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SIMULATION OF CARRAPATEENA UNDERGROUND HAULAGE OPERATIONS

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ABSTRACT

Truck haulage for underground mining typically operates on single width roadways, often with limited opportunities to pass returning empty and loaded trucks. Vehicle interactions and associated waiting delays at passing bays and turnouts can accumulate to be a substantial proportion of overall average truck cycle times. This limits the total capacity of the haulage system. Incidence of vehicle interactions can also change significantly with haulage throughput, truck fleet size and changes in haulage routes over time. This case study describes the application of simulation of the haulage operations at the Carrapateena underground mine in South Australia to evaluate the future capability of the haulage system. The representation of haulage operations includes detailed truck maneuvers to manage campaigning and passing of multiple trucks and management of ore and development waste stockpiles to both feed the downstream materials handling system and allow the upstream mine production and development to continue operating.

1 INTRODUCTION

The Carrapateena copper-gold mine is an underground sub-level cave (SLC), with horizontal slices of ore extracted from top to bottom of a vertically oriented ore body. Underground loaders, referred to as LHDs (Load, Haul, Dump), extract broken ore from a number of production levels concurrently to stockpiles near the entrance to each level. The depth of active production levels increases over time as the ore body is mined. A truck haulage operation is used to transport ore from stockpiles on each production level to an underground crushing station. Once crushed, ore is transported to the surface by a conveyor, which runs parallel to the main access decline. Development of lower levels of the SLC continues while the upper levels are in production. This produces development waste, which also needs to be hauled to the crushing station and conveyed to the surface.

Haul trucks cycle between loading locations on each production level and development areas, travelling loaded up the main decline tunnel to the crushing station, and then returning empty. Geomechanics and development cost constraints limit the haulage network to a single-width roadway, with limited passing bays and turnouts. Trucks travelling in the same direction can follow at a minimum separation distance. For loaded trucks to pass returning empty trucks, passing bays or turnouts are used, each of which may have the capacity to hold one or more trucks. Both the crushing station and some of the production levels incorporate a loop and predominately single direction movements from and back to the main decline to minimize~~d~~ interactions at these locations. The haulage network and associated truck movements require a look-ahead for future truck interactions to avoid haulage network deadlocks.

Mine plans detail the total haulage task for ore from each production level and development waste from lower levels. The set of ore and development waste stockpiles available to trucks at any time is limited by the number of available LHD’s to load trucks. The set of available stockpiles is modified during the shift as required to align haulage throughput from each stockpile with production and development targets.

The haulage fleet can transport both ore and development waste concurrently, but the crusher and conveyor system can only receive either production ore or development waste. Development waste can be stockpiled at the crushing station and later fed into the crusher during shift changes, when no ore trucks are running.

In addition to shift changes, which require trucks to park-up by a certain time of day, trucks also require refueling, personnel breaks and daily services during the shift. Unplanned breakdowns for trucks and the crushing station and interval maintenance also affect overall equipment availability.

A simulation model was developed and used to evaluate the future performance of the described haulage system.

2 SIMULATION MODEL OVERVIEW

The simulation model representation of haulage operations from ore and waste stockpiles in the mine through to the surface was developed with the intention of providing and accurate representation of the capability of the haulage system. Movement of trucks in the model were based on similar logic to the principles of block sections and safe working used in rail operations, with extensions to manage campaigning of trucks and different passing geometries. Occupation of paths in the haulage network was controlled to manage interactions between trucks and prevent network lockups. Haul truck performance characteristics were modelled, such as acceleration, loaded and empty haulage speed, deceleration and payload to enable accurate evaluation of future haulage requirements. Simulation of truck movements on the haulage network was integrated with a representation of the material handling system including equipment availability and reliability.

The model is data driven and enables changes to the haulage task (throughput from each production level), haulage network, equipment type and operational methodology. This allows testing of different stages throughout the life of the mine.

Scenario analysis using the simulation model was used to test the ability of the haulage system to keep up with future production and development targets. Different mine stages and haul truck fleet sizes were tested to quantify effects on production.

3 ANALYSIS OUTCOMES

Simulation analysis of the haulage operations highlighted the effect of increased truck fleet size and haulage targets on the frequency of truck interactions and corresponding delays. Waiting delays due to truck interactions on the constrained haulage network increase significantly as the haulage task and truck fleet is increased.

The relationship between throughput and the number of trucks operating on the haulage network was evaluated for a range of operational configurations. Limited opportunities for passing trucks and the complex maneuvers required to manage multiple trucks operating in close proximity, contribute to the increased delays as the truck haulage fleet is increased. While some increases in haulage throughput can be realized by adding trucks, gains become increasingly marginal as the fleet size is increased.

Haulage capacity results developed using the simulation model have been used to identify opportunities ~~to~~ for ~~improvements~~ improving the haulage operation, which will feed into the next stage of the mine development process. These improvements include potential changes to the haulage network and operating procedures.