ABSTRACT

Mineral Resources are extracted using surface or underground mining methods to generate maximum economic value for the mining company extracting the resources. The objective of value maximisation necessitates the development and application of optimisation algorithms that will ensure maximum value is realised. Several algorithms have been developed to solve the value optimisation problem for near surface deposits. Examples of these algorithms include the Lerch-Grossman algorithm and dynamic programming. It has been observed by some researchers that the study on open pit mine geometry optimisation has reached saturation levels as there are many algorithms that can produce a 'guaranteed optimal solution'. However, the underground geometry optimisation problem remains largely unsolved due to its complexity, thus, there are limited algorithms developed for it. This thesis was therefore, undertaken to contribute to the few existing algorithms for underground geometry optimisation by developing a more versatile algorithm in handling variable stope boundaries and it is a dual interchange algorithm (DIA) that works by combining the strengths of two existing generic algorithms.

Once an appropriate underground mining method has been selected to extract a mineral deposit, mine planners need to generate optimal layouts for development and infrastructure, stope and production schedules that incorporate equipment selection, which are solved as optimisation problems. These problems introduce a circular logic which introduces complexity in deciding on which part of the optimisation problem should be the starting point. In this study, the stope layout optimisation problem was selected as the starting point because when optimising for development layout, production schedule and equipment selection, the spatial position of the stopes to be extracted is one of the constraints.

The DIA was developed by incorporating the principles of the particle swarm optimisation (PSO) algorithm and genetic algorithm (GA). The PSO algorithm was applied for the stope layout optimisation problem to exploit its strength for solving the problem in three-dimensional (3D) space to generate feasible solutions. The GA was used to optimise the stope layout in each level since its evolution capabilities are well-suited for stope layout

optimisation. Since metaheuristic-based algorithms also do not guarantee true optimality, the DIA exploited the strengths of both PSO and GA to generate superior solutions in 3D space.

The DIA was then coded in Python programming language because it is simple to code in Python language and the execution of the code is much faster compared to other programming languages. The DIA was tested using a synthetic Platreef reef mineral deposit where a resource model was used as an input and then converted to an economic block model using economic parameters. The Platreef deposit is a platinum group elements (PGEs) deposit which is amenable to extraction using bulk (or massive) mining methods such as longhole stoping, making it an ideal candidate for stope boundary optimisation. Thereafter, the DIA generated several solutions and selected the one with a maximum value as the optimum solution. The results of the algorithm were validated using the Mineable Shape Optimizer (MSO) available in the commercial Datamine software.

Different scenarios were used to demonstrate the performance of the DIA in different mining scenarios. Two Scenarios A and C considered a fixed stope width, while Scenarios B and D considered a variable stope width to better reflect variable orebody boundaries or contours as encountered in actual mining practice. The DIA generated superior results compared to the MSO where the stope layout economic value solutions for Scenarios A, B and D were 0.3%, 3.4% and 8.3% more profitable than those generated by the MSO, while the MSO generated a solution that was 9.7% more profitable than DIA for Scenario C. The undiscounted economic value was used as a proxy since the study is on stope boundary optimisation, it does not include stope production scheduling. The DIA produced superior results because its architecture is such that it is best suited for variable stope width of the orebody. The solutions of the MSO were generated in much shorter run times than those of the DIA. This is alluded to the fact the MSO creates a single solution, while the DIA generates several solutions during the optimisation process. It is recommended that the DIA could be adapted and applied to other mineral resource models to maximise the economic value of the respective mining projects.