FEATURES OF DETERMINATION OF THE EFFICIENCY OF DEVICES FOR IMPROVEMENT OF ECOLOGICAL SAFETY LEVEL OF VEHICLES WITH RECIPROCATING ICE EXPLOITATION

This article describes the results of analysis and numerical study of prof. I.V. Parsadanov conversion formula as the one of relevant issues of the metrological features of determination of particulate matter mass hourly emission in exhaust gases flow of reciprocating internal combustion engine on the testing bench without dilution tunnel. Purpose of the study is detection of relationship between magnitudes of cleaning efficiency coefficients of particulate matter filter of diesel reciprocating internal combustion engine for unburned hydrocarbons volume concentration in exhaust gas flow and emission of particulate matters with using of conversion formula for whole diapason of changing of influencing factors. Object of the study is efficiency of operation of system of neutralization of legislative normalized pollutants in diesel internal combustion engine exhaust gases flow, namely particulate matter filter. Subject of the study is relationship between magnitudes of indicators that characterized object of the study which connected with each other by conversion formula. It was showed that the magnitudes of values of efficiency coefficients of operation of particulate matter filter of diesel reciprocating internal combustion engine for indicators of opacity and concentration of unburned hydrocarbons in exhaust gas which was obtained by direct measurements during bench motor tests and also mass hourly emission of particulate matter in exhaust gas flow which was obtained with using of the conversion formula, is not equal to each other for every individual operational regime of diesel engine. Calculation assessment and graphical illustration of relationship between magnitudes of this coefficients for unburned hydrocarbons volume concentration in exhaust gas flow and emission of particulate matter for whole diapason of changing of influencing factors was carried out. For the first time it was detected the differences between magnitudes of values of efficiency coefficients of particulate matter filter operation process of diesel internal combustion engine in pairs for mass hourly particulate matter emission with exhaust gases flow and opacity and toxicity of exhaust gases which connected with each other by conversion formula.

Key words: environment protection technologies; ecological safety; power plants; internal combustion engines; particulate matter emission; opacity; conversion formula; metrology; pollutants.

Introduction
In the 1st part of the study [1] was shown that the process of accident-free exploitation of power plants, namely vehicles, with reciprocating internal combustion engine (RICE), namely diesel, is characterized by certain indicators of its ecological safety level [1]. One of the main of legislative normalized indicators of that level is mass hourly emission of particulate matter (PM) in exhaust gas (EG) flow $G_{PM}$ in kg/h [2, 3]. The methodological basis of ensuring of necessary ecological safety level of the process is appropriate ecological safety management system (ESMS) that was developed and described in [2, 4]. The main manner for solving of the task is decreasing of magnitude of $G_{PM}$ by the way of processing of EG flow (neutralization), namely purification of EG flow from PM (filtration), and also the main instrument for such solving is diesel particulate matter filters (DPF) of different constructions [2]. Efficiency of functioning of ESMS should be assessed complexly with using of different known criteria based mathematical apparatuses [4, 5], which should takes into account the value of $G_{PM}$.

Problem statement
The value of $G_{PM}$ in accordance to normative documents should be obtained by experimental way thru using of gravimetric method and such measuring instruments as full- of partial-flow dilution tunnels [4, 5]. It should be noted that cost of such complexes of measuring instruments of foreign manufacturing are in range from two hundreds to two millions US dollars. But nowadays in Ukraine there are only two such complexes and only one of them are certificated. It means that the most of scientists who works within ICE field of knowledge such measuring instruments is not available.

In connection of worded above problem the widespread becomes the conversion formulas of different types that allows to converts the magnitudes of indicators of opacity (coefficient of weakening of light flux $N_0$ in %) and toxicity (volume concentration of unburned hydrocarbons $C_{CH}$ in ppm) of EG into the magnitudes of $G_{PM}$ value. Thus we are talking about the usage of readings of other measuring instruments that are more affordable and less expensive, namely opacimeters (around 2 thousand US dollars) and multicomponent gas analyzers (around 3 thousand US dollars). There are several known conversion formulas – Parsadanov [3], Alkidas [6], Muntean [7], MIRA [8], but the most widespread in Ukraine is the first of them.

The degree of purification of RICE EG flow from legislative normalized pollutant, namely PM, with using of aggregate of vehicle EG neutralization system, namely DPF, is characterized by magnitude of appropriate cleaning efficiency coefficient $K_{CE}$ [1, 2, 5]. In case when such device executes the purification of RICE EG flow from several pollutants simultaneously, albeit with different efficiency, than interest of scientific and technical kind is the task about relationship
between magnitudes of values of cleaning efficiency coefficients for different types of pollutants.

In case when the one ecological safety indicators of studied process forms the others and connected with each other by appropriate conversion formulas then worded above task takes the nature of methodical and instrumental errors [1, 2] what are the relevance of the study. Besides the additional relevance such to the study gives the results of intensive development of alternative energetic, namely solar energy technologies that based on photovoltaic converters which based on nanostructured semiconductor materials.

The data obtained by calculations using of observed conversion formula are in initial data set for executing of complex criteria-based assessment of ES level of accident-free exploitation process of power plants with PICE [4, 11].

**Purpose of the study**

Detection of relationship between magnitudes of cleaning efficiency coefficients of DPF for unburned hydrocarbons volume concentration in exhaust gas flow and PM mass hourly emission with using of conversion formula. *Object of the study* is efficiency of operation of system of neutralization of legislative normalized pollutants in diesel RICE EG flow, namely DPF. *Subject of the study* is relationship between magnitudes of indicators that characterized object of the study which connected with each other by conversion formula. *Tasks of the study* are the following. 1. Analysis of features of prof. I.V. Parsadanov conversion formula. 2. Determination of dependences of magnitudes of efficiency coefficients of DPF operation process from readings of measuring devices. 3. Calculated study of relationship between magnitudes of efficiency coefficients of DPF operation process for unburned hydrocarbons volume concentration in exhaust gas flow and PM mass hourly emission that connected with each other by conversion formula for different constant magnitudes of indicators of EG opacity. 4. Qualitative and quantitative analysis of the calculation study results.

**Analysis of publications**

In studies [2, 4] was developed ESMS of exploitation process of vehicle with PICE; in study [3] was proposed the conversion formula that developed based on results of analysis of data from certification tests of autotractor diesel engine SMD-31 on motor testing bench of Ricardo firm that equipped with full-flow dilution tunnel of AVL firm; in studies [4, 5] was investigated the certain metrological features of the conversion formula with using of mathematical apparatus of Pierson curves family; in studies [6 – 8] was proposed the other conversion formulas; in studies [9, 10] showed the experimentally obtained data about operational characteristics of DPF of nontraditional construction that used in this study as initial data for calculations and detects the differences in magnitudes of cleaning efficiency coefficients of DPF for opacity, emission of PM and unburned hydrocarbons in diesel RICE EG flow; in studies [4, 11] presented the results of calculation studies of certain aspects of application of complex fuel and ecological criterion for assessment of ES level of accident-free exploitation process of power plants with RICE, that operates with magnitudes of PM reduced effective mass hourly emissions obtained using the conversion formula. Other researches [13 – 21] are dedicated to close topic of the study scientific area.

The MIRA (The Motor Industry Research Association) conversion formula is described by formulas (1) – (3) [8].

\[
N = 100 \cdot (1 - \exp(-\varepsilon \cdot l \cdot C)), \%; \quad (1)
\]

\[
C_C = \ln(1 - N/100)/(\varepsilon \cdot l), \text{ g/m}^3; \quad (2)
\]

\[
\varepsilon = 3 \cdot d_v^4/(2 \cdot p \cdot d_l^2), \text{ m}^2/\text{g}; \quad (3)
\]

where \( C_C \) – PM volume concentration in EG flow, \( \varepsilon \approx 6,82 \text{ m}^2/\text{g} \) – specific coefficient of light flux transmittance; \( p \approx 1 \text{ g/m}^3 \) – PM density; \( d_v = 0,1 \times 10^{-6} \text{ m} \) – PM equivalent projective diameter; \( d_l \approx 0,13 \times 10^{-6} \text{ m} \) – PM equivalent volume diameter.

A.C. Alkidas’ conversion formula has the following form [6]:

\[
C_C = 565 \cdot (\ln(10/(10 – BSU)))^{0.206}, \text{ mg/m}^3; \quad (4)
\]

where BSU – EG flow opacity of Bosch scale.

G.G. Munteanu’s conversion formula [7]:

\[
C_C = (-184 \cdot BSU - 727.5) \cdot \ln(10 – BSU/10), \text{mg/m}^3. \quad (5)
\]

Ratio between measurement units of EG flow opacity for the Hartridge scale HSN and the Bosch scale BSU describes formula (6) [5].

\[
HSN = -2.64 \cdot 10^{-4} \cdot BSU^2 + \\
+ 0.111642 \cdot BSU - 1.023 \cdot 10^{-3}. \quad (6)
\]

**Analysis and calculated investigation of prof. I.V. Parsadanov conversion formula**

The said conversion formula that described in monograph [3] and was transformed in this study for greater clarity has the following form.

\[
G_{rpm} = (a \cdot N_D + b \cdot N_D^2 + c \cdot C_{CH} + d \cdot C_{CH}^2) \cdot k, \text{ kg/h}; \quad (7)
\]

\[
a = 2.3 \cdot 10^{-3} \text{ kg/(h\%)}; \quad b = 5.0 \cdot 10^{-5} \text{ kg/(h\%^2)};
\]

\[
c = 0.145 \cdot f, \text{ kg/(h/ppm)}; \quad d = 0.33 \cdot f^2 \text{ kg/(h/ppm^2)};
\]

\[
f = 4.78 \cdot 10^{-3} \cdot (G_{air} + G_f);
\]

\[
k = 10^{-3} \cdot (0.7734 \cdot G_{air} + 0.7239 \cdot G_f), \text{ kg/h}. \quad (9)
\]

where \( G_f \) and \( G_{air} \) – mass hourly fuel and air consumption of PICE, kg/h.

In accordance with results of motor bench tests of
autotractor diesel engine 2Ch10.5/12 exhaust system of which equipped with DPF that given in studies [9, 10] for specific points of RICE operational regimes field we can conclude the following points (see Table 1). Magnitude of the value \( N_D \) changes in the range from 20% (regime of minimal idle – regime A) to 70% (regime of maximal torque – regime C); magnitude of the value \( C_{CH} \) changes in the range from 70 ppm (regime of nominal power – regime B) to 210 ppm (regime A); magnitudes of the values \( K_{CE}(G_{PM}) \), \( K_{CE}(N_D) \) and \( K_{CE}(C_{CH}) \) are not equal each other for the same steady PICE operational regimes (points of RICE operational regimes field); magnitudes of the values \( N_D \) and \( C_{CH} \) has nonlinear impact on magnitude of the value \( G_{PM} \) because in formula (7) these values are both in the first and in the second degree; magnitude of the value \( N_D \) in the range that observed on motor test bench has much more significant impact on the value \( G_{PM} \) than the magnitude of value \( C_{CH} \). Equation (7) is illustrated on Fig. 1 in form of isolines family with constant magnitudes of influencing factors.

Analysis of relationship between magnitudes of operation efficiency coefficients of DPF for unburned hydrocarbons volume concentration in EG flow and PM emission

The data that experimentally obtained during bench motor tests of operational characteristics of DPF which was developed with the participation of the author of this study showed in studies [9, 10] and was used in the study as initial data.

![Fig. 1. Isolines of dependences of magnitude of mass hourly PM emission in PICE EG flow \( G_{PM} \) from the magnitudes of values coefficient of weakening of light flux \( N_D \) and volume concentration of unburned hydrocarbons in EG flow \( C_{CH} \)](image)

![Table 1. Parameters of operation of 2Ch10.5/12 diesel engine and DPF for specific operations regimes](table)

| Parameter | \( n_{is} \) | \( M_T \) | \( N_c \) | \( G_{inst} \) | \( G_{int} \) | \( \Delta P_{DFP} \) | \( \Delta G_{inst} \) | \( N_D \) | \( C_{CH} \) | \( G_{PM} \) | \( K_{CE}(N_D) \) | \( K_{CE}(C_{CH}) \) | \( K_{CE}(G_{PM}) \) |
|-----------|------------|-----------|---------|-------------|-------------|----------------|----------------|--------|--------|-------|----------------|----------------|----------------|---------------|
| Measur. units | rpm | Nm | kW | kg/h | kg/h | kPa | % | % | ppm | g/h | % | % |
| Regime A (min idle) | 800 | 0,0 | 0,0 | 0,493 | 48,8 | 1,046/5,230" | 1,03/5,15" | 19,1 | 210 | 2,6 | 28,3/53,4" | 14,1/27,5" | 32,5/60,1" |
| Regime B (nom. \( N_c \)) | 1800 | 95 | 17,9 | 4,321 | 109,1 | 3,844/19,220" | 0,73/5,40" | 38,9 | 72 | 14,7 | 33,7/56,8" | 7,9/22,3" | 43,5/66,5" |
| Regime C (max \( M_T \)) | 1200 | 110 | 13,8 | 3,593 | 72,3 | 2,283/11,415" | 1,08/3,65" | 67,6 | 105 | 22,7 | 62,0/75,3" | 9,3/23,4" | 75,5/85,5" |

Notation: * marks the parameters of DPF that is not filled by PM at all (at the beginning of the DPF interregeneration period); ** marks the parameters of DPF that is completely filled by PM (at the end of the DPF interregeneration period)

Under the term “DPF operational efficiency coefficient for opacity, PM and unburned hydrocarbons emission” we understand the values that described by formulas (10) – (12).
cases of PICE exhaust system of which equipped and not equipped with DPF respectively.

From the results of analysis of data from studies [9, 10, 12] we can conclude the following points (see Table 1). Studied DPF improves simultaneously indicators of EG opacity ($N_D$) and EG toxicity ($C_{CH}$), but together with declination of indicators of PICE fuel efficiency – from 0.73 % (regime B) to 1.08 % (regime C) at the beginning of the DPF interregeneration period (*) and from 3.65 % (regime B) to 5.40 % (regime C) at the end of the DPF interregeneration period (**) because it has the hydraulic resistance – from 1.046 kPa (regime A*) to 3.844 kPa (regime B*) and from 5.230 kPa (regime A**) to 19,220 kPa (regime B**). Magnitude of the value $K_{CE}(G_PM)$ changes in the range from 32.5 % (regime A*) to 75.5 % (regime C*) and from 60.1 % (regime A**) to 85.5 % (regime C**). Magnitude of the value $K_{CE}(N_D)$ changes in the range from 28.3 % (regime A*) to 62.0 % (regime C*) and from 53.4 % (regime A**) to 75.3 % (regime C**). Magnitude of the value $K_{CE}(C_{CH})$ changes in the range from 7.9 % (regime B*) to 14.1 % (regime A*) and from 22.3 % (regime B**) to 27.5 % (regime A**).

Magnitude of the value $G_PM$ changes in the range from 2.6·10^{-3} kg/h (regime A) to 22.7·10^{-3} kg/h (regime C).

Dependences of magnitudes of the values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ from magnitude of the value $C_{CH,ICE}$ at invariant magnitude of the value $C_{CH,DPF}$ for different diapasons of values of readings of gas analyzer is presented on Fig. 2.

On the Fig. 2 it can be seen that magnitude of the values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ in case of invariant values of readings of gas analyzer and presence of DPF $C_{CH,DPF}$ are depends from the values of readings of gas analyzer and absence of DPF $C_{CH,ICE}$ nonlinearily and also curvature of them decreases almost to zero due to decreasing of the value $C_{CH,DPF}$ as well as difference between magnitudes of the values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ that also increase due to increasing of value $C_{CH,ICE}$.

On the Fig. 3 there are curves of dependences of relationship between magnitudes of values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ from magnitudes of values $N_D,ICE$ (readings of gas analyzer) at constant magnitude of value $N_D$ (readings of opacimeter) that averaged on the step $\Delta C_{CH} = 10\%$ for whole diapasons of change of magnitude of influencing factors $C_{CH,ICE} = 0 – 5000$ ppm and $N_D = 0 – 100\%$.

Also on Fig. 3 showed the dependence of value of ratio $\Delta C_{CH}/C_{CH}$ from value $C_{CH,ICE}$.

Fig. 2. Dependences of magnitudes of the values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ from magnitude of the value $C_{CH,ICE}$ at invariant magnitude of the value $C_{CH,DPF}$ for different diapasons of values of readings of gas analyzer

On the Fig. 4 there are curves of dependences of relationship between magnitudes of values $K_{CE}(G_PM)$ and $K_{CE}(C_{CH})$ from magnitudes of values $C_{CH,ICE}$ at constant magnitude of value $N_D = 0$ ppm and constant magnitude of value $C_{CH,DPF}$ and $C_{CH} = 0 – 500$ ppm.

Thus, the Fig. 2 shows, that magnitudes of value $K_{CE}(C_{CH})$ always less than magnitudes of value $K_{CE}(G_PM)$. It means that in the case of assessment of DPF operational efficiency with using of the magnitudes of value $K_{CE}(C_{CH})$ such efficiency will always be under-valued in comparison with the case of using of magnitudes of value $K_{CE}(G_PM)$. The magnitude of such effect depends from magnitudes of value $C_{CH,ICE}$ (there is direct correlation) as well as from magnitudes of value $C_{CH,DPF}$ (there is reverse correlation). The qualitative aspects of that effect which was determined on the Fig. 2 can be assessed quantitatively based on data showed on the Fig. 3. It can be seen that the magnitude of such effect depends from magnitudes of value $N_D$ and reaches of its maximum 135 % at $N_D = 0\%$, $C_{CH,ICE}$
= 500 ppm and also $K_{CE}(C_{CH}) = \Delta C_{CH} = 10$ ppm. On the Fig. 3 can be seen that magnitude of ratio of coefficients $K_{CE}(G_{PM})/K_{CE}(C_{CH})$ on every selected step $\Delta C_{CH} = C_{CH,ICE} - C_{CH,DPF} = 10$ ppm has nonlinear dependence from magnitudes of the value of $C_{CH,ICE}$ and increase with it at any magnitudes of the value $N_D$.

The border curve at $N_D = 0 \%$ is not contain the points with magnitudes less than 1.0 and maximum value 1.35 the observed ratio reaches at $C_{CH,ICE} = 500$ ppm and then “go on the shelf”. Curvature of isolines decreases with increasing of magnitude of the value $N_D$ and at $N_D = 25 \%$ comes to naught and then change the sign. Influence of magnitudes of the value $N_D$ on magnitudes of the value observed ratio until $N_D = 15 \%$ with increasing of magnitudes of the value $C_{CH,ICE}$ up to 250 ppm are growing and at $N_D > 55 \%$ on the contrary − decreases; and when $C_{CH,ICE} > 250$ ppm the picture changes to the opposite. When $N_D > 0 \%$ the observed ratio can take on values that less than 1.0 at with well-defined magnitudes of the value $C_{CH,ICE}$.

The coordinates of the points of equality of magnitudes of the values $K_{CE}(G_{PM})$ and $K_{CE}(C_{CH})$, that is $C_{CH,ICE}$ and $N_D$, has direct correlation together. From certain magnitude of the value $N_D$ (about 30 \%) the value of observed ratio $K_{CE}(G_{PM})/K_{CE}(C_{CH})$ never has magnitudes more than 1.0. The curve $dx/x$ on the Fig. 3 reflexes the value of ratio $\Delta C_{CH}/C_{CH,ICE}$ and is the relative value of contribution of selected step of decreasing of absolute value of toxicity of EG flow with using of
Development of technology for assessment of magnitudes of values of operation efficiency of DPF of any construction existence of RICE EG efficiency and safety of nanotechnology products. The research was carried out in the science and research work of Applied Mechanics and Environment Protection Technologies Department of National University of Civil Defence of Ukraine «Using of fuzzy logic and psychophysical scales in a critical assessment of the level of ecological safety» (State Reg. № 0119U 001001, 2019 – 2021) and also Scientific work of young scientists that carried out at the expense of state budget of Ukraine of Berdyansk State Pedagogical University «Development of technology for assessing the quality and safety of nanotechnology products throughout the life cycle» (State Reg. № 0117U 003860, 2017 – 2020).

Conclusions

Thus, in this study were analyzed and numerical investigated the conversion formula of prof. I.V. Parsadanov about the influence of indicators of RICE EG opacity and toxicity on magnitude of value of PM mass hourly emission in diesel engine EG flow.

It was showed that the magnitudes of values of efficiency coefficients of operation of DPF of diesel RICE for indicators of opacity and concentration of unburned hydrocarbons in EG which was obtained by direct measurements during bench motor tests by opacimeter and gas analyzer and also for mass hourly emission of PM in EG flow which was obtained with using of the conversion formula, is not equal to each other for every individual operational regime of diesel engine. Calculation assessment and graphical illustration of relationship between magnitudes of this coefficients for concentration of unburned hydrocarbons in EG flow and mass hourly emission of PM in EG flow for whole diapason of changing of influencing factors was carried out.

It should be noted that for the first time it was detected the differences between magnitudes of values of efficiency coefficients of DPF operation process of diesel RICE in pairs for mass hourly PM emission with EG flow and opacity and toxicity of EG which connected with each other by conversion formula. Also for the first time it was carried out qualitative and quantitative assessed detected effect for whole diapason of changing of influencing factors – indicators of opacity and toxicity of EG of diesel RICE on its operation regimes field.

In terms of prospects of practical application of the obtained results the worded above conclusions shows that basing on the detected effect it is possible to substantiate the using for assessment of efficiency of operation process of DPF of any construction exactly mass hourly PM emission with EG flow even if its magnitudes calculated obtained by using of conversion formula but not by direct measurements with using of gravimetric method. Also it becomes clear that dasing on the results of qualitative and quantitative assessment of detected effect it is possible to develop the methodic of determination of appropriate part of methodical error at assessment of operation efficiency of DPF of any construction.

References:

1. Kondratenko O.M. Investigation of relationship between coefficients of operation efficiency of DPF of diesel ICE with using of conversion formula. Part 1: Particulate matter emission and opacity / O.M. Kondratenko // Двигатели внутреннего сгорания. – 2018. – № 1. – С. 63–69, DOI: 10.20998/0419-8719.2018.1.09. 2. Сучасні способи підвищення екологічної безпеки експлуатації енергетичних установок: монографія / С.О. Валбьоль, О.П. Сіровок, В.В. Валбьоль, О.М. Кондратенко. – Х.: Стиль-Іздат (ФОП Броній О.В.), 2015. – 212 с. 3. Пасєдраців І.В. Підвищення якості і конкурентоспроможності дизелей на основі комплексного паливо-екологічного критерію: монографія / І.В. Пасєдраців. – Х.: Центр НТУ «ХПІ», 2003. – 244 с. 4. Criteria based assessment of ecological safety level of exploitation process of power plants: Monograph / S.O. Vambol, V.V. Vambol, O.M. Kondratenko, I.V. Mischchenko. – Х.: Стиль-Іздат (ФОП Броній О. В.), 2018. – 320 s. 5. Kondratenko O.M. Metrological aspects of complex criteria-based assessment of ecological safety level of exploitation of reciprocating engines of power plants: Monograph / O.M. Kondratenko. – Х.: Стиль-Іздат (ФОП Броній О.В.), 2019. – 532 c. 6. Alkidas A.C. Relationship between smoke measurements and particulate measurements / A.C. Alkidas. – SAE Technical Paper Series, № 840412, 1984. – С. 10–21. 7. Muntean G.G. A theoretical model for the correlation of smoke number to dry particulate concentration in diesel exhaust / G. G. Muntean. – SAE paper, № 1999-01-0515, 1999. – 9 с. 8. Hardenberg, H., Albrecht, H. Grenzen der Rauchmassenmessung aus optischen Transmssungen // MTZ: Motortech. Z. 1987. – 482. – С. 51–54. 9. Mathematical model of efficiency of diesel particulate matter filter / O.M. Kondratenko, O.P. Strokov, S.O. Vambol, A.M. Avramenko // Scientific Bulletin of NMU. – 2015. – Issue 6 (150). – С. 55–61. 10. Assessment of improvement of ecological safety of power plants by arrangement of pollutants neutralization system / S. Vambol, V. Vambol, O. Kondratenko, Y. Suchikova, O. Hurenko // Eastern-European Journal of Enterprise Technologies. – 2017 – № 3/10 (87). – С. 63–73.
11. Kondratenko O.M. Selection of criterial apparatus for complex assessment of ecological safety level of exploitation process of power plants / O.M. Kondratenko // Technogenic and Ecological Safety. – 2018. – Issue 3 (1/2018). – C. 75–84. DOI: http://doi.org/10.5281/zenodo.1182858.

12. Criteria based assessment of the level of ecological safety of exploitation of electric generating power plant that consumes biofuels / O. Kondratenko, I. Mishchenko, G. Chernobay, Yu. Derkach, Ya. Suchikova // Book of Papers of 2018 IEEE 3rd International Conference on Intelligent Energy and Power Systems (IEPS-2018), 10–14 September 2018. – Kharkiv, NTU "KhPI". – C. 185–189. DOI: 10.1109/IEPS.2018.8559570. 13. Evaluation of power indicators of the automobile engine / H.A. Dhadah W.H. Alawee, A. Marchenko, D. Klets, O. Akimov // International Journal of Engineering and Technology. – 2018. – No 7(4.3). – C. 130–134. DOI: 10.14419/ijet.v7i4.3.19722.

14. Increasing the efficiency of intra-cylinder catalysis in diesel engines / I.V. Parsadanov, N.D. Sakhlenko, M. V. Vedel, I.V. Rykova, V.A. Khlyzhiyak, A.V. Karakurchi, A.S. Gorokhivskiy // Voprosy Khimi i Khimicheski Tekhnologii. – 2017. – No 6. – C. 75–81. 15. Samoilenko D. An alternative method of variable geometry turbine adjustment: A comparative evaluation of alternative method and nozzle ring adjustment / D. Samoilenko, A. Marchenko, A. Prokhorenko // Proceedings of 20th International Conference Transport Means 2016. – 2016. – Issue 2. – C. 517–521. 16. Samoilenko D. Improvement of torque and power characteristics of V-type diesel engine applying new design of Variable geometry turbocharger (VGT) / D. Samoilenko, A. Marchenko, H.M. Cho // Journal of Mechanical Science and Technology. – 2017. – Vol 31, Issue 10. – C. 5021–5027. DOI: 10.1007/s12206-017-0950-2. 17. Substantiation of expedience of application of high-temperature utilization of used tires for liquefied methane production / S. Vambol, V. Vambol, O. Kondratenko, V. Koloskov, Y. Suchikova // Journal of Achievements in Materials and Manufacturing Engineering. – 2018. – Vol. 87, Issue 2. – C. 77–84. DOI: 10.5604/01.3001.0012.2830. 18. Investigation of the ecological safety level of exploitation process of power plants / O.M., Mishchenko, I. Chernobay, Derkach, Yu., SuchikovaYa. (2018), “Criteria based assessment of the level of ecological safety of exploitation of electric generating power plant that consumes biofuels”, Book of Papers of 2018 IEEE 3rd International Conference on Intelligent Energy and Power Systems (IEPS-2018), 10–14 September, Kharkiv, Publ. NTU “KhPI”, 532 p. 19. Mun- tesan, G.G. (1999), “A theoretical model for the correlation of smoke number to dry particulate concentration in diesel exhaust gas”, No 1999-01-0515, 9 p. 9 p. Hardenberg, H., Albreht, H. (1987), “Grenzen der Rauchmassbestimmung aus optischen Transmissionsmessungen - MTZ. Motortechnik. Z. 4/2, 51–54. 13. Kondratenko, O.M., Strokov, O.P., Vambol, S.O., Avramenko A. M. (2015), “Mathematical model of efficiency of diesel particulate matter filter”, Scientific Bulletin of NMU, Issue 6 (150), pp. 55–61, URL: http://reposistc.nuca.edu.ua/handle/123456789/2227. 14. Vambol S., Vambol, V., Kondratenko, O., Suchikova, Y., Hurenko, O. (2017), “Assessment of improvement of ecological safety of power plants by power engines”, International Journal of Engineering and Electrical Safety, Issue 3 (1/2018), pp. 75–84. DOI: 10.5281/zenodo.1182858. 15. Kondratenko, O. Mishchenko, I. Chernobay, Derkach, Yu., SuchikovaYa. (2018), “A comparative evaluation of the level of ecological safety of exploitation of electric generating power plant that consumes biofuels”, Book of Papers of 2018 IEEE 3rd International Conference on Intelligent Energy and Power Systems (IEPS-2018), 10–14 September, Kharkiv, Publ. NTU “KhPI”, pp. 185–189. URL: www.ieps. org.ua, DOI: 10.1109/IEPS.2018.8559570. 20. Dhadah H.A., Alawee W.H., Marchenko A., Klets D., Akimov O. (2018), “Evaluation of power indicators of the automobile engine”, International Journal of Engineering and Technology, No 7(4.3), pp. 130–134. DOI: 10.14419/ijet.v7i4.3.19722. 21. Parsadanov I.V., Sakhlenko N.D., Vedel M.V., Rykova I.V., Khlyzhiyak V.A., Karakurchi A.V., Gorokhivskiy A.S. (2017), “Increasing the efficiency of intra-cylinder catalysis in diesel engines”, Voprosy Khimi i Khimicheski Tekhnologii, No 6, pp. 75–81. 22. Samoilenko D., Marchenko A. and Prokhorenko A. (2016), “An alternative method of variable geometry turbine adjustment: A comparative evaluation of alternative method and nozzle ring adjustment”, Proceedings of 20th International Conference Transport Means 2016, Issue 2, pp. 517–521. 23. Samoiled, O., Marchenko A., Chomo M.H. (2017), “Improvement of torque and power characteristics of V-type diesel engine applying new design of Variable geometry turbocharger (VGT)”, Journal of Mechanical Science and Technology, Vol. 31, Issue 10, pp. 5021–5027. DOI: 10.1007/s12206-017-0950-2. 24. Vambol S., Vambol, V., Kondratenko O., Koloskov V., Suchikova Y. (2018), “Investigation of efficiency of application of high-temperature utilization of used tires for liquefied methane production”, Journal of Achievements in Materials and Manufacturing Engineering, Vol. 87, Issue 2, pp. 77–84. DOI: 10.5604/01.3001.0012.2830. 25. Vambol S., Vambol, V., Sobyna V., Koloskov V., Poberezhnyi I. (2018), “Investigation of efficiency of waste utilization technology, with considering the use of
Кондратенко Олександр Микоолович – Cand.Sc.(Tech.), Docent of Applied Mechanics and Environment Protection Technologies Dep., National University of Civil Defence of Ukraine, Kharkiv, Ukraine, e-mail: kongratenko2016@gmail.com, http://orcid.org/0000-0001-9687-0454, Scopus ID: 57144373800.

Chernobay Gennadiy Olexandrovych – Cand.Sc.(Tech), Docent, Docent of Applied Mechanics and Environment Protection Technologies Dep., Docent of Applied Mechanics and Environment Protection Technologies Dep., National University of Civil Defence of Ukraine, Kharkiv, Ukraine.

Деркач Юрий Федорович – Cand.Sc.(Phys.-Math.), Senior Researcher, Lecturer of Applied Mechanics and Environment Protection Technologies Dep., National University of Civil Defence of Ukraine, Kharkiv, Ukraine.

Коваленко Світлана Андріївна – Lecturer of Applied Mechanics and Environment Protection Technologies Dep., National University of Civil Defence of Ukraine, Kharkiv, Ukraine.

ОсОБИлЬСТІ ВИЗНАЧЕННЯ ЕФЕКТИВНОСТІ ПРИСТРОЙІВ ДЛЯ ПОКАРАННЯ РІВНЯ ЕКОЛОГІЧНОЇ БЕЗПЕКИ ЕКСПЛЮТАЦІЇ ТРАНСПОРТНИХ ЗАСОБІВ З ПОРШНІВНИМ ДВЗ

Проаналізовано і розраховано формулу перерахунку проф. І.В. Парсаданова як одного з актуальніших питань метрологічних особливостей процесу отримання значень масового годинного викиду твердих частинок поршневого двигуна внутрішнього згоряння на моторному випробувальному стенду, не обладнаному тунелем розведення. Метою дослідження є виявлення співвідношення значень коефіцієнтів ефективності роботи фільтру твердих частинок дизельного поршневого двигуна внутрішнього згоряння з викидами твердих частинок та концентрацією негорілих вуглеводнів у відпрацьованих газах із застосуванням формул перерахунку для відстаней відмінності значень випливаючих факторів. Об’єктом дослідження є ефективність функціонування системи нейтRALізації законодавчо нормованих поллютантов у відпрацьованих газах дизельного двигуна внутрішнього згоряння, а саме фільтра твердих частинок.

ОсОБЕННОСТІ ОПРЕДЕЛЕНИЯ ЭФФЕКТИВНОСТИ УСТРОЙСТВ ДЛЯ УЛУЧШЕНИЯ УРОВНЯ ЭКОЛОГИЧЕСКОЙ БЕЗОПАСНОСТИ ЭКСПЛУАТАЦИИ ТРАНСПОРТНЫХ СРЕДСТВ С ПОРШНЯМИ ДВС

Кондратенко О. М., Черновой Г. О., Деркач Ю. Ф., Коваленко С. А.

Проанализирована и расчетно исследована формула пересчета проф. И.В. Парсаданова как одного из актуальных вопросов метрологических особенностей процесса получения значений массового часового выброса твердых частиц поршневым двигателем внутреннего сгорания на моторном испытательном стенде, не оборудованном тунNELем разведения. Меткой доследження является выявление соотношения значений коэффициентов эффективности работы фильтра твердых частиц дизельного поршневого двигателя внутреннего сгорания по выбросу твердых частиц и концентрации несгоревших углеводородов в отработавших газах с применением формулы пересчета для всего диапазона изменения значений впливающих факторов. Объектом исследования является эффективность функционирования системы нейтрализации законодательно нормированных поллютантов в потоке отработавших газов дизельного двигателя внутреннего сгорания, а именно фильтра твердых частиц. Предметом исследования является взаимосвязь между значениями показателей, характеризующих объект исследования, связанные между собой формулой пересчета. Показано, что значения коэффициентов эффективности работы фильтра твердых частиц дизельного двигателя внутреннего сгорания по показателям дымности и концентрации несгоревших углеводородов в отработавших газах, полученные прямыми измерениями при стендовых моторных исследованиях, а также массового часового выброса твердых частиц с потоком отработавших газов, полученные по уточнённой формуле пересчета, не совпадают для каждого стендового режима работы двигателя. Расчетно оценено и пропиллюстрировано графически соотношение значений этих коэффициентов по концентрации несгоревших углеводородов в отработавших газах и выбросу твердых частиц для всего диапазона влияющих факторов.

ISSN 0419-8719 ДВИГАТЕЛИ ВНУТРЕННЕГО СГОРАНИЯ 2’2019
А.П. Полив'ячук, І.В. Парсаданов, О.П. Строков, О.І. Каслін, О.О. Скурідіна

СТВОРЕННЯ НА БАЗІ МІКРОТУННЕЛА УНЕСЕРВІАЛЬНОЇ СИСТЕМИ ЕКОЛОГІЧНОГО ДІАГНОСТУВАННЯ ТРАНСПОРТНИХ ДВИГУНІВ І КОТЕЛЕНЬ

Наведено опис експериментального зразка універсальної системи екологічного діагnostування транспортних двигунів і котельних установок, розробленого фахівцями Харківського національного університету міського господарства ім. О.М. Бєкетова і Національного технічного університету «Харківський політехнічний інститут». Відзначено відмінні властивості цієї системи: універсальність, багатофункціональність, компактність, мобільність, простота в експлуатації, високі ступінь автоматизації та інформативність одержуваних результатів, можливість використання в науково-дослідній та у навчальної сферах. Розглянуто: структуру, склад та функціональні можливості основних модулів цієї системи: 1) вимірювального, що включає в себе пробовідбірний пристрій – мікротунель МКТ-2, прилади для обліку для безпосереднього контролю показників хімічного і фізичного забруднення навколишнього середовища; 2) тестувальномоделювання, що складається з автономної установки для дослідження аеродинамічних процесів у відкритих системах двигунів і димових трубах котельних, лабораторної стійки демонстраційного, що складається з приладів та обладнання для безпосереднього аналізу проб, відібраних в ході екологічних досліджень натурних об’єктів. Систематизовані методи і методики, що дозволяють визначати и аналізувати показники, що характеризують хімічні і фізичні забруднення навколишнього середовища транспортними двигунами і котельними. Представлені результати експериментального відпрацювання вимірювальної системи на натурних об’єктах: дизельному двигуну ВАЗ-21081, автотракторному дизелю - 4ЧН12/14, газових котлах - ДКВР-20/13, АОГВ-100Е, твердою теплову системою - КУ-М-2М-4. Випробування підтвердили практичну придатність створеної вимірювальної системи.

Ключові слова: транспортні двигуни; котельні установки; забруднюючі речовини; екологічне діагностування; універсальна система; мікротунель; експериментальне відпрацювання.

Вступ

Екологічність є одним з найбільш важливих показників якості сучасних транспортних двигунів (ТД) і котельних установок (КУ), що обумовлено значним негативним впливом хімічного та фізичного характеру цих об’єктів на довкілля. Сумарна частина у забруднення атмосферного повітря міського середовища комунальних КУ та транспортними ДВЗ досягає 90%. Систематичні викиди забруднюючих речовин з димовими газами котельних відпрацюваних газам двигунів призводять до погіршення показників якості навколишнього середовища (НС), підвищення канцерогенної небезпеки та виникнення регіональних і глобальних екологічних проблем. У зв’язку з цим створення систем екологічного діагностування ТД і КУ, які дозволяють ефективно оцінювати вплив цих об’єктів на довкілля, є актуальним напрямком дослідження.

До найбільш значимих властивостей систем екологічного діагностування ТД і КУ слід віднести:

– універсальність – можливість використання на моторних і безмоторних випробувальних станах, натурних об’єктах, різних за типом, призначенням, габаритами;
– багатофункціональність – можливість одночасного визначення екологічних показників, які характеризують хімічні та фізичні забруднення навколишнього середовища, зокрема масові і питомі викиди в атмосферу забруднюючих речовин і парникових газів з димовими газами (ДГ) котельних і відпрацьованими газами (ВГ) двигунів, акустичні й теплові забруднення, коливання, вібрації, ін.;
– забезпечення регламентованої точності вимірювань при меншій, ніж у аналогів, вартості обладнання;
– компактність, мобільність та зручність у експлуатації;
– забезпечення можливості тривалої автономної роботи без використання електричних мереж;
– висока інформативність отриманих результатів;
– інноваційність впроваджених технологічних та технічних рішень;