Developing an Ecological Passport for an Open-Pit Dump Truck to Reduce Negative Effect on Environment

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Abstract. Expanding the open-pit dump truck usage areas and the need to transport more and more minerals results in producing more and more powerful open-pit dump trucks, and this all is about environmental problems and potential health risks for the personnel. Harmful gas concentrations in working areas became threatening enough to have the work in some areas completely halted, until the contents of harmful substances in the air, as well as visibility on the roads, get back to norm. The article represents the new methodology for assessing comparatively the efficiency of modern transportation systems with performance and ecology characteristics taken into account, by developing an ecological passport for machines, facilitating design improvements and reducing pollution during operation.

1. Introduction

Implementing the recommendations by the UN Second International Conference (1992, Rio de Janeiro) on environmental challenges necessitates improving control over using and protecting natural resources, based on wide scale implementation of advanced methods for controlling their state, and developing ecological regulations and requirements when using water and soil resources. In connection therewith, the need emerges to develop new methodologies for assessing risks of adverse effect by technical facilities on various natural environment components.

The new concept resides on the fundamental statement that not only the existential threat for the humankind comes with the direct pollution of environment, but it also results from breaking the natural biological balance on Earth. To preserve it the way it is, one must not overcome the allowed disturbance threshold. It is necessary to develop the system for defining the effect on biological systems, based upon assessing qualitatively the changes that take place within those systems.

State of art methodologies used to design transport systems in mining enterprises do not account for ecological aspects of open-pit dump truck operation, neither do they allow comparing or selecting the optimal layouts of open-pit dump operation and transportation facilities, nor would they specify particular open-pit dump truck models (by structure, residual lifespan, cost). Analyzing the efficiency of the open pit atmosphere normalization is not a strong side of the state of art approach, too. What we have is the situation, when insufficient funds result in delayed equipment upgrade at enterprises, while the average wear-out of open-pit dump trucks at many facilities approaches 80% and more; open pit mining is to great extent monopolized in many lands, including in Russia, by products from several
manufacturers, like Caterpillar, Unit Rig and some others, with their competitors getting pushed away from the market, for example, this specifically relates to BelAZ.

2. Equipment and devices used in studies

Ecology is a weak point of any open-pit vehicle. Diesel engines produce harmful emissions in large amounts (all 17250 units of BelAZ open-pit dump trucks in CIS burn around 2.1 million tons of diesel fuel annually), resulting in degradation of ecology in mining work areas. Fines that businesses are charged for breaking environmental regulations became more costly recently. Therefore, open-pit dump truck manufacturers do their best to make their vehicles more fuel-saving, i.e. environmentally friendly.

When it comes to considering the operation of an open-pit dump truck, there are things that are usually neglected, although in reality those things are essential, too. This specifically relates to carter gases, oil leaks via failed seals, soil and water pollution with oil products, tire particles, processing sites being polluted with oil materials when fueling vehicles, servicing vehicles; powders from the load transported by vehicles, other open-pit dump truck parts wear-out particles, asphalt particles; noise, electromagnetic and electrostatic disturbances. The latter specifically relates to large heavy-duty open-pit dump trucks with electric mechanical transmission. In addition, a serious environmental challenge is the disposal of old broken cars, large car bodies and other metal structures. Large territories become cluttered, and environmental issues emerge in connection therewith.

Any open-pit dump truck, however perfect its design might be, would hardly perform well, unless optimized for working with open-pit excavators. The department of mining machines of the Mining University developed a math model for selecting optimal parameters for load/unload complex, with ecological factors taken into account [1, 2]. The methodology for defining an optimal excavator-vehicle complex for particular open pit mining site is simple to use, tested many times, and designers and workers successfully implemented it. This methodology still needs to be improved, as new machinery performance criteria start working under new conditions.

3. Results and discussion

System approach to assessing vehicle’s ecological characteristics assumes analyzing all types and sources of environment pollution factors when operating a vehicle (fig.1); then it also specifies the contribution of each particular type and source of pollution in overall adverse effect on environment; third – a car is considered a complicated dynamic system with characteristics, including those related to ecology, being modified in time, as the resource is getting spent out. Therefore, the total ecological characteristics of a car [1, 3, 5] certainly includes sanitary characteristics that describe harmful effect on an operator by noise, vibrations, gas and dust getting into the vehicle cabin, and also electrostatic and electromagnetic fields, especially when operating vehicles with electrical mechanical transmission.

Therefore, one should talk apart the complex ecological characteristic of a new vehicle:

$$EX_x = f (K_1, K_2, ..., K_i)$$

where $K_1, K_2, ..., K_i$ refer to design and technology parameters of individual subsystems and units in a vehicle. And the ecological characteristic of a vehicle in operation:

$$EXe = f (K'_1, K'_2, ..., K'_i)$$

where $K'_1, K'_2, ..., K'_i$ refer to design and technology parameters of a vehicle depending on its operating conditions and the lifespan part already spent.

For monitoring changes in ecological characteristics of a vehicle in operation, an open-pit dump truck ecological passport is proposed, which comprises the information about the natural resources used during the operation of the vehicle (natural, secondary etc.), and also the information, necessary to determine the effect on environment by years of its operation, after service and major repair work [3,4].

The passport is based on regulatory norms (GOST, industrial standards etc.), production indicators (official reference data), estimated values for maximum emissions allowed, maximum concentrations
and conditions in connection therewith, and also the data of the state statistical register, other regulatory and technological documents. The overall structure of the passport is presented herewith (fig.2). The passport is filled by manufacturer to be attached to the technical documentation kit for an open-pit dump truck. Signed by the chief engineer of the enterprise, the passport is to be approved by local nature protection committee.

**Figure 1** – All types and sources of environment pollution factors when operating a vehicle

Solving tasks by the vehicle passport accounts for experience of leaders like USA, Germany etc., the ecological strategy in which focuses not only on pollution itself, but even more on negative influence on environment, assuming that financial methods might be more efficient than administrative ones. The qualitative evaluation of damage from influence of different nature (harmful gases, waste, radiation etc.) resides on the financial criterion, i.e. paying the risk of exceeding maximum pollution levels allowed.

The vehicle passport solves the following tasks:
- defining the list of natural resources used when operating open-pit dump trucks;
- defining the list and the amount of maximum emissions allowed, as estimated based on regulatory norms and other documents;
- defining the amount of harmful substances and adverse effects exceeding the maximum concentration allowed, expressed via indicators; performing quantitative evaluation of harmful substances and the effect in connection therewith;
- evaluating quantitatively the ecological condition of an open-pit dump truck in general and by individual types of influence to form the vehicle park structure in a manner that would minimize environmental pollution.

It is proposed to develop the open-pit dump truck ecological passport system for all types of mining and processing diesel equipment of both open pit and drilling kinds. The presence of such document in vehicle facilities of mining facilities, open pit facilities, etc. facilitates more accurate comparison of the regulated amount and structure of emissions at enterprises with the real one. In addition the vehicle park structure may be optimized for lowering environmental pollution, thus
cutting costs on fines. Open-pit dump truck manufacturers become motivated for improving their product parts even further.

Onboard computers in modern open-pit dump trucks allow remote monitoring by relevant officials. The fig.6 illustrates such a system, developed on the basis of OLKON OJSC (former Olenegorsk mining and processing plant). The forms, reports and logs outputted correspond to standards accepted at the enterprise that issued the documents [6-9].

![Figure 2](image)

**Figure 2** – The overall structure of the passport

4. **Conclusions**

The proposed model suggests the selection of optimal transportation system to reside on minimum specific costs, accounting for ecology factors. The algorithm and the structure of economical and mathematical model are built in accordance with module principle, allowing inputting other calculation units for other types of transport without making serious changes. Module principle allows easy transformation into the model for combined transport. Fig.3 illustrates that ecological characteristic calculations may be set as reference for comparing various machine models to perform studies on disclosing the way for reducing harmful emissions.
Figure 3 – Subsystem integration of environmental considerations

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