Identification of the life of mining enterprises in context of reclamation processes

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V E Kislyakov[1], **S A Bobrov** [1]

[1.]Siberian Federal University, pr. Svobodny 79, Krasnoyarsk, 660025, Russia.

Abstract. The article proposes a methodological approach to determining the full life of mining enterprises, considering the mining and biological processes of land reclamation. It also describes the working area of the strip-pit with elements of stripping, mining and reclamation operations, which predetermine its contour and establish the main parameters of the working area, and the technology of opencast mining in the development of flat deposits. The paper also describes the time (the number, sequence, and duration of the mining and biological reclamation processes at the enterprise facilities) when it is necessary to achieve certain economic indicators based on calculations of mining operations efficiency by year.

1. Introduction

Mining companies have a pronounced effect on the economy, the community and the environment, which makes it important to ensure their sustainable development and corporate social responsibility for operator companies [1].

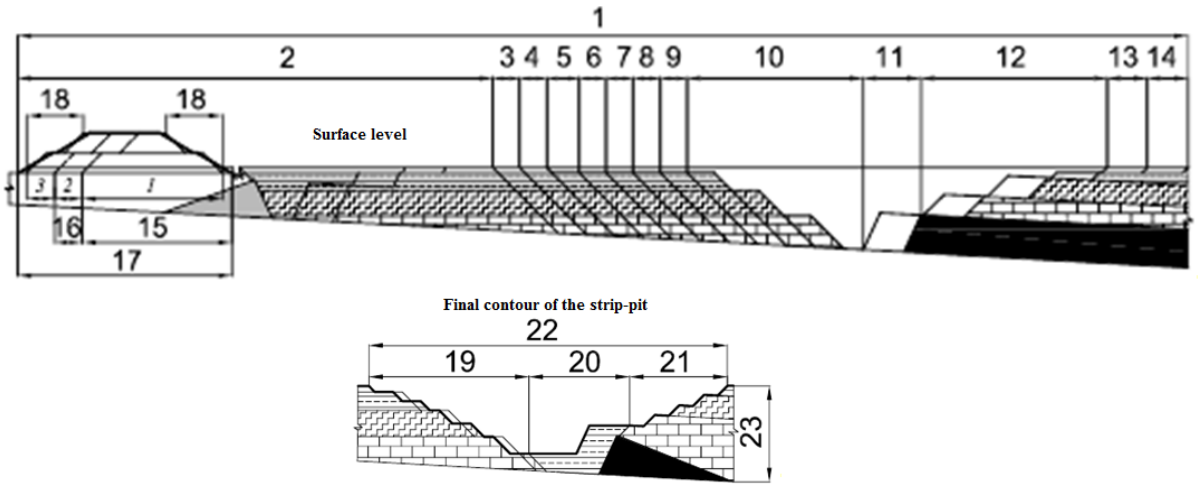
The design of the mine engineering reclamation of disturbed lands while developing of mineral deposits shall be performed according to the requirements for the normative-legal documents, regulations and scientifically grounded recommendations.

Despite the importance of determining the lifetime of mining enterprises, there are no methodological recommendations for designing or planning stripping, mining and reclamation operations in the rational (or optimal) mode of surface disturbance and restoration [2, 3, 4]. The issue arises when we face this practical task, which is a key interest for subsoil users and the state bodies exercising land management [5, 6, 7]. The main question is what time is needed for restoration of lands disturbed by mining operations considering the number, sequence, and duration of the mining and biological rehabilitation processes at the enterprise facilities and what is the full life of the mining enterprise[8, 9]. For this purpose, they present the working area of the strip-pit including the list of the reclamation processes, the place, number and sequence of their implementation.

2. Materials and methods

Figure 1 shows the elements of the working area in the development of flat deposits. By the requirements of [10, 11, 12,13] for the mining and engineering reclamation stage, for example, for agricultural land use, the following list of landscape restoration processes and recommendations is proposed. It is recommended to have plots of land equal to the annual advancement of the external (7, 18, 7, 8, 7, 6, 5, 4, 3 - provided that it is formed as shown in Fig. 2) and internal (7, 9, 8, 7 , 6, 5, 4, 3) dumps (Fig. 3). The relevant processes of mining and biological reclamation are carried out at these dumps by all regulations and guidelines to ensure the safety and efficiency of these operations [14,15,16]. According

to [11, 17, 18], there is duration of the biological stage of agricultural reclamation for pastures and hayfields in the external and internal dumps, as well as the sealing of the deposit and reclamation of the abandoned bench of the strip-pit will take eight years and three years respectively. It impacts the life of the mining enterprise, considering the mining and biological stages of reclamation, should be determined as follows.



1 - width of the strip-pit working area; 2 - width of the recultivated area; 3 - width of the biological reclamation area; 4 - width of the laying area and planning of the top soil; 5 - width of the area ensuring the safety laying and planning of the top soil; 6 - width of the section of the secondary layout of the dumps; 7 - width of the dump setting; 8 - width of the dump primary planning area; 9 - width of the area ensuring the safety of mining and planning works; 10 - width of the dumping operations area; 11 - width of the area of the annual advancement of mining; 12 - width of the stripping area; 13 and 14 - widths of the sections for removal and preparation for removal of the top soil; 15 and 16 - widths of sections for removal and preparation for removal of the top soil under the dump; 17 - width of the removal area of the top soil under the dump; 18 and 19 - widths of areas for flattening or terracing of external and internal dumps; 20 - width of the area of deposit sealing; 21 - width of the section for flattening and terracing of the abandoned bench; 22 - width of the residual mined space over the top; 23 - depth of strip-pit working area; *1-3* - dumping stages

Figure 1. Elements of the strip-pit working area with the distribution of stripping, mining and reclamation operations in the development of flat deposits.

For example, based on the list of these operations on the external dump the time needed to reclaim the land after stripping during three years of construction will be determined by the following logical sequence of the mining and biological reclamation processes. Mining-engineering reclamation of dumping stages (1–3) will end by the 9th year if the period of dump setting is conventionally accepted for one year and the processes of mining-engineering reclamation start from 2, 3 and 4 years respectively. At the same time, the mining engineering stage for the third stage of dumping will start on the 5th year and will end in the 12th year. Considering the duration of the biological reclamation processes at the sites of dumping stages (1-3), reclamation will finish in the 17th year. At the same time, since the main role is played by mode of stripping, mining and reclamation works and the methods of its regulation, it is proposed to carry out reclamation at sites of dumping stages 2 and 3 by moving the processes of biological stages (3*) in time, for example, for even distribution of the biological stage in the strip-pit working area. Reclamation of the third stage of dumping will be completed in the 20th year. Figure 2 shows a diagram explaining the identification of the reclamation duration for the external dump.

The volume of stripping work on the internal dumps of the operational period performed, for example, over 11 years of dumping (Fig. 3) and the adopted list of mining and biological reclamation

processes (Fig. 1) will be reclaimed over the period, which can be estimated as follows. Let us assume that during the construction stripping, the space developed in the internal dump of space required to pass the opening shafts and that the process of internal dumping, in this case, begins from 4 years. Reclamation of 1 year of dumping will end at the 14th year, two years - at the 15th, etc. Therefore, reclamation of the 11th year of dumping will start on the 24th year.

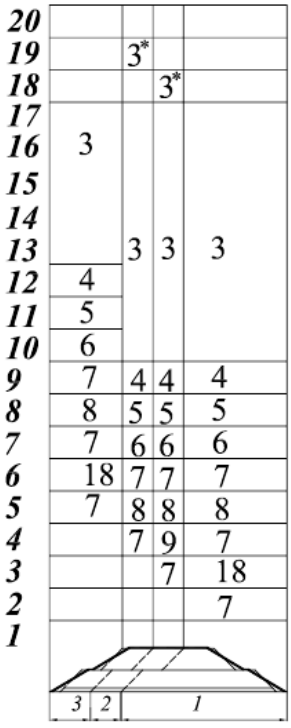


Figure 2. Calculation of the reclamation duration for the external dump: 1-20 – years; 3* - areas for regulation of the biological stage of reclamation**.**

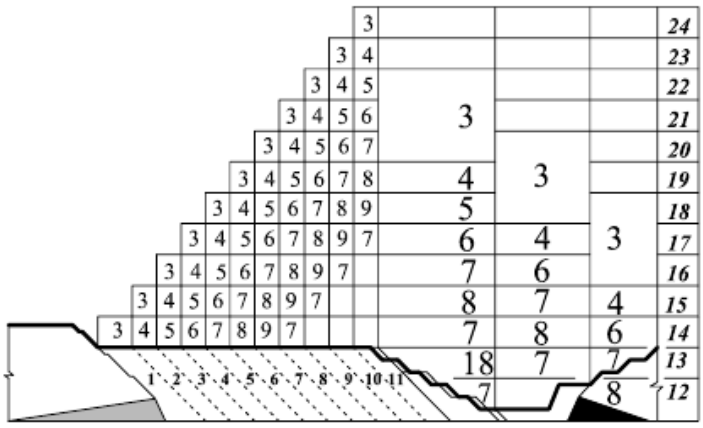


Figure 3. Calculation of the reclamation duration for the internal dump and residual workings: 1-11 – years of dumping; 14-24 – a period in years

Figure 3 shows the duration of the reclamation of the residual mined-out space (flattening or terracing the slopes of the internal dumps, the abandoned benches of the strip-pit and the sealing of the deposit) determined by the above calculation method. These calculations assume that the processes of land restoration on the internal dump, the abandoned benches of the strip-pit and the sealing of the deposit begin by the 12th and 13th year respectively.

Thus, the full life of the mining enterprise is determined by amount and sequence of the mining-engineering processes, and the number, duration, and sequence of the biological phase in the internal dump and will be 24 years. At the same time, it exceeds the conditionally established (11 years) period of mining balance reserves in the proposed example by 2.2 times.

By linking the mining and biological reclamation processes with the annual movement of the work front gives the principle (mapping elements of the strip-pit working area with the distribution of stripping, mining and reclamation works) and indicators for determining the full life of the mining enterprise (the main issue is linkage to the annual movement of the work front). There are other objects of reclamation at the mining enterprises, for example, technological roads, a pit of quarry waters, sites under various objects of a mining enterprise, etc. These facilities, as the balance reserves are mined (secondary attribute), are no longer used and must be recultivated. The combination of the principle and indicators determining the life of the mining enterprise, considering the reclamation works, is one of the main parameters of the strip-pit [5, 6]. Based on this parameter we can justify the feasibility of the open-pit mining method.

If we calculate the feasibility of the proposed open pit mining, for example, using the net present value (NPV) [7], then this value will be determined to take into account the cost of the encashed mineral and the income received from the reclaimed lands according to the formula:

$$NPV = \sum_{t=0}^{T^{Д}} \left(P_t^m \cdot Q_t^m - C_t^m + D_t^m - T_t^m - C_t^m\right) \cdot \left(1+E\right)^t + \sum_{t=0}^{T^{Р}} \left(P_t^r \cdot Q_t^r - C_t^r + D_t^r - T_t^r - C_t^r\right) \cdot \frac{1}{\left(1+E\right)^t},$$

where - P_t^m – coal price in the t-th year, rub/t; Q_t^m – production output in the same year, t; P_t^r – hayfield income in the t-th year, rub/ha; Q_t^r – the amount of reclaimed land in the same year, ha; C_t^m and C_t^r – annual operating costs of mining and reclamation works in the t-th year, rub/year; D_t^m and D_t^r – depreciation deductions of mining and reclamation in the t-th year, rub.; T_t^m and T_t^r – the amount of taxes paid and mandatory deductions of mining and reclamation works in the t-th year, rub.; C_t^m and C_t^r – capital investments of mining and reclamation works in the t-th year, rub.; E – capital investment ratio (E=0.08); T^M – period of balance reserves mining, years; T^R – reclamation period, years. In the above example: T^M=1 – 11 and T^R=14 – 24.

3. Conclusion

The proposed methodological approach to determining the life of mining enterprises at the design or planning stage of mining operations will ensure timeliness of reclamation works, a high rate of restoration of disturbed land, minimal time and area for their reclamation, as well as economical and safe development of mineral resources.

References

[1] Marinin M, Marinina O 2017 Improvement of project decisions efficiency and cost optimization at the mine engineering stage of reclamation in the context of open pit ore mining / 17th International Multidisciplinary Scientific Geo Conference *SGEM* **17(13)** 423-428 DOI: 10.5593/sgem2017/13/S03.054

[2] Marinin M A, Isheysky V A 2017 State-of-Art of mine engineering reclamation while developing of steep-dipping ore fields *Asian Journal of Microbiology, Biotechnology and Environmental Sciences* **19 (1)**, 246-252
[3] Bobrov S A, Kislyakov V E 2013 Regulirovanie rezhima vskryshnyh, dobychnyh i landshaftno-vosstanovitel'nyh rabot. *Sovremennye tekhnologii osvoeniya mineral'nyh resursov* **11** 111-114
[4] Bobrov S A 2014 Postanovka i reshenie zadach po ohrane zemel' pri obosnovanii tekhnologii vskryshnyh, dobychnyh i rekul'tivacionnyh rabot - put' racional'nogo i optimal'nogo ispol'zovaniya zemel'nyh i mineral'nyh resursov. *Sovremennye tekhnologii osvoeniya mineral'nyh resursov* **12** 69-77
[5] Khokhlov S, Safina E, Vasiliev V 2018 Risk-oriented approach implementation in departments ranking and teaching staff motivation International Journal for Quality Research **12 (2)** 501-516
[6] Safina E, Khokhlov S 2017 Paradox of alternative energy consumption: Lean or profligacy? *International Journal for Quality Research* **11 (4)** 903-916
[7] Mihail M, Isheyskiy V, Vadim D 2018 Drilling and blasting influence on the process of dust particles formation *International Journal of Mechanical Engineering and Technology* **9 (12)** 97-103
[8] Ponomarenko T V, Marinina O A 2017 Corporate responsibility of mining companies: Mechanisms of interaction with stakeholders in projects implementation. *Journal of Applied Economic Sciences* **12(6)** 1826-1838
[9] Isheyskiy V A, Marinin M A 2017 Determination of rock mass weakening coefficient after blasting in various fracture zones. *Engineering Solid Mechanics* **5 (3)** 199-204
[10] Kovalenko V S, SHtejncajg R M, Golik T V 2003 Rekul'tivaciya zemel' na kar'erah: Uchebnoe posobie. V 2 ch. (Izdatel'stvo Moskovskogo gosudarstvennogo universiteta)
[11] Cukerman I S, Igoshin V M, Moshchennikova M V, Nadrshin T K 1980 *Vremennye metodicheskie ukazaniya po rekul'tivacii narushennyh zemel' v ugol'noj promyshlennosti* (Perm', Mysl)
[12] Dolzhikov V V, Marinin M A 2017 Quality preparation improvement of mined rock for mining extraction considering spatial temporary formation of field strain *IOP Conference Series: Earth and Environmental Science* **87 (5)**
[13] Marinin M A, Dolzhikov V V 2017 Blasting preparation for selective mining of complex structured ore deposition *IOP Conference Series: Earth and Environmental Science* **87 (5)**
[14] Vadim D, Mikhail M, Valentin I 2018 Method of calculation of strain wave field for the boreholes blasting considering the blasting direction *International Journal of Mechanical Engineering and Technology* **9 (13)** 217-223
[15] Moldovan D V, Chernobai V I 2018 Improving Quality of Granulometric Composition at Open-Pit Mines of Construction Materials to Reduce Well Diameter *IOP Conference Series: Earth and Environmental Science* **194 (8)**
[16] Moldovan D V, Chernobai V I 2017 The rock pile quality control during the blasting operations at the construction materials open-cast mines *Journal of Industrial Pollution Control* **33 (1)** 1007-1012
[17] Paramonov G P, Mysin A V, Kovalevskyi V N 2018 Predicting the shotpile of blasted rock massat a granite deposit *International Journal of Mechanical Engineering and Technology* **9 (11)** 1926-1935
[18] Paramonov G P, Kovalevskiy V N, Mysin A V 2018 IMPACT of MULTICHARGE DETONATION on EXPLOSION PULSE VALUE *IOP Conference Series: Earth and Environmental Science* **194 (8)**