UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

ASSESSING THE PERCEPTION OF VEHICLE OWNERS AND MECHANICS ON THE EFFICIENCY OF FUEL INJECTION COMPARED TO CARBURETOR ENGINES OF VEHICLES IN THE TAMALE METROPOLIS

ABDUL-RAHMAN IDDRISU

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A Dissertation submitted in The Department of MECHANICAL TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for the award of the Master of Technology (Mechanical) degree.

AUGUST, 2015

DECLARATION

STUDENTS DECLARATION

I, **Abdul-Rhaman Iddrisu,** declare that this Dissertation, with the exception of quotation and references contained in the public works which have been identified and dully acknowledged, is entirely my own original work, and it has not been submitted, in part or a whole, for another degree elsewhere.

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SUPERVISORS 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: **PROF. N. KYEI-BAFFOUR**

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DATE:…………………………………………………....

ACKNOWLEDGEMENTS

Many people have contributed in diverse ways during the conduct of this study, and therefore deserve to be acknowledged. My initial thanks go to the almighty god for successfully seeing me through this project.

My sincere gratitude also goes to my supervisor, Professor N. Kyei-Baffour, for playing a significant role from the beginning of the dissertation to the end by constructively criticizing and offering suggestions to serve as a guide. I am also indebted to Mr. Baba Mohammed of Bondi Toh engineering works in tamale for giving me the needed assistance throughout the course of this study. My profound gratitude also goes to Mr. David Inusah Offere a lecturer at the tamale polytechnic for diverse roles towards this study and also to my entire course mates for their immeasurable contribution and criticisms.

It is my sincere wish to render gratitude to all my friends for their support and their prayers during the course of the project work. Ahmed M Dangkpema is not left out; because despite his busy work schedule, he did his best by devoting an appreciable time to assist in reading and editing the work.

I also thank all the lecturers of the department for the numerous lectures during the period of the programme.

DEDICATION

This work is dedicated to my beloved family, especially my Daughter who is five month old.

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ABSTRACT

The study assessed the perception of people on the efficiency of fuel injection and carburetor engines of vehicles in the Tamale Metropolis following an increase in the number of vehicles. The growth in the number of vehicles has significantly created a apperception on the efficiency and performance of carburetor or fuel injection engines. The study therefore evaluated the perception of people on the performance and efficiency of fuel injection and carburetor engines of vehicles using vehicle owners and mechanics in Tamale as a case study. The case study design was used, particularly targeting drivers, car owners and mechanics in the Metropolis. Using the questionnaires and interview, data was gathered. The key findings of the study revealed that, factors that determine engine fuel consumption includes the quantity of fuel used, vehicle owners need to examine the consumption capacity of vehicles before purchasing such vehicles. The most durable engine type in the market was carburetor engines. It was observed that, fuel injection engines were found to produce more emissions than the carburetor engines. The concerns of people and mechanics on the efficiency of the two engines types were found not to be the same. The advantages associated with carburetor engines include; carburetors can be adjusted. It is also possible to repair to ensure effective regulation of fuel consumption. Carburetor parts are replaceable and therefore do not need the services of an electrician. The study finally recommends that, the smoke emissions level should be examined by the prospective car owners and mechanics since it determines the fuel consumption level of vehicles. The most durable engine types, which were found to be the carburetor engines, should be the preferred choice of the owners when purchasing vehicles. Mechanics should seek for more skills on how to service fuel injection engine since they were found

to be producing most emissions. In view of the fact that, concerns of people and mechanics on the efficiency of the two engines types are not the same, prospective should always insist on having the operational manuals of engines in order that, the needed information would be obtained to assist them make an informed decision concerning the purchases and maintenance of vehicles. Carburetors that can be adjusted should always to be procured. The parts for replacement should be made available to prevent carburetor frequent break down. Since carburetor repairs require no electrical services, it certainly will reduce cost during the repair of such vehicles, hence, the need to go for carburetor engines.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

There have been an increasing number of vehicles in Ghana, especially in major cities such as Accra, Tema, Kumasi and Tamale. The growth in numbers of vehicles has significant effect on urban lifestyle and generates economic opportunities. However, the rise in vehicle fleet presents greater challenge to owners and drivers of such vehicles, particularly; increased perception on which of the two engines types namely carburetor or fuel injection offers the best performance. The performance of carburetor or fuel injection vehicles, has presented highly debated question among vehicle enthusiasts. Many believe that performance is best with a carburetor engines while others insist that the only way to go is with fuel injection gasoline engines. To determine which is best for one‟s vehicle, it is important to understand how both components work.

According to Davis (2010), the effective performance of carburetor and fuel injection to a larger extent depend on the amount of air and gasoline that can enter into the cylinders of the engines. The cylinders as Davis indicates contain the pistons and combustion chambers where energy is released from the combustion of gasoline. The carburetor and fuel injection systems will both feed fuel and air into the engine.

As Holder and Kunz (2009) emphasizes, the carburetor contains jets that will push the gas into the combustion chambers. The amount of fuel that can flow through these jets depends completely on the amount of air that can be pulled into the carburetor venture. The main issue with obtaining the best performance using a carburetor is that it cannot monitor the air to fuel ratio for each individual cylinder. If there was a carburetor for each cylinder then this would not be an issue. So with a carburetor, the best fuel to air ratio for each cylinder is approximated for the best performance. However, carburetors do last longer than fuel injection systems and are favored in motor sports. Carburetors are also much simpler to install than fuel injection systems, because there are no electrical components or return lines to the fuel tank. The carburetor is currently much less expensive than the electronic fuel injection systems (Holder & Kunz, 2009).

On the other hand, Aird (2011) stressed the fact that, fuel injection systems are becoming more popular for those expecting the best performance from their engines. Aird identified two different versions of fuel injection namely port fuel injection and direct injection. Port fuel injection is the most commonly used and direct fuel injection is the latest developed fuel injection system. This system was designed specifically for four or two stoke engines. The main benefits of using direct injection is that the amount of fuel and air can be perfectly released and then injected into the cylinder according to the engine load conditions. The electronics used in the system will calculate this information and constantly adjust. This type of controlled fuel injection results in a higher power output, greater fuel efficiency and much lower emissions. One of the main issues is that these systems are sophisticated and will cost much more than a carburetor. Installation of the fuel injection engines is more complicated as it uses an electrical component and custom cylinder head configuration.

It is against this background that, this study seeks to assess the performance of fuel injection and carburetor vehicles so as to determine the reality from the perceived notion of many who believe that performance is best with a carburetor while others insist that the only way to go is with fuel injection gasoline. To determine which is best for most vehicles, this study will delve into how the components work.

1.2 Statement of the Problem

The speed and distances driven by the different vehicle types are important data input needed to estimate the amount of fuel used by each of the two engines, thus fuel injection and carburetor vehicles. The basis for the prevailing perception is based on the fact that, which engine is best. It is fairly obvious that most automobiles will be changing to fuel injection systems due to the lower emissions. However, unless the cost of these systems decreases significantly then there will still be a massive following that will stick to carburetors.

Aird (2011) again emphasized the fact that, when looking at pure horsepower, the fuel injection system only delivers about 10 extra horsepower at peak. It is the ability to constantly be tuning the fuel and air intake for each cylinder that benefits the performance. However, mechanics and other people in the transport industry believe that, carburetors do last longer than fuel injection systems and are favored in the transport business. Holder and Kunz (2009) invariably held the view that, carburetors are much simpler to install than fuel injection systems, because there are no electrical components or return lines to the fuel tank, making carburetor engines currently much less expensive than the electronic fuel injection systems.

Though many believe that, the fuel injection systems are the best as they will decrease vibration and help to overcome steep grades that are traditional terrain on the roads, there had not been officially laid down standards to be used as a measure from the manufacturers" viewpoint to determine whether fuel injection engines and better than carburetor engines in terms of efficiency and performance. The measures used to determine the efficiency and performance of both engines are based on people"s imagination which might not be appropriate. Again, which one is best completely depends on where and how you're driving. This has therefore created a debate among people as to which of the two engines can perform better.

One major challenge that even worsens the situation is the fact that, 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). Another discussion is based on whether; most fuel injection systems are for gasoline or diesel applications, excluding engines that are on petrol fuel, further pushing the debate on. Following the never-ending debate resulting in the mergence of numerous perceptions on the efficiency and performance of the two engines, this study seeks to examine the perceptions of the people in order to determine the reality on the efficiency and performance of the fuel injection engines and carburetor engines.

1.3 Objectives of the Study

The main objective of the study was to evaluate the perception of people on the performance and efficiency of fuel injection compared to carburetor engines of vehicles using vehicle owners and mechanics in Tamale as a case study.

The specific objectives of the study were:

To identify the differences between fuel injection and carburetor engines of vehicles with the assistance of mechanics in the Tamale Metropolis.

To determine which of the two vehicle engine systems produces more vehicular emissions that contribute to the pollution of the environment.

To find out the underlying causes of the perception of people on carburetor and fuel injection vehicles in the Tamale Metropolis.

To assess the most patronized engine types between the carburetor and fuel injection vehicles.

1.4 Research Questions

In conducting the study of the assessment of the people"s perception on the performance of carburetor and fuel injection vehicles, the researcher intends to find answers to the following questions:

1. What are the differences between carburetor and fuel injection vehicles?
2. Do carburetor engines or fuel injection vehicles produce more vehicular emission?
3. What are the causes of the perception of people on carburetor and fuel injection vehicles in the Tamale Metropolis?
4. What are most the patronized engine types between the carburetor and fuel injection vehicles?

1.6 Significance of the Study

The functional objectives for fuel injection and that of carburetor engines systems cannot be under-estimated. All share the central task of supplying fuel to the combustion process, but it is a design decision how a particular system is optimized. As a result of this, the research will be of great significance to vehicles owners and the prospective owners on the type engine type to purchase. To the management of automobile mechanical shops involved in repairing the two engines, the finding and results of this study provides a more reliable scientific measure for describing and evaluating the conditions of such engines.

The study also serves as a source of information on the transmission differences of the engines. Therefore providing the empirical support for mechanics‟ decision in several critical areas of their operations, and above all, provides a justifiably valid and reliable guide to designing workable service delivery improvement strategies for fuel injection and carburetor engines. The study will also draw the attention of the researcher on the underlying challenges of the engines which adversely affect the affects the performance of the engines in terms of fuel consumption.

The study will also be useful to research students and research organizations since the research report will provide an important source of literature which would be relevant for further studies relative to the on the assessment of people‟s perception on the efficiency of the two engines. It is in the light of the above, that the researcher found it necessary to scientifically investigate the perception of people on the efficiency of fuel injection engines and carburetor engines; using some selected automobile mechanical shops and other vehicle owners as a case study in the Tamale Metropolis.

1.6 Scope of the Study

The study looks at the emerging perception of people on whether carburetor engines are efficient that fuel injection vehicle. This study also focuses on the differences between carburetor and fuel injection vehicles through the assistance of the mechanics at the various automobile repair shops in the Tamale Metropolis.

The study considers again determine efficiency of the two vehicle engine systems in term vehicular emissions which may contribute to the pollution of the environment. The underlying causes of the perception of people on carburetor and fuel injection vehicles in the Tamale Metropolis are also taking into consideration. Furthermore, the study examines the most patronized engine types between the carburetor and fuel injection vehicles.

1.7 Organization of Report

The study will be organized into five chapters. Chapter one outlines the introduction of the study, which consists of the background to the study, statement of the problem, research questions, objectives of the study, scope of the study, justification of the study, and organization of the report. Chapter two reviews related literature and defines some key relative to performance of both fuel injection and carburetor engines. Chapter three presents the research methodology which involves research design, data requirements and sources, population and sampling techniques and data collection techniques employed in carrying out the study. The fourth chapter presents and analyses the data. Finally, chapter five presents the key findings of study, and based on the findings, appropriate recommendations are made.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The thematic areas dealt with in this chapter are the history and development of vehicle engines, differences between carburetor and fuel injection vehicles, carburetor and fuel injection contribution to vehicular emissions and its impact on the environment, the perception of people on carburetor and fuel injection vehicles in the Tamale Metropolis as well as the most patronized engine types.

2.1 History and Development of Vehicle Engines

Herbert Akroyd Stuart developed the first device with a design similar to modern fuel injection, using a 'jerk pump' to meter out fuel oil at high pressure to an injector. This system was used on the hot bulb engines and was adapted and improved by Bosch and Clissie Cummins for use on diesel engines (Rudolf Diesel"s original system employed a cumbersome 'air-blast' system using highly compressed air). Fuel injection was in widespread commercial use in diesel engines by the mid-1920s (Walton, 2007). An early use of indirect gasoline injection dates back to 1902, when French aviation engineer Leon Levavasseur pioneered it on his Antoinette 8V aircraft power plant.

Ryan (2011) revealed that, another early use of gasoline direct injection (i.e. injection of gasoline, also known as petrol) was on the Heselman engine invented by Swedish engineer Jonas Hesselman in 1925. Hesselman engines use the ultra lean burn principle; fuel is injected toward the end of the compression stroke, then ignited with a spark plug. They are often started on gasoline and then switched to diesel or kerosene (Ryan, 2011).

Ryan said direct fuel injection was used in notable World War II aero-engines such as the Junkers Jumo 210, the Daimler-Benz DB 601, the BMW 801, the Shvetsov Ash-82FN (M-82FN). German direct injection petrol engines used injection systems developed by Bosch from their diesel injection systems. Later versions of the Rolls-Royce Merlin and Wright R-3350 used single point fuel injection, at the time called "Pressure Carburettor". Due to the wartime relationship between Germany and Japan, Mitsubishi also had two radial aircraft engines utilizing fuel injection, the Mitsubishi Kinsei (*kinsei* means "venus") and the Mitsubishi Kinsei (*kasei* means "mars").

Insang (2010) found that, 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. The engines had six electrically operated injectors and were fed by a semi-high-pressure circulating fuel pump system.

The invention of mechanical injection for gasoline-fueled aviation engines was by the French inventor of the V8 engine configuration, Leon Levavasseur in 1902 (Insang, 2010). Levavasseur designed the original Antoinette firm's series of V-form aero engines, starting with the Antoinette 8V to be used by the aircraft the Antoinette built that Levavasseur also designed, flown from 1906 to the firm's demise in 1910, with the world's first V16 engines, using Levavasseur"s direct injection and producing some 100 hp, flying an Antoinette VII monoplane in 1907.

Immediately following the war, hot rodder Stuart Hilborn started to offer mechanical injection for race cars, salt cars, and midgets, well-known and easily distinguishable because of their prominent velocity stacks projecting upwards from the engine they were used on (Agha, 2008).

According to Agha (2008), the first automotive direct injection system used to run on gasoline was developed by Bosch, and was introduced by Goliath for their Goliath GP700 automobile and Gutbrod in 1952. This was basically a high-pressure diesel direct-injection pump with an intake throttle valve set up. (Diesels only change the amount of fuel injected to vary output; there is no throttle.) This system used a normal gasoline fuel pump, to provide fuel to a mechanically driven injection pump, which had separate plungers per injector to deliver a very high injection pressure directly into the combustion chamber.

Agha (2008) further added that, the 1954 Mercedes-Benz W196 Formula 1 racing car engine used Bosch direct injection derived from wartime aero engines. Following this racetrack success, the 1955 Mercedes-Benz 300SL, the first production sports car to use fuel injection, used direct injection. The same engine was used in the Mercedes-Benz 300SLR famously driven by Stirling Moss to victory in the 1955 Mille Miglia. The Bosch fuel injectors were placed into the bores on the cylinder wall used by the spark plugs in other Mercedes-Benz six-cylinder engines (the spark plugs were relocated to the cylinder head). Later, more mainstream applications of fuel injection favored the less-expensive indirect injection methods.

As Rees (2007) put it, Chevrolet introduced a mechanical fuel injection option, made by General Motors" Rocheter Products division, for its 283 V8 engine in 1956

(1957 US model year). This system directed the inducted engine air across a “spoon shaped” plunger that moved in proportion to the air volume. The plunger connected to the fuel metering system that mechanically dispensed fuel to the cylinders via distribution tubes. This system was not a “pulse” or intermittent injection, but rather a constant flow system, metering fuel to all cylinders simultaneously from a central “spider” of injection lines. The fuel meter adjusted the amount of flow according to engine speed and load, and included a fuel reservoir, which was similar to a carburetor's float chamber. With its own high-pressure fuel pump driven by a cable from the distributor to the fuel meter, the system supplied the necessary pressure for injection. This was a “port” injection where the injectors are located in the intake manifold, very near the intake valve.

Rees (2007) again disclosed that, during the 1960s, other mechanical injection systems such as Hilborn were occasionally used on modified American V8 engine in various racing applications such as drag racing, oval racing and road racing. These racing-derived systems were not suitable for everyday street use, having no provisions for low speed metering, or often none even for starting (starting required that fuel be squirted into the injector tubes while cranking the engine). However, they were a favorite in the aforementioned competition trials in which essentially wide-open throttle operation was prevalent. Constant-flow injection systems continue to be used at the highest levels of drag racing, where full-throttle, high-RPM performance is key (Rees, 2007).

Another mechanical system, according to Ingraham (2009) made by Bosch called Jetronic but injecting the fuel into the port above the intake valve, was used by several European car makers, particularly Porsche from 1969 until 1973 in the 911 production range and until 1975 on the Carrera 3.0 in Europe. Porsche continued using this system on its racing cars into the late seventies and early eighties. Porsche racing variants such as the 911 RSR 2.7 & 3.0, 904/6, 906, 907, 908, 910, 917 (in its regular normally aspirated or 5.5 Liter/1500 HP Turbocharged form), and 935 all used Bosch or Kugelfischer built variants of injection. The early Bosch Jetronic systems were also used by Audi, Volvo, BMW, Volkswagen, and many others. The Kugelfischer system was also used by the BMW 2000/2002 Tii and some versions of the Peugeot 404/504 and Lancia Flavia. Lucas also offered a mechanical system that was used by some Maserati, Aston Martin, and Triumph models between 1963 and 1973.

2.1.1 Electronic Injection

The first commercial electronic fuel injection (EFI) system was Electrojector, developed by the Bendix Corporation and was offered by American Motors Corporation (AMC) in 1957 (Ingraham, 2009). The Rambler Rebel, showcased AMC's new 327 cu (5.4L) engine. The Electrojector was an option and rated at 288 bhp (214.8 kW). The EFI produced peak torque 500 rpm lower than the equivalent carburetored engine. The Rebel Owners Manual described the design and operation of the new system (ibid).

In Davis (2010) view, Chrysler offered Electrojector on the 1958 Chrysler 300D, DeSoto Adventurer, Dodge D-500 and Plymouth Fury, arguably the first series-production cars equipped with an EFI system. It was jointly engineered by Chrysler and Bendix. The early electronic components were not equal to the rigors of underhood service, however, and were too slow to keep up with the demands of “on the fly” engine control. Most of the 35 vehicles originally so equipped were field-retrofitted with 4-barrel carburetors. The Electrojector patents were subsequently sold to Bosch.

Bosch developed an electronic fuel injection system, called D-Jetronic (*D* for *Druck*, German for "pressure"), which was first used on the VW 1600TL/E in 1967. This was a speed/density system, using engine speed and intake manifold air density to calculate "air mass" flow rate and thus fuel requirements. This system was adopted by VW, Mercedes-Benz, Porche, Citroen, Saab and Volvo. Lucas licensed the system for production with Jaguar (Davis, 2010).

Bosch superseded the D-Jetronic system with the K-Jetronic and L-Jetronic systems for 1974, though some cars (such as the Volvo 164) continued using D-Jetronic for the following several years. In 1970, the Isuzu 117 Coupe was introduced with a Bosch-supplied D-Jetronic fuel injected engine sold only in Japan (Davis, 2010).

2.2 The Differences between Fuel Injection Vehicles and Carburetor Engines

2.2.1 Fuel Injector

Addo (2010) emphasized the fact that, the fuel injector opens and sprays the pressurized fuel into the engine. The duration that the injector is open (called the pulse width) is proportional to the amount of fuel delivered. Depending on the system design, the timing of when injector opens is either relative each individual cylinder (for a sequential fuel injection system), or injectors for multiple cylinders may be signaled to open at the same time (in a batch fire system).

2.2.2 Single-Point Injection

Single-point injection uses a single injector at the throttle body (the same location as was used by carburetors). It was introduced in the 1940s in large aircraft engines (then called the pressure carburetor) and in the 1980s in the automotive world (called Throttle-body Injection by General Motors, Central Fuel Injection by Ford, PGM-CARB by Honda, and EGI by Mazda). Since the fuel passes through the intake runners (like a carburetor system), it is called a "wet manifold system".

The justification for single-point injection was low cost. Many of the carburetor's supporting components- such as the air cleaner, intake manifold, and fuel line routing- could be reused. This postponed the redesign and tooling costs of these components. Single-point injection was used extensively on American-made passenger cars and light trucks during 1980-1995, and in some European cars in the early and mid-1990s.

2.2.3 Continuous Injection

In a continuous injection system, fuel flows at all times from the fuel injectors, but at a variable flow rate. This is in contrast to most fuel injection systems, which provide fuel during short pulses of varying duration, with a constant rate of flow during each pulse. Continuous injection systems can be multi-point or single-point, but not direct.

The most common automotive continuous injection system is Bosch"s K-Jetronic introduced in 1974. K-Jetronic was used for many years between 1974 and the mid-1990s by BMW, Lamborghini, Ferrari, Mercedes-Benz, Volkswagen, Ford, Porsch, Audi, Saab, Delorean and Volvo.

In piston aircraft engines, continuous-flow fuel injection is the most common type. In contrast to automotive fuel injection systems, aircraft continuous flow fuel injection is all mechanical, requiring no electricity to operate. Two common types exist: the Bendix RSA system, and the TCM system. The Bendix system is a direct descendant of the pressure carburetor. However, instead of having a discharge valve in the barrel, it uses a flow divider mounted on top of the engine, which controls the discharge rate and evenly distributes the fuel to stainless steel injection lines to the intake ports of each cylinder.

The TCM system is even simpler. It has no venturi, no pressure chambers, no diaphragms, and no discharge valve. The control unit is fed by a constant-pressure fuel pump. The control unit simply uses a butterfly valve for the air, which is linked by a mechanical linkage to a rotary valve for the fuel. Inside the control unit is another restriction, which controls the fuel mixture. The pressure drop across the restrictions in the control unit controls the amount of fuel flow, so that fuel flow is directly proportional to the pressure at the flow divider. In fact, most aircraft that use the TCM fuel injection system feature a fuel flow gauge that is actually a pressure gauge calibrated in gallons per hour or pounds per hour of fuel.

2.2.4 Central Port Injection

From 1992 to 1996 General Motors implemented a system called Central Port Injection or Central Port Fuel Injection. The system uses tubes with poppet valves from a central injector to spray fuel at each intake port rather than the central throttle-body. 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.

2.2.5 Multiport Fuel Injection

Multiport fuel injection injects fuel into the intake ports just upstream of each cylinder's intake valve, rather than at a central point within an intake manifold. MPFI (or just MPI) systems can be sequential, in which injection is timed to coincide with each cylinder's intake stroke; batched, in which fuel is injected to the cylinders in groups, without precise synchronization to any particular cylinder‟s intake stroke; or simultaneous, in which fuel is injected at the same time to all the cylinders. The intake is only slightly wet, and typical fuel pressure runs between 40-60 psi. Many modern EFI systems utilize sequential MPFI; however, in newer gasoline engines, direct injection systems are beginning to replace sequential ones.

2.2.6 Direct Injection

In a direct injection engine, fuel is injected into the combustion chamber as opposed to injection before the intake valve (petrol engine) or a separate pre-combustion chamber (diesel engine). In a common rail system, the fuel from the fuel tank is supplied to the common header (called the accumulator). This fuel is then sent through tubing to the injectors, which inject it into the combustion chamber. The header has a high pressure relief valve to maintain the pressure in the header and return the excess fuel to the fuel tank. The fuel is sprayed with the help of a nozzle that is opened and closed with a needle valve, operated with a solenoid. When the solenoid is not activated, the spring forces the needle valve into the nozzle passage and prevents the injection of fuel into the cylinder. The solenoid lifts the needle valve from the valve seat, and fuel under pressure is sent in the engine cylinder. Third-generation common rail diesels use piezoelectric injectors for increased precision, with fuel pressures up to 1,800 bars or 26,000 psi.

Direct fuel injection costs more than indirect injection systems: the injectors are exposed to more heat and pressure, so more costly materials and higher-precision electronic management systems are required.

2.2.7 Swirl Injectors

Swirl injectors are used in liquid rocket, gas turbine, and diesel engines to improve atomization and mixing efficiency. The circumferential velocity component is first generated as the propellant enters through helical or tangential inlets producing a thin, swirling liquid sheet. A gas-filled hollow core is then formed along the centerline inside the injector due to centrifugal force of the liquid sheet. Because of the presence of the gas core, the discharge coefficient is generally low. In swirl injector, the spray cone angle is controlled by the ratio of the circumferential velocity to the axial velocity and is generally wide compared with no swirl injectors.

2.2.8 Carburetor Engines

According to the Columbia Electronic Encyclopedia (2013), carburetor is part of a gasoline engine in which liquid fuel is converted into a vapor and mixed with a regulated amount of air for combustion in the cylinders. Land vehicles, boats, and light aircraft have a float carburetor, in which a float regulates the fuel level in a reservoir from which the fuel is sucked into the intake manifold at a restriction called a venturi. This venturi metering system controls the flow of a continuous pumped spray into the intake manifold downstream from the carburetor (Agyemang-Bonsu, Tutu-Benefoh, and Asiamah 2007).

Carburetor is also seen as a device used in petrol engines for atomizing the petrol, controlling its mixture with air, and regulating the intake of the air-petrol mixture into the engine (Collins Discovery Encyclopedia, 2005).

2.2.9 Features of Carburetor Engines

McGraw-Hill Dictionary of Scientific & Technical Terms (2003) explains that, carburetor is a device that controls the power output and fuel feed of internal combustion spark-ignition engines used for automotive, aircraft, and auxiliary services. Its duties include control of the engine power by the air throttle; metering, delivery, and mixing of fuel in the airstream; and graduating the fuel-air ratio according to engine requirements in starting, idling, and load and altitude changes. The fuel is usually gasoline or similar liquid hydrocarbon compounds, although some engines with a carburetor may also operate on a gaseous fuel such as propane or compressed natural gas. A carburetor may be classified as having either a fixed venturi, in which the diameter of the air opening ahead of the throttle valve remains constant, or a variable venturi, which changes area to meet the changing demand.

A simple updraft carburetor with a fixed venturi illustrates basic carburetor action (see illustration). Intake air charge, at full or reduced atmospheric pressure as controlled by the throttle, is drawn into the cylinder by the downward motion of the piston to mix with the unscavenged exhaust remaining in the cylinder from the previous combustion. A cylinder is most completely filled with the fuel-air mixture when no other cylinder is drawing in through the same intake passage at the same time. The fuel is usually metered through a calibrated orifice, or jet, at a differential pressure derived from the pressure drop in a venturi in the intake air passage.

A simple updraft carburetor with a fixed venturi illustrates basic carburetor action. Agyemang-Bonsu et al. (2007) on their part revealed the fact that. Intake air charge, at full or reduced atmospheric pressure as controlled by the throttle, is drawn into the cylinder by the downward motion of the piston to mix with the unscavenged exhaust remaining in the cylinder from the previous combustion. A cylinder is most completely filled with the fuel-air mixture when no other cylinder is drawing in through the same intake passage at the same time. The fuel is usually metered through a calibrated orifice, or jet, at a differential pressure derived from the pressure drop in a venturi in the intake air passage.

A device in Buron et al. (2009) view is used to meter the flow of fuel and to prepare a combustible mixture of liquid fuel and air for internal combustion engines with external mixing layouts. This process of preparing a combustible mixture as Buron et al. (2009) put is called carburetion. In order to achieve complete and rapid combustion and maximum heat release in the cylinder, the fuel must be mixed with air in a certain way. Preparation of the mixture consists of breaking down the liquid fuel into small droplets (atomizing), intensively mixing the fuel and air, and vaporizing the mixture (Nesamani et al. 2007). Atomization of fuel in a carburetor occurs when a thin jet of fuel is allowed to flow from an atomizer into a rapidly moving air stream. The air stream breaks up the fuel into small droplets which mix with the air and are conveyed through the intake manifold into the cylinders of the engine.

Carburetors can be classified into three groups with differing directions of air flow: downdraft (descending stream), updraft, and horizontal. Downdraft carburetors are used primarily in motor-vehicle engines. Carburetors with horizontal flow are used primarily in motorcycle, boat, and supercharged motor-vehicle engines.

Aird, (2011) further explained that, a carburetor is connected to the intake manifold of an engine. During the intake stroke the piston moves away from the cylinder head, creating a vacuum within the cylinder that outside air rushes to fill. The air passes with great velocity through the mixing chamber, where it picks up the fuel. The amount of combustible mixture fed into the cylinder is regulated by the throttle valve. The simplest types of carburetors are not equipped to change the composition of the combustible mixture, although changes are required if the operating conditions of the engine are changed.

This implies that, to adapt to changes in operating conditions, carburetors are equipped with automatically controlled metering devices. The graph of the compositional changes of the combustible mixture fed to the engine as a function of air consumption or as a function of engine load shows the operating characteristics of the carburetor. The adjustment and working condition of the carburetor greatly influence engine operation. Carburetors that are out of adjustment cause a deterioration of operating economy and engine performance and an increase in the toxicity of exhaust gases.

2.3 Carburetor and Fuel Injection Engines Contribution to Vehicular Emissions and Its Impact on the Environment

Road transportation contributes significantly to economic activities of all nations, and thus is one of the most important indicators of a countries‟ socioeconomic status. Nevertheless, people believe that, engines of vehicles exert numerous negative effects on society in the form of pollution, noise and accidents (Buron et al. 2004). Emissions from engines of vehicles constitute the single largest source of air pollution in urban areas (Agyemang-Bonsu et al. 2007). In Kumasi, for example, vehicle numbers have risen more than four-folds in the last 10 years (DVLA, 2010). In 2008 and 2010, the numbers of vehicles in Kumasi were 61278 and 230796 respectively. This growth in number of vehicles has serious economic, environmental and social implications for the people of Kumasi. It has significantly affected urban lifestyle and generated economic opportunities. On the other hand, the rise in vehicle fleet presents a challenge to urban authorities in that air quality continues to seriously deteriorate while traffic congestion increases (Xin, 2006).

The increasing of number of vehicles has over the past several decades caused vehicular emissions, especially in major metropolitan areas like Kumasi, Accra, Tema, Tamale etc. through rapid growth in travel (Nesamani, 2007), urban exodus and continuous increase in population motorization rate. Travel speed in Kumasi is slow and constantly getting worse over the years as vehicle population keeps rising (Agyemang-Bonsu et al. 2007). In the central areas, average peak hour speeds had been declining (Addo, 2010) and is anticipated to get worse as the current resident fleet stock of 134350 (16%) of national fleet is expected to rise (DVLA, 2010).

The soaring urban vehicular emissions contribute to the deteriorating local air quality and climate change which has health implications. Roadside air quality assessment conducted by EPA, Ghana in 2003 suggests that roadside users experience extreme pollution, particularly, from carbon monoxide, carbon dioxide, sulphur dioxide and particulate matter (EPA, 2010). This has put people in a state of confusion concerning which of the two engines produces large component of the vehicular emissions that causes harmful effects in the atmosphere. Vehicular emissions among others have been identified as key source of greenhouse gases, especially, CO_2 in Ghana (EPA, 2010). Although, it is recognized that vehicular emission is an important source of air pollution especially in urban metropolitan areas in Ghana, it remains unknown how much pollution vehicles produce, how various vehicle categories contribute to emissions due to the lack of national inventories of vehicular emissions.

Therefore, it is imperative to establish and contextualize people"s notion on which engine type causes vehicular emissions in the country. Few studies on the estimation of vehicular emission inventories have been carried out internationally. Vehicular emission inventories in Spain from 1988 to 2010 were estimated ((Xin, 2006). The emissions of several local, global, and fuel-related vehicular pollutants were analyzed and the reasons behind fully discussed.

Bellasio et al. (2007) estimated the road traffic emission inventory in Sardinia, Italy, by calculating emissions of several vehicular pollutants and the contribution of different vehicle categories to the overall emissions. Saija and Romano, (2012) estimate road transport emissions in Italy, and developed a top down approach when the required data for the local level estimation were unavailable. Other methods have been applied in estimating which engine type produces most vehicular emissions. Schifter et al. (2005) estimated emission for the metropolitan area of Mexico City, based on the emission factors derived from remote-sensing measurements and the vehicular engine performance obtained according to fuel consumption. In Africa, attempts have been made in South Africa (Van der Westhuisena, 2010), Kenya (US Environmental Protection Agency, 2008), Ghana (Kylander et al. 2013) and Egypt to estimate different kinds of vehicular emission pollutants.

In this study, vehicular emission estimation is done based on engine efficiency and performance. different methodologies was applied in the calculation of vehicle engine emissions because it considers most important pollutants such as CO_2, Pb, and CO; can most easily be linked to the technology in Europe and other the imported cars in Ghana and last but not least, it has a user-friendly interface (European Commission, 2003). Other available emission models software such as International Vehicular Emission Model (IVE) and MOBILE 6 Motor Vehicle Emissions model developed by the US EPA for estimating vehicular emissions were also considered at the inception of the study

2.3.1 Concept of Vehicle Engine Emission Estimation

Engines emissions from vehicles are mainly divided into two (2) categories: exhaust (tailpipe) emissions and evaporative (vapor) emissions (Agyemang-Bonsu et al. 2007). Exhaust or tailpipe emission is one of the major forms of emissions from on-road vehicles operations. It includes vehicle starts-up emissions and running emissions, which occur when the engines of vehicle are warmed up and operated in a hot stabilized mode.

Start emissions are broken down into cold start or warm start emissions depending on the engine temperature at the start of the vehicle. Evaporative emissions or vapour emissions, the other major form of emissions, consist entirely of Volatile Organic Compounds (VOC). They include running losses, which occur when the vehicle is operating in a hot stabilized mode, hot soaks emissions; results from fuel evaporation (especially gasoline fuels) from the still hot engine at the end of the trip; diurnal emissions; which results from evaporations of fuel from the gasoline tank whether the vehicle is driven or in steady state. Figure 2 shows the conceptual diagram of vehicle emission stages as a function of engine temperature.

2.3.2 Fuel Consumption as a Factor for Determining Engine Performance

The COPERT III model uses fuel use and distance traveled to estimate vehicle fuel consumption as a function of vehicular emissions. In Ghana, fuels other than petrol, LPG and diesel are considered less significant and were excluded from the emission calculations. National fuel production statistics on gasoline, diesel and LPG were obtained from the Tema Oil Refinery.

Specific fuel consumption data for Kumasi was non existing at the national level; however a critical operational assumption was made on the basis of proportional representation of fuel consumption relative to resident fleet numbers. Table 2 gives fuel consumption and the accompanying fleet numbers in Kumasi. Data on sulphur content, carbon and RVP were also obtained from the national fuel data.

Temporal Changes in Vehicular Emissions

Fuel consumption increased steadily from 206.6Gg in 2000 to 280.8Gg in 2005 and was used, particularly, in the cold start and hot emission stages of the annual trip distances. Conventional and Euro I vehicles respectively accounted for an estimated 55.8% and 32.2% of total fuel consumption among all classes of vehicles. The remaining 8.2% and 3.8% were consumed by Euro 2 and Euro 3 vehicles. Number of vehicles, average annual mileages, age distributed-mileages and distributions between driving patterns greatly influenced the total vehicle kilometer traveled and thus have analogous effect on the total estimated emissions. Total emission levels increased from 682.3Gg in 2000 to 883.4 in 2005.The rise is estimated at 14.7% per annum depending especially on the commensurate increase in fleet numbers and fuel consumption.

Similar emission results over years had been reported by (Saija and Romano, 2002) in Italy and (Hao and Shaodong, 2007) in China. The principal cause for the increasing emission levels could be ascribed to the progressive rise in population of vehicles, especially the significant increment of imports of used vehicles, followed by the increase in mobility stimulated by the economic growth, and the nonexistent regulations for fuel and vehicles. Poor adherence to maintenance regimes especially for commercial vehicles could contribute to the general rise in vehicular emissions. Between 2000 and 2002, the total emission curve flattened in response to the reduction in fuel consumption in Kumasi in the same period. The reduction in fuel consumption in 2000 and 2002 is attributed to a number of reasons including; underproduction of gasoline due to routine repairs at the refinery, high price of crude from the international market, and smuggling of gasoline products to neighboring countries due to price disparity. CO_2, CH_4 and N_2O

are key greenhouse gases from the transport sector in addition to ozone precursor gases such as NMVOC, CO and NOx.

Total greenhouse gases in this study are defined as an aggregate of CO_2, CH4 and N_2O and CO_2 equivalent to define global warming potential (GWP) of Carbon Dioxide (1), Methane (GWP 23) and Nitrous Oxide (GWP 320). Table 3 shows that total greenhouse gases from the road transport increased from 665Gg in 2000 to 860.3Gg in 2005. However, the CO_2 component constituted an average of 97.6 % of the total greenhouse gases between 2000 and 2005. Out of the remaining 2.4%, 2.1% and 0.3% were respectfully accounted for by CH_4 and N_2O. The amount of CO_2 emissions largely depends on initial carbon content in the fuel stock and fuel consumption levels (Figure 3b). The substantial growth of vehicle population, especially over-aged vehicles in Kumasi over the past years was the major cause. In responds to this traffic congestion in urban areas increased particularly during peak hours of the day, gross CO_2 emissions rose correspondingly in relation to increasing on-road fuel consumption.

Non-Direct GHG Emissions

The formation mechanism of CO is directly influenced by, among others, driving patterns, maintenance regimes, technology type, age and size. Largely, CO emissions from vehicular sources are a function of the efficiency of combustion engine. Nitrogen oxides are indirect greenhouse gases. They are particularly important vehicular emission because of their role of forming ozone (O3) as well as their effect on acidification. Their emissions are related to the air fuel mix and combustion temperatures. Proportions of nitrogen oxide concentrations in diesel-fuelled vehicle are generally lower than those for gasoline-fuelled vehicles. Levels of CO increased steadily from 8.55Gg in 2000 to 11.5Gg in 2005 whereas NOx marginally increased from 5.4Gg in 2000 to 7.3Gg in 2005.

Particulate matter is a non-greenhouse gas parameter. Diesel-fuelled vehicles are major source of particulate matter of varying diameters. Increase in PM levels over the years was marginal from 0.2Gg in 2000 to 0.35Gg in 2005 (Figure 4b). With current rate of growth of diesel vehicles, PM emissions are expected to reach 0.4Gg by year 2010. Sulphur dioxide is not a greenhouse gas but its presence in the atmosphere may influence climate. It reacts with a variety of photo chemically produced oxidants to form sulphate aerosols.

The concentration of these particles increase when there is burning of diesel fuel which contains sulphur. The emission curves flattened, although it subsequently rose but not in commensurate with the rate of growth before 2002 and 2003. Three primary sources of evaporative emissions from vehicles are namely, diurnal, hot soaks and running losses are usually determined for gasoline-fuelled vehicles. The amount of NMVOC and VOC are significantly affected by the volatility of the gasoline, absolute ambient temperature and temperature changes and vehicle technology type (fuel injection or carburetor engines). Both VOC and NMVOC increased marginally from 1.3Gg to 1.8Gg and 1.2Gg to 1.7Gg respectively. Flattening of VOC and NMVOC emission curves occurred between 2000 and 2002 and however, the emissions levels subsequently rose after year 2002 (Figure 5).

2.4 Contribution of each Vehicle Category to Emissions

Vehicle contribution to emissions of particular pollutants varied from category to category, due to different levels of emission factors of the pollutants, different population and mileages of vehicles. Passenger vehicles were classified as private or commercial and their net weight were mostly below 2600kg. 75% of passenger vehicles ply urban roads at average speed of 37km/h.

Passenger vehicles account for an average 69.7 % of total fleet stock in the Kumasi. Forty-eight percent of these vehicles were Conventional; 37% are Euro 1. Eight percent are Euro 2 vehicles whereas 6% are Euro 3. Emissions from passenger vehicles accounted for 70% of total emissions in the Kumasi Metropolis. Conventional-passenger vehicles are therefore a major emission category source among the sub-classes.

Aird (2011) is of the opinion that, light-duty vehicles constitute an estimated 18% of total vehicle population in the Kumasi compared to 70% from passenger vehicles within the same period. About 53% are conventional, 30% are Euro 1, while the remaining 11 and 6% are Euro 2 and Euro 3 respectively. Eighteen percent of the average total vehicular emissions were produced from light-duty vehicles. Of the total light-duty vehicle emissions, conventional vehicles account for a total of 95.7%.Whiles Euro 2 and Euro 3 vehicles form the remaining 2.9% and 1.34 % respectively. About 3.2% of total fleet populations in Kumasi are heavy duty vehicles. Out of this, 66.5% are conventional whereas 22.5% are Euro1. The remaining 7.4% and 3.6% are Euro 2 and Euro 3 respectively.

Agyemang-Bonsu et al. (2007) stressed the fact that, vehicular emissions from heavy duty vehicles constituted 2% average of the total fleet emissions in the Kumasi. Of the 2%, 78.2% and 15.4% are respectively attributed to and Euro 1 vehicles whereas 1.6% conventional and 1.9% are from Euro 2 and Euro accordingly. Total urban buses fleet in Kumasi 7.1% and account for 6.9% of total vehicular emissions between 2000 and 2005.Conventional vehicles accounted for 98% urban buses emissions. The remaining 2% are from fairly newer urban tracks. Coaches are vehicles that transport good and passengers mainly on feeder and highways.

Their average net weights range between 2500kg and 5000kg. Most coaches are meant for commercial use and normally operate between towns and villages. Their route usually starts from the urban sometimes through highways and finally to the rural roads. The average manufacturing year of the class of vehicles is 1993 and accounts for 1.1 percent of total Kumasi fleet stock (Agyemang-Bonsu et al. 2007).

Aird (2011) put across the argument that, coaches‟ account for 0.01 percent of total emissions. Mopeds are tricycle in nature with engine size less than $50cm^3$. Their traffic activities are predominating in urban areas. They constitute about 0.002 % of the entire Kumasi fleet. Conventional mopeds make up about 52 % of the moped fleet, followed by stage I and stage II in that order. In terms of emissions, mopeds contribute only of 0.001 % of the total vehicular emissions of which those manufactured before 1992 contributed 83%. Motorcycles are either 2-stroke or 4-stroke based on the engine size. Two stroke motorcycle engines are bigger than $50cm^3$ whiles that of 4-strokes are less than $25cm^3$. About 1 percent of the vehicle fleet in Kumasi is motorcycles. 0.36 % is

2-stroke and the remaining 0.34 % is 4-stroke motorcycles. Motorcycles contributed an estimated 2.5 % of vehicle emission to the total emissions.

"Conventional-passenger" vehicles dominate fleet stocks in Kumasi and undoubtedly contributed greatly to vehicles emissions in all categories. This is attributable to the increasing importation of over-aged vehicles into the country coupled with the hugely populated older vehicles resident in Kumasi. Most of these over-aged vehicles are used for commercial activities and for that reason consume a lot of fuel to cover relatively shorter mileages mostly in the city where traffic congestion is high. This implies low fuel use efficiency leading to high vehicular emissions.

Again, the deteriorating nature of engines of most conventional vehicles, unless otherwise retrofitted, contributes significantly to the high emissions. This observation, though, seemed expected since similar results had been widely reported by authors such as (Hao *et al.* 2007), (Bellasio *et al.* 2007) and (Xin, 2006); the percentage of conventional vehicles is greatly high relative to what had been reported in other African countries including Kenya and South Africa. These results become critically imperative in view of government‟s policy that allows importation of over-aged vehicles with penalty in addition to the fact that it built-up on the huge numbers of poorly maintained over-aged vehicles resident in the country. A more practical futuristic assessment of this policy dispensation is that importations of conventional vehicles over-aged vehicles will perhaps rise and inundate the streets to spur heavy traffic congestion specifically in urban areas.

2.5 Perception on Fuel Injection and Carburetor Engines

Social perception deals with how people form impressions of and make inferences about performance of fuel and carburetor engine. The study assesses feelings and emotions by picking up on information gathered from their physical appearance, and verbal and nonverbal communication. Facial expressions, tone of voice, hand gestures, and body position are just a few examples of ways people communicate without words.

An important term to understand when talking about Social Perception is attribution. Attribution is explaining a person"s behavior as being based in some source. Most importantly, social perception is shaped by individual's motivation at the time and emotions based on the performance fuel and carburetor engines. All of this combined determines how people attribute certain traits and how those traits are interpreted.

Fuel injection which is a system for admitting fuel into an internal combustion engine to some people does not have efficient fuel economy. 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 (Agyemang-Bonsu, et al 2007).

According to Agyemang-Bonsu et al. (2007), the primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturi tube to draw the fuel into the airstream. 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.

A large component of Social Perception is attribution. Attribution helps individuals understand and rationalize the behavior of others through the use of information gathered by observation.

People make attributions to understand the world around them in order to seek reasons for a particular individual‟s behavior. When people make attributions they are able to make judgments as to what was the cause of a certain behaviour. However, a common mistake people make is called Fundamental Attribution Error. This means that the original explanation for the behavior was misidentified. An example of this would be a mother misattributing her son's excitement to sugar from the candy he just ate, as opposed to the real cause of his excitement being that his favorite TV show is on.

Implicit personality theory is commonly associated with social perception because it identifies the biases we exhibit based on the limited information we know about unfamiliar people. Every day we interact with unfamiliar people and in those brief moments of interaction we pick up on the social cues presented and opinions are formed. Implicit Personality Theory states that people divide the personality traits of others into two groups: Central/Primary traits or Peripheral/Secondary traits. Central traits are the highly influential traits that have a strong impact on the overall impression of an individual. Peripheral traits are those produced and have smaller impact on the overall impression.

According to Rogers (1959), the self-concept is, "the organized, consistent set of perceptions and beliefs about oneself." Each person has their own self-concept that reflects all of their personal attributes, beliefs and attitudes. In summary, a self-concept is the evaluation of one's self and the things that make up the self. The Development of the self-concept starts in early childhood. Although how it develops and the distinct stages are still debated (Rogers 1959).

In simple terms, self-image is what an individual sees in his- or herself. Self-image is not based on reality but rather on the individual's perception. This is why many drives on one hand thinks carburetor engines performs better than fuel injection engines, whiles on the other hand, others think fuel injection and then carburetor in terms of performance, especially fuel economy..

2.5.1 Factors Influencing People's Perception on Fuel Injection and Carburetor Engines

This section deals with the various arguments put forward by different authors in relation to which of the two engines performs better. Thus, whether carburetor or fuel injection engines perform is the bone of contention.

2.6 Engine Tuning

Davis (2010) held the opinion that, the modern digital electronic fuel injection system is more capable at optimizing engine performance than earlier fuel delivery systems (such as carburetors). Carburetors have the potential to atomize fuel better, but unable to economize fuel better.

2.7 Benefits

The benefits include the following:

Driver Benefits

Operational benefits to the driver of fuel-injected vehicles include smoother and more dependable engine response during quick throttle transitions, easier and more dependable engine starting, better operation at extremely high or low ambient temperatures, smoother engine idle and running, increased maintenance intervals, and increased fuel efficiency (Aird (2011).

Aird (2011) added that, on a more basic level, fuel injection does away with the choke, which on carburetor-equipped vehicles must be operated when starting the engine from cold and then adjusted as the engine warms up.

2.7.1 Environmental Benefits

In his argument, Aird (2011) disclose that, fuel injection normally increases engine fuel efficiency. Aird further added that, with the improved cylinder-to-cylinder fuel distribution of multi-point fuel injection, less fuel is needed for the same power output (when cylinder-to-cylinder distribution varies significantly, some cylinders receive excess fuel as a side effect of ensuring that all cylinders receive sufficient fuel).

Bellasio, et al. (2007) believed that, exhaust emissions from fuel injection engines are cleaner because the more precise and accurate fuel metering reduces the concentration of toxic combustion byproducts leaving the engine, and because exhaust cleanup devices such as the catalytic converter can be optimized to operate more efficiently since the exhaust is of consistent and predictable composition.

Following from the on-going arguments and discussions from the different authors, it can be concluded with high level of certainty that, fuel injection engines are currently the choice of many automobile manufacturing companies. This also applies to prospective vehicle owners and drivers. The discussions in the literature has revealed that, carburetors engines are becoming outmoded and are gradually becoming unattractive to those who understand the operations of automobile engines.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the scientific and analytical framework for data collection, hence, the methodology adopted for data collection. it basically includes the research design, instrumentation, target population, validity of the instruments, reliability of instruments, sampling, categories of respondents and the data analysis, presentation and reporting

3.2 Research Design

The case study is the design adopted for this study. Case studies practically describe a type of a study put in place to address a particular problem (Naele, et al, 2006). Yin, (2008) looks at it as an empirical inquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and the context are not clearly evident, and in which multiple sources of evidence are used. It is also referred to as an investigation about something special on individuals, organization, processes, programs, neighbourhoods, institutions and even events. Case studies are often used to provide context to other data (such as outcome) offering a more complex picture of what happened and why (Yin, 2003).

The researcher identifies three basic principles underlying case studies namely "how" and "why" questions are used. However, "what" questions are used when the case study is for exploratory purposes. Secondly, case study requires no control over behavioral events and thirdly, the case study focuses on contemporary events.

In view of the above principles, the case study was selected for this research since the study fulfils all of them. This is due to the fact that, assessing the perception of people on the efficiency of fuel injection engines compared to carburetor engines of vehicles requires contemporary approaches and instruments of various players in the automobile industry. Yin (2003) indicates that case studies allow the researcher to present data collected from multiple methods. This study presents data from interviews, observations and questionnaires. Again, the use of case study provides much detailed information about the phenomenon being investigated (Naele, et al, 2006). Therefore the use of this design will provide detail information on the assessment of the perception of people on fuel injection and carburetor engines.

3.3 The Instruments

The researcher employs questionnaires and structured interviews in the data collection exercise. Each members of the sample group will be asked the same questions and therefore there will be fewer chances of the researcher being bias. Questionnaires will be distributed by the researcher to the literate respondents to provide answers to the questions since they can read and write. Visits will personally be made by the researcher to have face-to-face interaction with the respondents.

Interviews will be conducted to solicit information from the respondents in the automobile industry. The questionnaire contains various sections with different thematic areas that reflected the objectives of the study. Such thematic areas socio-demographic characteristics of respondents, the differences between fuel injection and carburetor engines of vehicles in the tamale metropolis, carburetor and fuel injection engines‟

contributions to vehicular emissions and its impact on the environment, the causes of the perception of people on carburetor and fuel injection vehicles in the tamale metropolis as well as the most patronized engine types between the carburetor and fuel injection engines of vehicles.

As a result of this, there will be common response to variables. Computation of findings will be made easy by the use of questionnaire. It will also offer opportunity for respondents to respond to variables at their convenience.

3.4 Target Population

The target population for this study consists of automobile mechanics, automobile sales outlets and automobile owners and drivers in the Tamale Metropolis. The reasons that necessitate the selection of the above respondents relates to the fact that, issues relating to the performance of vehicle engines basically occurs in the automobile industry.

3.5 Validity of the Instruments

The findings will be compared to the research objectives to ensure that there is sound reasoning. Once correlation between the findings and the research objectives is established, the validity of the study will however be assured leading to the collection of empirical data.

3.6 Reliability of Instruments

Administering of questionnaire and interviews will be done repeatedly on the same interviewees at different times for the purposes of ensuring reliability. Reliability of the instruments to be employed will be confirmed comparing the former and the latter responses.

3.7 Sampling

3.7.1 Sampling Technique

Two sampling techniques will be used to select the sample for data collection. These include purposive and simple random sampling techniques. Purposive sampling is a technique that allows a researcher to select respondents with the required information with respect to the objectives. This technique will be used to collect data from the automobile mechanics and sale outlets, especially Japan Motors in Tamale. Simple random sampling technique involves giving every subject a chance of being interviewed. This technique will be used to collect data from automobile owners and drives in the various communities of the Tamale Metropolis.

3.7.2 Sample Determination

For the purpose of this study, the various sampling units were identified.

Table 3.1: Selection of the Study Population

Target Population	Actual sample size
Automobile sale outlets	20 Respondents
Automobile mechanic	100 mechanics
Automobile owners	80 Car owners
Automobile drivers and others	120 drivers and others
Total	**320 Respondents**

Source: Field Data, 2015

3.8 Categories of Respondents

Data collected for this study was sourced from four categories of respondents as indicated in the above table; Table 3.7 indicates a total of 300 respondents comprising the key informants at the selected study sites earmarked for providing very relevant information. The inclusion of the various sampling units, especially automobile sales representatives and mechanics is necessitated by the fact that, issues relating to the determination of the performance automobile engines rest in their knowhow, hence the need to solicit ideas from these categories of respondents.

3.9 Data Analysis, Presentation and Reporting

Data from the field after the application of the required instruments will be edited to correct some mistakes in the instruments used in the field. Subsequently, the data will be categorized and tabulated to respond to the study objectives. Quantitative data collected will be coded in order to make it possible for using the SPSS in the construction of the required charts for data analysis.

Findings of the research will be reported using a combination of varied approaches and techniques. Quantitative and Qualitative analyses will be undertaken with reference to the study objectives. The use of tables, figures and charts will be employed to support the analysis of the data. The major findings will also be summarized in line with the objectives of the study.

CHAPTER FOUR

PRESENTATION OF RESULTS AND ANALYSIS

4.1 Introduction

This chapter deals with the presentation of and analysis of the results of the study. the thematic areas of the chapter consisting of the socio-demographic profile of respondents, the differences between fuel injection and carburetor engines of vehicles, the vehicle engine systems that produce more vehicular emissions, the perception of people on carburetor and fuel injection vehicles as well as the most patronized engine types.

4.2 Section 'A': Socio-Demographic Characteristics of Respondents

The data analyzed in this section deals with the different data pertaining to the socio-demographic features of the respondents who took part in the study. Demographic characteristics such as age, sex, education and job description are presented.

Table 4.1: Age Distribution of Respondents

Responses	Frequency	Percentage
21-30 years	45	15%
31-40 years	165	55%
41-50 years	60	20%
Above years	30	10%
Total	**300**	**100**

Source: Field Work: July, 2015.

Table 4.1 contains data on the age distribution of respondents who participated in the study. Out of the 300 respondents contacted for this data, 15% representing 45 respondents were aged between the age group of 21–30 years, 55% or 165 respondents of them were in the range 31 – 40 years. it was also revealed that, 20% (60 respondents) were found to be between 41 – 50 years were recorded. The ages of all the respondents appeared to be within 0- 50 years, but not above 50 years.

The above data therefore gives a picture that the workforce of the assembly is youthful. This also implies that the youthful nature of the workforce of the Tamale Metropolis if properly utilized will contribute effectively in the management of various Accounting Information Systems of the assembly.

Table 4.2: Sex Distribution of Respondents

Responses	Frequency	Percentage
Male	210	70%
Female	90	30%
Total	**300**	**100%**

Source**:** Field Work: July, 2015.

As shown in Table 4.2, the data reveals that, the respondents who were males constituted 70% or 210 respondents of the sample selected for this study. It was also observed that, 30% (90 respondents) of the remaining respondents were females. The data therefore shows that men appear to be forefront of the issues concerning the vehicle engine choices and its management in the Tamale Metropolis. However, there is the possibility that, many of the female residents in the Metropolis did not any interest in the study.

Table 4.3: Educational Background of Respondents

Educational Qualification	Frequency	Percentage (%)
Basic education	135	45
Senior High School	60	20
Diploma	30	10
Higher National Diploma	30	10
University Degree	15	05
Other	30	10
Total	300	100

Source: Field Work: July, 2015.

With regards to the educational background of respondents, it was realized that, the majority of respondents representing 45% or 135 respondents of the sample of this study had Basic education. Senior high school graduates constituted 20% or 60 respondents. Diploma and Higher National Diploma graduates represent 10% each. University degrees also represented 5% (respondents) of the sample. Those with other educational qualification such as technical and vocational knowledge represented 10% (30) of the respondents. The role of education is very essential in the appreciation of issues relating to e.g. seatbelts and its impact on safety driving.

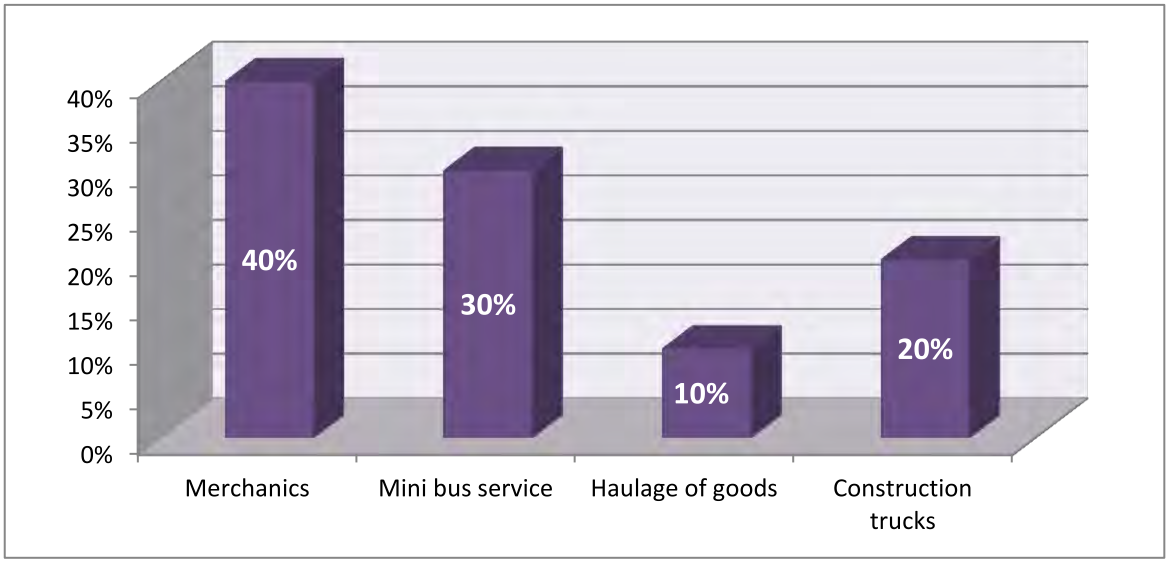

Figure 4.1: Job Description of Respondents

Source: Field Work: July, 2015.

Figure 4.1 represents the different work schedule of the respondents who were chosen for this study. Majority of the respondents representing 40% were found to be mechanics that are mostly located at the industrial area in Tamale. Also 30% of the respondents were working as mini bus service providers. The drivers involved in providing the services of haulage of goods also contributed their opinions. Drivers of construction trucks who were part of the study represented 20% of the respondents.

4.3 Section 'B': The Differences between Fuel Injection and Carburetor Engines of Vehicles in the Tamale Metropolis

As first objective of the study, the researcher in this section sought to determine the main differences between fuel injection and carburetor engines of vehicles. The variables identified to assist in the achievement of this particular objective include the efficiency of engine performance, the engine with the effective fuel economy and mechanics" conversance with repairs of the engines.

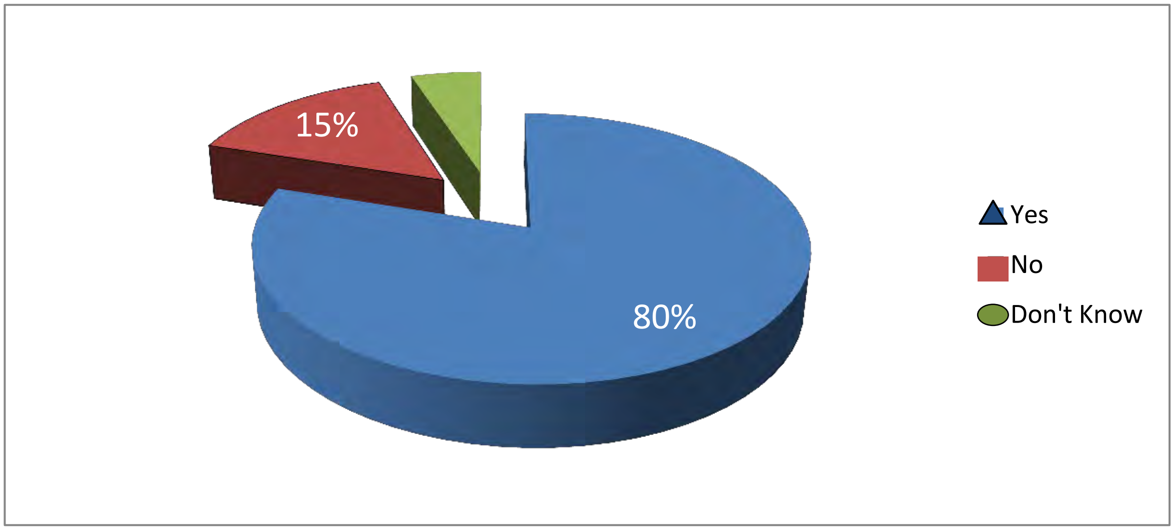

Figure 4.2: Engine Efficiency in Terms of Performance

Source: Field Work: July, 2015.

Having heard of the differences in performance of fuel injection and carburetor engines, the researcher went ahead to determine the efficiency of the two engines in terms of performance, and as the data in Figure 4.4 shows, quite a significant part of the respondents representing 80% answered in the affirmative indicating differences in efficiency in terms of performance. Contrary to this, 15% of the respondents never thought of differences in efficient in terms of performance. This implies that, both engines perform equally and provides the same level of satisfaction for users of the said vehicles. Surprisingly, 5% of the respondents were clueless, naive and inexperienced in issues relating to engines and could not provide any meaningful contribution.

Though majority of the respondents agreed to the differences in engines, they could not mention the type of engine that is efficient in its performance, except that, two different schools of thoughts put in their own views concerning the performance of engines. The first view which was advanced by Agyemang-Bonsu et al. (2007) points to the fact that, vehicles have a float carburetor, in which a float regulates the fuel level in a reservoir from which the fuel is sucked into the intake manifold at a restriction called a venturi. This venturi metering system controls the flow of a continuous pumped spray into the intake manifold downstream from the carburetor.

On the hand, Addo (2010) emphasized the fact that, the fuel injector opens and sprays the pressurized fuel into the engine. The duration that the injector is open (called the pulse width) is proportional to the amount of fuel delivered. Both schools sought to support the types of engines in the automobile industry.

For Agyemang-Bonsu et al. (2007), their justification for fuel injection engines was the low cost. This means that, many of the carburetor's supporting components- such as the air cleaner, intake manifold, and fuel line routing- could be reused.

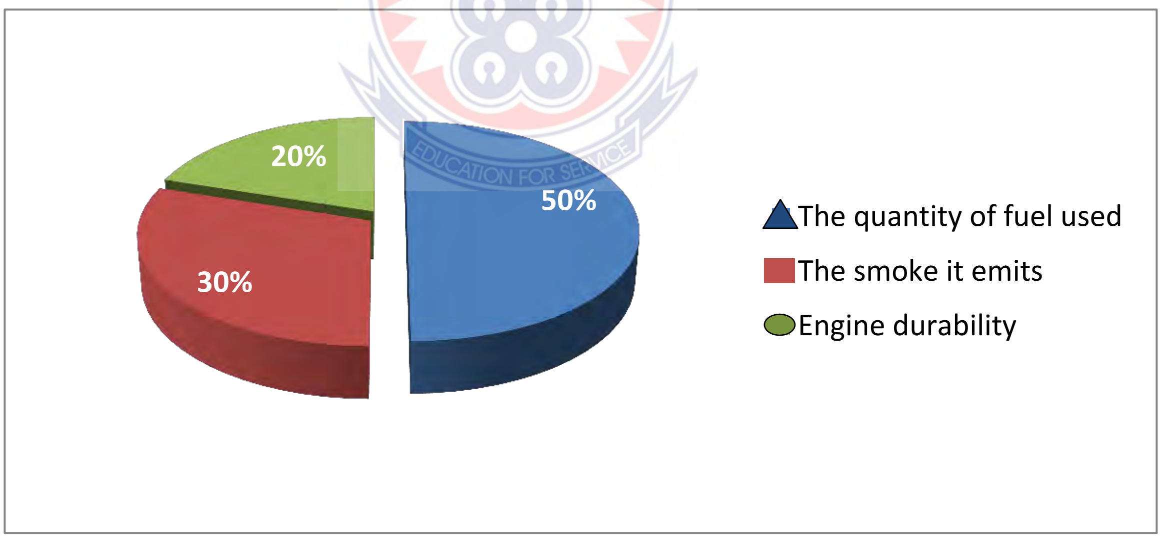

Figure 4.3: Engines Economy in terms of Fuel Consumption

Source: Field Work: July, 2015.

On factors that determine engine economy in terms of fuel consumption, majority (50%) of the respondents identified the fact that, the quantity of fuel used per kilometre determines the efficiency, thus the economy in terms of fuel consumption. It was also realized that 30% of the respondents, especially the mechanics held the view that, the amount of smoke which a particular engine emits also determine the economy of such an engine. 20% of the respondents revealed that, the durability of engines also serve as a determinant factor of engine economy.

Based on the mixed responses among the different categories of the respondents, one can make an argument to the effect that, both fuel injection and carburetor engines have good qualities.

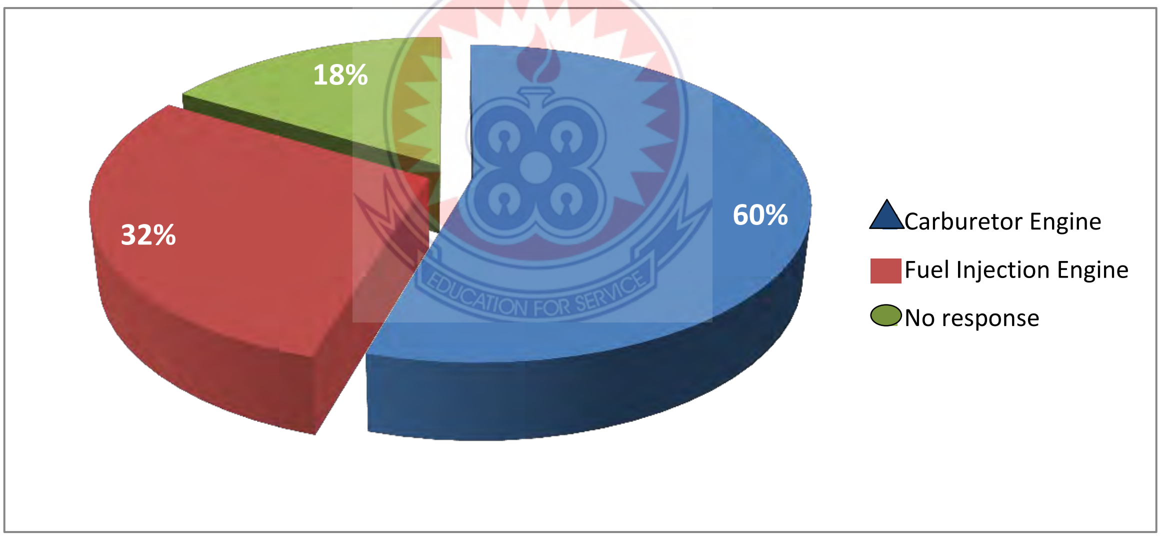

Figure 4.4: Mechanics Conversance with Engine Repairs

Source: Field Work: July, 2015.

Responding to which of the two engine types that mechanics are conversant with during repairs, 60% of the mechanics mentioned carburetor engines as the types of engine they are conversant with concerning the repair of such engines. However, 32% of the mechanics provided an opposing response since they opted for fuel injection engines.

This implies that, this category of mechanics are comfortable with the repairs and maintenance of fuel injection engines, Furthermore, 5% of the mechanics could not provide any response as to which engines types they are capable of repairing.

The mechanics did not hide the fact that, fuel consumption and maintenance are the two most important factors that must be taken into consideration when planning to repair the engines of their respective vehicles.

4.4 Section 'C': Carburetor and Fuel Injection Engines' Contributions to Vehicular Emissions and its Impact on the Environment.

As one of the objectives, this study sought to examine the contributions of the engines towards vehicular emissions and its impact on the environment. There are various contributions of the engines to vehicular emissions and its impact on the environment.

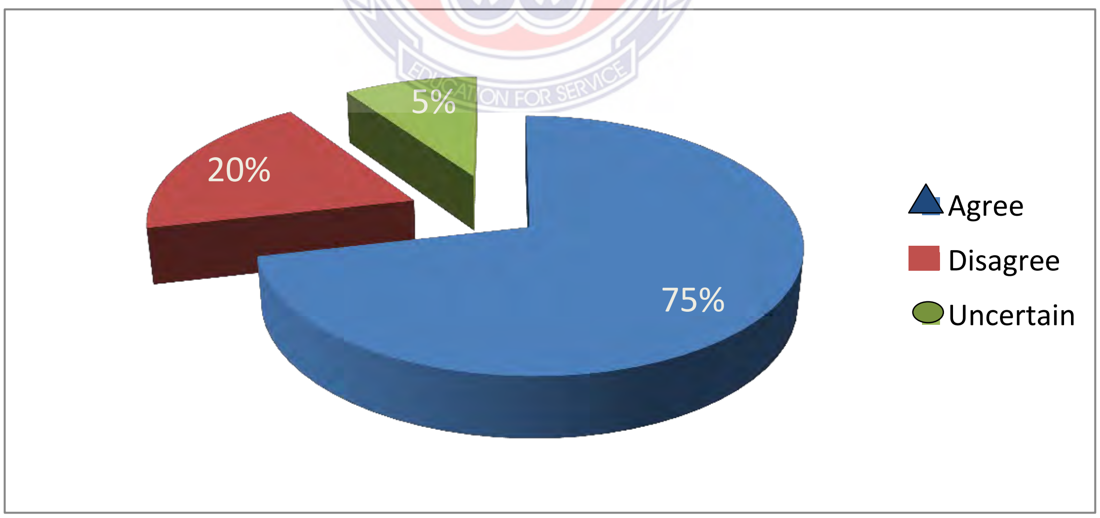

Figure 4.5: Engines Emissions by Carburetor and Fuel Injection Engines

Source: Field Work: July, 2015.

With regards to whether carburetor and fuel injection engines emit smoke into the atmosphere that turns to have an effect on the environment, it was realized that, majority of the respondents representing 75% expressed their agreement to the fact that, both carburetor and fuel injection engines produce emissions in terms of smoke to the atmosphere with its accompanying implications. Contrary to this assertion, 20% of the respondents disagreed with the explanation that, the operating mechanisms in the carburetor engines seems to control the flow of fuel thereby emitting minimal level of smoke and also less toxic. If this particular finding is anything to go by, then it finds expression in Agyemang-Bonsu et al. (2007) assertion that, emissions from engines of vehicles constitute the single largest source of air pollution in urban areas. Their assertion was not limited to a particular engine type. The last category of respondents representing 5% was uncertain and hence no contribution was made.

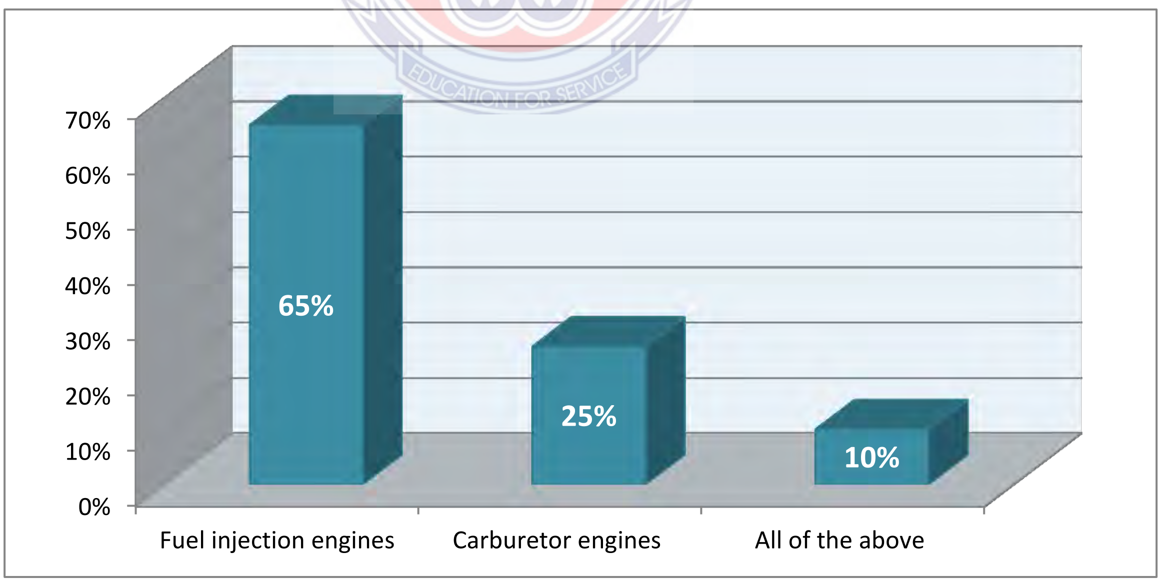

Figure 4.6: The Engine Type That Emits Toxic Gas

Source: Field Work: July, 2015.

As Figure 4.6 indicates, 65% of the respondents identified the fact that, fuel injection engines emit more of the toxic gases into the atmosphere. This Figure also contains data that indicates that, 25% of the respondents rather thought carburetor engines are the main cause of the problem. Additionally, 10% of the respondents referred to both engine types as emitting toxic gases in the atmosphere.

EPA (2010) confirms this, as their findings reveal that, the soaring urban vehicular emissions contribute to the deteriorating local air quality and climate change which has health implications. Vehicular emissions among others have been identified the as key sources of greenhouse gases, especially, CO_2 in Ghana. This implies that, the toxic gases release exerts numerous negative effects on society.

Table 4.4: Negative Effects of Toxic Gases on Society

Negative Effects	Frequency	Percentage (%)
Pollution	96	30
Noise	64	20
Diseases	112	35
Bad odour	48	15
Total	**320**	**100**

Source: Field Work: July, 2015.

As Table 4.4 demonstrates that 30% or 96 of the respondents identified pollution as one of the negative effects of toxic gases on society. Noise hard 20% (64 respondents) considered as very disturbing as most of the engines produce unbearable noise in the night when they retire home to relax. They held the view that, such noise is regarded as another negative effect of toxic gases on residents in the Tamale Metropolis. Also, majority of the respondents representing 35% or 112 indicated that the toxic gases cause several ailments in the communities. Moreover, 15% (48) of the respondents revealed that, the toxic gases create bad odour which is a source of great worry to residents, especially those who stay around the industrial area in Tamale. The findings obtained in this section correlates that of Hao et al. (2007) view that exhaust (tailpipe) emissions and evaporative (vapour) emissions are the most dangerous since they are very fast causing illnesses, lungs cancer.

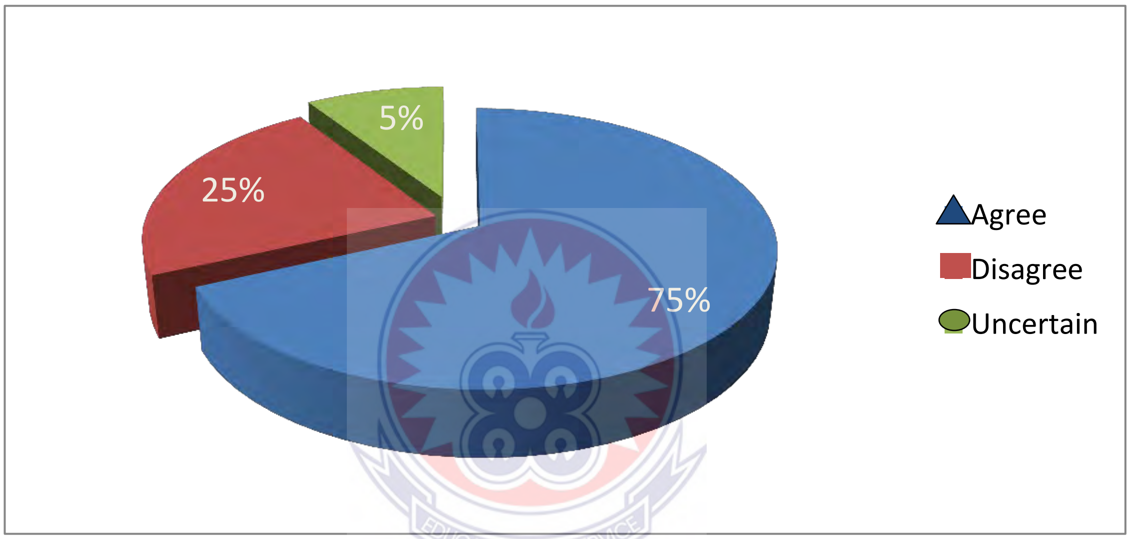

Figure 4.7: Constituents of the Gases Released

Source: Field Work: July, 2015.

With regards to whether gas release from the engines constitutes the single largest source of air pollution in urban areas, the data in Figure 4.9 reveals that, the majority of respondents representing 75% agreed to the fact that, gas release from the engines really constituted the single largest source of air pollution in urban areas.

Despite the explicit support declared by the majority of respondents in the above assertion, some of the officials representing 25% of the respondents disagreed to the fact expressed by most of the respondents. In addition to the above, 5% of the respondents were not sure of the fact and expressed their doubts concerning the significance of AISs in all the local government structure of the assembly.

Those whose response was in the affirmative referred to the increasing number of vehicles over the past several decades resulting vehicular emissions as a major contributor to this phenomenon of environmental pollution, especially in major metropolitan areas like Kumasi, Accra, Tema, Tamale. This finding relates to Nesamani, (2007) assertion which indicates that, through rapid growth in travel, urban exodus and continuous increase in population motorization rate.

The carburetor appeared to be the preferred engine type of vehicles in the automobile industry as most mechanics claimed they are conversant with carburetor engine during repairs and servicing of vehicles.

4.5 Section 'D': The Causes of the Perception of People on Carburetor and Fuel Injection Vehicles in the Tamale Metropolis

This study seeks to examine the causes of the perception of people on carburetor and fuel injection vehicles in the tamale metropolis. In the ensuing discussions the independent variable are discussed in full for better appreciation of the phenomenon.

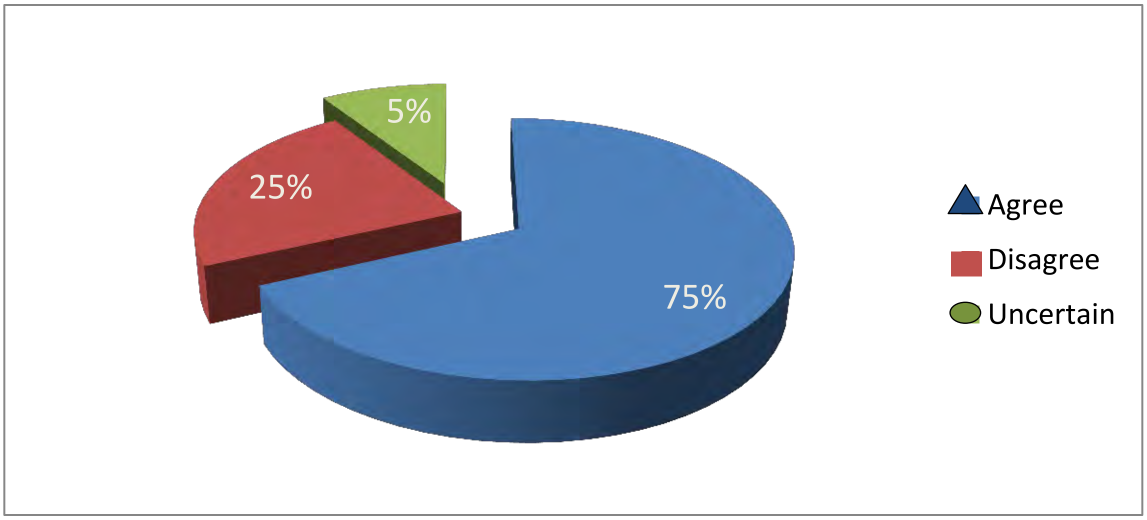

Figure 4.8: Perception on the Efficiency of Carburetor and Fuel Injection Engines

Source: Field Work: July, 2015.

With regards to whether respondents perceive the efficiency of carburetor and fuel injection engines of vehicles to be the same, the data in Figure 4.10 reveals that, the majority of respondents representing 75% agreed to the fact that, the efficiency of carburetor and fuel injection engines of vehicles seems to be the same.

Despite the explicit support declared by majority of the respondents, some of the officials representing 25% of the respondents disagreed to the fact expressed by most of the respondents. In addition 5% of the respondents were not sure of the fact and therefore expressed their doubts concerning the efficiency of the two engines.

Table 4.5: Factors Considered in determining the Efficiency and Performance of the Engine Types

Factors determining Efficiency	Frequency	Percentage
Previous experience	118	37
Complains from people	32	10
Record sale of the engines	90	28
Cost of maintenance	80	25
Total	**20**	**100**

Source: Field Work: July, 2015

With regards to the factors considered in determining the efficiency and performance of engines, 37% representing 118 respondents suggested that, their previous experience with the engines of their vehicles really served as the basis for their opinion on the efficiency and performance of the engines. As part of determinants of efficiency and performance of the engine types, it was realized that, 10% (32) of the respondents revealed that, complains from people who have tried carburetor engines indicated that, it is ineffective in terms of fuel consumption.

In the view of 28% or 90 of the respondents, record sale of the fuel injection engines also implies that, these types of engines are efficient and performs great. According to 25% of the respondents, especially, the car owners, the cost of maintenance of engines determines whether such engines are efficient and performs creditably.

The answers put forward by the respondents were informed by the perceptions and beliefs about self conviction. This, however, can be likened to Rogers (2009) proposition which states that, people beliefs are determined by the organized and consistent set of perceptions about oneself.

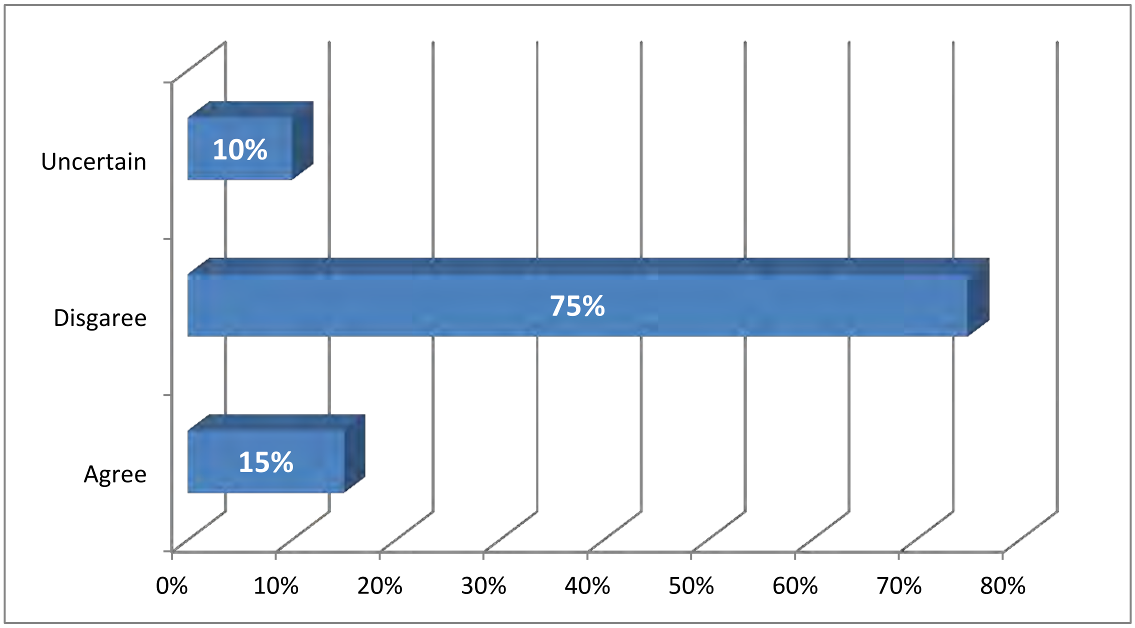

Figure 4.9: Concerns of People and Mechanics in terms of Engine Efficiency

Source: Field Work: July, 2015.

In responding to a question relating to the concerns of other people being the same as that of the mechanic on the efficiency of the two engines types, very significant part of the mechanics representing 75% maintained their disagreement to the fact that, perception of people out there does not matter. The most important issue raised was the fact that, one‟s carefulness and good maintenance culture is the determining factor in ensuring the efficiency of car engines and what people perceive. The data further revealed that 15% held a divergent opinion on the assertion stated above. Other respondents representing 5% could not offer any meaningful contribution to the discussion.

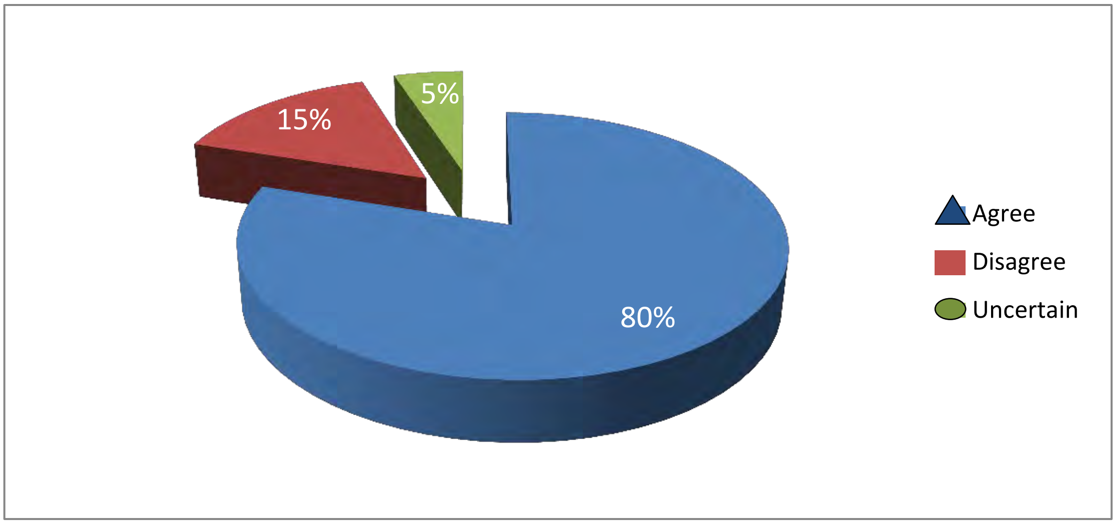

Figure 4.10: Drivers' Opinion on Engine Performances

Source: Field Work: July, 2015.

In terms of whether drivers have different opinions on the performance of the engines, 80% of the drivers believed it is possible to have different drivers sharing different opinion on it comes to the determination of the performance of the two engine types. Those who agreed to the above issue further added that, since people see and appreciate reality from different perspective, it is possible for them to think differently. However, 15% of the respondents thought otherwise since they considered all drivers to be the same. But only, 5% of the respondents appeared to be uncertain.

The category of drivers whose answers were in the affirmative further explained that, the operational benefits to the driver in the smoother and more dependable engine response during quick throttle transitions. This finding is in consonance with Aird (2011). In Aird (2011) view, fuel-injected vehicles perform smoothly making them more dependable engine, and easier and quick engine start, better operation at extremely high or low ambient temperatures, smoother engine idle and running, increased maintenance intervals, and increased fuel efficiency.

Based on the results shown above, it can be concluded with high level of certainty that, the carburetor engines are more efficient in their management and maintenance over the years. To further buttress their answers, both the car owners and the mechanics revealed the fact that, they are more familiar with the carburetor engines than the fuel injection engines.

4.6 Section 'E': The Most Patronized Engine Types between the Carburetor and Fuel Injection Engines of Vehicles

As the final objective which this section intends to achieve, the most patronized engine types between the carburetor and fuel injection engines of vehicles is being assessed. Other independent variable such as taking into consideration the type of engines during purchases and advantages associated with the engine types are outlined in order to achieve the above objective.

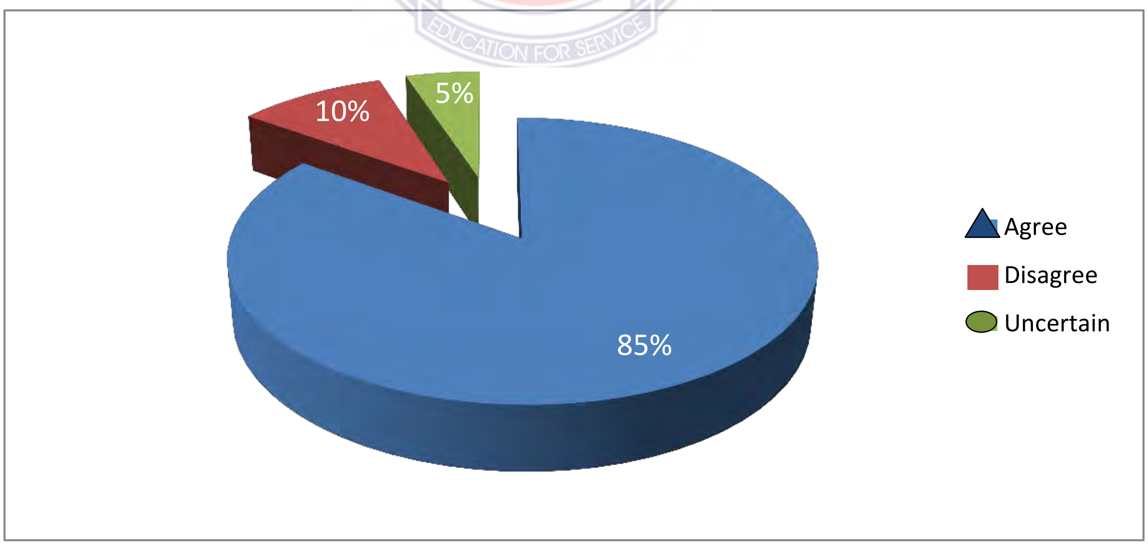

Figure 4.11: Type of Engines as Factor When Planning To Purchase a Vehicle

Source: Field Work: July, 2015.

On whether the type of engine are considered when planning to purchase a vehicle, 85% of the respondents mostly car owners agreed that people consider the type of engine when planning to purchase a vehicle. Those in agreement believed that, careful and proper examination of the engine type enables the prospective buyer to a select vehicle that would really serve their purpose. On the other hand, 10% of the respondents thought otherwise and therefore argued that there is no need trying to examine the type of engine before making any purchases once there are enough financial resources at the disposal of the prospective buyer. Similarly, 5% of the respondents appeared to be uncertain of the issue of the type of engine as a factor when purchasing a vehicle.

Reasons advanced to support the answer concerning the decision to know the type of engine is to be able to identify a mechanic to service the vehicle when the need arises. The price of the engine also influenced the prospective buyer to make most efficient choice when buying a vehicle.

The study also revealed the fact that, mechanics also consider the type of engine when planning for repair of vehicles since they are familiar and feel comfortable with carburetor engines of vehicles.

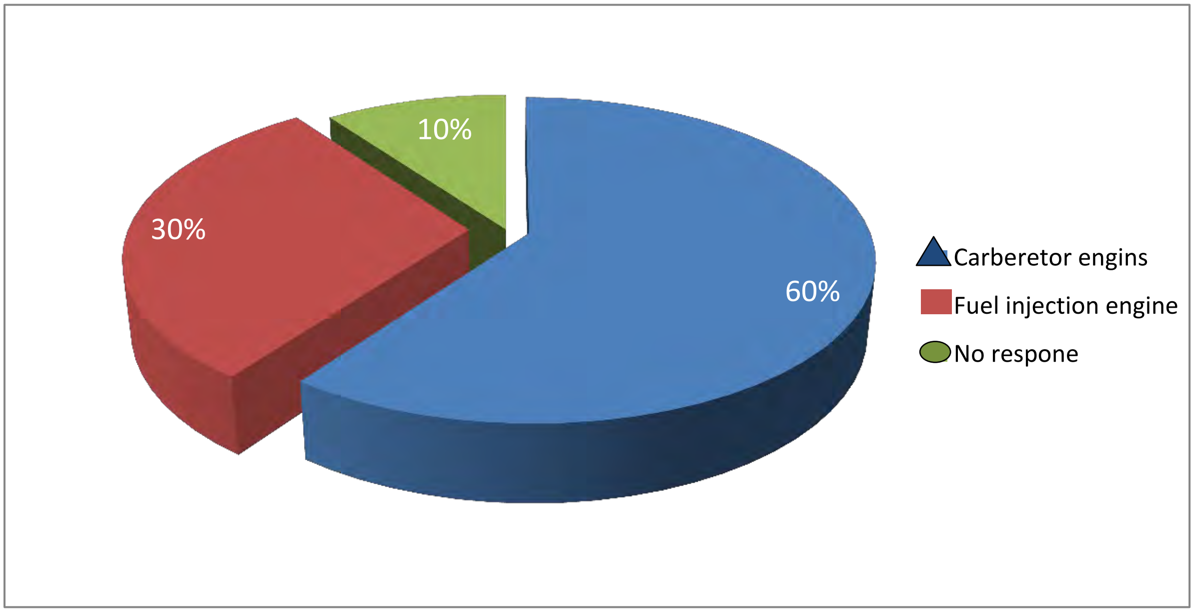

Figure 4.12: The Most Preferred Engine Type

Source: Field Work: July, 2015.

The type of engine which most people patronize is examined in this section. According to the data, 60% of the respondents agreed that the carburetor engine vehicles are their preferred automobile in the market. On the other hand, 30% of the respondents thought otherwise and therefore opted for fuel injection vehicles. Likewise, 10% of the respondents appear to be uncertain about the type of vehicle engine they prefer.

It can be deduced from the discussions that, car owner‟s tastes and preferences on vehicles are dependent on the impressions formed based on the inferences about performance of fuel injection and carburetor engines in the automobile industry. This is a justification that passengers do not have any business trying to consider the engine types of vehicle before they board the vehicles. This therefore created a kind of limitation to some of the respondents, especially the passengers concerning the performance of the type‟s vehicle engine available.

Table 4.6: Advantages Associated With the Carburetor Engine Types

Support Activities	Frequency	Percentage
It allows for adjustment	64	20
It can also be fixed	48	15
Parts for replacement	112	35
It does not need the services of an electrician	96	30
Total	**320**	**100**

Source: Field Work: July, 2015.

Table 4.6 contains data on the various advantages associated with the carburetor engine types. The first advantage in the view of 20% (64) of the mechanics relates to the fact that, it allows for adjustment when fuel consumption seems to be irregular and uncharacteristic. This particular strategy when achieved will go a long way to enable the mechanic to understand the workings of the vital components of the carburetor.

Secondly, 15% or 48 of the respondents indicated that, carburetor can also be repaired when it develops a problem without necessarily replacing the whole part. This will further boost the morale of the mechanics it will create an opportunity for bigger challenges ahead. According to majority of the respondents representing 35% or 112 of the respondents, engines with carburetors are very significant since they have enough parts for replacement.

Finally, 30% or 96 of the respondents thought that, in repairing carburetors the services of an electrician is virtually not needed. The mechanics also confirmed the advantages associated with the carburetor engine type vis-avis the fuel injection engine type.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter consists of summarizing the findings which were obtained after the analysis and interpretation of the data. Conclusion for this study was also drawn based on the findings, thereby leading to the proposition of recommendations to address the challenges and to improve upon efforts aimed at disabusing the minds of prospective car owner on the type of engine that is more preferable.

5.2 Summary of the Findings

The study found that, majority of the respondents were between the age group of 31-40 years indicating a youthful workforce that would contribute significantly to disabusing the minds and perception of the people out there.

The study also showed that, majority of the respond were males indicating that despite the higher population of women in the country, ownership and issues of vehicles were still skewed towards men in the automobile industry. Majority of the respondents had basic education making it very difficult for most of the mechanics to appreciate of technical issues that are related to the vital parts of the carburetor. The study disclosed that, most of the respondents were mechanic, others such as drivers and car owners made several inputs in the data gathered for the study.

The study also revealed that there are differences in perception of efficiency in terms of performance of engine types. It was also realized that, factors that determine engine fuel consumption includes the quantity of fuel used, the smoke engines emit and the durability of the engines. The study found that, mechanics are conversant with the repair of carburetor engines types.

The study again found that, though both carburetor and fuel injection engines produce emissions in terms of smoke in to the atmosphere, fuel injection engines were perceived to produce the most emissions. It was discovered that, pollution, noise, diseases and bad odour were found to be the negative effects of toxic gases on society.

Gas release from the engine according to the study really constitutes the single largest source of air pollution in urban areas. The study further reveals, the efficiency of carburetor and fuel injection engines of vehicles seems to be the same. The study disclosed that, previous experience complains from people, record sale of the engines and cost of maintenance were found to be the determiner of efficiency and performance of the engine type.

Majority of the respondents maintained the fact that, concerns of other people and the mechanic on the efficiency of the two engines types are not the same. The study discovered that, even among drivers their perceptions on the efficiency of the engines are not the same. As the study reveals, prospective car owners consider the type of engines when planning to purchase a vehicle. It was observed that, carburetor engine of vehicles are the most preferred automobile in the market.

The data obtained also revealed that, the possible allowance for adjustment and the possibility of fixing the carburetor engines, availability of parts for replacement and repairing without the services of an electrician were found as the advantages associated with the carburetor engine types.

5.3 Conclusion of the Study

It is important to examine the various differences in efficiency in terms of performance of engine types of vehicles during servicing of such engines as well when planning to purchase vehicles in the automobile industry. It should be noted that the utilization of this guiding principle is subject to the perception of players (car owners, drivers, and mechanics and car dealers) in the automobile industry which might not reflect the reality on the ground. In short, the perception of the players should be used in relation to the circumstances of the realities on the ground.

The option for carburetor engine vehicles has the potential of providing the prospective vehicle owner the opportunity to estimate realistic prices based on the possible adjustment and the possibility of fixing the carburetor engines, parts for replacement and repairing without the services of an electrician.

It is therefore, crucial that measures are taken to ensure the effective utilization of the carburetor engines of vehicles so as to make it possible for vehicle owners to have long vehicle life span. Every effort should, therefore, be made to ensure that effective educational campaign is properly implemented to reach all the players in the automobile industry to as make logical decisions when it comes to purchasing and servicing of their vehicles.

Though, the literature review showed that, fuel injection systems were found to be efficient compared to carburetor engines. However, the findings revealed contrary view to the literature reviewed in this study. The differences in the literature review and the findings of the study are due to the fact that, the geographical variations provided different environmental features for the two types of vehicle engines. In view of the fact that, the literature reviewed was dominated by foreign and western authors, that in itself resulted in the creation of the variation in the findings (carried out in Ghana) and the literature review obtained from the rest authors of the world.

5.4 Recommendations of the Study

The following recommendations are provided for the so as to ensure the following:

Since there are differences in efficiency in terms of performance of engine types, prospective car owners should always be vigilant as they try to buy the vehicle the vehicle they need.

Since factors that determine engine fuel consumption includes the quantity of fuel used, vehicle owners need to examine the consumption capacity of vehicles before purchasing such vehicles. The smoke emissions level should be examined by the prospective car owners and mechanics since it determines the fuel consumption level of vehicles. The most durable engine types should be the preferred choice of the car owners if the consumption of such engines is anything to go by. Since mechanics are conversant with the repair of carburetor engines types, prospective car owners and drivers should examine to identify this category of mechanics so as not to present fuel injections to the types of mechanics, because the fuel injections may pose challenges for them.

Mechanics are tasked to seek for more skills on how to service fuel injection engine since they were found to be producing most emissions. Punitive measure should be instituted against drivers and vehicle owners whose engines emits toxic gases on society so as to prevent people from being affected by the negative effects such as pollution, noise, diseases and bad odour. City authorities should concentrate their efforts on gas release from the fuel injection engines since it constitutes the single largest source of air pollution in urban areas. Given the fact that, the efficiency of carburetor and fuel injection engines of vehicles are not the same, importers of vehicles should make carburetor engines a top priority when importing vehicles into the country.

In order to reduce the suffering of prospective vehicle owners in search of new vehicle to buy, previous experience, complains from people, record sale of the engines and cost of maintenance should be taken into consideration so as to make an informed decision in determining the efficiency and performance of the engine types.

In view of the fact that, concerns of other people and mechanics on the efficiency of the two engines types are not the same, prospective should always insist on having the operational manuals of engines in order that, the needed information would be obtained to make an informed decision concerning the purchases and maintenance of vehicles.

Because perceptions on the efficiency of the engines among drivers are not the same, they should always seek for expert advice when planning to service their vehicles so as to keep their vehicles in good conditions and for long life span. Since carburetor engine of vehicles were found to be the most preferred automobile in the market, prospective buyers and drivers should always look for such vehicles to buy so as to safe themselves from more challenges of repairs.

Prospective vehicle owners, drivers and eleven mechanics should try as much as to secure carburetors that can be adjusted to ensure effective regulation of fuel consumption. The fact that it is possible to fix carburetors in engines when broken is an added advantage and should always be a guiding principles for prospective vehicle buyers, drivers and mechanics so that complete carburetors would not be often be replaced.

The parts for replacement should always be made available to prevent frequent break down of carburetors. Eventually, since repairing carburetors do not require the services of an electrician, prospective vehicles owners should always try as much as possible to ensure that, they buy vehicles with carburetor engines so as to incur less cost during the repair of such vehicles.

5.5 Directions for Further Research

The conduct of this study has resulted in the identification of several important areas for further and future research in the effective performance of carburetor and fuel injection the engine strength (strong point) and how it influence the mileage each of the two engine types can cover within a specified period of time. One intriguing direction for future research is to build on recent studies by examining the view of mechanics along as sampling unit so as to take study beyond the perceptions but into reality. For decades researchers have delved into areas that are similar to the perception on the performance of the engines types.

Instead of comparative studies such as this, a single study on the assessment of the robustness of either carburetor or fuel injection engines could also undertaken in the future to determine the dependability of the engines in rugged terrains, especially in tropical regions such as Ghana.

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APPENDIX (A)

UNIVERSITY OF EDUCATION, WINNEBA

As a final year student of the above Polytechnic pursuing Automobile Option of School of Engineering, it is expected that, a research is undertaken as a partial fulfillment of the course requirement. Following this a research entitled **'Assessing the Perception of People on the Efficiency of Fuel Injection Engines Compared to Carburetor Engines of Vehicles: A Case Study of Vehicle owners and mechanic in the Tamale Metropolis** is currently being undertaken by the student. The researcher would like to assure respondents that the information given will be treated as confidential and will be used for the purpose of data collection. Superintend

Questionnaires for Vehicle owners and other Members of Public

Section 'A': Socio-Demographic Characteristics of Respondents

(1) Age of respondents

(i) 20-30 [ ]

(ii) 31-40 [ ]

(iii) 41-50 [ ]

(iv) 51 and above.

(2) Sex distribution of respondents

(i) Male [ ]

(ii) Female [ ]

(3) Educational background of respondents

(i) Basic education [ ]

(ii) Senior High School [ ]

(iii) Diploma [ ]

(ii) Higher National Diploma [ ]

(iii) University Degree [ ]

(iv) Other, specify …………………………………………………………………

(4) Nature and type of services offered on the daily basis …………………………

Section 'B': The Differences between Fuel Injection and Carburetor Engines of Vehicles in the Tamale Metropolis.

(5) Have heard of fuel injection and carburetor engines of vehicles

(i) Yes [ ] (ii) No [ ] (iii) Don‟t know [ ].

(6) Do you have idea which of the two engine types is more efficient in terms of performance? (i) Yes [ ] (ii) No [ ] (iii) Don‟t know [ ]

(7) If your response to question 6 is in the affirmative, kindly mention the type of engine that is efficient in its performance ………………………………………..

(8) What make an engine is economical in terms of fuel consumption and maintenance? (i) The quantity of fuel used [ ] (ii) the smoke it emits [ ] (iii) engine durability [ ]

(9) In your opinion, which of the two engine types are mechanics conversant with during repairs (i) Yes [ ] (ii) No [ ] (iii) Don‟t know [ ]

Section 'C': The Most Patronized Engine Types between the Carburetor and Fuel Injection Engines of Vehicles

(21) Do people consider the type of engines when planning for repair of vehicles?

(i) Yes [ ] (ii) No [ ] (iii) Don't know [ ].

(22) Give reasons to support your answer In question 21...................................

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…..………………………………………………………………………………………

(23) Which of the two engine types do people mostly purchases?

(i) Fuel injection engines [ ] (ii) carburetor engines [ ] (iii) Don't know [ ].

(24) Do passengers also consider the engine types of vehicle before they board the vehicles? (i) Yes [ ] (ii) No [ ] (iii) Don't Know.

(25) Provide reasons to support your answer in question 24 ……...…………………

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(26) Indicate the specific advantages associated with the engine types that influence people to patronize them? ……………………………………………………...

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…………………………………………………………………………………………

APPENDIX (B)

UNIVERSITY OF EDUCATION, WINNEBA

As a final year student at the above University pursuing Automobile Option of School of Engineering , it is expected that, a research is undertaken as a partial fulfillment of the course requirement. Following this a research entitled **'Assessing the Perception of People on the Efficiency of Fuel Injection Engines Compared to Carburetor Engines of Vehicles: A Case Study of Vehicle owners and mechanic in the Tamale Metropolis** is currently being undertaken by the student. The researcher would like to assure respondents that the information given will be treated as confidential and will be used for the purpose of data collection. Superintend

Questionnaires for Automobile Mechanics

Section 'A': Socio-Demographic Characteristics of Respondents

(1) Age of respondents

(i) 20-30 [ ]

(ii) 31-40 [ ]

(iii) 41-50 [ ]

(iv) 51 and above.

(2) Sex distribution of respondents

(i) Male [ ]

(ii) Female [ ]

(3) Educational background of respondents

(i) Basic education [ ]

(ii) Senior High School [ ]

(iii) Diploma [ ]

(ii) Higher National Diploma [ ]

(iii) University Degree [ ]

(iv) Other, specify ……………………………………………………………………

(4) Area of specialization …………………………………………………………

Section 'B': The Differences between Fuel Injection and Carburetor Engines of Vehicles in the Tamale Metropolis

(5) Have you repaired or maintained fuel injection and carburetor engines of vehicles? (i) Yes [ ] (ii) No [ ] (iii) Don‟t know [ ].

(6) Is there any differences in the repair and maintenance of fuel injection and carburetor engines of vehicles? (i) Yes [ ] (ii) No [ ] (iii) Don‟t know [ ].

(7) If your response to question 6 is in the affirmative, kindly mention the type of engine that you are conversant with during repair or maintenance ………………

…………………………………………………………………………………………

(8) Which of the two engines is more economical in terms of spare parts?

(i) Fuel injection engines [ ] (ii) carburetor engines [ ] (iii) Don‟t know [ ].

Section 'C': Carburetor and Fuel Injection Engines' Contributions to Vehicular Emissions and its Impact on the Environment

(9) Do carburetor and fuel injection engines produce emissions in terms of smoke in to the atmosphere? (i) Yes [ ] (ii) No [ ] (iii) Don"t know [ ].

(10) Which of the two engine types emits more of the toxic gases into the atmosphere?
(i) Yes [ ] (ii) No [ ] (iii) Don"t know [ ].

(11) The toxic gases release exerts numerous negative effects on society
(i) Yes [ ] (ii) No [ ] (iii) Don"t know [ ].

(12) In which form do the toxic gases exert negative effects society
(i) Pollution [ ] (ii) Noise [ ] (iii) Accidents [ ] (iv) Other ……………………

(13) Do you agree to the assertion that, gas release from the engines constitutes the single largest source of air pollution in urban areas?
(i) Yes [ ] (ii) No [ ] (iii) Don"t know [ ].

Section 'D': The Causes of the Perception of People on Carburetor and Fuel Injection Vehicles in the Tamale Metropolis

(14) Do you perceive the efficiency of carburetor and fuel injection engines of vehicles to be the same? (i) Yes [ ] (ii) No [ ] (iii) Don"t know [ ].

(17) What is responsible for your opinion and attitude on the efficiency and performance of any of the engine types? (i) Previous experience [ ]
(ii) Complains from people [ ] (iii) frequent repairs of the engines [ ].

(18) Which of the two engines requires frequent repairs or maintenance?
(i) Fuel injection engines [ ] (ii) carburetor engines [ ] (iii) Don"t know [ ].

Section 'E': The Most Patronized Engine Types between the Carburetor and Fuel Injection Engines of Vehicles

(19) Which of the two engines do people present for repairs or maintenance?

(i) Fuel injection engines (ii) carburetor engines [ ] (iii) Don"t know [ ].

(20) Give reasons to support your answer In question 19. …………………………….

……………………………………………………………………………………

…...…………………………………………………………………………………

(21) Do you consider the engine types of vehicle before any attempt to repair or maintained? (i) Yes [ ] (ii) No [ ] (iii) Don"t Know.

(22) Indicate the specific advantages associated with the repair of the engines?

(i) Fuel injection engines…………………………………………………………...

……………………………………………………………………………………

……………………………………………………………………………………

(ii) Carburetor engines ……………………………………………………………

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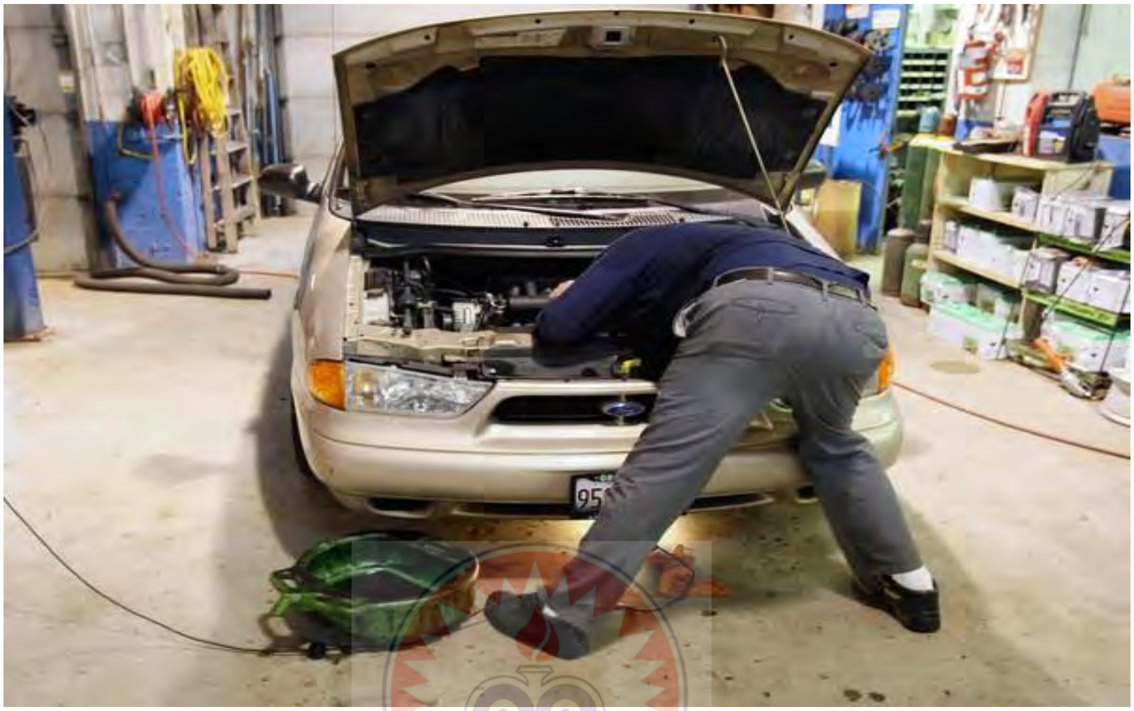
APPENDIX (C)



A mechanic servicing a carburetor of an engine