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Automotive Emissions: Sources, Environmental Effects, and Control Measures

Stephen Bamidele OBEBE[1], Abdullahi KOLO[2], Pius Peter YUSUF[3]
[1]Department of Mechanical Engineering, Bayero University Kano, P.M.B. 3011, Kano, Nigeria.
[2]Department of Engineering Services, Niger State Agricultural Mechanization and Development Authority, P.M.B. 132, Minna, Niger State, Nigeria.
[3]Department of Mechanical Engineering, Bayero University Kano, P.M.B. 3011, Kano, Nigeria.

Abstract:- Air pollution can be caused by human activities and among such activities is the automotive emissions. Vehicles are able to obtain their energy from the combustion of fossil fuels. During the process of combustion, vehicles are able to emit into the environment exhaust gases, thereby resulting to serious health and environmental concerns. But this study is restricted to only one aspect of the effects which is environmental effects. The emissions consist of Ozone (O_3), Oxides of sulphur (SOx), Oxides of nitrogen (NOx), Carbon dioxide (CO_2), Carbon monoxide (CO), hydrocarbons and particulate matter. Some of these gases are also known as Green House Gases (GHGs). Air pollution have caused various environmental hazards such as global warming, acid rain, depletion of the ozone layer, and are leading causes of climate change. Everyone is aware of the serious climatic problems being faced all over the world such as excessive flooding, droughts etc. Nigeria is one of the countries facing these environmental disasters. Other environmental hazards include soil pollution, leading to poor agricultural yields, and water pollution that causes aquatic death. There are three main automotive sources which emissions emanate. They are the exhaust, the fuel system (evaporative) and crankcase ventilation gases. An automobile exhaust produces harmful gases like oxides of nitrogen, carbon monoxide, etc that adversely affects the environment besides causing devastating effects on human body. This paper reviews the present and modern knowledge of automotive emissions, the sources, the environmental effects, control measures, and fuel economy. Fuel economy and low emissions together makes the engineering effort more difficult. Emissions and fuel economy are inter-related because both are influenced by the engine combustion system design.

Keywords:- *Automotive Emissions, Catalytic Converter, Environmental Effects, Exhaust Gases, Fuel Economy, Pollution.*

I. INTRODUCTION

Automobile emission is a constituent of air pollution. The emission is a major environmental hazard both in developing and developed countries. Exhaust gas is a major component of motor vehicle emissions and it may also come from stationary internal combustion engines. The use of solid fuels for cooking, burning waste, and traffic pollution from very old tyres are also contributing factors to air pollution [7]. Motor vehicle is a well known main source of pollutants. It is found everywhere in the globe. Many countries have imposed different standards and test procedures showing different degree of stringency [4].

According to [8], research have shown that there is no nation that can exist without vehicles. Vehicles are very vital assets which enhance the socio-economic development of a country. They serve as fast and effective means of transport for people and movement of goods and services from one place to another. They allow human existence on the globe to be easy and convenient. There are various mode of transportation which includes motorcycles, car, tricycles, buses, airplanes, trains, trucks, engine powered boats, etc. While putting the great benefits obtained from the use of vehicles, their health and environmental effects, vehicular emissions have resulted into a global issue [8]. It is very good for humans to ensure and promote a cleaner and healthier environment all over the globe. The government need to enforce regulations on vehicular emissions so as to achieve good air quality and ensure that all vehicles plying the Nigerian roads meet the emission standards included in the regulations. This could be achieved with the efforts of National Environmental Standards and Regulations Enforcement Agency (NESREA) and Public, Private Partnership (PPP) arrangements [8]. It does not speak well of any country seen vehicles with heavy emission plying the roads and highways. Some of these vehicles are not worthy of plying the roads and highways since the owners of these vehicles refuse to go for emission test.

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II. OBJECTIVES OF STUDY

The main objective of the studies is to have good potentials of improved fuel economy and adequate emission control. The safety of people and pollution-free environment are contributory factors to the good standard of living of the inhabitants of any town/city and optimum survival of the living organisms. This was able to achieve through the modern emissions control technology and has led to reductions in automobile emissions.

III. SOURCES OF AUTOMOTIVE EMISSIONS

The exhaust system collects the exhaust gases from the cylinders of the motor-vehicle engine and conducts them to the rear of the car where they are discharged to the atmosphere, and does so with a minimum of power loss, noise, vibration and transfer of heat to the car body [3]. Also, this heat is later given out to the air which is being inhaled by humans and at the same time the heat is being felt by the human body system. The emissions from an individual car are generally low, relative to the image many people associate with air pollution [1]. The automotive emissions come principally from three automotive sources. They are the fuel system (evaporative), the exhaust, and crankcase ventilation gases. This showed that there are three different types of auto emissions.

A. The Fuel System (Evaporative)

The fuel system emits the evaporative emissions. Gasoline (i.e petrol), antifreeze, and other auto liquids are made up of hydrocarbons that can be released into the air in many different ways. Diurnal evaporation is a process where gasoline (i.e petrol) evaporates from the engine leading to increase in the temperature outside [2]. These emissions are released into the environments which have effect on it. Generally, evaporative emissions are consequence of gasoline (i.e petrol) vapours escaping from the vehicle's fuel system.

B. Exhaust

The exhaust gives out emissions. The exhaust emissions are the gasses emitted after the engine has burnt the gasoline (i.e petrol) while operating the vehicle [2].

C. Crankcase Ventilation Gases

As soon as vehicle is filled with fuel, there are emissions that are given off into the atmosphere. If someone can observe closely as he/she fuel his/her vehicle particularly on hot days, emissions can be easily seen as they leave. This is referred to as refueling losses.

IV. COMBUSTION PROCESS

Motor vehicle exhaust emissions is an important source of pollution, which include nitrogen oxides, carbon monoxide and hydrocarbons. These pollutants could be dangerous to human health and the environment resulting to the formation of ground level ozone (i.e smog). Motor vehicle is an engine and before there can be emissions from the exhaust, the combustion process must take place in an engine. This research reveals that motor vehicle is an internal combustion engine. Generally, in internal combustion engines (I.C engines), the combustion of the fuel with oxygen occurs within the cylinder of the engine. In engines, the engine exhaust blows out through the muffler [6]. In Air-Fuel Mixtures, the theoretically perfect mixture of air to one (1) part of gasoline (i.e petrol). When a uniform mixture of these proportions can be obtained, the mixture burns without leaving an excess of fuel or air. With a liquid fuel such as gasoline, however, it is difficult to obtain this perfect mixture, especially with low-test gasoline.

There is a range of proportions of air to fuel between which combustion will take place. The boundaries of this range are known as the upper limit of combustion and the lower limit of combustion. The lower limit of combustion is generally between 7 to 10 parts of air by weight to 1 part of fuel. This mixture is barely explosive and burns with a reddish –yellow flame. The upper limit generally consists of about 20 parts of air by weight to 1 part of fuel. This mixture burns with a white flame, slowly and irregularly. The rate of burning and the exact upper and lower limits will vary slightly according to the pressure and temperature conditions in the cylinder, the character of the fuel, the uniformity of the mixture and the design of the combustion chamber [3].

V. FUEL ECONOMY

The engine combustion system design has effect on the automotive emissions and fuel economy [4]. According to [4], in the operating economy, cost per mile of operation is dependent on fuel economy. Miles per gallon is determined by many factors only one of which is the nature of the fuel. The engine condition, speed, nature of road, and vehicle weight and load are among the other important contributory items. A low-cost, low-grade fuel usually gives less miles per gallon than does a higher priced high-grade fuel; as a result, the cost per mile of operation may be higher even through the fuel costs less per gallon [3].

VI. TYPES OF EXHAUST EMISSIONS

There are many air pollutants in which their emissions have different negative effects on the natural environment and public health. The concerned emissions that are major pollutants consist of oxides of nitrogen, carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC), sulfur oxides (SOx), particulate matter, volatile organic compounds (VOCs), ozone and lead compounds.

- **Nitrogen Oxides (NOx):** This is formed due to the reaction between the nitrogen in the air and oxygen at high temperature and pressure inside the engine. The reaction between oxygen and nitrogen gases could not take place at

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normal temperatures, but nitrogen and oxygen react together to form nitric oxides due to the presence of very high temperature.

$$N_2 + O_2 \longrightarrow NO \quad (1)$$

Nitrogen Oxygen Nitric Oxide

The nitric oxide very quickly reacts with more oxygen to form nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2 \quad (2)$$

Nitric Oxide Oxygen Nitrogen Dioxide

Both of the nitrogen compounds are together well known as nitrogen oxides or NOx.

Therefore, research has shown that the increase in road usage has led to high volume of traffic along our streets which is causing an increase in pollution emitted exhaust gases.

- **Carbon monoxide:** It is a products of incomplete combustion. According to [2], carbon monoxide is one of those toxic compounds that is created as a result of the imperfections of the combustion process. This is a compound that can affect a human's bloodstream and cause complications for people with any kind of heart condition, but this paper only restrict us to the environmental effects.
- **Carbon dioxide:** It is a greenhouse gas. It constitutes about 21 percent of the air pollution from vehicles. [18] ascertained that when there is rise in concentration of carbon dioxide in the surrounding, this can also lead to rise in temperature in degree Celsius (^oC) of the environment. There is need to observe that these environmental catastrophes may affect human health and our ecosystem [18]. Research showed that apart from the automotive emissions being an air pollutant releasing carbon dioxide to the atmosphere, human activities also have a great contribution to the atmosphere. According to [18], human activities have continuously increased the concentration of carbon dioxide to the atmosphere in the Federal Capital Territory (FCT), Abuja, Nigeria where investigation was carried out on Geospatial Evaluation of Carbon Dioxide Pollutant Concentration and have now reached dangerous levels. Movement of vehicles in the study area is energy intensive and it utilizes petroleum based fuels such as petrol, diesel, kerosene etc., in which transport related emissions which have risen rapidly, and that is the reason why AYA junction is highest contributor of carbon dioxide pollution area because of traffic congestion in the area. Forest in many areas in the FCT has been cleared for logging development, conversion to farms and for land use purposes. Developments bring about clearing of forest and deforestation, and when this is done, a large amount of carbon dioxide become stocked in the atmosphere, thereby increasing the concentration level of carbon dioxide in the environment. Since deforestation reduces the amount of trees to sink the level of carbon dioxide by natural mean, as a result of this, concentration of carbon dioxide is gradually accumulating in the atmosphere in the area, which has led to the present level of carbon dioxide in FCT of Nigeria, Abuja.
- **Hydrocarbons (HC):** Hydrocarbon belongs to a class of burnt or partially burnt fuel. They are toxins. Hydrocarbons have contributed mainly to smog which could result to a main problem in urban areas and other commercial cities. According to [10], for each gasoline blend, hydrocarbon emissions differs, and these depend on the combustion chamber geometry, original fuel components, and engine operating parameters also affect the HC components spectrum [10].
- **Particulate Matters:** The exhaust of C.I. engines consists solid carbon particles that are obtained in the fuel-rich zones within the cylinder during combustion processes. These are seen as exhaust smoke and they cause an unfavorable odourous pollution to the environment [7]. The particulates have devastating effects on human health but this paper is restricted to the environmental effects.
- **Sulfur Oxides (SOx):** It is a general term for oxides of sulfur, in which the emissions are emitted from motor vehicles burning fuel consisting sulfur. When the level of fuel sulfur becomes reduced, this is at the same time also reduces the level of sulfur oxide emitted from the tailpipe [4]. Many fuels that are used in C.I. engines consist of small amount of sulfur. According to [5], at high temperatures, sulfur combines with hydrogen to form H_2S and with oxygen to form SO_2;

$$H_2 + S \longrightarrow H_2S \quad (3)$$
$$O_2 + S \longrightarrow SO_2 \quad (4)$$

Engine exhaust can contain up to 20ppm of SO_2, SO_2 then combines with oxygen in the air to form SO_3;

$$2SO_2 + O_2 \longrightarrow 2SO_3 \quad (5)$$

- **Volatile Organic Compounds (VOCs):** These are the organic compounds that exist as gases in the atmosphere or that evaporate into the atmosphere. Examples are hydrocarbons emitted by the leaves of many plants, and methane (CH_4), a greenhouse gas that is twenty times more effective per molecule than CO_2 is at warming the atmosphere through the greenhouse effect [7].
- **Ozone (O_3):** It is a colourless and highly reactive gas. It can cause different health problems in human being such as lung and heart diseases etc. Also, it damages plants, rubber in tyres, fabrics and paints [7]. It has many negative effects throughout the ecosystem [9]. The air pollution from motor vehicles constitute 9% of the ground level ozone.

- **Lead Compounds:** One air pollutant that has been greatly reduced is lead. Most of the lead once released into the atmosphere was emitted by automobile exhaust systems. While lead is not naturally a significant component of petroleum, one particular lead compound, tetraethyl lead, had been a gasoline additive since the 1940s as an antiknock agent to improve engine performance [11]. Lead has effects on the ecosystems [12].

VII. ENVIRONMENTAL EFFECTS OF AUTOMOBILE EMISSIONS

There are various ways in which the environment is affected by vehicle emissions. Automobiles emit greenhouse gases such as carbon dioxide contributing to global warming. There are some particulate matter and air pollutants that are emitted by cars which later become deposited on soil and surface waters through which they get entrance to the food chain in the ecosystem. The reproductive, respiratory, immune and neurological systems of animals become affected by these substances [13]. Due to these, it s not only the environment where humans reside that is being affected, also the ecosystem of the animals/organisms become destabilized thereby making their habitats harmful to live. The depletion of ozone layer, acid rain etc are threats to the environment. [17] reported that due to the rapid growth of roads, energy consumption upstream production, and the lack of strict implementation of environmental regulation, the pollutants are flowing into the air, water, and soil. Apart from industries, the vehicle is one of the major contributors to air pollution not only the air pollutants have affected health conditions.

A. Effects on the ozone layer

One of the greatest threats posed by the automobile emissions to the environment is the depletion of ozone layer. The ozone layer has assisted to protecting life on earth from the ultraviolet rays of the sun, but human activities have contributed to the rapid depletion of protective nature of the shield [13].

B. Effects on Global Warming

Global warming is the gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of chlorofluorocarbons (CFCs), carbon dioxide and other pollutants. Likewise, in Nigeria today, the transportation sector has contributed immensely to global warming. The number of cars and trucks plying our roads have increased and some of these roads are filled with pot-holes making them not to be motorable thereby increasing the emission of carbon dioxide (CO_2) while escaping the pot-holes along the roads.

C. Effects of Air, Soil and Water

The effects of car pollution/automobile emissions are widespread, which affect the soil, air and water quality. Oil and fuel spills from cars and trucks seep into the soil near highways, and discarded fuel and particulates from vehicle emission contaminate rivers, lakes and wetlands [14]. As the soil is being affected, it makes it not to be suitable for agricultural purposes , and depletion of the soil fertility may takes place.

D. Effects on Acid Precipitation and Deposition (i.e Acid Rain)

Acid precipitation refers to any precipitation such as rain, fog, mist, or snow that is more acidic than usual. Because dry acidic particles are also found in the atmosphere, the combination of precipitation and dry-particle fallout is called acid deposition [14]. This has affected the ecosystems in diverse ways [14], and other agricultural activities as well.

VIII. CONTROL MEASURES OF AUTOMOTIVE EMISSIONS

Vehicle emissions control involves alleviating the motor vehicle emissions produced by motor vehicles particularly internal combustion engines. There are many air pollutants in which their emissions have shown that they have different negative effects on public health and the natural environment. These have led to different technologies being developed to reducing and controlling the emissions produced by our motor vehicles. It is not possible to continue watching/seen smoky vehicles plying our roads without necessary measures being taken. So, emissions need to be regulated. [17] asserted that each vehicle emits gases, although the barrier normally encountered is when emissions are higher than the standardized standards and the major reason behind this violation is the incomplete combustion of the fuel supplied to the engine which occur as a result of improper maintenance of vehicles. This emission cannot be totally abolished in vehicles, but it could be put under control.

An emission from an automobile could be controlled mainly by three systems which are Exhaust Gas Recirculation (EGR), Blow-by gas system, and catalytic converter.

- **Exhaust Gas Recirculation (EGR):** The EGR is used primarily in diesel engines for controlling Nitrogen oxides due to the presence of high combustion temperatures inside the cylinder. At different temperatures, nitrogen can form various oxides (NOx). In order to reduce the amount of nitrogen oxides from the exhaust, we need to increase the HC (hydrocarbon) content and thus create a balance between the two. To restrict the emission control level, the combined value of HC and NOx is put into consideration. The basic purpose of EGR system is to tap-out part of exhaust gas from exhaust manifold and mix with intake air of the engine during certain conditions to reduce the amount of oxides of nitrogen. The Exhaust Gas Recirculation is located between the intake and the exhaust manifold. The Exhaust Gas Recirculation are of two types. They are the internal EGR and external EGR [16].
- **Blow-by Gas System (Crankcase Ventilation System):** It is a one way passage for the gases to escape from the

crankcase of an internal combustion engine in a controlled manner so that some of the gases (blow-by gases) from the combustion leak past the piston rings which cannot resist high pressures due to those blow-by gases, as it is already known that diesel engines have high compression ratio and hence high pressure. The gases which escape through the compression rings and reach the crankcase of a diesel engine are called blow-by gases [16].

- **Catalytic Converter:** The catalytic converter is a device which is placed in the exhaust pipe, converting hydrocarbons, carbon monoxide, and NOx into less harmful gases by using a combination of rhodium, palladium, and platinium as catalysts. Catalytic converters are normally used in combination with internal combustion engines fueled by either petrol (i.e gasoline) or diesel including lean-burn engines as well as kerosene heaters and stoves [4]. There are two types of catalytic converter, they are a two-way and a three-way catalytic converter. Two-way catalytic converters were common until the 1980s, when three-way catalytic converters replaced them on most automobile engines [4]. Today however, the most important control device on cars is the catalytic converter. As exhaust flows through this device, two different catalysts are at work: a reduction catalyst that transforms NOx emissions to harmless nitrogen gas and an oxidation catalyst that oxidizes unburnt hydrocarbons and carbon monoxide to carbon dioxide [15].

IX. FINDINGS AND SUGGESTIONS

- Cars, buses, and trucks release nearly half of the pollutants affecting our air and well-being of humans and organisms.
- Exhaust of vehicle gives out volatile organic compounds (VOCs), carbon monoxides, and nitrogen oxides resulting to ground-level ozone and peroxyacetyl nitrates (PANs).

X. CONCLUSION

When the engine of a car is running (particularly in old vehicle like the average 10 years old plus contraption on our roads), several different types of pollutant gases and particles are emitted that can have detrimental effects on the environment. In Nigeria, since the inception of democracy in 1999 when President Olusegun Obasanjo came into power as the elected president, he did increment in salary for all civil servants and public servants, this made Government workers to afford buying cars thereby increasing the number of cars plying our roads and the rate of exhaust emissions become increased. But with the activities of the Vehicle Inspection Officers (VIO) and Federal Road Safety Commission (FRSC) members/marshals, they are able to bring the whole activities under their control. Also, it is observed that upon the increase in number of vehicles plying the roads, the air quality today is better than it was in the 1970s, due to emission-cleaning technologies such as evaporative emission system, improved engine system, and catalytic converter etc. In fact, leaded emissions from cars have been almost completely eradicated because of the phasing out of leaded gasoline.

Generally, automobile emissions have become reduced. This was able to be achieved due to a general reduction in the size of passenger vehicles considering array of pollution-control devices, among which is one that could afford the computerized control of fuel mixture and ignition timing, thereby allowing more complete combustion of fuel and decreasing VOC emissions.

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