THE EFFICIENCY OF STREET CAR POLLUTION REDUCTION EQUIPMENTS

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Abstract: *The present paper presents an evaluation of the technical efficiency degree of a collection and treatment facility for pollutants resulted from high intensity road traffic, characteristic for the urban traffic. The analysis of the version proposed started from the results obtained on a tested equipment -"hall type" application; there it was studied on one hand the polluted airflow, and on the other hand the speed and treatment process, the installation being equipped with active carbon filters. The results showed that for the urban areas with high traffic and especially for periods of high ambient temperatures, the solution proposed allows the collection of aprox. 60-70% of the exhaust gasses eliminated by the buses that starts from a standstill.*

Keywords*: (urban pollution, road traffic, active coal filter)*

1. Introduction

Street car pollution is one of the most relevant issues facing large urban agglomerations, from the point of view of heat island [1-4], as well as canyon effects [5-8]. The solutions proposed to reduce the pollution are various and are based on interventions aimed at increasing the green areas, ventilation of critical areas, use of new building materials and/or strategies for urban space optimization etc.

Regarding the equipments that can be used for the purpose of gas depollution resulting from traffic, they can be classified according to the area where the phenomenon occurs and can describe: "tunnel type" applications, "closed parking type" applications, "garage-service", "hall" applications, "intersection" applications. The difference between the various facilities consist in the openness degree of the space they service – the fluid flow in closed, opened or semi-opened spaces – and in the pollutant parameter variation – temperature, concentration, density, on which depends the correct calculation of the filtering modules.

In this paper, we studied the equipment destined to decontaminate the urban open spaces, intersection type, extending the results of the study of a "hall" type equipment.

2. Urban car pollution – Case Study: Bv. N. Bălcescu and Bv. Carol I

The main source of pollution is the fuel for motor vehicles, accounting for over 96%. To determine the environmental impact emissions, the gasses have been classified into: gasses that affect climate (CO_2, CH_2, N_2O), damage of the ozone layer gasses (NOx and CFC), determining their eco toxicity and human toxicity. The mechanisms through which motor fuels produce environmental contamination are determined by two chemical phenomena: evaporation of unburned fuel, exhaust gas ejections into the atmosphere.

It is considered a contribution to environmental pollution the evaporation phenomenon (conventional) of the fossil fuel to 15%. Exhaust gas ejections is contributing up to 85% and two areas are located: crankcase gases, contributing about 15%, exhaust gases through the exhaust system about 70%.

Table 1.

Emissions depending on the nature of the fuel

Nature of the fuel	**gr/1 kg of fuel**	
	Gasoline	**Diesel**
CO	465	21
NO	23	27
HC	4	12
SO_2	0,8	4,8
Particles	0,1	0,8

Besides the nature of fuel used, engine operating conditions influence also the degree of pollution. Variable speed and load, together with the speed of the vehicle and the transitional arrangements appearance permanently change the level of emissions. Given the fact that pollutant emissions from motor vehicles occur close to the ground, their maximum impact on air quality occurs in the vicinity of the traffic path, the human respiratory tract level (effective emission height is about 2 m). In the center of large cities, where the traffic arteries are "canyon type", the polluting agents persist a longer time at the respiratory level and domestic windows. Pollution is much greater and more adverse effects where vehicles are stationed with engines running: at signalized intersections, at bus stops, on roads with traffic jams and when the ambient temperature is high, in the summer. If in open spaces and under certain weather conditions, emissions can be dispersed by wind, in closed spaces (underground and outdoor car parking, garages, buildings or warehouses) decontamination of the air is mandatory.
This study deals with the area at the intersection of Boulevard Nicolae Balcescu and Carol I, where we have previous data referring to traffic [9] as per figures 1 and 2.

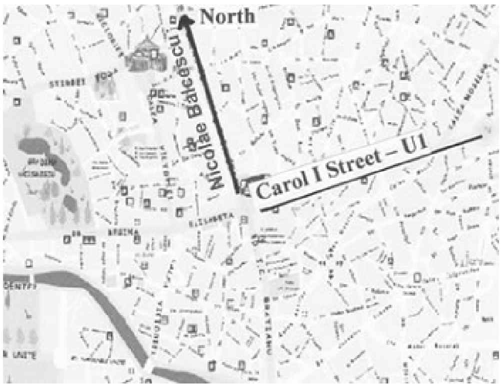

Fig.1

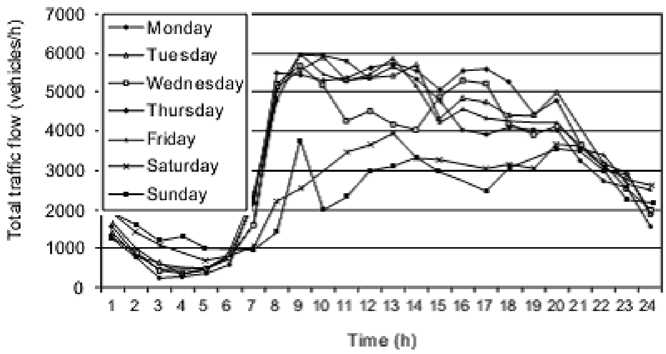

Fig.2

Fig. 1 Bv. N. Balcescu and Bv. Carol I
Fig. 2 Traffic frequency in the street canyon called U_1 for each day of the week, annual averages.

According to measurements, there is relatively high level of traffic flow around two times a day: between 7:00 and 10:00 a.m. local time, and in between 16:00 and 19:00 p.m. local time; very high levels recorded for NO_x (up to 1500 μg/m^3) were registered, while for SO_2 the values are below 30 μg/m^3. The traffic congestions and the stop-start traffic flows lead to high pollution and strong temporal variability because they enhance emission rates from vehicle engines. This means that the fluidization of the traffic is very necessary, or the use of methods to decontaminate the area.

3. Installation setup

For the "intersection" type application, we propose a technical solution based on the idea that the aspiration of polluted air must be ensured along the length of the urban bus stations, pathway along which most of the emissions are discharged as a result of motor torque acceleration. According to technical data of the busses from the Bucharest fleet and from the preliminary experiments, we determined that the necessary length is about 20 m and this statistically represents about two vehicle lengths (max. 12 m according to the Directive 2002/7/CE).
Furthermore, besides establishing the length for the capture of pollutants it is also necessary to determine the flow rate that needs to be sucked by the exhausters placed in the roadway structure, on whose aspiration the active carbon filters are placed. The filters are designed depending on the degree of pollutant load of air aspirated from the ground level, namely from aprox. 1 m above zero altitude, considered to cover the exhaust pipe axis of the vehicle. The installation shown in figure 3 [10] is automatic, working in a system which takes into account the pollutant concentration variations in the air below the vehicle when stationary – site presented in figure 4.
The site considered is the alignment of the transport station in the vicinity of the intersection described in Figure 1 (University of Bucharest).

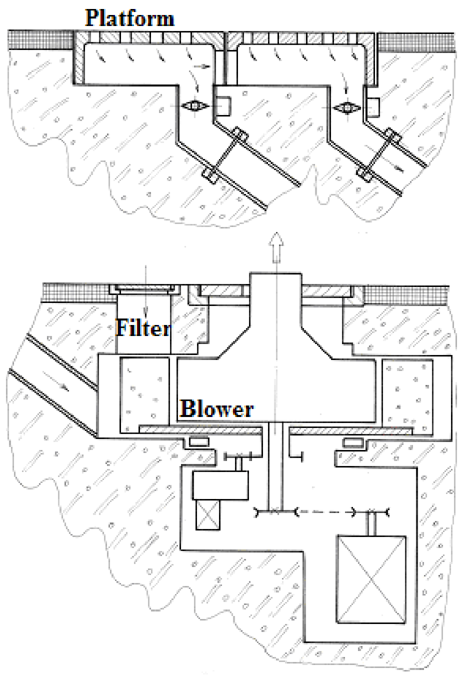

Fig. 3

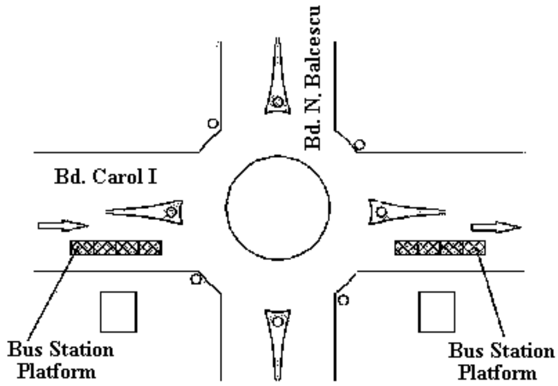

Fig.4

Fig.3 Filtration unit and blower system located underground

(Section I: Channel polluted air reception; Section II: Channel polluted air transport; Section III: Distribution system; Section IV: Filtering station; Section V: Blower unit)

Fig.4 Installation site

The structure of the scheme is available in figure nr. 5 were both components and installation functions are described.
Number of vehicles currently waiting at traffic lights or at the station is noticed by presence sensors SP1, SP2, ... SPn. According to the number of active sensors, the adding machine signals the R1 regulator which commands the actuators AC1, AC2… in order to regulate the crossing section of fluidic resistance VF1, VF1… and sends a signal to regulator R2 that adjusts engine M2 speed blower S drive.

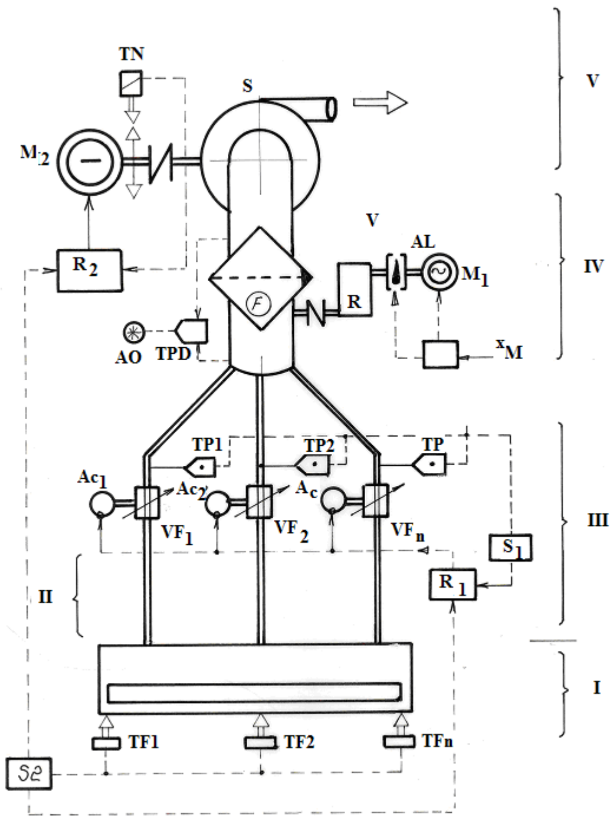

Fig.5 Decontaminating equipment type "intersection" Constructive diagram

I - Pollution channel, Presence sensors (SP_i); II - Tube ϕ 100 ... 150 mm; III - Fluid resistance (VF_i), Actuators (AC_i), Transducers (TP_i), IV - Collectors Ring filter (F), Reducer (M1 + Ab + R), Pressure transducer (TPD); V – Blower (S), Motor (M2), Velocity transducer (TM); Control System - Distribution regulator (R1), Front transducers block (S2), Electric motor converter (R2), Manual drive (M2)

The reaction circuit contains also the TN sensor, which according to a program, corrects the commanded speed.
On the other hand, equalizing piping elements' pressures is sensed by depression transducers TP1, TP2…which, through the adder S1, send a signal to regulator R1, who is in command of Actuators AC1, AC2 etc.
The mode of control and maneuver for the filter ring is as follows: if the pressure drop in the filter increases, it is noticed by the differential pressure transducer TPD, that triggers a warning system AU; handling the filter elements is done through a semiautomatic control system of platform herd rotation, with a manual control motorcycle gear, which at a manual command performs an angular race equivalent to the moving of a filter element towards the external access channel.
The two ducts are located in the ground, the emissions reception device is as much as possible in the vehicle exhaust pipes area, and the transport emissions device is located perpendicular to the road axis. Under polluted air channel is the channel that directs rainwater from the street-to-street sewer.

3. Experimental results

In order to evaluate the efficiency of the installation functional tests were performed. The installation was introduced in a hall with a volume of air of about 1000 m^3 – see figure nr. 6. In this case there will be neglected the influence of horizontal air current but correction coefficient could be introduced. The objective of the tests was to calculate the optimum size of the active coal filter as function of pollution concentration gases, materials used and centrifugal fan flow rate. One used an absorbent circular column (inside diameter of D= 500 mm and height H = 1 m) and the velocity of the gas throughout the filtering cylinder with steady layer was 0.5 m/s. The circulation of the toxic air was from bottom to the top and the fan intake covered basic needs: $Q_{min} = 400\ m^3/h$, $H_{min} = 17{,}6\ mm$.

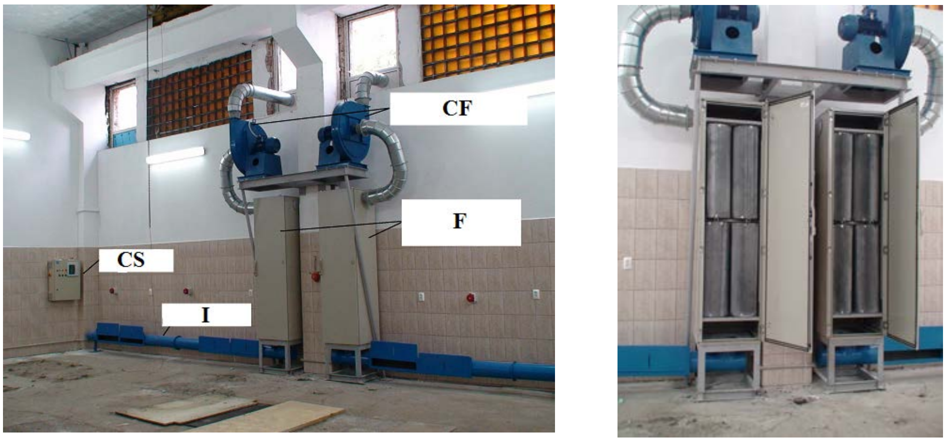

Fig.6 The tested installation

The functional model of depolluting filter with active coal AD 3 – ROMCARBON Buzau – had good performances for the following toxic gases: NO, NO_2, COV (9 volatile organic compounds). For CO the filter was equiped with activate hopcalite. In figure nr. 7 one presents results of filtering process for NO_2 and COV [11].

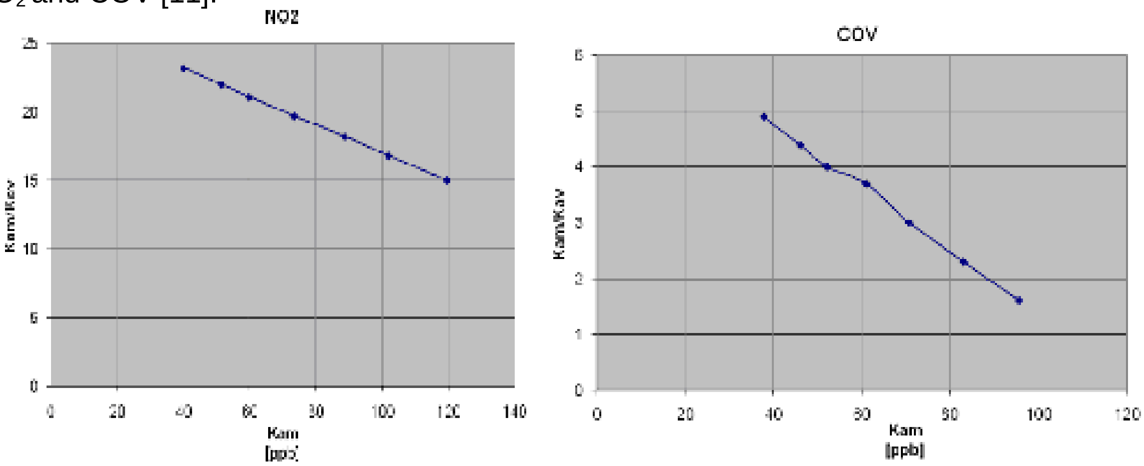

Fig. 7 Filter efficiency

(K_{am} - the concentration of toxic gases before the depolluting filter; K_{av} - the concentration of toxic gases after the depolluting filter)

Semnificant concentration decrease of the polluting gases was recorded – 10 to 15 times for NO_x and 2 to 5 times for COV. In order to simulate the real situation an used automobile was placed inside the hall. Automatization of the system was tested for various concentration of the polluting gases obtained including and start/stop comand at minium level of the accepted concentrations.

Testing the installation as a "hall application" one can consider that all the functional parameteres are efficient also in a "road intersection application" since high air volume and real automobile was consedered. Also, the intake pipe ot the instalation is aprox. 10 m similar to a bus length.

Conclusions

A "hall" application was tested in order to assess the efficiency of an instalation designed in order to decrease the level of pollution in urban areas. The installation is consisting in two active coal circular filters connected at two centrifugal fans. Automation was used in order to meassure in real time the values of polluting gases and to regulate the performances of the ansamble. The tests performed for various concentrations of the pollution gases and for relevant air flow rates throughout the installation had relevant results concerning the reducing level of polluting air and the velocity of the process. The results allows the conclusion that the installation could be used in a "cross road application" in certain conditions such the location proposed in the paper: Bv. N. Balcescu – Bv. Carol I.

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