OPEN PIT MINE SCHEDULING UNDER UNCERTAINTY : A ROBUST APPROACH

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EXTENDED ABSTRACT

For the purpose of production scheduling, open pit mines are discretized into three-dimensional arrays known as block models. Production scheduling consists in deciding which blocks should be extracted, when they should be extracted and how each extracted block should be processed. It is known that this problem can be formulated as a large-scale integer programming problem (Johnson, 1969), that is very difficult to solve due to the large size of real-world instances (millions of blocks). In a recent paper (Bienstock & Zuckerberg, 2010), authors provide an algorithm to solve the LP relaxation of this problem. Efficient implementations of this algorithm, together with good rounding-heuristics (Muñoz et al, 2012) allow us to obtain near-optimal solutions of this (deterministic) problem, even for large and complicated instances.

However, a major concern of mine planners is the volatility of ore prices. Nowadays, real mine are planned with a fixed long-term ore price, even if the time-horizon of a mine spans along several decades. In this talk, we describe an extension of Bienstock-Zuckerberg algorithm for open-pit mine scheduling to incorporate the uncertainty of ore prices. Using a mean-reverting stochastic process, we construct confidence intervals for ore prices along the years. We include these prices in a robust optimization framework, as an additional second-order conic constraint for each ore (Ben-Tal, Nemirovski, 2001). We show how to extend Bienstock-Zuckerberg algorithm to include this type of non-linear constraints efficiently. This extension allows us to solve robust models of millions of blocks in a few hours. Extensive computational results on real data sets are presented. We also present the impact of different levels of uncertainty into the resulting plan for three real mines.

KEYWORDS. Open-pit mining. Uncertainty. Conic programming.

Main area: Operations Research in Forestry and Mining

References

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