

CONDITIONS IN EXHAUST PIPE IN CI ENGINE IN LIGHT OF MONITORING OF CATALYTICAL CONVERTER

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Abstract

The paper presents main method of monitoring catalytically converter in CI engines. In this paper presents modified test bed witch used to testes of exhaust pipe in light of determination possibility of application measurement probe to determine of NO_x concentration. Those investigation could help to evaluate of possibility catalytically converter monitoring within the framework on board diagnostic systems

The OBD system is an integral part of the vehicle connected with the engine control system. Nowadays the investigation on the on board diagnostic systems in their different applications are one of the basic problems that the OBD method is concerned with. The implementation of the investigation method for the OBD system efficiency is one of the main questions of the matter in hand. Diagram of modification exhaust pipe with installed catalytically converter in test bed and present of measurement points, distribution of temperature in measurement point T0-T8 exhaust pipe of testing engine without catalytically converter during realization ESC test, distribution of temperature in measurement point T0-T8 exhaust pipe of testing engine with 200 cpsi catalytically converter during realization ESC test, distribution of pressure in measurement point p0-p8 exhaust pipe of testing engine without catalytically converter during realization ESC test, distribution of temperature in measurement point p0-p8 exhaust pipe of testing engine with 200 cpsi catalytically converter during realization ESC test are presented in the paper.

Keywords: *catalytic converter, emission, monitor, pressure, sensor, temperature*

1. Introduction

The OBD system (*On Board Diagnostic* system; known in the United States as the OBD II system and in Europe as the EOBD one) is a set of diagnostic tests and calculation and decisive procedures which are performed in a real time and are intended as a measure for evaluation of the emission efficiency and the efficiency of elements responsible for the passive and active safety of a vehicle. The OBD system is an integral part of the vehicle connected with the engine control system. Nowadays the investigation on the on board diagnostic systems in their different applications are one of the basic problems that the OBD method is concerned with. The implementation of the investigation method for the OBD system efficiency is one of the main questions of the matter in hand.

In order to satisfy such postulates the realization of the implemented diagnostic procedures during the real operation of vehicles and in the possible shortest time is necessary. Thus the evaluation of the operating efficiency OBDE (*On Board Diagnostic Efficiency*) of the OBD system is also necessary.

2. Tested station

The engine research work presented in this paper was carried out in the laboratory of the Institute of Combustion Engines and Transport at Poznan University of Technology. For the research needs an exhaust system of the tested engine was adequately adapted. The engine test

stand consisted of the following elements [4]:

- 4CT90 compression-ignition engine manufactured by WSW Andoria,
- AMX-210/100 eddy-current brake with water cooling,
- reducing catalytic converter (*catalyst*) equipped with carriers of 200 cpsi density,
- HORIBA MEXA 7100 exhausts emission analyzer,
- temperature sensors,
- pressure meter.

For determining the efficiency of the applied catalyst, and NO_x probe as well, on the adapted test stand under the engine test bench conditions (Fig. 1), some preliminary tests were carried out according to the obligatory ESC (*European Stationary Cycle*) test.

A special catalytic converter equipped with carriers of 200 cpsi density was built for the test needs. It consists of five blocks with dimensions of 125×50 mm. The catalyst casing enables performing the tests for a variable number of catalytic blocks and taking the measurements behind each block.

A chemical composition of the catalytic converters was developed (*selected*) in the Institute of Internal Combustion Engines at Poznan University of Technology in cooperation with the Department of Inorganic Chemistry at AGH University of Science and Technology in Krakow. The catalytic layers were produced by means of the USPD (*Ultra Spray Pyrolysis Deposition*) and sol-gel methods for CeO₂-ZrO₂/PtPd and CeO₂-ZrO₂/PtRu components [5].

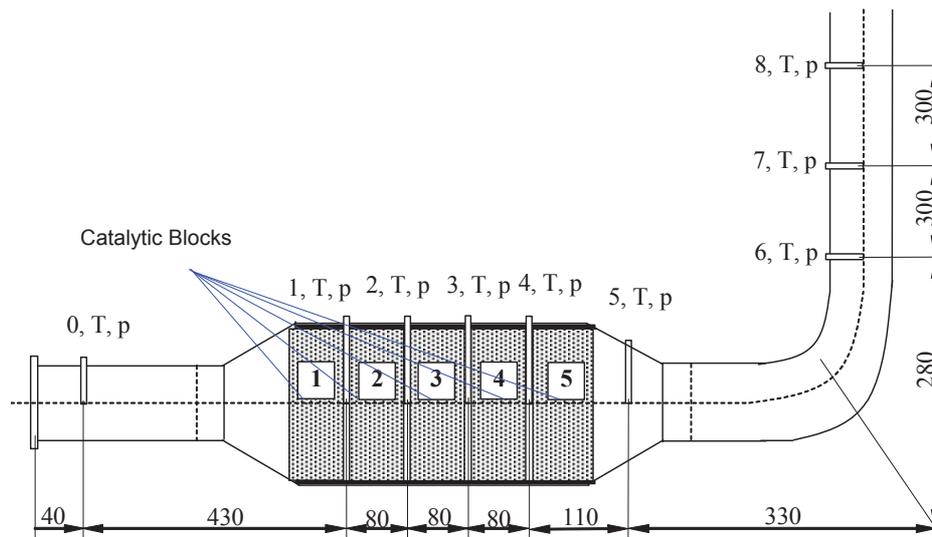


Fig. 1. Diagram of modification exhaust pipe with installed catalytically converter in test bed and present of measurement points [5]; 0-8 – measurement points: (T) – temperature, (p) – pressure

3. Analyses of temperature dissolution in exhaust pipe

The temperature is a basic parameter affecting the ability of generating voltage signals by the sensors produced in the „sensor to sensor” technology. Owing to the design of sensors and the constructional materials used for the execution of electrodes in the individual areas, as shown in papers [3-5], it was necessary to provide an additional reheating to reach the temperatures which enable starting the oxygen pumps. Taking into consideration the operating parameters of the engine examined on the engine test bed the exhaust gas temperatures during the realization of the ESC test could reach the range in which generating the diagnostic signals by the sensors was possible. Overheating the measuring probe of a sensor caused by too high temperatures of exhaust gas while supplying, a system of heaters with an external voltage can result in a degradation of electrodes. Therefore the developed laboratory system requires a manual selection of the voltage

for supplying a sensor in a way eliminating a risk of exceeding the threshold voltage value for given engine operating conditions. To complete the gathered knowledge on the possibilities of delivering the supply voltage depending on the temperature in the exhaust engine system an analysis of the temperature distribution was carried out in the measuring points of the exhaust system, provided for the NO_x sensors (Fig. 2 and 3) [3].

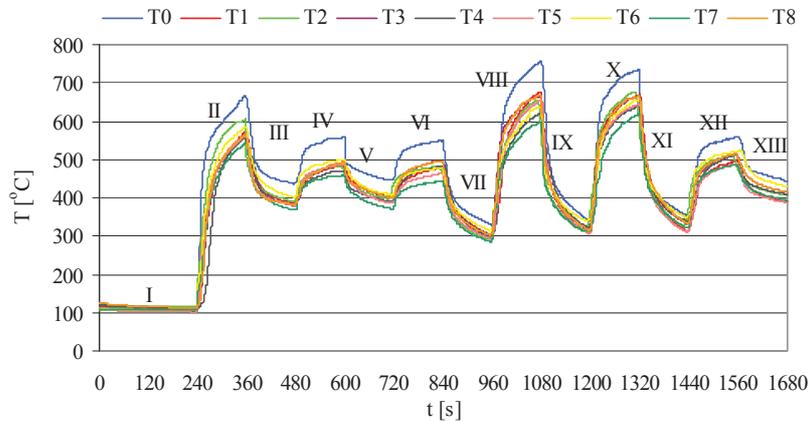


Fig. 2. Distribution of temperature in measurement point T0-T8 exhaust pipe of testing engine without catalytically converter during realization ESC test [3]

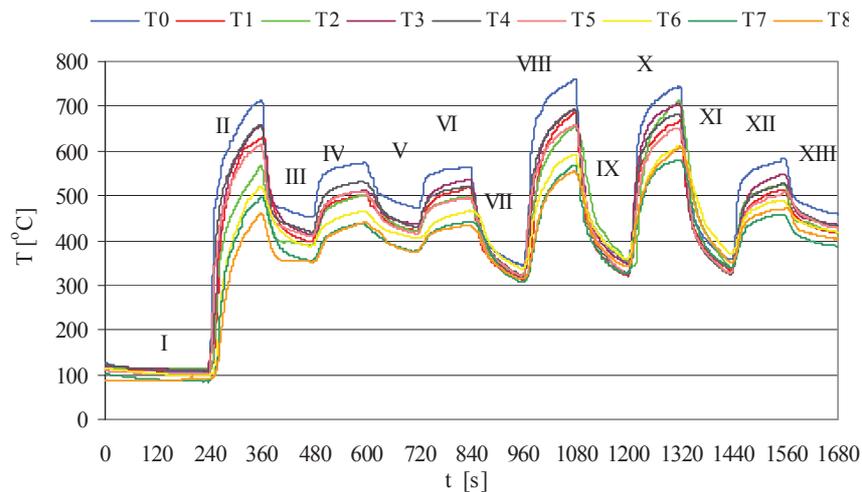


Fig. 3. Distribution of temperature in measurement point T0-T8 exhaust pipe of testing engine with 200 cpsi catalytically converter during realization ESC test [3]

The performed analysis indicates that with regard to the exhaust gas temperatures the phases II, VIII and X are most critical. It concerns both temperatures measured without and with the catalyst provided. In case of phase II the highest temperature of 710°C was reached at the T0 point of the exhaust system equipped with a catalyst with a carrier of 200 cpsi density.

In case of phases VIII and X the exhaust gas temperatures were reaching the values ranging from 737°C to 759°C. These are temperatures at which the sensors, owing to their design and constructional materials for electrodes, are able to generate voltage signals without necessity of reheating. For all other test phases the highest temperatures were reached at the T0 point and the recorded temperatures were not exceeding the value of 600°C.

This analysis indicates that in case of phases VIII and X, during a realization of the engine test bed examinations, the applied sensors will be most sensitive to the controlled supply voltage value. The obtained temperature distribution suggests that for these phases the sensor reactions should be fastest as the optimum sensor temperatures can be reached without necessity of reheating.

However, the above applies to the sensor installed at T0.

4. Analyses of pressure dissolution in exhaust pipe

The rate of chemical reactions is a function of the reactive exhaust gas components, exhaust gas temperature, type of the applied catalyst and pressure. For reactions proceeding in a gaseous phase the concentrations and pressures are interdependent. However, the pressure can independently affect the reaction rate values, thereby the response times of the sensor in the considered system. In order to find the importance of these variables the experiments should be carry out in a way which makes possible a simultaneous change of the smallest number of parameters. It is impossible to perform such experiments in case of examination being realized under the engine test bed conditions. For this reason the importance of pressure is limited to its effect on the sensor response time with regard to the exchange of exhaust gas present in the sensor's probe.

The pressure in the exhaust system affects the intensity of the gas exchange in a sensor by affecting the pressure present in a measuring probe, as shown in papers [3-5]. When an increase in pressure in a measuring area is faster the speed of the gas exchange in the individual regions of the NO_x increases and thereby a frequency of the voltage signals should be greater.

With reference to the classic catalyst the engine exhaust system pressure results in a number of the molecules adsorbed within a catalytic layer. Regarding it to the sensor conditions a number of the collisions of oxygen molecules with the electrode *Pt* should be also higher what can directly result in the sensor response time value.

In the phase I of the test, in which the engine was operating at idling speed, the average overpressure in the exhaust system without the catalyst was of $0.03 \cdot 10^{-4}$ Pa (Fig. 4). In case of the exhaust system equipped with the catalysts with the 200 cpsi carriers such same overpressure values of $0.03 \cdot 10^{-4}$ Pa were recorded. From the considered research point of view such values do not allow to get information necessary for the realisation of the next assumed examination.

Analysing a distribution of pressure in the exhaust system without the catalyst it can be found that for all phases of the test the pressure differences between the p0-p5 points are small (Fig. 4). In points p6-p8 which are distant from the point p5 by 60 cm the pressure values are also similar. In every phase, depending on the overpressure values, the measuring points can be separated into two groups of p0-p5 and p6-p8 points. In points p6-p8 the overpressure values in every phase are smaller what results from their greater distance from the exhaust collector. The differences in the overpressure values measured in the measuring points of the individual groups can be explained by the pressure fluctuation in the engine exhaust system and an indication error of the applied pressure measuring sensors (Fig. 5).

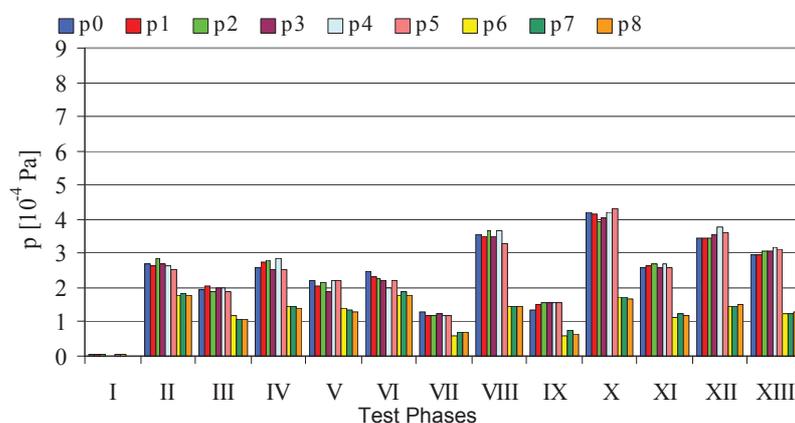


Fig. 4. Distribution of pressure in measurement point p0-p8 exhaust pipe of testing engine without catalytically

converter during realization ESC test [3]

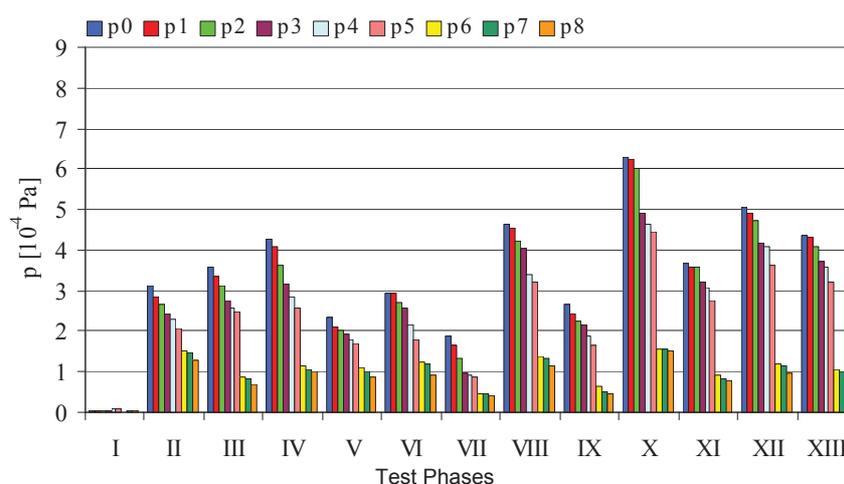


Fig. 5. Distribution of temperature in measurement point p0-p8 exhaust pipe of testing engine with 200 cpsi catalytically converter during realization ESC test [3]

As the distance from the exhaust collector increases the pressure value decreases. In case of measuring points before (p0), in (p1-p4) and just after the catalyts (p5), the differences in the overpressure values are caused by the exhaust gas flow resistance in the individual catalytic blocks. For every test phase in points distant from the catalyst (p6-p8) the pressure values are much lower and continue their falling tendency depending on the distance in relation to the exhaust collector.

In case of the catalyst the highest overpressure values were recorded for the phase X at the point p0 and they were of $6.3 \cdot 10^{-4}$ Pa for the catalyst equipped with the 200 cpsi carrier.

5. Conclusions

On the basis of the performed examinations and obtained test results the following conclusions can be drawn:

1. The analysis of the NO_x concentrations in exhaust gas from the compression-ignition engine can be based on the indications of the voltage probes with the modified electrodes of the oxygen pump,
2. The application of the reduction conditions in the voltage probes using the nitrogen oxides reduction by the electro-catalytic way depends on the exhaust gas parameters, the values of which change depending on the rotational crankshaft speed and engine load. For this reason obtaining the diagnostic signal for the whole engine operation range is impossible. The control of the correctness of the catalyst operation regarding the nitrogen oxides reduction can be realised for the defined operating parameters of the tested engine,
3. For phases VIII and X of the ESC test the reheating the test probe installed before the catalyst was unnecessary owing to the high exhaust gas temperature (737-759°C).

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