AUTOMOBILE COMPRESSION IGNITION ENGINES POLLUTION

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Abstract: *The dynamic intensity in growth of the number of motor vehicles, and with that the high quantity of exhaust emissions, significantly contributes the air contamination and other serious problems with his quality, especially in urban places. Today, the total number of vehicles globally exceeds 800 million; from witch 300 million are loading freight vehicles. These numbers are disturbing, and the concern is that the constant growth of these vehicles and the consumption of the fossil fuels will continue to raise the negative effects on the environment through the air contamination and to cause serious health problems. In this document is given the analyses for the quality of exhaust emission of diesel engines, identification of the factors which have dominant affect, actual situation about pollution from diesel engines and conclusions about future use of diesel engines vehicles, especially in the countries which are not member of EU.*

Keywords: EXHAUST EMISSION, COMPRESSION IGNITION ENGINES, TOXICALLY COMPONENTS

1. Introduction

According the fact that needs for transportation are increasing, International Community (Agencies) have had effort for ecology protection, for decreasing bad impact of environment from transportation. For obtaining results which are lower than valid Euro standards, investigations for exploring all relevant factors which have had influence on the quality of exhaust emissions, like: Quality of the fuel; Quality of the lubricants; Constructive parameters of diesel engine which have had direct or indirect influence of exhaust emission quality; Regime of the vehicle exploitation; Influence of the systems which regulate fuel-air mixture and ignition process; The influence of elements and devices reliability on the engine exploitation.

With detail analysis of all factors, we can conclude that some factors have had an influence in the time of engine construction, but others are appearing and influent on the exhaust emission in the time of engine exploitation.

Old generation of Diesel engines are characteristic with smoking of exhaust gases. Besides that exhaust emissions are having more PM, which are high percent cancer-causing particles consisted.

1.1 Products of combustion of compression ignition engines

- Not combustion carbon hydrogen (CH)

In the process of combustion, carbon hydrogen are forming in the region of not burning nucleus of a jet, the fuel on the walls and post splashing part of the fuel. Molecules of CH mechanism of forming and oxidation depending of work parameters of combustion engines.

- Coefficient of surplus air - λ

Increase the ratio fuel - air has depending from the oxidation reactions on different ways. It results in long periods of splashing besides that periods and quantities staying constant, more fuel is splashing later in the cycle.

Increasing the ratio fuel - air also causes lower concentration of oxygen. Higher temperature is attaching a bit because it's burnt more fuel.

On lower loading and an empty course, we've predicted that the fuel is not arrived to the walls and that it's concentration in the nucleus is low. On this conditions not burning CH are generally from the area of not burning.

The ratio of not burning CH according to splashing fuel is the highest on an empty course, and this ratio decrease with the increasing the ratio fuel-air.

- filling up

Increasing of pressure and temperature in the cycle is filling up causing. With the same concentration of O_2 this increase is increasing the quantity of oxidation reactions and we have lower CH in the combustion products. Higher temperatures of the products of the combustion also cause longer oxidation in the exhaust branch.

- Angle of before splashing

Increasing the angle of splashing follow longer period of hiding combustion which condition creating higher quantities of vapor and lower drop will be transported with air - storm and it's broadness the area of not burning.

- storming

With increasing the storm its better the process of mixing and oxidation of CH. Exaggeration storm can negative depending producing more quantity of CH in the products of combustion, because of broadness the area of not burning.

- Carbon monoxide CO

In time of early stadiums of combustion CO is forming on the limit between the area of un-burning and before on time burning. Because the local temperatures are not enough high so it becomes low reactions of oxidation. In time of process of combustion, temperatures increase and improve this reaction.

On low loading ratio fuel - air is high because of low temperatures of gas and low oxidation reactions. With increasing the loading or with ratio fuel - air, it is decreasing emission of carbon monoxide because of higher temperature.

- Smoking

Depending of work conditions it is different kinds of smoking:

Liquid components like a white cloud of vapor on cold starting, an empty course and low loading are generally consisting from fuel and small quantity of oil for lubrication which is not burning;

Black smoke is a product of uncompleted combustion by maximum loading, remaining products, including oil for lubrication and additives of the oil. Black smoke is consisting from bigger fine parts of carbon hydrogen's. They are forming in present or absent of oxygen.

Components in the smoke also are forming from a deposit on the walls with same mechanism like in the nucleus of the jet on high loading. These components of carbon can be oxidized later in the flame formed on time of the process of combustion. Intensity of the oxidizing reactions depends from the present of oxygen near the surface of particles of ashes and from a temperature.

Parameters which depending from the intensity of smoking is:

Fuel: Investigations are showing that higher "Ceten" - number which are used for speed course transport compression ignition engines have pretended to more smoking. This can be explained with low level stability of these fuels.

Angle of earlier splashing: Earlier splashing besides rest unchangeable parameters and later splashing have decreasing smoking.

Holes on jet-makers: Dimensions of holes and ratio of their lengths have influence on smoking. Bigger diameters are slightly atomizing the fuel and smoke is bigger. Increasing the ratio l/d over the limit also has some influence.

Temperature of the air in the cylinder: Higher temperature of the air is giving higher temperature in the time of combustion and emptying which go to increase the intensity of smoking.

- Nitrogen oxide

Nitrogen oxide is forming in time of combustion on all parts of a yet. Reactions are:

$$O_2 \Leftrightarrow 2O \qquad (1)$$
$$O + N_2 \Leftrightarrow NO + O$$
$$N + O_2 \Leftrightarrow NO + O$$

NO_x is forming in the flame in bigger quantities with richer mixtures from stoichiometry, but final concentration is the biggest on little poor mixture. On concentration of NO_x have depending ratio fuel - air (Fig. 1).

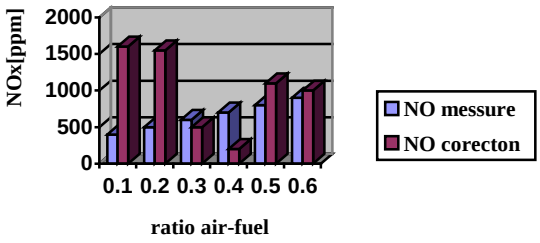

Fig. 1 *NO_x concentration from the ratio of fuel-air dependence for mono-cylinder with direct splashing.*

Quality of the fuel, lower "Ceten" - number, angle of before splashing (bigger angle of before splashing cause higher concentration of NO_x) and filling ups cause higher concentration of NO_x.

2. Emission standards[1]

Emission standards are the legal requirements governing air pollutants released into the atmosphere. Emission standards set quantitative limits on the permissible amount of specific air pollutants that may be released from specific sources over specific timeframes. They are generally designed to achieve air quality standards and to protect human health.

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU and EEA member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

According to these standards, values are depending from these division: passenger cars (Category M*); light commercial vehicle ≤1305 kg reference mass (Category N_1-I); light commercial vehicles 1305–1760 kg reference mass (Category N_1-II); light commercial vehicles >1760 kg reference mass max 3500 kg (Category N_1-III & N_2); Emissions for trucks and buses (for HD Diesel Engines, g/kWh; Emissions for large goods vehicle (for category N3);

2.1 European emission standards for passenger cars (Category M)[1]*

These standards are dividing depending type of vehicles; they are different for various types or categories. Polutant are from exhaust emission diesel cars which have to be measured given below.

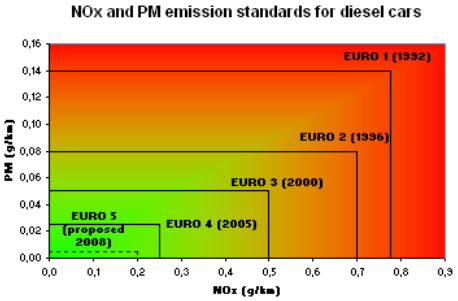

Fig. 2 *Emission standards for NO_x and PM of diesel cars.*

Table 1: *European emission standards for passenger cars (Category M*), g/km.*

Tier	Date	CO	THC	NMHC	NO_x	HC+NO_x	PM
Diesel							
Euro 1	July. 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	0.14 (0.18)
Euro 2	Jan. 1996	1.0	-	-	-	0.7	0.08
Euro 3	Jan. 2000	0.64	-	-	0.50	0.56	0.05
Euro 4	Jan. 2005	0.50	-	-	0.25	0.30	0.025
Euro 5a	Sept. 2009	0.50	-	-	0.180	0.230	0.005
Euro 5b	Sept. 2011	0.50	-	-	0.180	0.230	0.005
Euro 6	Sept. 2014	0.50	-	-	0.080	0.170	0.005

3. Pollution from the diesel engines, actual situation in the Republic of Macedonia

Today, compression ignition engines are 95% of Commercial vehicles powered. Besides that, they are used for off-road equipment from construction, agricultural, warehouse and mining equipment, locomotive and marine engines and mobile and stationary generators.

Diesel has long been known for delivering power and performance along with fuel efficiency. At the United States of America is Diesel Forum web site formed for data contribution all over the world.

New developing technology of compression ignition engines must follow new European standards, which are very restricting with past compared. Significant developing is for new standards satisfying evidenced on 2014 year, but on 2015 year reduction of emissions from exhaust vehicles emission is from 88% to 96% decreasing on new "clean" technologies, and the reductions are about PM particulars and NO_x gases[6] (Fig 3 and Fig 4).

***Table 2**: NOx and PM review reduction in the period of 1988-2015 year.*

Year	NOx in grams per brake horsepower-hour [g/bHp-hr]	PM [g/bHp-hr]
1988	14,96	0,6
1991	5,64	0,25
1994	5,64	0,1
1997	5,64	0,1
2000	4,01	0,1
2003	4,01	0,1
2006	2,00	0,1
2009	2,00	0,09
2012	0,19	0,09
2015	0,15	0,09

A lot of studies all over the world are done about directions and opportunities to change diesel engines with new technology – diesel engines. So, when asked during the Congressional hearings on the VW situation about its random vehicle audit of all light-duty diesels, Chris Gundler, U.S. EPA Director of the Office of Transportation & Air Quality, replied: "I don't have concerns with diesel technology in general. I don't expect to find widespread problems but we are going to be taking a very close look."

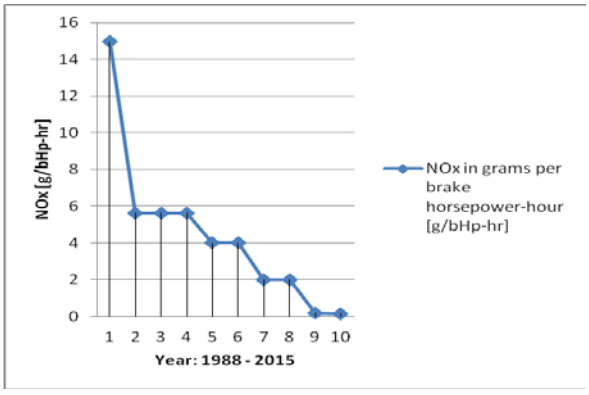

***Fig.3** NO_x reduction of emissions in the period 1988-2015 year.*

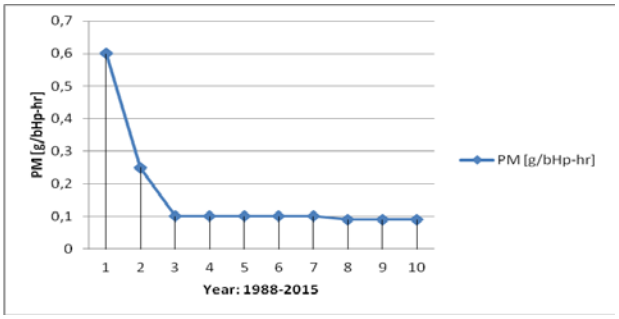

***Fig.4** A PM emission reduction in the period 1988-2015 year.*

In the European Union countries European emission standards are implementing, but in the European not member countries, like in Macedonia, today is very hard for emission standards implementation.

Besides with changing the Low for environment protection including additive taxes, upon year of vehicle produced, active engine volume and kind of vehicles using fuel, used M1 categories vehicles with Euro 2 standard (not produced before 1996 year) started to be imported from 5th of July 2010 year until 31 of December 2014 year. Today, the number of imported used vehicles, where in the Technical Inspection Organizations were homologation made is around 52,000 (fifty-two thousand).

From the 1st of January 2015 year, in Republic of Macedonia were started to import used vehicles with minimum Euro 3 standard and produced not later than 2000 year.

According to the low regulative connecting motor vehicles, which are correspondence of Ministry of Economy, there are not any obligations for vehicles to be installed catalyst or other ecological systems for reduction the toxicant elements of exhaust emissions. Statistical analysis of Ministry of economy at 2010 year has shown that around 55,000 used vehicles are imported (for all categories), more than 35,000 at 2011 year, around 18,000 at 2012 and 2013 year, and more than 20,000 at 2014 year. These numbers are shown big ecological problem which have to be solved next years.

4. Factors which have had most influence of the exhaust emission quality

Producers of combustion engines have had different possibilities to assent exhaust emission with low regulations. Like the most new possibilities which are applying on the last constructions of engines with internal combustion for decrease the toxicant of the exhaust emission are:

Recirculation of the exhaust gases

On compression ignition engines recirculation is more effect on direct splashing and better working on low number of rotation. With cooling the products of combustion in the system of filling are received better results.

Level of compression - ε

With increasing the value of ε we have got: decreasing a period of hide combustion and emission of carbon hydrogen's; increasing: a temperature to the end of compression, a quantity of smoke, emission of NO_x and economic of fuel consumption. Because of high temperatures of gas oxidation of carbon hydrogen's - CH we have lower them in the exhaust emission. Situation with NO_x is worse; NO_x is forming by maximum loading but CH by low loading.

With changing a dynamic angle of splashing can be received very well results. Because of bigger smoking, limit of a smoke we can move to the bigger value of ε decreasing the power of engine. With increasing the value of ε it comes to increase a tension in engine.

Level of storming in engines with internal combustion

Level of storming in engines with internal combustion is caused air moving. Destination of storming is to be prepared need energy for mixing the fuel and air to be received more homogeny mixture what will result complete combustion. Storming can be ensured with adequate construction of combustion chamber or with adequate construction of filling up line branch or by using deflectors on the filling valve.

Angle of before splashing

Decreasing the value of the angle of before splashing can be acceptable depending on decreasing NO_x on engines with internal combustion with direct or undirected splashing. It is result of decreasing the period of hide combustion and maximum temperatures in the place of combustion.

On engines with internal combustion with direct splashing smoking is increasing with decreasing the period of before on time burning (because of the smaller mixing of the fuel and air). With increasing the level of air storming we have smaller sensitive of changing the angle of before splashing, what results optimization by rest of searching.

On engines with internal combustion with undirected splashing, storming is bigger when the piston is moving to the outside limit position where the mixing of the fuel and air is the biggest, than smoking is decreasing with decreasing the angle of before splashing. But if with this work is over limit, it will not be filling, what increase CH. It is obviously that searching for decreasing NO_x and CH are opposite so we have to find optimum.

Engines with internal combustion with direct splashing have more quantities of NO_x than engines with internal combustion with undirected splashing because of a small lose of heat which is beginning with the storming.

With increasing the number of rotating of engines with internal combustion, the time for burning is smaller. To have bigger angle of before splashing, in this situation is need, for not to become increasing the emission of CH. With decreasing the load decrease fuel quality and temperature in the combustion place and because of a dangerous for skipping the burning we must move splashing forward. This two searching must be satisfied by splashing fuel equipment to have less toxicant components in the exhaust emission.

Because of a Low, regulations for air pollution, besides intensively working for declining imperfections of engines with internal combustion in look of pollution the life surrounding. It is working on investigation and perfection to the other systems for power the vehicles, like: electric (with accumulator battery), gas turbine, steam engine, etc.

5. Conclusion

New generations of Diesel engines are cleaner than ever before, and in the next few years the diesel industry will virtually eliminate key emissions associated with on and off-road diesel equipment. This environmental progress is the result of the new clean diesel system - combining clean diesel fuel, advanced engines and effective exhaust-control technology.

Refiners are working to reduce the sulfur content in diesel fuel by 97 percent. Just as taking the lead out of gasoline in the 1970s enabled a new generation of emissions control technologies that have made gasoline vehicles over 95 percent cleaner, so will removing the sulfur from diesel help usher in a new generation of clean diesel technology. By October 2006, clean diesel refiners are committed to making ultra-low sulfur fuel (ULSD) available nationwide.

Diesel is the world's most efficient internal combustion engine. It provides more power and more fuel efficiency than alternatives such as gasoline, compressed natural gas or liquefied natural gas.

Advanced new technologies such as electronic controls, common rail fuel injection, variable injection timing, improved combustion chamber configuration and turbo charging have made diesel engines cleaner, quieter and more powerful than past vehicles.

With the introduction of lower sulfur diesel fuel, a number of exhaust treatment systems can further reduce emissions from diesel engines. Particulate Traps - collect particulate matter as the exhaust gases pass through and can reduce particulate emissions by 80-90 percent using a catalytic reaction or an auxiliary heating element. Catalytic Converters - use a chemical reaction to convert emissions into harmless substances. Some catalysts - such as selective catalytic reduction (SCR) devices and NOx absorbers - focus on nitrogen oxides and can reduce these emissions by 25-50 percent.

In nearly future, Macedonia and other countries from the Balkan must have one common Strategy for environmental protection from used motor vehicles. We have to be organized, not just formally, through our Ministries (for Ministry of Environment and Physical planning and Ministry of Economy) and to be Action plans for environmental protection made from used vehicles pollution.

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