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STUDY THE INFLUENCE OF GAS SAMPLE TEMPERATURE ON THE EFFICIENCY OF ECOLOGICAL DIAGNOSTICS SYSTEMS FOR AUTOMOTIVE DIESEL ENGINES

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Research problems. When using compact systems for environmental diagnostics of automotive diesel engines - mini- and microtunnels, the requirement to ensure their accuracy should be met: relative deviations of the measurement results of the normalized indicator PM - mass emission of particulate matter with exhaust gases (EG), determined by compact (partial flow) and reference (full flow) systems should not exceed ±5% [1, 2]. When using compact tunnels to measure the PM index, a methodological error arises in measuring this value - δPM_t, due to a change in the temperature of diluted HS in the tunnel, on which the mass of the soluble organic fraction (SOF) in the PM composition depends [3-5]. The δPM_t error can be eliminated by using sample temperature controllers in compact systems that provide the conditions for dilution of the EG corresponding to the reference system. Since such regulators are expensive, high-tech devices, the installation of which complicates and increases the cost of measuring systems, the feasibility of their use should be investigated.

Analysis of recent research and publications. In accordance with the requirements of regulatory documents - UNECE Regulation R-49, international standard ISO 8178, etc. measurement of mass emissions of PM from automotive diesel engines can be carried out using various measuring systems [1]: reference full-flow tunnels with 1 and 2-fold dilution of EG with clean air and compact partially flow

tunnels, which are divided into minitunnels (have a diameter of 7.5 ... 12 cm and a length of 75...120 cm) and microtunnels (they have a diameter of 2.5...4 cm and a length of 25...40 cm). The best-known partially flow tunnels include: a minitunnel with an isokinetic sampler MT 474 (AVL), a multi-pipe type minitunnel (Mitsubishi), microtunnels with a differential method for determining the mass flow of EG - SPC 472 (AVL), PTR 200 [6-9].

To determine the normalized environmental indicator PM - the average operational mass emission of PM from the EG, bench tests of automotive diesel engines are carried out according to regulated test cycles, consisting of normalized engine operation modes with specified values of the crankshaft speed - n, engine shaft load - L, weight factor WF, taking into account the relative time of operation of the diesel engine in the mode during operation, and the duration of the test mode - τ. At the same time, various modes of diluting EG by air can be used in tunnels: D1 - mode with a constant mass flow rate of diluted EG or CVS-mode; D2 - CVS-mode with external air cooling of the tunnel; D3 - mode with a constant dilution factor of EG; D4 - mode with a constant dilution ratio of the EG and external air cooling of the tunnel.

The degree of influence of the temperature of the sample in the tunnel on the controlled mass emission of PM can be estimated from the results of experimental studies of foreign and domestic authors [7,9,10], indicating the following: 1) an increase in the temperature of diluted EG in front of the filters - t_f leads to a decrease in the PM emission controlled by the weight of the PM sample - mf and vice versa; 2) the influence of temperature t_f on the value of m_f can be taken into account using the established empirical linear dependences [7, 10]; 3) the value of the coefficient of proportionality of these dependencies depends on the mode of operation of the engine: with an increase in diesel power, their value decreases.

Formulation of the problem. The purpose of the work was to assess the feasibility of sample temperature control in compact systems - mini- and microtunnels (fig. 1) based on studies of their accuracy, taking into account the methodological error in measuring the PM index. To achieve this goal, the following tasks were solved: 1) analysis of literary sources on the research topic; 2) development of mathematical models for determining the temperature of a sample of diluted EG in the tunnel and the resulting measurement error of the PM index - δPM_t; 3) study of the feasibility of sample temperature control in mini- and microtunnels.

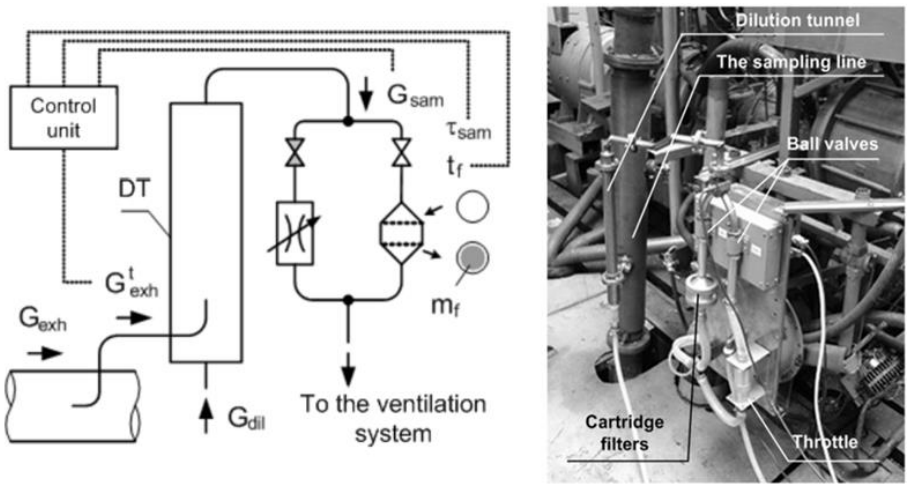

Fig. 1. Schematic diagram and general view of microtunnels MKT-2 [5]

Presentation of the main material of the study.

At the heart of the mathematical model for determining the temperature of a sample of diluted EG in the tunnel is t_f. the heat balance equation for the process of heat exchange of heated gas in a cylindrical pipeline with ambient air was used [11]. As a result of the transformation of this equation, the main calculation formula was obtained to determine the temperature of the gas flow at the end of the pipelines for the flow of diluted EG. Sequential calculation of the final temperatures of gas flows in all pipelines of the EG dilution system makes it possible to determine the sample temperature before the filter - t_f.

The mathematical model for determination of the resulting error of PM indicator measurements - δPM provides determination of this quantity as sum of its instrumental - δPM_{in} and methodical - δPM_t components: The magnitude δPM_{in} is determined by the dependence for calculation of the error of indirect measurement result [10]. The error δPM_t is numerically equal to the relative deviation of the controlled mass emission of PM determined at the actual temperature t_{fi} from the mass emission of PM determined at the temperature t_{f0i}, taken as the reference and corresponding to the dilution of HB in the reference system at t_{dil} = 20 ° C, $t_{f(max)}$ = 52 °C [12].

Studies of the feasibility of regulating the temperature of the sample in mini- and microtunnels were carried out on the criterion of relative deviation of the results of measurements of the RM by partial-flow and reference systems - δPM*. Based on the results of environmental tests of diesels 1Ch12/14, equipped with a minitunnel MT-1, and 4ChN12/14, equipped with a microtunnel MKT-2 [5, 10, 12] on a 13-stage ESC cycle using these mathematical models calculated calculations of absolute temperature deviations samples in a full-flow system with a diameter of 46 cm from similar temperatures in a minitunnel with a diameter of 10 cm and a microtunnel with a diameter of 3 cm - Δt_f, as well as the resulting methodological errors in measuring mass emissions of PM - m_f (fig. 2).

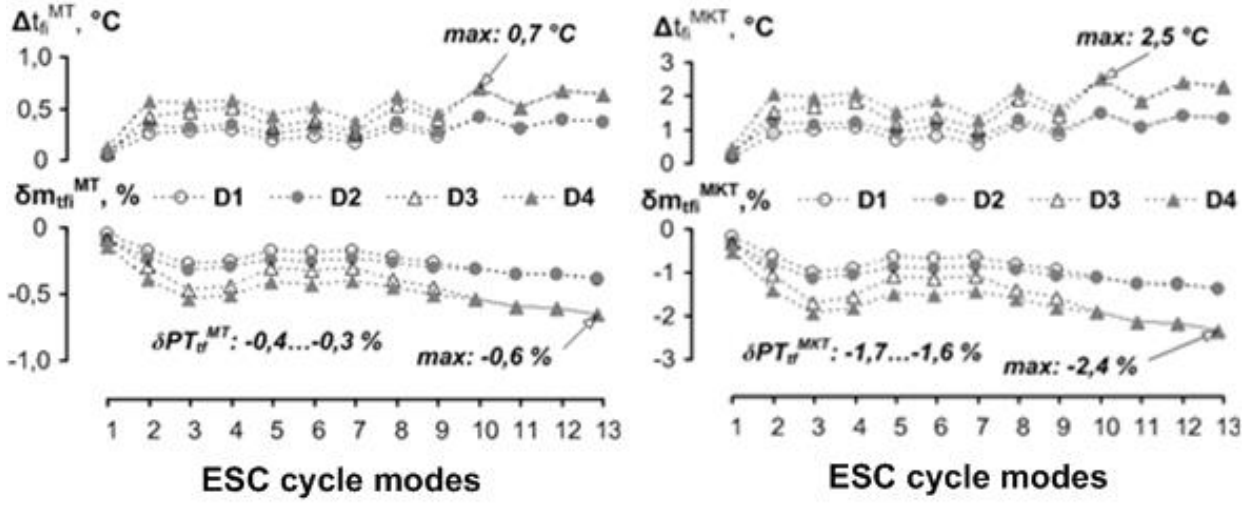

Fig. 2 - Results of experimental studies of the accuracy of mini- and microtunnels

The results of the studies indicate the following: thermal conditions of dilution of hydrogen sulfide in a minitunnel and a reference system are approximately equal:

deviations of sample temperatures in these systems are less than 0.7 ºC, resulting in methodical errors of PM measurements do not exceed 0.4 % and do not affect significantly the resulting error of the tunnel; thermal conditions of hydrogen sulfide dilution in a microtunnel and a reference system have significant differences: sample temperature deviations in these systems reach 2.5 ºC, the resulting methodological errors of RM measurements are 1.6 - 1.7%, which leads to an increase in the resulting error up to ± 5.9%. Thus, adjustment of the sample temperature in minitrunnels can be not used, but in a microtunnel it is expedient and allows to provide the necessary accuracy of PM measurements.

Conclusions. Based on the results of the analysis of regulatory documents - UNECE Rules R-49, R-96, international standard ISO 8178, etc., world and domestic experience in the use of dilution tunnels, the following were established: technical characteristics and operating conditions of reference full-flow and partial-flow tunnels, empirical dependences of the degree of temperature impact samples in the tunnel for the accuracy of measurements of mass emissions of PM in different operating modes of the diesel engine. Mathematical models have been developed to determine: the temperature of a sample of EG diluted with air in tunnels of various types, the resulting error in determining the average operational PM emission - the PM indicator, taking into account the influence of the sample temperature in the tunnel on the accuracy of PM measurements. Based on the test results of diesel engines 1Ch12/14 and 4ChN12/14 in the ESC cycle and the developed mathematical models, computational studies were carried out to assess the effect on the accuracy of a minitunnel and a microtunnel with diameters of 10 cm and 3 cm, respectively, of the temperature regimes of sample preparation, which were compared with a diameter of 46 cm The results of the research proved the expediency of controlling the temperature of the sample in the microtunnel to eliminate significant methodological errors in the measurements of the PM index,

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