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PROBLEMS OF PARTICULATE MATTER MASS EMISSION IN DIESEL EHXAUST EXPERIMENTAL DETERMINATION

Requirements for the ecological characteristics of diesel vehicles obligatory in the territory of Ukraine, the Russian Federation and the European Union, as fixed legislatively – UNECE Regulation № 49 and № 96 level of EURO III, IV and V respectively [1]. These documents defines a list of normed pollutants in the exhaust gas (EG) of diesel engines, limits for their mass emissions, bench testing methodology and a list of stationary test cycles modes (13 and 8 respectively), is a model of the operation of such vehicles. This sets the method for measuring a mass emissions of particulate matter (PM) – gravimetric and means of its realization – full- or partially-flow tunnels. The high cost of manufactured tunnels, extreme science intensity of their development and the complexity of their certification determine the need to find methods and means for determining the of PM mass emissions, alternative for tunnels and suitable for preliminary and comparative laboratory studies [1].

In Piston Power Plants Dept. of A.N. Podgorny Institute for Mechanical Engineering Problems of NAS of Ukraine developed particulate matter filter (DPF) with new modular unconventional construction for diesel vehicles in operation. Thus its operating characteristics under real operating conditions determined during the bench experimental studies. They were carried out on the engine test bench (ETB), equipped with an autotractor diesel engine D21A1 (2Ch10.5/12), but isn't equipped with a tunnel [1]. Test programs are based on standardized stationary testing 13 and 8-mode cycles, which are a models of operation of the vehicle [1]. The main operating characteristics of the developed DPF is the efficiency coefficient K_{CE} of cleaning a diesel EG flow from the PM, which defines by the following formula [1]: $K_{CE}(G_{PM}) = (G_{PM.ICE} - G_{PM.DPF}) \cdot 100 / G_{PM.DPF}$, %, where G_{PM} – PM mass emission with diesel EG, kg/h; indexes *ICE* and *DPF* refers to cases of absence and presence of DPF in the exhaust system of a diesel engine. This raises the following problems, the solution of which require the use of appropriate approaches.

The approach to determining of PM mass emissions. It involves direct measurement of EG samples opacity (by Opacimeter INFRAKAR-D) and the volume concentration of unburnt hydrocarbons in EG (Five-component gas analyzer AUTO-TEST-02.03.P) [1], and the recalculation of these data into units of a of PM mass emissions according to the formula proposed by I.V. Parsadanov (Dr.Sci.(Tech.), Prof., NTU "KhPI") and obtained in certification tests of the autotractor diesel engine SMD-31 of the company Ricardo bench, equipped with a full-flow tunnel [1].

$$G_{PM} = \left(2{,}3 \cdot 10^{-3} \cdot N_D + 5 \cdot 10^{-5} \cdot N_D^2 + 0{,}145 \cdot \frac{C_{CH} \cdot 4{,}78 \cdot 10^{-7} \cdot \left(G_{air} + G_{fuel}\right)}{0{,}7734 \cdot G_{air} + 0{,}7239 \cdot G_{fuel}} + \right.$$

$$\left. + 0{,}33 \cdot \left(\frac{C_{CH} \cdot 4{,}78 \cdot 10^{-7} \cdot \left(G_{air} + G_{fuel}\right)}{0{,}7734 \cdot G_{air} + 0{,}7239 \cdot G_{fuel}}\right)^2\right) \times \frac{\left(0{,}7734 \cdot G_{air} + 0{,}7239 \cdot G_{fuel}\right)}{1000},$$

where N_D – light absorption coefficient of EG sample, %: C_{CH} – volume concentration of unburned hydrocarbons of EG sample, ppm; G_{air} и G_{fuel} – mass flow of air and fuel in the diesel engine on steady-state operation, kg/h.

The approach to the implementation of standardized test cycles. The list of operating modes of diesel engine included in above-mentioned standardized test cycles, there are modes, the implementation of which (transferred on this mode and its characterize parameters automatic maintenance) is difficult for diesel engines and the ETB, not equipped with an electronic control system – this is the mode with zero and closest to it effective power [1]. The second problem in this case is a hit of measured values in the area of the lower measuring range of measuring instruments of ETB and, as a consequence, the output of errors of their measurement beyond the limits of established by standards [1]. Therefore, the parameters of the diesel engine and DPF for the modes from the list of toxicity regulations obtained in the study of polynomials derived when describing by the linear regression method of the results of motor tests, in which registered the following characteristics of a diesel engine: the external speed, the loading with the engine speed of maximum torque mode, the loading with the engine speed of nominal power mode and the characteristic of idling [1].

The approach to comparative tests of various designs DPF. These tests were carried out as part of the exhaust system of ETB in order to obtain DPF working characteristics by registering one external speed characteristics of diesel engine that has the following features [1]: 1) exhaust gas flow along it (the exhaust gas mass flow rate per unit of the characteristic section of the experimental sample) changes in the most widely for diesel; 2) it contains a maximum torque mode, which is usually observed global minimum air excess factor α in the diesel engine operating conditions (the so-called "smoke limit" at α equal to 1.3) and, as a result, the global maximum exhaust smoke. Also on this mode there is a global maximum of EG temperature. It is also important that on this mode at the absence of autotractor diesel engine electronic control systems, the rest of his work parameters agreed to achieve global minimum specific fuel consumption; 3) it contains a diesel engine nominal power operating mode, in which there is a global maximum weight hourly fuel consumption; 4) on its mode EG temperature is changed in the range that sufficient for prediction it depending on the operating characteristics of the experimental sample.

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ADVANCED COMBINED DISCHARGES IGNITION IN DIFFERENT FUELS

It is well understood that achieving an ignition process that combines energy efficiency and engine emissions reduction in spark-ignition engines is a very complicated problem. The ignition system must function with the engine operating at high pressures, over a wide range of loads, with different turbulent intensities and optimum timing and must provide the reduction of greenhouse gas emissions associated with vehicles. One of the ways to address the above problems is to use combined discharges ignition with different controllable characteristics for enhanced ignition and combustion, when a first short-pulsed laser discharge serves as a source of initial seed electrons and excited particles for the second discharge with a controllable energy input. Main theoretical question here is connected with an ambipolar recombination decay of the laser discharge in different fuels because this process is responsible for the different ignition delay time.

Dynamics of the ambipolar recombination decay in the lean methane-air mixture is shown in Fig. 1 at time t=40 ns. It was obtained that at t=20 ns we still had a quasi-neutral plasma channel but stratification of charge increased with time and since 30 ns a positive column had formed with a pool of negative ions and electrons on the boundary with a neutral medium (Fig.1).