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Literary Review on Optimizing Open Pit Mining under Surpac and Whittle

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Abstract: ***This study focuses on pit optimization, the search for a single project, the optimal long-term pit deposit of a mining project. The objective is to carry out several technical and economic analyzes taking into account the variations of the prices of the main element of the project 's deposit on the international market, in order to choose a pit which will be technically feasible and which will allow the company, from make the most profit during the whole operation. To achieve this objective, the holes are re-made on the deposit to allow the construction of the mineralized body and the model block; then an estimate of total resources is made. To obtain the optimal pit of the project, a first optimization from the technical point of view is made with the Surpac software, starting from the current costs on the market and while placing itself in the unfavorable conditions, in order to give a scenario as profitable as possible . With Whittle software, a second optimization procedure is conducted economically, taking into account Surpac projects separately. After several technical and economic analyzes, the optimal pit is retained as well as the cost of departure to obtain the best pit of the deposit. Then an analysis of exploitation sequences is carried out in order to orient the production towards the most promising places. And finally the mineral reserves contained within the limits of the optimal long-term pit are determined.***

Keywords: optimization, optimal pit, model block, mineralized body, resources

1. Introduction

The objective of open-pit mining is to achieve the maximum recovery of ore at the lowest possible cost and to achieve maximum profit (Ramazan and Dimitrakopoulos, 2012) [4]. Hochbaum and Chen (2000) considered the problem of open pit mining as a problem in determining the contours of a mine, based on economic data and technical feasibility requirements, in order to generate the maximum net income possible. [3]. Due to high capital requirements and ever-changing economic factors, each company must design an optimized well of high value and very stable in the face of economic changes; ensure maximum extraction, low stripping rate and at the same time satisfy all slope constraints (Aseidu-Asante, 2012) [4]. Then the optimization of the pits becomes an essential strategic tool to define the limits in the realization of a project of open pit mine. Lack of optimization and poor design may have adverse effects such as: failure to recover maximum ore and maximum profit or premature closure of the mine due to an unpredictable reduction in the price of metals on the market [4]. This optimization can speed up and facilitate the design process, reduce the risks in the mining operation and significantly increase the profitability of the project. To achieve this optimization, the development of the project must be based on the determination of the optimal pit to define precisely the volume and tonnage to be exploited within the exploitation limits, as well as the sequencing of the rational exploitation of the mineral extraction. Knowing that this field contains significant capital in terms of investments and profitability, the acquisition of markets becomes difficult because the competition is very large. The optimization and design of the open pit is so laborious that it is almost impossible to do it manually. Fortunately, there are computer programs such as Datamine, Minemap, Mineshed, Surpac and Whittle that help mine engineers do the job. [4] Despite the advanced knowledge of the deposit and the technical and economic parameters, the different designers offer extremely profitable projects to win markets. During operation, companies are faced with different risks from a technical point of view. And it is difficult to achieve the expected results economically. Hence the search for the optimal pit becomes lacunary on the question of the respect of the technico - economic analyzes in the optimization of the pits. As a result, there are two questions that constitute the problem of this study: What is the best optimal pit for a mining project? What is the best starting price in the optimization of the deposit pit of a project? Thus, it will be a question of making a study on the optimization of the pits, being based on various technical-economic analyzes and taking into account the variations of the prices of the main element of the deposit on the international market, in order to choose the best optimal pit of the project while setting the best starting price. That is to say, a pit that will be technically feasible and that will allow the company to make the most profit in the long term.

2. Objective

The main purpose of this study is to mount how to properly optimize a deposit to define the optimal pit to delineate the contours of the pit. This is to allow a proper extraction that allows you to make the most profit.

3. Methodology and material

In the case of conventional open pit mining, the pit optimization, which aims to design a pit that allows both a very good recovery of the deposit and a cost of the extracted metal as low as possible, is one of the most important elements. essential elements of the feasibility study. This optimization is done using specific software. These calculate the pit that will be economically the most profitable (that is to say the maximum net present value) according to the data of the deposit (geometric envelope of the deposit, contents, distribution of the contents within this envelope). , ...), economic data (unit costs of extraction operations, ore treatment costs, metal prices, etc.) and technical data (maximum slopes ensuring the stability of the pit, plant performance, dilution during extraction, ...). [1]. As hardware, we will use the software surpac and whittle. Our study will start with a data organization to create a foundation. The database will be created from the information collected on the surveys carried out on the project deposit. This is to show the distribution of the mineralization of the deposit, then, follow the creation of the solid by a three-dimensional modeling that will illustrate the mineralized body of the project. This will be followed by the estimation of the project deposit using the inverse distance and variogram analysis method, which will make it possible to estimate the value of a regionalized variable at a point or in a block of a resource; key parameter of a mining project. First, we will define the geostatistical estimation techniques that require a preliminary analysis of the experimental data and determine the distribution of the data in space, and study their degree of homogeneity, search and visualize the observations. of our variables. The calculation of the reserves being an operation by which the quantity of the useful mineral substances contained in a deposit is determined, it will be done thanks to the geological data of prospection and exploration, this computation will constitute the base on which one decides to pass to the exploitation of the deposit. It will be a question of determining the tonnage of ore and the average grade of the deposit. To achieve this, we will use the results obtained on the found mineralized body which represents the spatial limits of our deposit; and the characterization of the variability of the content of the main element of the deposit by statistical and geostatistical analyzes. After this step, a first estimate of the pit will be done with the software Surpac, because the input parameters are simple, and the calculation is fast. So we will have an idea of estimating the pit from a purely technical point of view, which will lead or not to widen the model block, the topography, and to define parameters of entries then more precisely. This step is useful to technically estimate the size of the pit that would contain all the minerals and make a comparison with the optimal pit that will be created in the Whittle software with the following. This optimum pit will be determined under the most adverse conditions to provide a most cost-effective scenario, shielding us from any fluctuation in the price of the main element of the deposit on the market. Finally, the search will be to find a pit that will make a project technically feasible and economically viable during years of operations and this regardless of the variation of the price of the main element of the project deposit on the international market. To achieve a better result, we will conduct several simulations taking into account the average price per ton of the main element of the project deposit in the market according to the different families obtained with the Surpac home. Then we will do several analyzes to choose the best pit, the one that will maximize the profit and that will be technically feasible. The analysis will consist in targeting the sensitive parameters of this project by limiting their number to the parameters controllable by the knowledge that one has of the deposit at the time of the optimization. We will set the best starting point for the optimal pit to allow us to reach the ore quickly, while maintaining a technically feasible operating schedule.

4. Results and Discussions

4.1. On the issue of data organization and construction of the ore body, the data from the project's deposit holes are used to create the ore body that represents the spatial boundaries of the project deposit. The goal of this exercise is to build a correct geometry of the formations to exploit. Which geometry will be used for qualitative and quantitative evaluations of the materials contained in the area to be exploited later. The mineralized zones are determined on each hole for a specific cut-off grade, using the main element of the project deposit as the primary variable. From the mineralized intersections of the boreholes, different mineralized surfaces are defined and joined between the sections to build the solid of the ore body. After having reassured that the modeling of the geological layers of the mineralized zones passes through the solids, the topographic surface is created, starting from the data of polls. And finally, the mineralized body that represents the desired deposit is created.

4.2. On the question of the variability study of the content of the main element of the project deposit, it is possible thanks to the different data imported into the Surpac software. This information makes it possible to carry out a variographic analysis of the values of the main element contents of the project deposit. And the variograms are constructed from the original data to characterize the spatial continuity of the data set. Variographic analysis gives different directional variograms and preferential variance with azimuth, dip and dip. These geostatistical data make it possible to deduce the parameters necessary for the distribution of these contents in the blocks made using the inverse distance method to easily evaluate the total resources of the project.

4.3. On the question of the estimation of resources, Considering the orebody created with considerable precision thanks to the surveys carried out, and taking into account the results obtained during the geostatistical analyzes and by the method of the inverse distances. The model block is created by subdividing it according to the different zones of mineralization. After analyzing the data, a block size is used as the model block of the project. The model block is assigned different attributes and classified the materials according to different grade classes that give an idea of the reserves of the deposit. After estimation by inverse distances, the results show an estimate of the resources.

4.4. On the question of optimization on a technical aspect, it is performed, using the software Surpac through its optimized Pit module. The pits are generated using the evaluated technical-economic operating parameters. Considering the current price of the main element of the project deposit on the market and to which several discount are applied to see the behavior of the different pits. In observing the results, one remark is that on a technical aspect the net value of the resources is high for the largest pit and small for the smaller pit, which leads to say that the best pit would be the one that takes the maximum ore whatever the quantity of waste rock that we should extract, which requires a new purely economic optimization that will be carried out with the Whittle software to give us much more precision. The different pits obtained are grouped into families that will constitute projects in whittle software in order to choose the best optimal pit, which will be considered as technically feasible and economically profitable in the long term.

4.5. On the issue of technical and economic optimization, the optimization performed produced a set of pit contours nested using Whittle software. The sensitivity analysis validates the pits as valid and the technical analysis validates the pits as technically feasible. The best possible scenario is proposed using Whittle software to properly sequence mining to maximize revenue, and then push-backs are programmed to reach the ultimate pit. The contours of these pits are exported from the Whittle software to the Surpac software to properly evaluate the different quantities of materials that are classified according to the different zones of mineralization while taking into account the different cut-off levels proposed.

5. Conclusion

This study focused on the literary review on the optimization of pits, the search for the optimal long-term pit for the profitability of a project's deposit. The objective was to look for a single project, the optimal long-term pit, the pit that will be technically feasible and economically profitable to maximize the benefit over the life of the mine. To achieve this objective, the geological data base, which contained several information on the various boreholes carried out on the project field, the geotechnical data, economic data such as different extraction costs, processing costs at the plant, marketing costs in order to obtain our results as accurately as possible. To achieve better results, the work started with the organization of data, by creating a database from all the information we have on the soundings to show the distribution of mineralization in our deposit. We created the solid using Surpac software which represents the mineralized body of the project. In order to make a good estimate of the resources of the deposit, a study of the variability of the copper content was carried out, by defining its distribution through various statistical and geostatistical studies and the interpolation method chosen to arrive at good results was the reverse distance method.These results were used as interpolation parameters for estimating total resources. For the construction of the model block, a few simulations were made to obtain a model block that reflects the reality of the terrain. To be more exact in our estimation, the size of the blocks has undergone different variations. In choosing the best block the observation made is that with large blocks we can be led to a greater imprecision in the measurement of resources on the ground, imprecision linked much more to problems of excessive dilution during exploitation. And with much smaller blocks, we can be led to a problem of higher operating costs related to operational problems.The technical aspects of the equipment used on the project site were also chosen. Then a first optimization was carried out with the Surpac software. With the Whittle software, a second optimization could be carried out on a more economical aspect, taking into account separately the projects formed. Several analyses have been carried out to make the choice of the best pit, the one that will maximize the profit while remaining technically feasible.

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