Global Scientific Review
A Peer Reviewed, Open Access, International Journal
www.scienticreview.com
Volume 29 July 2024 ISSN (E): 2795-4951

# Methodology Of Comparative Analysis Of Cars In Urban Conditions Using Information Technologies

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**Annotation.** There are many methods in the world to reduce the fuel consumption of passenger cars, in most cases aimed at increasing the structural efficiency of the equipment. In real-life operating conditions, traditional methods for assessing modern passenger car designs need to be improved. One of the ways to solve the problem is to use mathematical models of the relevant processes using information technology. This article provides software for modeling the fuel efficiency of passenger cars during the driving cycle.
**Keywords.** Passenger car, fuel efficiency, petroleum product

Currently, the number of models and modifications of passenger cars in the world exceeds 3000. Their production volume is more than 75% of the 89.7 million total production volume, including trucks and buses [4]. In terms of the volume of petroleum products used by motor vehicles, passenger cars account for 67% [5]. The majority of passenger cars are operated in urban environments.

Ensuring the fuel efficiency of cars is an urgent task of our time and depends on many factors, in particular on operating conditions. The fuel efficiency of vehicles operated in various conditions is usually determined using international driving cycles [2, p. 93]. The standard driving cycle expresses the sequence of modes (stopping, accelerating, braking and moving at a constant speed) according to the degree of traffic congestion during the operation of the vehicle over time (Fig. 1). For the purpose of comparatively assessing the fuel efficiency of vehicles, this method relatively covers large-scale and varied operating conditions. Skills have been developed to assess the level of perfection of cars using fuel efficiency indicators based on general driving cycles [2, p. 12].

The increase in the number of cars in cities, traffic intensity and traffic density, and the difference in average speeds [4] determine the need to continue research in the direction of increasing fuel efficiency. Therefore, the development of a standard driving cycle that expresses the characteristics of specific urban conditions and determining fuel consumption using the developed driving cycle is relevant.

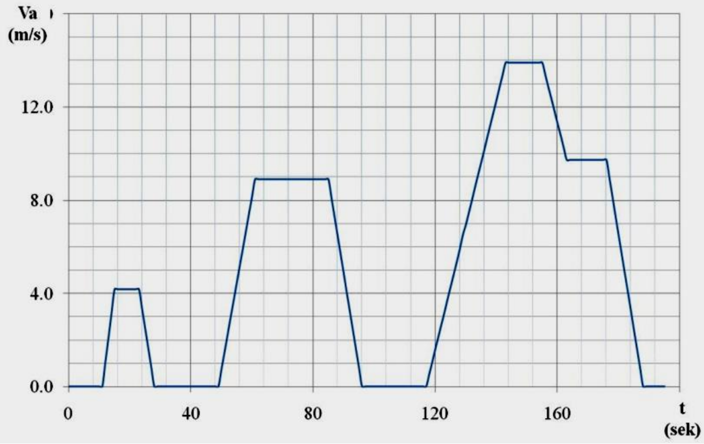


*Fig 1. Standardized European urban driving cycle*

It is known that the fuel efficiency indicators of passenger cars are different under the same driving conditions, and also each car is differently adapted to driving conditions in terms of fuel consumption.

Choosing an economical car for specific driving conditions and justifying its parameters requires complex, long-term experimental studies and processing of voluminous statistical data of the research results. Solving the problem is possible using modern information technologies and mathematical modeling methods with the development of their software.

For these purposes, we have developed software using the "Microsoft Visual" studio application. The developed software is designed to select an efficient passenger car for specific driving conditions, as well as to select effective driving conditions for specific vehicles. In addition, it is possible to assess the complexity of the traffic conditions.

Below is the main software window for selecting the appropriate performance evaluation mode (Fig. 2):

- Mode 1. Selecting an efficient vehicle for specific traffic conditions;
- Mode 2. Selecting an efficient traffic condition for a specific vehicle;
- Mode 3. Assessing the degree of difficulty of the traffic condition.

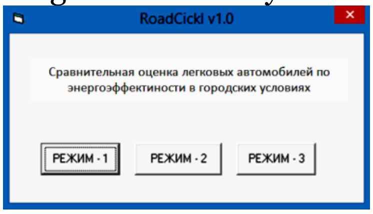


*Fig. 2. View of the main software window*

Mode 1. To determine an effective car in specific driving conditions, it is necessary to select a driving cycle (Fig. 3), which simulates the driving conditions of cars, as well as two different brands of cars. Currently, there are more than 55 standard driving cycles and many car models in the world, the parameters of which are entered into the software database. Initial vehicle data includes the following technical parameters: $N_e$- maximum engine power,[кВт]; $M_e$- Maximum engine torque, [Нм]; $w_N$- maximum angular velocity of the crankshaft, [c$^{-1}$]; $m_a$- Gross vehicle weight [кг]; B- car width, [м]; H- car height, [м]; $U_o$- final drive ratio; $U_{кп}$- gear ratio of the gearbox;

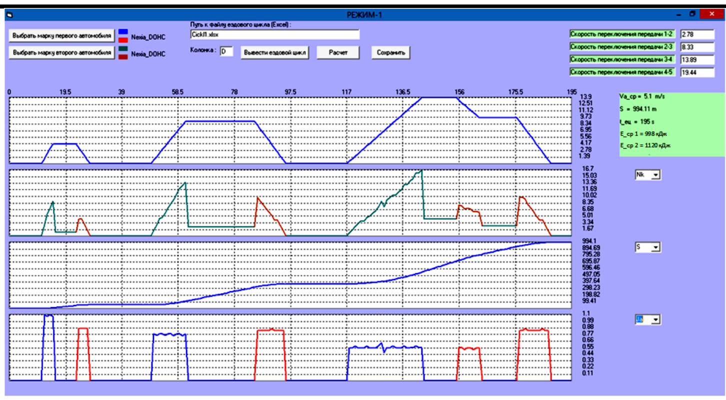

*Fig 3. General view of the first calculation mode window*

Therefore, when you click the 'calculate' button, the program calculates the required values in the following order:

a. Determination of crankshaft angular velocity $\omega_e$

$$\omega_e = \omega_a \cdot U_{mp} = \frac{V_a}{r_k} \cdot U_{\kappa n} \cdot U_0 \,;\, [\, c^{-1} \,]$$

Here: $V_a$ - vehicle speed (the angular velocity of the crankshaft is determined for each vehicle speed given in the driving cycle every second);

$U_0$ - final drive ratio;

$U_{\kappa n}$ - gear ratio of the gearbox (in the driving cycle, the gear shift time is standardized according to the vehicle speed. Therefore, on the first mode window there is an item for entering the vehicle speed in m/s, at which the gearbox operating mode changes);

$r_k$ - wheel rolling radius.

$$r_k = 0{,}5 \cdot d + \Delta \cdot B \cdot \lambda \,;\, [\, \text{м} \,]$$

Here: $d$ – rim diameter; $B$ – tire section width; $\lambda$ – tire profile radial deformation coefficient; $\Delta = \dfrac{H}{B}$ – profile height to width ratio; $\lambda_{c\text{м}}$ – coefficient of vertical deformation of a tire (for passenger cars $\lambda$ см = 0,85...0,9).

b. Determination of fuel consumption. The vehicle's fuel consumption varies depending on the driving mode (idling, accelerating, decelerating, driving at a constant speed). Therefore, it is necessary to determine the vehicle's driving modes during the driving cycle as follows:

- engine idle condition $V_n = V_{n+1} = 0$;
- condition of the vehicle acceleration mode $V_n \prec V_{n+1}$;
- condition of the vehicle deceleration mode $V_n \succ V_{n+1}$;
- condition of the vehicle moving at a constant speed $V_n = V_{n+1} \neq 0$.

Fuel consumption in idling mode per second is determined by the formula obtained by approximating experimental data:

$$G_{txx} = \left( 162.84 \cdot 10^{-9} \cdot \left( \frac{\omega_{xx} \cdot 30}{\pi} \right)^2 - 119.61 \cdot 10^{-6} \cdot \left( \frac{\omega_{xx} \cdot 30}{\pi} \right) + 0.42936 \right) \cdot 0.217 \,;\, [\, \text{гр}/c \,]$$

here: $\omega_{xx}$ - angular velocity of the crankshaft in idle mode.

In deceleration mode, the engine is disconnected from the transmission and goes into idle mode. Therefore, the condition for determining fuel consumption for the deceleration mode is determined similarly to the idle mode. In addition, modern power systems for injection engines have a forced idle mode, in which the fuel supply is turned off up to a certain angular speed of the crankshaft, which will also be taken into account in future program updates.

Fuel consumption when the vehicle is moving at a constant vehicle speed is determined by the formula [2]:

$$G_T = \frac{N_k \cdot g_e}{\eta_{TP} \cdot 3600};[гр/с]$$

here: $\eta_{TP}$ - Transmission efficiency;

$N_к$ – power supplied to the drive wheels. When driving at constant vehicle speeds, this indicator is determined as follows:

$$N_к = (m_a \cdot g \cdot \psi \cdot V_a + 0.78 \cdot B \cdot H \cdot k_в \cdot V_a^3)/1000; \ [кВт]$$

here: $\psi$ – road drag coefficient; $m_a$ – vehicle weight, [кг]; $g$ – free fall acceleration 9.81 [$м/c^2$]; $V_a$ - steady car speed [$м/c$]; H– car height, [м]; B – car width, [м]; $k_в$ – air resistance coefficient, [$Н \cdot C^2/м^4$];

$g_e$ - specific fuel consumption, кг/квт · ч

$$g_e = g_{en} \cdot K_И \cdot K_\omega; \ [кг/квт \cdot ч]$$

Here: $g_{en}$ – specific fuel consumption at maximum power, g/kW·hour; $K_\omega$ – coefficient of relationship between crankshaft angular velocity and specific fuel consumption.

$$K_\omega = 1.01\varpi^2 - 1.34\varpi + 1.33;$$

here: $\varpi = \omega_e / \omega_N$ - relative angular velocity of the engine shaft.

$\omega_e$ – crankshaft angular velocity, $c^{-1}$; $\omega_N$ – maximum angular speed of the crankshaft, $c^{-1}$; $K_И$ – coefficient of relationship between the degree of engine power utilization and specific fuel consumption.

$$K_И = 2.43И^2 - 3.83И + 2.4;$$

here: И – engine power utilization rate

$$И = \frac{m_a \cdot g \cdot \psi \cdot V_a + 0.78 \cdot B \cdot H \cdot k_в \cdot V_a^3}{M_e(-1.4561 \cdot \varpi^2 + 1.8582 \cdot \varpi + 0.58739)\omega_e \eta_{TP}};$$

here: $M_e$ – maximum engine torque, Нм;

Fuel consumption in vehicle acceleration mode is determined by the formula [2]:

$$Q_{sp} = \frac{(V_k - V_H) \cdot (\mu_H + \mu_k)}{t};[гр/с]$$

here: $V_H$ – initial vehicle speed;

$V_k$ – final speed of the car;

$t$ – acceleration time (the vehicle's fuel consumption is calculated for every second, so acceleration time can be ignored);

$\mu_H$ – fuel consumption coefficient at the vehicle's initial speed;

$\mu_k$ – vehicle final speed fuel consumption coefficient.

$\mu$ – determines fuel consumption per unit increment of vehicle speed and is determined as follows:

$\mu = G_T / j_a$; [$гр \cdot c/м$]

here: $j_a$ – car acceleration $j_a = \frac{(V_k - V_H)}{t}$ [$м/c^2$];

$G_T$ – hourly fuel consumption [$гр/c$]

$$G_T = \frac{N_k \cdot g_e}{\eta_{TP} \cdot 3600}; [гр/c]$$

here: $N_к$ – power supplied to the drive wheels. When a car is accelerating, this indicator is determined as follows:

$$N_к = (k_в \cdot F \cdot V_a^3 + \psi \cdot m_a \cdot g \cdot V_a + j_a \cdot \delta_{вр} \cdot m_a \cdot V_a)/1000; \ [кВт]$$

here: $\delta_{вр}$ – rotating mass factor, $\delta_{вр} = 1{,}04 + 0{,}04 * U_i^2$;

v. Determination of the vehicle's distance traveled:

$S = V_a t$; [м]

The distance traveled by the car must be determined for each second to build a graph $S = f(t)$, as well as the total distance of the vehicle along the driving cycle.

g. Determination of acceleration (deceleration) of a car:

$$J_a = \frac{V_K - V_H}{t}; [м/c^2]$$

here: $V_K$ - final speed of the car; $V_H$ - initial vehicle speed.

The acceleration or deceleration of the car must be determined for each second to build a graph $J_a = f(t)$, as well as the maximum and minimum values of acceleration and deceleration of the vehicle during the driving cycle.

d. Determination of the average speed of the car:

$V_{acp} = \frac{\sum S}{\sum t}$; m/c

The calculation results are reflected in graphical and digital form. As can be seen in Fig. 3 there are 4 graphics, one of which standardly shows the driving cycle, that is $V_a = f(t)$, the remaining 3 graphics are at the user's discretion selected from a number of the following functions: $S = f(t)$; $J_a = f(t)$; $N_e = f(t)$; $N_k = f(t)$; $Q_s = f(t)$; $\Sigma Q_s = f(t)$; $\omega_e = f(t)$. The graphs show the results of two cars for comparison. In this case, the time scale on the display is 60 s. You can use the cursor to view other results.

Values in digital form are intended for viewing the following summary results: $V_{acp}$, $S$, $t$, и fuel consumption of two cars $Q_s$.

For thorough analysis, all calculation results must be exported to Microsoft Excel format.

Mode 2. To determine the effective driving conditions for a specific vehicle, it is necessary to select (Fig. 4) two different driving cycles and one vehicle.

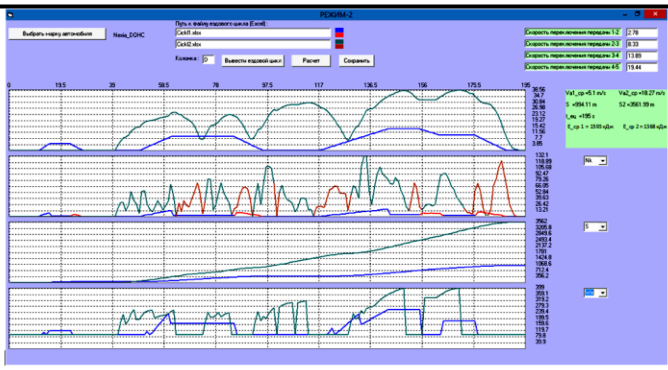

*Fig 4. General view of the second calculation mode window*

The calculation of the results of cut 2 is identical to cut 1.

The following final results are displayed digitally:

$V_{acp}, S, t, Q_s$ for two driving cycles.

Mode 3. Determining the complexity of movement in driving cycles. The movement of a car on the driving cycle is accompanied by a change in the driving mode, which creates a multifactorial task in determining the complexity of movement. But it is known that factors affecting the car ultimately affect fuel consumption. Taking this into account, it is proposed to evaluate the difficulty of movement on the driving cycle for the selected vehicle by relative fuel consumption.

To determine the complexity of the movement, a driving cycle and a vehicle are selected (Fig. 5) and, according to mode 1, the fuel consumption of the vehicle is determined $Q_{es}$ .

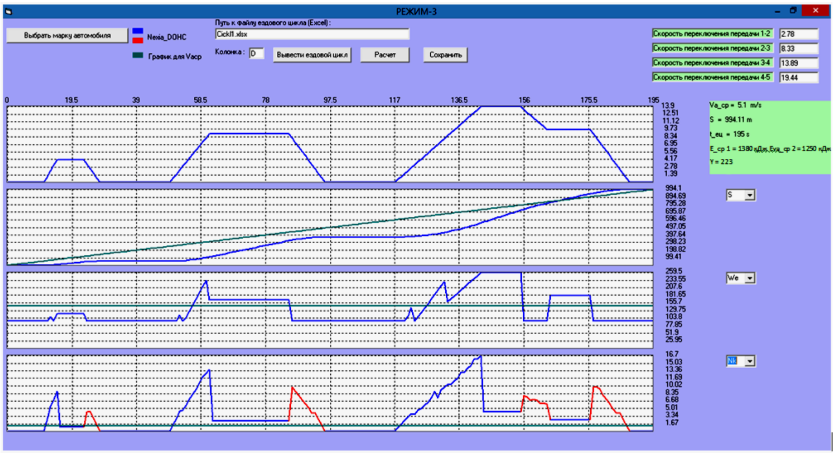

*Fig 5. General view of the third calculation mode window*

It is known that the effective value of fuel consumption corresponds to the vehicle driving at a constant speed. Therefore, to determine the effective fuel consumption of a vehicle, the average speed during the driving cycle is calculated.

Taking the value of the average speed during the driving cycle as a constant speed during the time t of the entire driving cycle, the fuel consumption of the vehicle is determined. A certain fuel consumption value is considered effective for a selected vehicle on a given driving cycle.

Taking into account the above, it has been established that the degree of complexity of the driving cycle for the selected vehicle is determined by the following expression

$$\gamma = \frac{Q_{es}}{Q_{Vasr}}$$

According to the expression, minimizing the degree of complexity of the driving cycle in specific urban conditions is achieved by improving the organization of traffic and the transport infrastructure of the city or by choosing a vehicle more adapted to the existing traffic conditions.

The developed software can be used to analyze and improve the city's transport infrastructure, in order to ensure economic and environmental safety, as well as to select the most suitable vehicle in terms of fuel efficiency for specific urban operating conditions.

**REFERNCE:**

1. Abdurazzokov, U., Sattivaldiev, B., Khikmatov, R., & Ziyaeva, S. (2021a). Method for assessing the energy efficiency of a vehicle taking into account the load under operating conditions. E3S Web of Conferences, 264, 05033. https://doi.org/10.1051/e3sconf/202126405033
2. Abdurazzokov, U., Sattivaldiev, B., Khikmatov, R., & Ziyaeva, S. (2021b). Method for assessing the energy efficiency of a vehicle taking into account the load under operating conditions. E3S Web of Conferences, 264, 05033. https://doi.org/10.1051/e3sconf/202126405033
3. Dashdamirov, F., Abdurrazzokov, U., Ziyaev, K., Verdiyev, T., & Javadli, U. (2023). Simulation testing of traffic flow delays in bus stop zone. E3S Web of Conferences, 401, 01070. https://doi.org/10.1051/e3sconf/202340101070
4. Faizullaev, E. Z., Rakhmonov, A. S., Mukhtorjanov, U. M., Turdibekov, S., & Nasirjanov, Sh. I. (2023). Parameters of the access road for disaster situations on the roads in the mountain area. E3S Web of Conferences, 401, 03022. https://doi.org/10.1051/e3sconf/202340103022
5. Fayzullaev, E., Tursunbaev, B., Xakimov, S., & Rakhmonov, A. (2022). Problems of vehicle safety in mountainous areas and their scientific analysis. 030099. https://doi.org/10.1063/5.0089596
6. Fayzullayev, E., Khakimov, S., Rakhmonov, A., Rajapova, S., & Rakhimbaev, Z. (2023). Traffic intensity on roads with big longitudinal slope in mountain conditions. E3S Web of Conferences, 401, 01073. https://doi.org/10.1051/e3sconf/202340101073
7. Ikromov, A. (2023). Components modifying methods with the using of energy technologies. 060037. https://doi.org/10.1063/5.0115559
8. Kasimov, O. (2023). Method for regulation of permissible irregularity of brake forces on front axle. E3S Web of Conferences, 401, 02033. https://doi.org/10.1051/e3sconf/202340102033
9. Kasimov, O., & Tukhtamishov, S. (2023). Mathematical model of braking process of car. E3S Web of Conferences, 401, 02034. https://doi.org/10.1051/e3sconf/202340102034
10. Keldiyarova, M., Ruzimov, S., Bonfitto, A., & Mukhitdinov, A. (2022). Comparison of two control strategies for range extender hybrid electric vehicles. 2022 International Symposium on Electromobility (ISEM), 1–6. https://doi.org/10.1109/ISEM55847.2022.9976663
11. Khakimov, S., Fayzullaev, E., Rakhmonov, A., & Samatov, R. (2021). Variation of reaction forces on the axles of the road train depending on road longitudinal

slope. E3S Web of Conferences, 264, 05030. https://doi.org/10.1051/e3sconf/202126405030
12. Kulmukhamedov, Z., Khikmatov, R., Erbekov, S., & Saidumarov, A. (2022). Maximum temperature values of the engine and auto motor vehicles units in conditions of elevated ambient temperatures. 030040. https://doi.org/10.1063/5.0093466
13. Kulmukhamedov, Z., Khikmatov, R., Saidumarov, A., & Kulmukhamedova, Y. (2021). Theoretical research of the external temperature influence on the traction and speed properties and the fuel economy of cargo-carrying vehicles. Journal of Applied Engineering Science, 19(1), 68–76. https://doi.org/10.5937/jaes0-27851
14. Kutlimuratov, K., Khakimov, S., Mukhitdinov, A., & Samatov, R. (2021). Modelling traffic flow emissions at signalized intersection with PTV vissim. E3S Web of Conferences, 264, 02051. https://doi.org/10.1051/e3sconf/202126402051
15. Mavlonov, J., Ruzimov, S., Tonoli, A., Amati, N., & Mukhitdinov, A. (2023). Sensitivity Analysis of Electric Energy Consumption in Battery Electric Vehicles with Different Electric Motors. World Electric Vehicle Journal, 14(2), 36. https://doi.org/10.3390/wevj14020036
16. Mukhitdinov, A., Abdurazzokov, U., Ziyaev, K., & Makhmudov, G. (2023). Method for assessing the vehicle energy efficiency on a driving cycle. 060028. https://doi.org/10.1063/5.0114531
17. Mukhitdinov, A., Ziyaev, K., Abdurazzokov, U., & Omarov, J. (2023). Creation of the driving cycle of the city of Tashkent by the synthesis method. 060029. https://doi.org/10.1063/5.0126363
18. Mukhitdinov, A., Ziyaev, K., Omarov, J., & Ismoilova, S. (2021). Methodology of constructing driving cycles by the synthesis. E3S Web of Conferences, 264, 01033. https://doi.org/10.1051/e3sconf/202126401033
19. Nurmetov, K., Riskulov, A., & Ikromov, A. (2022). Physicochemical aspects of polymer composites technology with activated modifiers. 020011. https://doi.org/10.1063/5.0106358
20. Sanjarbek, R., Mavlonov, J., & Mukhitdinov, A. (2022). Analysis of the Powertrain Component Size of Electrified Vehicles Commercially Available on the Market. Communications - Scientific Letters of the University of Zilina, 24(1), B74–B86. https://doi.org/10.26552/com.C.2022.1.B74-B86
21. Topalidi, V., Yusupov, U., & Allaberganov, S. (2022). Improving the efficiency of transport logistics support. 030072. https://doi.org/10.1063/5.0089587
22. Tursunov, S., & Khikmatov, R. (2023). Increasing environmental safety, increasing service life of ice units and assembly and saving fuel consumption through application of multifunctional fuel additives. E3S Web of Conferences, 365, 01012. https://doi.org/10.1051/e3sconf/202336501012
23. Usmanov, U., Ruzimov, S., Tonoli, A., & Mukhitdinov, A. (2023). Modeling, Simulation and Control Strategy Optimization of Fuel Cell Hybrid Electric Vehicle. Vehicles, 5(2), 464–481. https://doi.org/10.3390/vehicles5020026
24. Yusupov, U., Kasimov, O., & Anvarjonov, A. (2022). Research of the resource of tires of rotary buses in career conditions. 030073. https://doi.org/10.1063:/5.0089590
25. Yusupov, U., & Mukhitdinov, A. (2023). Evaluation of the influence of the longitudinal slope of carriage roads on the tire life. E3S Web of Conferences,

401, 03025. https://doi.org/10.1051/e3sconf/202340103025

26. Avdeychik, S., Goldade, V., Struk, V., Antonov, A., & Ikromov, A. (2020). THE PHENOMENON OF NANOSTATE IN MATERIAL SCIENCE OF FUNCTIONAL COMPOSITES BASED ON INDUSTRIAL POLYMERS. Theoretical & Applied Science, (7), 101-107.
27. Ziyaev K, Omarov J, Research of passenger traffic in public transport, AIP Conference Proceedings, 2024, 3045(1), 040030, DOI: 10.1063/5.0197314
28. Mukhitdinov, A., Yusupov, U., Tukhtamishov, S., Urinbayev, Q., Results of the study of the influence of an average longitudinal slope of routes on the life of tires in the quarry, AIP Conference Proceedings, 2024, 3045(1), 040041, DO:I10.1063/5.0197301
29. Abdurazzoqov, U., Anvarjonov, A., State of transport system organization in developed cities, AIP Conference Proceedings, 2024, 3045(1), 040012, DOI:10.1063/5.0197302
30. Tursunov, S.R., Sharipov, S.S., Khikmatov, R.S. Saving natural gas through the use of used oils in replacement by the method of their safe burning, AIP Conference Proceedings, 2024, 3045(1), 050022, DOI:10.1063/5.0197545
31. Tursunov, S.R., Khikmatov, R.S., Khusanov, S.N.-U., Increasing the efficiency of the use of mining transport due to increasing the periodicity of maintenance time, AIP Conference Proceedings, 2024, 3045(1), 050021, DOI:10.1063/5.0197547