

PAPER • OPEN ACCESS

Study of the Features of the Operation of a Dump Truck BelAZ 75131 at the Enterprise of JSC “AGD DIAMONDS” in the Conditions of the Far North

To cite this article: I Toskunin *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **459** 042042

View the [article online](#) for updates and enhancements.

You may also like

- [AUTONOMOUS GAUSSIAN DECOMPOSITION](#)
Robert R. Lindner, Carlos Vera-Ciro, Claire E. Murray et al.
- [Average glandular dose in digital mammography and digital breast tomosynthesis: comparison of phantom and patient data](#)
R W Bouwman, R E van Engen, K C Young et al.
- [The 21-SPONGE H i Absorption Line Survey. I. The Temperature of Galactic H i](#)
Claire E. Murray, Snežana Stanimirovi, W. M. Goss et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Study of the Features of the Operation of a Dump Truck BelAZ 75131 at the Enterprise of JSC "AGD DIAMONDS" in the Conditions of the Far North

I Toskunin¹, A Tyagunin², A Lagunov², Yu Kutinov³ and Z Chistova³

¹JSC "AGD DIAMONDS", Arkhangelsk, Troickij prospekt, 168, Russia; 163001

²Northern (Arctic) Federal University named after M.V. Lomonosov, Severnaya Dvina Emb. 17, Arkhangelsk, Russia; 163002

³Federal Center for Integrated Arctic Research, Severnaya Dvina Emb. 23, Arkhangelsk; 163000

E-mail: a.lagunov@narfu.ru

Abstract. The circumpolar region has large natural reserves in the bowels. To develop these reserves, the company AGD "DIAMONDS JSC" uses a BelAZ 75131 mining dump truck, but at the same time difficulties arise due to the influence of low negative temperatures on the performance of the equipment. We conducted an analysis, identified the main features of the operation of the dump truck, identified the factors that affect simple machinery, made recommendations on reducing failures associated with the destruction of metal structures, on preparing the engine, undercarriage and brake systems, on equipping the production base, on labor protection and life safety when working on the BelAZ 75131 mining dump truck at low negative temperatures in order to minimize the failures of equipment operating in the Far North.

1. Introduction

A special place in the system of ensuring strategic national interests of the countries of the circumpolar region in the field of economy and transport, environmental protection, innovation, defense, and geopolitics occupy areas adjacent to the Arctic zone [1-2]. The unique resource potential of this region allows, under the condition of the formation of a special system of state regulation of the economy, to ensure dynamic, sustainable development of both the Arctic regions and the country as a whole [3].

Minerals mined in the Arctic, their reserves and projected reserves, explored in the 20th century, make up the bulk of the mineral resource base of the countries of the circumpolar region. The enterprises produce more than 90% of nickel and cobalt, 60% of copper, more than 96% of platinum metals, about 80% of gas and 60% of Russian oil. At the same time, the forecast resources of the listed types of raw materials from other countries of the circumpolar region exceed 70–90% of Russian. For certain types of raw materials (nickel, diamonds, platinum metals, oil, and gas), the Arctic regions of Russia occupy a leading position in the world [4]. In forecasting diamond-bearing provinces, digital modeling is currently widely used. We have built a model for the formation of kimberlite provinces, the results of calculations on which indicate that the manifestations of kimberlite magmatism are confined to direct forms of reflection of the basement structures in the modern relief, structurally characterized as a "ledge-ledge"; the subgroup of tectonic nodes include the Zimmie coastal kimberlite



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

region and areas promising for the discovery of kimberlite regions and fields according to geochemical data. The results obtained allow us to develop additional search features of kimberlite magmatism [5].

In tectonic terms, the V.Grib diamond deposit is located in the zone of the structural joint of the Baltic Shield and the Mezen syncline, within the Arkhangelsk zone of tectonomagmatic activation [6]. In the geological section of the region, two sharply different rock complexes are distinguished: the Archean – Lower Proterozoic crystalline basement and sedimentary cover, composed of terrigenous formations of Riphean and Vendian, and to a lesser extent, carbonate – terrigenous sediments of the Paleozoic and Cenozoic [7]. The V.Grib diamond deposit is part of the Verkhotinsky kimberlite field, which is localized within the Ruchevsky ledge of the crystalline basement and combines four kimberlite pipes and six olivine melilitic pipes. Middle Carboniferous and Quaternary sedimentary rocks, whose total thickness varies from 53 to 83 m, block the pipes. Quaternary sediments consist of interbedded loam and sand with lenses of clay and sandy loam up to 20 m thick. Silica dolomites and dolomitic limestones of the Olmug and Okunev undivided formations lie under friable Quaternary sediments. Down the section are carbonate deposits with a thickness of 11 to 29 m and green and gray-colored siltstones, clays and sandstones of the Vorechensky Formation with a thickness of 1-2 to 19 m. Deposits on the eroded surfaces of the tubes are deposits of the Ursug Formation of Middle Carboniferous with a thickness of 17-40 m. They are sandstones with subordinate intercalations of siltstones, clays, and gravelites in the lower parts of the section of the suite. In terms of the surface pipe, the V.Grib diamond deposit has a rhomboid shape, elongated, like the pipes of the V. Lomonosov deposit, in the north-northeast direction. In a vertical section, it is an inverted cone with a bell in the upper part; the drop is steep (70-85°C) in a southwest direction. The maximum size of the tube on the surface is 575x500 m, on the vent - 475x370 m, at a depth of 500 m - 425x305 m. The shape of the vent surface to a depth of 300 m follows the shape of the crater surface. With depth, the elongation of the tube increases in the north-north-east direction, and at depths of more than 800 m, it turns into an asymmetric dike-shaped body with a north-north-east orientation [8].



Figure 1. Development of the diamond field named after V. Grib.



Figure 2. BelAZ-75131.

The enterprise is developing a diamond deposit named after V. Grib openly (Fig.1). The complex geological structure described above creates significant difficulties in the operation of quarry equipment. An additional challenge is climatic conditions [9]. The company JSC "AGD DIAMONDS" [10] operates mainly in climatic zones, where temperatures can reach several tens of degrees Celsius with a minus sign. The Arctic climate zone, which lies between 82° and 71° northern latitudes, includes these areas. Winter temperature is -41°C, and the summer temperature is close to 0°C; subarctic climate zone - located between latitudes 60° and 70° north. Winter temperatures average -20°C to -18°C. In summer, temperature indicators range from +16°C to +20°C. In the cold season, ice

mists usually form in troughs at temperatures below -40°C , which complicates the work and hurts the performance of the equipment. Seasonal freezing of the upper layer of overburden begins in the second half of October and reaches 1.5 m. Thawing of frozen rocks begins in May and ends by early July. Low temperatures lead to a change in the properties of structural and operational materials, as well as the physicommechanical properties of soils, which negatively affect the performance and reliability of machines: the number of failures of hydropneumatic systems, electrical equipment, and metal structures increases, which leads to an increase in machine downtime [11]. Climate change significantly worsens operating conditions for mining equipment [12-14].

It is necessary to investigate the problem of safe operation of mining trucks. Issues of environmental safety of transport are under special control of the governments of countries of the circumpolar region and scientists. The above problems determine the strategic direction of research within the framework of the development of the Northern (Arctic) Federal University named after M.V. Lomonosov (NArFU) [15] in the international project Thematic Network on Working in the Arctic [16]. The overall objective of the network is to develop a global partnership of educational and scientific organizations in the North for study and support of human working capacities in the Arctic.

2. Operational features of BelAZ 75131 at the enterprise of AGD "DIAMONDS JSC"

As a research method, we used the analysis of mining service logs and questionnaires for employees. When developing the field, the V.Grib diamond deposit in the enterprise uses 74 units of mining equipment. In the fleet of the JSC "AGD DIAMONDS", there are 40 heavy-duty dump trucks on the balance sheet, 30 of them are BelAZ 75131 (Fig.2). These dump trucks showed the greatest efficiency in the process, and therefore, we chose this model for analysis. Analysis of the fleet of dump trucks AGD "DIAMONDS JSC" shows that about half the time the equipment is idle since their utilization is in the range of 0.55. Moreover, the main causes of downtime are: scheduled, non-scheduled repairs, and maintenance.

The imperfection of the maintenance system, imperfection of the repair base, lack of necessary components in the warehouse, insufficient operational and repair manufacturability explain the long repair time. Analyzing the documents received in the service department of the enterprise such as: "statements of the replacement of units"; "Accounting of BelAZ repairs"; "List of technical conditions", it was found that 23% of all breakdowns of the BelAZ 75131 dump truck are in the frame, 19% is the engine (Fig.3).

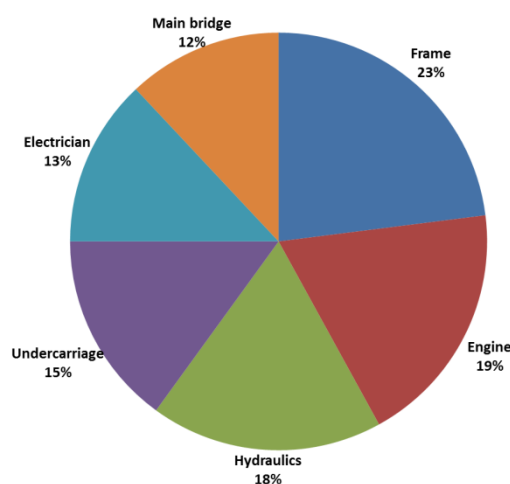


Figure 3. Damage to the BelAZ 75131 dump truck systems.

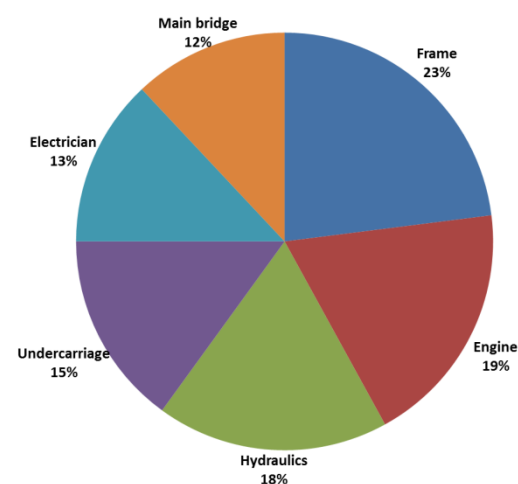


Figure 4. Damage to major engine systems.

Hydraulics breaks in 18% of cases. The main malfunctions are wear of nozzles and high-pressure hoses. Failures associated with the chassis occur in 15% of cases. The main failures are wear of pivot fingers; wear of the gearbox of the wheel motor; wear of articulated bearings; failure of brake resistors. We recorded cases of damage to the drive axle at 12%, and damage to the power supply system in 13 % of cases. Failures associated with normal wear and tear are less than half the cases.

The diagram (Fig.4) shows that the most critical systems are the gas distribution mechanism and the fuel system. They account for almost 60% of all engine failures, because, systems use liquids (oil, fuel), the characteristics of which are most susceptible to low temperatures. Damage to the generator and the pneumatic starter are mainly associated with the formation of condensate on the blades, which leads to jamming of the rotor. The truck's mileage of 16,000–30,000 km and 39,000–43,000 km provides the largest number of service calls. Typical failures are leakage of various nozzles; burnout of cylinder heads; breakouts of laying; packing wear; burnout of pistons.

Figure 5 and 6 presents frame defects that occur during operation of the truck.



Figure 5. Dump truck frame crack.



Figure 6. Front suspension defect.

An analysis of the literature [17-19] shows that the authors obtained similar data as a result of studies of the performance indicators of the dump truck fleet at various mining enterprises, in particular, in open mining operations in the North and Siberia. The authors of the studies pay special attention to the strength and reliability of the support frames, which we also found when analyzing documents from the service department. In the analysis, we found malfunctions not related to the wear of parts, assemblies, structural elements, but related to mechanical damage caused by external factors. Such failures require a significant recovery time of the machine.

According to the company's service department employees: "repair of dump trucks, especially at low freezing temperatures, has its specifics that must be taken into account, for example, emergency repairs cannot be predicted in advance, they are carried out if necessary."

Negative temperatures affect the quality and duration of repair work during their manufacture in the open air, because, with a large temperature difference in the weld metal and the heat-affected zone, large thermal stresses arise and carbides of alloying elements precipitate, which leads to an increase in the fragility of structural materials and a decrease in the operational reliability of repaired parts.

As a result, vehicle shutdowns during the period of exposure to critical negative temperatures, as well as technical downtime associated with emergency repairs caused by insufficient temperature resistance of metals and increased loads in nodes, greatly affect the efficiency of using BelAZ 75131 dump trucks at JSC "AGD DIAMONDS".

3. Experimental results and discussion

We will calculate direct losses from 1 hour of downtime for mining vehicles at the company JSC "AGD DIAMONDS" [20]. The mode of using dump trucks at the enterprise is intense. The calculation shows that from one dump truck for 1 hour of downtime, there are \$ 4.5 direct losses to the enterprise. The calculation of indirect losses shows that from one dump truck for 1 hour of downtime there are \$ 5989 of indirect losses to the enterprise. Thus, the indirect losses from the downtime of the truck are much greater than direct losses. The total loss from the idle of a mining truck is \$ 5993.5 for 1 hour. Such a large amount of losses requires the implementation of several measures to prevent the downtime of mining trucks.

As an alternative to complete downtime, we recommend lowering the load level of the dump truck body in the temperature range from -10°C to -50°C . A rational way to maintain the required temperature of the battery is to store the heat accumulated during the operation of the truck. In this case, we recommend installing the battery in an insulated box. In friction units, depending on the conditions and modes of their operation, it is necessary to use various greases. For those friction units that can be in contact with water, it is necessary to use synthetic solids suitable for use in wide temperature ranges from $+70^{\circ}\text{C}$ to -40°C . Specialists use this type of lubricant for most friction components of the chassis and running gear of cars. We recommend using brake fluid with a viscosity of no more than 1500 cSt at a temperature of -50°C and pour point not higher than -65°C to ensure reliable operation of the hydraulic brake system at low temperatures.

We recommend creating or modernizing a production base adapted to low-temperature conditions to provide the necessary conditions for safe, productive work with high-quality maintenance, repair, and storage of rolling stock. The company must ensure that the indoor air temperature is at a comfortable level of $18-20^{\circ}\text{C}$ and equip gates with tambours and thermal protection to reduce the influx of cold air into industrial premises from the street. Production units should be located in the same building or interconnected by passages so that workers in light overalls do not go out at low freezing temperatures.

The height of the premises of the areas of maintenance and repair of rolling stock should provide the possibility of carrying out these works at specialized posts of the floor type. We recommend that industrial and engineering equipment of buildings and structures located outside industrial buildings be adapted for maintenance and repair at low temperatures. You can also provide for the use of a hoist to lift heavy parts during repairs without the need for a crane.

The heating and ventilation systems of parking spaces in enclosed spaces must provide the ability to control indoor air temperatures. After the return of cold cars from the line, the temperature in the parking room should be maintained at least $18-20^{\circ}\text{C}$ for the cars to dry, and then reduced to 5°C . The roof structure of buildings provides the possibility of mechanized snow removal. For areas of cold climate, there should be triple glazing of windows.

The design of the garageless parking should provide the possibility of mechanized cleaning of the territory in the cold season. Designs of equipment for cleaning dump truck parking should ensure reliable start-up of plants at outdoor temperatures of -60°C .

4. Conclusion

We conducted a study of the effect of low negative temperatures on the characteristics of the BelAZ 75131 dump truck. The analysis of the dump truck fleet at AGD DIAMOND JSC shows that their utilization coefficient is within 0.55. Moreover, the main causes of downtime are: scheduled, non-scheduled repairs, and maintenance. Employees of the enterprise explain the long repair time by the imperfection of the service system, the imperfection of the repair base, the lack of necessary components in the warehouse, as well as insufficient operational and repair manufacturability.

Analyzing the documents received in the service department of the enterprise such as: "statements of the replacement of units"; "Accounting of BelAZ repairs"; "List of technical conditions", it was revealed that 23% of all breakdowns of the BelAZ 75131 dump truck are in the frame, 19% are in the engine. Hydraulics breaks in 18% of cases. The main malfunctions are wear of nozzles and high-

pressure hoses. Failures associated with the chassis occur in 15% of cases. The main failures are the wear of the pivot pins, the wear of the gearbox of the wheel motor, the wear of the articulated bearings, the failure of the brake resistors. We found damage to the drive axle at 12% of all cases, and damage to the power supply system at 13% of cases. We recorded the largest number of calls to the service department with a running time of 16,000–30,000 km and 39,000–43,000 km. Typical failures are leakage of various nozzles, burnout of cylinder heads, gasket breaks, wear of stuffing box packing, burnout of pistons. As measures to prevent malfunctions and downtime of mining trucks, we recommend: reduce the load of the truck at low temperatures, install the battery in a warm box, use low-temperature greases, low-temperature brake fluid with a viscosity of not more than 1500 cSt, modernize the production base in order to adapt operation and repair at low temperatures.

We have identified the main causes of failures and developed guidelines that the company JSC "AGD DIAMONDS" will use when preparing heavy equipment for use in the Far North.

References

- [1] Retrieved 20/08/2019 URL <https://www.rt.com/business/423913-northern-sea-route-us/>
- [2] Ingimundarson V 2018 *International History Review* **40** 893-915
- [3] Kovalev V, Kasyanov V, Bortsov Y, Goloborod'ko A and Skudnova T 2017 *European Research Studies Journal* **20** 499-508
- [4] Gramberg I, Glebovsky V, Grikurov G, Ivanov V, Korago E, Kos'ko M, Maschenkov S, Piskarev A, Pogrebitsky Y, Shipelkevitch Y and Suprunenko O 1999 *Polarforschung* **69** 3-15
- [5] Polyakova E, Kutinov Y, Chistova Z and Mineev A 2019 *Sovremennye Problemy Distantionnogo Zondirovaniya Zemli iz Kosmosa* **16** 75-83
- [6] Sinitsin A, Grib V, Ermolaeva L and Stankovsky A 1991 *Vestnik - Leningradskogo Universiteta, Seriya Geologiya i Geografiya* **1** 33-42
- [7] Pendelyak R, Verichev E and Golovin N 2014 *Gornyi Zhurnal* 16-21
- [8] Shchukina E, Agashev A, Golovin N and Pokhilenko N 2015 *Doklady Earth Sciences* **462** 497-501
- [9] Retrieved 20/08/2019 URL <https://seasonsyear.com/Russia>
- [10] Retrieved 20/08/2019 URL <http://www.agddiamond.ru>
- [11] Retrieved 20/08/2019 URL <http://aktivel.ru/informaciya/ekspluatatsiya-avtomobilya-v-zimnij-period/>
- [12] Gray V 2007 *Energy and Environment* **18** 433-440 URL
- [13] Kolokolov Y and Monovskaya A 2015 Multidimensional analysis of dynamics of annual warming-cooling cycles on the basis of index model of temperature observations vol 2 pp 631-637
- [14] Kolokolov Y and Monovskaya A 2016 *International Journal of Bifurcation and Chaos* **26**
- [15] Retrieved 20/08/2019 URL <https://narfu.ru/en/>
- [16] Retrieved 20/08/2019 URL <https://www.uarctic.org/organization/thematic-networks/working-in-the-arctic/>
- [17] Drygin M and Kuryshkin N 2018 Raising quality of maintenance and control of metallic structures in large-load technological machines vol 944
- [18] Vesnin A, Sistuk V and Bogachevskiy A 2015 *Metallurgical and Mining Industry* **7** 268-271
- [19] Andreeva L 2018 *Mining Informational and Analytical Bulletin* **2018** 136-143
- [20] Kishorilal D 2016 *International Journal of Applied Engineering Research* **11** 5516-5518

Acknowledgments

The research was prepared during the state assignment of the Federal Center for Integrated Arctic Research of the Russian Academy of Sciences named after academic N.P. Laverov, the state registration number AAAA-A18-118012390305-7; and with the financial support from Russian Foundation for Fundamental Research (project 18-05-60024).