NORMS AND LEGAL REGULATIONS TO LIMIT TOXIC EMISSIONS FROM INTERNAL COMBUSTION ENGINES WHEN USING ALTERNATIVE FUELS AS ENVIRONMENTALLY ELIGIBLE IN RELATION OF CONVENTIONAL FUELS

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Abstract: *During the decades-long development of internal combustion engines, the main criteria for optimality were the increased power, the low fuel consumption and the adjustment of the working process under non-stationary operating conditions. Even when the air quality in some settlements was significantly worsening, due to the high degree of motorization, special attention has been paid to polluting the atmosphere with exhaust gases from the engines. Problems that are created due to the increased environmental pollution significantly influence the choice of providing minimal environmental conditions, they receive priority, especially in urban areas. As toxic components are considered CO, CnNm, NOx, solid particles, etc. So if we know the conditions in which they are created then they can be the criterion for optimality. The requirements also affect their reduction within certain permitted limits.*

Keywords: *norms, legal regulations, internal combustion engines, environmental criteria.*

1. Introduction

The adoption of the legal regulations for limiting the emissions of toxic components from the exhaust gases of internal combustion engines initiated many extensive examinations mainly in the interior of the engine and the additional treatment of exhaust gases through thermal and catalytic reactors, contributed to the reduction of toxic emissions.

The day-to-day development of internal combustion engines is aimed at reducing the toxic emissions of exhaust gases at the barrier level and reducing fuel consumption, while maintaining the good engine characteristics.

Environmental pollution is a permanent process and it is a complex phenomenon that is relatively slowly being explored and the legitimacy of these are completely not defined. For many occurrences, there are only hypotheses and assumptions, such as the warming of the atmosphere in global proportions.

The biological existence of a human is inextricably linked to the biosphere that is the main ecosystem of the country, which, with the help of natural self-regulatory processes, is in the state of dynamic equilibrium. Until the beginning of the rapid development of industrialization, urbanization and motorization, which took place in different countries at different times, it was considered that pure air and water were in unlimited quantities, and the pollution that occurred as a result of human activity was easily assimilated and removed, as a result of the great power of self-awareness of these media. Alongside with the increase in human activity in various spheres, the first signs of degradation of the environment.

The more the man wanted to change the environment, the more he burdened the country of the ball with various degradation problems, seeking the most urgent solution. The degradation of the environment gradually slowed down all over the environment in which the human being lives, so it is difficult to determine its dimensions and the consequences that it causes.

2. The efficiency of the internal combustion motors in the aggregate pollution of the atmosphere

Due to the huge economy, the favorable specific power and the favorable dimensions, the engines are accepted as the most suitable source of thermal mechanical energy in many areas of application. In road transport, they represent an exceptional means of propulsion.

With combustion of 1 (t) fuel in the engine, depending on the type of engine, the operating mode and regulation, can occur in the exhaust gases: 150 – 800 kg CO, 7,5 – 40 kg NO_x and 30 – 100 kg C_nH_m .

Table 1. *Air pollution in the US on an annual level*

	Harmful substance (10^6 t)				
SOURCES	CO	Particles	CO_2	C_nH_m	NO_x
Transport	110.9	0.8	1.0	19.5	11.7
Combustion in stationary installations	0.8	6.0	21.5	0.6	9.4
Industry	11.4	13.3	6.4	5.5	0.2
Combustion of waste	7.2	1.4	0.1	2.0	0.4
Rest	18.3	4.0	0.2	7.3	0.5
SUMMARY	148.6	25.5	29.2	34.9	22.2

The data for the participation of internal combustion engines as aeronautics are very diverse. These data are in some ways one of the main indicators for industrial development. In addition, the most developed countries are the largest aerospace producers.

Observing the impact of internal combustion engines as aeronautics, in Central Europe, was noted that their share in the CO emission is 65%, the NOx emission is 55%, CnHm is 40%, and the SO2 is 3%. The estimated impact of the main air pollutants in relation to the emissions of wastes in R. of North Macedonia for the end of the twentieth century is shown in the impact assessment. Table 2 shows that the largest part of all emissions originated from the combustion processes. The traffic is the largest emitter of carbon monoxide, hydrogen peroxide and nitrogen oxides. On the other hand, the largest part of the emitted sulfur originates from the stationary power stations of the electric power station and from the local and general consumption. This structure of issuers and emissions is also valid for other countries, depending on their degree of industrialization, urbanization and motorization

Table 2. The estimated impact of the main air pollutants in relation to the emissions of wastes in R. of North Macedonia for the end of the twentieth century is shown in the impact assessment.

	HARMFUL SUBSTANCE (%)				
POLLUTANTS	**CO**	**CnHm**	**NOx**	**CO_2**	**Solid particles**
Electricity distribution	1	1	28	43	27
Industrial	13	22	13	28	20

pitches					
Individual pitches	21	28	4	20	33
Traffic	65	39	54	3	13
Total combustion processes	100	90	99	94	93
Other industrial process	0	10	1	6	7
In total	**100**	**100**	**100**	**100**	**100**

Engines with internal combustion, regardless of the degree of combustion, emitted emissions which pose a potential danger to the environment, while at the same time impairing the safety in traffic.

It was noted that when combining 1 l. petrol is obtained from about 10 (m3) gas gases. Out of the total produced amount of lead (which is about 2 million annual losses of about 50 thousand tons), about 10% is spent on antidetonator additives, which the exhaust gases are grounded in the environment.

The SO emission is most likely to emerge from the traffic and, for example, in the past 1982.

In terms of SO_2 emission, industrial facilities have a far-reaching role, thermal power installations and the heaters (installations in which the fuel oil is oil and coal). From these pollutants it is assumed that SO_2 plays, a decisive role in the creation of the so-called "acid rains" that destroy the plants across the length of the main roads in Europe.

The given data clearly indicate the gradual acceleration of the pollution of the atmosphere on the planet's surface. The distribution of the pollution is not uniform across the entire planet's surface, so the pollutant has recorded more pollution (93% of the total pollution) of the atmosphere relative to the southern hemisphere. This is due to the uneven development of the industry, because the developed industrial countries are located on the northern hemisphere. About 90% of these pollutants pollute 8 - 10% of the surface of the planet's surface (parts of Europe, North America and Japan), or 3% of the total surface of the planets.

On this basis, an orientation assessment can be given for the needs of the air for combustion of the planet's fuel. In 2000, they amount to 22.1012 (m3 / year), which is 0.01% of the total mass of the atmosphere.

For the calculation of the maximum terrestrial concentration of harmful substances from conventional fuels as sources of pollution, the known equation of Voeikov is used to calculate the maximum ground concentration from precise sources of pollution, where:

- A - coefficient of temperature stratification of the atmosphere, which depends on the meteorological conditions;
- $E_{s,p}$ (g/s) – emissions of sulfur and nitrogen dioxide, or solid particles from all vehicles at the intersection;
- F_f – without a dimensional coefficient that takes into account the speed of road charges, which depends on the level of clearance and in this case it can be taken $F_f = 3$;
- min – without dimensional coefficients which take into account the exhaust outlet conditions and are calculated according to the following expressions;

$$m = \frac{1}{0{,}67 + 0{,}1\sqrt{f} + 0{,}34\sqrt[3]{f}}$$

f – parameter that is calculated:

$$f = \frac{10^3\, W_g^2\, d^0}{H_0^2 \Delta T}$$

d_o (m) – the diameter of the exhaust pipe light;

w_g (m/s) – the speed of the combustion products of the exhaust pipe, which can be calculated according to the following level;

$$W_g = 1{,}27 \frac{V_g}{d_0^2}\ (m/s)$$

To compile,to calculate the coefficient "n", it is necessary to pre-calculate the Vm parameter:

$$V_m = 0{,}65\sqrt[3]{\frac{V_g\, \Delta T}{H_0}}$$

at:

$$V_m \le 0{,}3 \qquad n = 0{,}3$$

$$0{,}3 < V_m \le 2{,}0$$

$$n = 3 - \sqrt{(V_m - 0{,}3)(4{,}36 - V_m)}$$

$$V_m \le 2{,}0 \qquad n = 1{,}0$$

Vg (m^3/s) – volume flow of combustion products reduced to a condition that governs the exit of the exhaust pipe;

$\Delta T = t_g - tsr_v$ (°C) - the temperature difference between the temperatures of the products of combustion (exhaust gases) on the exit of the exhaust pipe and the medium temperature of the air.

The exhaust gas temperature of the exhaust pipe is different for vehicles with internal combustion (t_{gB}) and diesel motors (t_{gD}), so because of that in this case, work with medium temperature of the combustion products:

$$t_g = \frac{t_{gB} + t_{gE}}{2}\ ^\circ C$$

An important magnitude that is penetrated in the calculation is the diametre of the adopted exhaust pipe which in this case is:

$$d_o = n_e\, d_{ic}$$

n_e – number of vehicles at the intersection

d_{ic} (m) - diameter of the exhaust pipe of one vehicle (equivalent vehicle).

The concentration of harmful substances in urban areas is influenced by several factors:

a) Influence of meteorological factors
- Impact on the speed of air movement (wind);
- Impact on the temperature of the outdoor air;
- Impact on the direction of air movement (wind),

b) the impact of the factor taking into account the geographic position of the urban environment;

c) impact of the factors that depend on the thermal power plants in the urban environment.

Pi (%) – percentage representation of vehicles with internal combustion and diesel engines (for internal combustion motors much more in relation to Diesel engines), at intersections,

n_{ei} – total nubmer of vehicles on the intersection

The volume flow of the combustion products (exhaust gases) under normal conditions is calculated according to the expression:

$V_{gi}^{o} = 0{,}2778\, n_{ei}\, B_i V_{igi}\ (m/s)$

i = B, D

Bi (t/h) – fuel / diesel consumption

Vigi – volume of the products of the consumption during consumption fuel or diesel

n_{ei} - number of equivalent vehicles with internal combustion and diesel motors).

The volume flow of combustion products is reduced to the conditions that the control of the exhaust pipe from the exhaust pipe is calculated according to the expression:

t_{gi}C) - temperature of the products of combustion of the exhaust from the exhaust pipe for the Oto or Diesel engine, which varies, but is usually less than 100 (˚C). By measuring the $t_g$of several vehicles idling on the engine, the following values were obtained:

- for internal combustion motors $t_g = 70(^\circ C)\ or\ 343(K)$
- for diesel motors $t_g = 60(^\circ C)\ or\ 333(K)$

Measured temperatures are in accordance with the temperatures of the combustion products in the cylinder at the end of the extraction process, which move in the following borders:

- for internal combustion motors $t_p = 800 - 1100\ (K)$
- for diesel motors $t_p = 700 - 900\ (K)$

The total volume flow of the combustion products is the sum of the volume flows of the combustion products from internal combustion and diesel motor respectively:

$$V_g = \sum V_{gi} = V_{gB} + V_{gD}\,(m^3/s)$$

CO_2 emission from vehicle with internal combustion or diesel motor is calculated with the following expression:

$$E_{SO_2 i} = 5{,}556\, B_i S_i \left(1 - n_{SO_2}\right)\left(1 - n_{SO_2}\right)$$

i=B (petrol), D (diesel)

B_i (t/h) – petrol or diesel fuel consumption

S_i (%) – content of petrol or diesel fuel

n_{SO2} – coefficient that takes into account the percentage of SO_2 retention in the exhaust part of the engine and runs for liquid fuels (petrol and diesel) within the limits (0,0 – 0,2)

$n_{SO2} = 0$ - a coefficient that takes into account the percentage of SO2 in the purifier of solid particles and in the vehicle is zero at all under the condition that there is no purifier of the combustion products

The total SO2 emission of all vehicles at the intersection is calculated according to the following expression:

$$E_{SO_2} = \sum_i nei \sum SO_2 i = n_{eB} E_{SO_2 B} + n_{eD} E_{SO_2 D}\ (g/s)$$

$n_{eB}\ n_{eD}$ – number of vehicles with internal combustion or diesel motors at the intersection.

The NO_2 emission from the vehicle with the internal combustion and diesel engine is calculated according to the expression:

$D_{ei} = \sqrt{\frac{4A_{ci}}{\pi}}$ (m) – the equivalent diameter of the combustion area for internal combustion and diesel motor

$A_{ci} = \frac{\pi D_{ci}}{4}\, n_{ci}$ (m^2) – cross section of the cylinder for internal combustion and diesel motor

S_i – piston path for internal combustion and diesel motor

D_{ci} – the diameter of the cylinder for internal combustion and diesel motor

For internal combustion motor $S_B = 1{,}1 -> 1{,}3$

$$\frac{S_B}{D_{cB}} = 0{,}8\ => S_B = 0{,}8\ D_{cB}$$

For diesel motor $S_D = 1{,}3 -> 1{,}7$

$$\frac{S_D}{D_{cD}} = 1{,}3 => S_D = 1{,}3\ D_{cD}$$

$$V_{cD} = \frac{\pi D_{cD}^2}{4} 1{,}3 D_{cD} = 0{,}325 \pi D_{cD}^3$$

$$D_{cB} = \sqrt[3]{\frac{V_{cB}}{0{,}2\pi}}\quad (cm)$$

$$D_{cD} = \sqrt[3]{\frac{V_{cD}}{0{,}32\pi}}\quad (cm)$$

We will get the values for V_{ci} from the cylinder displacement:

$$V_{ci} = \frac{V_i}{n_{ci}}\ (cm^3)$$

n_{ci} – number of cylinders at internal combustion and diesel motors

The total NO_2 emissions from all vehicles at the intersection are calculated according to the following expression:

$$E_{NO^2} = \sum_i n_{Ei} E_{NO^2 i} = n_{eB} E_{NO^2 B} + n_{eD} E_{NO^2 D}\ \left(\frac{g}{s}\right)$$

n_{ei}, n_{eB}, n_{eD} – number of vehicles with internal combustion or diesel motors at the intersection.

The emission of solid particles from a vehicle with internal combustion or diesel engine is calculated according to the expression:

$$E_{pi} = 277{,}778\ B_i \left[\left(1 - \frac{U4_i}{100}\right) A_i a_g + \frac{U4_i}{100}\right]\ \text{(g/s)}$$

A_i – ash content in petrol or diesel fuel

$U4_i$ % - heat loss due to chemically incomplete combustion, in the vehicle with internal combustion or diesel engine that moves:

$U4 = 0{,}5 -> 0{,}7$

a_g – part of the ash, which comes out with the products of combustion that the vehicles are carrying

$a_g = 0 -> 0{,}1$

The total emission of solid particles from all vehicles at the intersection is calculated according to the following expression:

$$E_p = \sum_i n_{ei} E_{pi} = n_{eB} E_{pB} + n_{eD} + E_{pD}\quad (g/s)$$

$n_{ei}(n_{eB}, n_{eD})$ – number of vehicles with internal combustion and diesel motors at the intersection

The CO emissions from vehicles with internal combustion or diesel engine are calculated according to the expression:

$$E_{COi} = \frac{12{,}5U4_iHd_iBiV_{CO_2i}}{3{,}6(23544{,}235\,C_i - U4_iHd_i)}\ (g/s)$$

Bi (t/h) – consumption of petrol i.e. diesel fuel

$U4_i$ (%) – heat loss due to chemically incomplete combustion, in the vehicle with internal combustion or diesel engine that moves:

$U4 = 0{,}5 -> 0{,}7$

Hd_i (kJ/kg) – lower thermal power on petrol or diesel fuel

V_{CO_2i} (m³) – volume of the CO_2 combustion products at internal combustion and diesel motors

$V_{CO_2i} = \frac{M_{CO_2i}}{\rho\ CO_2i}$ (m³)

Tg_i (K) – temperature of the combustion products on the exit of the exhaust pipe for internal combustion and diesel motors, usually lower than 100 ̊C.

- internal combustion motor $T_{Gb} = 70°C = 343\ K$
- diesel motor $T_{Gd} = 60°C = 333\ K$

M_{CO_2i} – weight of CO_2 in combustion products

$\rho\ CO_2 i$ – density CO_2 of in combustion products at petrol and diesel fuel

$$\rho_{CO_2} = \frac{100000}{1000R_{CO^2i}(T_{Gi} + 273{,}5)} (kg/m^3)$$

R_{CO^2i} – gas constant for CO_2 at internal combustion and diesel motor

The total CO emissions from all vehicles on the intersection are calculated according to the expression:

$$E_{CO} = \sum_i n_{ei}E_{COi} = n_{eB}E_{COB} + n_{eD}n_{COD}\ \ (g/s)$$

$n_{ei}(n_{eB,}n_{eD})$ – number of vehicles with internal combustion and diesel motor.

3. Alternative fuels and their ecological qualities in relation to conventional fuels

Since it has been established that the utilized energy potential of the Earth has been completed, the term "energy crisis" is emerging. The energy crisis and knowledge of the limitations of natural reserves for the production of conventional fuels, gasoline and diesel fuel are increasingly given to them the significance of fuels that can be produced from raw materials that are available in practically unlimited quantities.

Resolving environmental problems also leads to research focused on the selection of appropriate fuel as an alternative fuel, which would be a worthwhile replacement of the used white derivatives - gasoline and diesel fuel for internal combustion engines.

In order to be able to be replaced accordingly, alternative fuels are set to meet the requirements to be fulfilled. They should be easily transported, maintained in the long-term storage, not polluting the environment more than the existing fuels with the exhaust emission gases, to be profitable and competitive.

Alternative fuels that could be alternatives to existing fuels would be: different liquid hydrocarbons, methanol, ethanol, natural gas, liquefied petroleum gas, water, etc.

Today, the most suitable source of energy in many areas, especially in road transport, is internal combustion engines fueled with petrol or diesel fuel. Accordingly to the researches of these engines, they do not have a bright future ahead.

- *Methanol – one kind of alternative fuel*

Methanol (methyl alcohol - CH_3OH) is a colorless, transparent, low-viscosity liquid characterized by an alcoholic scent. It is made of stone, coal, natural gas, purifier, organic waste or as a by – product in the organic – chemical industry. Physical – chemical characteristics of methanol, differ from commonly used fuels and have a significant impact on the course of combustion and emission of exhaust gases.

The following conclusions are important:

- Viscosity, density, as well as the heat in the mixture of petrol and methanol, differ significantly.
- The presence of chemical oxygen in the alcohols reduces the heat of combustion. That's why methanol has an enlarged specific consumption.
- The optimum pre-ignition angle of the engine with methanol is less often used when working with gasoline, which indicates a change in the combustion engine, the second and the faster progress of the combustion process.
- The effective degree of usefulness - when working with methanol is higher because of the low heat losses and the lower exhaust gas temperature.
- Methanol has a higher octane number, which is the reason for increasing the compression ratio ε = 12 ÷ 14: 1, and thus increasing the effective power of the engine.
- When working with methanol, the limits of the flammability of the mixture, especially in the context of its impotence, are being sprayed.
- In the field of rich mixture in (λ <1) when working with methanol, the CO is significantly reduced in the exhaust gases. The drive with methanol showed favorable emissions of uncombusted gases. The methanol drive showed a favorable emissions of both carbon dioxide CH, in the whole field of interest in the high-air coefficient. The values of the total quantities of undamaged hydrofoils shown in the diagram are measured using a flame - ionizing FID analyzer. Measured on FID - Regulations showed confidence in the analysis of the products of combustion. The sensitivity of FID alcohol analyzers is considerably smaller than the usual components contained in normal fuels: paraffins, olefins and aromatics. In this way, a large part of the combusted hydrocarbons can not be registered with the current common method of measurement.
- The environmental indicators of the engine while working on methanol are virtually identical and significantly improved as they work on gasoline. The low pressure of the saturated steam of the methanol impairs the initial engine qualities, as it will be necessary to add to the wood-volatile hydrocarbons. In winter conditions, electric heating is necessary.
- Methanol mixing in any proportion with water is successful, but the mixture of methanol and water causes corrosion of the engine parts.
- The disadvantage of methanol as motor fuel is that there is a large amount of aldehydes in the exhaust gases.
- Methanol vapors are often more harmful to human health than petrol’s.

An interesting variant of the drive is the operation of the internal combustion engine with a mixture of gasoline and methanol. The conversion of 20% methanol in the fuel is achieved, without any changes in the engine, the oscillation of the mixture by 8.8% and that is so called M20 fuel. In this way, the composition of the exhaust gases is significantly improved. Such a reduction was achieved by 75% SO, 30% for HC and 22% for NO. Secondary problems are not recorded.

Conclusion

The day-to-day development of internal combustion engines is aimed at reducing the toxic emissions of exhaust gases at the barrier level and reducing fuel consumption, while maintaining the good engine characteristics.

Engines with internal combustion, regardless of the degree of combustion, emitted emissions which pose a potential danger to the environment, while at the same time impairing the safety in traffic.

Resolving environmental problems leads to research focused on the selection of appropriate fuel as an alternative fuel, which would be a worthwhile replacement of the used white derivatives – gasoline and diesel fuel for internal combustion engines.

Methanol is one kind of alternative fuel that is alternative to existing fuels, it is a colorless, transparent, low-viscosity liquid characterized by an alcoholic scent. The effective degree of usefulness - when working with methanol is higher because of the low heat losses and the lower exhaust gas temperature.

Methanol and other alternative fuels will be the new fuels which are going to be use for motors with internal combustion.

Alternative fuels are healthier for the environment, cheaper for the consumers and with better combustion than standard fuels.

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