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VEHICLE POLLUTION FOR COLD ENGINE FUNCTIONING

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***Abstract*—** This paper present a study regarding the emissions produced at the engine cold start. The main goal of this work is to describe the relative cold start extra emissions as a function of exhaust gas temperature. Experimental research has been done for two light vehicle, Dacia Sandero 1.4 liter SIE and Dacia Logan 1.5 liter CIE. There were been made several tests, in different temperature conditions, using a portable analyzer, GA-21 plus (produced by Madur Austria). The parameters measured with the analyzer and used in the analysis are: CO, NO, NO_2 and SO_2. It was concluded that the highest pollutants values are recorded until the point when the catalyst sistems comes into operation and exhaust gas temperature is 40-50ºC for SIE and 35-40ºC for CIE.

***Keywords*—** Cold, Air, Pollution, Diesel, Spark Ignition Engine.

I. INTRODUCTION

Vehicle pollution produced by the vehicles are responsible for 60% of air pollution in urban areas. The major pollutants emitted by motor vehicles including CO, NO, NO_2, SO_2, HC and suspended particulate matter (PM2,5, PM10), have damaging effects on both human health and environment degradation [1].

The high density of traffic in cities has a negative impact on the health of the population and on the environment. According to the publication Factum [2], half of all trips in urban areas are shorter than 5 km and one third is shorter than 3 km. Between 60% and 80% of the toxic air emissions from automobiles occur during this cold-start period. Since catalysts are effective only at high temperature, above 200ºC, emissions are more significant during the initial part (cold phase) of a trip when engine and catalyst are cold. Catalysts have become so effective in the last 15 years that it is even becoming difficult to measure the regulated pollutants as CO, HC and NO_x, when the catalyst has reached its light-off temperature. Nowadays, due to catalyst improvements the most significant part of the total emission during a trip, especially for short trips (<10 km), takes place during the cold phase. Therefore, the analysis of additional emissions during the cold phase, referred to as the cold start extra emissions, has gradually gained significance in improving emission models and thus emission inventories [3].

II. POLLUTION MEASUREMENT METHODOLOGY

Experimental research has been done for two light vehicles:

1) Dacia Sandero equipped with a 1390 cm^3 Spark Ignition Engine with Power = 55 kW at 5500 rpm.

2) Dacia Logan equipped with a 1461 cm^3 Compression Ignition Engine with Power = 50 kW at 4000 rpm.

There were been made two tests, in different temperature conditions, from starting the engine to the point that optimum operating temperature is reached. The engines ware operated at idle speed throughout the measurements. In Fig. 1 it is presented the equipment and the placement of it in order to perform the measurements.

Fig. 1. Madur portable analyzer, GA-21 plus

The measurements ware made with a portable analyzer, GA-21 plus (produced by Madur Austria) like in Fig. 2.

The tests were made as follows:

1) 11 February 2014 Test (ambient temperature ~ 8 ºC) - for Dacia Sandero 1.4 liter SIE.

2) 19 March 2014 (ambient temperature ~ 15 ºC) -

for Dacia Logan 1.5 liter CIE.

The GA-21 plus is a multi-functional flue gas analyzer. Electrochemical sensors are used for the measurement of gas concentration. The analyzer is fitted with Oxygen O_2, Carbon monoxide CO, Nitric oxide NO, Sulphur dioxide SO_2, Carbon dioxide CO_2 and Nitrogen oxides NO_x sensors [4].

Fig. 2. Vehicle pollution measurements

The first four gases (O_2, CO, NO, SO_2) are measured directly using the electrochemical cells. The remaining components are calculated. The concentrations of oxygen and carbon dioxide are shown in percent. The concentration of the remaining gases is shown as follows: volume concentration in ppm; absolute mass concentration in mg/m^3; mass concentration relative to the oxygen content in mg/m^3.

In addition, the air inlet or ambient temperature and flue gas temperature are measured. Using the measured temperatures, gas concentrations and the known fuel parameters the analyzer calculates a variety of combustion parameters such as Stack Loss - SL, Efficiency - h, Excess Air - λ, Loss through Incomplete Combustion - IL [4].

III. POLLUTION REORDERED DATA

At spark ignition engines, the properties of the exhaust gases depend directly on the rotary speed, on the weight/load of the engine and on the value of the dosage of the mixture air-fuel in its cylinders [5]. The temperature of burnt gases varies between 300-400ºC at empty running and 900ºC at full load. The chemical composition of burnt gases is influenced by the operating conditions of the engine, by the quality of the mixture air-fuel and by the ambient temperature [6].

The results resulted after the tests were downloaded and it was created a database in order to analyze them. To exemplify, 11 February 2014 Test will be presented as follows.

Measurements were made from cold engine start, saving reports at every two minutes. The test contains 9 reports for exhaust gas temperature ranging from 19 to 70°C. The collected data are saved as database in order to analyze the results. Fig. 3 presents MadCom software interface, for results visualization and data processing.

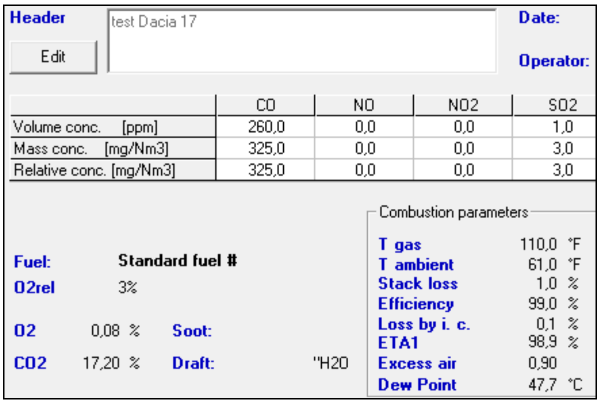

Fig. 3. Presenting the results of one report using MadCom software

For every report following parameters are saved: parameters values (CO, NO, NO_2, SO_2, H_2S, H_2) measured by the equipment cells and expressed in [ppm]; calculated parameters values (O_2%, CO_2 %, NO_x ppm); calculated parameters values (CO, NO, NO_2, SO_2, H_2S, H_2) expressed in mg/m^3; flue gas temperature, T_{gas}ºC; ambient temperature T_{amb}ºC; excess air factor λ [4].

IV. DATA ANALYSIS

The main pollutants variations depending on exhaust gas temperature for 1.4 liter gasoline engine are presented in Fig. 4, Fig. 5, Fig. 6 and Fig. 7.

After the collected data analyze, it results:

The concentration of carbon monoxide is very high at engine cold start. Until the exhaust gases reach a temperature of about 40ºC, the concentration of CO is between 4000 and 6000 mg/m^3.

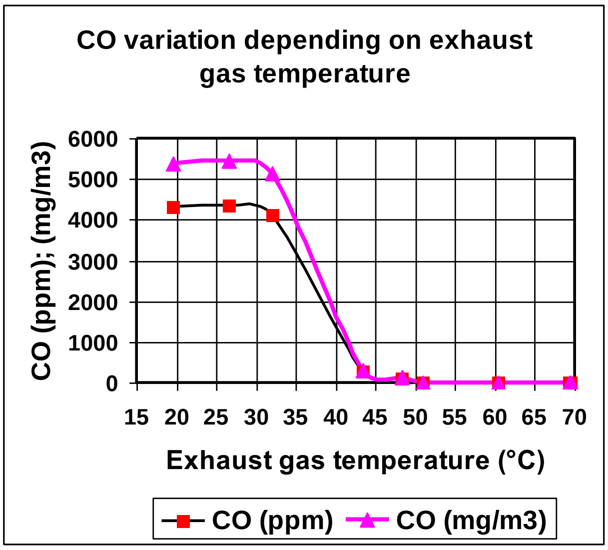

Fig. 4. CO variation in function of exhaust gas temperature

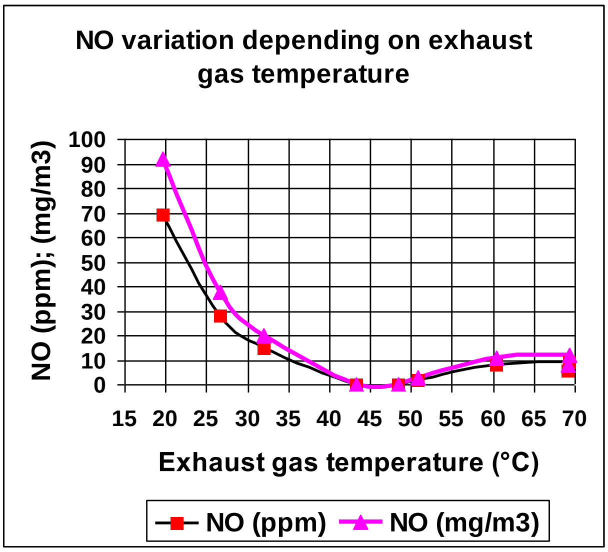

Fig. 5. NO variation in function of exhaust gas temperature

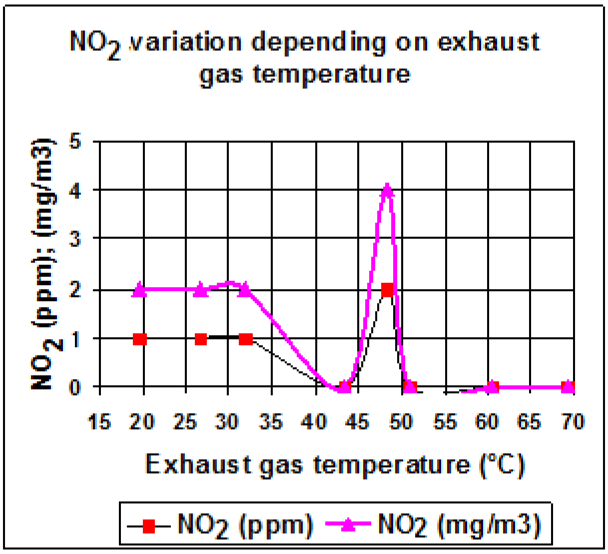

Fig. 6. NO_2 variation in function of exhaust gas temperature

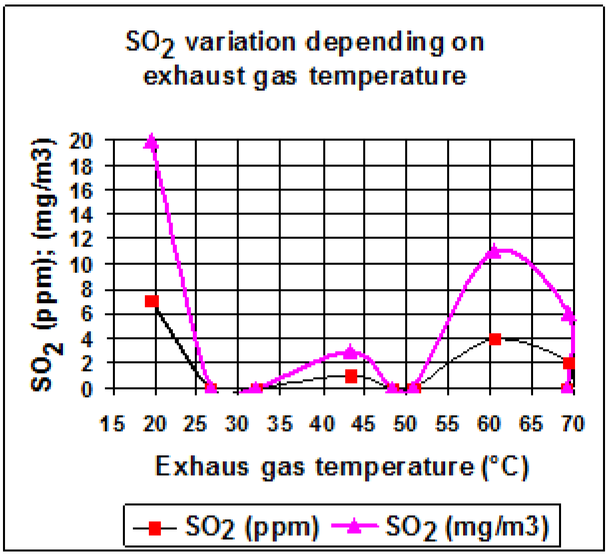

Fig. 7. SO_2 variation in function of exhaust gas temperature

After the exhaust gases reaches a relatively optimum temperature (around 50ºC), the concentration of CO tends to 0 mg/m^3. The concentration of nitrogen monoxide is also very high at engine cold start.

The maximum NO values, about 90 mg/m^3 are reached at engine start (exhaust gases temperature is around 40ºC). The concentration of NO decreases to 0 mg/m^3 upon reaching a temperature of 45-50ºC, then increases up to a relatively constant value, around 10 mg/m^3. In sulphur dioxide case, the maximum values are registered at engine start (around 20 mg/m^3). Also, in this case, NO_2 values oscillates until T_{gas} reaches an optimum temperature (about 50ºC), when it will tend to 0 mg/m^3. It can be concluded that the highest pollutants values are recorded until the point when the catalyst comes into operation (when the gas temperature entering the catalyst is approx. 200ºC and exhaust gas temperature is 40-50ºC.

The main pollutants variations depending on exhaust gas temperature for 1.5 Diesel engine are presented in Fig. 8, Fig. 9, Fig. 10 and Fig. 11.

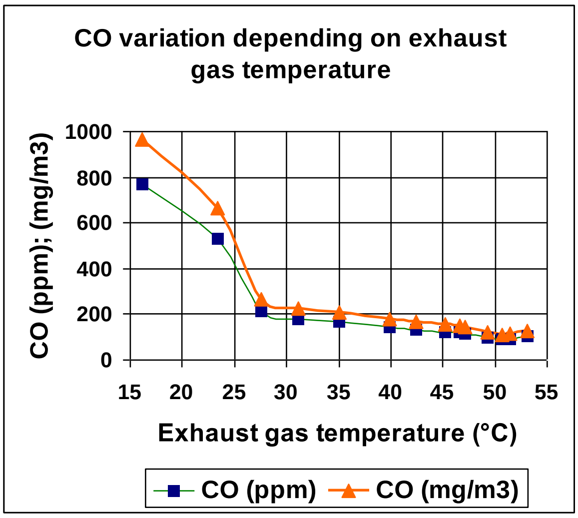

Fig. 8. CO variation with exhaust gas temperature for CIE

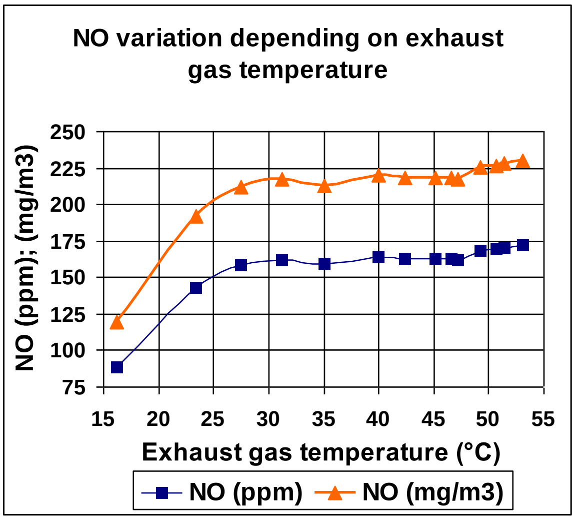

Fig. 9. NO variation with exhaust gas temperature for CIE

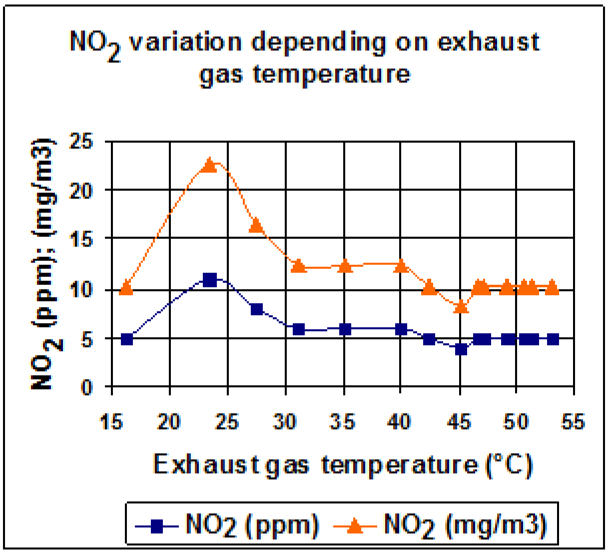

Fig. 10. NO_2 variation with exhaust gas temperature for CIE

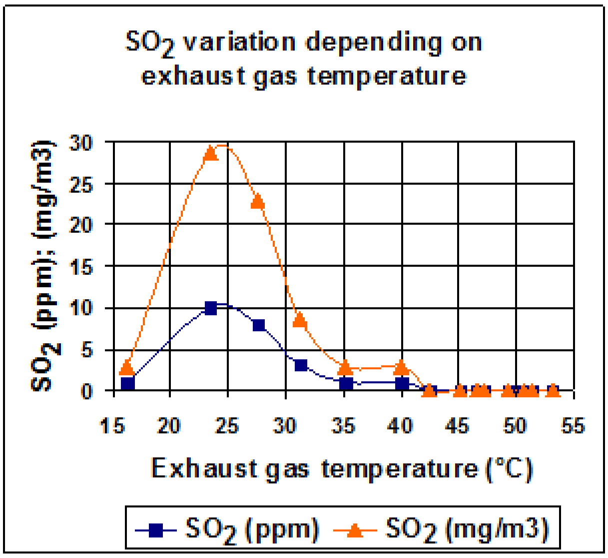

Fig. 11. SO_2 variation with exhaust gas temperature for CIE

The concentration of carbon monoxide is high for Diesel engine cold start. Until the exhaust gases reaches a temperature of about 35ºC, the concentration of CO is between 400 and 1000 mg/m^3. The maximum NO values, about 225 mg/m^3 are reached when the engine is warming. In sulphur dioxide case, the maximum values are registered at engine start (around 25 mg/m^3). Also, in this case, NO_2 values oscillates until T_{gas} reaches an optimum temperature (about 50ºC), when it will tend to 10 mg/m^3. It can be concluded that the highest pollutants values are recorded until the point when exhaust gas temperature is 35-40ºC.

All engine situations when the engine and the fluids have not reached operating temperature are deemed to be cold starts. At temperatures below 50°C changing the injection timing and amount is required. These changes should optimize the combustion stability and reduce the emissions during the warm-up phase of the engine. Temperatures below 0°C require further and more radical changes [7].

V. CONCLUSION

Exhaust pollution level is always very high for the engine cold start. In this paper we analyzed the level of pollution for two light vehicles, Dacia Sandero equipped with a 1390 cm^3 Spark Ignition Engine with Power = 55 kW at 5500 rpm and Dacia Logan equipped with a 1461 cm^3 Compression Ignition Engine with Power = 50 kW at 4000 rpm. The tests were made in February and March of 2014. There were analyzed the variations of CO, NO, NO_2 and SO_2 in function of exhaust gas temperature.

After the results analysis was observed that the highest pollutants values are recorded until the point when the catalyst comes into operation (when the gas temperature entering the catalyst is approx. 200ºC and exhaust gas temperature is 40-50ºC in case of Spark Ignition Engine. For Diesel Ignition Engine NO concentration values are increase with the exhaust gas temperature. Also, like SIE emissions, CO, NO_2 and SO_2 concentration are high for the cold engine functioning and decreasing to optimal values after T_{gas} reaches an optimum temperature (about 40ºC).

To reduce air pollution in urban areas we must: avoid using your car for short or unnecessary journeys; walking or cycling short journeys; using public transportation; plan our journeys; try to combining trips (such as shopping and the school run) to avoid taking the car out several times; try to use less congested routes and avoid rush hours if possible.

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