Amirkabir University of Technology
(Tehran Polytechnic)

Amirkabir Jounrnal of Science & Research
Civil and Enviromental Engineering (ASJR-CEE)
Vol. 48, No. 3, Fall 2016, pp. 125-126

An Integer Programming Algorithm for Stope Layout Optimization

V. Nikbin[1*], M. Ataee-pour[2]

1- PhD Candidate, Department of Mining and Metallurgical Engineering, Amirkabir University of Technology
2- Associate Professor, Department of Mining and Metallurgical Engineering, Amirkabir University of Technology

(Received 12 March, 2014, Accepted 18 April, 2015)

ABSTRACT

The optimization of stope layout is defined as looking for a boundary with the highest profit considering technological and geometrical constraints. The first algorithms were presented about five decades ago for optimization of mining limits. Most of algorithms, presented till now, have been applied for optimization of open pit limits. Few algorithms have been presented for underground cases, most of which have been tailored for a specific mining method or use heuristic techniques. These heuristic algorithms do not guarantee the true optimum. There are, however; some rigorous algorithms, which provide true optimum, but they fail to provide 3^D solution. In this paper, a new algorithm is introduced to optimize stope layout, using integer programming technique. The algorithm is implemented on a specific model, derived from conventional block model. It is a rigorous algorithm and provides a realistic optimum solution, compared to its alternatives. For the first time, two more constraints, namely the minimum width of rib pillars and the maximum stope height, are considered in the proposed algorithm.

KEYWORDS:

Modeling, Optimization, Stope Layout, Integer Programming

[*] Corresponding Author, Email: vahidnikbin@yahoo.com

1- Introduction

The first algorithm for optimization of mining layout was presented more than four decades ago. Most of presented algorithms have been offered for open pit optimization and have been improved during time. Unlike open pit mining, the rate of development of these algorithms in the subject of underground mining has been very slow due to large number of mining methods, complexity of economic modeling of mining area and the simplifications required in the design of these algorithms. Each of the algorithms developed for the ultimate underground layout, have only considered few constraints. Some of them are heuristic which do not guarantee the true optimum and others, that have a rigorous logic, are not suitable for implementation on 3^D cases. Accordingly, so far; no comprehensive algorithm or model has been reported to be appropriate for all mining methods. The Floating Stope of Datamine [1], Maximum Value Neighborhood (MVN) [2] can be run on 3^D block models, but they are heuristic and may not find the true optimum layout. Further, although the dynamic programming of Riddle [3], Branch and Bound technique [4] and dynamic programming of Jalali et al. which is called Optimum Limit Integrated Probable Stope (OLIPS) [5] are rigorous, they have been presented for 2, 1 and 2 dimension problems, respectively. In this paper a new integer programming model is presented for optimization of the stope boundaries. The new proposed model has been implemented on a hypothetical 2^D model by using the CPLEX software tool.

2- Methodology

The new proposed model is run on a special kind of block model that is called secondary block model and derived from an economic block model. Both the dimensions and the value of blocks in the secondary block model are different from the primary model. The secondary block model has some virtual columns which are added to the model for solving the problem. Since these virtual columns are not selected in the ultimate underground stope, a large negative number is allocated for the worth of the blocks that are located in these columns. By the definition of this model it can be guaranteed that the result is the largest in the scope of its constraints. After building this model, in the CPLEX environment it is run on a hypothetical 2^D model and its results are compared to the results of Riddle and OLIPS algorithms.

3- Conclusion

A new Integer programming model has been described for optimization of underground stope layout. This model is run on a specific block model, which is called secondary block model. The objective function of this model has been presented based on maximizing the profit. Almost all of the important and critical constraints in this scope have been considered and even some of them such as the minimum width of rib pillars are taken into account for the first time. The value of stopes found by the new model is the same as that obtained from OLIPS algorithm. Results show that the new model provided more stope value compared to using dynamic programming of Riddle. Also wide range of application and mathematical formulation of this model are its advantages. However, it is a 2^D model and it is recommended that a 3^D model will be presented in the future researches.

4- References

[1] Alford, C.; "Optimisation in Unerground Mine Design,", *25th International Symposium on the Application of Computers and Operations Research in the Mineral Industry*, The Australasian Institute of Mining and Metallurgy, pp. 213–218, 1995.

[2] Ataee-pour, M.; "A New Heuristic Algorithm to Optimise Stope Boundaries," Proceeding of the *2nd Regional APCOM Symposium on Computer Applications in the Mineral Industry*, Moscow, Russia, 1997.

[3] Riddle, J.; "A Dynamic Programming Solution of a Block Caving Mine Layout," *14th International Symposium on the Application of Computers and Operations Research in the Mineral Industry*, Society for Mining, Metallurgy and Exploration, Colorado, pp. 767–780, 1977.

[4] Ovanic, J. and Young, D.; "Economic Optimisation of Stope Geometry using Separable Programming with Special Branch and Bound Techniques," *3rd Canadian Conference on Computer Applications in the Mineral Industry*, Balkema Rotterdam, pp. 129–135, 1995.

[5] Jalali, S. E.; Ataee–pour, M.; "A 2^D Dynamic Programming Algorithm to Optimize Stope Boundaries," in 2004 Proceedings of the *13th symposium on Mine Planning and Equipment Selection*, Rotterdam, Balkema, pp. 45–52, 2004.