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Research of a transport process of transportations of metallurgical slag of tippers is in the conditions of southeast of Ukraine

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Abstract: Research aim - taking into account terms and specific of work of tippers at transportation of metallurgical slags and products of their processing, to work out conclusions that will result in the increase of the productivity and reduction of specific expense of fuel of tippers. As a result of research the analysis of exploitation of tippers of BelAZ -7540 - is conducted on a metallurgical enterprise in the conditions of southeast of Ukraine. Described climatic terms of southeast of Ukraine. Distinguished and research factors that influence on efficiency of the use of tippers. Got conclusions in relation to efficiency of the use of tippers, namely the studied change of expense of fuel is depending on the terms of work of tippers. Thus in the process of research there was the educed periodicity of oscillation of expense of fuel of tippers. The got results can be drawn on for the decision of complex of the tasks related to the rational use of fuel, in particular, at determination, planning, setting of norms of necessary amount of fuel that for today is one of the most essential and actual tasks for modern metallurgical enterprises.

Keywords: tippers, slag, transportation, transport process, metallurgical enterprise, open pit.

1. Introduction

Motor transport, in particular, industrial transport of enterprise - the constituent of a transport system of Ukraine is important. An industrial transport works in workshops, on open works, prevails in careers. He is presented, mainly, by the tippers of different carrying capacity. Dump trucks are used for transportation in opencast mines [1]. Him structural subdivisions and transport vehicles provide continuity and reliability of production. Worsening of operating indexes of work of tippers in a career results in systematic lag of volumes of booty to worsening of the productivity of work of quarry motor transport, rising in price of eventual products. Optimization of work of tippers in the routes of transportation of metallurgical slags and products of their processing in the conditions of quarry of metallurgical enterprise is important direction of scientific and technical progress on a transport. The for today operating events of increase of the productivity at transportation of metallurgical slags and products of their processing operating of tippers conditions cannot recreate in the conditions of quarry of metallurgical enterprise. Energy consumption rises as mines extract ore from deeper levels [2].

Fuel consumption of mining dump trucks accounts for about 30% of total energy use in surface mines [3]. The "empty idle time" truck was the main contributor to unnecessary fuel consumption [4].

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Nowadays, there is a strong tendency to optimize—in wide sense—production efficiency, safety of operations, environmental impact etc. in mining industry. One can notice in different media that mining industry evolves to be green, intelligent, smart, invisible, safe and effective. Different actions have been taken to achieve it. Undoubtedly, transfer of technology to mining industry that covers monitoring system, IT solutions, computer aided management systems, automation/robotics, etc. significantly helps in modernization of mining industry [5].

Vehicle platooning has become important for the vehicle industry. Yet conclusive results with respect to the fuel reduction possibilities of platooning remain unclear. The focus in this study is the fuel reduction that heavy uty vehicle platooning enables and the analysis with respect to the influence of a commercial adaptive cruise control on the fuel consumption [6].

Nowadays and in the near foreseeable future the quarry road transport will be the most common in the open-cut mining method. This is due to a range of advantages of open-pit dump trucks usage as compared with other types of quarry transport, i.e. autonomy, the possibility of using in any mining engineering and climatic conditions etc [7].

Automobile quarry transport, namely heavy tippers, occupy an important place in a transport system of industry [8]. Automobile quarry transport has significant advantages over other types of transportation, therefore at this stage of open development of deposits it is used most often by domestic and foreign miners. The experience of the use of road transport has confirmed its high technical and economic performance in certain mining conditions. Due to the release of new high-performance large-capacity cars and improvement of their maintenance and repair system, the scope of this type of transportation has expanded significantly in recent years (in Ukraine it is approximately 60...70% of the total volume of transport). It is known that automobile quarry transport has high mobility; it does not depend on external power supplies, which allows it to be used in difficult conditions of mineral deposits, during the construction phase of a career, as well as in the development of deposits with limited reserves and a short lifetime. By car you can move rocks with different physical and mechanical properties; it can overcome the rather steep climb of the highways, which reduces the length of the routes and allows you to save on mining costs during the construction of outgoing trenches; simplify the process of transportation. A significant disadvantage of road transport is its dependence on climatic conditions and the state of highways, which inevitably leads to a decrease in traffic volumes during the periods of rains, snowfalls and ice. In addition, its use implies a short distance of transportation (3...4 km, and most appropriate for 1.2...1.5 km); in the process of work there is a high level of pollination and pollution of the atmosphere by harmful emissions (up to 200 tons per year) of exhaust gases due to the high intensity of traffic and limited size of the career; Also, there is a low level of staff productivity due to the need to maintain a state of drivers; at the same time, we note the relatively high energy consumption of cars and significant operating costs. Currently, in the quarries used heavy truck dumpers and trains BelAZ brand with a hydro mechanical and electromechanical transmission, load capacity from 27 to 220 tons. Road transport can be used quite effectively for the construction of quarries when developing fields with irregular contours, with a selective extraction of useful fossil fuels The rational distance of transportation of cargoes cannot exceed 3...4 km, therefore the transport will be appropriate in the quarries, which in terms of relatively limited size (up to 2.0...2.5 km). Divers of roads can be 80...100%, and the size of the largest radius of rotation on the roads can reach 40...50 m, the smallest 8...12 m. The depth of quarries where the road transport works usually does not exceed 200...250 m. The prospect of its use in deep quarries may be realistic due to combined transport schemes within the CPT, by improving the routes of vehicles in the quarry, developing automated control systems for dump trucks, along with excavation excavators [9].

2. Literature review

Unlike other modes of transport, industrial transport is rigidly associated with the technology of basic production. Technological transportations by dump trucks of metallurgical slags determine extremely stressful working conditions and high expenses of fuel resources, which make up a considerable share in the cost of road transport. In addition, the reliability of the transport system of the metallurgical enterprise as a whole depends on the efficiency of transport and the quality of fuel and its availability. At the same time, there is a problem of increasing productivity and maximally accurate valuation and forecasting of fuel consumption by dump trucks during transportation of

metallurgical slag and products of their processing in the conditions of a metallurgical enterprise career. On the basis of estimated numbers of hours for both overnight idling by sleepers and long-duration idling by all size classes during their workdays, the total fuel use by idling trucks is estimated to be more than 2 billion gallons per year [10]. The rational use of fuel dump trucks in the routes of transportation of metallurgical slag and products of their processing in the conditions of a metallurgical enterprise career is an important direction of scientific and technological progress in transport. Current measures to increase productivity and reduce fuel consumption when transporting metallurgical slags and their products are not well-known and, of course, can not adequately reproduce the current conditions for the operation of dump trucks in the conditions of a metallurgical enterprise career. The metallurgical industry in the country's economy occupies an important place, being the basic industry.

Modern metallurgical combines are characterized by complex production technology, large volumes and assortment of products and, as a consequence, a significant need for iron and other types of raw materials. A characteristic feature of the promotion of material flows of such enterprises is that, throughout their trajectory, from the receipt of raw materials to the shipment of finished products, they necessarily include in their structure transport links [11].

Large metallurgical enterprises are characterized by complex production technology, large volumes of production reaching 5-6 million tons per year, and with their high transport capacity (up to 10-12 tons) - a significant need for material resources [12].

In modern conditions, an open way of developing minerals is characterized by further deepening of quarries and, consequently, more stringent requirements for the stability of the operation of the transport and technological complex [13].

At present, theoretical and scientific-practical ways and measures for increasing productivity and reducing fuel consumption of mining dump trucks are considered in many scientific works of domestic and foreign scientists.

The article [14] examines the dependence of dumper performance on technical performance indicators and the introduction of cargo monitoring and control systems as one of the ways to increase productivity in the mining industry. This paper investigates the factor parameters of the transport process of the BelAZ truck dump truck and develops ways to increase the productivity of dump trucks under specific conditions of operation.

In article [15] the peculiarities of transportation of mining mass by automobile quarry transport are analyzed. The technical and operational parameters of work of the rolling stock on the route that influence the transport process are determined. It was established that the technological process of transportation of mined weight has a high level of mechanization, which, in turn, requires the organization and planning of transportation in order to effectively use it.

The article [16] investigates the performance of dump trucks and increases their productivity in the conditions of the field of migmatites. According to the author, one of the important factors in improving the efficiency of the use of dump trucks is the status of quarry roads. The state of the quarry roads directly affects their performance. On the basis of graphical and analytical dependencies, we obtained indicators that allow us to determine the ways of increasing the productivity of dump trucks in the conditions of the Stryzhavsky deposit of migmatites.

This paper discusses the fuel economy question with respect to road geometry data and future speeds, a condition that can be determined for an autonomous haulage system with relative ease [17].

This paper a new raster-based GIS model that combines multi-criteria evaluation and least-cost path analysis was developed to determine the optimal haulage routes of dump trucks in large scale open-pit mines [18].

3. Research methods

The study of the transport process of transport of metallurgical slag by dump trucks was carried out on the basis of existing statistical information. The method of complex systematization of statistical information was used. Namely, the collection of primary statistical material through the registration of facts; construction and grouping of collected data during statistical observation of primary data by dividing them into certain groups or classes on one or more grounds; analysis of consolidated data

based on generalized synthetic indicators in the form of absolute, relative or average values; on the basis of analytical indicators. The mentioned method was used in article [14, 28, 3, 23].

4. Research of parameters of a transport process of transportations of metallurgical slag

Automobile career transport has become widespread in the open development of mining industries around the world. The use of motor transport in mining affirms its high technical and economic performance when used in difficult conditions: deep or complex deposits of minerals, the development of deposits with limited resources (with a limited size in the plan of up to 2.5 km) or a short lifetime [19]. Dump trucks today are the main means of transport for the extraction of rock mass from quays in mining, delivery of rocks for the construction of tailings dams at iron ore mines and for the transport of slags in metallurgical enterprises [20]. The mining industry provides more than 80% of material and energy resources necessary for mankind [21].

Due to its advantages, road transport is widely used in various mining conditions practically on most enterprises of the mining industries of Ukraine, other countries of the former USSR, as well as all developed countries of the world. At the iron ore quarries of Ukraine, motor transport has become the most widespread: it carries about 60...70% of the entire mining mass. The volume of these transportation at large mining and processing enterprises of Ukraine and Russia makes 30...130 million tons each year. In particular, in Ukraine, iron ore quarries transport 50...125 million tons of cargo annually. The use of automobile quarry transport is a technological process for the transfer of mining mass from quarries by dump trucks, in combination with reloading points to reception facilities of concentrating factories or in dumps. As has been noted more than once, this type of transport is characterized by high maneuverability of rolling stock, and cars are able to overcome steep slopes to a slope of 80...100% at a fairly high speed, which results in a significant reduction in the length of transport communications, in addition to increasing the productivity of excavators on 15...25% in comparison with work in the scheme of rail transportation, thanks to reduction of downtime in anticipation of loading. Under these conditions, the process of transportation is simplified due to the less complexity and the possibility of reducing the area of dump trucks; and also it is possible to provide high speed management of rolling stock. In the meantime, when using road transport, it is necessary to take into account its negative characteristics, which include restrictions on the rational distance of transportation to 3 ... 4 km; the dependence of the operation of roads and rolling stock on climatic conditions; high level of dustiness and environmental pollution in conditions of high traffic intensity and limited size of a career; low labor productivity, due to the need for a large number of drivers; high energy intensity, considerable expenses for operation and repair of rolling stock and highways, and therefore, relatively high cost of transportation [9].

The rolling stock of vehicles is usually estimated according to the following technological parameters:

- Load-carrying capacity (t), that is, the maximum weight of the load that the tool maintains in terms of structural strength (dump trucks with a load capacity of 10 to 180 tons and more, but often 75...120 tons);
- geometric capacity of the body (m3), which ensures maximum use of lifting capacity;
- This parameter distinguishes machines for small and medium cargo (the bulk density of the breed is 1.0...1.2 t/m3), as well as heavy duty vehicles (1.75...2.0 t/m3);
- utilization rate of the container, which is the ratio of the vehicle's own weight to its load-carrying capacity(in modern dump trucks with hydro mechanical transmission it equals 0.7...0.77, and with electromechanical transmission - 0.71...0.85);
- Specific power (kW/t), that is, the ratio of engine power to the full weight of the vehicle, reflects the traction properties or the ability of an dumper to overcome resistance to movement in different road conditions (in modern cars is 5...6 kW/t);
- speed (V=25...35 km/h, maximum up to 60 km/h);
- normalized braking distance (lg=16 m, if V=30 km/h);
- fuel consumption (from 140 to 700 liters per 100 km of run);
- minimum radius of the curve (10...12 m). The concept of the effectiveness of road transport gives the following main characteristics of this type of transport: - volume of transportation, million tons/year;

- Annual volume of transportation in recalculation on one registered dump (in the quarries of Ukraine it is 1.5...3.0 million tkm);

- average annual mileage, which, depending on mining conditions, fluctuates within 20...60 thousand km;

- coefficient of using the fleet of cars, the value of which is determined by the level of organization of work and repair of dump trucks (is in the range 0.2...0.8) [9].

Road haulage is considered to be effective under the following conditions: during the development of quarries, in particular, in the development of fields with irregular contours of limited size in the plan (2.0...2.5 km), as well as during selective extraction of minerals. At the same time, the annual volume of transportation may exceed 80 million tons; the rational length of transportation is 3...4 km, the depth of the quarries is 200...300 m. The further development of motor vehicles is associated with the use of large-capacity cars, increasing their reliability and service life, improving roads and systems of technical exploitation [9].

Dump trucks are one of the main means of transportation of metallurgical slags and their processing products. To date, dump trucks have become widespread in the quarries of metallurgical enterprises. This is primarily due to its high technical and operational performance in difficult operating conditions. When transporting and producing hot-metal metal in which the BelAZ-7540 dump trucks are used, they determine extremely stressful operating modes with high resource costs. In the system of PJSC "Mariupol Metallurgical Combine them. Ilyich "the park of dump trucks BelAZ-7540 works on 18 different routes, differing among themselves conditions of a transport process.

For transportation of slag it is the most stressful conditions and often forced work determined by the instability of physical and chemical properties of the cargo, the distance of cargo, the distance of transportation from 5 to 17 km, the daily volume of transportation from 850 to 2500 tons, the intensity of traffic to 16 trips per day. A similar situation exists in many other metallurgical enterprises. In the conditions of metallurgical enterprises, the organization of work of dump trucks career dump is built in accordance with the interests of industrial material flow, coordinated interaction with the rhythm of shops and units, with work in difficult environment transport and logistics system [22]. The mining operations of loading and haulage have an energy source that is highly dependent on fossil fuels [23]. It is possible to substantially increase the productivity of mining equipment by improving the system of maintenance and repair, which will reduce the length of time of cars in the repair zone [24].

The efficiency of the use of quarry transport depends on various factors that determine the parameters of the machine, which can be attributed [25, 26]: climatic conditions (temperature and humidity of the ambient air, wind speed), productivity of the enterprise, distance of transportation, relief, the type and quality of the road surface, the type of lorry, the type of cargo and its characteristics, the condition of the repair base, the speed modes of the machine, the type and age of the machine [27]. The productivity of a quarry dumper primarily depends on the speed of their movement and load capacity [28].

To date, the question remains about the production of innovative models of dump trucks that will meet the conditions of transportation of rock mass in quarries [29].

In this work, climatic conditions and their impact on fuel consumption of dump trucks were investigated.

In Figure 1-3 shows the dynamic series of climatic conditions of dump truck operation in the conditions of the southeast of Ukraine.

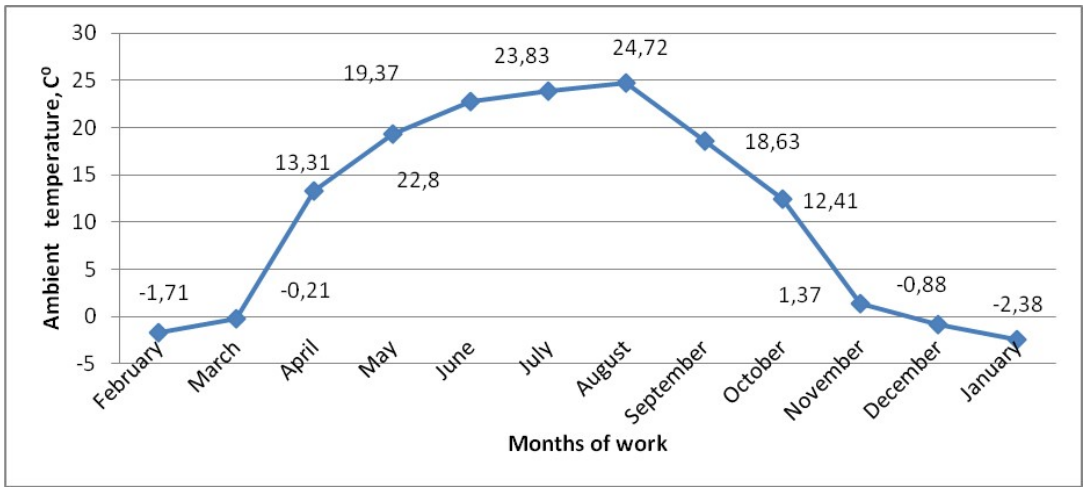

Figure 1. Dynamic row of monthly mean values of ambient temperature.

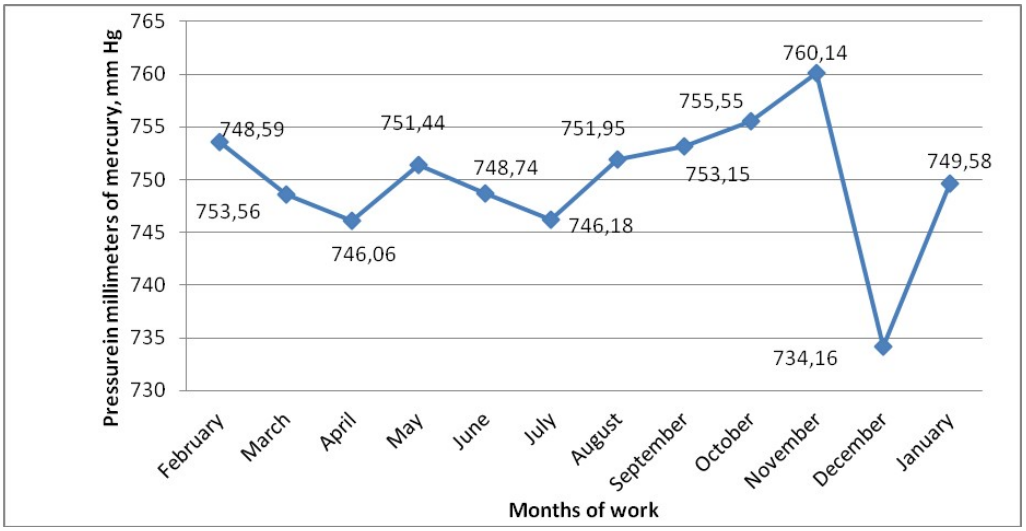

Figure 2. Dynamic row of monthly mean values of atmospheric air pressure.

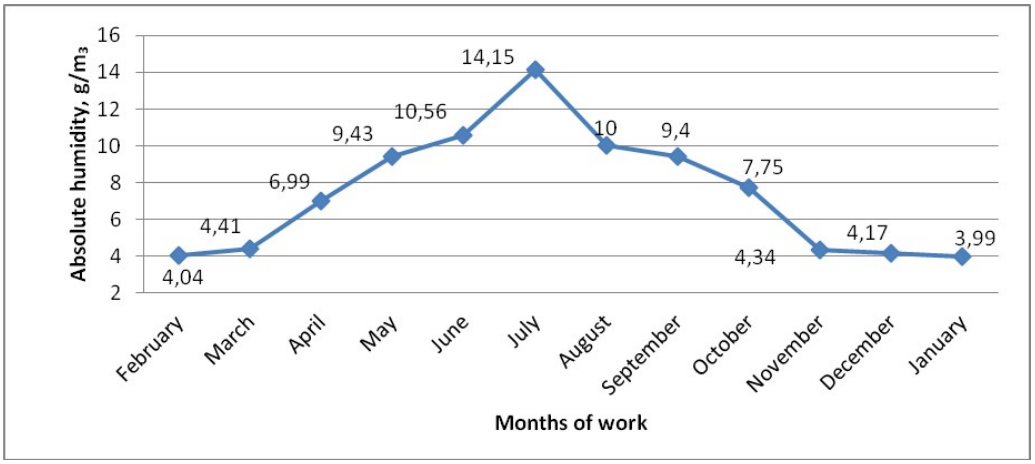

Figure 3. Dynamic row of monthly mean values of absolute humidity.

On Figure 4-9 dynamic rows over of climatic external of tippers environments are brought in the conditions of southeast of Ukraine.

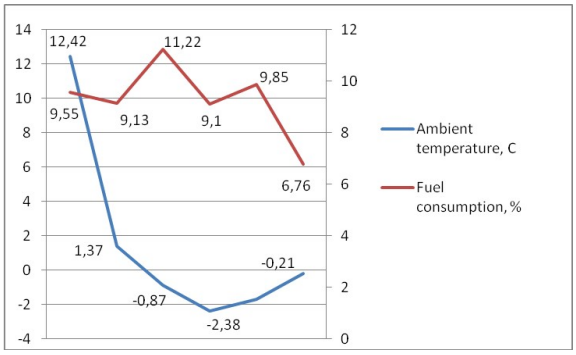

Figure 4. Dynamic row of average monthly values of ambient temperature and overrun of fuel in a cold period.

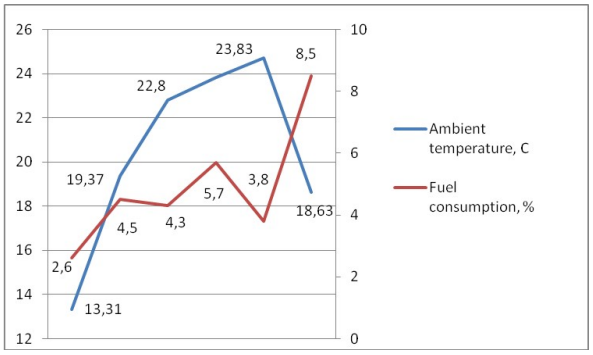

Figure 5. Dynamic row of average monthly values of ambient temperature and overrun of fuel in a warm period.

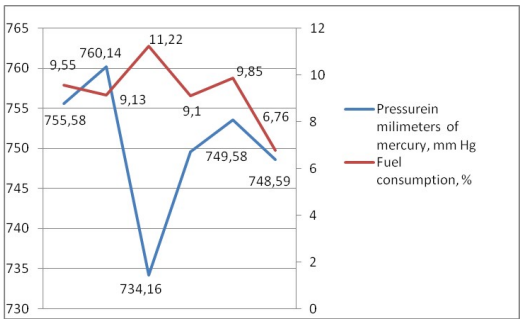

Figure 6. Dynamic row of average monthly values of atmospheric pressure and overrun of fuel in a cold period.

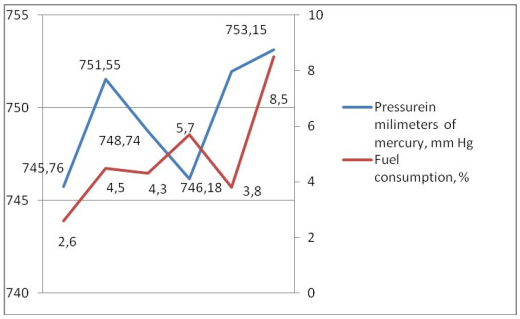

Figure 7. Dynamic row of average monthly values of atmospheric pressure and overrun of fuel in a warm period.

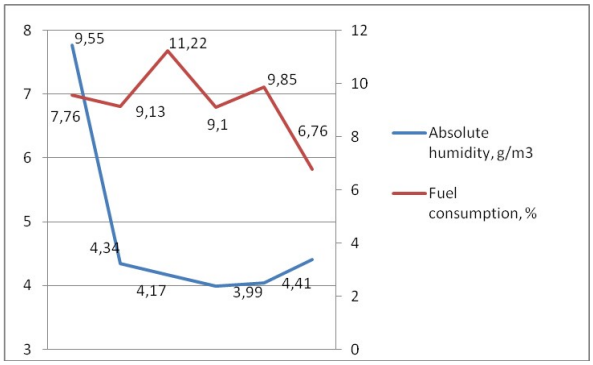

Figure 8. Dynamic row of average monthly values of absolute humidity and overrun of fuel in a cold period.

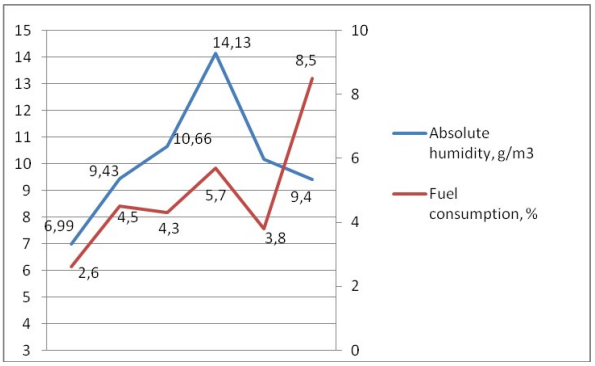

Figure 9. Dynamic row of average monthly values of absolute humidity and overrun of fuel in a warm period.

5. Discussion of the results

The study produced the following results. The territory of the southeast of Ukraine is characterized by the following climatic conditions (Figure 1-8). The average annual temperature is 11 degrees Celsius, and the warmth of the year is only 6 months: April May, June, July, August, and September, where the warmest month is August, and the remaining months are the cold season. The average annual atmospheric pressure is 749.9 mm Hg. The average annual atmospheric humidity is 7.44 g/m3. In cold period, excessive fuel consumption than in warm period. In cold period, the average monthly fuel consumption was - 9.27%. In warm period, the average monthly fuel consumption was - 4.9%.

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