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METHOD FOR COMPATIBLE CONSIDERATION OF MOTOR FUEL VAPOR AND THERMAL ENERGY EMISSIONS DURING CRITERIA-BASED ASSESSMENT OF THE ECOLOGICAL SAFETY LEVEL OF EXPLOITATION OF RECIPROCATING ICE OF FIRE-FIGHTING AND EMERGENCY-RESCUE EQUIPMENT IN CONDITIONS OF ARMED AGGRESSION

The study is aimed at improving the method for compatible consideration of motor fuel vapor and thermal energy emissions during complex criteria-based assessment of the ecological safety level of exploitation of power plants with reciprocating ICE, namely firefighting and emergency-rescue vehicles units, taking into account the realities of the functioning of the divisions and institutions of the SES of Ukraine in conditions of armed aggression and in the perspective of the post-war reconstruction of critical infrastructure and the economy of our country. The object of the study is the ecological safety level of the exploitation process of power plants with reciprocating ICE, in particular firefighting and emergency-rescue vehicles units of the institutions and divisions of the SES of Ukraine, considering the negative technogenic impact of compatible thermal energy of motor fuel vapor and thermal energy emissions into environment. The subject of the study is contribution to the numerical values of the indicators of the object of the study of the compatible thermal energy motor fuel vapor and thermal energy emissions into the environment. The scientific novelty of the research results is that the method for compatible consideration of the emission of thermal energy and motor fuel vapor emissions from fuel tank into the environment from power plants with reciprocating ICE, in particular firefighting and emergency-rescue vehicles units, in a complex criteria-based assessment of the indicators of the ecological safety level during their exploitation has been further developed. The practical significance of the research results consists is providing a quantitative and qualitative assessment of the studied effects and developing technical solutions and organizational measures on this basis to reduce or eliminate them by developing an appropriate environment protection technology with executive devices on the methodological basis of the ecological safety management system.

Keywords: *environmental protection technologies, ecological safety, power plants, firefighting and emergency-rescue vehicles, reciprocating internal combustion engines, fuel vapors, thermal pollution, complex criteria-based assessment, armed aggression, post-war reconstruction.*

Relevance of the study

The relevance of the research presented in this article is driven by several important considerations. To provide a comprehensive assessment of the ecological safety (ES) level during the exploitation of power plants (PP) equipped with reciprocating internal combustion engines (RICE) [1], which include fuel tanks, it is appropriate to use the mathematical apparatus of the complex fuel-ecological criterion (K_{fe}) developed by Prof. Parsadanov (NTU «KhPI», Kharkiv, Ukraine), as outlined in [2] and further improved in [3].

A hierarchically structured classifier of ES factors [3], where the source is the RICE within the PP, namely units of firefighting and emergency-resque vehicles (FERV) of divisions and institutions of the State Emergency Service (SES) of Ukraine, during its exploitation, includes not only the emissions of legally regulated pollutants with exhaust gases (EG) flow but also the consumption of motor fuel as a non-renewable energy resource (a product of mineral processing), and the emission of fuel vapors caused by the phenomena of small (SBR) and large (LBR) breathing of the fuel tanks as well as the emissions of thermal energy.

However, in the structure of ES factors considered by the original K_{fe} criterion mathematical apparatus, the first of these factors is only indirectly accounted (methods for evaluating the ponderability of RICE fuel consumption as the ES factor are described in [3]), and the 2nd and the 3rd ES factor is not considered at all.

Incorporating these additional ES factors alongside the existing ones fully aligns with the concept of improving the K_{fe} criterion mathematical apparatus as presented in [4], supports the goals of sustainable development set by the Presidential Decree of Ukraine № 722/2019 (dated 30.09.2019) [5], and corresponds to the provisions of the Regulation on Environmental Support within the State Emergency Service of Ukraine, approved by SES Order № 618 dated 20.09.2013 [6].

Fuel consumption by RICE leads to cumulative pollution of all environmental components – atmosphere, hydrosphere, and lithosphere – as well as a technogenic impact on the biosphere in general and humans in particular. The primary effect arises from thermal energy produced by exothermic redox reactions in the RICE combustion chamber. This energy is partially transferred to the environment via heat exchange with RICE parts and EG flow, partially lost to dissipative forces within the RICE, and the remainder dissipates throughout the PP system during its exploitation. Accounting for such impacts as an ES factor in a criterion-based complex assessment of PP with RICE is an equally important scientific and technical challenge.

It should also be noted that RICEs are significant sources of environmental pollution through factors of various physical natures. This represents the qualitative dimension of the study’s relevance. In peacetime, such systems generate up to 75 % [2] of mechanical and electrical energy in the country, and during the armed conflict and anticipated post-war reconstruction, this share rises to 85–90 % [6,7]. This represents the quantitative aspect of the study’s relevance.

There FERV powered by RICE, used by divisions and institurions of the SES of Ukraine, both during armed conflict and throughout the post-war restoration of the country's economy and infrastructure, further emphasizing the importance of this study.

The purpose of the study. Improving the method for compatible consideration motor fuel vapor and thermal energy emissions during complex criteria-based assessment of the ES level of exploitation of PP with RICE, namely FERV units, taking into account the realities of the functioning of the divisions and institutions of the SES of Ukraine in conditions of armed aggression and in the perspective of the post-war reconstruction of critical infrastructure and the economy of our country.

Problem of the study. The imperfection of existing methods for complex criteria-based assessment of the ES level of the exploitation of the PP with RICE, especially considering the realities of the functioning of the institutions and divisions of the SES of Ukraine and their FERV units in conditions of armed aggression and in the perspective of the post-war reconstruction of the critical infrastructure and economic of our country.

Idea of the study. Improving the methodology for determining the values of the K_{fe} criterion by expanding the ES factors taken into account by its mathematical apparatus, in particular, compatible consideration of thermal energy motor fuel vapor and thermal energy emissions into environment.

Main task of the study. Determination of quantitative and qualitative aspects of the effect of compatible consideration of the thermal energy motor fuel vapor and thermal energy emission into the environment during a complex criteria-based assessment of the ES level of the exploitation process of PP with RICE, namely FERV units of the institutions and divisions of the SES of Ukraine, using the steady standardized ESC test cycle (in accordance with UNECE Regulations № 49 [9]) based on the improved mathematical apparatus of the complex fuel-ecological criterion K_{fe}.

Object of the study. ES level of the exploitation process of PP with RICE, in particular FERV units of the institutions and divisions of the SES of Ukraine, taking into account the negative technogenic impact of compatible thermal energy motor fuel vapor and thermal energy emissions into environment.

Subject of the study. Contribution to the numerical values of the indicators of the object of the study of the compatible thermal energy motor fuel vapor and thermal energy emissions into environment.

Research methods. Analysis of specialized scientific and technical, reference, patent and regulatory literature, analysis of the results of bench engine tests using standardized steady test cycles, the position of the scientific discipline «Theory of Internal Combustion Engines» [10], improved mathematical apparatus of the complex fuel-ecological criterion of Prof. Parsadanov, the method of least squares.

The objectives of the study are as follows:

1. Development of the method for calculating the values of the complex fuel-ecological criterion with compatible consideration of the emissions of motor fuel vapors caused by the phenomena of LBR and SBR of FERV with RICE fuel tanks;
2. Development of the method for calculating the values of the complex fuel-ecological criterion with compatible consideration of the thermal energy emissions in the environment during the operation of FERV with RICE;
3. Development of the method for complex calculating the values of the complex fuel-ecological criterion with compatible consideration of the motor fuel vapor emissions and taking into account thermal energy emissions in the environment during the exploitation of FERV with RICE;
4. Obtaining the set of initial data for carrying out a calculation study for the standardized steady ESC test cycle and the 2Ch10.5/12 autotrucktor diesel engine.
5. Calculated assessment of the values of the complex fuel-ecological criterion with compatible consideration of the motor fuel vapor emissions caused by the phenomena of LBR and SBR of FERV with RICE fuel tanks fuel tanks and their analysis;
6. Calculated assessment of the values of the complex fuel-ecological criterion with compatible consideration of the thermal energy emissions in the environment during the exploitation of FERV with RICE;
7. Calculated assessment of the values of the complex fuel-ecological criterion twith compatible consideration of the motor fuel vapor emissions and taking into account thermal energy emissions in the environment during the exploitation of FERV with RICE;

Tasks №№ 1, 4, 5 and №№ 2, 6 was caried out in the ghtvious parts of this study – articles [7,8]. So, in this study presented the results of the carieng out of the tasks №№ 3 and 7.

The study has been carried out on the example of a D21A1 autotrucktor diesel engine (2Ch10.5/12 according to ISO 3046-1:2002 «Reciprocating internal combustion engines. General technical conditions»), the technical description of which is given in the source [11].

The topic of this study corresponds to the content of the Resolution of the Cabinet of Ministers of Ukraine № 476 dated 30.04.2024 «On approval of the list of priority thematic areas of scientific research and scientific and technical developments for the period until December 31 of the year following the termination or abolition of martial law in Ukraine» [12], the content of the Specialty Passport 21.06.01 «Ecological Safety», approved by the Resolution of the Presidium of the Higher Attestation Commission of Ukraine №. 33-07/7 dated 04.07.2001 [13]. In accordance with the Order of the SES of Ukraine № 618 dated 20.09.2013 «On Approval of the Regulations on the Organization of Ecological Support of the State Emergency Service of Ukraine» [6]. In accordance with the Decree of the President of Ukraine № 722/2019 dated 30.09.2019 «On the Sustainable Development Goals of Ukraine for the period up to 2030» [5], national security issues, in particular the security and defense sector [14], and the current trend of greening PP with RICE – decarbonization of their operation [15].

Analysis of researches and publications

In the study [16], the results of an experimental study of the effectiveness of the method for reducing harmful environmental pollution by thermal energy of a low-heat-dissipating RICE operating on the basis of a mixture of preheated linseed oil and nanoadditives are presented. In the study [17], a new trend of deep utilization of waste heat from RICE is described by using condensing economizers in waste heat boilers. In the study [18], the issue of optimizing hydrogen production and increasing system efficiency by utilizing exhaust heat in a hydrogen-consuming RICE is discussed. In the study [19], the results of an experimental evaluation of the effectiveness of a plate heat exchanger as a cold air suction system for an RICE with spark ignition using a car air conditioning system in the context of reducing thermal environmental pollution are presented. In the study [20], the issue of effective extraction of exhaust heat from an automotive RICE using thermoelectric generation technology is discussed. Source [21] is devoted to the analysis of the results of the consolidated study of the injection strategy from the point of view of gas dynamics and heat transfer in a hydrogen diesel-ignition RICE. The waste heat recovery system for marine RICE has been optimized using the rank preference learning function built into the Bayesian optimizer as an aspect of reducing heat emissions into the atmosphere is discussed in the study [22]. The performance assessment and multi-criteria optimization of a new transcritical CO_2 Rankine cycle for the recovery of RICE waste heat is performed in the study [23]. The improvement of the heat transfer performance of air-cooled RICE fins using geometric analysis and material analysis for more efficient use of waste heat is achieved in the study [24]. The study [25] substantiates the choice of material under uncertainty for the recovery of waste heat in a diesel generator. The design and performance analysis of a methanol reforming reactor for the utilization of waste heat from the EG of a marine diesel RICE have been optimized in the study [26]. The thermodynamic study of a diesel RICE with an HCCI cycle operating on hydrogen-enriched natural gas for efficient electricity generation, heating of the consumer coolant, and cooling of the engine itself has been described in the study [27].

Study [28] shows the results of integrating cooling and adsorption technologies in improving gasoline vapor recovery in oil storage facilities. Study [29] is devoted to the use of an optimized method for assessing the efficiency of vapor recovery equipment control and estimating volatile organic compound emissions from evaporation from urban oil depots based on data from an extensive study. The results of the studies in [30–32] are an assessment of the human health effects, neurotoxicity, and subchronic inhalation toxicity of gasoline and fuel oxygenate vapors. The history, genotoxicity, and carcinogenicity of carbonaceous fuel and its emissions are described in the study [33]. The development of a new method for reducing light hydrocarbon losses at oil tank breather valves is performed in the study [34]. An analysis of the negative environmental consequences of fires in the fuel composition is provided in the study [35]. The transformation processes in primary particulate emissions to secondary organic aerosol from the EG of diesel RICE idling in China were reviewed in the study [36]. Polycyclic aromatic hydrocarbons in motor fuel vapors emissions and their effects on human health were analyzed in [37].

In this case, both the emission of motor fuel vapors and the environmental thermal energy pollution can be assessed using the developed efficiency index of the environment protection technologies (EPT) executive devices, as shown in works [4, 38]. In this case, it is possible to take into account the features of the use of alternative types of motor fuel and the operation of the RICE according to the models of exploitation of a vehicle with a hybrid drive of the propulsion and an electric generator, as illustrated in works [39,40]. The results of such an assessment can be initial data for both implementation of physical and mathematical modeling of working processes in the EPT executive devices, and verification of the results of such modeling, as described in the monograph [41], as well as modeling of the processes of pollutant formation in the working process of the RICE and their transformation in the exhaust tract, for example, using the method of digital twins [42].

Statement of the problem and its solution

The value of the K_{fe} criterion for the i-th steady regime of exploitation of the DRICE with the value of the weighting factor *WF* is determined by formula (1) [1–4], and the place in it of the mass hourly emissions of motor fuel vapors caused by the phenomena of LBR and SBR is suggested in this work to be determined by formula (2).

$$K_{fe} = \eta_e \cdot (1-\beta) = \frac{3600}{H_u \cdot g_e} \cdot \left(1 - \frac{Z_e(P_f)}{Z_f(P_f) + Z_e(P_f)}\right) = \frac{3600 \cdot N_e(M_{кр}, n_{кв})}{H_u \cdot G_{fuel}} \times \frac{1}{1 + \sigma \cdot f \cdot \sum_{m=1}^{h} (A_k \cdot G_k) / G_{fuel}}, ‰, \quad (1)$$

$$\sum_{m=1}^{h} (A_k \cdot G_k) = A(PM) \cdot G(PM) + A(NO_x) \cdot G(NO_x) + A(C_nH_m) \cdot G(C_nH_m) + A(CO) \cdot G(CO), \text{ kg/h}, \quad (2)$$

where the index *i* denote the values for a separate representative regime of operation of the RICE on landfill in the model of its exploitation; H_u = 42.7 MJ/kg [2] – lower heat of combustion of motor fuel; N_e – effective power of the diesel engine, kW; G_{fuel} – mass hourly fuel consumption, kg/h; G_k – mass hourly emission of the *k*-th pollutant in the EG flow, kg/h; A_k – dimensionless indicator of the relative aggressiveness of the *k*-th pollutant in the EG flow (A_{NOx} = 41.1; A_{PM} = 200; A_{CnHm} = 3.16; A_{CO} = 1.0 [2]); h = 4 [2] – total number of pollutants in the TG flow; σ – dimensionless indicator of relative pollution safety in different territories (for automobile diesel σ = 1.0, for tractor σ = 0.25 [2]); *f* – dimensionless coefficient that takes into account the nature of dispersion of EG in atmospheric air (when operating diesel engines of various designations on the territory of Ukraine f = 1.0 [2]); $\delta = P_f$ – dimensional indicator that converts the point estimate into a cost estimate, \$/kg; *WF* – relative share of diesel engine operation on the *i*-th polygon of exploatation model (weight factor); η_e – effective efficiency of diesel engine; β – coefficient of relative operational environmental monetary costs; Z_e and Z_f – monetary costs for compensation of environmental damage and fuel, \$/(kW·h); g_e – specific effective mass hourly fuel consumption of the internal combustion engine, kg/(kW·h); M_T and n_{cs} – torque and crankshaft speed of the RICE, N·m and min^{-1}; P_f = 2.482 \$/kg – price per unit weight of motor fuel (at P_f = 57.0 UAH/l and exchange rate 42.0 UAH/\$); U_e – cost of compensation of environmental damage, \$/kg; g_{pr} – specific induced mass emission of pollutants in the EG flow, kg/(kW·h).

Development of the method for complex calculating the values of the complex fuel-ecological criterion with compatible consideration of the motor fuel vapor emissions and thermal energy emissions in the environment during the exploitation of FERV with RICE

In accordance with the previous two sections of the work, this section suggests a method for calculating the values of a complex fuel-ecological criterion with the joint account of motor fuel vapor emissions and thermal energy emissions into the environment as a common indicator of the negative impact on the components of the environment of a PP with DRICE exploitation, which is directly related to the use of motor fuel, together with the actual impact of motor fuel consumption as a non-renewable energy resource (see source [3,4,39,40]).

The suggested method is essentially a combination of the two previous methods. Accordingly, the formula (2) takes the form of a formula (3).

$$\sum_{m=1}^{h} (A_k \cdot G_k) = A(PM) \cdot G(PM) + A(NO_x) \cdot G(NO_x) + A(C_nH_m) \cdot G(C_nH_m) + A(RB) \cdot G(RB) + A_Q \cdot G_Q, \text{ kg/h}. \quad (3)$$

where *A*(RB) – ponderability of the motor fuel vapor emission (dimensionless value); *G*(RB) – mass hourly emission of motor fuel vapor, kg/h; A_Q – ponderability of the thermal energy emission (dimensionless value); G_Q – mass hourly emission of thermal energy, kg/h.

In the previous research [8] it was determined and justified that the value *A*(RB) is equal to ponderability of the fuel component of the K_{fe} criterion, averaged over the field of operating regimes of the diesel engine 2Ch10.5/12, calculated in the monograph [3] when equating the expressions for the partial derivatives of the K_{fe} criterion with the quantities G_{fuel} and G_k, that is A(RB) = A_{fuel} = 38.4. Also, it was shown that the value G(RB) is equal to the sum of the emissions of the of motor fuel vapor at the manifistation of large breafing reservoir phenomena G(SB) and the emission at the small breathing reservoir phenomena G(IB).

In the previous research [7] it was determined and justified that the value A_Q is equal to multiplication result of the A_{fuel} value and the energy coefficient k_E = 0.75 value, so A_Q is 28.8. Also, it has been shown that the value G_Q is equal to multiplication result of the mass hourly fuel consumption G_{fuel} (in kg/h) value and the value of difference between 1 and effective efficiency coefficient η_e (dimensionless value) value.

The calculated assessment of the values of the complex fuel-ecological criterion has been carried out taking into account the emissions of motor fuel vapors caused by the phenomena of LBR and SBR on the PP with DRICE. It has been established that the individual regime value of the emission of motor fuel vapors from the tank is observed in the minimum idle regime, and the maximum – in the nominal power regime of DRICE. It has also been found that the average operational values of the K_{fe} criterion for the ESC cycle for the 2Ch10.5/12 diesel engine are almost not affected (up to 0.25 %), however, for the variant of taking into account the effect of the LBR phenomenon, such an impact is significant (up to 5.25 %) [8].

The calculation evaluation of the values of the complex fuel-ecological criterion was carried out taking into account thermal energy emissions in the environment during the exploitation of the PP with the DRICE. It has been established that the individual regime value of the motor fuel consumption as an equivalent of thermal energy emissions in the environment during the exploitation of the PP with the DRICE is observed at the nominal power regime and is 3.3 kg/h, and the minimum – at the minimum idle regime and is 0.5 kg/h. It has also been found that for the average operational values of the K_{fe} criterion for the ESC cycle for the 2Ch10.5/12 diesel engine, taking into account thermal energy emissions in the environment during the exploitation of the PP with the DRICE for the current version of the calculation study is 12.5 ‰, i.e. the effect of taking into account such ES factor δK_{fe} is –80 %. For the pessimistic version of the calculation study, this effect is –89 % [7].

Calculation study variants

The study will consider the following variants: Variant A – «Reference» – without taking into account both ES factors. Variant B – «Best» – taking into account the full values of motor fuel vapor emissions according to the LBR and SBR mechanisms and the minimum values of thermal energy emissions into the environment. Variant C – «Worst» – taking into account the full values of motor fuel vapor emissions according to the lLBR and SBR mechanisms and the maximum values of thermal energy emissions into the environment.

Results of the calculation study

Fig. 1 and Fig. 2 show the distribution of the values of the criterion K_{fe} and effect δK_{fe} according to ESC test cycle regimes for an autotractor diesel engine 2Ch10,5/12 for all studied variants, taking into account the values of both ES factors. Fig. 3 shows the following data for the average operational values of the criterion K_{fe} and effect δK_{fe} for all studied variants, taking into account the values of both ES factors.

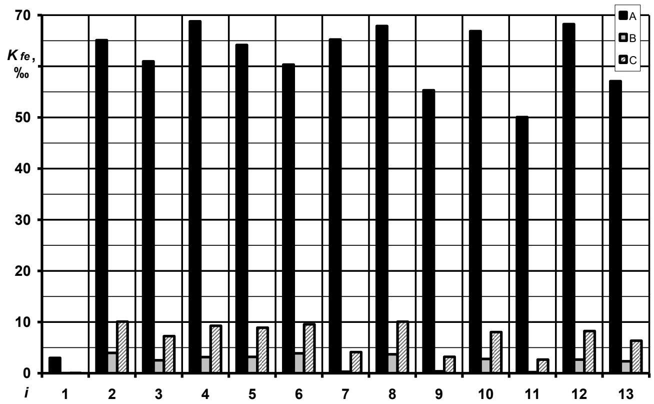

Fig. 1. Distribution of criterion values K_{fe} according to ESC test cycle variants for autotractor diesel engine 2Ch10,5/12 for all studied variants of taking into account the emission of both ES factors

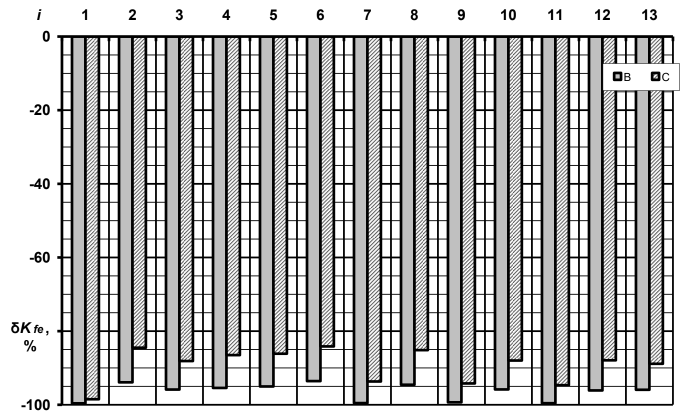

Fig. 2. Distribution of effect values δK_{fe} according to ESC test cycle regimes for autotractor diesel engine 2Ch10,5/12 for all studied variants of taking into account both ES factors

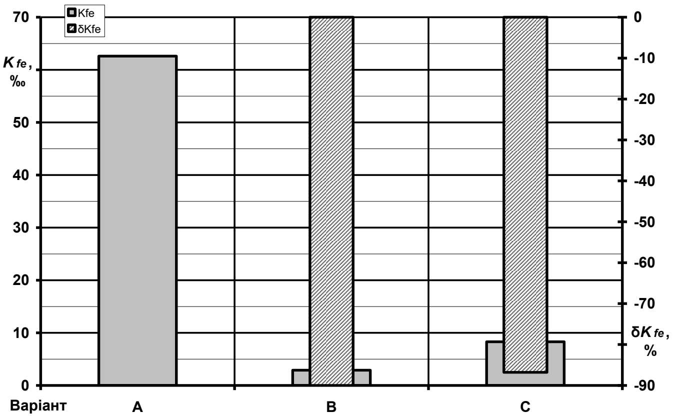

Fig. 3. Distribution of average operational values of the criterion K_{fe} and value δK_{fe} for autotractor diesel engine 2Ch10,5/12 and all studied variants for taking into account the emission of both ES factors

Conclusions

The calculated assessment of the values of the complex fuel-ecological criterion has been carried out, taking into account the total emissions of motor fuel vapors due to LBR and SBR phenomena and thermal energy emissions in the environment as a common indicator of the negative impact on the environment components of the operated PP with the DRICE, which is directly related to the use of motor fuel, together with the actual impact on the consumption of motor fuel as a non-renewable energy resource.

It has been found that for the average operational values of the K_{fe} criterion for the ESC cycle for the 2Ch10.5/12 diesel engine, taking into account the emission of both ES factors when operating the PP with the DRICE for the best variant of the calculation study is 8.3 ‰, i.e. the effect of taking into account such an ES factor δK_{fe} is –86.8 %. For the worst case variant of the computational study, this effect is –95.4 %.

Scientific novelty of the results of the study.

The method for compatible consideration of the emission of thermal energy and motor fuel vapor emissions from fuel tank into the environment from PP with RICE, in particular FERV units, in a complex criteria-based assessment of the indicators of the ES level during their exploitation has been further developed.

Practical significance of results of the study.

The results obtained are suitable for providing a quantitative and qualitative assessment of the studied effects and developing on this basis technical solutions and organizational measures to reduce or eliminate them by developing an appropriate EPT with executive devices on the methodological basis of the ESMS.

The analysis of the results of the performed study shows that compatible consideration of the emission of thermal energy and motor fuel vapor emissions from fuel tank into the environment from PP with RICE, in particular FERV units of divisions of SES of Ukraine and other special equipment of institutions of sector of safety and defense of Ukraine, in conditions of armed aggression is an urgent task in view of the need to ensure compliance with the requirements contained in the Order of the SES of Ukraine № 618 (on the main activity) dated 20.09.2013 «On approval of the Regulations on the organization of ecological support of the State Emergency Service of Ukraine» both during armed aggression and during the post-war reconstruction of the country's critical infrastructure and economy in the historical perspective of ensuring the goals of sustainable development, defined in the Decree of the President of Ukraine № 722/2019 dated 30.09.2019 «On the Goals of Sustainable Development of Ukraine for the period up to 2030».

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At the same time, the materials from the VCU library system were used, including electronic versions of journals and other materials, databases, interlibrary subscription as part of participation in Non-Resident Academic Associates program co-sponsored by the College of Humanities and Sciences at Virginia Commonwealth University (VCU) and the Davis Center for Eurasian Studies at Harvard University in 202–2025 academic year.

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References:

1. Сучасні способи підвищення екологічної безпеки експлуатації енергетичних установок: монографія / С.О. Вамболь, О.П. Строков, В.В. Вамболь, О.М. Кондратенко. – Х.: Стиль-Издат (ФОП Бровін О.В.), 2015. –212 с. 2. Парсаданов І.В. Підвищення якості і конкурентоспроможності дизелів на основі комплексного паливно-екологічного критерію: монографія / І.В. Парсаданов. – Х.: Центр НТУ «ХПІ», 2003. – 244 с. 3. Кондратенко О.М. Метрологічні аспекти комплексного критеріального оцінювання рівня екологічної безпеки експлуатації поршневих двигунів енергетичних установок: монографія / О.М. Кондратенко. – Х.: Стиль-Издат (ФОП Бровін О.В.), 2019. – 532 с. 4. Кондратенко О.М. Науково-методологічні основи захисту атмосферного повітря від техногенного впливу енергоустановок з поршневими двигунами внутрішнього згоряння: дис. д-ра техн. наук: спец 21.06.01 [Рукопис] / О.М. Кондратенко. –Х.: НУЦЗ України, 2021. – 465 с. 5. Указ Президента України № 722/2019 від 30 вересня 2019 року «Про цілі сталого розвитку України на період до 2030 року» [Електронний ресурс]. – URL: https://zakon.rada.gov.ua/laws/show/ 722/2019#Text. 6. Наказ Державної служби України з надзвичайних ситуацій від 20 вересня 2013 року № 618 (за основною діяльністю) «Про затвердження Положення про організацію екологічного забезпечення ДСНС України» [Електронний ресурс]. –URL: https://zakon.rada.gov.ua/rada/show/ v0618388-13#Text. 7. Determination of quantitative and qualitative aspects of environmental pollution by thermal energy from power plants with reciprocating internal combustion engines / O. Kondratenko, V. Koloskov, H. Koloskova, O. Lytvynenko // Техногенно-екологічна безпека. – 2025. – № 17(1/2025). – С. 18–31. – DOI: 10.52363/2522-1892.2025.1.2. 8. Kondratenko O.M. Accounting the emissions of engine fuel vapors in the criteria-based assessment of the ecological safety level of power plants with reciprocating ICE exploitation process / O.M. Kondratenko, V.A. Andronov, T.R. Polishchuk, N.D. Kasionkina, V.A. Krasnov // Двигуни внутрішнього згоряння. –2022. – № 1. – С. 40–50. – DOI: 10.20998/0419-8719.2022.1.06. 9. Uniform provision concerning the approval of compression ignition (C.I.) and natural gas (NG) engines as well as positive-ignition (P.I.) engines fuelled with liquefied petroleum gas (LPG) and vehicles equipped with C.I. and NG engines and P.I. engines fuelled with LPG, with regard to the emissions of pollutants by the engine: regulation United Nations Economic and Social Council Economics Commission for Europe Inland Transport Committee Working Party on the Construction of Vehicles of 26 January 2013 year Regulation No. 49. – Revision 6. – Geneva, UNECE, 2013. 10. Двигуни внутрішнього *згоряння: серія підручників у 6 томах / А.П. Марченко, І.В. Парсаданов, Л.Л. Товажнянський, А.Ф. Шеховцов. – Т.5: Екологізація ДВЗ. – Х.: Прапор, 2004. – 360 с. 11. Ефрос В.В. Дизелі з повітряним охолодженням Володимирського тракторного заводу / В.В. Ефрос [та ін.]. – Машинобудування, 1976. – 277 с. 12. Постанова Кабінету Міністрів України № 476 від 30.04.2024 «Про затвердження переліку пріоритетних тематичних напрямів наукових досліджень і науково-технічних розробок на період до 31 груд-ня року, що настає після припинення або скасування во-єнного стану в Україні». [Електронний ресурс]. –URL: https://zakon.rada.gov.ua/ laws/show/476-2024-%D0%BF# Text. 13. Паспорт спеціальності 21.06.01 «Екологічна безпека», затверд-жений постановою Президії ВАК України № 33-07/7 від 04.07.2001 [Електронний ресурс]. –URL: https://zakon.rada.gov.ua/rada/show/ va7_7330-01#Text. 14. Kondratenko O. Exploring the digital landscape: interdisciplinary perspectives. Monograph. Chapter 5: Artificial intelligence and innovative educational approaches in digital society. Subsection 5.6: Ecological safety of transport as a component of national security of Ukraine during armed aggression and as a prerequisite for a «green» transition during post-war reconstruction. Materials of 6th International scientific conference «Digital economy and digital society», Section 6 «Learning for the green and digital transition» (Academy of Silesia, Katowice, Poland, April 09–10, 2024) [Електронний ресурс] / O. Kondratenko. – Katowice: The University of Technology in Katowice Press, 2024. – P. 853–869. – DOI: 10.54264/M036. 15. Marchenko A.P. Criteria for assessing the effectiveness of transport power plants decarbonisation in accordance with implementation of the sustainable development concept / A.P. Marchenko, I.V. Parsadanov // Двигуни внутрішнього згоряння. – 2024. – № 1. – С. 3–11. – DOI: 10.20998/0419-8. 16. Elumalai P.V. An experimental study on harmful pollution reduction technique in low heat rejection engine fuelled with blends of pre-heated linseed oil and nano additive / P.V. Elumalai, D. Balasubramanian, M. Parthasa-rathy, A.R. Pradeepkumar, S.M. Iqbal, J. Jayakar, M. Nambiraj // Journal of Cleaner Production. – 2021. –Vol. 283. –124617. –DOI: https://doi.org/10.1016/j.jclepro.2020. 124617. 17. Elumalai P.V. A new trend in combustion engine's deep waste heat recovery by application of condensing economizers in exhaust boilers / V. Kornienko, M. Radchenko, R. Radchenko, A. Pavlenko, A. Radchenko // Applied Thermal Engineering. – 2025. –Vol. 261. –125150. –DOI: https://doi.org/ 10.1016/j.applthermaleng.2024. 125150. 18. Shahid M.I. Optimization of hydrogen production and system efficiency enhancement through exhaust heat utilization in hydrogen-enriched internal combustion engine / M.I. Shahid, M. Farhan, A. Rao, H.A. Salam, T. Chen, Q. Xiao, X. Li, F. Ma // Energy. –2025. –Vol. 319. –135051. – DOI: https://doi.org/10.1016/j.energy. 2025.135051. 19. Ikhtiar U. Experimental assessment of lamella heat exchanger as cold intake air system for spark ignition engine by utilizing vehicle air conditioning system / U. Ikhtiar, A.A.B Hairuddin., A.B. Asarry, K.A.B.Md. Rezali, H.M. Ali, R.I.A. Jalal // International Communications in Heat and Mass Transfer. – 2023. – Vol. 148. – 106989. – DOI: https://doi.org/ 10.1016/j.icheatmasstransfer. 2023.106989. 20. Asaduzzaman Md. Exhaust heat harvesting of automotive engine using thermoelectric generation technology / Md. Asaduzzaman, H.Md. Ali, N.A. Pratik, N. Lubaba // Energy Conversion and Management: X. –2023. –Vol. 19. –100398. –DOI: https://doi.org/10.1016/ j.ecmx.2023.100398. 21. Qin Zh. A coupled study of injection strategy on gas motion and heat transfer in a diesel ignition linear hydrogen engine / Zh. Qin, H. Zhang, F. Liu, X. Wang, W. Weng, Ch. Yin, Zh. Han // International Journal of Hydrogen Energy. – 2024. – Vol. 82. – P. 502–512. –DOI: https://doi.org/10.1016/j.ijhydene.2024.07. 444. 22. Díaz-Secades L.A. Waste heat recovery system for marine engines optimized through a preference learning rank function embedded into a Bayesian optimizer / L.A. Díaz-Secades, R. González, N. Rivera, E. Montañés, J.R. Quevedo // Ocean Engineering. – 2023. – Vol. 281. – 114747. – DOI: https://doi.org/ 10.1016/j.oceaneng. 2023.114747. 23. Xia J. Performance assessment and multi-objective optimization of a novel transcritical* CO_2 *Rankine cycle for engine waste heat recovery / J. Xia, J. Hou, J. Wang, J. Lou, S. Yao // Case Studies in Thermal Engineering. – 2024. – Vol. 62. – 105223. – DOI: https://doi.org/10.1016/j.csite.2024.105223. 24. Sachar Sh. Heat transfer enhancement of the air-cooled engine fins through geometrical and material analysis: A review / Sh. Sachar, Y. Parvez, T. Khurana, H. Chaubey // Materials Today: Proceedings. – 2023. – P. 207–212. – DOI: https://doi.org/ 10.1016/j.matpr.2023.03.447. 25. Bavadharani B. Selection of phase change material under uncertainty for waste heat recovery in diesel engine generator / B. Bavadharani, G.S. Mahapatra, N.M. Sivaram, P. Balasundaram, B. Baranidharan // Journal of Energy Storage. – 2025. – Vol. 108. – 114982. – DOI: https://doi.org /10.1016/j.est.2024.114982. 26. Cai W. Optimization design and performance analysis of methanol reforming reactor for exhaust waste heat recovery of marine engine / W. Cai, Zh. Zhang, B. Wang, Z. Wang, Z. Yin, Zh. Zhang // International Journal of Hydrogen Energy. – 2024. – Vol. 49. – Part A. – pp. 1593-1604. – DOI: https://doi.org/10.1016/j.ijhydene.2023.11.015. 27. Almatrafi E. Thermodynamic investigation of a hydrogen enriched natural gas fueled HCCI engine for the efficient production of power, heating, and cooling / E. Almatrafi, M.A. Siddiqui // International Journal of Hydrogen Energy. – 2024. – Vol. 82. – P. 111–122. – DOI: https://doi.org/ 10.1016/j.ijhydene.2024.07. 238. 28. Liang J. Advancing gasoline vapor recovery in oil depots: Integrating cooling and adsorption technologies / J. Liang, L. Sun, Ch. Cheng, K. Wang, T. Zhu, T. Li // Energy. – 2024. – Vol. 313. – 133823. – DOI: https://doi.org/10.1016/ j.energy.2024.133823. 29. Man H. Utilizing a optimized method for evaluating vapor recovery equipment control efficiency and estimating evaporative VOC emissions from urban oil depots via an extensive survey / H. Man, X. Shao, W. Cai, K. Wang, Zh. Cai, M. Xue, H. Liu // Journal of Hazardous Materials. – 2024. – Vol. 479. – 135710. – DOI: https://doi.org/10.1016/ j.jhazmat.2024.135710. 30. Henley M. Health assessment of gasoline and fuel oxygenate vapors: Generation and characterization of test materials / M. Henley, D.J. Letinski, J. Carr, M.L. Caro, W. Daughtrey, R. White // Regulatory Toxicology and Pharmacology. – 2014. – Vol. 70. – Issue 2. Supplement. – P. S13–S17. – DOI: https://doi.org/10.1016/j.yrtph.2014. 05.012. 31. O'Callaghan J.P. Health assessment of gasoline and fuel oxygenate vapors: Neurotoxicity evaluation / J.P. O'Callaghan, W.C. Daughtrey, Ch.R. Clark, C.A. Schreiner, R. White // Regulatory Toxicology and Pharmacology. – 2014. – Vol. 70. – Issue 2. Supplement. – P. S35-S42. – DOI: https://doi.org/ 10.1016/ j.yrtph.2014.05.002. 32. Clark Ch.R. Health assessment of gasoline and fuel oxygenate vapors: Subchronic inhalation toxicity / Ch.R. Clark, C.A. Schreiner, C.M. Parker, T.M. Gray, G.M. Hoffman // Regulatory Toxicology and Pharmacology. – 2014. – Vol. 70. –*

Issue 2. Supplement. – P. S18-S28. – DOI: https://doi.org/ 10.1016/j.yrtph.2014.07.003. 33. Claxton L.D. The history, genotoxicity, and carcinogenicity of carbon-based fuels and their emissions. Part 3: Diesel and gasoline / L.D. Claxton // Mutation Research/Reviews in Mutation Research. – 2015. – Vol. 763. – P. 30–85. – DOI: https://doi.org/10.1016/j.mrrev.2014.09. 002. 34. Farhan M.M. Development of a New Method for Reducing the Loss of Light Hydrocarbons at Breather Valve of Oil Tanks / M.M. Farhan, M.M. Al-Jumialy, A.D. Al-Muhammadi, A.S. Ismail // Energy Procedia. – 2017. – Vol. 141. – P. 471–478. – DOI: https://doi.org/10.1016/j.egypro.2017.11.061.

35. Mishra K.B. Lessons learned from recent fuel storage fires / K.B. Mishra, K.-D. Wehrstedt, H. Krebs // Fuel Processing Technology. – 2013. – Vol. 107. – P. 166–172. – DOI: https://doi.org/10.1016/ j.fuproc. 2012.08.003. 36. Deng W. Primary particulate emissions and secondary organic aerosol (SOA) formation from idling diesel vehicle exhaust in China / W. Deng, Q. Hu, T. Liu, X. Wang at al // Science of The Total Environment. – 2017. – Vol. – 593–594. – P. 462–469. – DOI: https://doi.org/10.1016/j.scitotenv.2017.03. 088. 37. Mallah M.A. Polycyclic aromatic hydrocarbon and its effects on human health: An overeview / M.A. Mallah, L. Changxing, M.A. Mallah, S. Noreen at al // Chemosphere. – 2022. – Vol. 296. – 133948. – DOI: https://doi.org/ 10.1016j.chemosphere.2022.133948. 38. Kondratenko O. Development and Use of the Index of Particulate Matter Filter Efficiency in Environmental Protection Technology for Diesel-Generator with Consumption of Biofuels / O. Kondratenko, V. Andronov, V. Koloskov, O. Strokov // 2021 IEEE KhPI Week on Advanced Technology: Conference Proceedings (13–17 September 2021, NTU «KhPI», Kharkiv). – Kharkiv: NTU «KhPI», 2021. – P. 239–244. – DOI: 10.1109/KhPIWeek 53812. 2021.9570034. 39. Kondratenko O. Criteria based assessment of efficiency of conversion of reciprocating ICE of hybrid vehicle on consumption of biofuels / O. Kondratenko, V. Koloskov, S. Kovalenko, Yu. Derkach, O. Strokov // 2020 IEEE KhPI Week on Advanced Technology, KhPI Week 2020: Conference Proceedings (05–10 October 2020. Kharkiv). – P. 177–182. – DOI: 10.1109/KhPIWeek 51551.2020.9250118. 40. Kondratenko O. 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 // 2018 IEEE 3rd International International Conference on Intelligent Energy and Power Systems (IEPS–2018): Book of Papers (10–14 September, 2018. Kharkiv). – P. 57-1–57-6. – DOI: 10.1109/IEPS. 2018.8559570. 41. Кондратенко О.М. Фізичне і математичне моделювання процесів у фільтрах твердих частинок у практиці критеріального оцінювання рівня екологічної безпеки: монографія / О.М. Кондратенко, В.Ю. Колосков, Ю.Ф. Деркач, С.А. Коваленко // – Х.: Стиль-Издат (ФОП Бровін О.В.), 2020. – 522 с. 42. Online free system for modeling the working processes of reciprocating internal combustion engines using digital twins Blitz-PRO: official site [Електронний ресурс]. – URL: http://blitzpro.zeddmalam.com/application/index/ signin.

Bibliography (transliterated):

1. Vambol S.O., Strokov O.P., Vambol V.V., Kondratenko O.M. (2015) Modern methods of increasing the environmental safety of the operation of power plants: monograph [Suchasni sposoby pidvyshchennia ekolohichnoi bezpeky ekspluatatsii enerhetychnykh ustanovok: monohrafiia] CKharkiv, Publ. Stil-Izdat (FOP Brovin O.V.), 212 p. 2. Parsadanov I.V. (2003) Improving the quality and competitiveness of diesel engines based on a complex fuel-ecological criterion: monograph [Pidvyshchennia yakosti i konkurentospromozhnosti dyzeliv na osnovi kompleksnoho palyvno-ekolohichnoho kryteriiu: monohrafiia], Kharkiv, Publ. Center of NTU «KhPI», 244 p. 3. Kondratenko O.M. (2019) Metrological aspects of a complex criteria-based assessment of the ecological safety level of the exploitation of reciprocating engines of power plants: monograph [Metrolohichni aspekty kompleksnoho kryterialnoho otsiniuvannia rivnia ekolohichnoi bezpeky ekspluatatsii porshnevykh dvyhuniv enerhetychnykh ustanovok : monohrafiia], Kharkiv, Publ. Stil-Izdat (FOP Brovin O.V.), 532 p. 4. Kondratenko O.M. (2021) Scientific and methodological foundations of protecting atmospheric air from the technogenic impact of power plants with internal combustion piston engines: dissertation of DSc (Enineering): spec 21.06.01 – ecological safety [Manuscript] [Naukovo-metodolohichni osnovy zakhystu atmosfernoho povitria vid tekhnohennoho vplyvu enerhoustanovok z porshnevymy dvyhunamy vnutrishnoho zghoriannia: dys. d-ra tekhn. nauk: spets 21.06.01 – ekolohichna bezpeka], Kharkiv, NUCP of Ukraine of SES of Ukraine, 465 p. 5. Decree of the President of Ukraine № 722/2019 of September 30, 2019 «On the Sustainable Development Goals of Ukraine for the period up to 2030», URL: https://zakon.rada.gov.ua/laws/show/722/2019#Text. 6. Order of the State Emergency Service of Ukraine dated September 20, 2013 № 618 (by main activity) «On approval of the Regulations on the organization of environmental support of the State Emergency Service of Ukraine», URL: https://zakon.rada.gov.ua/rada/show/ v0618388-13#Text. 7. Kondratenko O., Koloskov V., Koloskova H., Lytvynenko O. (2025) Determination of quantitative and qualitative aspects of environmental pollution by thermal energy from power plants with reciprocating internal combustion engines. Technogenic and ecological safety, 17(1/2025), 18–31. doi: 10.52363/2522-1892.2025.1.2. 8. Kondratenko O.M., Andronov V.A., Polishchuk T.R., Kasionkina N.D., Krasnov V.A. (2022) Accounting the emissions of engine fuel vapors in the criteria-based assessment of the ecological safety level of power plants with reciprocating ICE exploitation process. Internal Combustion Engines. № 1. pp. 40–50. DOI: 10.20998/0419-8719.2022.1.06. 9. Uniform provision concerning the approval of compression ignition (C.I.) and natural gas (NG) engines as well as positive-ignition (P.I.) engines fuelled with liquefied petroleum gas (LPG) and vehicles equipped with C.I. and NG engines and P.I. engines fuelled with LPG, with regard to the emissions of pollutants by the engine: regulation United Nations Economic and Social Council Economics Commission for Europe Inland Transport Committee Working Party on the Construction of Vehicles of 26 January 2013 year Regulation No. 49, Revision 6, Geneva, UNECE, 2013. 10. Marchenko A.P., Parsadanov I.V., Tovazhnyansky L.L., Shekhovtsov A.F. (2004) Internal combustion engines: a series of textbooks in 6 volumes. T.5. Ecologization of internal combustion engines [Dvyhuny vnutrishnoho zghoriannia: seriia pidruchnykiv u 6 tomakh. T.5. Ekolohizatsiia DVZ], Kharkiv, Publ. Prapor, 360 p. 11. Efros V.V. (1976) Diesel engines with air cooling of the Vladimir tractor plant [Dyzeli z povitrianym okholodzhenniam Volodymyrskoho traktornoho zavodu], Publ. Mashynobuduvannia, 277 p. 12. Resolution of the Cabinet of Ministers of Ukraine № 476 dated 04/30/2024 «On approval of the list of priority thematic areas of scientific research and scientific and technical developments for the period until December 31 of the year following the termination or abolition of martial law in Ukraine», URL: https://zakon.rada.gov.ua/laws/show/476-2024-%D0%BF# Text. 13. Specialty passport 21.06.01 «Ecological Safety», approved by the resolution of the Presidium of the Higher Attestation Commission of Ukraine № 33-07/7 dated 04.07.2001, URL: https://zakon.rada.gov.ua/rada/show/va7_7330-01#Text.

14. Kondra-tenko O., Lytvynenko O. (2024) Exploring the digital landscape: interdisciplinary perspectives. Monograph. Chapter 5 «Artificial intelligence and innovative educational approaches in digital society». Subsection 5.6. Ecological safety of transport as a component of national security of Ukraine during armed aggression and as a prerequisite for a «green» transition during post-war reconstruction [Electronic resource] (materials of 6th International scientific conference «Digital economy and digital society», Section 6 «Learning for the green and digital transition», Academy of Sile-

sia, Katowice, Poland, April 09–10, 2024), Katowice: The University of Technology in Katowice Press, pp. 853–869, URL: http://www.wydawnictwo.wst.pl/uploads/files/f22f3113112eb3a985d36ee5fcdb6747.pdf, DOI: 10.54264/M036. 15. Marchenko A.P., Parsadanov I.V. (2024) Criteria for assessing the effectiveness of transport power plants decarbonisation in accordance with implementation of the sustainable development concept, Internal Combustion Engines, № 1, pp. 3-11, DOI: 10.20998/0419-8719.2024.1.01. 16. Elumalai P.V., Balasubramanian D., Parthasarathy M., Pradeepkumar A.R., Iqbal S.M., Jayakar J., Nambiraj M. (2021) An experimental study on harmful pollution reduction technique in low heat rejection engine fuelled with blends of pre-heated linseed oil and nano additive, Journal of Cleaner Production, Vol. 283, 124617, DOI: https://doi.org/10.1016/ j.jclepro.2020.124617. 17. Kornienko V., Radchenko M., Radchenko R., Pavlenko A., Radchenko A. (2025) A new trend in combustion engine's deep waste heat recovery by application of condensing economizers in exhaust boilers, Applied Thermal Engineering, Vol. 261, 125150, DOI: https://doi.org/10.1016/j.applthermaleng.2024. 125150. 18. Shahid M.I., Farhan M., Rao A., Salam H.A., Chen T., Xiao Q., Li X., Ma F. (2025) Optimization of hydrogen production and system efficiency enhancement through exhaust heat utilization in hydrogen-enriched internal combustion engine, Energy, Vol. 319, 135051, DOI: https://doi.org/10.1016/j.energy.2025.135051. 19. Ikhtiar U., Hairuddin A.A.B., Asarry A.B., Rezali K.A.B.Md., Ali H.M.,Jalal R.I.A. (2023) Experimental assessment of lamella heat exchanger as cold intake air system for spark ignition engine by utilizing vehicle air conditioning system, International Communica-tions in Heat and Mass Transfer, Vol. 148, 106989, DOI: https://doi.org/10.1016/j.icheatmasstransfer.2023.106989. 20. Asaduzzaman Md., Ali H.Md., Pratik N.A., Lubaba N. (2023) Exhaust heat harvesting of automotive engine using thermoelectric generation technology, Energy Conversion and Management: X, Vol. 19, 100398, DOI: https://doi.org/10.1016/j.ecmx.2023.100398. 21. Qin Zh., Zhang H., Liu F., Wang X., Weng W., Yin Ch., Han Zh. (2024) A coupled study of injection strategy on gas motion and heat transfer in a diesel ignition linear hydrogen engine, International Journal of Hydrogen Energy, Vol. 82, pp. 502-512, DOI: https://doi.org/10.1016/j.ijhydene.2024.07.444. 22. Díaz-Secades L.A., González R., Rivera N., Montañés E., Quevedo J.R. (2023) Waste heat recovery system for marine engines optimized through a preference learning rank function embedded into a Bayesian optimizer, Ocean Engineering, Vol. 281, 114747, DOI: https://doi.org/10.1016/j.oceaneng.2023.114747. 23. Xia J., Hou J., Wang J., Lou J., Yao S. (2024) Performance assessment and multi-objective optimization of a novel transcritical CO2 Rankine cycle for engine waste heat recovery, Case Studies in Thermal Engineering, Vol. 62, 105223, DOI: https://doi.org/10.1016/j.csite.2024.105223. 24. Sachar Sh., Parvez Y., Khurana T., Chaubey H. (2023) Heat transfer enhancement of the air-cooled engine fins through geometrical and material analysis: A review, Materials Today: Proceedings, DOI: https://doi.org/10.1016/j.matpr.2023.03.447. 25. Bavadharani B., Mahapatra G.S., Sivaram N.M., Balasundaram P., Baranidharan B. (2025) Selection of phase change material under uncertainty for waste heat recovery in diesel engine generator, Journal of Energy Storage, Vol. 108, 114982, DOI: https://doi.org/10.1016/j.est.2024. 114982. 26. Cai W., Zhang Zh, Wang B., Wang Z., Yin Z., Zhang Zh. (2024) Optimization design and performance analysis of methanol reforming reactor for exhaust waste heat recovery of marine engine, International Journal of Hydrogen Energy, Vol. 49, Part A, pp. 1593-1604, DOI: https://doi.org/10.1016/j.ijhydene.2023.11.015. 27. Al-matrafi E., Siddiqui M.A. (2024) Thermodynamic investigation of a hydrogen enriched natural gas fueled HCCI engine for the efficient production of power, heating, and cooling, International Journal of Hydrogen Energy, Vol. 82, pp. 111-122, DOI: https://doi.org/10.1016/j.ijhydene.2024.07.238. 28. Liang J., Sun L., Cheng Ch., Wang K., Zhu T., Li T. (2024) Advancing gasoline vapor recovery in oil depots: Integrating cooling and adsorption technologies, Energy, Vol. 313, 133823, DOI: https://doi.org/10.1016/j.energy.2024. 133823. 29. Man H., Shao X., Cai W., Wang K., Cai Zh., Xue M., Liu H. (2024) Utilizing a optimized method for evaluating vapor recovery equipment control efficiency and estimating evaporative VOC emissions from urban oil depots via an extensive survey, Journal of Hazardous Materials, Vol. 479, 135710, DOI: https://doi.org/10.1016/j.jhazmat.2024.135710. 30. Henley M., Letinski D.J., Carr J., Caro M.L., Daughtrey W., White R. (2014) Health assessment of gasoline and fuel oxygenate vapors: Generation and characterization of test materials, Regulatory Toxicology and Pharmacology, Vol. 70, Issue 2, Supplement, pp. S13-S17, DOI: https://doi.org/10.1016/j.yrtph.2014.05.012. 31. O'Callaghan J.P., Daughtrey W.C., Clark Ch.R., Schreiner C.A., White R. (2014) Health assessment of gasoline and fuel oxygenate vapors: Neurotoxicity evaluation, Regulatory Toxicology and Pharmacology, Vol. 70, Issue 2, Supplement, pp. S35-S42, DOI: https://doi.org/10.1016/j.yrtph.2014.05.002. 32. Clark Ch.R., Schreiner C.A., Parker C.M., Gray T.M., Hoffman G.M. (2014) Health assessment of gasoline and fuel oxygenate vapors: Subchronic inhalation toxicity, Regulatory Toxicology and Pharmacology, Vol. 70, Issue 2, Supplement, pp. S18-S28, DOI: https://doi.org/10.1016/j.yrtph.2014.07.003. 33. Claxton L.D. (2015) The history, genotoxicity, and carcinogenicity of carbon-based fuels and their emissions. Part 3: Diesel and gasoline, Mutation Research/Reviews in Mutation Research, Vol. 763, pp. 30-85, DOI: https://doi.org/10.1016/j.mrrev.2014.09.002. 34. Farhan M.M., Al-Jumialy M.M., Al-Muhammadi A.D., Ismail A.S. (2017) Development of a New Method for Reducing the Loss of Light Hydrocarbons at Breather Valve of Oil Tanks, Energy Procedia, Vol. 141, pp. 471-478, DOI: https://doi.org/10.1016/j.egypro.2017.11.061. 35. Mishra K.B., Wehrstedt K.-D., Krebs H. (2013) Lessons learned from recent fuel storage fires, Fuel Processing Technology, Vol. 107, pp. 166-172, DOI: https://doi.org/10.1016/j.fuproc.2012.08.003. 36. Deng W., Hu Q., Liu T., Wang X., Zhang Y., Song W., Sun Y., Bi X., Yu J., Yang W., Huang X., Zhang Zh., Huang Zh., He Q., Mellouki A., George Ch. (2017) Primary particulate emissions and secondary organic aerosol (SOA) formation from idling diesel vehicle exhaust in China, Science of The Total Environment, Vol. 593–594, pp. 462-469, DOI: https://doi.org/10.1016/j.scitotenv.2017. 03.088. 37. Mallah M.A., Changxing L., Mallah M.A., Noreen S., Liu Y., Saeed M., Xi H., Ahmed B., Feng F., Mirjat A.A., Wang W., Jabar A., Naveed M., Li J.-H., Zhang Q. (2022) Polycyclic aromatic hydrocarbon and its effects on human health: An overeview, Chemosphere, Vol. 296, 133948, DOI: https://doi.org/10.1016/ j.chemosphere.2022.133948. 38. Kondratenko O., Andronov V., Koloskov V., Strokov O. (2021) Development and Use of the Index of Particulate Matter Filter Efficiency in Environmental Protection Technology for Diesel-Generator with Consumption of Biofuels, 2021 IEEE KhPI Week on Advanced Technology: Conference Proceedings (13–17 September 2021, NTU «KhPI», Kharkiv), pp. 239–244, DOI: 10.1109/KhPIWeek53812.2021.9570034. 39. Kondratenko O., Koloskov V., Kovalenko S., Derkach Y., Strokov O. (2020) Criteria based assessment of efficiency of conversion of reciprocating ICE of hybrid vehicle on consumption of biofuels, 2020 IEEE KhPI Week on Advanced Technology, KhPI Week 2020, 05–10 October 2020. Conference Proceedings, Kharkiv, pp. 177–182, DOI: 10.1109/KhPIWeek51551.2020.9250118. 40. Kondratenko O., Mishchenko I., Chernobay G., Derkach Yu., Suchikova Ya. (2018) Criteria based assessment of the level of ecological safety of exploitation of electric generating power plant that consumes biofuels, 2018 IEEE 3rd International International Conference on Intelligent Energy and Power Systems (IEPS–2018): Book of Papers, 10–14 September, 2018. Kharkiv, pp. 57-1–57-6, DOI: 10.1109/IEPS.2018.8559570. 41. Kondratenko O.M., Koloskov V.Yu., Derkach Y.F., Kovalenko S.A. (2020) Physical and mathematical modeling of processes in particulate filters in the practice of criteria-based assessment of the level of environmental safety: monograph, Kharkiv, Publ. Stil-Izdat (FOP Brovin O.V.), 522 p. 42. Online free system for modeling the working processes of reciprocating internal combustion engines using digital twins Blitz-PRO: official site, URL: http://blitzpro.zeddmalam.com/application/index/signin.

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МЕТОДИКА СУМІСНОГО ВРАХУВАННЯ ВИКИДІВ ПАРІВ МОТОРНОГО ПАЛИВА ТА ТЕПЛОВОЇ ЕНЕРГІЇ ПРИ КРИТЕРІАЛЬНОМУ ОЦІНЮВАННІ РІВНЯ ЕКОЛОГІЧНОЇ БЕЗПЕКИ ЕКСПЛУАТАЦІЇ ПОРШНЕВОГО ДВЗ ПОЖЕЖНОЇ ТА АВАРІЙНО-РЯТУВАЛЬНОЇ ТЕХНІКИ В УМОВАХ ЗБРОЙНОЇ АГРЕСІЇ

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У дослідженні, метою якого є удосконалення методики сумісного врахування викидів теплової енергії та парів моторного палива під час комплексного критеріального оцінювання рівня екологічної безпеки експлуатації електроустановок із поршневими ДВЗ, а саме одиниць пожежної та аварійно-рятувальної техніки, з урахуванням реалій функціонування підрозділів та інституцій ДСНС України в умовах збройної агресії, повоєнної відбудови критичної інфраструктури та економіки нашої країни. Об'єктом дослідження є рівень екологічної безпеки процесу експлуатації енергетичних установок з поршневими ДВЗ, зокрема одиниць пожежної та аварійно-рятувальної техніки підрозділів та інституцій ДСНС України, з урахуванням негативного техногенного впливу сумісного викиду теплової енергії та парів моторного палива в навколишнє середовище. Предметом дослідження є внесок у числові значення показників об'єкта дослідження сумісного викиду теплової енергії та парів моторного палива в навколишнє середовище. Наукова новизна результатів дослідження полягає в тому, що отримала подальшого розвитку методика сумісного врахування викидів теплової енергії та викидів парів моторного палива з паливного бака в навколишнє середовище від енергоустановок з поршневими ДВЗ, зокрема одиниць пожежної та аварійно-рятувальної техніки, у комплексному критеріальному оцінюванні показників рівня екологічної безпеки під час їх експлуатації. Практичне значення результатів дослідження полягає в тому, що отримані результати придатні для проведення кількісного та якісного оцінювання досліджуваних впливів і розробки на цій основі технічних рішень і організаційних заходів щодо їх зменшення або усунення шляхом розробки відповідної технології захисту навколишнього середовища з виконавчими пристроями на методологічній основі системи управління екологічною безпекою.

Ключові слова: технології захисту навколишнього середовища; екологічна безпека; енергоустановки; пожежна та аварійно-рятувальна техніка; поршневі двигуни внутрішнього згоряння; пари палива; теплове забруднення; комплексне критеріальне оцінювання; збройна агресія; повоєнна відбудова.