ЕКОЛОГІЧНА БЕЗПЕКА ОТОЧУЮЧОГО СЕРЕДОВИЩА

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IMPROVING THE EFFICIENCY OF EMISSION CONTROL DISPERSED PARTICLES FROM DIESEL EXHAUST GASES

The estimation of methodical error of measuring of the mass of hinge-plate of diesel particulate matters is conducted. This error arises up by reason of influence on the result of measuring of parameters of process of stabilizing of working filters: temperatures of atmospheric air and duration of period of self-control of filters before weighing.

Key words: diesel engine, exhaust gases, disperse particles, working filters, accuracy of measuring

Полив'янчук А. **ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ КОНТРОЛЮ ВИКИДІВ ДИСПЕРСНИХ ЧАСТИНОК З ВІДПРАЦЬОВАНИМИ ГАЗАМИ ДИЗЕЛІВ**

Проведено оцінку методичної похибки вимірювань маси навішування дизельних твердих частинок, яка виникає з причини впливу на результат вимірювань параметрів процесу стабілізації робочих фільтрів: температури атмосферного повітря і тривалості періоду витримки фільтрів перед зважуванням.

Ключові слова: дизель, відпрацьовані гази, дисперсні частинки, робочі фільтри, точність вимірювань

Поливянчук А. **ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ КОНТРОЛЯ ВЫБРОСОВ ДИСПЕРСНЫХ ЧАСТИЦ С ОТРАБОТАВШИМИ ГАЗАМИ ДИЗЕЛЕЙ**

Проведена оценка методической погрешности измерений массы навески дизельных твердых частиц, которая возникает по причине влияния на результат измерений параметров процесса стабилизации рабочих фильтров: температуры атмосферного воздуха и продолжительности периода выдержки фильтров перед взвешиванием.

Ключевые слова: дизель, отработавшие газы, дисперсные частицы, рабочие фильтры, точность измерений

Introduction

The stabilization of the working filters before their being weighed is one of the stages of the certification procedure of measuring the normalized ecological index - the mass emission of particulates (PT) with the exhaust gases (EG) of the diesel engine [1-10]. At this stage the filters with the collected PT are held in a special chamber or a room during a certain time interval – τ_{st} at the designed temperature – t_{st}. The permissible ranges of these parameters are set down by normative documents: in testing diesel engines of cars (according to Rules R-83 [4]) - τ_{st} = 2 … 80 hour, t_{st} = 22±3 °C; in testing diesel engines of trucks and buses (according to Rules R-49 [5]) - τ_{st} = 2 … 36 hour, t_{st} = (20 … 30) ±6 °C.

The results of the research carried out by the leading firms producing the equipment for the ecological diagnostics of diesel engines show that the parameters of the stabilization process of the working filters - the values τ_{st} and t_{st} - influence the estimated values of the sample mass of PT – m_f, which results in the appearance of the methodical error in measuring the given value - δm^{st}_f [11-16]. Taking this error into account will enable one to reduce the uncertainty of measuring the value mf and to increase the accuracy of measuring mass emission of PT with EG of the diesel engine.

The problem stated

The aim of the research is to estimate the uncertainty of the result of measuring the sample mass of PT which appears as a result of its being influenced by the parameters of the stabilization processes of the working filters. The following problems have been solved to achieve the aim set:

1. The experimental data about the influence of the parameters τ_{st} and t_{st} on the value mf have been analyzed.

2. The methods of estimating the error δm^{st}_f have been developed.

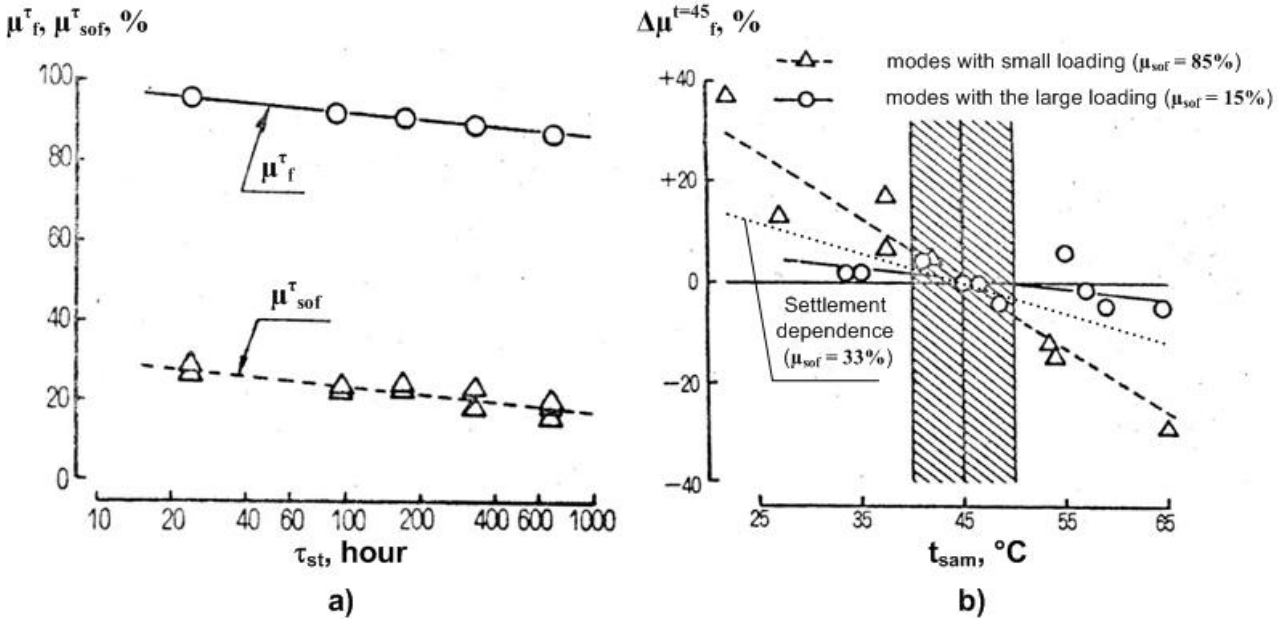
3. The recommendations for reducing the error δm^{st}_f have been given.

4. The uncertainty of the result of measuring the sample mass of PT during the certification tests of diesel engines of cars and trucks has been estimated.

The analysis of the experimental data

To estimate the influence of the parameters of the stabilization process of the working filters on the sample mass of PT, the results of the experimental research carried out by the firm Mitsubishi (fig. 1) [11] have been used.

The data presented in fig.1. a) testify to the reduction of the relative sample mass of PT- μ^{τ}_f with the increase of the duration of the stabilization period according to the logarithmic dependence. Such a change of the value μ^{τ}_f is caused by reducing the quantity of soluble organic fraction (SOF) due to the evaporation of hydrocarbons from the surface of PT [17-21].



a) the influence of τ_{st} on the relative sample mass of PT – μ^{τ}_f and SOF – μ^{τ}_{SOF};
b) the influence of the sample temperature before the filters t_{sam} on deviations $\Delta\ \mu^{\tau}_f$.

Fig. 1 – The experimental data about the uncertainty of results of measuring the sample mass of PT

Fig. 1,b) shows how the sample mass of PT is influenced by the temperature of the sample of the gas flowing through the filters for catching PT – t_{sam}. It can be considered that in the range $t_{sam} = 25\pm5°C$, $t_{sam} \approx t_{st}$. The experiment showed that in the modes with a small loading and a high content of SOF in PT the influence of the temperature t_{sam} on the sample mass of PT was more essential than in the modes with a large loading and a low content of SOF in PT.

Having executed the transition from the logarithmic scale of the value τ_{st} to the uniform one (see fig. 1 a)) we will obtain the value of the initial function $\mu^{\tau}_f(\tau_{st})$:

$$\mu_f^\tau = 100 - 5{,}15 \cdot \lg\left(\frac{\tau}{2}\right) \qquad (1)$$

Differentiating the given dependence we will obtain the expression for the speed of changing the relative sample mass of PT (fig. 2):

$$\frac{d\mu_f^\tau}{d\tau} = -2{,}24\frac{1}{\tau}. \qquad (2)$$

The analysis of the expressions (1) and (2) shows that the sample mass of PT measured at τ_{st} = 2 hour, decreases with the increase of the duration of the filters stabilization period : at τ_{st} = 10 hour – by 3,6 % (at a speed of 1,1 … 0,2 % / hour); at τ_{st} = 36 hour – by 6,4 % (at a speed of 0,2 … 0,06 % / hour); at τ_{st} = 80 hour – by8,2 % (at a speed of 0,06 … 0,03 % / hour). As this takes place, beginning with τ_{st} = 20 hours and more, the speed of reducing the sample mass of PT doesn't exceed 0,1 % / hour.

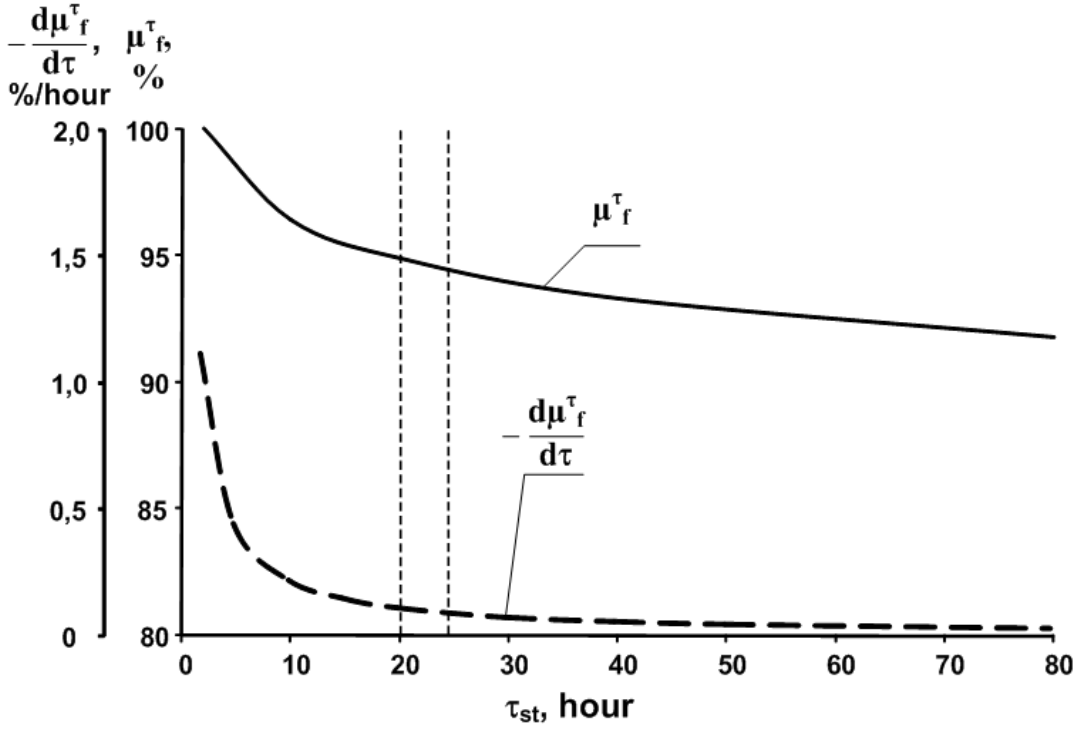


Fig. 2 – The initial function μτ f (τ_{st}) and its derivative

Using the data about the content of SOF in PT, obtained during the certification test of the diesel engine (see fig. 1 a) – μ_{sof} = 33 %), as well as the assumption about the proportionality of the value and the angular factor reflecting the influence of t_{sam} on $\Delta\,\mu^t_f$ (see fig. 1 b)), we will obtain the designed dependence for estimating the influence of temperature t_{sam} on the sample mass of PT:

$$\Delta\mu_f^{t=45} = k_{45} \cdot (t_{sam} - 45°C), \qquad (3)$$

where k_{45} = - 0,55 is the angular factor corresponding to μ_{sof} = of 33 % and to the temperature of comparison t_{sam} = 45°C.

The methods of estimating the uncertainty of the sample mass of pt

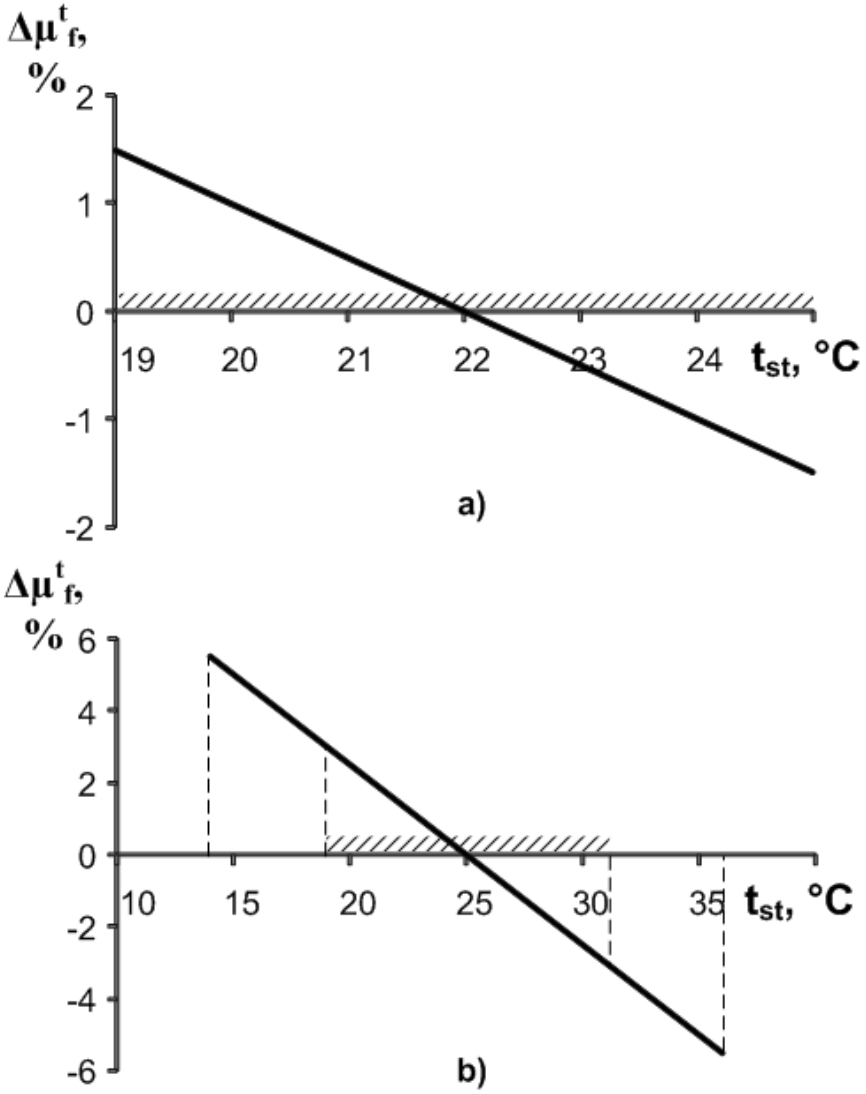
The methodical error of measuring the sample mass of PT is regarded as the sum of two components taking into account the influence of the duration and temperature of the filters stabilization process on m_f:

$$\delta m_f^{st} = \Delta\mu_f^\tau + \Delta\mu_f^t \qquad (4)$$

The value $\Delta\,\mu^\tau_f$ is calculated from the formula:

$$\Delta\mu_f^\tau = \mu_f^\tau - 100 = -5{,}15 \cdot \lg\frac{\tau}{2} \qquad (5)$$

To calculate the value $\Delta\,\mu^t_f$ the dependence (fig. 3) is used:



a) in the range t_{st} = 22±3 °; b) in the range t_{st} = (20 … 30) ±6 °C.

Fig. 3 – The influence of the temperature t_{st} on the sample mass of PT

$$\Delta\mu_f^t = k_{t0}(t - t_0), \qquad (6)$$

where k_{t0} is the proportionality factor; t_0 is the set temperature of the filters stabilization: according to the requirements of Rules R-83 it is 22°C; according to the requirements of Rules R-49 the working temperature is in the range 20 … 30°C.

The value of factor k_{t0} is calculated from the expression:

$$k_{t0} = \frac{k_{45}}{0{,}01 \cdot k_{45}(t_0 - 45) + 1}. \qquad (7)$$

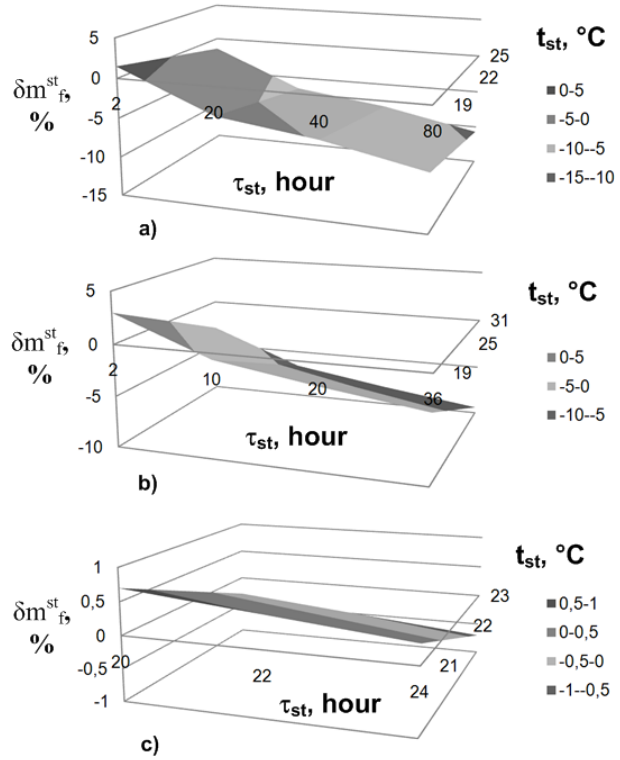
The authors' recommendations for reducing δm^{st}_f. The results of the research

The analysis of the experimental data obtained by the firm Mitsubishi shows that the error δm^{st}_f can be essentially reduced. For this purpose the authors of the article recommend to reduce the ranges of the parameters variations τ_{st} and t_{st} to the intervals: τ_{st} = 22±2 hour and t_{st} = 22±1 °C. The results of estimating the error δm^{st}_f by the method described above show that (fig. 4):

- when the values τ_{st} and t_{st} conform to the requirements of Rules R-83, the spread in the values of the sample mass of PT is 12,2%: δm^{st}_f = -10,7…1,5%;
- when the values τ_{st} and t_{st} conform to the requirements of Rules R-49, the spread in

the values of the sample mass of PT is 12,4 %: δm^{st}_f =-9,4 … 3,0 %;

- when the parameters τ_{st} and t_{st} vary in the recommended ranges, the spread in the values of the sample mass of PT is reduced by a factor of 8.8 and is equal to 1,4 %: δm^{st}_f =-0,7 … 0,7 %.



a) in testing cars (R-83); b) in testing trucks (R-49); c) in testing in accordance with the recommendations made.

Fig. 4 – The estimation of the methodical error δm^{st}_f:

Conclusions

1. The uncertainty of the result of measuring the sample mass of PT is as follows: in testing diesel engines of cars (the requirements of Rules R-83: τ_{st} = 2 … 80 hour, t_{st} = 22±3 °C) – 12,2 %; in testing diesel engines of trucks (the requirements of Rules R-49: τ_{st} = 2 … 36 hour, t_{st} = (20 … 30) ±6 °C) – 12,4 %.

2. As a result of the reduction of the permissible ranges of varying the temperature - t_{st} and the duration – τ_{st} of the stabilization process of filters to the intervals recommended by the authors (t_{st} = 22±1 °C and τ_{st} = 22±2 hour) the uncertainty of the result of measuring the sample mass of PT has been reduced to 1,4 %, i.e. by a factor of 8.8.

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