The effect of operational modes of diesel engines to emissions of nitrogen oxides

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Abstract. The levels of nitrogen oxides (NO\textsubscript{x}) emissions are presented depending on the operating modes of diesel engines, which determine on the one hand the existence of high temperatures in the cycle, at which there is intense nitrogen oxidation, and on the other hand, depending on the value of the excess air coefficient \(\alpha\), the excess of free oxygen for nitrogen oxidation.

Reducing the impact of motor transport on the environment is the most urgent and urgent task of modern society. The consequences of this impact are not only affecting our generation, but may also affect the future if we do not take serious measures to reduce or even eliminate the effects of the impact and the impact itself. Global problems of modern civilization-energy and environmental-are directly related to the development of internal combustion piston engines, as the main consumers of fuels of oil origin and sources of environmental pollution [1-6].

Figure 1. Nature of changes in NO\textsubscript{x} emissions taking into account the type of mixing.
Since internal combustion engines have found the widest distribution as a power unit of vehicles, it is natural that they should be characterized not only by high fuel efficiency, but also by the necessary environmental safety in accordance with current norms and regulations. It is obvious that improving environmental parameters is one of the main tasks of modern diesel construction [7-13].

The control of diesel emissions toxicity is regulated by the introduction of legal restrictions and the implementation of measures that ensure these restrictions. Legal restrictions on regulated harmful substances are established by regulatory documents (national and international standards), which also contain requirements and provisions for testing, the scope and validity of the standard, measuring instruments, rules for processing test results and properties of the fuels used [14-19]. Strict legal requirements, currently introduced in almost all developed countries of the world, provide for restrictions on concentrations in diesel combustion products of harmful components such as NOx, which pose the greatest danger to humans, flora and fauna [20-23].

![Figure 2](image.png)

**Figure 2.** The nature of changes in NOx, CH and CO emissions of diesel 8CHN16.5/17.0:
- n=1800 min\(^{-1}\);
- n=1300 min\(^{-1}\).

![Figure 3](image.png)

**Figure 3.** Specific NOx, CH and CO emissions of diesel 8CHN16.5/17.0:
- n=1800 min\(^{-1}\);
- n=1300 min\(^{-1}\).

The existence of a maximum of NOx emissions by load characteristic in the area of loads equal to \(N_r/N_{en}=75...87\%\) is associated with a combination of high temperature and a sufficient value of the excess air coefficient \(\alpha\) (figure 1).
Further increase in power is associated with the deterioration of the mixing conditions, a drop in the values of α and accompanied by a decrease in NO\textsubscript{x} emissions. Therefore, in some cases, for gas-turbine supercharged diesels, the maximum NO\textsubscript{x} emissions may almost coincide with the maximum load capacity [24-28].

The implicit existence of a maximum of NO\textsubscript{x} emissions by load characteristic can change NO\textsubscript{x} emissions, for example, when the charge air pressure reaches 0.203 MPa (figure 2).

Figure 2 shows that for a supercharged gas turbine diesel engine, there are no clearly defined NO\textsubscript{x} emission maxima in terms of load characteristics [29-31].

Figure 3 shows the specific NO\textsubscript{x}, CO and CH emissions of diesel 8CHN16.5/17.0. When the speed is increased, diesels tend to have higher levels of harmful emissions [32-34].

Figure 4 shows the levels of harmful emissions of diesel 6H13.0/14.0 with supercharged at \( p_c = 0.172 \) MPa.

Figure 5. Multi-parameter characteristics of diesels: a - KAMAZ-740; b - YAMZ-236.
Here, NO\textsubscript{x} emission maxima between loads of 60...80\% are observed. For constant-power engines with an external speed characteristic, NO\textsubscript{x} emissions decrease as the crankshaft speed increases from \(n_m\) to \(n_e\). Thus, NO\textsubscript{x} emissions from constant-power engines are reduced by external speed characteristics from 3.5 g/m\(^3\) at 1200 min\(^{-1}\) to 2.4 g/m\(^3\) at 1750 min\(^{-1}\) [35-38].

The most complete understanding of the impact of speed and load conditions on NO\textsubscript{x} emission levels can be obtained by reading the multi-parameter characteristics of diesels (figure 5, a, b).

Considering the multiparameter characteristics for KAMAZ-740 diesels (figure 5 a) and YAMZ-236 (figure 5 b), it is obvious that the zones of the greatest NO\textsubscript{x} emissions lie in the areas of \(p_e=0.3...0.5\) MPa at rotation speeds from 1500 min\(^{-1}\) and higher [39-42].

![Figure 6. Multi-parameter characteristics of diesels: a - A-01M; b - A-41.](image)

Comparison of multiparameter indicators of diesels A-01M (figure 6 a) and A-41 (figure 6 b) shows that for this type of diesels, the most dangerous modes, in terms of NOx emissions, are combinations of \(p_e=0.5...0.7\) MPa at speeds of more than 1500 min\(^{-1}\) [43-45].

However, the selection of the above-mentioned factors as fundamental in determining NO\textsubscript{x} concentration levels would not be correct, since their effect can be detected in combination with adjustments, fuels, combustion chamber geometry, environmental conditions, and so on [46-48].

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