American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-03, pp-13-19
www.ajer.us

Research Paper Open Access

Investigating Emission Values of a Passenger Vehicle in the Idle Mode and Comparison with Regulated Values

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Abstract: This paper presents an experimental study of emission values of a passenger vehicle in idle mode in comparison to regulated values. The results from the emission test conducted on the Golf 3 GTi Volkswagen 1996 model popularly used as "Taxi" in Nigeria were compared with emission value in Euro 2 to depict the year the car was manufactured. The devices used in the experimental work consist of a SV-5Q automobile exhaust gas analyzer and SV-1 engine tachometer. The measured emission results were 12.98, 1.43 and 1.58g/km for CO, HC and NO respectively. Generally, age and fatigue will produce a number of poor performances of engine such as break down in major operating variables that affect sparks ignition, engine performance, emission control (catalytic converter) if installed. This study showed high emission values in the aged vehicle and concluded that efforts to reduce the rate of emissions are necessary and to set standards for vehicular emission in the country using the accepted standards.

Keyword: *Idle, RPM, Emissions, Standards*

I. INTRODUCTION

Emission is the most common problem associated with vehicle idling in urban driving. The automobiles in Nigeria are mostly fairly used vehicles (high-mileage vehicles) yet with the growing fleet of vehicles and escalating amount of time spent in traffic by the drivers and passengers the emissions seem to increase. These vehicles usually consumed more fuel and emit more pollutants as a result of operational conditions. There is a hierarchy of emission estimation techniques (EETs), ranging broadly from the most accurate and site-specific to generic and least accurate, namely: direct emission measurement; indirect measurement; mass balance calculation; models and physicochemical relationships; emission factors; and engineering judgment. Vehicle characteristics such as engine size, power rating and weight are also factors influencing fuel consumption and emission rates. Generally, vehicles with large engine sizes (2.0L and above) emit more pollutants than vehicles with small engines, and large engine sizes are commonly accompanied with high maximum-horsepower. Ambient temperature is an important parameter affecting both exhaust and evaporative emissions. Previous studies, Kuhns , [1] and Chan [2] commented that older vehicles emitted more pollutants than newer ones. Chan [2] also observed that the older trucks had higher CO emission factors but lower NOx emission factors due to poor engine combustion associated with their high usage rates and limited maintenance. For engine in idling mode the friction, the heat losses are greater than once fully warmed and the time required to reach steady-state operating temperature is longer. These factors contribute to a longer period of relatively poor combustion and consequent need for more fuel enrichment (operation with more fuel than required for stoichiometry). The combination of these factors results in higher exhaust concentration of unburned fuel in the form of hydrocarbon and carbon monoxide. Fossil fuels are the major contributors to urban air pollution and source of greenhouse gases. Due to unabated high emission rates, the ozone layer which plays a critical role in screening harmful ultra violet radiation is depletion thereby allowing the harmful radiation to reach the earth surface. Hence, it is highly desirable to reduce vehicular emissions more so as international concerns are being raised for control and restriction and strict environmental legislations.

II. MATERIALS AND METHODS

Materials

a) SV-5Q Automobile Exhaust Gas Analyzer
b) SV-1 Engine Tachometer
c) SV Oil Temperature Profile
d) Volkswagen (Golf GTi Model 1996)
e) Black and Decker 400 (watt) Inverter
f) Petrol (PMS) standard of with Research Octane Number (RON) 90
g) HP Laptop with SV-5Q Gas Analyzer PC Contactor Interface Software System

Methods

The SV-5Q Automobile Exhaust Gas Analyzer is set for emission tests by connecting one side of sampling tube to the end of sampling while the other side is connected to the exit of fronted filter. Connect one side of short catheter with the front of fronted filter, while the other side is connected to sample gas vent of the analyzer. Every point is then checked to make sure they are firmly connected and no leakages.

Followed is separately connecting the power line, engine temperature measurement and speed tachometer, and temperature signal socket and speed signal socket. The analyzer is then powered and immediately goes into preheating for duration of 10 minutes for the analyzer to warm up. The tachometer was clipped to the high tension lines of engine's ignition distributor, and the undulation switch of the tachometer is set to number of strokes and cylinder of the engine under study, followed by inserting the temperature profile device into the lubricating oil rod vent of engine until it touches engine oil in the engine's bottom plate. Connected then is the device to the temperature measurement input port at the back of the gas analyzer. The results are displayed simultaneously as the analyzer reads emission values on Volkswagen (Golf GTi Model 1996) in the idle mode after the engine run for a time duration of 10 minutes from cold start. The readings were recorded at time duration of 30 seconds for every test conducted.

Plate 1: Conducting emission tests on the Golf 3 Volkswagen Vehicle in Abuja, Nigeria

Plate 2: Researcher carrying out exhaust emission tests on a 3-wheeler automobile in Hitec City, Hyderabad, India

III. RESULTS AND DICSUSSIONS

Table I: Result of Idle Tests at 1000 RPM

Time (sec)	Engine RPM	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)	NO (ppm)	□ (air/fuel equivalence ratio)	Engine Temp (^0C)
30	1000	0.2	8.2	160	2.63	35	1.16	44.6
30	1000	0.12	8	162	2.48	34	1.17	47
30	1000	0.34	7.36	328	2.88	137	1.21	45.2
30	1000	0.42	8.9	120	4.03	142	1.22	56
30	1000	0.12	7.04	212	2.85	170	1.27	56.2
30	1000	0.1	7.22	206	3.08	130	1.26	57.3
30	1000	0.2	7.62	120	2.95	150	1.3	57.1
30	1000	0.38	9.5	116	3.47	165	1.22	48
30	1000	0.24	6.84	208	4.08	86	1.36	47.2
30	1000	0.26	6.84	286	5.04	81	1.41	49.8
30	1000	0.14	7.52	116	4.73	20	1.41	50.8
30	1000	0.12	7	214	4.62	20	1.44	51.8
30	1000	0.3	6.42	326	5.23	90	1.47	50.8
30	1000	0.3	7.12	174	5.83	168	1.5	51.1
	Total	3.24	105.58	2748	53.9	1428	18.4	712.9
	Mean	0.23	7.54	196.29	3.85	102.00	1.31	50.92

Results

Table II: Result of Idle Tests at 1500 RPM

Time (sec)	Engine RPM	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)	NO (ppm)	□ (air/fuel equivalence ratio)	Engine Temp (^0C)
30	1500	0.26	8.42	176	2.42	36	1.14	47
30	1500	0.26	8.42	204	1.71	34	1.09	47.9
30	1500	0.38	8.04	322	2.24	244	1.14	46.2
30	1500	0.48	10.02	124	2.33	225	1.1	56.1
30	1500	0.14	7.52	204	1.71	195	1.11	57
30	1500	0.12	7.44	224	2	150	1.14	57.6
30	1500	0.28	7.9	166	2.31	170	1.16	58
30	1500	0.46	10.46	118	2.41	200	1.13	48.2
30	1500	0.38	7.04	214	2.52	214	1.19	47.9
30	1500	0.42	7.84	304	2.74	198	1.2	50.5
30	1500	0.24	7.78	122	2.87	51	1.23	50.9
30	1500	0.22	7.1	242	3.2	52	1.28	51.9
30	1500	0.32	7.12	296	2.74	179	1.2	50.9
30	1500	0.32	8.3	164	3.1	249	1.21	51.2
	Total	4.28	113.4	2880	34.3	2197	16.32	721.3
	Mean	0.31	8.10	205.71	2.45	156.93	1.17	51.52

Table III: Result of Idle Tests at 2000 RPM

Time (sec)	Engine RPM	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)	NO (ppm)	□ (air/fuel equivalence ratio)	Engine Temp (^0C)
30	2000	0.3	8.48	172	0.83	170	1.03	47.2
30	2000	0.22	9.4	190	0.98	138	1.04	48
30	2000	0.36	8.02	296	2.05	265	1.12	46.4
30	2000	0.5	10.1	186	1.36	327	1.04	56.3
30	2000	0.18	8.12	202	1.36	230	1.03	57.1
30	2000	0.22	8.22	238	1	182	1.04	57.9
30	2000	0.3	8.86	164	1.22	340	1.04	58
30	2000	0.44	11.16	122	1.16	414	1.04	48.3
30	2000	0.32	7.06	198	1.25	377	1.07	48.3
30	2000	0.36	8.14	328	1.5	398	1.03	50.3
30	2000	0.28	8.7	120	1.5	137	1.09	50.9
30	2000	0.18	8.16	226	1.7	158	1.12	51.9
30	2000	0.34	8.02	328	1.27	370	1.1	50.95
30	2000	0.36	9.16	126	1.45	357	1.07	51.2
	Total	4.36	121.6	2896	18.63	3863	14.86	722.75
	Mean	0.31	8.69	206.86	1.33	275.93	1.06	51.63

Table IV: Result of Idle Tests at 2500 RPM

Time (sec)	Engine RPM	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)	NO (ppm)	□ (air/fuel equivalence ratio)	Engine Temp (^0C)
30	2500	0.32	9.24	192	1.09	856	1.04	47.5
30	2500	0.32	9.46	270	0.7	317	1.01	48.2
30	2500	0.4	9.02	350	0.82	653	1.01	46.5
30	2500	0.52	10.84	154	0.92	367	1.01	56.6
30	2500	0.24	8.8	200	0.67	304	1.02	56.9
30	2500	0.34	7.76	306	1.02	860	1.04	58
30	2500	0.36	8.6	194	1	627	1.04	58.2
30	2500	0.48	11.1	124	1.01	633	1.03	50
30	2500	0.36	8.38	244	1.07	690	1.05	50
30	2500	0.38	8.3	318	1.21	740	1.05	50
30	2500	0.3	8.72	124	1.36	330	1.07	51
30	2500	0.26	8.36	288	1.22	367	1.06	52
30	2500	0.38	8.32	344	1.03	603	1.03	51
30	2500	0.4	9.7	228	1.21	697	1.05	51.3
	Total	5.06	126.6	3336	14.33	8044	14.51	727.2
	Mean	0.36	9.04	238.29	1.02	574.57	1.04	51.94

Table V: Result of Idle Tests at 3000 RPM

Time (sec)	Engine RPM	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)	NO (ppm)	□ (air/fuel equivalence ratio)	Engine Temp (^{0}C)
30	3000	0.4	9.18	250	1.03	783	1.03	48
30	3000	0.3	9.08	292	0.53	295	1	48.3
30	3000	0.38	9.12	330	0.75	793	1.01	47
30	3000	0.44	11.36	176	0.7	307	1.01	57
30	3000	0.23	8.54	244	0.58	457	1.01	57.1
30	3000	0.33	8.1	324	0.75	1000	1.02	58.1
30	3000	0.34	9	204	0.85	793	1.03	58.2
30	3000	0.46	10.42	126	0.93	798	1.02	53
30	3000	0.32	8.14	240	0.91	886	1.03	49.2
30	3000	0.32	8.26	304	1.03	935	1.04	49.2
30	3000	0.32	9.38	166	0.97	380	1.04	51
30	3000	0.28	8.68	252	1.07	327	1.05	52.5
30	3000	0.4	8.54	364	0.87	743	1.02	51.5
30	3000	0.42	9.72	200	0.92	770	1.03	51.8
	Total	4.94	127.52	3472	11.89	9267	14.34	731.9
	Mean	0.35	9.11	248.00	0.85	661.93	1.02	52.28

Table VI: Summary of Mean Values from the Results of the Idle Tests

S/N	Engine RPM	CO (%)	CO^2 (%)	HC(ppm	O_2 (%)	NO (ppm)	λ (air/fuel equivalence ratio)	Engine Temp (^{0}C)
1	1000	0.23	7.54	196.29	3.85	102	1.31	50.92
2	1500	0.31	8.1	205.71	2.45	156.93	1.17	51.52
3	2000	0.31	8.69	206.86	1.33	275.93	1.06	51.63
4	2500	0.36	9.04	238.29	1.02	574.57	1.04	51.94
5	3000	0.35	9.11	248	0.85	661.93	1.02	52.28
Total	10000	1.56	42.48	1095.15	9.5	1771.36	5.6	258.29
Mean	2000	0.312	8.496	219.03	1.9	354.272	1.12	51.658

Table VII: Measured values compared with Indian emission standards (4-wheel vehicles) for passenger cars

Type	Reference	Year	CO (g/km)	HC (g/km)	NOx (g/km)	CO_2 (not regulated)
Bharat Stage I	Euro 1	1992	4.5	0.60	0.49	-
Bharat Stage II	Euro 2	1996	3.28	0.34	0.25	-
Bharat Stage III	Euro 3	2000	2.30	0.20	0.15	-
Bharat Stage IV	Euro 4	2005	1.0	0.10	0.08	-
Average measured Values (g/km)	-	-	12.98	1.43	1.58	-

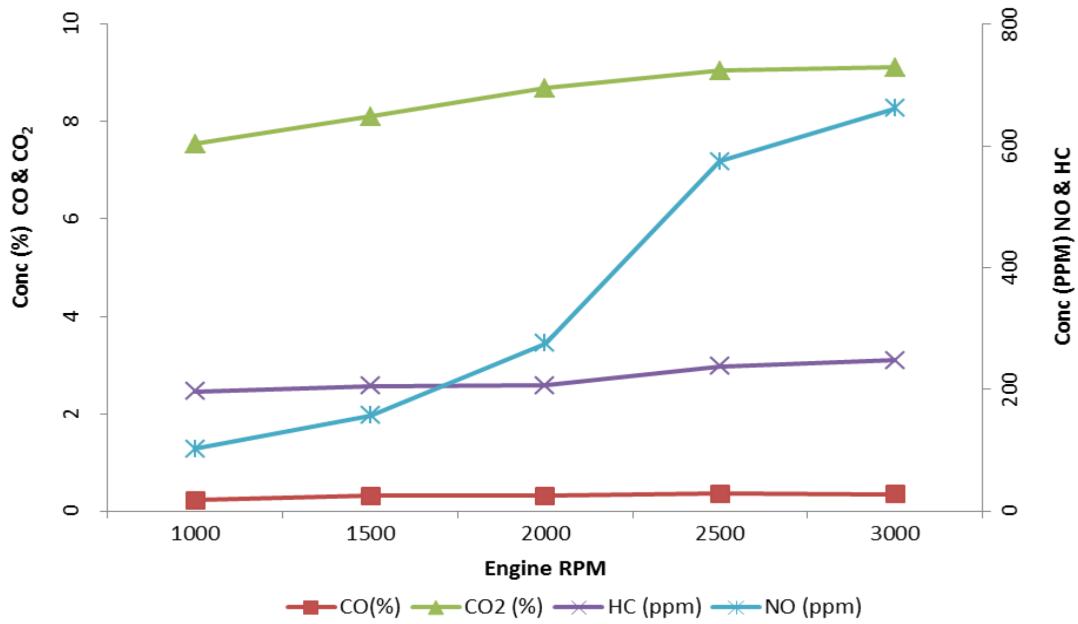

Figure 1 : Plot of emissions with engine RPM at Idle

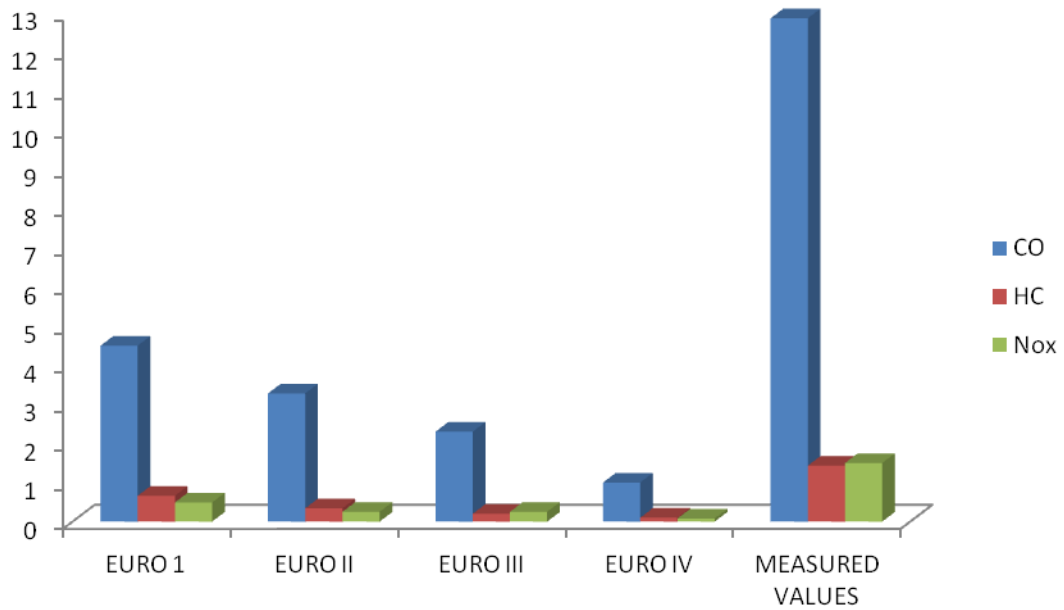

Figure 2: Plot of measured emission values with emission standard values

IV. DISCUSSIONS

Figure 1 shows the emission concentrations and the engine rpm of the vehicle under study, it was observed that the emission values of carbon monoxide (CO) concentration increase from 0.23% to 0.35%, carbon dioxide (CO_2) from 7.54% to 9.11%, Nitrogen Oxide (NO) from 102 to 661ppm and Hydrocarbon (HC) from 196 to 248 as the engine speed progressively moved from 1000 to 3000 rpm. The Idle test agrees with Vijayan [3] observations that emissions increase with engine speed (load), and that engine rpm is one of the most important variables affecting the concentrations of emissions. This is also substantiated by Roumegoux [4] that there is a correlation between emissions with engine speed.

Figure 2 shows the result of the mean idle emissions compared with the acceptable emission standards from Euro 1 to Euro 4 (and Bharat Stage I to IV for India standard). The results of the emission tests were analysed along with the Euro 2 indicating the year in which the vehicle under study was manufactured. The measured emission results were 12.98, 1.43 and 1.58g/km for CO, HC and NO respectively and compared with Euro 2 values of 3.28, 0.34 and 0.25 g/km for CO, HC and NO respectively. These measured high values cannot even stand comparable to Euro 4 (European standards by United Nations Economic Commission for Europe) and the proposed emission reduction of carbon monoxide by 23% , hydrocarbons by 6.5% reduction and oxides of nitrogen by 14% reduction in 2020, based on the Euro 4 values intended to limit average fuel consumption from new petrol passenger vehicles to 6.8L/100km as reported by Coffey [5]. The observed high values of emission vis-à-vis regulated standard is in agreement with Kuhns [1] that older vehicles emits more pollutants than new ones.

V. CONCLUSION

There is the need to work holistically and explore ways to reduce emissions from used vehicles found in Federal Capital Territory, Abuja Nigeria. The Government should set a high standard for the importation of used vehicles. Exhaust emission standards should be set by the relevant agencies and should be enforced with strict compliance. And as a matter of urgency, plans should be expedited to set standards for vehicular emission in the country using the accepted standard for vehicular emission which is the European standard adopted by most countries globally.

REFERENCES

[1] Kuhns H., Etyemezian V. and Nikolich G (2004). Precision and Repeatability of the TRAKER Vehicle-based Paved road Dust Emission Measurement Desert Research Institute, Division of Atmospheric Sciences, 755 E. USA pp 95

[2] Chan T.L., Ning Z., Leung C.W., Cheung C.S., Hung W.T. and Dong G. (2004). On- road Remote Sensing of Petrol Vehicle Emissions Measurement and Emission Factors Estimation in Hong Kong. Atmospheric 140 Environment 38, pp205

[3] Vijayan A. (2007) Characterization of Vehicular Exhaust Emissions and Indoor Air Quality of Public Transport Buses Operating on Alternative Diesel Fuels. Ph.D Dissertation

[4] Roumegoux J.P. (1995). The Science of Total Environment 169, pp280

[5] Coffey Geosciences(2006), Fuel Quality and Vehicle Emissions Standards Cost Benefit Analysis Pprepared for MVEC Review of Vehicle and Fuel Standards Post pp 94