Indicators of massive cluster of nitrogen oxides within the operation of a diesel CI engine on methyl hydroxide

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Abstract. NOx can be formed in the incineration chamber within high-temperature oxidation of azote in the air, as a result of low-temperature oxidation of azote-containing ignitable compounds, due to the collision of hydrocarbon radicals with azote molecules in the incineration reaction zone in the presence of temperature fluctuations. To analyze the education of NOx in the topper of inland incineration CI engine, attempts have been made to apply a bimolecular mechanism. In some cases, using the indicated mechanism, a fairly good agreement was obtained between the experimental and calculated cluster of NOx. The data obtained on variations in the indexes of the massive cluster of NOx within the operation of a CI engine on methyl hydroxide are presented in this article. The readings were taken experimentally on a two-topper CI engine at various plant corners for determining ignitable shot.

1. Introduction
Nitrogen oxides (NOx) represent a set of the following compounds: N2, O, NO, N2, O1, NO2, N2, O4 and N2, O5. NOx prevails (99% in gasoline compression ignition (CI) engine and over 90% in engines).

NOx can be formed in the incineration chamber: within high-temperature oxidation of air azote (thermal NOx), as a result of low-temperature oxidation of azote-containing ignitable compounds (fuel NOx), due to the collision of hydrocarbon radicals with azote molecules in the incineration reaction zone in the presence of temperature (T) pulsations (fast NOx) [1-5].

In the procedure of ignitable incineration, NOx (practically only NOx) are formed as a result of azote oxidation by atmospheric oxygen. Both azote in the ignitable and azote in the air can participate in the NOx education reaction.

Petroleum issuance contains up to 5% azote compounds (0.3-0.6% by weight of pure azote). The main azote-containing components of solid and liquid ignitable are pyridine and its derivatives. Ignitable azote reacts more easily with oxidation than atmospheric azote.

When the azote content in the ignitable was 1.4% by weight, an increase in NOx emission of about 10 times was recorded within the incineration procedure [6-9].

The degree of oxidation of azote in a ignitable depends on its cluster in the ignitable and on the type of flame. So, for example, at α = 1.1 in a pre-blended flame of methane in air and an addition of ammonia from 1 to 9.3%, the conversion of NH3 to NOx decreases from 95 to 63%. In a diffusion flame, NOx is formed 2-3 times less than in a pre-blended one [10].

The studies of R. A. Lipshtein show that azote distillation remains in heavy fractions within oil distillation. Fractions with a distillation T up to 350 °C contain no more than 4% of all azote in oil.
Therefore, for diesel fuels (DF), and especially gasoline derived from oil, one cannot take into account when analyzing the education of NOx reactions with ignitable azote.

The generally accepted theory of the education of NOx from atmospheric azote and oxygen in the incineration procedure is the thermal theory [11-14].

The main points of this theory are given below:

- NOx occurs behind the flame front in the zone of incineration issuance;
- The output of NOx depends on the max incineration T, the cluster of azote and oxygen in the incineration issuance and is not determined by the nature of the ignitable (in the absence of azote in the ignitable);
- NOx occurs by a chain mechanism. The main thing is the reaction. Its speed is determined by the cluster of atomic oxygen. When there are water vapors in the gas blend, the education of NOx can become combined. But still, the main mechanism of thermal education is a chain reaction through oxygen atoms;
- The NOx yield is determined by the cooling rate of the incineration issuance;
- Within the incineration of lean blends (with low reaction mobility), the NOx yield depends on the max explosion T, i.e., on the kinetics of its education. Within the incineration of rich blend, the NOx yield is no longer determined by the max explosion T and depends on the decomposition kinetics, that is, on the "quenching" of the formed NOx;
- The cluster of NOx will not be more equilibrium at the max T of the explosion;
- Mahe action (uneven T distribution in the zone of incineration issuance) noticeably affects the NOx output within incineration of poor blend and weakly when incineration rich blend.

To analyze the education of NOx in the topper of inland incineration CI engine, attempts have been made to apply a bimolecular mechanism. In some cases, using the indicated mechanism, a fairly good agreement was obtained between the experimental and calculated clusters of NOx. However, the calculations show that under the conditions existing in the CI engine topper within the incineration procedure, the share of the bimolecular mechanism in the overall procedure of NOx education is insignificant (compared to the chain mechanism). In recent years, in connection with the emission of significant amounts of NOx from the exhaust gases (EG) of inland incineration CI engine, many studies have been conducted to elucidate the mechanism of education of NOx in the topper of various types of CI engine and the action of the parameters of the operative procedure on the amount of NOx in the EG. The study of the education of NOx in the topper of an inland incineration CI engine is complicated by a variation in the volume of the incineration chamber (due to piston movement), heterogeneity of the air-ignitable blend, movement of the blend in the incineration chamber, dissociation of the incineration issuance, uneven distribution of ignitable between individual topper and cyclic unevenness. It was found that at max cycle the CI engines and spark ignition engine (Tmax = 1800 ÷ 2800 K), only NOx is practically formed from NOx. In the EG of CI engine with spark ignition, the NO content is 99% of the amount of all NOx, and in the EG of CI engine - more than 90%. In the exhaust system of the CI engine (in the presence of oxygen in the incineration issuance), after the EG exit into the atmosphere, NO is oxidized to NO2 [15-23].

2. Experimental part

Work on the conversion of a 2H 10.5 / 12.0 CI engine to methyl hydroxide with a pilot portion of DF. Studies on the action of methyl hydroxide apply have shown the results of variations in output indexes, massive cluster of NOx in the EG [24-27].

Figure 1, shows the graphs of the action of the apply of methyl hydroxide in CI engine when with various plant of fuel injection angle (FIA) on the massive cluster of CNOx of NOx in the EG, calculated from the experimental data obtained at the rated CI engine speed (n = 1800 min⁻¹), taken at Θad (30 ... 38°) and Θm (30 ... 38°) [28-32].
If at the optimum values of the plant FIA ($\Theta_{df} = 34^\circ$ and $\Theta_m = 34^\circ$) the massive cluster of $C_{NOx}$ of NOx in the CI engine EG is 0.45 g/m$^3$, then with a larger value of $\Theta_m = 38^\circ$ the massive cluster of $C_{NOx}$ in the EG of the CI engine increases and is 0.54 g/m$^3$. When $\Theta_m = 30^\circ$, the massive cluster of $C_{NOx}$ of NOx is 0.47 g/m$^3$ [33-35].

The curves of the variations in the massive cluster of $C_{NOx}$ of NOx in the CI engine EG, obtained with the plant of FIA $\Theta_{df} = 30^\circ$ and various methyl hydroxide shot corners of $\Theta_m$, show that with the plant of the FIA of NOx $\Theta_m$ equal to 34$^\circ$ and 30$^\circ$, the massive cluster of $C_{NOx}$ NOx in the CI engine EG is respectively, 0.48 g/m$^3$ and 0.45 g/m$^3$ [36-39].

The graphs of the variations in the massive cluster of $C_{NOx}$ of NOx in the CI engine EG, obtained with the plant of FIA $\Theta_{df} = 38^\circ$ and various shot corners of methyl hydroxide $\Theta_m$, show that with the plant of the FIA of NOx $\Theta_m$ equal to 38$^\circ$, 34$^\circ$ and 30$^\circ$, the massive cluster of $C_{NOx}$ NOx in the EG of the CI engine 0.48 g/m$^3$, 0.43 g/m$^3$ and 0.46 g/m$^3$, respectively. It can be seen from the graph that with an increase in the FIA $\Theta_m$ angle, the massive cluster of $C_{NOx}$ of NOx in the CI engine EG variations according to a complex dependence [40-44].

Figure 1 shows the graphs of the action of methyl hydroxide apply in CI engine when with various plant of FIA on the massive cluster of FIA $C_{NOx}$ of NOx in the EG calculated from the experimental data obtained at the CI engine speed ($n = 1400$ min$^{-1}$), taken at $\Theta_{df}$ (30 ... 38$^\circ$) and $\Theta_m$ (30 ... 38$^\circ$).

If at the optimum values of the plant FIA ($\Theta_{df} = 34^\circ$ and $\Theta_m = 34^\circ$) the massive cluster of $C_{NOx}$ in the EG of CI engine NOx is 0.47 g/m$^3$, then with a larger value of $\Theta_m = 38^\circ$ the massive cluster of $C_{NOx}$ in the EG of CI engine increases and is 0.55 g/m$^3$. When $\Theta_m = 30^\circ$, the massive cluster of $C_{NOx}$ of NOx is 0.48 g/m$^3$ [45-51].

The curves of the variations in the massive cluster of $C_{NOx}$ of NOx in the CI engine EG, obtained with the plant of FIA $\Theta_{df} = 30^\circ$ and various methyl hydroxide shot corners of $\Theta_m$, show that with the plant of the FIA of NOx $\Theta_m$ equal to 34$^\circ$ and 30$^\circ$, the massive cluster of $C_{NOx}$ NOx in the CI engine EG is, respectively, 0.50 g/m$^3$ and 0.47 g/m$^3$ [52-56].

The graphs of the variations in the massive cluster of $C_{NOx}$ of NOx in the CI engine EG, obtained with the plant of FIA $\Theta_{df} = 38^\circ$ and various shot corners of methyl hydroxide $\Theta_m$, show that with the plant of FIA of $\Theta_m$ equal to 38$^\circ$, 34$^\circ$ and 30$^\circ$, the massive cluster of $C_{NOx}$ NOx in the EG CI engine is 0.49 g/m$^3$, 0.45 g/m$^3$ and 0.48 g/m$^3$, respectively [57-65].
3. Conclusion
Experimental studies and calculation have determined the values of the content of NO$_x$ of the massive cluster of NO$_x$ in the EG of CI engine depending on the variation in speed. The content of C$_{NOx\,calc}$ at $n = 1200$ min$^{-1}$ decreases from 0.76 g/m$^3$ when operative on DF to 0.49 g/m$^3$ when operative on methyl hydroxide, or by 35.5%. At a rotation frequency of $n = 2000$ min$^{-1}$, when operative on DF with NO$_x$, the calculation is 0.59 g/m$^3$, and when operative on methyl hydroxide, only 0.40 g/m$^3$. The decrease is 32.2%.

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