Mobile lubrication and filling units to reduce mining machines and equipment downtime when providing maintenance

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Abstract. Currently in the mining industry there is an observed increase in demand for portable lubrication and filling units used by technical maintenance and repair of different quarry machinery. These oil-servicing mobile workshops provide the possibility to organize maintenance at facilities, situated far from each other, and quick delivery of everything necessary for technical maintenance and repair at mining machines and equipment operation location.

1. Introduction
A wide range of transportable capital-intensive equipment belongs to the mining industry. Mainly the conditions of this machinery exploitation are extremely severe (temperature and pressure jumps, dust, etc.) and it leads to multiple failures in work causing incidents. The machinery failures and the following downtime make a considerable contribution to the total costs of technical maintenance, operation and proximately the production. Referring to statistical information, the service and maintenance costs in the mining industry vary from 30 to 50 per cent of the operational costs. To support the mining machines systems in working condition that are unique in its field, it is necessary to take into consideration the matters connected to technical maintenance strategies, the level of machines maintainability, qualification of machine runners and technicians to provide service [1].

The basic parameter influencing the stable equipment work is high-quality in-time maintenance and its main part is providing lubrication and filling operations that approximately take 20 - 30 per cent of the total time necessary for technical maintenance and repair (TMR). A significant quantity of operations is executed during season maintenance (SM) periods that specify also total disposal of the old grease, flushing the machine systems and change of working fluid, etc. [2]. The purpose of the paper is to describe factors that enhance the service and maintenance of equipment during machinery exploitation allowing avoiding failures and reducing maintenance costs.

2. Lubrication system
Like in any modern high-technology machinery, the in-time accurately dosed lubrication fed to an assembly of friction is a base of failure-free mechanism functioning. For example, up to 53 per cent of all the failures (figure 1) happen due to non-proper bearings lubrication. This seems in its turn to be one of the main causes for equipment incidents, unreasonably high costs for machinery renovation and overrun of lubrication materials [3].
However, non-sufficient lubrication is not the only problem. The lubrication system choice also influences the work of assemblies and mechanisms.

In spite of the fact that the manual greasing method continues to be a standard in most of technical maintenance scheduled work, its application can lead to excessive lubrication of key working points. As a result, it causes not only lubricating materials and real costs overrun but also the territory contamination, dust and abrasive particles accumulation just next to the contacting pairs, safety problems and maintenance costs increase.

The advantages of the automatic centralized lubrication system (ACLS) are obvious. The ACLS greases several machine points using a pump installed in an easy access place. The system distributes small accurately measured lubricant quantities in short intervals of time while a machine continues its work.

3. The study of the structure of the modified lead-tin-base bronze
It is necessary to mention that after the right lubrication type choice and the optimization of lubricant feed in target quantity and in determined time intervals, the mining machine should be provided properly by required quantity of this lubricant, as far as it is to function constantly during the mining process. The mining machinery and equipment are constantly used in face of the quarry, and the lubricant supply, its restocking or replacement with the following stock keeping can become and usually become a problem. To solve this matter, it is necessary to create the scientifically based stock keeping, transportation, recycling and filling means for lubrication fluids and consistent grease [4].

Currently the works are held to create mobile and autonomous technical means to execute the operations of lubricants delivery, stocking, recycling and collecting the used oils and grease in the periods of TMR schedule (figure 2). The technical means are to provide improved machinery maintenance, to increase the maintenance quality, to organize production mechanization and to decrease economic costs by TMR of machinery used for main and auxiliary works in realization of mining technologies.
Figure 2. Typical layout of a universal mobile unit: 1 – body–van; 2 – self–winding drums with sleeves with dispensing pistols; 3 – pumping unit; 4 – compressor; 5 – lubricant capacity 6 – diagnostic equipment; 7– regeneration device; 8 – spent material.

The main function of such units is mobile service of mining machinery. The units are possible to be used either by presence of stationary power supply or when it is absent, in autonomous mode. In autonomous mode, the power is provided with the electric generator driven from automobile transmission.

In the unit capacities the pressure (from the compressor) can be created to supply lubricating materials or the vacuum (from the motor suction pipe) to fill in the tanks with lubricants. All the management functions are placed on the control unit. The unit allows executing the external washing of machines, filling and lubricating with oils and consistent grease, blowing radiators, pumping wires, collecting the used lubricating materials and making technical maintenance operations.

In the mobile unit set of supply there can be the equipment to receive, to keep, to distribute and to process the following liquids and materials:

- motor oil;
- hydraulic oil;
- transmission oil;
- coolant;
- consistent grease;
- diesel fuel;
- collected used fluid.

The used transmission oils used in quarry machinery and other mining machines are not capable to suit the necessary norms and requirements and subject to obligatory change into new materials or to utilization.

To solve the matter of the used oils regeneration, the innovation technology is proposed to refine the transmission oils. The technology allows decreasing the refining time, increasing the energy efficiency and ecological safety by ultrasound method. It can be applied in the mobile unit with additional equipment during providing the lubrication and filling works.
It is also rather important from the ecological point of view that by usage of the units described there should be no need to create special keeping places for different materials, including combustibles and lubricants, spare parts, tooling, production waste.

4. Main component of mobile aggregate

It is necessary to add that the most important components of each ACLS should be capacities for lubricants, pumps and filters.

To dose grease and oils, the three main types of pumps are used: piston type pump, diaphragm pump, squeeze pump. On the Russian market, the most popular ones are the diaphragm pumps that unfortunately have a number of significant disadvantages: it is a high apparatus vibration and the efficiency ratio is lower than of the piston type ones. It is also worth mentioning that very few models of Russian origin diaphragm pumps have the adjustable feed of lubricant to the system, and the foreign analogues are expensive and complicated in maintenance [5, 6].

The dosing piston pump aggregates of Russian origin that provide high accuracy of pumped grease/oil dosing, for example, pumps of ND (‘НД’) series produced by The Metering Machinery Plant “AREOPAG”, have the possibility to change the feed rate without changing the pump drive shaft rotation speed. Figure 3 presents the sketch of such dosing pump gearbox [7].

![Figure 3. Dosing pump gearbox.](image)

In the represented pump design, there is no possibility to adjust the fluid feed rate without stopping the pump, and the transmitted forces are very small. The pump is also rather bulky and complicated in assembling and parts matching. It is also worth mentioning that this pump has a very short lifetime.

5. Conclusion

When preparing the scientific base to choose the structure and parameters of the mobile oil-distributing units, it is necessary to design a high-pressure gear and piston type pump with optimized toothed gearing geometry and variable piston stroke. In addition, it is necessary to carry out additional research to collect and summarize the information about lubricant oils, consistent grease and hydraulic fluids application and usage.

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