the voluntary export restraints in the US and set up assembly plants known as transplants within North America. Towards the latter half of 1990s Japanese cars accounted for 40% of the total North American sales. In addition to cost savings by way of cheap labor, they also initiated better manufacturing techniques such as the Toyota Production System, developed by Taiichi Ohno in the 1960s and 1970s based on lean production techniques in the 1980s (Table 1).

*"Lean Production is a system of work organization that strives to deliver high quality, low-cost products through the efficient use of resources and the elimination of waste." (*http://www.lir.msu.edu/piers/leanproduction.htm).

Table 2.1: Mass Production versus Lean Production - a Comparative Analysis

Mass Production	Lean Production
Complete inter-changeability of standardized parts and the simplicity of attaching them to each other.	More general resources e.g. multi-skilled workers and general purpose machines, for flexible production.
A standardized product design that enabled production in large batches to achieve economies of scale, coupled with large buffers of inventory stock to prevent any interruptions in production.	Small buffers and lot sizes to facilitate a market strategy of responding quickly to demand fluctuations with a greater variety of product designs.
A centralized hierarchy that controlled and coordinated specialized and narrowly defined tasks.	More decentralized authority with greater lateral communication across functional boundaries, team work, and operators' participation in quality circles and continuous improvement activities.

Source: Sako (2006)

Toyota Production System was built on two main principles namely, 'Just-In-Times' production and 'Jidoka.' The underlying concept of the system was 'Good Thinking Mean Good Product.' The approach helped to manage equipment, materials, and labor in the most efficient manner while ensuring a healthy and safe work environment. Just-In-Time referred to the manufacturing and conveyance of only what is needed, when it is needed, and in the manner needed. Jidoka referred to the ability to stop production lines, by man or machine, in the event of problems such as equipment malfunction, quality issues, or late work, thereby preventing the passing of defects, helping to identify and correct problem areas using localization and isolation, building quality to the production process.

Sako (2006) in his report on 'Automobile Industry,' discussed the research findings highlighting the advantages of lean production. A study undertaken by the International Motor Vehicle Program in 1989 proved that North American and European assembly plants were taking on an average 50% and 100% longer time, respectively to assemble a car than their Japanese counterparts. In 1990, Womack *et al* conducted a study on the quality parameter. Quality was found to be considerably worse for American and European plants than in Japanese plants. The same study, repeated in 1993, indicated that lean production techniques were becoming popular throughout the world. Clark and Fujimoto in 1991, studied product development projects during 1983-87 from auto-makers in Japan, US and Europe and found that the Japanese producers took 47 months of engineering time to design a new vehicle, compared with 60 months in the US and Europe. This was done by fully exploiting the overlapping product development phases and effectively using the suppliers as part of the development team. Gutiérrez (2003), reported that the Toyota Production System heralded the third major revolution in manufacturing (http://www.autoindustry.co.uk/statistics/production/uk/Top%20Manufacturers), and was the brain child of Eiji Toyoda, who served as the CEO and Chairman of Toyota until 1994. The main features of the system included greater product variety, fast response or flexibility, stable production schedules, supply chain integration and demand management. Supply chain management was done with greater effectiveness in Toyota Production System, ushering in steady production volume, leaner processes in terms of cost/flexibility/quality and more profits for the suppliers.

Thus the global automobile industry had covered a remarkable journey spanning through centuries covering craft production, mass production and currently excelling in lean production techniques, setting standards for manufacturing sector (Table 2).

Table 2.2: Trends in Production Techniques - A Comparative Analysis

		CRAFT PRODUCTION	MASS PRODUCTION	LEAN PRODUCTION
Role of Machinery		Augments the skills of the craftsperson	Displaces the skills of the worker	Same as mass
Organization		Independent or small shop	Hierarchical, workers vs management	Team-based, collaborative
Skill Level		Extremely high, often the point of differentiation	Low as possible.	Very high. Flexibility, responsibility for process improvement are key.
Flow of Product		Little. Worker moves to each "project"	High. Large batches.	High, but small batches.

Production level		Small, somewhat "build-to order"	Large, production level determined by forecast	Large, but break-even point much lower than that of Mass Production. Market pull is ideal.
Supplier relationships		Forced to buy "off the shelf", some "customizing" done before incorporation	Parts often designed by company, order bid on by suppliers	Tier system, high degree of collaboration. Therefore, small # of suppliers.

Source: http://camm.queensu.ca/mech426_2004/notes.htm

2.2 Automobile Maintenance Management

In the view of http//: umpir.ump.edu.my/..Rafidah_Rahim.pdf, maintenance is the recurring day-to-day, periodic, or scheduled work required to preserve or restore facilities, systems, and equipment to a given condition. In the early stages of industrial development, maintenance practices were simple, primarily of the housekeeping and breakdown types. However, as the complexity of facilities, equipment and systems increased, so did the problems and expenses involved in maintenance are operations (http//: umpir.ump.edu.my/..Rafidah_Rahim.pdf). It became increasingly obvious that improvement of maintenance management practices and procedures was essential to achieve efficiency and effectiveness of the maintenance operations.

In fact, the greatest and most successful system is one that is simple, practical and gives the preferred results. Nowadays, maintenance of engineering equipment in the field has been a challenge. Although impressive progress has been made in maintaining equipment in the field in an effective manner, maintenance of equipment is still a challenge due to factors such as size, cost, complexity, and competition (http//:umpir.ump.edu.my/.Rafidah-Rahim.pdf).

Today's maintenance practices are market driven, in particular for the manufacturing and process industry, service suppliers, and so on. An event may present an immediate environmental, performance, or safety implication. Thus, there is a definite need for effective asset management and maintenance practices that will positively influence critical success factors such as safety, product quality, and speed of innovation, price, profitability, and reliability delivery (http//: umpir.ump.edu.my/.Rafidah-Rahim.pdf).

Nevertheless, http//: en.wikipedia.org/wiki/service_(motor vehicle) pinpointed that vehicle service is a series of maintenance procedures carried out at a set time interval or after the vehicle has travelled a certain distance. The service intervals are specified by the vehicle manufacturer in a service schedule and some modern cars display the due date for the next service electronically on the instrument panel. In along with http//: en.wikipedia.org/wiki/servicing, maintenance tasks commonly carried out during a motor vehicle service include: change the engine oil, replace the oil filter, replace the sparks plug etc.

2.3 Auto mechanic

An auto mechanic is a mechanic with a variety of automobile makes or either in a specific area or in a specific make of automobile (www.thefreedictionary.com/auto_mechanic). In repairing cars, www.youtube.com/channel/HCleioGnOAU0 revealed that the main role of mechanic is to diagnose the problem accurately and quickly of any vehicle. Further, they have to estimate prices for their customers before commencing work or after partial disassembly for inspection. In the observation of http:// en.wikipedia.org/wiki/auto-mechanic, vehicle maintenance is a primary part of a mechanic's work in modern industrialized countries, while in others they are only consulted when a vehicle is already showing signs of failure. Preventative maintenance is also a fundamental part of a mechanic's job, but this is not possible in the case of vehicles that are not regularly maintained by a mechanic (http//: en.wikipedia.org/wiki/auto-mechanic).

With the rapid advancement in technology, http:// en.wikipedia.org/wiki/auto-mechanic suggested that the mechanic's job has evolved from purely mechanical, to include electronic technology. In addition http:// en.wikipedia.org/wiki/auto-mechanic, vividly explained, vehicles today possess complex computer and electronic systems, mechanics need to have a broader base of knowledge than in the past.

Due to the increasingly complex nature of the technology that is now incorporated into automobiles, most automobile dealerships and independent workshops now provide sophisticated diagnostic computers to each technician, without which they would be unable to diagnose or repair a vehicle (http:// en.wikipedia.org/wiki/auto-mechanic).

2.4 Maintenance Methods

Lindley and Brautigam (1994) asserted maintenance methods should be actions undertaken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Unfortunately, www.1.ere.energy.gov/../OM_5.pdf reviewed that data obtained in many studies over the past decade indicates that most private and government facilities do not use the necessary resources to maintain equipment in proper working order. Rather, they wait for equipment failure to occur and then take whatever actions are necessary to repair or replace the equipment. Nothing lasts forever and all equipment has associated with it some predefined life expectancy or operational life.

Ideally, maintenance is performed to keep equipment and systems running efficiently for at least design life of the components (www.1.ere.energy.gov/./OM_5.pdf). The design life of most equipment requires periodic maintenance. Belts need adjustment, alignment needs to be maintained, and proper lubrication on rotating equipment is required. Lindley and Brautigam (1994) highlighted certain components need replacement, (e.g., a wheel bearing on a motor vehicle) to ensure the main piece of equipment last for its design life. Anytime we fail to perform maintenance activities proposed by the equipment's designer, we shorten the operating life of the equipment observed on www.1.ere.energy.gov/../OM_5.pdf. In addition to waiting for a piece of equipment to fail (reactive maintenance), preventive maintenance, predictive maintenance, or reliability centered maintenance can be applied.

2.4.1 Reactive maintenance

Reactive maintenance is mostly the run it till it breaks maintenance mode (www.1.ere.energy.gov/./OM_5.pdf). No actions or efforts are taken to maintain the equipment as the designer originally projected to ensure design life is reached. Studies as recent as the winter of 2000 indicate this is still the major mode of maintenance in the United States (www.1.ere.energy.gov/./OM_5.pdf).

2.4.2 Preventive maintenance

Preventive maintenance described as the care and servicing by personnel involved with maintenance to keep equipments in satisfactory operational state by providing for systematic inspection, detection, and correction of incipient failures either prior to their occurrence or prior to their development into major failure (Richard, 1999). Thus, objectives of preventive maintenance are to reduce critical equipment breakdowns, allow better planning and scheduling of needed maintenance work, and promote health and safety of maintenance personnel (www.1.ere.energy.gov/./OM_5.pdf).

2.4.3 Predictive maintenance

According to Lindley and Brautigam (1994) predictive maintenance can be defined as measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Results indicate current and future functional capability.

In essence, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule (www.1.ere.energy.gov/./OM_5.pdf).

2.4.4 Reliability centered maintenance

Moubray (1997) and Nissen *et al.* (2006) defined reliability centered maintenance (RCM) as a systematic method to quantitatively estimate the need to perform or update preventive maintenance effort and procedures on safety basis and economical consequences. Mostly, reliability centered maintenance methodology deals with some key issues not dealt with by other maintenance methods. NASA (2000) recognized that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others.

2.5 Training of Technicians in Modern Vehicle Maintenance

Automotive service technicians inspect, maintain, and repair automobiles and light trucks that run on gasoline, electricity, or alternative fuels (http://www.portal.state.pa.us/portal/server.pt/document/1244898/pos_470604_pdf). Responsibilities of automotive service technicians and mechanics have evolved from simple mechanical repairs to high level technology related work. The increasing complexity of automobiles requires workers who are able to use computerized shop equipment and work with electronic components while maintaining their skills with traditional hand tools (http://www.portal.state.pa.us/portal/server.pt/document/1244898/pos_470604_pdf). As a result, automotive service workers are usually called technicians rather than mechanics.

Integrated electronic systems and complex computers regulate vehicles and their performance while on the road. Based on this http://www.portal.state.pa.us/portal/server.pt/document/1244898/pos_470604_pdf revealed that technicians must possess the following:

- An increasingly broad knowledge of the complexity of components of vehicles.

- Able to work with electronic diagnostic equipment, digital manuals and reference materials.
- Able to use a variety of tools in their work.

Nevertheless, Computers are also commonplace in modern repair shops. Through the internet or software packages, most shops receive automatic updates to technical manuals and access to manufacturers' service information, technical service bulletins, and other databases that allow technicians to stay current with industry standards (http://www.portal.state.pa.us/portal/server.pt/document/1244898/pos_470604_pdf). Most employers regard the successful completion of a training program in automotive service technology as the best preparation for trainee positions.

In the United States, several programs and schools that offer training for those interested in pursuing competencies as an automotive mechanic or as an auto technician already exist (http:// en.wikipedia.org/wiki/auto-mechanic). Areas include powertrain repair and diagnosis, emissions, and suspension. The National Automotive Technicians Education Foundation (NATEF) is responsible for evaluating technician training programs against standards developed by the automotive industry (http:// en.wikipedia.org/wiki/auto-mechanic).

Therefore, the technology used in automobiles changes very rapidly and the mechanic must be equipped to learn these new technologies and systems (http:// en.wikipedia.org/wiki/auto-mechanic).

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

This chapter describes the study area including population, the research design and methodology, sources of data, sampling techniques, and instrument for data collection and method of data analysis.

3.1 Description of Study Area

3.1.1 Study area

The study area encompassed the territories of the Suame Industrial Area, popularly called "Suame Magazine". This was purposively selected [against the background that it is the largest single car maintenance location in the country (Ghana)] to ascertain the level of maintenance of electronic fuel injection vehicle in the country.

3.1.2 Location

The "Suame Magazine" is located in the Kumasi Metropolis in the Ashanti region of Ghana. Suame an industrialized area of Ghana. It is located on coordinates 6°45′0″N 1°42′0″W, and 10 kilometers from Kumasi the capital of the Ashanti Region (Blogspot archives, 2011). It is in the Suame constituency of Ghana and part of the KMA's administrative district. It is the best industrialized zone in Ghana and one the biggest industrialized zone in Africa.

Fig. 3.1: Location of the Suame Industrial Area in Kumasi, Ghana (circled)

[Source: Ghana Districts, 2010]

3.1.3 Population

According to Damptey (2013) the population of the Suame Magazine as at 1995 stood at 150, 000. This was evaluated by The Garages which had been formed in 1982 (Damptey, 2013).

3.1.4 The Suame Magazine

According to Damptey (2013), the history of the Suame Magazine dates back to 1982, when the then president, J. J. Rawlings decided to develop and bring together the then scattered vehicle workshops at Kejatia. The aim was to train workers from students and Youth Task Force to gain requisite knowledge in vehicular maintenance.

In 1982, Mr. Damptey was appointed as the secretary and the leader of student and youth taskforce during the PNDC era under President Rawlings (Damptey, 2013). After that mobilization he was served a letter to launch what was called 'cannibalization'. This took place at Technology Consultancy Center (TCC). Cannibalization as used by Damptey referred to "the process of using broken down vehicle parts to repair another vehicle into good condition". So with this method, they were able to put eighteen (18) government vehicles into good condition. The report reached the then government and with immense contributions in creativity and innovations, it quickly paved the way for them to use Suame Foundry Limited to produce simple agricultural tools and simple spare parts such as bolts, nuts, etc. He used that opportunity to recruit about 30.to 35% of Secondary/ elementary school leavers, those drop-outs from schools and unfortunate ones who could not have access to education, and taught them the basic skills in automobile engineering.

Currently, the Suame Magazine is run on administrative basis by The Kumasi Association of the Garages. Their vision is to design and produce vehicles in the near future for sale; whiles their mission states that "The Suame magazine exists to deliver services in the maintenance of modern electronic vehicles as well as old vehicles to reduce the rate of motor accidents in the country. Typical workshop at the Suame Magazine is depicted in Plate 3.1.

Plate 3.1: A workshop at the Suame Magazine

3.1.5 Organizational Structure of the Suame Magazine

The Suame Magazine is made up of artisans of various departments of vehicle maintenance. These include autobody, engine mechanics, auto electrical, spraying, upholstery, auto electrical workshops, welding and fabrication, vehicle air conditioning, fuel pump servicing, vulcanizing and many others. The various departments, though owned by individual or group of masters, are well coordinated under the auspices of The Kumasi Association of the Garages, with Head office located on site [Suame Magazine].

3.1.6 Current plans of the Kumasi Association of the Garages

Under the administration of the Kumasi Association of the Garages, an NGO called Suame Magazine Industrial Development Organization (SMIDO) was formed in the year 2005 for the sole establishment of new mechanic sites to accommodate the ever-increasing expansion of the present site. Consequently, SMIDO has been able to acquire 1000 hectares of land at Kodie-Adobreso Kesse on the Kumasi-Techiman road. The site is under vigorous construction, hopefully to be opened to artisans in the year 2014.

3.2.1 Research Design

This study used a descriptive survey design based on Seekaran (2003) case study approach. This study sought to gather information with the intention of generalizing a sample of Kumasi Metropolis Mechanics/technicians, at the Suame Magazine, to a population of mechanic/technicians in Ghana.

3.2.2 Sources of data

The data for the study were collected through the principal methods of field research (a survey). Both primary and secondary data were employed for the study.

3.2.3 Primary data

The primary data was obtained through a structured questionnaire. Questionnaire was designed for all respondents. Respondents were the workshop owners who were senior mechanics practicing on the field. Questionnaires sought to assess respondents views on the difficulties in the maintenance and servicing of modern electronic fuel injection vehicles. Moreover, focus group discussions were also used to source relevant information regarding the perception and general trends in difficulties encountered in vehicular maintenance.

3.2.4 Secondary data

Data was also collected from secondary sources. Sources of secondary data assessed for this study included literatures on the research area and topic. Information was also sourced from The Mechanical Association, an umbrella group of various workshops and artisans operating within the Suame Magazine catchment area. Views of opinion leaders at the study area were also considered, especially at the pre-diagnostic/familiarization phase of the study.

3.2.5 Sample size determination

Based on The Kumasi Association of the Garages administrative structure, the Suame Magazine is divided into two (2) major sites; the Old Site (old Suame) and New Site (Tafo and Asafo). The Old Site is further zoned into six (6) operational zones, appropriately named Zone 1, Zone 2, Zone 3, Zone 4, Zone 5 and Zone 6 (Table 3.1). Meanwhile, the new site comprises twenty six (26) zones, appropriately named as above. For each site, five (5) zones were randomly selected for the survey. A total of 20 respondents, 10 each for auto-mechanics and auto-electrical, were also randomly selected for each zone (i.e. from the total list of workshops identified in the familiarization stage). Random selection was done by way of secret ballot. Thus, a combined total of four hundred (400) senior mechanics and electricians were investigated in this survey.

Table 3.1: The Distribution of the Category of the Study: Study Population and Sample Size

***LOCATION**		**NUMBER OF RESPONDENTS**	
		Auto-mechanics	**Auto-Electricals**
OLD SITE	Zone 1	10	10
(Old Suame,)	Zone 2	10	10
	Zone 6	10	10
	Zone 4	10	10
	Zone 5	10	10
NEW SITE	Zone 7	10	10
(Tafo)	Zone 21	10	10
	Zone 3	10	10
	Zone 14	10	10
	Zone 15	10	10
TOTAL		100	100

The Kumasi Metropolis of the Garages **(Source: Damptey, 2013)**

3.2.6 Sampling Techniques /Procedure

Completely randomized sampling procedure was adopted for the selection of the respondents in order to minimize bias to the barest minimum.

3.3.7 Research Instrumentation Technique

The structural data was ascertained by way of structured questionnaires. There were five (5) sections in this questionnaire based on the specific objectives of the study;

namely, the demographic characteristics, difficulties in servicing modern vehicles, equipment used in servicing modern vehicles and impact on job satisfaction, type of training needed by the artisans and ways of improving the conditions of service to enhance job satisfaction. The researcher's interaction with the technicians at the Suame Magazine during the field survey is depicted in Plates 3.2 and 3.3.


Plate 3.2: Researcher administering questionnaires to technicians at the Suame Magazine

Plate 3.3: One of the artisans asking questions in relation to the questionnaire

3.4 Data Analysis and Presentation Procedure

The data collected were cleaned, coded and organized into tables for analysis using the Statistical Package for Social Sciences (SPSS). Analysis were done based on the research questions formulated and administered in this study. Both qualitative and quantitative analytical procedures were used. The data were quantitatively analyzed using means. Simple percentages were found on responses and the views of mechanics on some important issues in the questionnaires. Data were presented in the form of tables, bar graphs and line graphs for easy visual interpretations. Chi-square test for homogeneity of the study was used to ascertain significant differences at 5%; this was also used to determine the homogeneity of the respondents selected from the different study groups under investigation ($p < 0.05$).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 INTRODUCTION

This chapter looks at the results gathered from the field survey and the resultant implication of the data collated. It deals with the summary of the data, analysis and interpretation of trends.

4.1 DEMOGRAPHIC INFORMATION OF THE RESPONDENTS UNDER STUDY

4.1.1 Gender of respondents under study

From Fig. 4.1.1, both males and females were identified in the study such that male artisans recorded the highest, 91.0% whiles female artisan had 9.0%. The error bars in the Fig. 4.1.1 reveal that the differences between the gender groups are significant ($p < 0.05$).

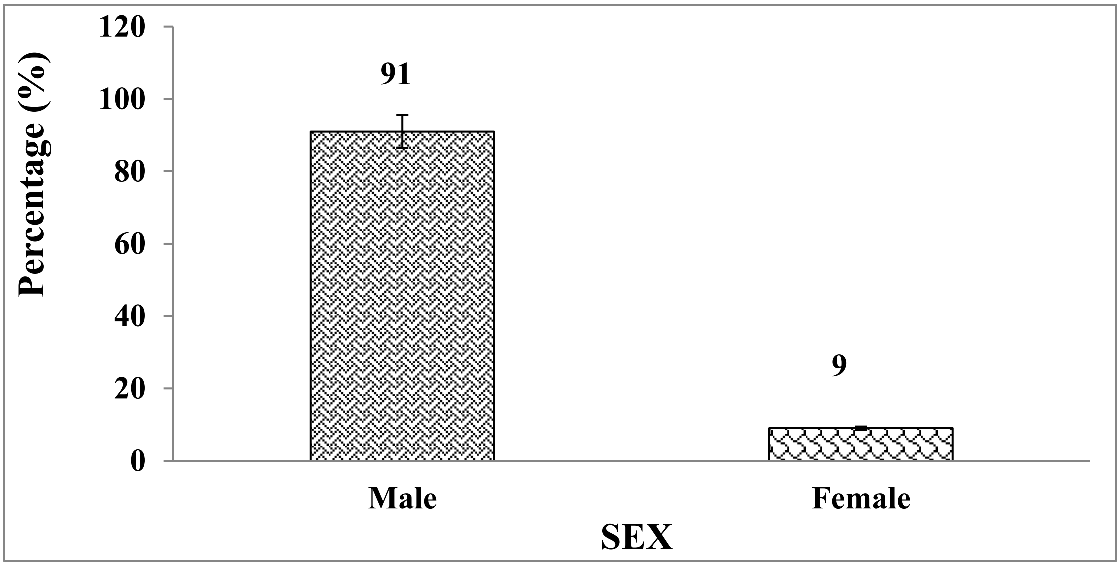

Fig. 4.1.1: Gender of respondents under study

4.1.2 Age groups of respondents under study

All the age categories investigated were represented among the respondents, such that the 21 – 40 year group recorded the highest, 41.5% (Fig. 4.1.2). The lowest age group was identified to be below 20 age group which had 9.0%. From the error bars in Fig. 4.1.2, significant differences exist among all the age groups surveyed in this study at 5%.

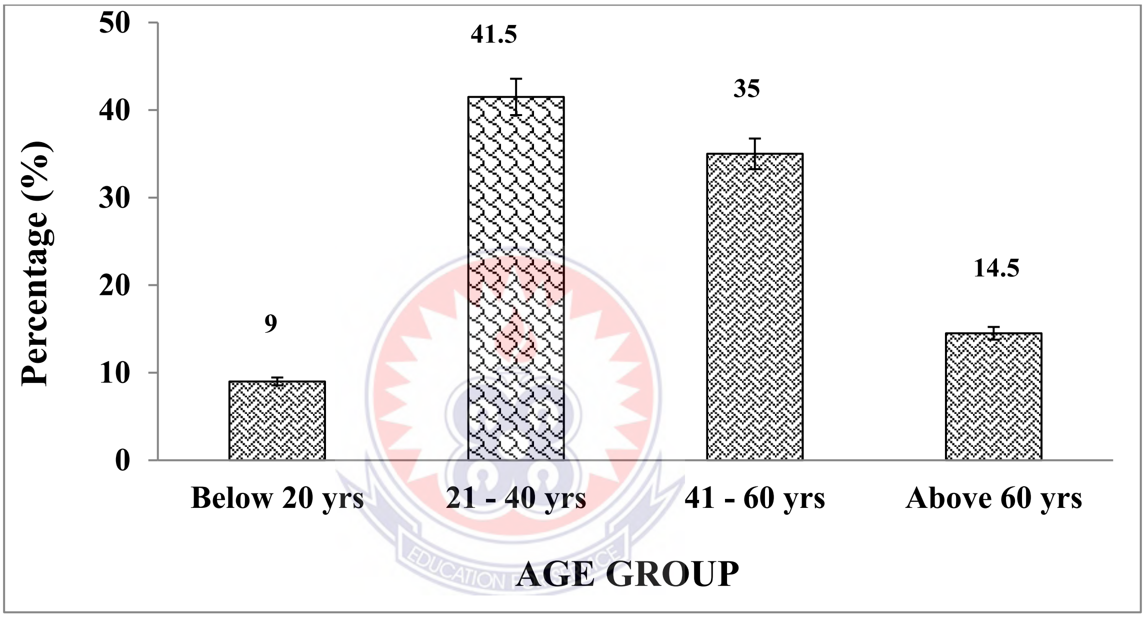

Fig. 4.1.2: Age groups of respondents under study

4.1.3 Educational background of respondents under study

While some of the respondents had no formal education (17.5%), 10% had been educated to the tertiary level. However, the MSLC/JHS recorded the highest percentage (60.5%) and the SHS & A level recorded the lowest (5.0%). From Fig. 4.1.3, the percentages recorded for the various categories of educational statuses were significantly different ($p < 0.05$) from one another.

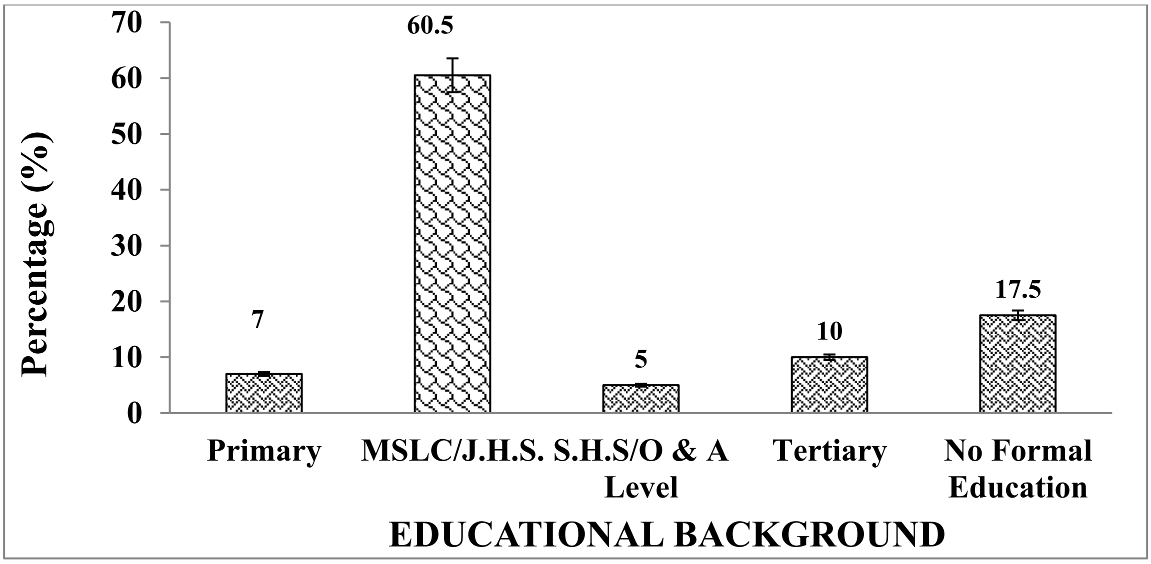

Fig. 4.1.3: Educational background of respondents under study

4.1.4 Marital status of respondents under study

About 60% (59.0%) of respondents were married whiles 3.5% had been widowed. Artisans who were yet not married constituted 28.0% whiles divorcees represented 9.5% of the respondents (Fig. 4.1.4). the error bars in Fig. 4.1.7a reveal that differences among the marital statuses of the rspondents are significant ($p < 0.05$).

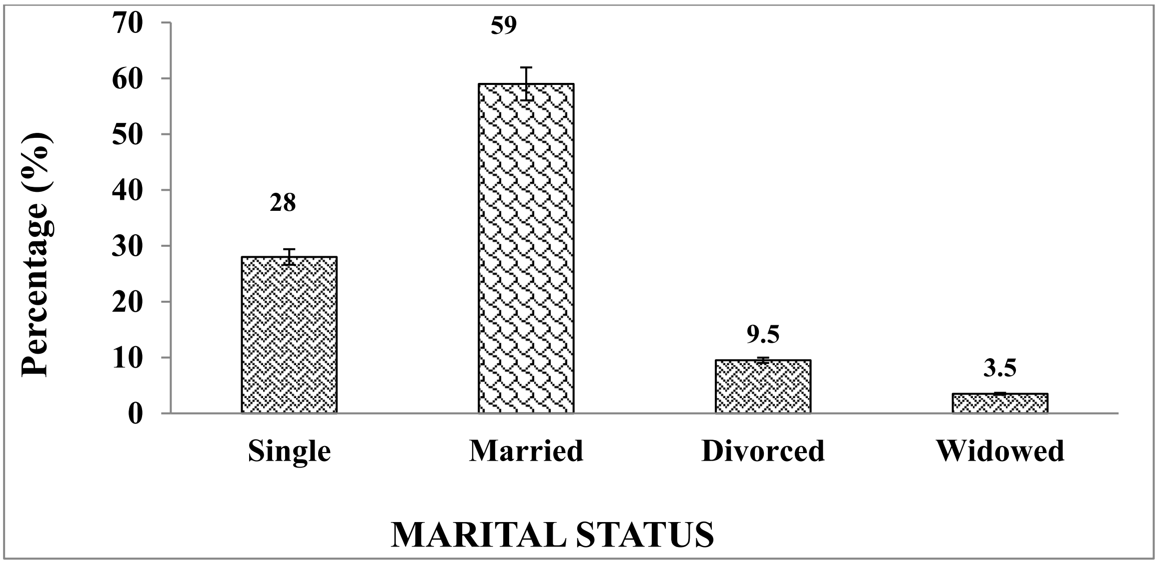

Fig. 4.1.4: Marital status of respondents under study

4.1.5 Number of apprentices of respondents under study

The study identified varying number of apprentices for the respondents. It was revealed that among the respondents, artisans with less than 6 apprentices dominated with 40.5%, though not significant from those with 6 to 10 apprentices (Fig. 4.1.5). Artisans with 11 – 15 apprentices and those with above 15 apprentices recorded 11.5% each, and these were also not different.

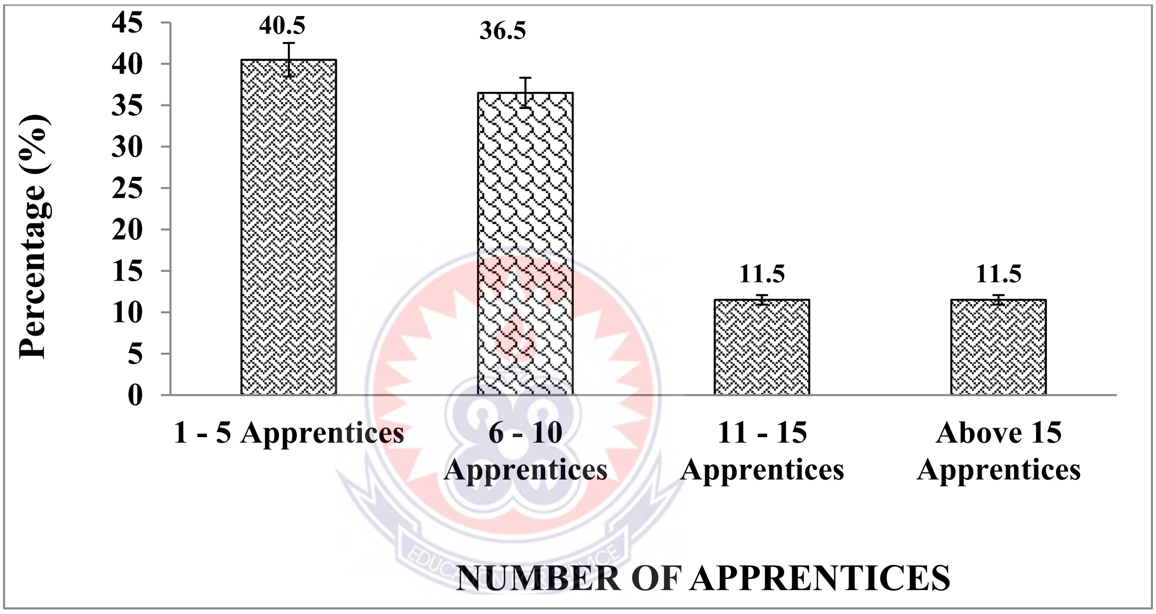

Table 4.1.5: Number of apprentices respondents under study of

4.2 DIFFICULTIES IN SERVICING MODERN VEHICLES

4.2.1 Availability of modern vehicle at workshops

The survey revealed that about 95 % (94.5%) of the respondents serviced modern vehicles whiles 5.5% emphasised that they do not service modern vehicles. It is apparent from the error bars in Fig. 4.2.1 that the difference between the two responses is significant ($p < 0.05$). It follows from the responses of the master mechanics and electricians at the Suame magazine that modern vehicles abound in the Ghanaian society.

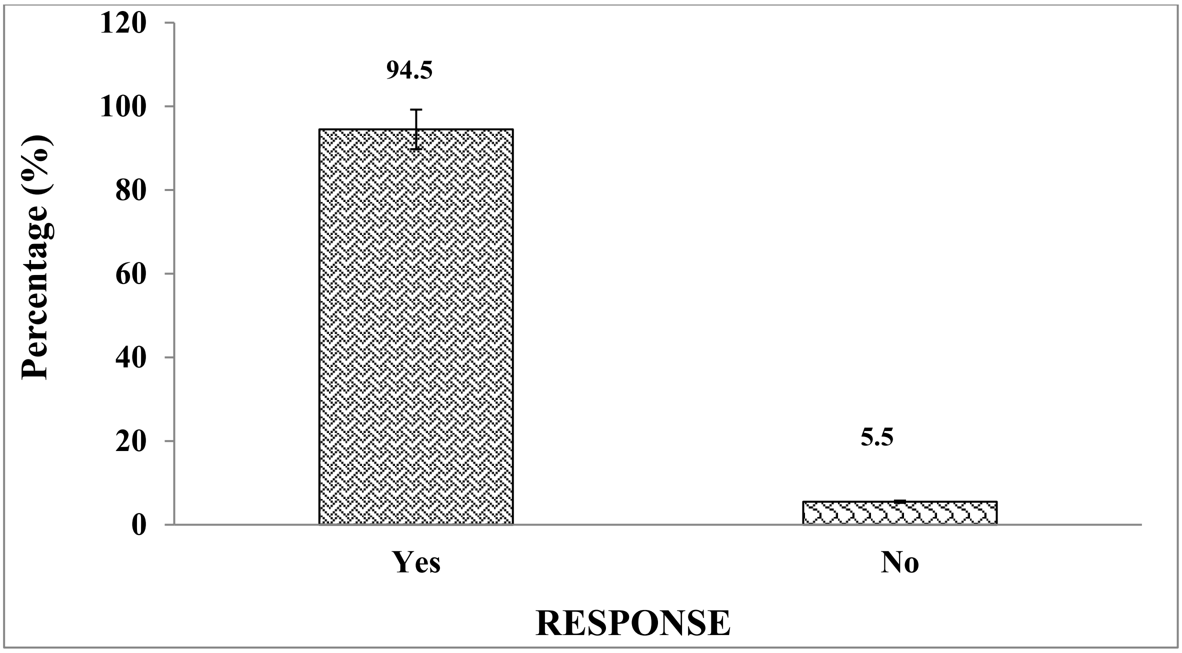

Fig. 4.2.1 a: Response availability of modern vehicle at workshops

Further, those who worked on modern vehicles revealed that they have been serving modern vehicles for varying number of years. Therefore, investigation proved that those who have had experiences in the auto-mechanical and auto-electrical industry on modern vehicles for less than 5 years were the highest (50.8%) whiles those who identified 10 – 14 years recorded the lowest (5.7%). It is worth noting that 7.8% of the respondents indicated experiences with modern vehicles for more than 15 years (Table 4.3). The results predict a recent influx of electro-mechanic modern vehicles into the country (Plate 4.1), probably due to taste for modern technology and ease of use.


Plate 4.1: Sample of modern vehicles at the Suame Magazine

Table 4.3: Number of years in servicing modern vehicles

Service years	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 5 years	97	48.5	50.3	50.3
5 - 9 years	70	35	36.3	86.5
10 - 14 years	11	5.5	5.7	92.2
15 years and above	15	7.5	7.8	100
Total	193	96.5	100	
Missing System	7	3.5		
Total	**200**	**100**		

4.2.2 Difficulties in servicing modern vehicles

From Fig. 4.2.2a, about 98% of respondents revealed that serving of modern vehicles was difficult. Meanwhile, 2.5% emphasised that difficulties were manageable. The error bars in Fig. 4.2.2a reveals that difference between the two responses is significant ($p < 0.05$).

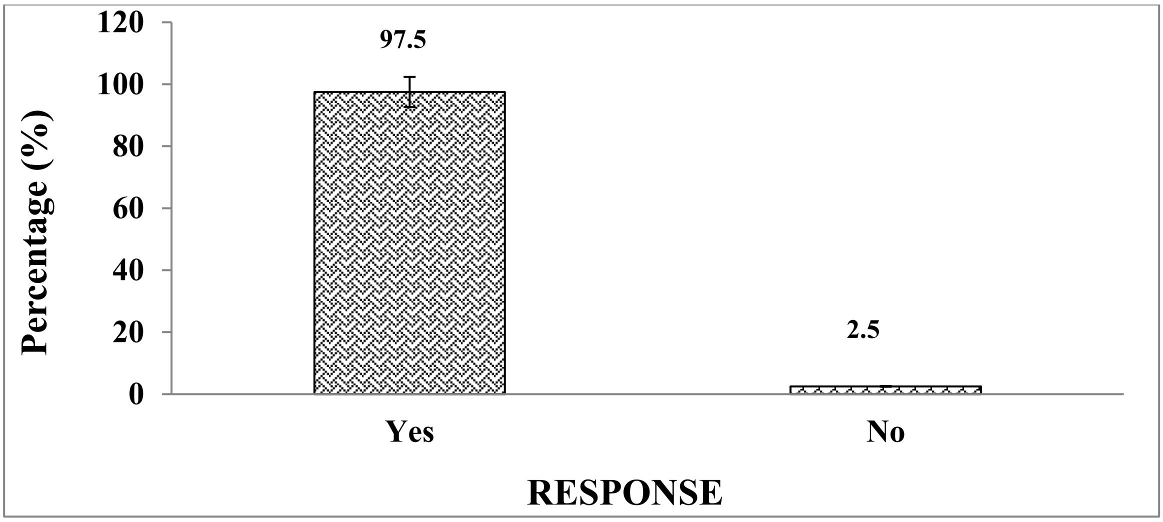

Fig. 4.2.2a: Difficulty level of modern vehicles

Further investigation revealed that the difficulties encountered by the artisans in servicing modern vehicles included difficulties in identifying faults and use of modern diagnostic equipment, which leads to damage to control boards of modern vehicles due to 'trial and error methodology' and a host of electro-mechanical difficulties resulting in frustrations. Fig. 4.2.2a indicates that difficulty in identifying faults in modern vehicles was the greatest challenge (40.5%) followed by lack of modern diagnostic equipment (22.0%)and difficulty in using available diagnostic equipment (19.0%). A host of other problems relating to electro-mechanical circuitry in modern vehicles also recorded 1.0%. From Fig. 4.2.2b, differences between the challenges are significant ($p < 0.05$) except the difference between respondents who emphasised difficulty in using diagnostic devices and those who revealed that control boards are damaged due to 'trial and error' procedure (Plate 4.2).

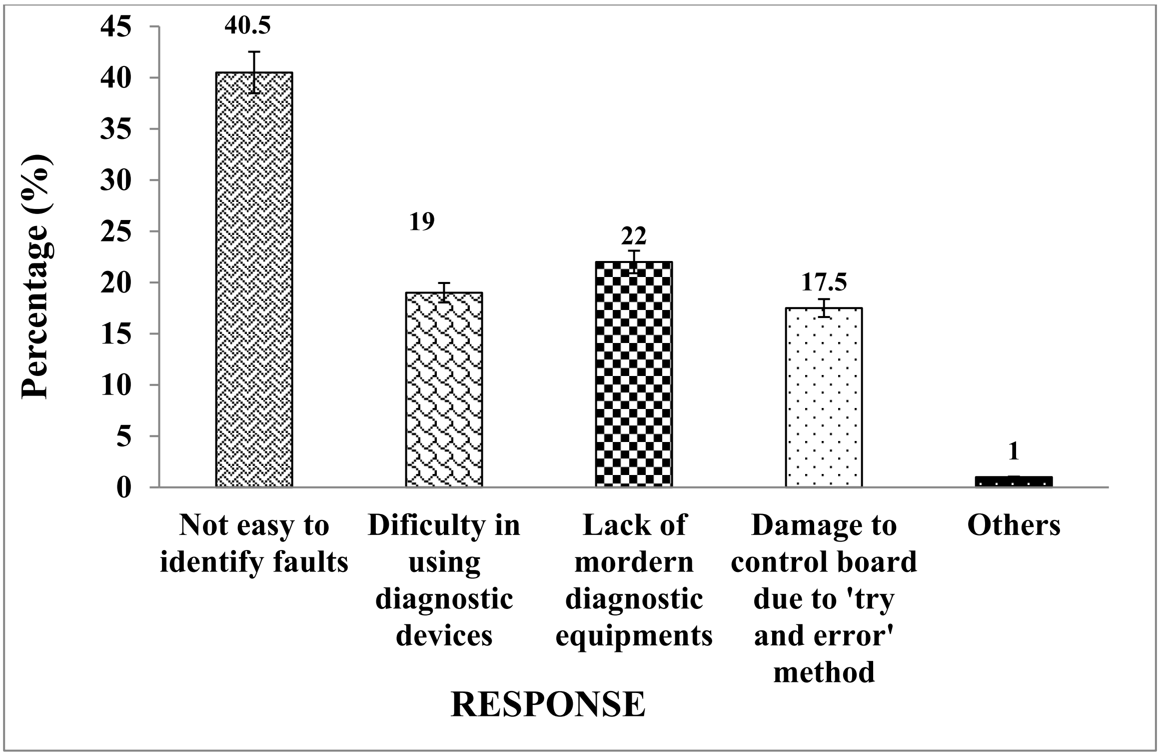

Fig. 4.2.2b: Difficulties encountered in servicing modern vehicles

Plate 4.2: These vehicles at the Suame Magazine have damaged control boards

Further studies conducted into how some of the difficulties and challenges in servicing modern vehicles are handled revealed that replacement of hardware (control board) ranked highest (33.0%), whiles those who abandoned the job entirely ranked lowest (13.0%). Whilst, 31% of the artisans would secretly seek help from other well-experienced masters, 31% will direct outrightly, the customer to other persons deemed able to handle the job (Fig. 4.2.2c). The error bars in Fig. 4.2.2c indicate that significant differences exist among all the responses at $p < 0.05$. It follows that about 87% of the artisans are always keen on getting the jobs done and would employ all means possible rather than abandoning the job. This is so because once a job is abandoned the owner of the vehicle might not bring any servicing needs again and the artisan may be tagged incompetent. This may affect the artisan's level of income. However, their efforts do not always yield good results, as damage are sometimes exacerbated and vehicles abandoned altogether (Plates 4.3 & 4.4).

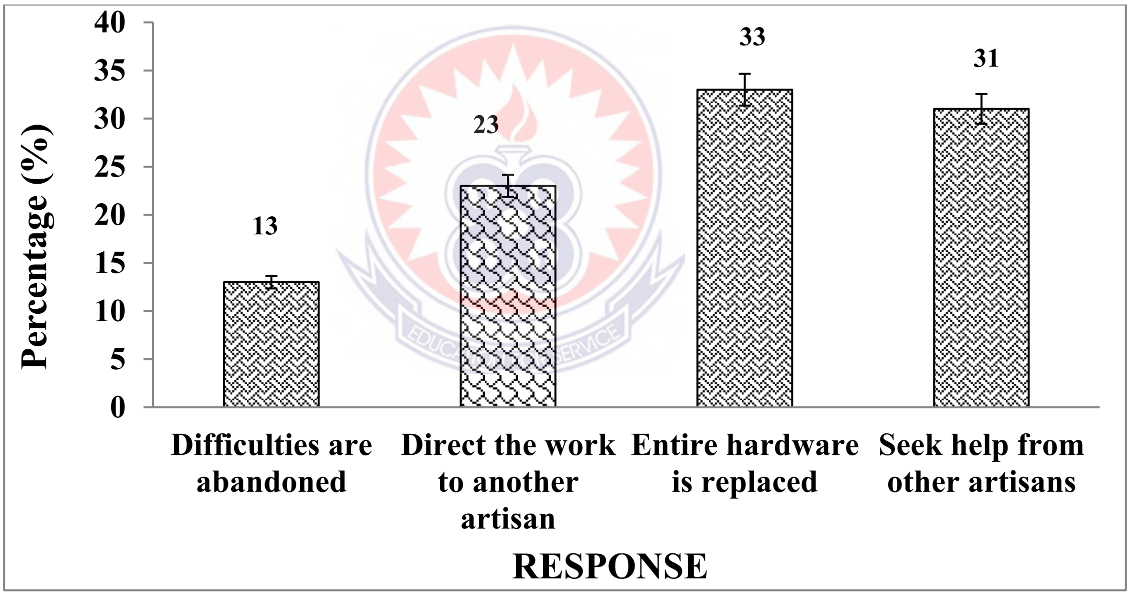

Fig. 4.2.2c: How difficulties are handled

Plate 4.3: An abandoned vehicle at the Suame Magazine

Plate 4.4: These vehicles have been at the workshop for more than two years

4.2.3 Job satisfaction

Despite the strategies developed by artisans to ensure good job delivery and servicing, among the respondents who serviced modern vehicles, only 33.5% said that they were satisfied with their level of servicing whilst a significant ($p < 0.05$) 66.5% revealed that their job output on modern vehicles is not satisfactory (Fig. 4.2.3).

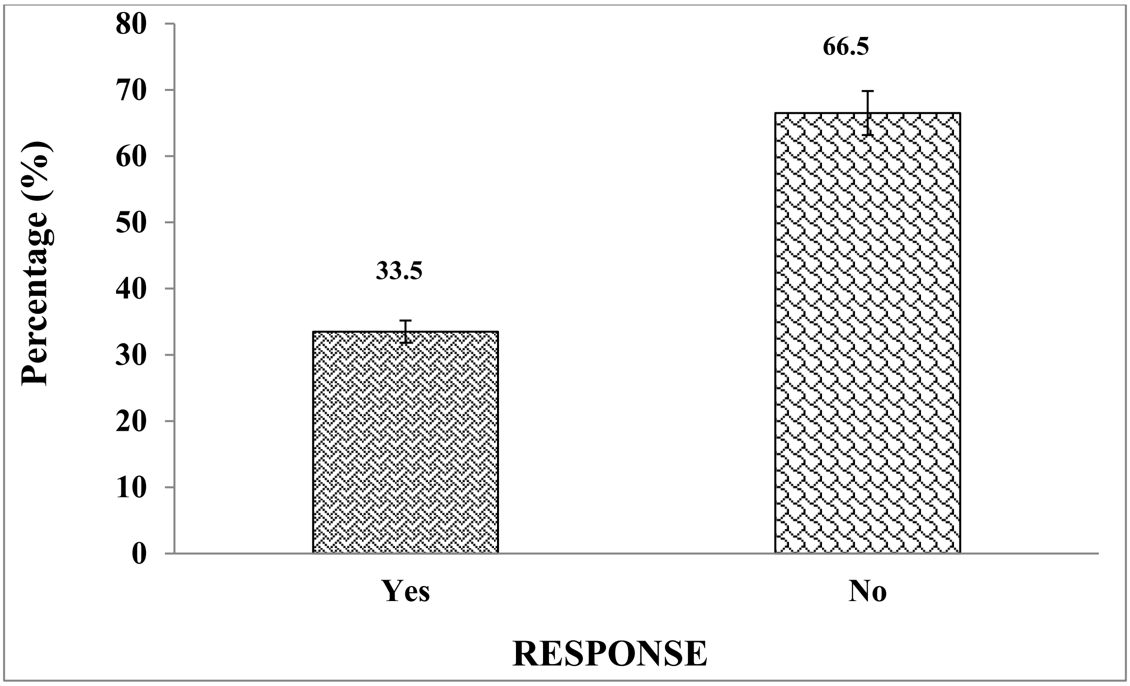

Fig. 4.2.3: Satisfaction from job performance

Reasons attributed to non-satisfaction included risk associated with trial and error methodology (such as damages and drain on artisans' finances due to compulsory replacement), delay in job delivery (resulting in complaints by customers), recurrence of problems after service and replacement of unaffected undamaged parts due to association with damaged devices (Table 4.4). Respondent's non-satisfaction in job delivery was mostly attributed to the risk associated with trial and error procedure highest (35.2%), followed by customer complains (32.6%), recurrence of the same problem after servicing (23.2%), replacement of identified parts (7.2%) and a host of factors such as general difficulties in disassembling certain parts of modern vehicles (0.7%). All the responses were identified to be different from one another ($p < 0.05$).Plate 4.5 indicates re-occurrence of fault 24 hrs after maintenance whiles Plate 4.6 shows delayed maintenance due to difficulty in diagnosing faults. Plate 4.7 shows damaged modern vehicles whose damaged parts are difficult to get in the country.

Table 4.4: Reasons to non-satisfaction in maintaining modern vehicles

Reasons	Frequency	Percent	Valid Percent	Cumulative Percent
Using try and error method is risky	50	25	36.2	36.2
Customers complain of delay	45	22.5	32.6	68.8
Problems recur after service	32	16	23.2	92
Identified parts have to be replaced	10	5	7.2	99.3
Others	1	0.5	0.7	100
Total	138	69	100	
Missing System	62	31		
Total	200	100		

Plate 4.5: An example of re-occurred problem at the Suame Magazine

Plate 4.6: Technicians finding it difficult to identify fault after almost 3 months

Plate 4.7: Damaged parts of these vehicles could not be replaced due to lack of spare parts

4.3 EQUIPMENT USED BY ARTISANS AT THE SUAME MAGAZINE

4.4.1 Equipment used by artisans in servicing modern vehicles

Majority of respondents (40.0%) used local hand tools and individual knowledge and ingenuity in servicing modern vehicles, whilst an insignificantly less percentage (9.5%) used exhaust gas analyser (Fig. 4.3.1a). Moreover, those who employed electronic vehicle scanner and those who used electronic fuel diagnostic device were not significantly different ($p < 0.05$), 24.5% and 26.0% respectively (Fig. 4.3.1a). It is evident from the results that modern diagnostic equipment exists for use at the Suame Magazine. However, most artisans still hold unto traditional hand tools, probably due to resistance to change or dynamics related to availability and technicalities of usage.

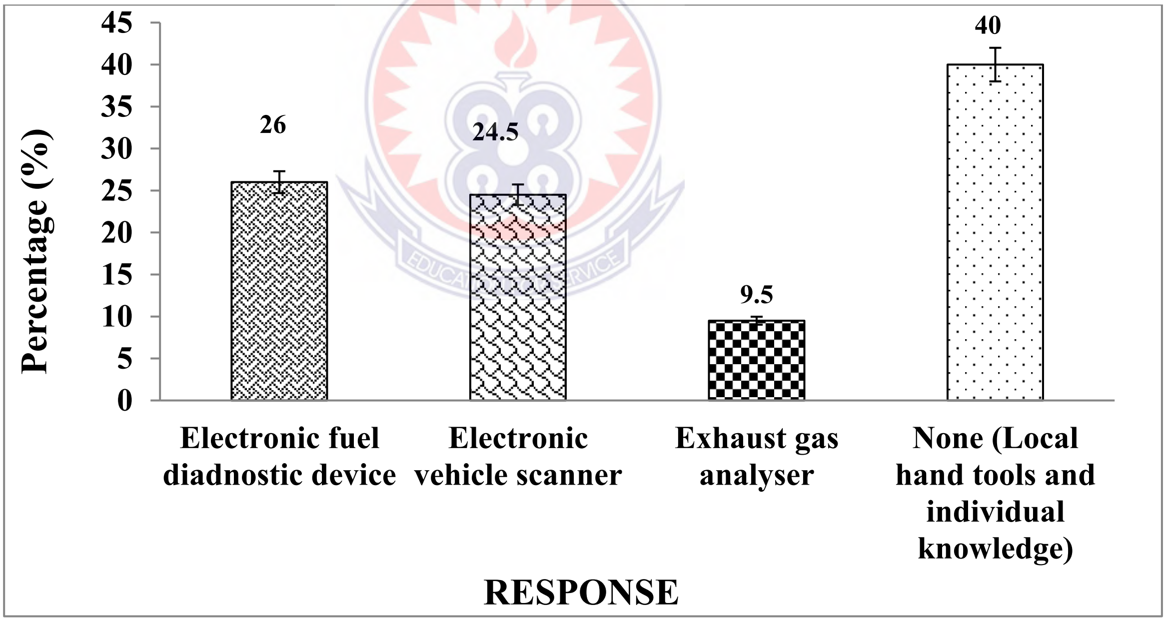

Fig. 4.3.1a: Equipment used by artisans in servicing modern vehicles

Consequently, 89.0% of the respondents indicated that their service equipment were modern (Fig. 4.3.1b) contrary to the results in Fig. 4.3.1a which revealed that 60% of artisans' equipment fall within modern categorization. The discrepancy could be due to availability of recently introduced hand tools, which some artisans tagged as modern equipment. Due to new technology and probably lack of correct diagnostic devices, some engineers have developed a whole range of hand tools to aid in disassembling and assembling of machine parts for proper servicing. This, though might not lead to proper job satisfaction, one could argue that in the absence of sophisticated diagnostic machinery, locally manufactured hand tools are commendable.

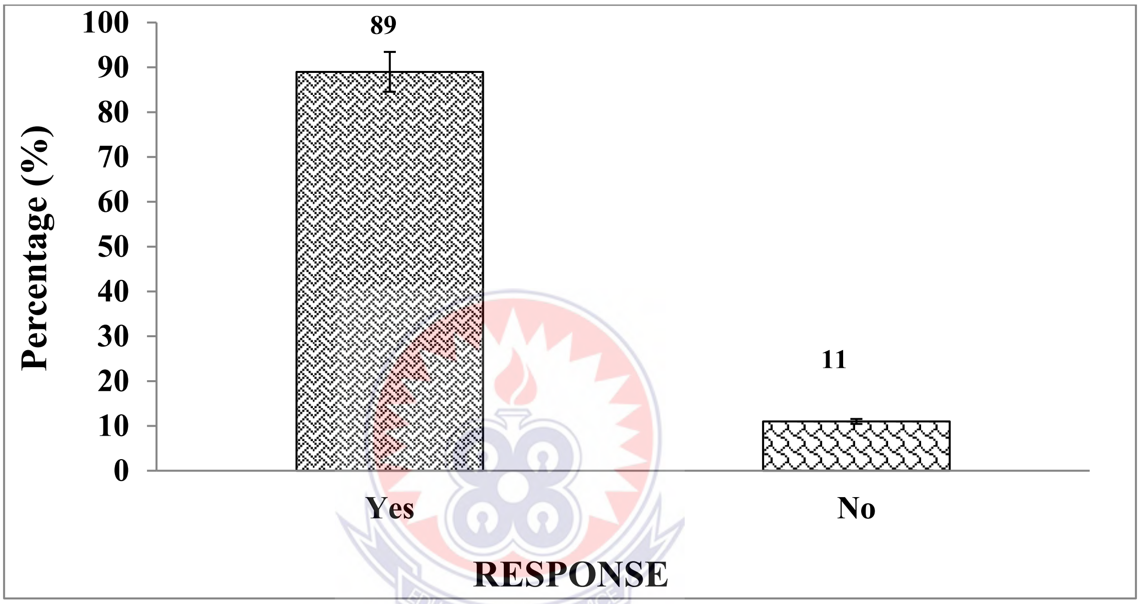

Fig. 4.3.1b: Response to whether tools used are modern equipment

4.3.2 Difficulty in using modern equipment

Respondents continued to emphasise that, despite progress made in acquiring some electro-mechanical diagnostic devices, their use pose equally significant challenge to the artisans, such that 77.9% of the respondents indicated this assertion to be true (Fig. 4.3.2a). Meanwhile 22.1% stressed that they were comfortable using the modern equipment in the servicing of modern vehicles.

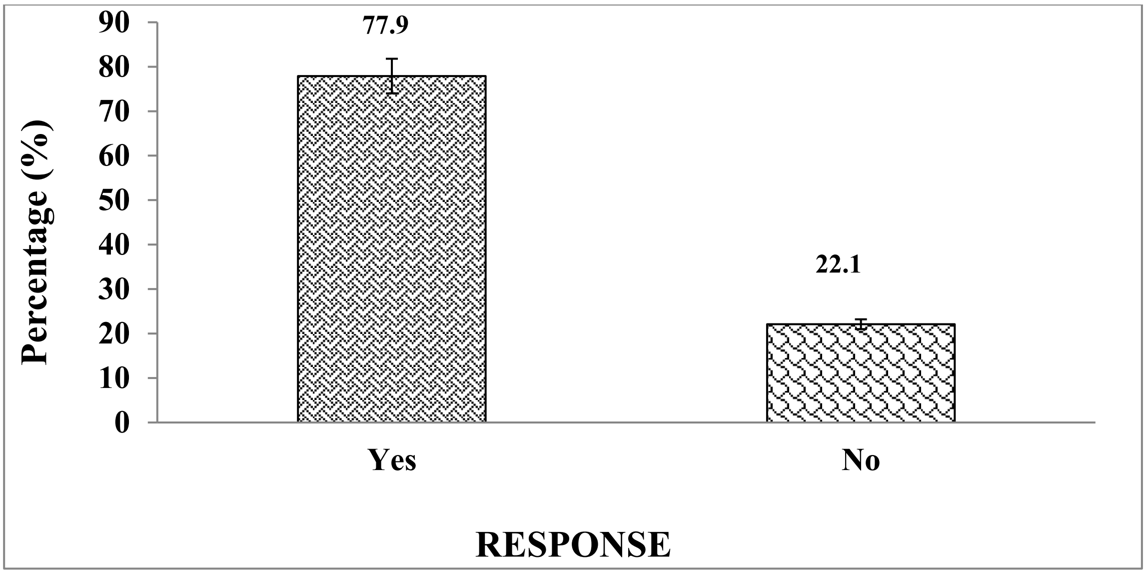

Fig. 4.3.2a: Response to whether there are difficulties with the use of modern equipment

About 70% (69.8%) of respondents indicated that their diagnostic equipment sometimes malfunctioned whilst an insignificant 4.5% said they have never experienced malfunctioning with their devices (Table 4.5). The error bars in Fig. 4.3.2b revealed that all the responses were significantly different from one another. Consequently, about 95% of respondents identified some level of malfunctioning with their equipment. Further investigation revealed that most malfunctions of diagnostic equipment have to do with operator setting or human error. In that, level of technical expertise on modern diagnostic and computer-related equipment is low.

Table 4.5: Equipment malfunctioning status

Malfunctioning status	Frequency	Percent	Valid Percent	Cumulative Percent
Never	9	4.5	4.5	4.5
Sometimes	139	69.5	69.8	74.4
Often	32	16	16.1	90.5
Always	19	9.5	9.5	100
Total	199	99.5	100	
Missing System	1	0.5		
Total	200	100		

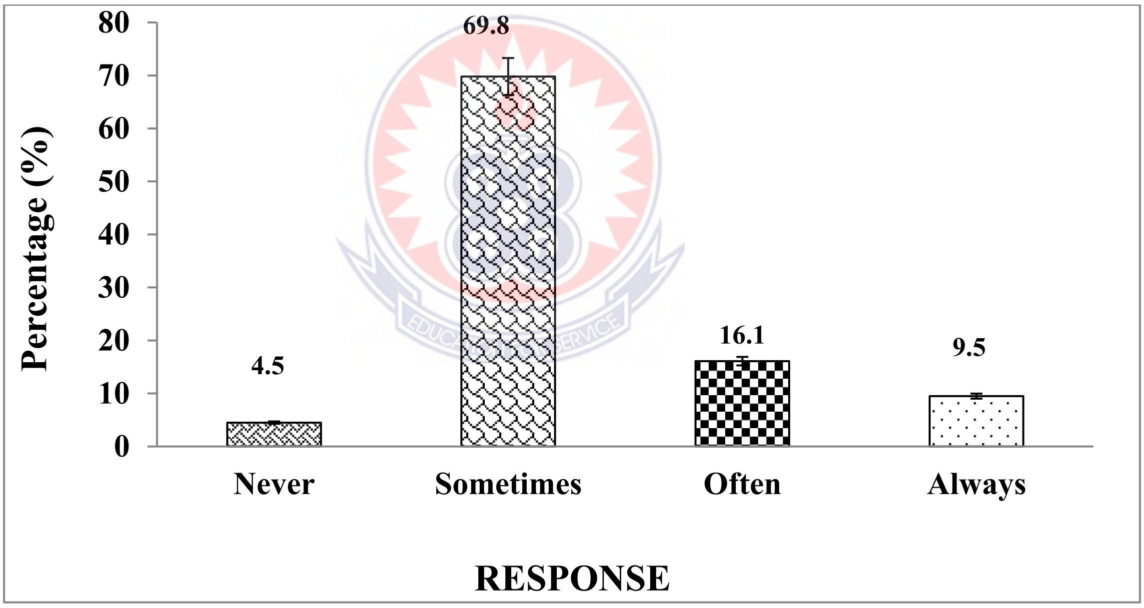

Fig. 4.3.2b: Equipment malfunctioning status

4.3.3 Customers perception on equipment used

Since satisfaction is a two-way nexus, investigation was launched into customer satisfaction relating to service equipment. Fig. 4.3.3a shows that about 85% of customers were not satisfied with the level of technology and equipment employed in servicing their vehicles. Only 15.5% were satisfied with the servicing equipment.

Since owing a vehicle is a capital-intensive venture, vehicle owners are critical of the equipment used to service their vehicles.

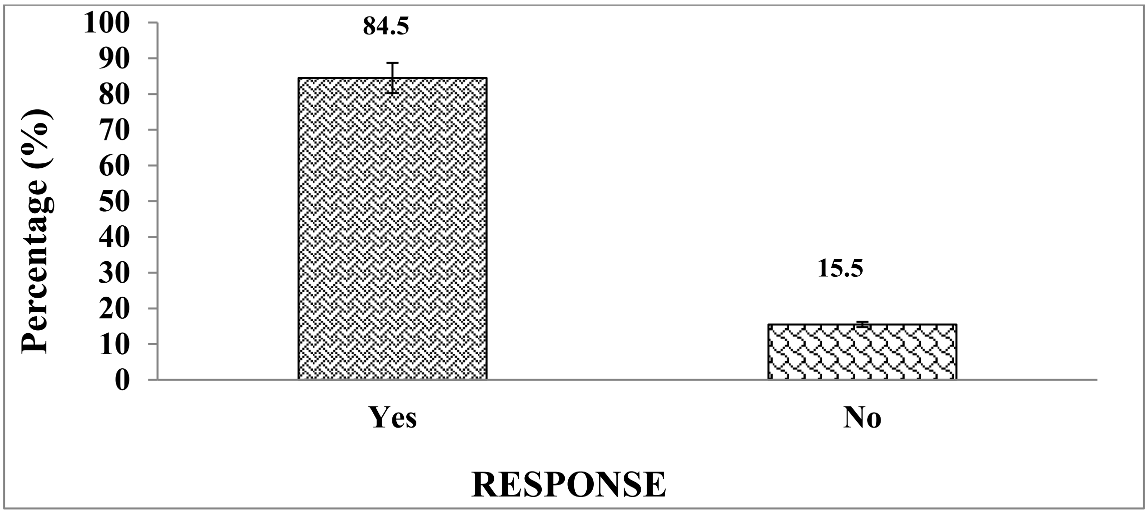

Fig. 4.3.3a: Customers complain about maintenance equipment

Investigation into customers complain showed that customers were impatient with long delays in servicing their vehicles (38.7%) whiles poor work delivery recorded the lowest percentage (3.5%) [Table 4.6]. Complaints relating to poor knowledge about modern electro-mechanical devices accounted for about 96% of the complaints. While some artisans could not solve the problems of modern vehicles (22.0%), 17.3% cause damage to vehicles in their quest to servicing modern vehicles and 11.0% of problems solved reoccur within a short period (Plates 4.8 & 4.9). Error bars (Fig. 4.3.3) indicates that differences are significant ($p < 0.05$) among all the responses.

Table 4.6: Customers complaints

Customers complains	Frequency	Percent	Valid Percent	Cumulative Percent
Problems reoccur	19	9.5	11	11
Artisans could not solve the problem	38	19	22	32.9
Long maintenance time	67	33.5	38.7	71.7
Difficulty identifying faults by artisans	13	6.5	7.5	79.2
Poor work done	6	3	3.5	82.7
Damage to vehicles by artisans	30	15	17.3	100
Total	173	86.5	100	
System	27	13.5		
Total	**200**	**100**		

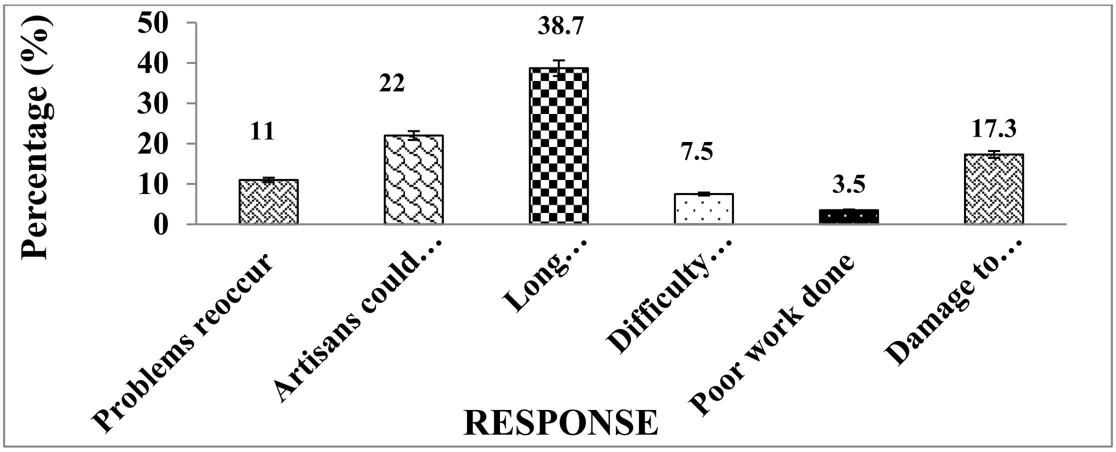

Fig. 4.3.3b: Customers complaints

Plate 4.8: Damaged and abandoned modern vehicles at the Suame Magazine

Plate 4.9: Vehicles whose damaged parts need replacement at the Suame Magazine

In handling customer complaints, 32.8% direct complainants to other technicians, 30.6% seek advice from other technicians, whiles 6.6% ignore the complaints (Table 4.7). However, 30.1% pay attention to customer complaints. It follows that communal and collaborative approach to problem solving constitutes about 63.4% of the approach to managing complaints. Thus, artisans have managed to form a system built on mutual inter-dependence.

Table 4.7: How technicians deal with customer complaints

Reaction to customer complaints	Frequency	Percent	Valid Percent	Cumulative Percent
Ignore them	12	6.0	6.6	6.6
Pay attention to complaints	55	27.5	30.1	36.6
Direct complainants to other technicians	60	30.0	32.8	69.4
Seek advice from other technicians	56	28.0	30.6	100.0
Total	183	91.5	100.0	
System	17	8.5		
Total	200	100.0		

4.3.4 Modern equipment needed at the workshop

Artisans desired an array of modern diagnostic equipment to help complement their efforts in servicing the ever-increasing availability of modern vehicles at the workshops. Whiles 38.5% desired electronic diagnostic equipment, 6.5% still wanted to hold on to their traditional hand tools (Fig. 4.3.4). Twenty-five percent emphasised the need for computerised workshops and 14.5% needed a variety of electronic gadgets. From Fig. 4.3.4a, differences were significant ($p < 0.05$) among the responses given by the artisans. It is worth noting that some technicians revealed that manuals and reference materials would be enough for them. While some deemed computerised and electronic systems as too complicated to use, majority (64.0%) would want to use these gadgets.

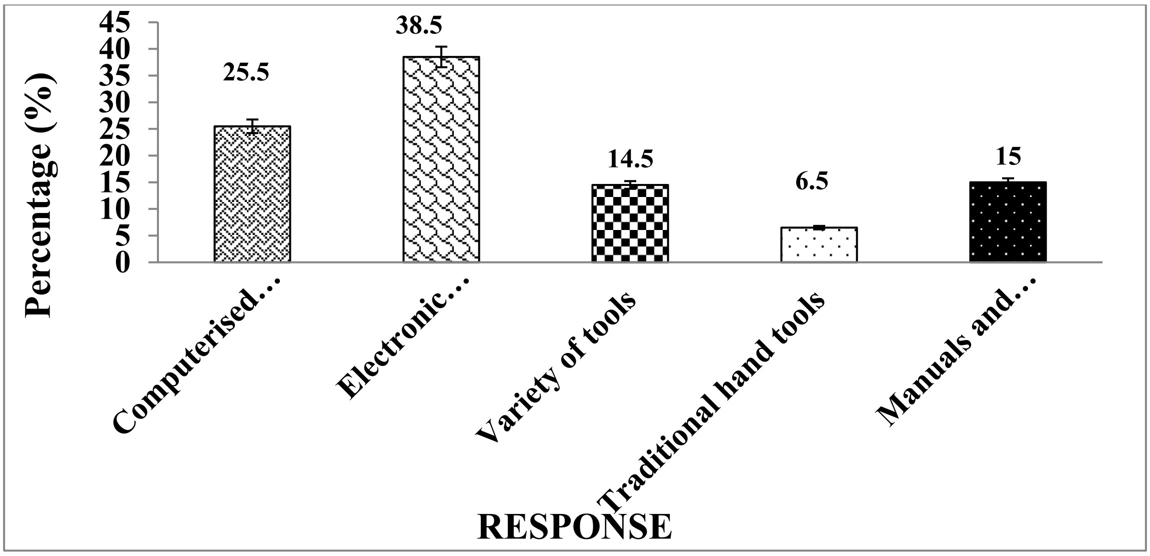

Fig. 4.3.4a: Modern equipment needed by the artisans at the Suame Magazine

Respondents identified two major reasons for which modern electronic and computerised systems were needed: identification of faults and easy diagnosis. Thus, 61.2% would want to use modern equipment to identify faults whiles 38.8% would want to use modern equipment to make work generally easy (Fig. 4.3.4b).

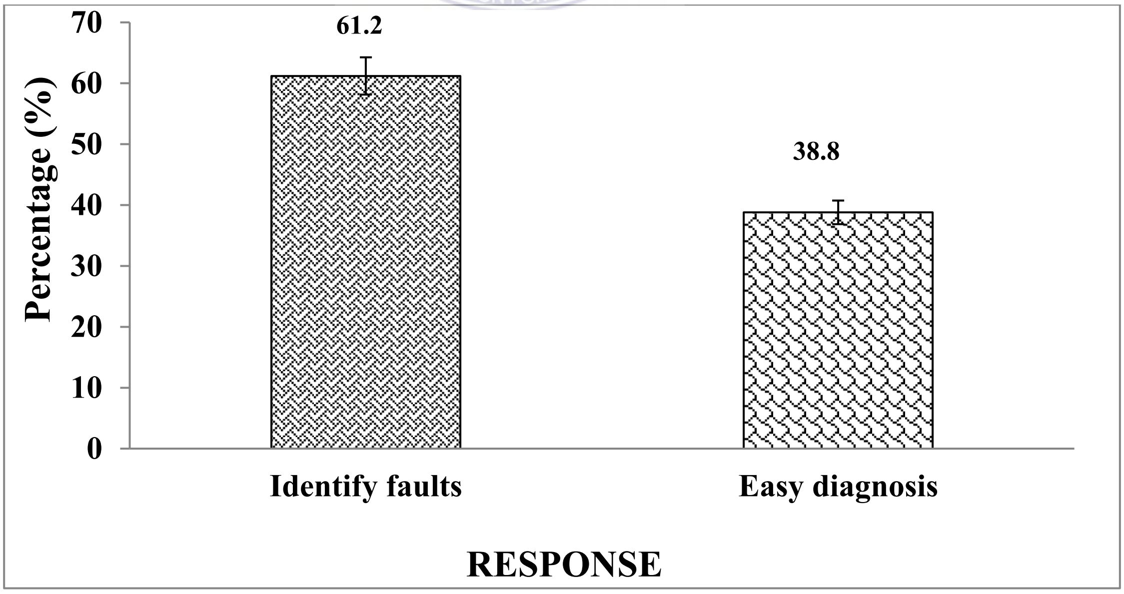

Fig. 4.3.4b: Reasons why respondents would like to have modern diagnostic equipment

4.4 Training workshops organised for the artisans at Suame Magazine

4.4.1 Frequency of workshop training

The results revealed that 38.5% attended regular training whiles 61.5% did not attend any training (Fig. 4.4.1a). Reasons for not attending training workshops were attributed to workload at their individual workshops and lack of finance to register for these workshops. It needs to be emphasised that, preliminary studies on those who ever attended such workshops revealed that no registration fee were charged and in situations where any amount was charged it was used to refresh the participants. It follows that, some artisans intentionally withdraw from training sections with the notion that productive hours are wasted, decreasing their income.

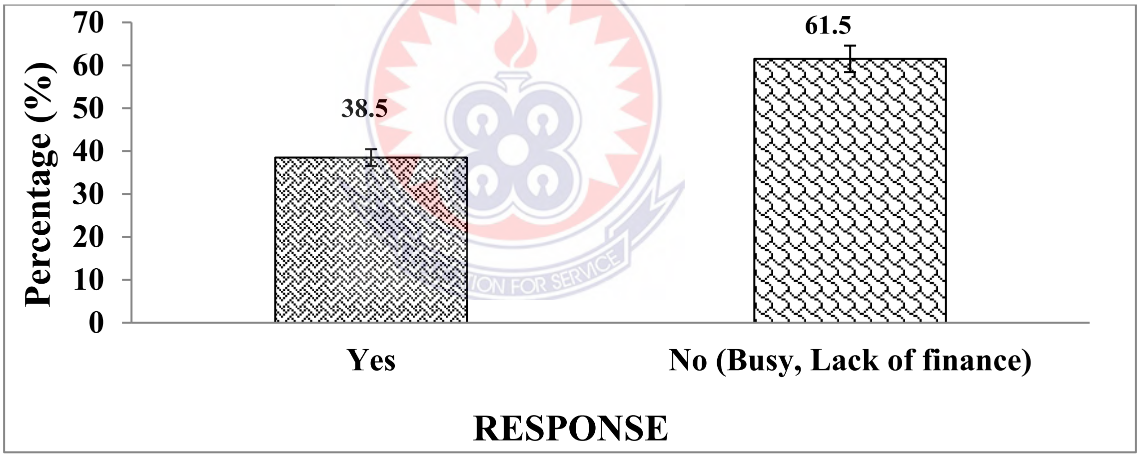

Fig. 4.4.1a: Response to whether respondents attended regular training

Among the respondents who asserted that training sections had been offered them, various organisations were identified as the trainers; Vehicle Manufacturers, Association of Garages, Organised Groups of Masters, SMIDO and others wrote that they received training via internet. Thus, organised group of masters offered training to 38.9% of the respondents investigated, then SMIDO (27.8%), whiles various vehicle manufacturers were the least (3.3%) [Table 4.8]. It follows that the artisans have a sense of sharing ideas among themselves, especially in the face of increasing vehicular technologies that pose serious challenge to the artisans.

Table 4.8: The bodies who offered training to artisans

Sources of trainers	Frequency	Percent	Valid Percent	Cumulative Percent
Various vehicle manufacturers	3	1.5	3.3	3.3
Association of garages	17	8.5	18.9	22.2
Organised groups of masters	35	17.5	38.9	61.1
SMIDO	25	12.5	27.8	88.9
Others (Internet search)	10	5	11.1	100
Total	90	45	100	
Missing System	110	55		
Total	200	100		

Assessing the frequency of training workshops for the artisans, it was revealed that majority of respondents had received training only once (60.9%), although 14.9% each had received training 3 and four times respectively (Fig. 4.4.1b). The trend could be due to the youthful (below 40 years) workforce, which constituted about 51% of the total respondents under survey. These have not been in business for long.

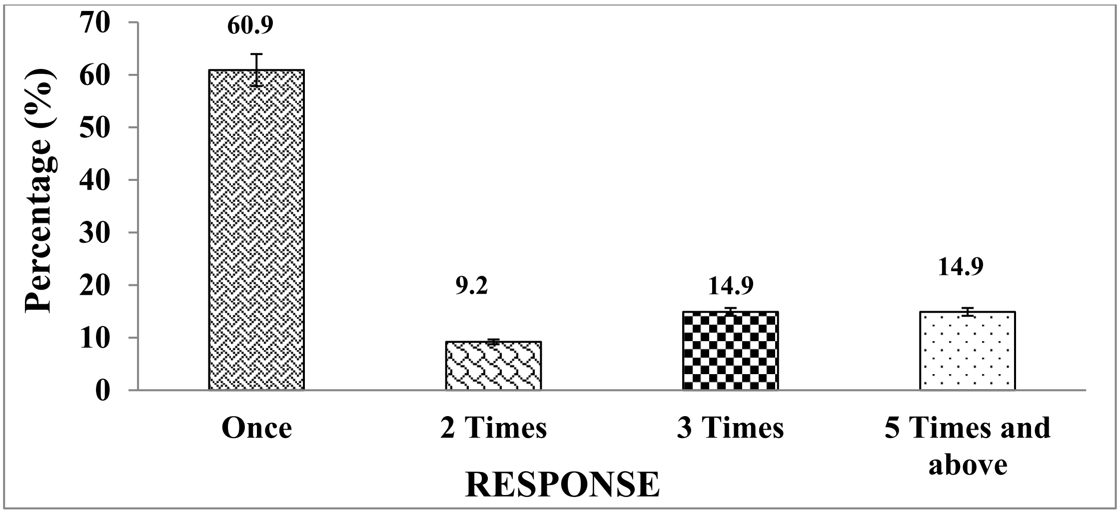

Fig. 4.4.1b: Frequency of training workshops for artisans

Consequently, Table 4.9 indicates that 67.8% of the respondents had received training recently (less than a year) whilst 5.6% received their last workshop training about 6 years ago. About 20.0% of the respondents had received some form of training within 2 years. These variations could be attributed to the differences in age groups which cast a shadow into the number of years artisans have been in business. Contrary, it is believed that new entrants into the business tend to patronise workshops more than older folks.

Table 4.9: Last in-service training

Period	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 1 year	61	67.8	67.8	67.8
1 - 2 Years	18	20	20	87.8
3 - 4 Years	6	6.7	6.7	94.5
5 - 6 Years	5	5.6	5.6	100.1
Total	90	100.1	100.1	

4.4.2 Workshop training versus artisans' needs

Out of the 140 respondents who had received some form of organised training, 70.7% revealed that the training sections met their needs and was helpful in various ways (Table 4.10). However, About 30% of the respondents who attended some of the training workshops indicated that it was a waste of time as nothing new was learnt. The statistical difference between the two respondents proved significant ($p < 0.05$).

Table 4.10: Response to whether the training workshops meet artisans' needs

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	99	49.5	70.7	70.7
No	41	20.5	29.3	100
Total	140	70	100	
Missing System	60	30		
Total	200	100		

Further investigation carried into the nature of benefit derived from the workshop training sections revealed that the training helped the artisans to maintain modern vehicles easily (30.0%), easy use of equipment (28.3%), easy diagnosis of faults (28.3%) and solved some difficulty in diagnosing some faults (13.3%). With the exception of offering solution to the diagnosing of faults, the rest of the responses were different at 5% (Fig. 4.4.2a).

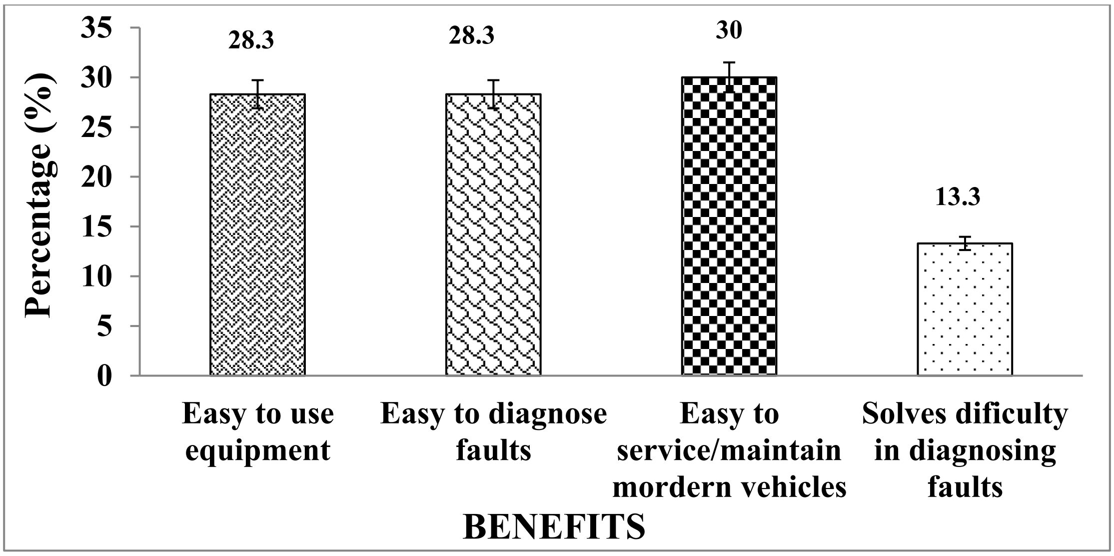

Fig. 4.4.2a: Benefit from training workshops

Among the respondents who indicated that the training sections were not useful, three issues were raised as contributing to the failure of the training workshops (Fig. 4.4.2b). Majority of the artisans (86.8), among those who emphasised that the workshops have not met their needs, still had problems with the use of modern equipment after the training sections, whilst an insignificant ($p < 0.05$) proportion indicated continuous difficulty in diagnosing faults (7.4%); 5.9% has to consistently fall on other artisans for technical help.

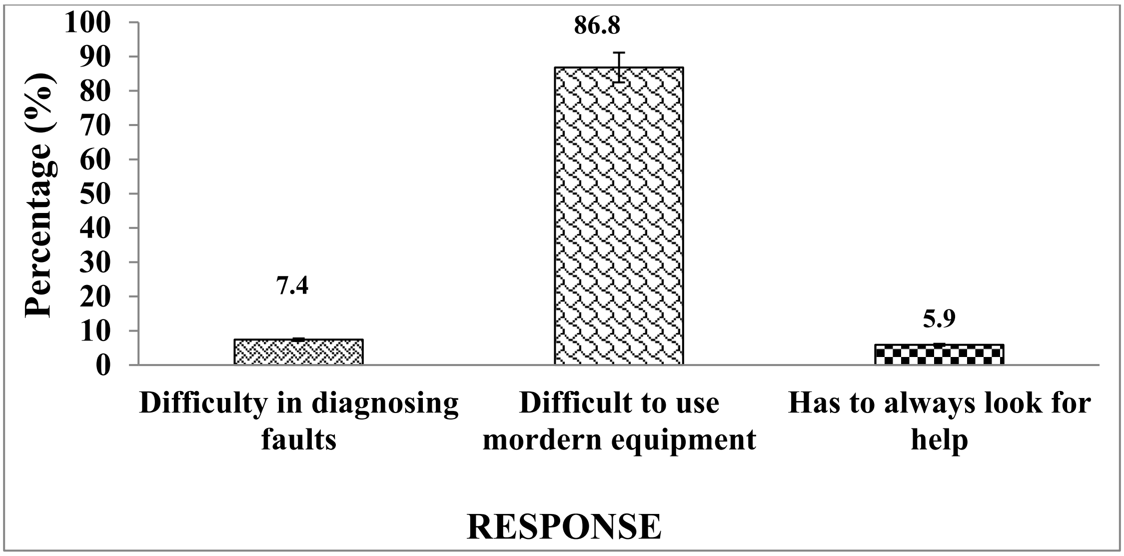

Fig. 4.4.2b: Reasons why training sections were not beneficial

It follows generally that, majority of the artisans are not satisfied with the level of expertise in their chosen profession (67%) whilst only 33.0% emphasised that they were satisfied with their current technical status (Table 4.11). The high level of unsatisfaction is indicative of the frustrations presented by electro-mechanical modern vehicle, since artisans are either auto electricians or auto mechanics and will have to liaise ideas with others to solving problems of modern electronic vehicles.

Table. 4.11: Response to whether artisans are satisfied with the level of expertise in the job

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	66	33	33	33
No	134	67	67	100
Total	200	100	100	

4.5.3 Anticipated training by artisans

Since the challenges posed by modern vehicles cannot be overlooked due to the proliferation of such electro-mechanical vehicles in the system, artisans overwhelmingly (92.5%) emphasised that they require additional training in the face of the current trend in the vehicle industry (Fig. 4.4.3). About 8% did not need any additional training. Differences were ascertained to be significant ($p < 0.05$). From the foregoing, the necessity for finding a solution created by challenges in servicing electro-mechanical vehicles will result in the readiness of artisans to imbibe new technology. This means that they will not be hostile to the introduction of new technology.

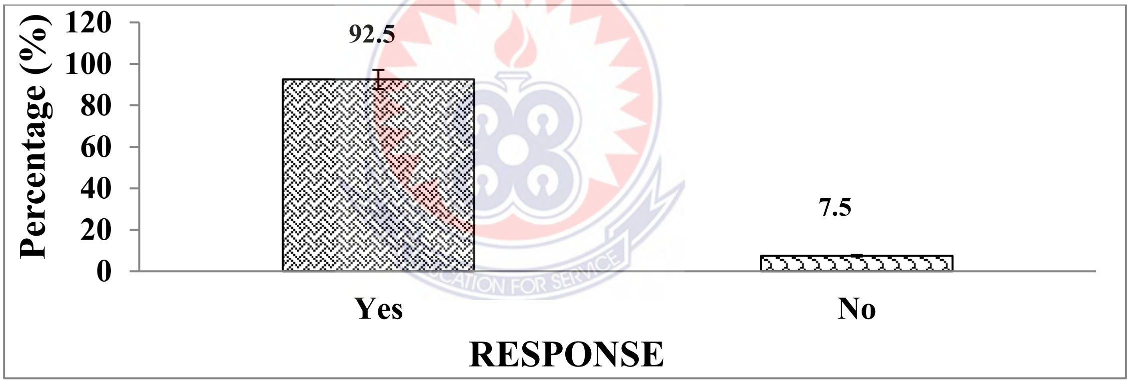

Fig. 4.4.3: Response to whether artisans required additional training

Whilst 36% of the respondents needed in-service training every 3 months, 32.5% needed training yearly, 30.5% needed training twice every years and only 1.0% needed training every two years (Table 4.12). Only the 1.0% response was significantly different from the rest of the responses ($p < 0.05$). Consequently, 99.0% of the respondents would require at least one training section every year.

Table 4.12: Training required to enhance performance in the job

Required training	Frequency	Percent	Valid Percent	Cumulative Percent
In-service training after every three (3) months)	72	36	36	36
In-service training once every year	65	32.5	32.5	68.5
In-service training twice (2) every year	61	30.5	30.5	99
In-service training every two (2) years	2	1	1	100
Total	200	100	100	

4.4.4 Assessment of trainer of trainees approach

Training services organised for master technicians came with the intention that knowledge and expertise gained will be transmitted to their respective apprentices, thereby achieving the multiplicity effect trainer of trainees approach to innovation. When the artisans were interrogated on knowledge transmission to their apprentices, a significant proportion (87%), affirmed that knowledge gained from training sections were transmitted where as 13% indicated that they made no conscious effort of transmitting their skills to their apprentices (Fig. 4.4.4a).

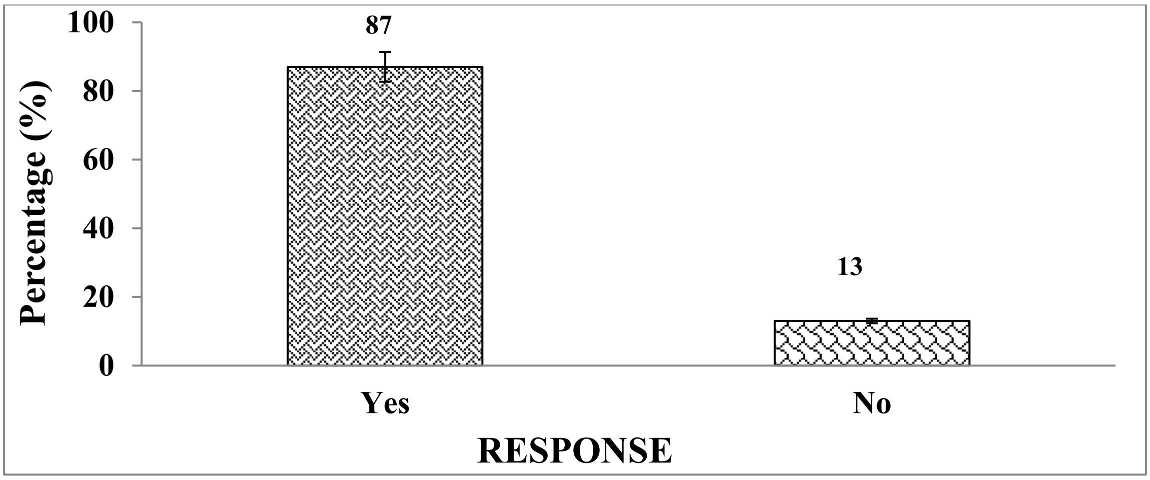

Fig. 4.4.4a: Response to whether master technicians imparted knowledge gained from training sections to their apprentices

Artisans who imparted the knowledge and skills gained from the training workshops identified various means through which apprentices were made to acquire relevant knowledge and skills (Table 4.13). On-the-job training was the highest form of skills transmission to apprentices (48.9%) followed by imitation methods (22.4%) and organised workshops for apprentices (20.7%). Differences were found to be significant ($p < 0.05$) among all the responses given (Fig. 4.4.4b). The prospects of trainer-of-trainees approach in introducing innovative skills in servicing modern vehicles is bright, since about 77.1% of master technicians made conscious efforts to impart knowledge gained from training workshops.

Table 4.13: How do you transmit your training information?

Methods of skill transfer	Frequency	Percent	Valid Percent	Cumulative Percent
In-service training	13	6.5	7.5	7.5
On-the-job training	85	42.5	48.9	56.3
Organizing workshops	36	18	20.7	77
Imitation	39	19.5	22.4	99.4
Others	1	0.5	0.6	100
Total	174	87	100	
Missing System	26	13		
Total	200	100		

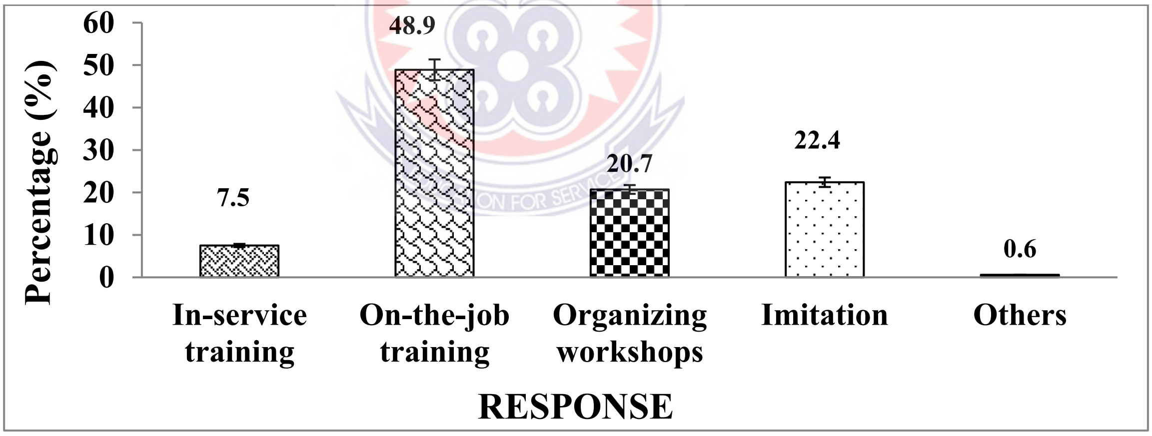

Fig. 4.4.4b: Means of skills transfer to apprentices

4.5 MAJOR AREAS OF INTERVENTION AT THE SUAME MAGAZINE

4.5.1 Interventions needed by artisans

From Fig. 4.5.1, 76% of the respondents are not satisfied with their condition of service whilst 24% are satisfied.

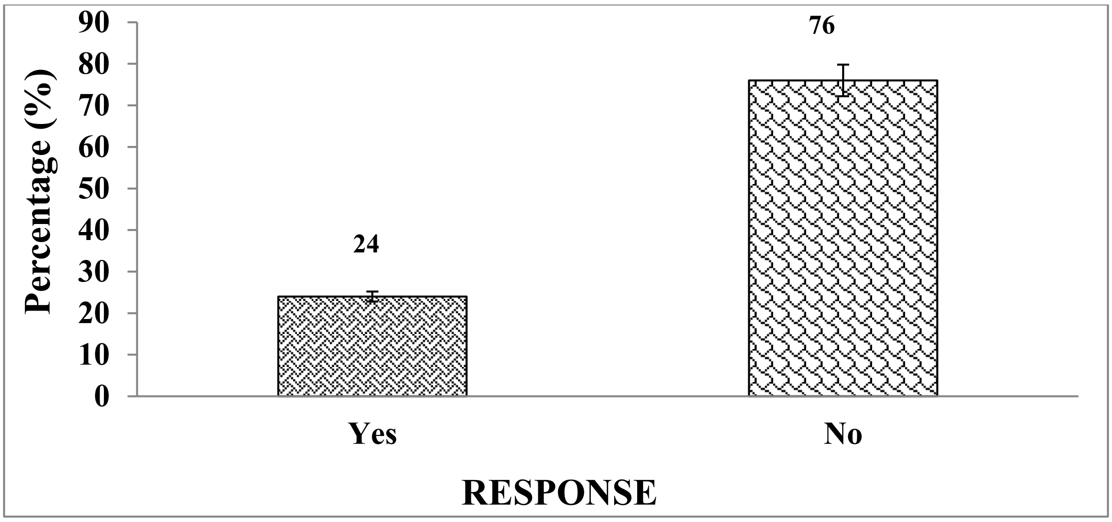

Fig. 4.5.1: Response to whether artisans are satisfied with their condition of service

Reasons for not being satisfied with the condition of service were variously attributed to lack of modern diagnostic equipment (40.5%), long service hours (31.1%), lack of spare parts (16.9%) and lack of packing space (11.5%), especially for breakdown vehicles (Table 4.14). Consequently, challenges relating directly to modern vehicles contributed to about 87.5% of unsatisfaction at the workshops.

Table 4.14: Reasons why some respondents are not satisfied

Reasons for job unsatisfaction	Frequency	Percent	Valid Percent	Cumulative Percent
Vehicles are kept too long at the work	46	23	31.1	31.1
Lack of spare parts	25	12.5	16.9	48
Lack of parking space for breakdown vehicles	17	8.5	11.5	59.5
Lack of modern equipment	60	30	40.5	100
Total	148	74	100	
Missing System	52	26		
Total	200	100		

The master technicians believed that government and NGOs must come to their aid and help them out of some of the challenges militating against the sector. About 40% (38.5%) of the artisans want government and/or NGOs to establish a training school for them; 33.5% would want government to provide subsidized electronic modern equipment, whilst 21.0% would want supply of such equipment to be free; 4.5% requested for computers and internet availability at all workshops; 2.5% believe that mechanisms should be put in place to assess work done against standards (Table 4.15).

Table 4.15: Contributions of government and NGOs needed at the Suame Magazine

Interventions needed	Frequency	Percent	Valid Percent	Cumulative Percent
Provide subsidized electronic diagnostic modern equipment	67	33.5	33.5	33.5
Establish training school	77	38.5	38.5	72
Puts up mechanisms to check work done against standard	5	2.5	2.5	74.5
Provide free modern electronic equipment	42	21	21	95.5
Provide computers and internet connections to various workshops	9	4.5	4.5	100
Total	**200**	**100**	**100**	

With the exception of one (1) respondent who abstained from sharing his opinion, 100% of the respondents expressed the desire for government to organise periodic training for them (Table 4.16).This openness to training workshops is very encouraging as it will provide a platform for technology assimilation and reduce hostility to interventions. Government and other stakeholders should capitalise on the hunger new skills created by challenges posed by modern vehicles to establish organized workshops for the artisans.

Table 4.16: Response to whether government should organise periodic workshops

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	199	99.5	100	100
No	0	0	0	100
Missing System	1	0.5		
Total	200	100		

4.5.2 Computer-based knowledge of artisans

Majority of respondents (69.0%) denied that they possess any knowledge in computer and internet search engines whilst 31% asserted that they have varying degrees of computer knowledge (Fig. 4.5.2a).

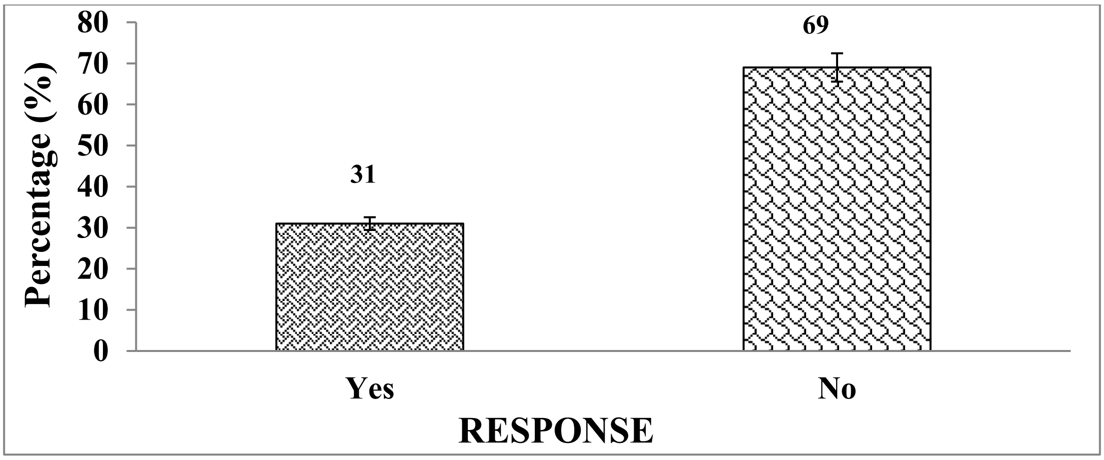

Fig. 4.5.2a: Response to whether artisans possessed computer knowledge

Despite the knowledge of computer and sophisticated electronic systems possessed by some, almost all respondents (94.5%) depended more on the use of traditional hand tools (Fig. 4.5.2b). About 6% depended solely on electronic equipment.

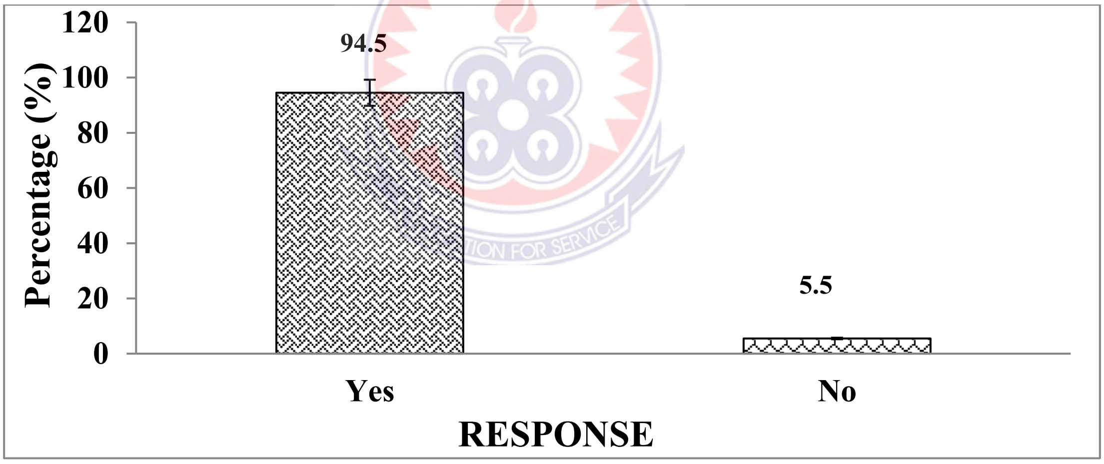

Fig. 4.5.2b: Response to whether respondents used traditional hand tools

Whilst 46.5% of the respondents investigated used electronic diagnostic equipment, digital manuals and reference materials to access information concerning work, 53.5% of them depended on individual skills and expertise to handle service challenges (Fig. 4.5.2c).

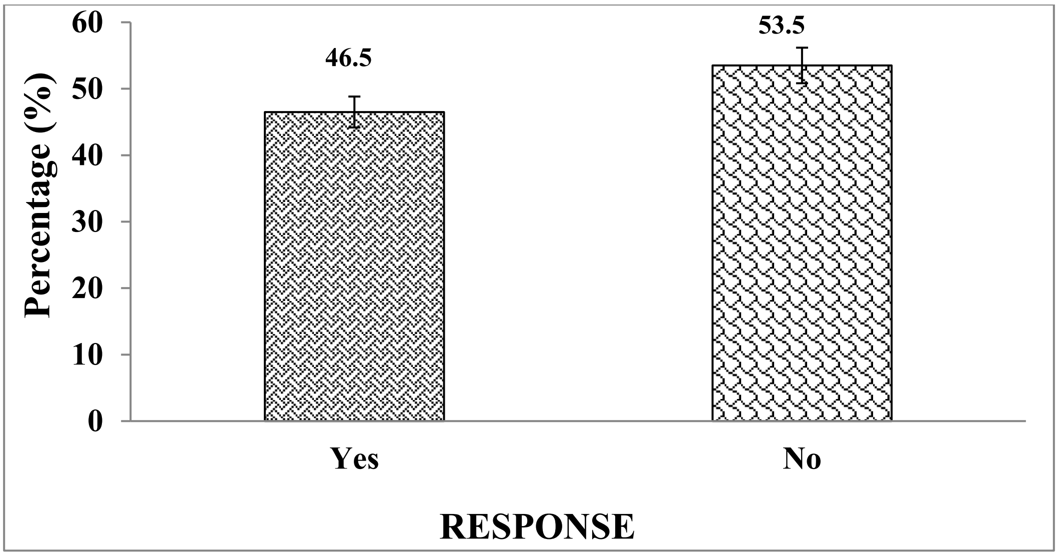

Fig. 4.5.2c: Response to whether respondents use modern equipment to access information on faults

Most respondents (51.0%) revealed that they use computer-based knowledge to access faults and fully understand the nature of electro-mechanical devices (Fig. 4.5.2d). Meanwhile, 49% of the technicians had never used computer –based knowledge to access information to service vehicles. Consequently, the respondents recognise the importance of the computer and internet in modern societies. In that, most issues relating to almost every field has been documented on the internet for easy access. The inculcation of computer literacy into artisan's training would provide very tangible results by facilitating the servicing of modern vehicles.

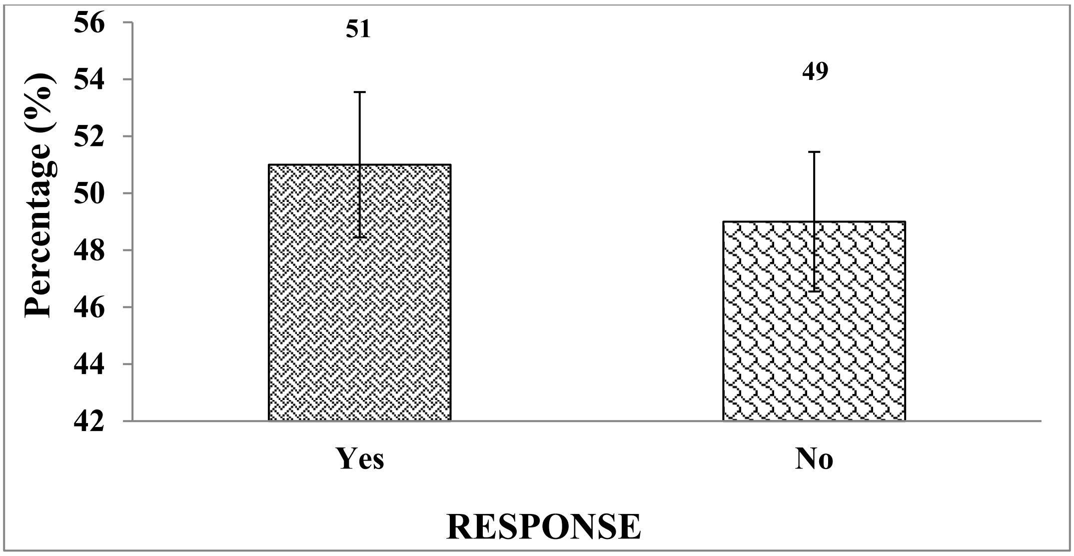

Fig. 4.5.2d: Response to whether artisans used computer to aid servicing of modern vehicles

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Suame magazine holds many prospects as it is a true reflection of indigenous knowledge and skills at work. Over the years, local Ghanaian technicians have managed to service vehicles with little formal knowledge about vehicles. Being mostly illiterates and in some cases dropouts from the formal educational system, the artisans at Suame magazine have managed to carve for themselves, a place in the Ghanaian economy such that prominent people in society, both great and small seek their services on a daily basis. Consequently, their knowledge base has evolved over the years to meet various challenges relating to vehicular maintenance. However, the pace of their skill evolution is not able to match the rate of scientific innovations in recent years. Hence, the field of mechatronic, which combines, otherwise and previously separate electrical and mechanical components into single units, pose serious challenges to, not only technicians, but vehicle owners alike.

5.2 Conclusion

From the results and discussion, it can be concluded that;

- Artisans at the Suame Magazine have difficulties in servicing modern vehicles, and prominent among the challenges are how to identify faults in the current electromechanical systems in modern vehicles, and the use of modern diagnostic equipment.
- The major diagnostic tools at the sector are local hand tools, dotted about sporadically with some modern diagnostic equipment; computerized systems

are virtually non-existent. Artisans mostly depend on experience and indigenous knowledge to servicing modern vehicles, hence, trial and error methodology about.

- Level of job satisfaction is low, especially with the increase in modern vehicles and all the sophistications they come with. These sophistications have not been met with commensurate upgrade of technical skills and technology. Consequently, it takes longer time to service vehicles, and in most cases problems recur. Also, vehicles are sometimes condemned which results in embarrassment to the artisan.
- Urgent training is needed by artisans on the field in order to match the current level of technology with technical know-how

5.3 Recommendation

From the conclusions established from the study, it is recommended that;

- Government, NGOs, vehicles manufacturers and other stakeholders in the vehicle maintenance sector should organize periodic training sections for the artisans. The openness of the artisans to training workshops is very encouraging as it will provide a platform for technology assimilation and reduce hostility to interventions. Government and other stakeholders should capitalise on the hunger for new skills created by challenges posed by modern vehicles to establish organized workshop trainings for the artisans.
- Dealers in spare parts should maintain active intelligence on the field in order to ascertain the trend of modern vehicles in the system so as to supply appropriate spare parts to technicians.

- Investors can take advantage of the gap created by lack of modern diagnostic equipment to enter the market and supply such modern equipment to artisans.

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APPENDIX

QUESTIONNAIRE

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION

SCHOOL OF GRADUATE STUDIES

KUMASI

This questionnaire is to help the researcher work on the topic Maintenance of modern electronic fuel injection vehicles (a case study at the Suame Magazine Kumasi

(A) DEMOGRAPHIC INFORMATION

1. Main Job
   a. Auto-mechanic
   b. Auto-electrician
2. Location:……………………………………………………………………………
3. Zone:………………………………………………………………………………
4. Date:……………………………………………………………………………...
5. Sex: Male [ ] Female [ ]
6. Age Group(Actual)
   (a) below 20 [ ]
   (b) 21 – 40 [ ]
   (c) 41 – 60 [ ]
   (d) above 60 [ ]

7. Educational Status

(a) Primary [ ]

(b) MSLC/J. H. S. [ ]

(c) S. H. S./O & A Level [ ]

(d) Tertiary [ ]

(e) None [ ]

Others specify……………………………………………………

8. How many apprentices do you have?

a. 1 – 5 [ ]

b. 6 – 10 [ ]

c. 11 – 15 [ ]

d. Above 15 [ ]

(B) Difficulties in servicing modern vehicles

1. Do you service modern vehicles?

a. Yes [ ]

b. No [ ]

2. For how long have you been servicing modern vehicles?

a. Less than 5 years [ ]

b. 5 to 9 years [ ]

c. 10 to 14 years [ ]

d. 15 years and above [ ]

3. Are modern vehicles difficult to service?

a. Yes [ ]

b. No [ ]

4. If yes, what are some of the difficulties you encounter in the servicing of modern vehicles?

   a. **I t is not** easy to identify faults [ ]

   b. **Di**fficult using equipment to finding faults [ ]

   c. Difficult to locate the exact problem without modern equipment [ ]

   d. Control board gets damage as a result of try and error methods sometimes [ ]

   e. Others, specify...

5. How do you go about these difficulties?

   a. Abandon work [ ]

   b. Give it to another person [ ]

   c. Replace hardware [ ]

   d. Seek help from other artisans [ ]

6. Are you satisfied with the way you handle difficulties in servicing modern vehicles?

   a. **Yes** [ ]

   b. **No** [ ]

7. If no, why are you not satisfied?

   a. Try and error methods are sometimes used [ ]

   b. Customers complain of delay [ ]

   c. Vehicles are brought back for the same complain [ ]

   d. Identify parts have to be imported [ ]

   e. Other State..

(C) Equipment used in servicing modern vehicles and impact on job satisfaction

1. What equipment do you use in servicing modern vehicles?

a) Electronic diagnostic equipment [ ]

b) Electronic Vehicle Scanners [ ]

c) Exhaust Gas Analyser [ ]

d) None of the above [ ]

e) Others, state...

2. Are there modern equipment?

a. Yes [ ]

b. No [ ]

3. Are the equipment difficult to use?

a. Yes [ ]

b. No [ ]

4. Equipment ……………………………..malfunctions.

a. Never [ ]

b. Sometimes [ ]

c. Often [ ]

d. Always [ ]

5. Are you satisfied with maintaining vehicles with the equipment you use?

a. Yes [ ]

b. No [ ]

6. Do customers complain about the type of equipment you use?

a. Yes [ ]

b. No [ ]

7.

8. If yes, what are the complains?

a. Mechanics/ artesans not able to solve their problems [ ]

b. Problems still existing after attending to other workshops [ ]

c. Long time being spent on vehicle at the workshop [ ]

d. Mechanics/ artesans not able to identify faults [ ]

e. Poor work done [ ]

f. Other mechanics/ artesans spoiling their vehicles [ ]

9. How do you deal with these complains?

a. Ignore them [ ]

b. Take them in good fate [ ]

c. Direct them to a different technician [ ]

d. Seek advice from other technicians [ ]

10. What equipment would you want to have in other to enhance your services?

(a) Computerised workshop equipment [ ]

(b) Electronic diagnostic equipment, digital manual and reference materials [ ]

(c) Variety of tools [ ]

(d) Traditional Hand tools [ ]

(e) **Electronic** diagnostic equipment [ ]

11. What would you use these equipment for, state

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(D) Type of training needed by the artisans

1. Do you go for regular training?

a. Yes [ ]

b. No [ ]

why (state reason)

……………………………………………………………………………

…………………………………………………………………………

If yes, where/who offer you training?

c. By various vehicle manufacturers [ ]

d. By association of garages [ ]

e. By organised group of masters [ ]

f. By SMIDO [ ]

g. Others,state...

.

2. How often do you have training/meeting per year?

a. 1 time [ ]

b. 2 times [ ]

c. 3 times [ ]

d. 4 times [ ]

e. 5 times [ ]

f. Above 5 times [ ]

3. Do the trainings meet your needs?

a. Yes [ ]

b. No [ ]

4. If yes, how does it meet your need?

a. Easy to use equipment [ ]

b. Easy to use diagnose faults [ ]

c. Easy to service or maintain modern vehicles [ ]

d. Difficult to diagnosing faultS [ ]

e. Others (state)……………………………………………………………

5. If no, why?

a. Difficult in diagnosing faults [ ]

b. Difficult to use modern equipment [ ]

c. Has to always look for help [ ]

d. Customers are leaving for other shops [ ]

e. Others, state...

6. Do trainers sometimes come to your workshop to offer you training?

a. Yes [ ]

b. No [ ]

7. Are you satisfied with your level of expertise in the job?

a. Yes [ ]

b. No [ ]

8. Will you re quire additional training?

a. Yes [ ]

b. No [ ]

9. If yes, what kind of training would you require to enhance your performance in the job?

a. In-service training after every three months [ ]

b. In- service training ones every year [ ]

c. In- service training twice every year [ ]

d. In- service training every two years [ ]

e. In- service training every five years[ ]

f. Other,(State)……………………………………………………………

10. Do you transmit your training information to your apprentices?

a. Yes [ ]

b. No [ ]

11. If yes, how?

a. In-service training [ ]

b. On-the-job training [ ]

c. Organizing workshops [ ]

d. Imitation [ ]

e. Others,(state):……………………………………………………………

(E) Improving the conditions of service to enhance job satisfaction

1. Are you satisfied with the conditions under which you work?

a. Yes [ ]

b. No [ ]

2. If no, why are you not satisfied?

a. Vehicles are kept too long at the workshop [ ]

b. There are no parts available [ ]

c. No enough parking space breakdown vehicles [ ]

d. No modern equipment available at the workshop [ ]

e. Other,(state)……………………………………………………………

3. What do you think should be done by government and NGOs to help the sector.

a. Provide subsided electronic diagnostic modern equipment [ ]

b. Establish training school [ ]

c. Put down mechanism to check done against standards [ ]

d. Provide modern electronic equipment for free [ ]

e. Provide computers and internet connections to various workshops [ ]

f. Other,(state): …………………………………………………………

4. Would you want government to periodically organize workshops for you?

a. Yes [ ]

b. No [ ]

DECLARATION

STUDENT'S DECLARATION

I, Michael Donkor Nifacan, declare that this Dissertation, 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 has not been submitted, either in part or whole, for other 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 Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: MR. S.K. AMOAKOHENE

SIGNATURE:………………………………………

DATE:………………………………………………

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This I recall to my mind, therefore have I hope. It is of the Lord's mercy that we are not condemned because his compassion fail not, "They are new every morning, great is thy faithfulness." Lamentation 3:21-23. The King David went in and sat before the Lord and he said , " who am I O sovereign Lord, and what is my family that you have brought me this far?" 2nd Samuel 7:18. I thank the Almighty God for bringing me this far.

I thank my supervisor, Stephen K. Amoakohene for his patience and guidance during the research work. His constructive criticism has contributed a lot to producing this "magnificent edifice".

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I will entreat the readers of this thesis to join me say a big "thank you" to my wife, Christiana Acheampomaa, and my children, Michael Donkor N. Jnr., Geneveive Donkor N., Selina Donkor N., Jeffrey Donkor N. and Jacquilene Donkor N.

Finally, to all my friends and course mates, without whom this venture would have been unbearable, and all those who contributed in diverse ways to make my schooling a success. May God richly bless you all.

DEDICATION

This work is exclusively dedicated to Rev. Farther Donkor, former Parish Priest of Holy Rosary Catholic Church, Suame.

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LIST OF ACRONYMS

SMIDO – Suame Magazine Industrial Development Organisation

GPS – Global Positioning System

EPA – Environment Protection Agency

NATEP – The National Automotive Technicians Education Foundation

NASCAR – Nationwide Series Camping World Truck Series

EFI – Electrical Fuel Injection

AMC – American Motor Corporation

ECU – Electrical Control Unit

EEU – Electrical Engine Unit

GM – General Motors

TBI - Throttle Body Injection

KMA – Kumasi Metropolitan Assembly

TCC – Technology Consultancy Assembly

PNDC – Provitioal National Defence Council

RCM – Reliability Centered Maintenance

VW – Volkswagen

NGO – Non- Governmental Organisation

ABSTRACT

Continuous innovations of new models of vehicles have resulted in diverse combinations of electro- mechanical components. These have resulted in continuous pressure on the maintenance industry in the country, to maintain and service these vehicles. Therefore, a 3-month survey was conducted at the Suame-Magazine. In Kumasi to document the challenges faced by artisans, critical analysis of the sector and appropriate recommendation.. Using the case study research approach, and basing on the administrative zonation of The Kumasi Association of Garages, a total of 200 workshops, 100 senior electricians and 100 senior mechanics, were random selected and probed using structured questionnaires. Data were cleaned, evaluated and analyzed using SPSS. About 95% of the respondents have been servicing modern vehicles for varying number of years, though those with experience within 5years abounded (50.8%), whilst a few (5.7%) have had longer experience (10-14years). Respondents perceived servicing of modern vehicles to be difficult (98%); 2.5% could manage some of the challenges. Difficulties relating to faults identification recorded (40.5%), lack of modern diagnostic equipment also (22.0%) difficulty in using available diagnostic equipment obtained (19.0%). Generally, artisans would replace hardware (control board) (33.0%); some would secretly seek help from other well-experience masters (31.0%); direct customers to other technicians deemed able to handle the job (23.0%); whilst (13.0%) would abandon the job entirely. Though, the sector holds much prospects, the pace of skill evolution does not match with the rate of current scientific innovations. Thus, artisans lack commensurate upgrade in technical skills in technology. Urgent training is needed by artisans in order to match the current level of technology.