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ANALYSIS OF EMISSION FROM VEHICLES IN SOME SELECTED AREAS IN ACCRA

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ABSTRACT

In this study, vehicular emissions from light vehicles within the central business district and the out skirt of Accra, Ghana, were measured and compared with the current European emission standards. The essence of the study was to provide primary emission data of vehicular transport in the city and to evaluate the effect of vehicular aging on emissions. The results show a higher failure rate (33-64%) for vehicles that are more than 10 years. For the gases tested carbon dioxide failure was the highest irrespective of the vehicle brand, age or vehicular capacity. Issues with contaminated or bad catalytic converters, poor positive crankcase ventilation (PCV) valve and temperature cooling sensor were major causes of emission test failure for older cars (>10 years) whereas faulty EGR, faulty catalytic convertor, poor engine cooling system and dirty oil in engines were identified as causes of emission failure in newer vehicles. With the formulation and introduction of emission control regulation, it is anticipated these failure rate will significantly reduce over time.

Key Words: vehicular emissions, emission control regulation, combustion engine

Introduction

Exhaust analysis are statutory requirements for the operation and maintenance of vehicles in many countries. Properly analysed exhaust emissions are necessary to combat the effects of emissions on human beings and the environment as well. The effects from these emissions are not only evident in the poisoning human breathing with bad air but also in the introduction of airborne pathogens-infections, particles, chemicals as well as the changing of interactions between the atmosphere and sun, weather effects, effects on plants and oceans which has enormous implication on climate change. Emission Testing checks the levels of hazardous material that escape from a motor vehicle with a combustion engine. The goal of emission testing is to cut down on pollutants that are harmful to the environment, with the particular focus on improving air quality. (www.automotivesolutions.ca). Different countries and regions have different emission standards for various vehicles. For instance, in the European Union, emission regulations for new light duty vehicles (passenger cars and light commercial vehicles) were once specified in Directive 70/220/EEC with a number of amendments adopted through 2004. This directive was replaced by regulation 715/2007(Euro5/6) which was in force in 2007. With the

new directive, emission standards for light duty vehicles are applicable to all vehicles category with a reference mass not exceeding 2610 kg (Euro 5/6). EU regulations introduced different emission limits for compressions ignition (diesel) and positive ignition (gasoline) vehicles. Positive ignition vehicles were expected from PM standards through the Euro 4 stage. Euro 5/6 regulation introduced the PM mass emission standards equal to those for diesels. For positive ignition vehicles with C.I engines. (Dieselnet, 2012). Similarly, in the early 2000s, Australia began harmonizing Australian Design Rule Certification for new motor vehicle emissions with Euro categories. Euro III was introduced in January 2006 and was progressively introduced to align with European introduction dates.

In Ghana, the EPA in pursuant to its mandate as asset out in section 2 of the Environmental Protection Agency Act 1994 (Act 490), has developed guidelines for motor emissions and they are in the process of transforming the guidelines into standards. It is anticipated that when the emission standards are introduced, the mandatory motor emission tests which will be part of road worthiness certification would ensure that vehicles plying the roads are not a danger to the environment. Meanwhile, the current practice of emission testing is carried out by private licensed DVLA Vehicle Inspection stations which are well equipped. Due to the absence of a wide spread data on emissions from vehicle in Ghana and the impact of aging on emission, this paper seeks to (1) provide primary information on vehicular emissions; (2) compare the data obtained from this exercise to European standards and (3) identify current challenges with vehicle emission analysis and propose recommendation torectify and minimize recurring problems.

Materials and Methods

Study Area

The study was conducted in Kokomlemle in the central business district of the Accra Metropolitan Area and Dome in the Ga East Municipal District. The site was chosen for the study due to (1) its high population density (2) it usage as the central transportation hub and (3) peculiar positioning within Accra – the central business area. The area which lies 5º34’27.67’’N and 0º12’29.18’’W is known for it marketing hub. It within the catchment area of major restaurants, hotels and the Kotoka International Airport (KIA). Its location makes vehicular transport and its emission an important issue to consider.

Sampling and data collection

Overall 150 vehicles using petrol engines were randomly selected within the study area. Emission test were conducted at VITO (Dome in Ga East Municipal District) and ATTC (Kokomlemle) in the Accra metropolis comparing it with EU emission standard. Emission data were collected using the Automotive Emission Analyzer, Model 4000 (QROTECH Co. Ltd, Bucheon city, Korea) with accuracy and repeatability of ±1% for O_2, CO, CO_2 and HC and ±2% of full scale for NO. The analyser was zero calibrated for all measurable gases prior to data collection. The probe filter was properly clean and connected to the analyser. A 2-minute equilibration period was allowed before measurement were taken and printed out. All testing was done in triplicate.

Standards and Measurement

Table 1 shows the standards used in this study for emission assessment. The data represents the approved EU emission standards from Euro 1, Euro 2, Euro 3, Euro 4, Euro5 and Euro 6. For the purposes of this paper the data shows only the emission limits of gasoline operated light commercial vehicle which was the focus of this study. Measurement was limited to emissions of nitrogen oxides (NOx), Hydrocarbon (HC), Carbon monoxide (CO) and Particulate matter (Pm). These are regulated for most vehicle types including cars, Lorries and tractors. For each vehicle type different the appropriate standard was applied. Compliance was determined by running the engine at a standardized test cycle.

Table 1: European Emission Standards for Light Commercial Vehicles

Category	Stage	Date	CO	HC	HC+NO_x	NO_x	PM	PN
			g/km					#/km
Class I ≤1305kg	Euro 1	1994.10	2.72	-	0.97	-	-	-
	Euro 2	1998.01	2.2	-	0.50	-	-	-
	Euro 3	2000.01	2.3	0.20	-	0.15	-	-
	Euro 4	2005.01	1.0	0.10	-	0.08	-	-
	Euro5	2009.09	1.0	0.10	-	0.06	0.005	-
	Euro 6	2014.09	1.0	0.10	-	0.06	0.005	6.0x10
Class II 1305-1705kg	Euro 1	1994.10	5.17	-	1.40	-	-	-
	Euro 2	1998.01	4.0	-	0.65	-	-	-
	Euro 3	2001.01	4.17	0.25	-	0.18	-	-
	Euro 4	2006.01	1.81	0.13	-	0.10	-	-
	Euro5	2010.09	1.81	0.13	-	0.075	0.005	-
	Euro 6	2015.09	1.81	0.13	-	0.075	0.005	6.0x10
Class III 1760 kg	Euro 1	1994.10	6.90	-	1.70	-	-	-
	Euro 2	1998.01	5.0	-	0.80	-	-	-
	Euro 3	2001.01	5.22	0.29	-	0.21	-	-
	Euro 4	2006.01	2.72	0.16	-	0.11	-	-
	Euro5	2010.09	2.72	0.16	-	0.082	0.005	-
	Euro 6	2015.09	2.72	0.16	-	0.082	0.005	6.0x10
N 2	Euro 5	2010.09	2.27	0.16	-	0.082	0.005	-
	Euro 6	2015.09	2.27	0.16	-	0.082	0.005	6.0X10

Source: www.dieselnet.com.standards

Data Analysis

The data collected were analysed using JMP statistical software, version 11 (SAS Institute Inc., NC, USA). Analysis of variance were conducted to ascertain significance. ($p<0.05$) was considered statistically significant.

Results and Discussion

Effect of vehicle aging with emissions

Test for Carbon Monoxide (CO)

Carbon monoxides test were conducted on all samples (n=150). From 2002-2004, 13 vehicles passed the test whist 15 vehicles failed the test,33 vehicles pass the test whilst 10 vehicles failed the test for the year 2005-2007,49 vehicles passed the test whilst 14 vehicles failed for the year 2008-2011, 10 vehicles passed the test whilst 6 vehicles failed for the year 2012-2013. The results obtained were compared to that of the European Union standards which was observed that the fuel and air ratio was not proportional and there was evidence of incomplete combustion or burning of the air/fuel mixture in vehicles in the past years. The result shows that using a student t-test to compare the mean percent CO emission failure rate, vehicles manufactured after 2004 were not significantly different but those within the 2002 and 2004 period were significantly different.

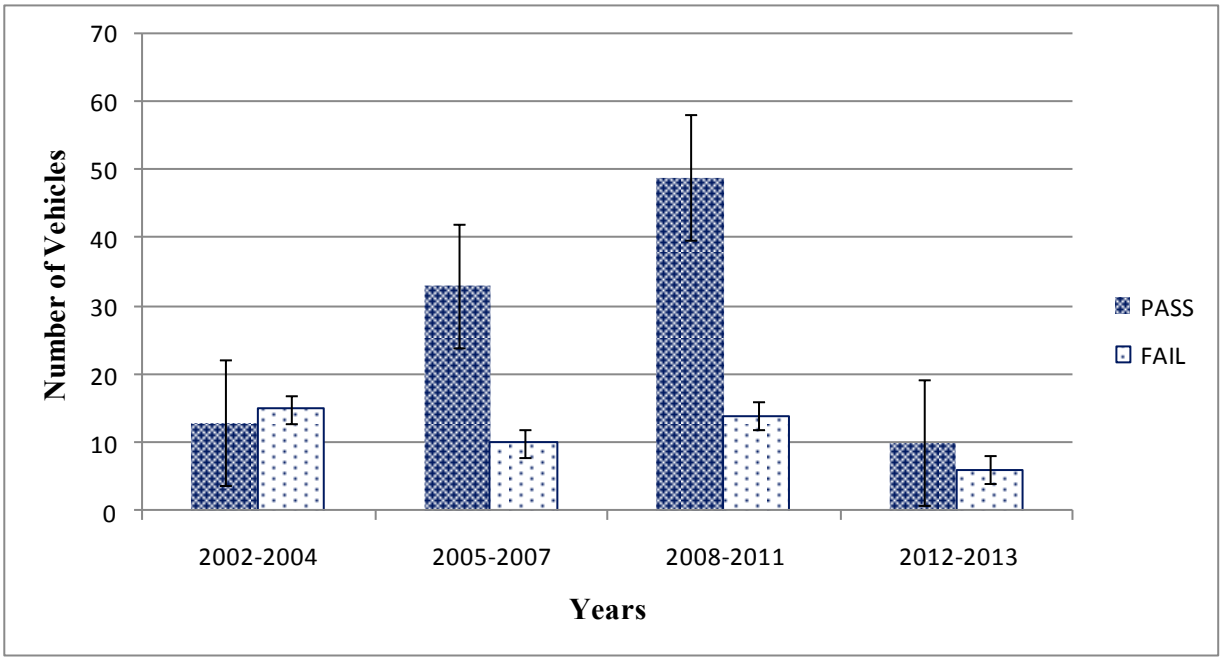

Figure 1: ***Chart for Carbon Monoxide (Co) Emission Test***

Test for Carbon Dioxide (CO_2)

Tests were conducted on 150 vehicles for Carbon Dioxide (Co_2), out of One Hundred and Fifty (150) vehicles sampled. From 2002-2004, 10 vehicles passed the test whist 18 vehicles failed the test,29 vehicles pass the test whist 14 vehicles failed the test for the year 2005-2007,53 vehicles passed the test whilst 10 vehicles failed for the year 2008-2011, 9 vehicles passed the test whilst 7 vehicles failed for the year 2012-2013. The results obtained were compared to that of the European Union standards and it was observed that CO_2 is not a pollutant but it is a by-product of good combustion.

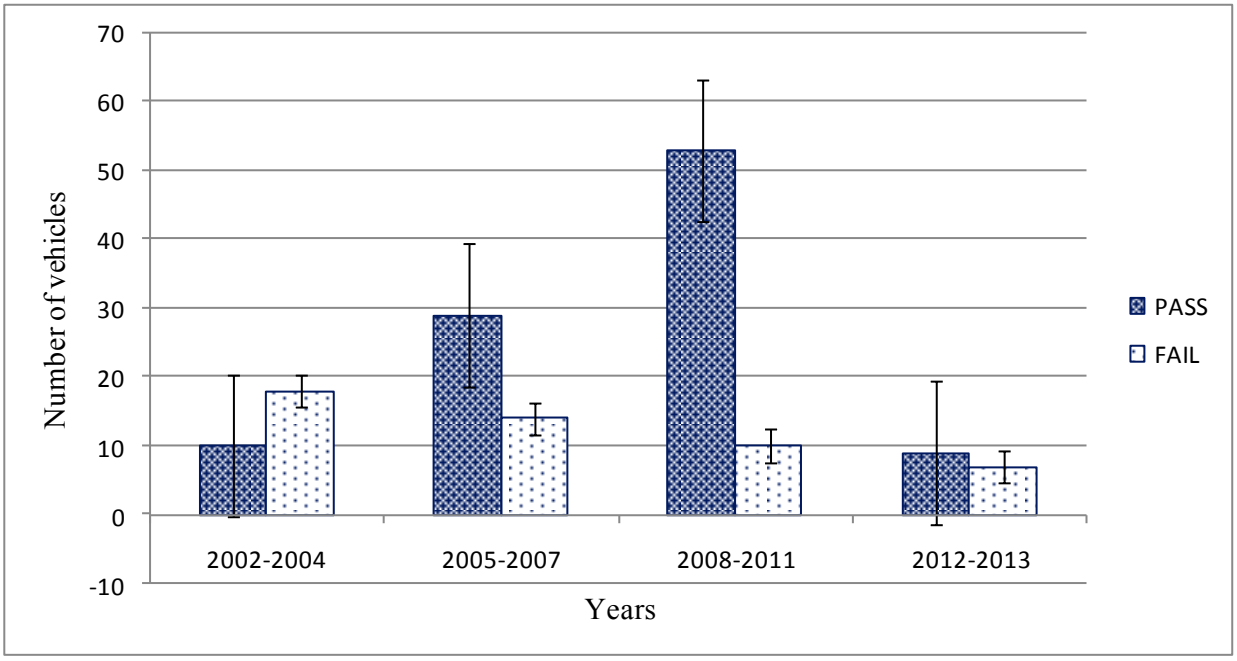

Figure 2: ***Chart for Carbon Dioxide (CO_2) Emission Test***

Test for Hydrocarbon (HC)

Tests were conducted on 150 vehicles for Hydrocarbon (HC), out of One Hundred and Fifty (150) vehicles sampled. From 2002-2004, 15 vehicles passed the test whilst 13 vehicles failed the test. 35 vehicles passed the test whilst 8 vehicles failed the test for the year 2005-2007. 55 vehicles passed the test whilst 8 vehicles failed for the year 2008-2011. 11 vehicles passed the test whilst 5 vehicles failed for the year 2012-2013. The results obtained were compared to that of the European Union standards and it was observed that most of the engines did not operate at normal operating temperature and produced lean mixture causing misfiring in most of the vehicles for those year groups

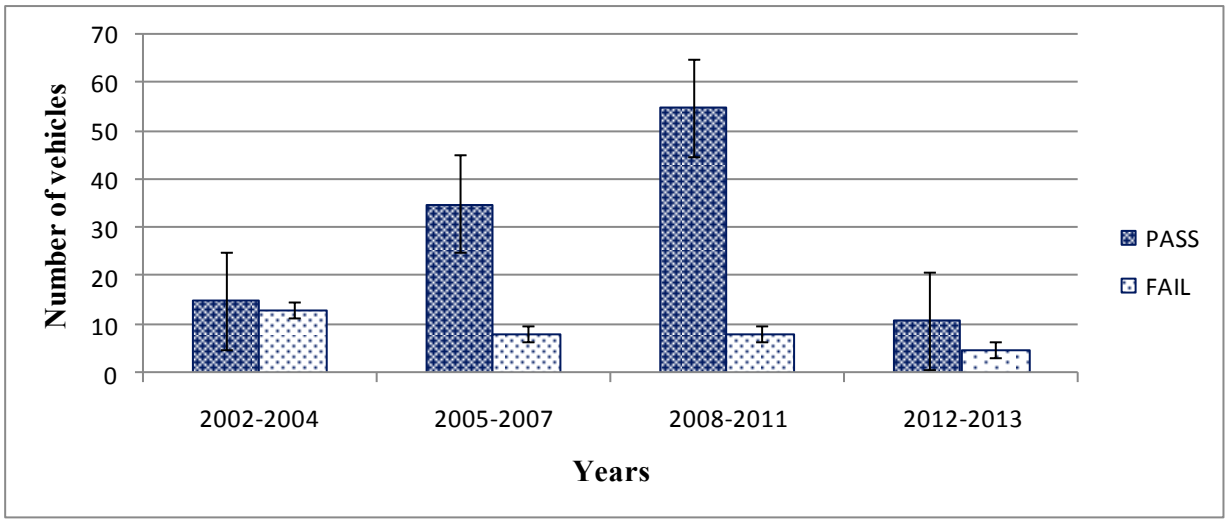

Figure 3: ***Chart for Hydrocarbon (HC) Emission Test***

Test for Nitrogen oxide (NO_2)

Tests were conducted on 150 vehicles for Nitrogen Oxide (NO_2), out of One Hundred and Fifty (150) vehicles sampled. From 2002-2004, 19 vehicles passed the test whilst 9 vehicles failed the test, 37 vehicles passed the test whilst 6 vehicles failed the test for the year 2005-2007. 56 vehicles passed the test whilst 7 vehicles failed for the year 2008-2011. 13 vehicles passed the test whilst 3 vehicles failed for the year 2012-2013. The results obtained were compared to that of the European Union standards and it was observed that lean fuel mixture due to improper operation of the EGR valve as a result of misrouted EGR vacuum lines and carbon build-up in the engine's combustion chambers.

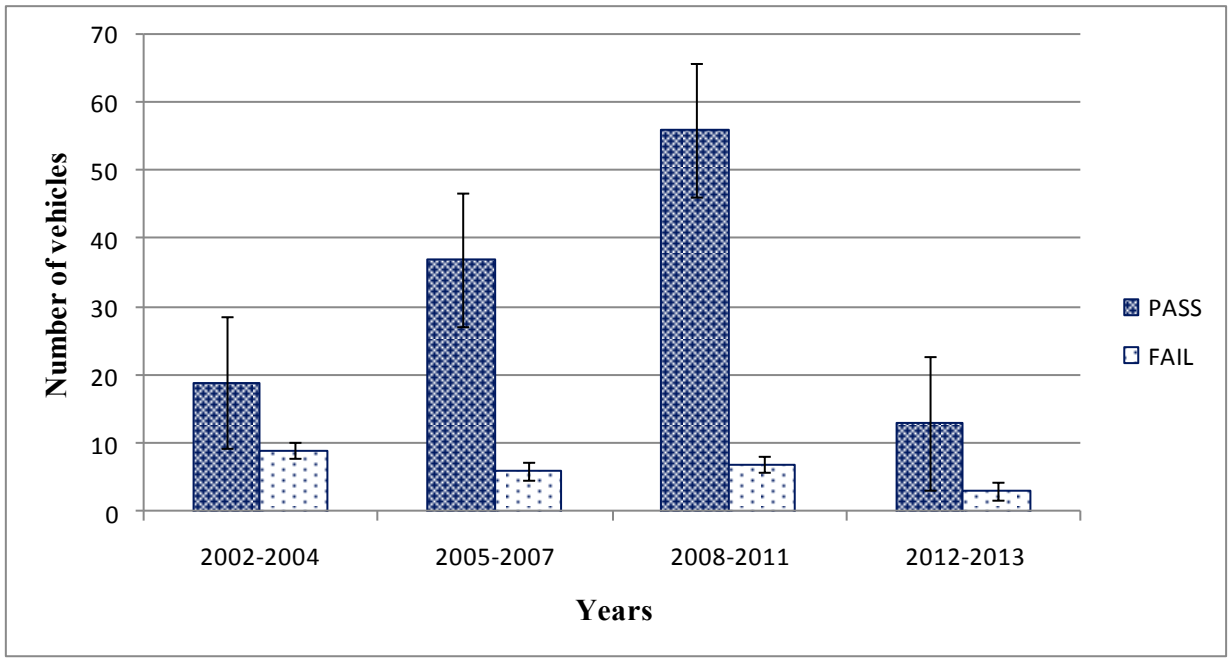

Figure 4: ***Chart for Nitrogen Oxide (NO_2) Emission Test***

Emission problems associated with vehicle aging

From the results shown in section 3.1, it is evident that vehicular aging degrades the emission reduction capabilities of vehicles tested. It is interesting to note that vehicle produced had different emission related problems. For instance, it was observed that more 84% of vehicles produced during the 2002-2004 which failed the emission test were due to contaminated or bad catalytic converters, poor positive crankcase ventilation (PCV) valve and temperature cooling sensor. For those manufactured within 2005-2007, emission test failure occurs as a result of clogged air filter, blocked manifold and oil leakage into combustion chamber. As improvement takes place in vehicular emission reduction techniques, it was observed that most of the earlier identified emission related issues had been resolved in vehicles produced beyond 2007. This is

evident in the higher emission test pass rate in the sample set for the 2008 and beyond vehicles. This higher rate may be due to stringent emission control regulations. That not with standing, issues of engine misfiring, worn out spark plugs and dirty air filter. As the automobile industry gets more sophisticated, recent models like the 2012 and 2013 model vehicles seem to have their emission test failures as a result of faulty EGR, faulty catalytic convertor, poor engine cooling system and dirty oil in engines.

It is obvious that some of these problems are due to negligence of the vehicle owners in ensuring proper maintenance of their vehicles. With the commencement of the emission test regulation in Ghana, accompanied with stricter punishment much attention would be paid to emission related issues both from vehicle owners and institutions responsible for compliance.

Recommendation for policy formulation

The Driver Vehicle Licensing Authority (DVLA) who are mandated by law to check emissions from vehicles are not equipped with emission testing equipment. It is therefore recommended that DVLA is equipped with modern emission testing equipment to enable them conduct emission tests on all vehicles during road worthiness tests. The Motor Transport and Traffic Directorate (MTTD) do not have technical personnel to arrest vehicles that have poor emission. It is recommended that the MTTD of Ghana Police Service should recruit technical officers to check and impound vehicles with poor emission on our roads. Due to harmful nature of exhaust emission, State Transport Unions such as GPRTU, Metro Mass Transit, and STC should have their own emission analysers to check all their vehicles and inspectors to monitor their outcome.

Conclusion

Emission testing checks the levels of hazardous material that escape from motor vehicles with combustion engine. The goal of emission testing is to cut down on pollutants that are harmful to the environment, with the particular focus on improving air quality. Emission testing was the result of research into the dangers of vehicle emission and the struggle to create public awareness about it. Emission Test swere conducted on One Hundred and Fifty (150) vehicles within Dome in the Ga East Municipal District and Kokomlemle in the Accra Metropolitan area of Ghana using the European Union standards. An overall 76.6% pass rate was observed. The failure rate increase with vehicle aging. Largely, emission failure was as a result of ineffective emission control components such Exhaust Gas Recirculatory valve, Fuel pump, Oxygen sensor, Catalytic convertor and carburettor.

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