Application of Keshtel algorithm for long term production planning in open pit mines

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ABSTRACT

Ultimate pit limit optimization and production mine planning have always been the main challenges in the field of mining activities. The production mine planning can be determined through accurate methods and artificial intelligence techniques. While exact methods provide better and optimal results, they may require significant time to answer the problem due to the large number of blocks involved. In such cases, it is more suitable to use collective algorithms or a planned approach to determine the production mine planning. Production mine planning is similar to other optimization problems that can be addressed using logical algorithms in MATLAB software. In this study, Keshtel's algorithm, implemented in MATLAB, is utilized to optimize the production mine planning. Initially, Keshtel's algorithm is employed to solve the two-dimensional and three-dimensional problems. Subsequently, the Songun Copper Mine is chosen as a case study and the results of determining the production mine planning by Keshtel's algorithm are compared with the findings of NPV Scheduler software. The outcomes show that Keshtel's algorithm, used to determine the production mine planning of the Songun Copper Mine, differs by only 1.8%, when compared to the NPV Scheduler software. Moreover, the comparison of Keshtel's algorithm with the results of Gershon in two-dimensional production mine planning, as well as the comparison with NPV Scheduler software in three-dimensional problems, demonstrates its efficiency in solving these issues effectively.

KEYWORDS

Production Mine Planning, Optimization, Keshtel Algorithm

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1. Introduction

Ultimate pit limit optimization and production mine planning have always been the main challenges in the field of mining activities. These two issues, especially production planning, determine the effective components in mining process and the important decisions of a mining project. Production planning of an open pit mine means determining the order of extraction of blocks located in the ultimate limit, so that the net present value of the mine is maximum according to the existing restrictions. So far, various search-based methods and mathematical approaches have been proposed to solve the problem of production planning. Search-based methods are used in many scientific and engineering problems and have been able to obtain optimal or near-optimal answers. Until now, many metaheuristic algorithms have been used to solve the problem of production planning in mines [1]. One of the most recent metaheuristic algorithms is Keshtel algorithm. This algorithm is one of the intelligence algorithms inspired by nature that takes advantage of the feeding behavior of a kind of duck in the pond. In the present study, the efficiency of this algorithm is evaluated in the production planning problem of open pit mines.

2. Methodology

Many metaheuristic algorithms have been used to solve the problem of production planning in mines. But in these studies, many limitations or uncertainties (such as the uncertainty of price and grade) have not been investigated. Researchers are looking for flexible methods or algorithms to be able to solve all the mentioned cases and even more, and if a variable is added or subtracted in the future in this field, the changes can be applied easily. One of the most recent metaheuristic algorithms is Keshtel algorithm. In the current research, this algorithm has been used to solve the problem of production planning in open pit mines.

Keshtel algorithm is inspired by a process in nature (the behavior of a duck). The steps of implementing the algorithm are [2]:

1- Creating the initial answer (landing the boat in the pond)
2- Keep operator
3- Swirl
4- Replace operator
5- Move operator
6- Stop condition

3. Results and Discission

The model proposed in this research was implemented to optimize the production mine planning. Initially, Keshtel's algorithm is employed to solve the two-dimensional and three-dimensional problems. Subsequently, the Songun Copper mine is chosen as a case study and the results of determining the production mine planning by Keshtel's algorithm are compared with the findings of NPV Scheduler software. The findings of production planning with a discount rate of 10% for 36 years using Keshtel's algorithm is equal to $3543489776 and using NPV Scheduler software is equal to $3609099664. Figure 1 shows the ultimate pit limit of Songun Copper mine and figure 2 depicts the its production planning. Figure 3 also shows the amount of ore and waste production in this mine by year (using Keshtel's algorithm).

4. Conclusion

The issue of determining the ultimate limit and production planning in mines is classified as NP Hard problems due to the number of components and variables. These types of problems can be solved using two deterministic and search-based methods. In this research, Keshtel algorithm, which is one of the new metaheuristic approaches, has been used for the first time in solving the two-dimensional and three-dimensional production mine planning problems. To conduct the study, first, 4*10 and 8*8*4 hypothetical blocks were used to solve the two-dimensional and three-dimensional problems, respectively. In the next step, Keshtel algorithm was applied and its outputs were compared with the answer of NPV Scheduler software. The results show that the answers obtained from the implementation of Keshtel's algorithm and NPV Scheduler software are almost similar. Finally, the Songun Copper mine's data were used to evaluate the Keshtel algorithm. The outcomes also depict that Keshtel algorithm, used to determine the production mine planning of the Songun Copper mine, differs by only 1.8%, when compared to the NPV Scheduler software. Moreover, the comparison of Keshtel algorithm with the results of Gershon in two-dimensional production mine planning, as well as the comparison with NPV Scheduler software in three-dimensional problems, demonstrates its efficiency in solving these issues effectively.

5. References

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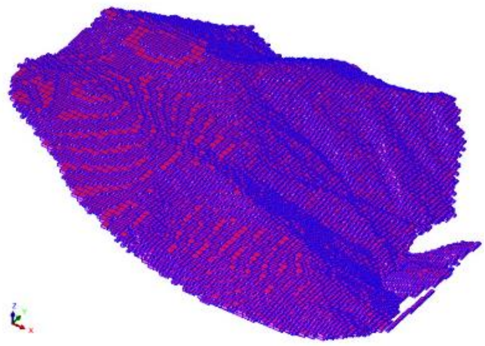

Figure 1. The three-dimensional ultimate pit limit of Songun Copper mine

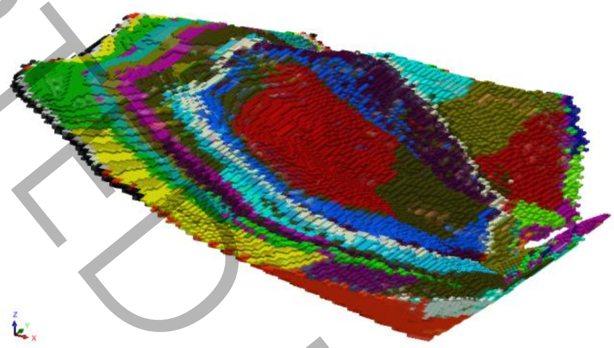

Figure 2. The production planning of Songun Copper mine using Keshtel's algorithm

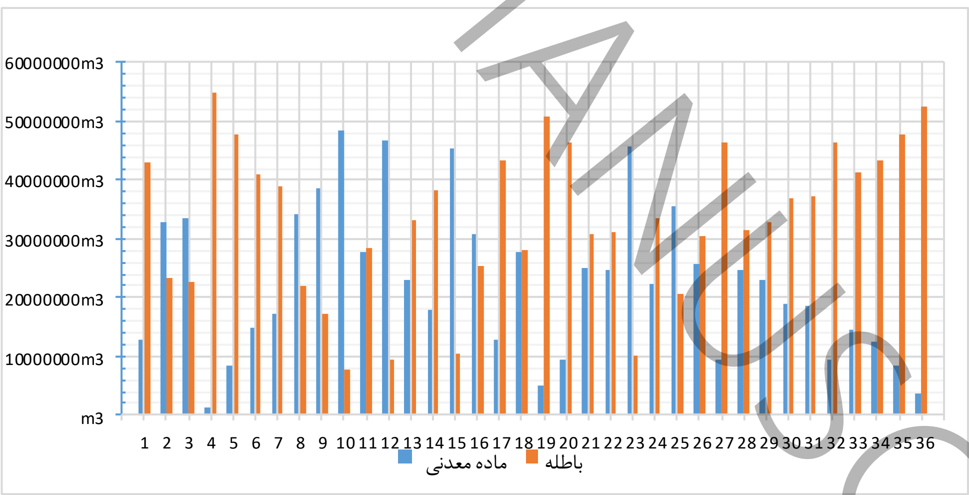

Figure 3. The amount of ore and waste production in Songun Copper mine by year (using Keshtel's algorithm)