Proceedings of the 2020 Winter Simulation Conference
K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.

SIMULATION CAPACITY ANALYSIS FOR THE CARRAPATEENA BLOCK CAVE

Colin Eustace
Lewis Bobbermen

Polymathian
76 Ernest St,
South Brisbane
QLD 4101 AUSTRALIA

Daniel Lagacé

OZ Minerals
2 Hamra Drive,
Adelaide Airport
SA 5950 AUSTRALIA

ABSTRACT

Underground mining operations have recently commenced at Carrapateena, which is one of the largest copper reserves in Australia. OZ Minerals is studying an expansion from the current sub-level cave operation to a block caving operation for the lower portion of the orebody. This involves undermining the orebody so that it collapses and breaks up under its own weight and then extracting the ore from an array drawbells on the production level. With production operations concentrated on a single level, operational complexities and constraints can have a significant effect on overall mine performance and output. Simulation of production operations including: loader interactions; drive availability; secondary break and drawbell constraints; was used to identify potential operational limitations that may prevent the mine from reaching target throughput. Alternative production level layouts, equipment types and operational methodologies were evaluated to guide refinement of the block cave design for following detailed design studies.

1 INTRODUCTION

The Carrapateena copper-gold mine produced first concentrate in December 2019 and is ramping up to achieve a production rate of 4.25Mtpa by the end of 2020. It is an underground sub-level cave (SLC) with an estimated mine life of 20 years. Development of lower levels of the SLC continues while the upper levels are in production. OZ Minerals is currently studying an expansion to 12 Mtpa by utilizing block caving (BC) for the lower portion of the orebody. Using an SLC operation for the upper portion and a BC operation for the lower portion is possible due to the near-vertical alignment of the ore body. Combining the mining methods both reduces development lead time to commencement of production for the SLC and minimizes operating costs later in the project once the BC operation is established.

Block caving is a high-throughput underground mining method that involves undermining an ore body, allowing it to progressively collapse under its own weight. A large undercut creates a controlled collapse of the orebody, creating a cavern filled with the broken ore. The ore progressively breaks up as it is gravity-fed into an array of drawbells, which are accessed via drawpoints on a single extraction level below the orebody. The drawpoints are positioned on either side of a number of parallel extraction drives. Underground loaders, referred to as LHDs (Load, Haul, Dump), transport the broken ore from each of the drawpoints to a crushing station, which feeds a decline conveyor to the surface.

As all of the production operations for the block cave mine are concentrated on a single level, careful design and analysis of the BC operations is required to ensure that the mine will be able to meet target production output. A number of factors combine to add operational complexity on the extraction level. Many LHDs working in a small footprint can lead to interactions between LHDs and consequent cycle delays. The relative amount of ore that can be taken from each drawpoint is constrained to control caving progression. Allocation decisions for LHDs need to consider relative priorities for each drawpoint as well as the interplay with secondary break operations, to keep the drawpoint operational and drive availability. A simulation model was developed and used to assess planned production rates for the BC with consideration for complex equipment allocation decisions, equipment interactions and mining constraints.

2 SIMULATION MODEL OVERVIEW

The simulation model representation of extraction level operations was developed with the intention of providing realistic timing of each loading/ tipping cycle for each production LHD including cycle delays as well as LHD ancillary activities. Equipment movements on the level are based on a path network including representation of extraction drives, drawpoint and tipple access and turnaround points. Movement of LHDs in the model are based on similar logic to the principles of block sections and safe working used in rail operations. Occupation of paths in the extraction level network is controlled to manage interactions between LHDs and prevent network lockups. Equipment performance characteristics are modelled, such as acceleration, tramming speed, deceleration and bucket loading to facilitate relative performance estimates for different equipment types. Simulation of equipment movement on the extraction level is integrated with a representation of drawpoint hang-ups, ancillary operations such as secondary break and material handling system availability and reliability.

The model is data driven and enables changes to the caving profile, mine layout, equipment type and operational methodology. This allows testing of different stages throughout the life of the BC operation.

Scenario analysis using the simulation model was used to test the ability of the extraction level operations to achieve future production targets. Different extraction level layouts, drawpoint tonnage profiles, operational methodology, and equipment types were tested to quantify effects on production.

3 ANALYSIS OUTCOMES

Simulation analysis of the BC extraction level operations highlighted the conflict between draw constraints, imposed to control caving progression and the operational limitations of a high-throughput, small-footprint extraction level. Higher throughput targets and limited availability for central extraction drives constrain the rate at which ore can be drawn from these areas and the required caving profile imposes these rate limitations on the remainder of the extraction level.

The relationship between throughput and the number of LHDs operating on the extraction level was evaluated for a range of operational configurations. Limited opportunities for passing LHDs and the complex maneuvers required to manage multiple LHDs operating in close proximity, result in increased delays due to LHD interactions as the production fleet is increased. While some increases in throughput can be realized by adding LHDs, gains become increasingly marginal as the fleet size is increased for the operational methodology tested.

Constraints associated with caving progression were modified to optimize the balance of production hours required in each extraction drive. The results were used to test whether production capacity can be increased through revision of the caving (drawbell tonnage) profile and the extent of modifications required to realize production improvements.

Production capacity results developed using the simulation model have been used to identify opportunities for improvements for the BC design which will feed into the next stage of the mine development process. These improvements include potential changes to the extraction level layout and consideration for the relationship between the way geotechnical constraints are applied and resulting operational performance. Quantification of the relative performance for different equipment types will also be used to guide the development.