STUDY OF VEHICULAR EXHAUST EMISSION ESTIMATION

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Abstract - *Transportation is a major source of air pollution. Pollutant produced by vehicle exhaust includes carbon monoxide, hydrocarbon, nitrogen oxide, particulate, volatile organic compound and sulfur dioxide. Passenger vehicle are a major pollution contributor, producing significant amounts of NO_x, CO and other pollution. Objective of this research to; determine of the emission of CO, HC and NO_x in standstill test. For validation purposes, results were compared to the emission factors provided by the COPERT emission model. Emissions of CO_2, HC and CO correlated well with COPERT values, regardless of the distance split selected for average speed calculations. However, NOx emission levels were consistently higher than the applicable emission standard and the COPERT emission factors.*

***Key Words*: *Control Emission, COPART* (Computer Programme to estimate Emissions from Road Transport).**

1. Introduction

COPERT 5 (Computer Programme to estimate Emissions from Road Transport) is a Microsoft Windows software program which is developed as a European tool for the calculations of emissions from the road transport sector. The emissions calculate includes regulated (CO, NOx, VOC, PM) and unregulated pollutants (N_2O, NH_2, SO_2, NMVOC speciation). COPERT 5 equations to interpret the expulsion of emissions from combustion engines. It takes parameters from certain vehicles such as engine size, the technology level and the average speed in kilometers per hour and gives the resultant in (g/km).

2. Experimental Study

The COPERT methodology has been used to calculate a traffic emission inventory and the fuel consumption factor of each COPERT 5 vehicle category the annual fuel consumption for gasoline, diesel and LPG is estimated. There are three general vehicle emission types, one which is minor and two which are major. The minor one is evaporative emissions (EEVAP). The other two major emissions are cold-start emission (ECOLD) during transient thermal engine operation and hot emissions (EHOT) during stabilized hot engine operation. Two devices of Autologic gas analyzers have been used. The first one runs into a portable PC (laptop) and does not read the emission factors in gram per mile while the second one runs into pocket PC with a built-in software package that can convert emission factors into gram per mile. The analyzer can measure 5 separate types of gas HC, CO, CO_2, O_2, NOx and also Lambda and Air Fuel ratio. Standstill testing allowed recording of gas analyzer background data. This motionless test meant that certain parameters were eliminated in these tests such as speed, traffic jams and driving characteristics. This study include the comparison of UDC (the trip via city centre urban driving cycle was full of stop and vehicle speed was full of stops and vehicle speed was up to 74[km/hr]) and EUDC (Extra-Urban Driving Cycle had few stops and the speed reached 100 [km/hr] many times).

3. Results and Discussion
3.1. Standstill Tests

During this operation, slight increase in emissions were noticed the engine speed was between 1400-1600rpm. It was noticed that when there was an increase in engine speed, a corresponding increase in the amount of emissions.

3.1.1 Emission of HC

In the case of Hydrocarbon emissions, there was an increase over the 10 minute test period. This concluded that as time increased the HC emissions increased gradually. The level of HC emissions also increased with increased engine speed. In general at low engine speed, the amount of CO being produced is higher that the corresponding HC emission values as it shown in figure. 1

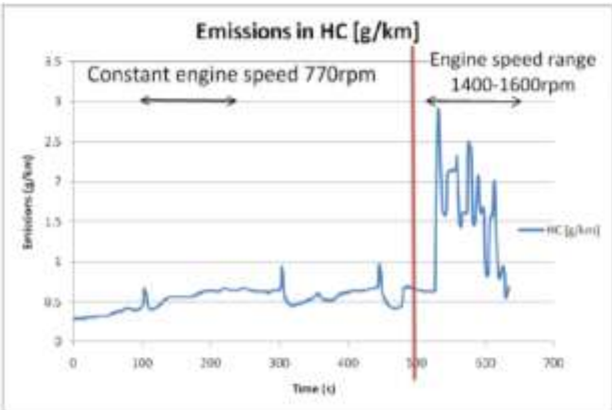

Figure 1: Hydrocarbons Emissions of Standstill Testing

3.1.2. Emission of CO

When the number of revolutions increased there is a sharp increase in the amount of CO produced but then drops back to a level that is higher than the previous levels. This means that over an extended period of time as the engine speed is kept constant at a higher level, the sum of CO is increasing constantly.

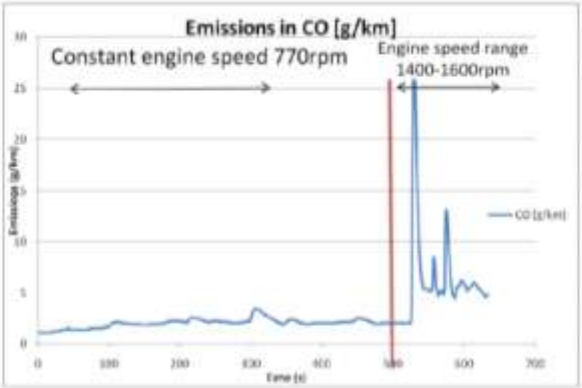

Figure 2: Carbon Monoxide Emissions of Standstill Testing

3.1.3 Emission of NOx

The amount of emissions for NOx during standstill testing is negligible in comparison to HC and CO produced for the same test.

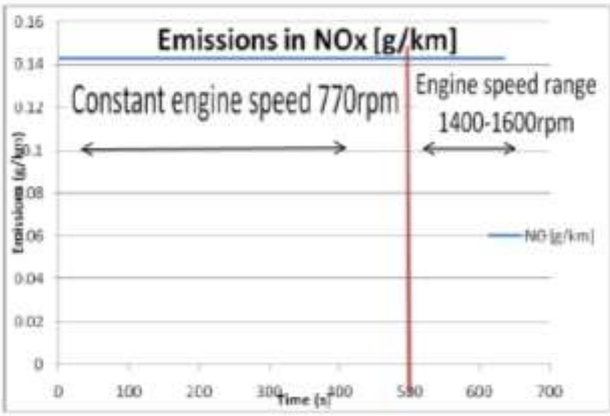

Figure 3: Nitrogen Oxide Emissions of Standstill Testing

3.2 Short Urban Route

The only emissions that will be taken into account are CO and NO_x during the short urban route. It was noticed from the results that some of the independent driving pattern factors have a significant effect on fuel consumption and emissions in urban areas.

3.2.1 Emission from Short Urban Cycle

The amount of CO produced is significantly greater than that of NO_x. While this result was expected, the amount of CO produced was quite unexpected. The pollutants emitted an average of NO_x is 0.22898 gram per kilometer and an average CO produced is 3.37 gram per kilometer. This is over a distance travelled of 4.442 kilometers. It is noticed from the results that the amount of total CO produced through exhaust emissions for short urban use is nearly 15 times the total amount of NO_x produced. The total amount of NO_x and CO produced over the distanced travelled is 1.01715 grams and 14.97135 grams respectively. Figure .4 shows the emissions relative to one another. NO_x and CO emissions are produced under similar conditions.

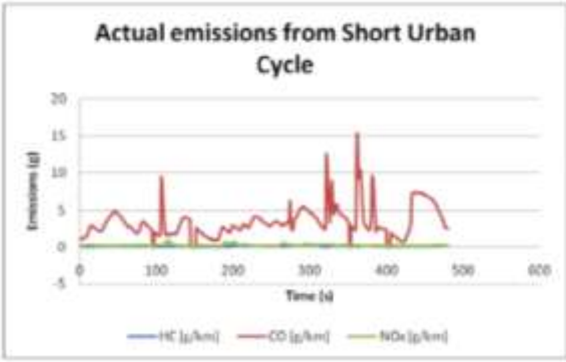

Figure 4: All emissions from Short Urban Route.

3.3 Comparison of UDC and EUDC

A comparison between these two cycles of 14 km has been made. The first trip took 2703 s and the average speed was 19.547 km/hr. The second trip took 850s and the average speed was 59.6 km/hr. CO emissions, NOx emissions, and fuel consumption for both trips were compared in terms of average emission per second [g/s], average emissions per unit distance [g/km], and total emission [g/trip] as mentioned in Table 1.

	Urban Drive cycle Distance travelled = 14.678 km Average Speed = 19.547 km/h Time = 2703.3 seconds			Extra-Urban Drive cycle Distance travelled = 14.073 km Average Speed = 59.614 km/h Time = 849.9 seconds		
	CO	NOx	FC	CO	NOx	FC
Average Emissions per second [g/s]	0.003	0.0004	0.345	0.014	0.0010	0.884
Average Emissions per Unit Distance [g/km]	0.544	0.076	63.59	0.837	0.059	53.38
Total Emissions [g/trip]	7.990	1.112	933.3	11.776	0.826	751.2

Table .1 Comparison in between of UDC and EUDC

4. Application of COPERT 5

The results obtained in this experimental study have shown a noticeable deviation between the COPERT 5 theoretical CO and NO emission factors calculated and the actual values.
It has been found that the CO estimation was overestimated while NO was underestimated. For this reason, the emission variations has been investigated and compared to vehicle speed for a Euro 3 legislative standard car which has the coefficients set up for the tested car by COPERT methodology.

Table 2: Comparison between Measured and Estimated Emissions.

	Measured	Estimated
NOx [gr/km]	1.137	0.421
CO [gr/km]	28.67	66.49

4.1. Variation in CO with Speed

In order to investigate the differences in CO and NOx emissions, two graphs have been plotted for the two emission factors in term of vehicle speeds. Figures 5. and 6. shows the EF variations for vehicle speed from zero speed to 100km/hr.

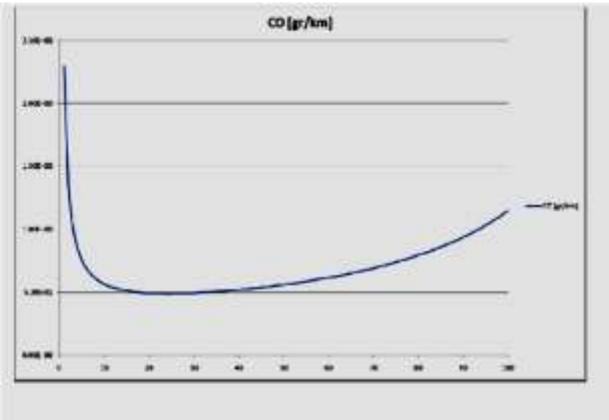

Figure 5 CO with Speed in COPERT Methodology.

4.5.2 Variation In NOx with Speed

It was found that CO has a significant emission number when the car on the idle time (zero speed) which covered 17% of the total test time. That led to a noticeable difference in real emissions. In relation to NOx emissions, the variation was slightly different among speed steps including idle time.

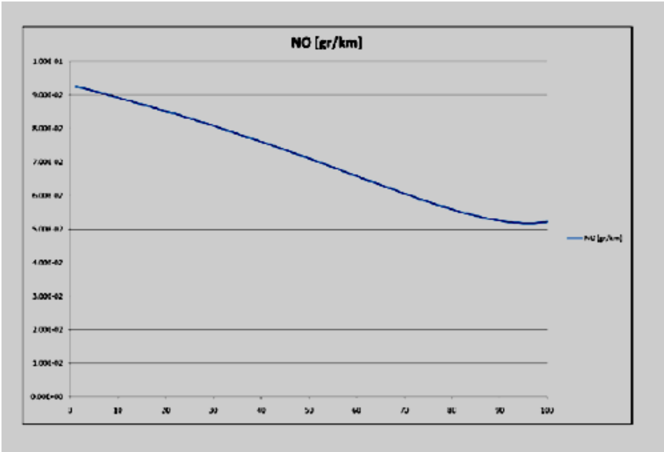

Figure 6 NO_x with Speed in COPERT Methodology

Table 3 shows the critical car speeds for CO and NOx variations. In relation to CO, If idle time was excluded from the total time, CO emission would be Underestimated.

Table 3: The Critical Car Speeds for CO and Nox Variations.

Speed [km/hr]	0	1	25	96	100
CO [gr/km]	71.8	2.4	0.40	-	1.16
NOx [gr/km]	0.0920	0.0927	-	0.0519	0.0524

Conclusions

- In 10 min test period the engine speed was between 1400-1600 rpm it was noticed that when there was an increase in engine speed a corresponding increase in the amount of CO and HC produced. But the amount of NOx during standstill testing is negligible in comparison to HC and CO produced for the same test.
- Comparison in between Urban Driving cycle and Extra driving cycle has been made two cycles of 14 km, Average emission per second [g/s] ,average emission per unit distance [g/km] and total emission [g/trip] of EUDC is greater than UDC.
- COPERT, one of most commonly a deployed tool has been used which makes use of bulk traffic movements and average vehicle speeds in order to estimate the variation of CO and NOx emission with speed.

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