**IRSTI 73.31.75**

**I.A. Pak[1], N.I. Baurova[2], B.K. Kurmasheva[1], A.Zh. Karsakova[1], I.A. Kadyrova[3]**

*[1]Karaganda Technical University, Karaganda, Kazakhstan,*
*[2]Moscow Automobile and Road Construction State Technical University, Moscow, Russia;*
*[3]Karaganda medical University, Karaganda, Kazakhstan*
*(E-mail: i.pak@mail.ru, n.baurova@mail.ru, happiness_b@mail.ru, karsakova84@mail.ru, irina.adilevna@gmail.com)*

# Technical and Economic Efficiency of Devices for Ultrasonic Cleaning of City Bus Exhaust Gases

**Abstract.** The article substantiates the use of devices for ultrasonic cleaning of exhaust gases for city buses, provides the design and principle of operation of an accumulative device for ultrasonic cleaning of exhaust gases, as well as layout solutions for their placing on buses. A calculation method is presented that makes it possible to determine the main parameters of ultrasonic equipment for cleaning and disposal of exhaust gases from internal combustion engines of city buses, as well as to calculate the proportion of finely dispersed soot particles deposited, which characterizes the degree of purification of exhaust gases from fine soot particles, based on which there is calculated economic efficiency of ultrasonic cleaning devices.

**Keywords:** city bus, internal combustion engine, exhaust gases, storage device, ultrasonic cleaning, coagulation, recycling.

**DOI:** doi.org/10.32523/2616-7263-2022-139-2-133-142

## Introduction

In large cities with a large traffic flow, the issue of gas pollution from the exhaust gases of internal combustion engines of vehicles is acute. In the area of bus stops, at intersections, where there is a large accumulation of public vehicles, the most intense air pollution by combustion products occurs, and the highest concentration of toxic and polluting components of exhaust gases is recorded, which negatively affects people's health.

Despite the measures taken, such as introducing the Euro environmental standards, the control of exhaust gas toxicity during technical inspections of vehicles, etc., the situation with environmental pollution remains tense. In most cities of Kazakhstan, the pollution indicator exceeds the permissible norm by several times. In 2021, clean air was only in Aktau and Petropavlovsk [1].

Increasing the number of diseases including cancer, for which Kazakhstan ranks among the first places in the Commonwealth of Independent States (CIS) countries, is currently associated with significant environmental pollution [2].

At present, when assessing the environmental situation, much attention is paid to the content of finely dispersed particles in the air with the size of 2.5 microns or smaller. The microscopic size of such particles permits them to be deeply absorbed into the bloodstream when inhaled, potentially causing diseases such as asthma, lung cancer, heart disease, migraines, Alzheimer's, Parkinson's and others.

The central streets of the city are most susceptible to pollution, especially during "rush hours". In the central part of the city of Karaganda, there is a ban on the trucks passing with the gross weight of more than 3.5 tons. However, alongside with passenger cars, shuttle buses carry passengers along the central streets of the city. They are mainly equipped with diesel engines characterized by increased soot formation.

To reduce the content of soot particles in the exhaust gases, various filters are used. A device is known for cleaning exhaust gases from small solid particles by filtering gases through porous partitions or a special woolen, cotton or glass cloth.

Regenerative type filters are considered to be one of the best design solutions for a soot trap [3, 4, 5].

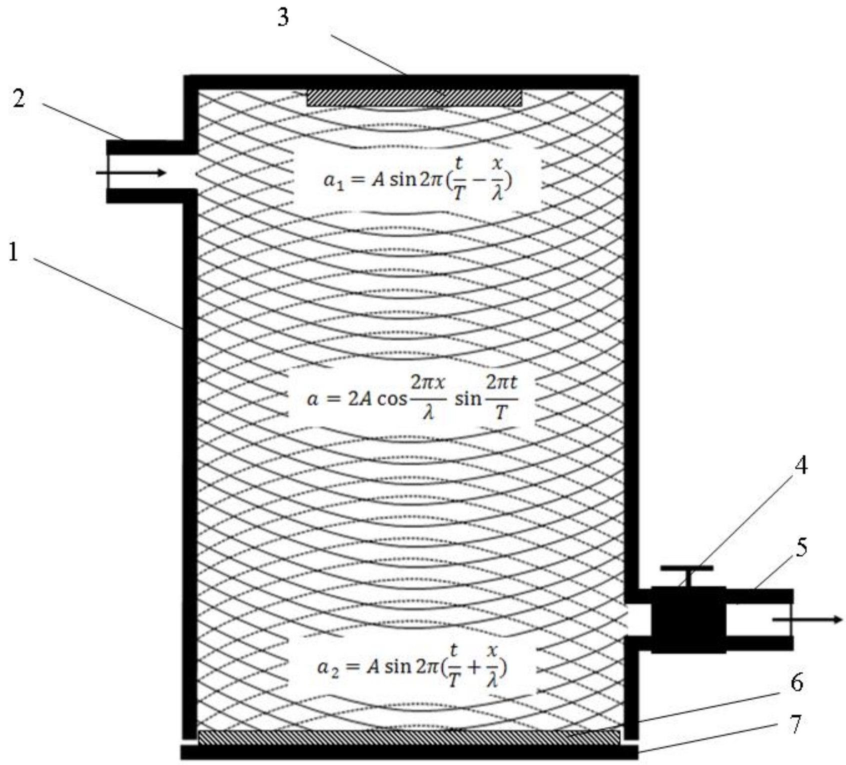
They are a honeycomb nozzle with rectangular cells. The filter material is porous cordierite (porous ceramics) with sufficient mechanical strength, resistance to aggressive chemicals, resistance to melting and cracking under thermal effects, as well as thermal stability. Such filters are now widely used on motor vehicles. However, according to the studies by German scientists, "existing filters do not retain microparticles that are smaller than 10 microns and aromatic fractions, and these exhaust components most of all initiate the development of cancer. Moreover, as the filters are used, deposits accumulate in them, and instead of retaining the most dangerous microparticles for health, the filters become their source" [6].

In connection with the foregoing, it is necessary to modernize the existing and to develop new exhaust gas control systems.

**Design and principle of operation of the device for cleaning and utilizing exhaust gases**

The authors propose a device for ultrasonic cleaning and utilizing exhaust gases (Figure 1) [7], which, unlike the filters used, does not burn out solid particles accumulated in the course of the cleaning process, mainly soot, but allows collecting and utilizing exhaust gases, as well as limiting their emission into the atmosphere, while reducing the concentration of harmful substances in the air in places where vehicles are most congested (bus stops, intersections, etc.).

The accumulative device of ultrasonic purification of exhaust gases developed allows cleaning by coarsening and depositing soot particles with their subsequent disposal. Soot emissions from diesel engines are up to 15 kg per ton of fuel burned. In the world practice, there has been a tendency to consider soot as a secondary material resource (carbon black) with its use for the needs of the tire industry [3].



*1 - storage tank; 2 – inlet branch pipe; 3 – ultrasonic generator; 4 - bypass valve; 5 - outlet pipe; 6 - reflector of sound waves; 7 - tray*

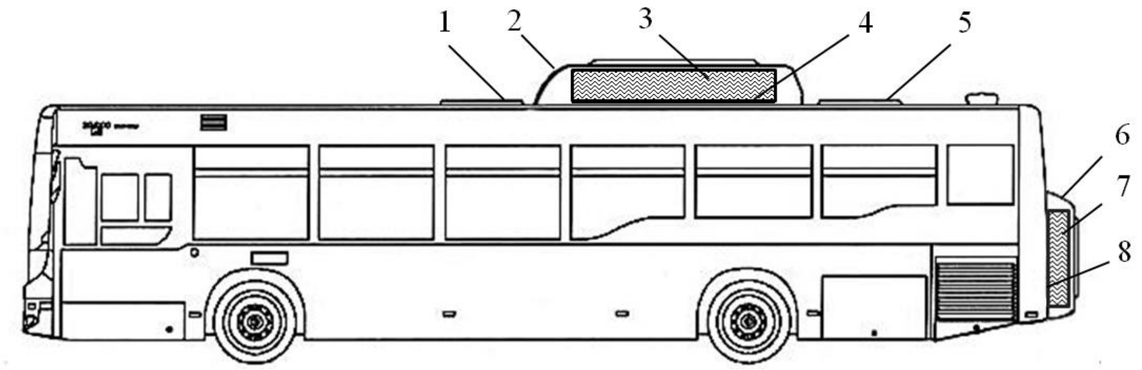
Figure 1 - Device for ultrasonic cleaning of exhaust gases

The device contains a storage tank with an inlet pipe and an outlet pipe with a bypass valve. An ultrasonic generator is mounted in the storage tank, there is a sound wave reflector in the lower part, and the device tray is removable [8, 9].

From ultrasonic generator 3 located on top, there arises a direct wave. On tray 7 of the tank there is reflector of sound waves 6. When reflected, the direct and reflected waves move towards each other, interference occurs and a standing wave is formed. When the standing wave occurs, the efficiency of the coagulation process increases significantly.

The experiments and calculations performed showed increasing the intensification of the coagulation processes of soot particles under the action of ultrasound [9, 10].

It is proposed to place on city buses two containers that work alternately (Figure 2). That is, at the time when the first container is filled with exhaust gas, the second container that is already filled with exhaust gas, is ultrasonically cleaned.




*1, 5 - ventilation hatches of the bus; 2, 6 - soundproof casing;*
*3, 7 - ultrasonic exhaust gas cleaning device; 4, 8 - soundproof gaskets*

Figure 2 - Ultrasonic equipment placement on the roof
and in the back of the bus

**Feasibility study of the efficiency of devices for ultrasonic cleaning of exhaust gases of city buses**

To determine the required volume of the storage tank needed for the most efficient operation of ultrasonic cleaning equipment, and to establish the degree of the exhaust gas purification, it is necessary to determine the rational time for ultrasonic treatment of the exhaust gas.

Let's take the entire volume of soot present in the tank, both in suspension and settled on the bottom of the device as a result of coagulation, as a unit, and determine what part of the solid particles is deposited using the formula for the dependence of the calculated concentrations of suspended solid particles of gas on time:

$$n = n_0 \exp(-kt), \quad (1)$$

where $n$ and $n_0$ are the number concentrations of aerosol particles, current and at the initial moment, respectively; $k$ is the coagulation coefficient; $t$ is the time.

The empirical dependence of changing the coagulation coefficient on time has the following form:

$$k = (-0.0000012t^3 + 0.0012994t^2 - 0.4562322t + 69.30) \cdot 10^{-4}. \quad (2)$$

The *s=1-n* value characterizes the amount of deposited solid particles and determines the degree of the exhaust gases purification from solid particles. Assuming that at the initial time *t = 0*, all the soot particles are in suspension $n_0 = 1$, $s = 0$.

$$n = n_0 \exp(-(-0.0000012t^3 + 0.0012994t^2 - 0.4562322t + +69.3) \cdot 10^{-4}) \cdot t); \quad (3)$$

$$s = 1 - n_0 \exp(-(-0.0000012t^3 + 0.0012994t^2 - 0.4562322t + +69.3) \cdot 10^{-4}) \cdot t). \quad (4)$$

The calculation results are presented in Table 1.

Table 1 – Calculating the degree of the exhaust gases purification *s* depending on the time of irradiation with ultrasound

| t | k | $n_0$ | n | s |
|---|---|---|---|---|
| 0 | 0.00693 | 1.00 | 1 | 0 |
| 60 | 0.004634 | 1.00 | 0.76 | 0.24 |
| 120 | 0.003119 | 0.76 | 0.52 | 0.48 |
| 180 | 0.002228 | 0.52 | 0.35 | 0.65 |
| 240 | 0.001806 | 0.35 | 0.23 | 0.77 |
| 300 | 0.001698 | 0.23 | 0.14 | 0.86 |
| 360 | 0.001747 | 0.14 | 0.07 | 0.93 |
| 420 | 0.001799 | 0.07 | 0.03 | 0.97 |
| 480 | 0.001698 | 0.03 | 0.02 | 0.98 |
| 540 | 0.001288 | 0.02 | 0.01 | 0.99 |
| 600 | 0.000414 | 0.01 | 0.01 | 0.99 |

The graphs of the *n(t)* and *s(t)* dependence are shown in Figure 3. According to the graph of the *s(t)* dependence, there is determined the required time of exposure to ultrasound for a given degree of purification. For example, for 80 % degree of purification, the required time of ultrasonic exposure will be t = 260 s.

The volume of the storage tank is calculated based on the hourly fuel consumption of the engine at idle $q_{xx}$ and the ratio established in work [11]: for 1 liter of fuel consumed, there is required the storage tank with the volume of 16 m$^3$ and is calculated by the formula:

$$V = 16 * q_{xx}/3600 * t, m^3 \quad (5)$$

If the fuel consumption of a city bus at idle $q_{xx}$ is 2 l/h and the required ultrasonic exposure time t = 260 s, then:

$$V = 16 * \frac{2}{3600} * 260 = 2,31\, m^3.$$

The given calculation method makes it possible to determine the main parameters of ultrasonic equipment for cleaning and recycling of internal combustion engines exhaust gases of city buses, as well as to calculate the proportion of finely dispersed soot particles deposited, on the basis of which the economic efficiency of ultrasonic exhaust gas cleaning devices is calculated.

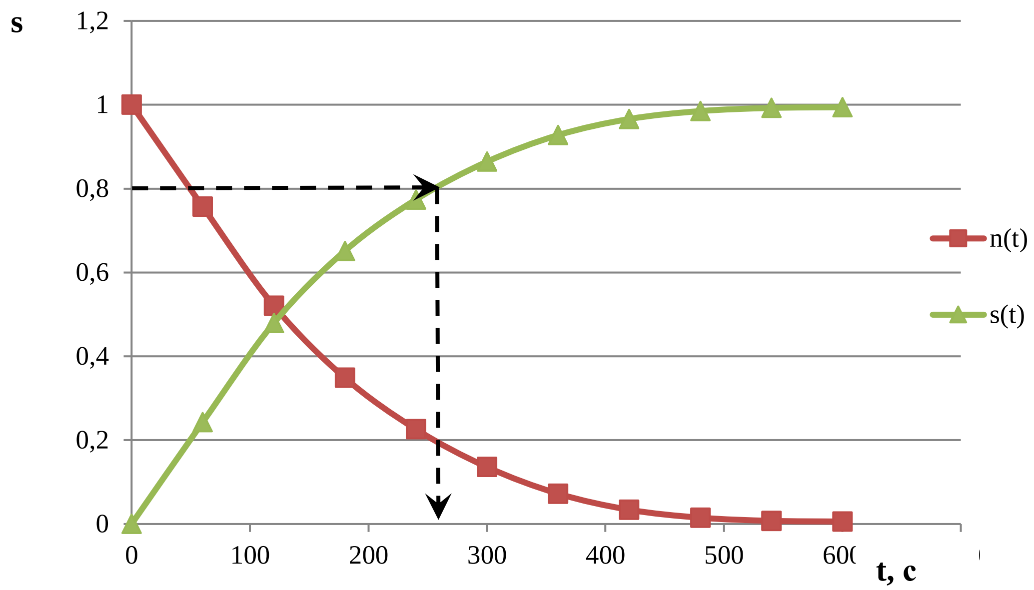



Figure 3 - Graphs of the number concentrations of the gas suspended solid particles *n(t)* and the degree of the exhaust gases purification *s(t)*

The economic efficiency (*E*) can be expressed through the prevented environmental and economic damage *(ΔU*), which is determined by the formula [12, 13]:

$$E = \Delta U = U_1 - UУ_2, \text{ tenge/year}, \qquad (6)$$

where $U_1$ is the annual environmental and economic damage before the events, tenge/year;
$U_2$ is the annual environmental and economic damage after the events, tenge/year;

$$U = \sigma \cdot \gamma \cdot f \cdot \text{M}, \text{ tenge/year}, \qquad (7)$$

where σ is the dimensionless indicator accounting for the type of the territory polluted (σ=4 for Karaganda);
γ is the of valuating 1 conv. tons of pollutants, tenge/conv.t (assumed equal to 1 MCI);
*f* is the dimensionless coefficient accounting for the nature of the nature of the impurities dispersion in the atmosphere (since motor transport is an unorganized source, the indicator *f*=10);
M is the reduced mass of a pollutant, standard tons/year, determined by the formula:

$$\text{M} = \sum_{i=1}^{N} m_i \cdot A_i, \qquad (8)$$

where $m_i$ is the annual mass of the *i*-th matter emission, t/year;
$A_i$ is the coefficient of relative hazard of the *i*-th matter, conv.t (in this case for soot A = 20 cond.t) is determined by the formula:

$$A_i = \frac{1}{MPC_i}, \qquad (9)$$

where $MPC_i$ is the average daily MPC of the *i*-th matter, mg/m³, (soot MPC is 0.05 mg/m³).

Thus, the prevented environmental and economic damage is determined by the formula:

$$E = \Delta U = \sigma \cdot \gamma \cdot f \cdot A_i \cdot (m_1 - m_2), \text{ tenge/year}, \quad (10)$$

where $m_1$ is the annual mass of emission before the events, t/year;
$m_2$ is the annual mass of emission after the events, t/year.

Let us calculate the environmental and economic efficiency of devices for ultrasonic cleaning of exhaust gases from internal combustion engines of large-class buses operating on intracity transportation.
The initial data for the calculation are presented in Table 2.

Table 2 - Initial data for calculating the environmental and economic efficiency

| Indicators | Values |
|---|---|
| Average daily mileage $l_{cc}$, km | 180 |
| Output ratio $\alpha$ | 0.76 |
| Time on duty, h | 16 |
| Dimensionless indicator, taking into account the type of polluted territory б | 4 |
| Cost estimate of 1 conv. tons of pollutants $\gamma$, tenge/cond.t | 2778 |
| Dimensionless coefficient that accounts for the nature of impurities dispersion in the atmosphere, f | 10 |
| Coefficient of relative hazard of the i-the matter Ai, cond/t | 20 |

The annual masses of soot emission before and after the introduction of devices, considering the 80 % level of ultrasonic cleaning, will be determined by the method described in the literature [12, 13].
The calculation results are shown in Table 3. The following designations are used in Table 4.3:
W, WH, H – storage conditions of buses, respectively, warm parking, parking without heating, parking equipped with heating facilities;
W, C – warm and cold period of the year, respectively.
Table 3 - Calculating the environmental and economic efficiency of devices for ultrasonic cleaning of exhaust gases of diesel internal combustion engines of large class buses

| Indicators | Large class buses of the CIS production | | | Large class buses of foreign production | | |
|---|---|---|---|---|---|---|
| | W | WH | H | W | WH | H |
| Soot emissions of large class buses during warming up, g/min | 0.04 | 0.16 | 0.08 | 0.02 | 0.04 | 0.03 |
| Warm-up time, min | 1.5 | 22 | 6 | 1,5 | 22 | 6 |
| Daily soot emission during heating, g | 0.06 | 3.52 | 0.48 | 0.03 | 0.88 | 0.18 |
| Running soot emissions of large class buses, g/km | W | C | Average | W | C | Average |
| | 0.25 | 0.35 | 0.28 | 0.2 | 0.3 | 0.23 |
| Soot emissions of large class buses at idle, g/min | 0.04 | | | 0.02 | | |

| | | |
|---|---|---|
| The daily mass of soot emitted by a large class bus during warming up, given that 70% of buses park in warm boxes in the ATP, 20% in heated parking lots, 10% without heating in cold months, g | 0.20 | 0.07 |
| Daily mass of soot emitted by a large class bus for an average daily run, g | 51.00 | 42.00 |
| The daily mass of soot emitted by a bus of a large class at idle, given that in urban conditions $T_{xx}$=0.4$T_n$, g | 15.36 | 7.68 |
| Total daily soot emission of a large class bus, g | 66.56 | 49.75 |
| Annual soot emission m1 before the introduction of equipment, taking into account the emission factor, g | 18464.67 | 13800.19 |
| Annual soot emission $m^2$ after the introduction of the equipment, taking into account the emission factor, g | 3692.93 | 2760.04 |
| Environmental damage, tenge | 41035.9 | 30669.5 |
| Environmental damage after the introduction of equipment, tenge | 8207.2 | 6133.9 |
| Economic effect from damage reduction, tenge | 32828.7 | 24535.6 |

**Conclusion**

The results of the feasibility study show the effectiveness of using ultrasonic cleaning devices in road transport, especially in the conditions of operating areas prone to the greatest pollution: bus stops, intersections, etc. In addition, the economic effect will be increased due to the utilization of the soot collected in the course of the ultrasonic cleaning process.

References

1. Bozhenko Ya. Environmental problems of Kazakhstan and ways to solve them. [Electronic resource]. Access mode: https://www.nur.kz/fakty-i-layfhaki/1666860-ekologicheskie-problemy-kazakhstana/. (Date of access: 08/01/2021).

2. Chigarkin A. V. Geoecology of Kazakhstan (geographical aspects of nature management and conservation): textbook. allowance for un-comrade. Almaty: Kazakh University, 2006. 414 p.

3. Ecology and environmental safety of the car: textbook / M.V. Grafkina, V.A. Mikhailov, K.S. Ivanov. 2nd ed., rev. and add. M.: FORUM: INFRA-M, 2016. 320 p. (Professional education).

4. Baturin N.V., Titov D.N., Medvedev G.V., Novoselov A.A., Grabovskaya N.N. Improving the design of diesel engines and their environmental performance // Polzunovskiy Bulletin. 2009. No. 1-2. P. 73–80.

5. What is a particulate filter? [Electronic resource]. Access mode: http://avto-blogger.ru/texchast/sazhevyj-filtr.html. (Date of access: 09/10/2019).

6. Tsintsevich L. To make the air cleaner. Modern technologies for cleaning exhaust gases. [Electronic resource]. Access mode: https://sitmag.ru/article/10586-chtoby-vozduh-stal-chishche-sovremennye-tehnologii-ochistki-otrabotavshih-gazov. (Date of access: 20/02/2022).

7. Kadyrov A.S., Pak I.A., Kadyrova I.A., Ganyukov A.A. Physics of the process of ultrasonic coagulation of exhaust gases of internal combustion engines of motor vehicles. Vestnik PGU. Energy series. Pavlodar: PSU, 2020. No. 1. P.219-230.

8. Ibatov M.K., Pak I.A. The device for cleaning exhaust gases of transport equipment. Proceedings of the Intern. scientific-practical. conf. "Integration of science, education and production - the basis for the implementation of the Plan of the Nation" (Saginovsky Readings No. 11), Karaganda: KSTU, 2019. P. 335-336.

9. Ibatov M.K., Kadyrov A.S., Pak I.A., Kadyrova I.A., Askarov B.Sh. Results of experimental studies of the operation of capacitive equipment for ultrasonic cleaning of vehicle exhaust gases. Coal. M.: LLC "Editorial office of the Coal Journal, 2020. No. 2. P. 73-78. DOI: 10.18796/0041-5790.

10. Kadyrov A., Ganyukov A., Pak I., Suleyev B., Balabekova K. Theoretical and Experimental Study of Operation of the Tank Equipment for Ultrasonic Purification of the Internal Combustion Engine Exhaust Gases. // Communications - Scientific Letters of the University of Zilina, 23(3), B219-B226. https://doi.org/10.26552/com.C.2021.3.B219-B226.

11. Ibatov M.K., Aliev S.B., Balabayev O.T., Askarov B.Sh. The main results of experimental studies of the isolation of the exhaust gases of internal combustion engines of mining diesel locomotives. Coal. M.: LLC "Editorial office of the journal" Coal ", 2019. No. 7. P.28-30.

12. Methodology of calculating emissions of pollutants from motor transport enterprises. Appendix No. 3 to the Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated April 18, 2008 No. 100-p.

13. Ecological expertise and environmental audit: textbook and workshop for SPO / E.Yu. Kolesnikov, T.M. Kolesnikov. 2nd ed. rev. and add. M : Yurayt Publishing House, 2019. 469 p. (Series: Vocational education).

**И.А. Пак[1], Н.И. Баурова[2], Б.К. Курмашева[1], А.Ж. Карсакова[1], И.А. Кадырова[3]**

*[1]Қарағанды техникалық университеті, Қарағанды, Қазақстан*
*[2]Мәскеу автомобиль-жол мемлекеттік техникалық университеті, Мәскеу, Ресей,*
*[3]Қарағанды медицина университеті, Қарағанды, Қазақстан*

## Қалалық автобустардың пайдаланылған газдарды ультрадыбыстық тазарту құрылғыларының техникалық-экономикалық тиімділігі

**Аңдатпа.** Мақалада қалалық автобустар үшін пайдаланылған газдарды ультрадыбыстық тазарту құрылғыларын қолдану негізделеді, пайдаланылған газдарды ультрадыбыстық тазартудың жинақтау құрылғысының конструкциясы мен жұмыс принципі, сондай-ақ автобустарға орнатудың орналасу шешімдері келтірілген. Қалалық автобустардың ішкі жану қозғалтқыштарының пайдаланылған газдарын тазарту және кәдеге жарату құрылғыларының ультрадыбыстық жабдықтарының негізгі параметрлерін анықтауға, сондай-ақ қалдықтарды ұсақ бөлшектерден тазарту дәрежесін сипаттайтын тұндырылған ұсақ бөлшектердің үлесін есептеуге мүмкіндік беретін есептеу әдісі ұсынылған, соның негізінде ультрадыбыстық құрылғылардың экономикалық тиімділігі есептеледі.

**Кілт сөздер:** қалалық автобус, ішкі жану қозғалтқышы, пайдаланылған газ, сақтау құрылғысы, ультрадыбыстық тазарту, коагуляция, кәдеге жарату.

**И.А. Пак[1], Н.И. Баурова[2], Б.К. Курмашева[1], А.Ж. Карсакова[1], И.А. Кадырова[3]**

[1]*Карагандинский технический университет, Караганда, Казахстан*

[2]*Московкий автомобильно-дорожный государственный технический университет, Москва, Россия*

[3]*Медицинский университет Караганды, Караганда, Казахстан*

**Технико-экономическая эффективность устройств ультразвуковой очистки отработавших газов городских автобусов**

**Аннотация.** В статье обосновывается применение устройств ультразвуковой очистки отработавших газов для городских автобусов, приводятся конструкция и принцип работы накопительного устройства ультразвуковой очистки отработавших газов, а также компоновочные решения установки на автобусах. Представлена методика расчета, позволяющая определить основные параметры ультразвукового оборудования устройств очистки и утилизации отработавших газов двигателей внутреннего сгорания городских автобусов, а также рассчитать долю осаждаемых мелкодисперсных сажевых частиц, характеризующую степень очистки отработавших газов от мелкодисперсных сажевых частиц. На основании этого рассчитывается экономическая эффективность ультразвуковых устройств очистки отработавших газов.

**Ключевые слова:** городской автобус, двигатель внутреннего сгорания, выхлопные газы, накопительное устройство, ультразвуковая очистка, коагуляция, утилизация.

**Список литературы**

1. Боженко Я. Экологические проблемы Казахстана и пути их решения. [Электронный ресурс]. – Режим доступа: https://www.nur.kz/fakty-i-layfhaki/1666860-ekologicheskie-problemy-kazakhstana/. (Дата обращения: 01.08.2021).

2. Чигаркин А. В. Геоэкология Казахстана (географические аспекты природопользования и охраны природы): учеб. пособие для ун-тов. – Алматы: Қазақ университеті, 2006. – 414 с.

3. Экология и экологическая безопасность автомобиля: учебник / М.В. Графкина, В.А. Михайлов, К.С. Иванов. – 2-е изд., испр. и доп. – М.: ФОРУМ: ИНФРА-М, 2016. – 320 с. – (Профессиональное образование).

4. Батурин Н.В., Титов Д.Н., Медведев Г.В., Новоселов А.А., Грабовская Н.Н. Совершенствование конструкций дизелей и их экологические показатели // Ползуновский вестник. – 2009. – №1-2. – С. 73–80.

5. Что такое сажевый фильтр? [Электронный ресурс]. – Режим доступа: http://avto-blogger.ru/texchast/sazhevyj-filtr.html (Дата обращения: 10.09.2019).

6. Цинцевич Л. Чтобы воздух стал чище. Современные технологии очистки отработавших газов. [Электронный ресурс]. - Режим доступа: https://sitmag.ru/article/10586-chtoby-vozduh-stal-chishche-sovremennye-tehnologii-ochistki-otrabotavshih-gazov. (Дата обращения: 20.02.2022).

7. Кадыров А.С., Пак И.А., Кадырова И.А., Ганюков А.А. Физика процесса ультразвуковой коагуляции выхлопных газов двигателей внутреннего сгорания автотранспортной техники // Вестник ПГУ. Энергетическая серия. – Павлодар: ПГУ, 2020. - №1. - С.219-230.

8. Ибатов М.К., Пак И.А. Устройство очистки выхлопных газов транспортной техники // Труды Междунар. науч.-практ. конф. «Интеграция науки, образования и производства – основа реализации Плана нации» (Сагиновские чтения № 11), Караганда: КарГТУ, 2019. - С335-336.

9. Ибатов М.К., Кадыров А.С., Пак И.А., Кадырова И.А., Аскаров Б.Ш. Результаты экспериментальных исследований работы емкостного оборудования ультразвуковой очистки отработавших газов автотранспорта // Уголь. - М.: ООО «Редакция журнала «Уголь», 2020. № 2. - С. 73-78. DOI: 10.18796/0041-5790.

10. Kadyrov A., Ganyukov A., Pak I., Suleyev B., Balabekova K. Theoretical and Experimental Study of Operation of the Tank Equipment for Ultrasonic Purification of the Internal Combustion Engine Exhaust Gases. // Communications - Scientific Letters of the University of Zilina, 23(3), B219-B226. https://doi.org/10.26552/com.C.2021.3.B219-B226.

11. Ибатов М.К., Алиев С.Б., Балабаев О.Т., Аскаров Б.Ш. Основные результаты экспериментальных исследований изоляции отработавших газов ДВС карьерных тепловозов. // Уголь. - М.: ООО «Редакция журнала «Уголь», 2019. - №7. - С.28-30.

12. Методика расчета выбросов загрязняющих веществ от автотранспортных предприятий/ Приложение № 3 к Приказу Министра охраны окружающей среды Республики Казахстан от «18» апреля 2008 года № 100-п.

13. Экологическая экспертиза и экологический аудит: учебник и практикум для СПО / Е.Ю. Колесников, Т.М. Колесникова. 2 изд. пер. и доп. –М.: Издательство Юрайт, 2019. - 469 с. - (Серия: Профессиональное образование).

**Information about authors:**

***Pak I.A.*** - Ph.D., Senior Lecturer of the Department "Transport Equipment and Logistics Systems", Karaganda Technical University, Karaganda, Kazakhstan.

***Baurova N.I.*** - Doctor of Technical Sciences, Professor of the Department "Production and Repair of Cars and Road Vehicles", Moscow Automobile and Road State Technical University, Moscow, Russia.

***Kurmasheva B.K.*** - Candidate of Technical Sciences, Associate Professor, Dean of the Faculty of Transport and Road, Karaganda Technical University, Karaganda, Kazakhstan.

***Karsakova A.Zh.*** - Ph.D., Senior Lecturer of the Department "Transport Equipment and Logistics Systems", Karaganda Technical University, Karaganda, Kazakhstan.

***Kadyrova I.A.*** - Ph.D., Senior Researcher at the Research Center, Karaganda Medical University, Karaganda, Kazakhstan.

***Пак И.А.*** - Ph.D, "Көлік техникасы және логистикалық жүйелер" кафедрасының аға оқытушысы, Қарағанды техникалық университеті, Қарағанды, Қазақстан.

***Баурова Н.И.*** - техника ғылымдарының докторы, "Автомобильдер мен жол машиналарын өндіру және жөндеу" кафедрасының профессоры, Мәскеу автомобиль-жол мемлекеттік техникалық университеті, Мәскеу, Ресей.

***Курмашева Б.К.*** - техника ғылымдарының кандидаты, асс.профессор, жол-көлік факультетінің деканы, Қарағанды техникалық университеті, Қарағанды, Қазақстан.

***Карсакова А. Ж.*** - Ph.D, "Көлік техникасы және логистикалық жүйелер" кафедрасының аға оқытушысы, Қарағанды техникалық университеті, Қарағанды, Қазақстан.

***Кадырова И.А.*** - Ph.D, Ғылыми-зерттеу орталығының аға ғылыми қызметкері, Қарағанды медицина университеті, Қарағанды, Қазақстан.