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LEGAL AND TECHNICAL LIMITATIONS OF THE IMPACT OF TOXIC COMPONENTS OF MOTOR VEHICLE EXHAUST GASES ON THE ENVIRONMENT

The article describes the impact of toxic components of exhaust gases on the environmental pollution and the resulting problems that have a direct impact on human health. It presents the legal regulations in force in the European Union which oblige vehicle manufacturers not to exceed the limit values for emissions of toxic exhaust components. It shows the influence of the motor vehicle speed on the level of emissions and it presents selected technical systems which are used in motor vehicles and have a direct impact on reducing emissions.

Keywords: emissions, combustion engines

1. THE POLLUTION EMITTED BY ROAD TRANSPORT

The pollution resulting from transport in large urban areas accounts for 75-80% of total contamination. Unfavourable phenomena, especially in the urbanenvironment, are getting worse along with the reduction of the role ofpublic transport and with a steady increase in the number of cars in use [Merkisz, Piekarski, Słowik 2005]. The transport in Europe is responsible for harmful levels of air pollution and one quarter of greenhouse gas emissions in the European Union. According to a recent report from the European Environment Agency (EEA), many of the resulting environmental problems can be solved by stepping up efforts to implement the new European Union's objectives. Although air pollution has decreased in the last two decades, it remains a serious problem in many fields. "European standards" for

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Fig. 1. Air pollution in urban areas [2]

vehicles have not resulted in the reduction of NO_2 emissions to the levels specified in the law although they have generally contributed to a significant improvement in air quality [European Envinomment Agency 2016].

2. EMISSIONS IN EU COUNTRIES

The people living in the vicinity of the roads characterized by a high degree of traffic intensity are particularly exposed to excessive levels of pollution in the air. In 2010, the NO_2 levels exceeding the limit guaranteed by law were registered in 44% of roadside air monitoring stations. The concentration of PM10 dust suspension in these areas exceeded limits at the level of 33%. These pollutants havea direct effect on the cardiovascular system, lungs, liver, spleen and blood [European Environment Agency 2016].

Atmospheric emissions of particulate matter PM also affect the environment negatively. The spread of PM in various areas has a significant impact, both direct and indirect, on the development of regional and global climate [Merkisz i Pielecha 2014]. Nearly one-third of the population in European cities are exposed to the concentrations of particulate matter (PM) in the air that are too high. Particulates involve the greatest danger in terms of hazard to human health because they penetrate into the sensitive parts of the respiratory system. In recent decades, the EU has made progress in reducing air pollutants that cause acidification, but a new report published recently by the European Environment Agency (EEA) shows that in many parts of Europe there are persistent problems with concentrations of particulate matter in outdoor air and of ozone in the ground layer of the atmosphere [European Environment Agency 2016]. Carbon monoxide, benzene and heavy metals

(arsenic, cadmium, nickel, lead) – their concentrations in the outdoor air in the EU are generally low, local and sporadic, and rare are the cases where the target and limit values set out in the EU legislation are exceeded [European Environment Agency 2016].

3. THE IMPACT OF PERFORMANCE PARAMETERS ON THE EMISSIONS

There have been road tests carried out on passenger cars in real traffic conditions, and they showed a significant effect of the speed achieved on the emissions of gaseous substances in the exhaust. It has been shown that these compounds have significantly lower road emissions when traveling at 70 km/h (as opposed to 90 km/h) and that there is a significant increase in the emissions in a car moving at 100 km/h [Merkisz et al. 2014].

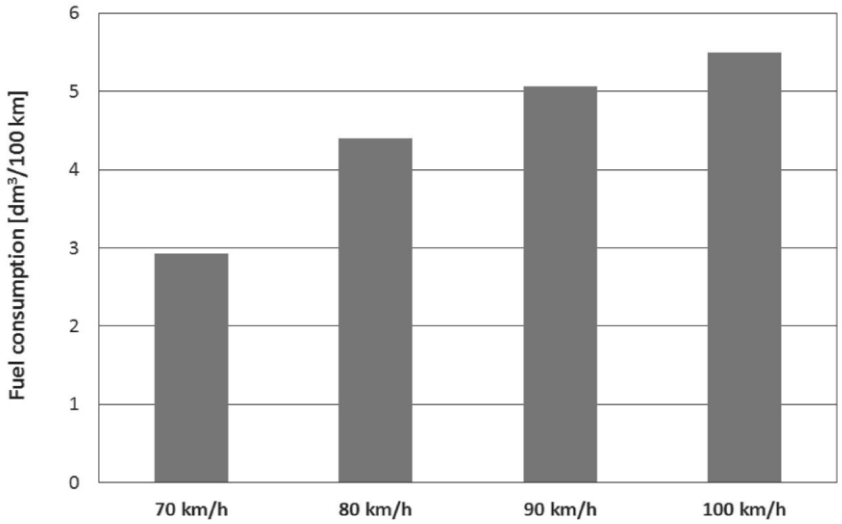

Fig. 2. Fuel consumption to speed [3]

The diagram in Figure 1.3 indicates that the most noticeable for driving at a speed V = 70 km/h are the reduction of CO_2 in the exhaust gas (decrease in emissions by more than 40%) and the reduction of NO_X emissions – a reduction by almost 60%. But for v = 100 km/h the increase in the emissions of hydrocarbons is clearly visible. As already mentioned, the increase in hydrocarbon emissions is then approximately 40% [Merkisz et al. 2014].

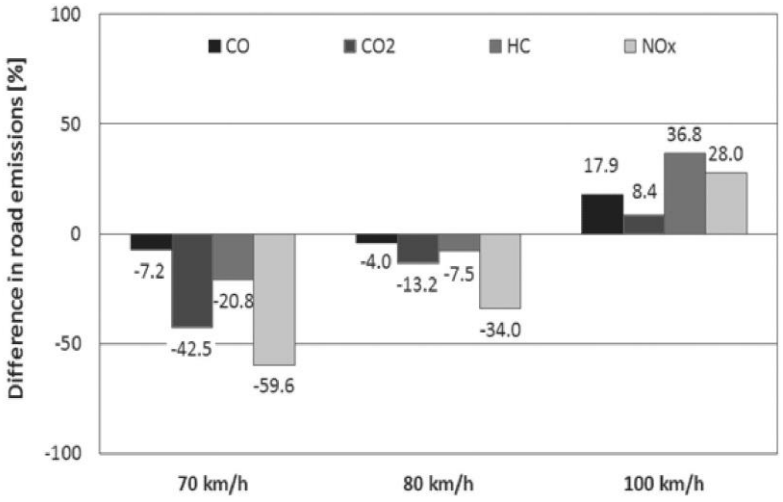

Fig. 3. Difference in emissions in a relation to the variable speed of vehicles [3]

4. REGULATIONS RELATED TO PUTTING LIMITS ON EMISSION

Emission standards appeared in the 1990s. They were introduced to reduce the amount of nitrogen oxides (NO_X), hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM) emitted into the atmosphere. Euro 6 came into force on 1 September 2014 for new cars, and on 1 September 2015 for the registration and sale of new types of vehicles. In total, since 1990 particulate emissions in vehicles with diesel engines have been limited to 99%. A modern compression-ignition CI vehicle emits today almost 98% less nitrogen oxide compared to cars from the early 1990s [Moto.pl/ 2016]. Exhaust emission limit values in particular standards are presented in the table (1, 2).

Exhaust gas emission limit values in particular Euro standards for vehicles with petrol engines [Wikipedia.pl 2016].

Table 1

The emission limit values in particular Euro standards for SI engines

Emmission [g/km]	**Euro 1**	**Euro 2**	**Euro 3**	**Euro 4**	**Euro 5**	**Euro 6**
CO	2,72	2,2	2,3	1	1	1
HC	–	–	0,2	0,1	0,1	0,1
NO_x	–	–	0,15	0,08	0,06	0,06
$HC+NO_x$	0,97	0,5	–	–	–	–
PM	–	–	–	–	0,005*	0,005*

Table 2

The emission limit values in particular Euro standards for CI engines

Emmission [g/km]	**Euro 1**	**Euro 2**	**Euro 3**	**Euro 4**	**Euro 5**	**Euro 6**
CO	3,16	1	0,64	0,5	0,5	0,5
HC	–	0,15	0,06	0,05	0,05	0,05
NO_x	–	0,55	0,5	0,25	0,18	0,08
$HC+NO_x$	1,13	0,7	0,56	0,3	0,23	0,17
PM	0,14	0,08	0,05	0,009	0,005	0,005

5. THE EFFECT OF APPLYING TREATMENT SYSTEMS ON REDUCING EMISSIONS

During the combustion of different types of fuel, exhaust gases are produced and they contain harmful ingredients. The task of reducing harmful ingredients is taken by the catalytic converter. The emission limits for harmful pollutants are defined in the Euro standards [Wikipedia.pl 2016].

Compliance with increasingly stringent emission standards for emissions of toxic components in exhaust gases requires not only improving combustion processes, but also further purifying the exhaust gas becomes necessary Idzior [2012]. Modern car engines emit a large amount of pollutants. Due to the limited possibilities of reducing the emissions during engine operation, it is necessary to use exhaust treatment systems outside of the engine, composed of many elements, such as DPF (Diesel Particulate Filter) Fig 4. The particulate filter is mounted in the exhaust gas systems in vehicles with engines performing combustion-ignition cycle. It purifies

the particulate matter in the exhaust. There is also an oxidation reactor (oxicat) reducing emissions of CO and HC. It is composed of a spatial structure of high total surface area of porous walls or fibres made of metal, ceramic materials, in which sooth particles settle. In new constructions, it is necessary to mount additional components that significantly improve the emission balance. The type and number of the elements very often depend on the design of the combustion engine. Some research is being conducted into reactors with materials enabling direct oxidation of particulate matter (PM). In the reactors currently in use (Fig. 4), the materials applied (ionic conductors) conduct O_2 (Cr, Zr, Mn) in order to combust soot in the direct contact between the conductor and the soot, instead of O_2 in the gas phase [Moto.pl 2016].

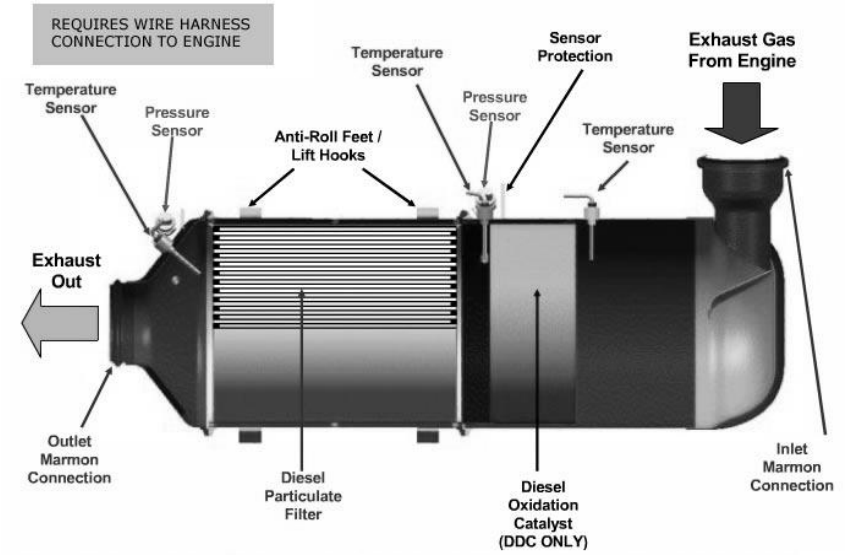

Fig. 4. The diagram of a purification system of exhaust gases from CI engines [11]

To prevent the particulate filter from getting dirty or completely blocked, which results in reducing its efficiency, it must be regularly regenerated by the process of burning the soot which has accumulated within the filter. We can distinguish between several types of regeneration. The basic one is passive regeneration: soot particles are burned continuously without the intervention of the ECU. This is achieved at standard, high speed (approx. 3,000 revs/min). The exhaust gas temperature reaches about 660 °C – 930 °C.

The active regeneration is used mainly in case of driving conditions typical of urban areas, the temperature does not usually reach a sufficient level to obtain passive regeneration. Therefore, the soot particles are not eliminated, and so to avoid their accumulation within the filter, after reaching the level restricting the free flow of exhaust gas (18 g), the engine computer will force active regeneration.

The basic device which is installed in vehicles with spark ignitionSI and contributing to the reduction of gaseous exhaust emissions is TWC (Three Way Catalyst) – the three-way catalytic converter shown in Fig 5. It reduces the NO_X content and simultaneously oxidizes CO and CH. It is a part of the exhaust gas system in all modern cars, trucks, buses, and it plays the role of a system for reducing the amount of harmful gaseous components in the exhaust. The principle of operation for the converter is mainly based on the reaction of substances in the exhaust gases with the catalyst contained in the ceramic or metal carrier – depending on the type of construction of the exhaust system [Moto.pl 2016].

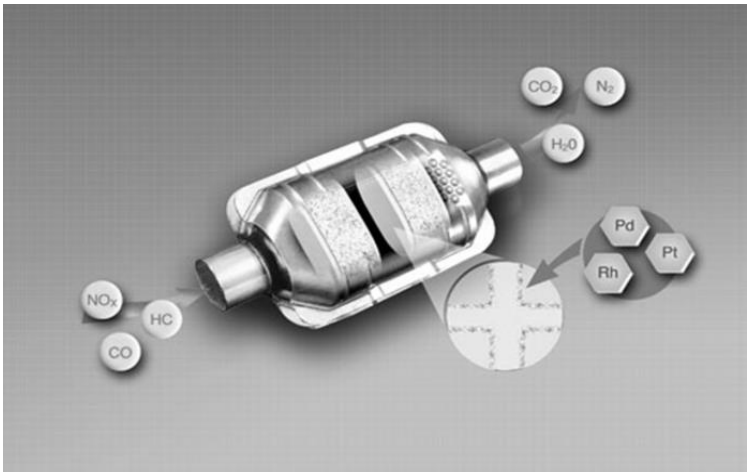

Fig. 5. The view of a three-way catalytic converter [10]

The converter reaches the optimum operating conditions by setting the ignition on the basis of the data obtained from the lambda probe. Only by maintaining a proper ratio of fuel and air can the catalytic converter carry out oxidation and reduction reactions. Inside the converter there are noble metals – platinum, rhodium and palladium. When it comes to the reaction of harmful substances like carbon monoxide, hydrocarbons, or nitrogen oxides there will arise the following compounds:from carbon monoxide and hydrocarbons – water and carbon dioxide (oxidation), from nitrogen oxides – nitrogen, oxygen, and carbon dioxide (reduction) [NGK 2016].

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OGRANICZENIA PRAWNE I TECHNICZNE WPŁYWU TOKSYCZNYCH SKŁADNIKÓW GAZÓW WYLOTOWYCH Z POJAZDÓW SAMOCHODOWYCH NA ŚRODOWISKO

Streszczenie

W artykule został przedstawiony ogólny problem wpływu toksycznych składników spalin z pojazdów silnikowych na środowisko naturalne i zdrowie człowieka w Europie. Wykazano, że prędkość jazdy samochodem ma duży wpływ na zużycie paliwa i na poziom emisji toksycznych składników gazów wylotowych . Przedstawiono rozwiązania techniczne mające na celu ograniczanie emisji szkodliwych składników spalin. Przedstawiono aktualnie obowiązujące dotyczące nowych pojazdów w Unii Europejskiej normy Euro dotyczce ograniczenia poziomu emisji szkodliwych substancji znajdujących się w spalinach.Ponadto zademonstrowano rozwiązania techniczne wpływające na ograniczenie emisji szkodliwych substancji spalin.

Słowa kluczowe: emisja, silnik spalinowy