Using Innovative Technologies of 3D Modeling for Advanced Planning of Reclamation Results

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Abstract **— The problems of open pit mining area reclamation and computer modeling of areas under the most intensive anthropogenic impact are the topics of worldwide discussions. The solution of the problem to define reclamation area is described as the precise computer graphical design of surface landscape restoring including visualization of a faulted area before and after reclamation. It allows presenting the planned results by a visual presentation, choosing and substantiating scientifically and economically coherent technology to provide significant environmental and social effects of surface reclamation. So the article presents the comparative characteristic of reclamation works made with 3D computer graphics and without it.**

Keywords **— innovative technologies, 3D modeling, reclamation, planning, open pit mining, geo-ecology, green economy.**

I. INTRODUCTION

Kuznetsk coal basin (Kuzbass) is one of the largest coal deposits in the world, located in Western Siberia, Kemerovo Region. There are more than 60 quarries and 40 mines in the basin.

The development of Kuzbass coal industry has led to an acute crisis of land using. Coal mines annually withdraw from circulation a few thousand hectares of farmland. During the period of Kuznetsk Coal Basin exploitation, less than 20% of disturbed lands are reclaimed. Half of them remained after closed and being closed enterprises. The probability of their recovery in the coming decade is minimal.

A significant reduction of time and material costs during mining and dump works is provided when reclamation factors are taken into account. In Kuzbass, areas of sludge ponds located near the pit edges are used for the rock overburden dumps disposition more often [1]. Along with that, it is extremely important to provide sustainability of mine structure "pit edge – sludge pond – rock dump" during exploitation and subsequent reclamation. In view of the sustainability problem there are different approaches offered by the scientists, such as modeling of geomechanical state of the array [2], technological solutions of improving the efficiency of open pit mining [3], as well as the creation of technical devices for sealing the dump, increasing the safety of the waste dumps formation [4].

In addition, the dumps are used as artificial filter arrays that provide efficient purification of quarry wastewater [5-9], significantly reducing the negative impact on water bodies.

At the present time, an important role is played by the advanced planning of reclamation works to restore the earth surface from the open pit mining activity [10, 11]. Nowadays in developing of designing and planning works and for making the best decision on the implementation of remediation projects it is advisable to use a three-dimensional computer graphics, which allows to see visually the milestones and the final result at the design stage, select cost-effective technologies [12-15] for the implementation of the project and to exclude undesired costs through adjustments in the project at its development stage.

Three-dimensional computer graphics or 3D graphics is the creation of three-dimensional model using special computer programs [16]. On the basis of drawings, pictures, detailed descriptions, or any other graphic or textual information a three-dimensional image is created. In a special program the model can be viewed from all sides (top, bottom, side), can be built on any plane and in any environment. Three-dimensional computer graphics can be of any complexity. You can create a simple three-dimensional model of poorly detailed and simplified form, or more complex model, in which there is the smallest detail contrast, texture, professional techniques are used (shadows, reflections, refraction of light, and so on). Today three-dimensional modeling is used in many areas and has many advantages over other imaging methods. Three-dimensional modeling gives very accurate model as close as possible to the reality. Modern programs help to achieve high detailing. To present a three-dimensional object in a two-dimensional plane is quite difficult, while the creation of a three-dimensional object in a three-dimensional space, that is, 3D visualization object, gives the opportunity to explore it thoroughly and to observe all the details. This dramatically increases the visibility of the project, which is very important when presenting the results to the customers.

II. MATERIALS AND METHODS

To identify the importance and necessity of using the computer graphics for advanced planning of reclamation and restoration of the earth surface from mining activity, we proposed to use 3D modeling and visualization of wasted landscape for open pit "Kedrovsky" in Kemerovo (Western Siberia, Russia).

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Advanced planning of reclamation works and selection of the method of reducing damage to the landscape caused by open pit mining to a major extent depends on the conditions of the physical and chemical composition of the substrate and on the possibility of its utilization, its ability to self-overgrowing and the direction of the reclamation.

Lands, on which all the vegetation was destroyed during open pit mining operations, hydrology and terrain area were altered, contaminated soil cover was removed, are called faulted. Such waste land areas cause significant damage to agriculture and present the pits of certain depth and square.

The reclamation of wasted quarry segments and surface deformed as a result of conducted coal extracting begins after the end of mining operations or after the termination of movements of the rock arrays. The direction of reclamation is adopted in accordance with the provisions of the current National standard "Nature Conservancy. Lands. Classification of disturbed land for reclamation" and the technical conditions of reclamation.

Reclamation of disturbed lands is carried out in two consequent stages: the technical and the biological ones, in accordance with the requirements of the above-mentioned standards (Fig. 1.).

The technical stage of the reclamation is a preparatory element for the biological reclamation. The main goal of this stage is a technical improvement of disturbed areas, preparation of conditions for normal growth of trees and development of vegetation. At this stage, we suggested using the possibilities of three-dimensional graphics and 3D visualization of consequent actions and events in advanced planning of reclamation works on the example of the exhausted segment of the earth surface.

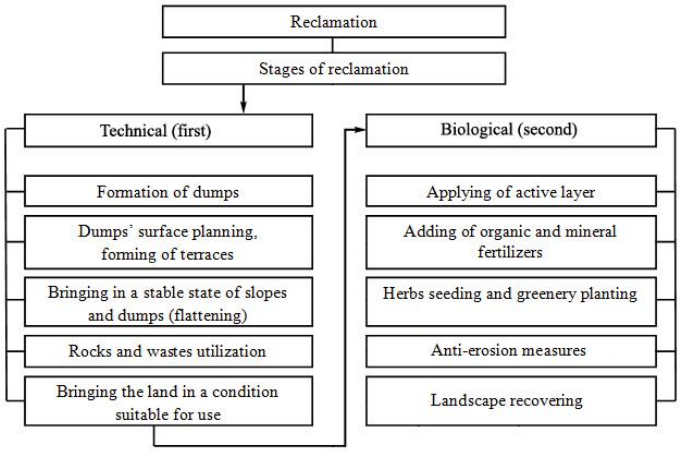

Fig. 1. The stages of the reclamation with the list of necessary events

The process of modeling and visualization of any object or process includes several operations:

- the creation of a three-dimensional model of the object;

- texturing - giving material properties to the model from which the object is manufactured;

- lighting - installation and configuration of the light sources;

- animation - making motion objects;

- The process of modeling and visualization of any object or process includes several operations:

- the creation of a three-dimensional model of the object; (Fig. 2).

Fig. 2. General view of mining operations at the quarry

Building a 3D model of the quarry pit for the previously processed segment allowed us calculating accurately the volume and species of the earth surface disturbance, being a clear result in the advanced planning.

After that, the visualization of the earth surface was produced for the layout of a potentially fertile layer of soil with the capacity of 1.5-2.0 m. According to this, the 3D model of the planned and leveled potentially fertile surface was constructed and visualized with a slight slope to drain excess rainfall.

During the 3D modeling of reclamation activities, the measures to manipulate the water flow are also provided. On the territory adjacent to the sides of the open pit's segment at the distance of at least 50 m, we calculated the depressions which must be removed as well as the cracks, washouts, dormant ditches, and the previously planned surface is filled with greenery (Fig. 3).

To achieve photorealistic visualization of the surface on the 3D model of the disturbed earth areas occupied by quarries as well as the landscaped of reclaimed vegetated area of earth surface we used realistic textures and texture.

At the end of the design phase of the advanced technical planning of reclamation on the basis of constructed 3D models the issues related to biological reclamation stage, namely, the process of planting trees, shrubs, and grasses can be resolved directly.

Fig. 3. Photorealistic visualization of results of reclamation measures for the restoration of the earth surface area damaged by open pit mining

The relationship between the principal and related rocks, and shrubs in mixed forest stands should provide them with the highest biocompatibility and stability. We recommended for the biological reclamation stage to consider such relationship in mixed forest cultures: the main breeds to 60%, related breeds to 20% and shrubs up to 20%, which is clearly visible on the photorealistic image of reconstructed earth surface at the end of the planned reclamation.

III. RESULTS AND DISCUSSION

During the experiment, the comparative analysis of the characteristics of the stages of advanced planning project to restore the earth surface of the open pit “Kedrovsky” was carried out. Comparative characteristics of the reclamation steps in the development of advanced planning of reclamation of disturbed earth surface with the use of 3D modeling and visualization of the proposed operations, and without the use of 3D computer graphics options, are presented in the graph (Fig. 4), which reflects the time periods of the planned works.

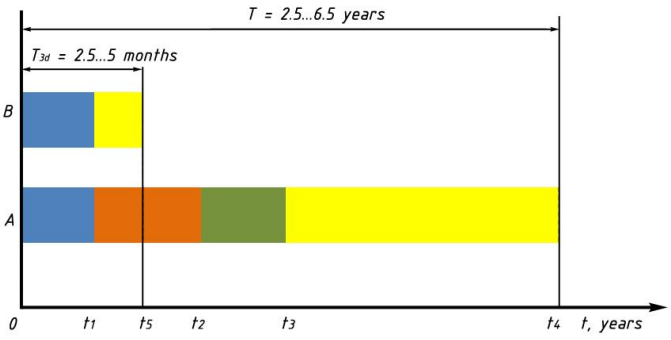

Fig. 4. The comparative characteristics of the stages of reclamation works for advanced planning with and without the use of 3D modeling and visualization

Fig. 4: A - option of reclamation works conducted without the use of 3D modeling and visualization; B - option of reclamation works conducted with using 3D modeling and visualization; t1 - the time of reclamation designing (1-3 months); t2 - the time of the technical stage of reclamation (1-3 months); t3 – the time of the biological reclamation stage (1-3 months); t4 – the time of visualization of the reclamation results without 3D modeling and visualization (2-5 years); t5 – the time of visualization of the reclamation results with the use of 3D modeling and visualization (1 month).

According to the data presented in the chart (Fig. 4), it should be noted that the time intervals of the reclamation stages in order to achieve visible results of restored land using 3D modeling and visualization are significantly reduced. It allows minimizing time for the final evaluation of the design solutions and clearly observing the restored earth surface after 5 months maximum from the beginning of the design, whereas without the use of 3D computer graphics the results of visual landscape reclamation are expected in 2.5 years minimum.

Thus, using modern technologies of three-dimensional computer graphics in advanced planning of reclamation works to restore the landscape disturbed by the activities in the quarry leads to the following conclusions:

1. The implementation of 3D modeling and visualization in the design phase of all stages of reclamation allows a clear solution to the problem of the correctness of choice of means and methods of reclamation.

2. The 3D modeling and visualization of disturbed lands allows determining the amounts and forms of violations of the earth surface with high accuracy, which is necessary for calculating the required amount of the planned works at the technical (primary) stage of reclamation.

3. The 3D modeling and visualization of biological reclamation stage allows quick visualizing of the results of all consequent stages of design and economic optimization of reclamation management from the moment of the territory survey and till the end of the biological stage, which takes a few years.

IV. CONCLUSION

In this article, the authors discussed the possibility of using computer 3D graphics for advanced planning of reclamation of wasted landscape of "Kedrovsky" open pit (Kemerovo, Western Siberia, Russia). On the basis of experimental studies, we substantiated the urgency of implementation of 3D modeling and visualization of wasted landscape at various stages of reclamation, and described the benefits of advanced planning of the reclamation using means of 3D computer graphics compared to the traditional design of reclamation works.

Today the need for reclamation of abandoned and newly disturbed landscape is a very actual topic of research as well as the need for land is growing steadily. During open pit mining and other industrial activities dramatically worsening the condition of the landscape, it is necessary to provide a set of reclamation activities. Therefore, it is strictly important to plan the creation of optimal conditions for the subsequent reclamation of disturbed lands during the planning of the open pit mining operations. To substantiate scientifically and

establish cost-effective advanced planning reclamation, using three-dimensional graphics and computer simulation of the individual stages of reclamation is required. This would clearly show the result of the design at all reclamation stages, and eliminate errors at the stage of design and calculation of measures of technical and biological reclamation stages, as well as justify the economic feasibility of the design solutions. Such advanced planning of the reclamation has a great future and opens up broad prospects for the sectors of science and technology related to environmental issues management.

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