Productive System Simulation of Diablo Regimiento Mine, El Teniente

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ABSTRACT

Ore loading and hauling is a key process regarding production output in Block/Panel Caving mines. Operational interferences, infrastructure maintenance and inefficiencies of the extraction process (such as oversize granulometry and hang up) frequently affect this operation. Block/Panel caving mine planning requires estimating production plans certainty, taking into consideration the mining process variability.

To address this issue the simulation of discrete events appears as a tool with high potential to model the various problems, allowing representing the mining process in a robust and reliable way.

In this work, a simulation tool, DSIM, is used to simulate the Diablo Regimiento sector of El Teniente Mine. This tool is used to model the LHD hauling Production Level and a crusher & conveyor system in the Intermediate Transport Level, taking operational practices into consideration as simulation input data.

The proposed model is meant to complement Panel Caving in its advanced variant planning tools currently used in El Teniente Division of Codelco, considering the historical database of failures, repairs, hang-up frequency and productions reports of the mine and accounting for the logic of the operation and the interaction between the level of production, the crushers, and the intermediate level of transport (conveyors level).

The main results of the study show a high correlation between the simulation and reality, achieving a relative error that does not exceed 10 %. In this way, it is possible to identify the main interferences that exist in the handling of materials of the studied mine sector, being this the allocation of LHD equipment to the different streets and phases of the mine. It is noted that allowing over extraction in the model, accounts for the variability that exists in the actual extraction of the mine.

INTRODUCTION

The fulfillment of the mining plan is one of the most significant challenges in a mining operation, being one of the sources of discordance between operations and planning areas. In this context, the need to identify and estimate the main problems that exist in the mining operation arises; in order to incorporate those in a given sector plan. In this work, the Diablo Regimiento sector of El Teniente Mine will be simulated, thus considering a LHD production level discharging directly to the crusher's hopper (one for each phase). The crushed material is fed to a conveyors system.

The aim of this work is to estimate the maximum productive capacities a mine level, taking into consideration failure and maintenance of LHDs, jaw crushers, plate feeders and conveyors. Added to the fact that conveyors systems have not been studied in the El Teniente Division, robust conveyor belt models may be very relevant for Nuevo Nivel Mina (NNM) materials handling system.

The advantages of Delphos Simulator (DSIM) usage in materials handling simulation are relate to: its successful implementation in different open pit mines and current development of its underground mining module, its friendly user interface, was designed for the mining industry and has flexibility to meet the clients requirements in terms of modelling and reporting.

The simulation of discrete events in mining allows identifying and managing operational interferences between levels, usually left behind as it is seen as a negative externality associated to the respective level. Moreover, it propitiates a more profitable management and a more efficient sizing of the resources

The simulation carried out with DSIM for a material handling system were used in a Block / Panel Caving mine, and validated with Diablo Regimiento production data. According to the validation criteria, the model should not exceed 10% relative error regarding the total tonnage mined in order to build production plans P0 and P1 issued by the Superintendence of Mining Metallurgical Planning of the El Teniente Division.

Background

El Teniente mine is a mining-metallurgical complex belonging to the Chilean National Copper Corporation (CODELCO), which considers among its main assets the set of sectors that make up "El Teniente Mine" with its respective production facilities and infrastructure necessary for the processing of copper and molybdenum minerals. It is the largest underground mine in operation in the world, with an approximate area of 6 km^2, a vertical extension of 1 km and has more than 3,000 km in tunnels. Currently, El Teniente Division produces about 141,000 tpd of ore, of which approximately 490 kt/y of fine copper and 10 kt/y of molybdenum sold (Robles, 2016)

The simulated sector will be the phases 1, 2, 3 and 4 of the Diablo Regimiento Mine, of El Teniente mine. Phase V is not included, because the validation of the model is done with the operational phases of the year 2015. Figure 1 (a) shows the production level, and the crushers of the 4 simulated phases, in addition to the location of the station oil and equipment maintenance workshop. Figure 1 (b)**¡Error! No se encuentra el origen de la referencia.** shows the level of intermediate transport with the belts that exist and empty finally in an Ore Pass.

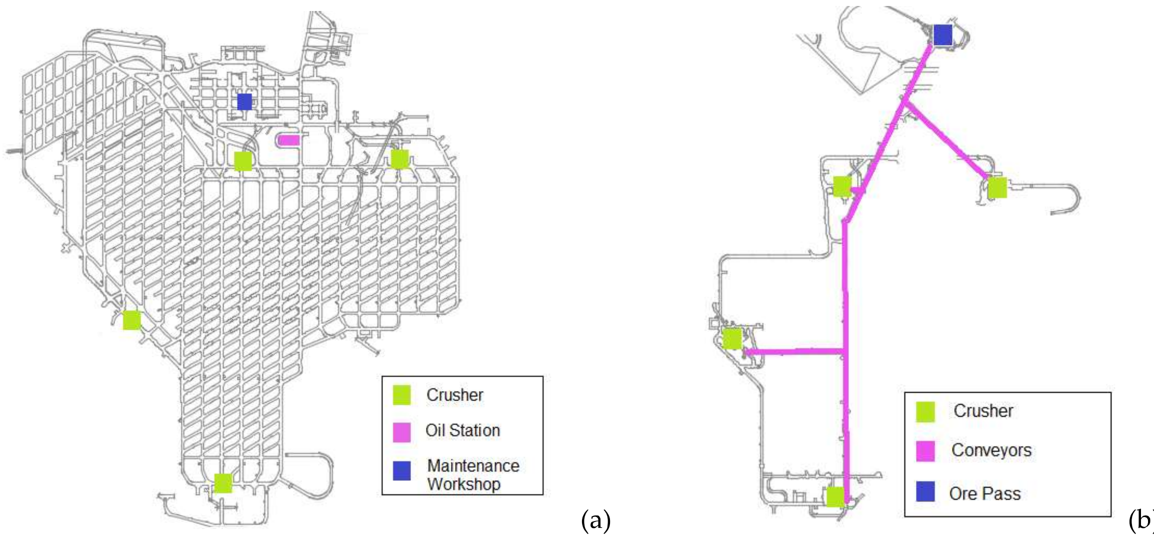

Figure 1 (a) Production level, (b) Intermediate Transport Level

METHODOLOGY

The methodology used for this research is summarized in Figure 2.

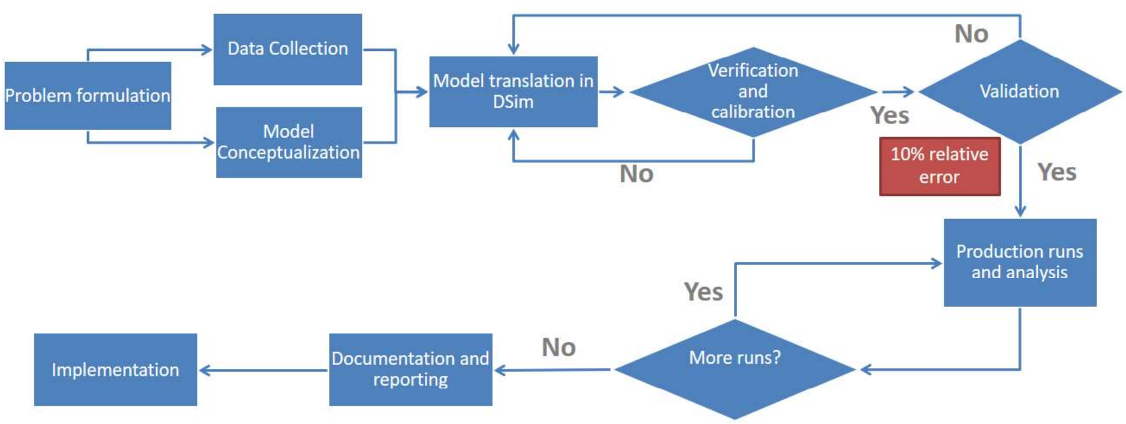

Figure 2 Methodology used

The data collection is based on interviews with people from the operation, who provide information on the different operating criteria of LHD, crushers and belts, along with technical data, such as belt capacity [ton/hr], belt speed [km/hr], LHD capacity [ton], mean time between failures [hr], mean time to repair [hr]. On the other hand, from the Production plans P-0 and P-1 of the Superintendence of Mining Metallurgical Planning the productivities of the different sectors are obtained, to which the certainty will be estimated after the simulation.

The conceptualization of the model is performed by characterizing how the different elements of the model will interact with each other, according to; the objectives of the model, the targets, and the battery limit.

The creation of the material handling system simulation model is based on DSIM, which is developed in C++ and the Python programming language.

Calibration is the process in which the model adjusts to a period, which in this case is the month of June 2015 of the Production Plan P-0. An acceptable calibration criterion for this work is a simulated productivity with a relative error of less than 5% relative to the real value. Subsequently, it is validated for the months of March and September of the same year, where the acceptable error is 10% between the simulated and the real productivity.

Finally, the production plan P-1 of 2017 is simulated to estimate its certainty, identifying the main limitations in the materials handling system. The belts system is also simulated exclusively, allowing the estimation of the maximum productive capacities of the level, considering the failures and maintenance of the equipment.

RESULTS AND DISCUSSIONS

Variability of model replicas

One of the first steps in the application of the simulation is to estimate the number of replicates that must be performed to obtain a reliable result. As shown in Figure 3, for this application a small number or replicas (10) is enough for the productivity indicator to converge.

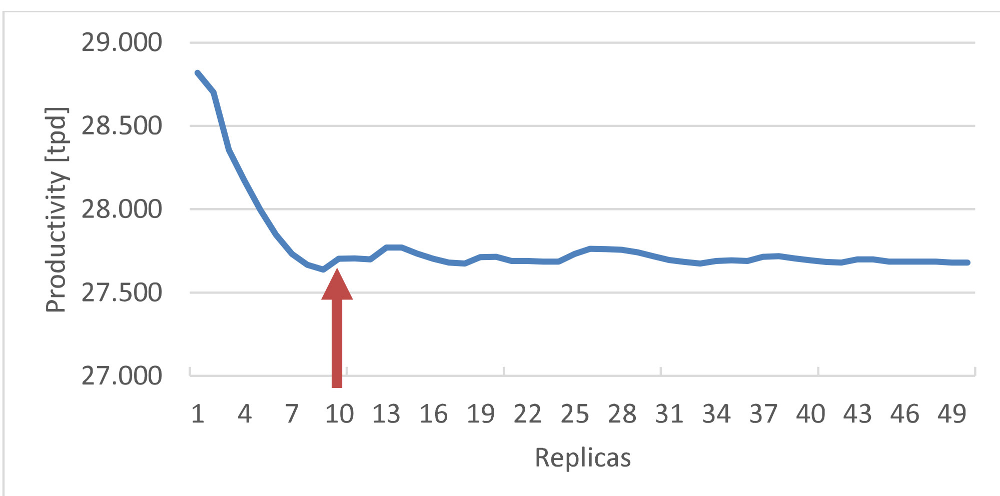

Figure 3 Variability of replicas

Model Calibration and validation

The developed model considers an initial column height and a final with the objective of considering the geomechanical constraints given by the Production Plan determined by El Teniente Division. The determining variable that allowed the calibration and validation of the model was the final column height given to each of the extraction points of the mine. Two models were constructed, a base model, in which all the final column heights are respected as indicated by the plans, and another model in which the heights of phases 2 and 3 of the mine are released, with the aim of considering the phenomenon of over-extraction that is presented in operation.

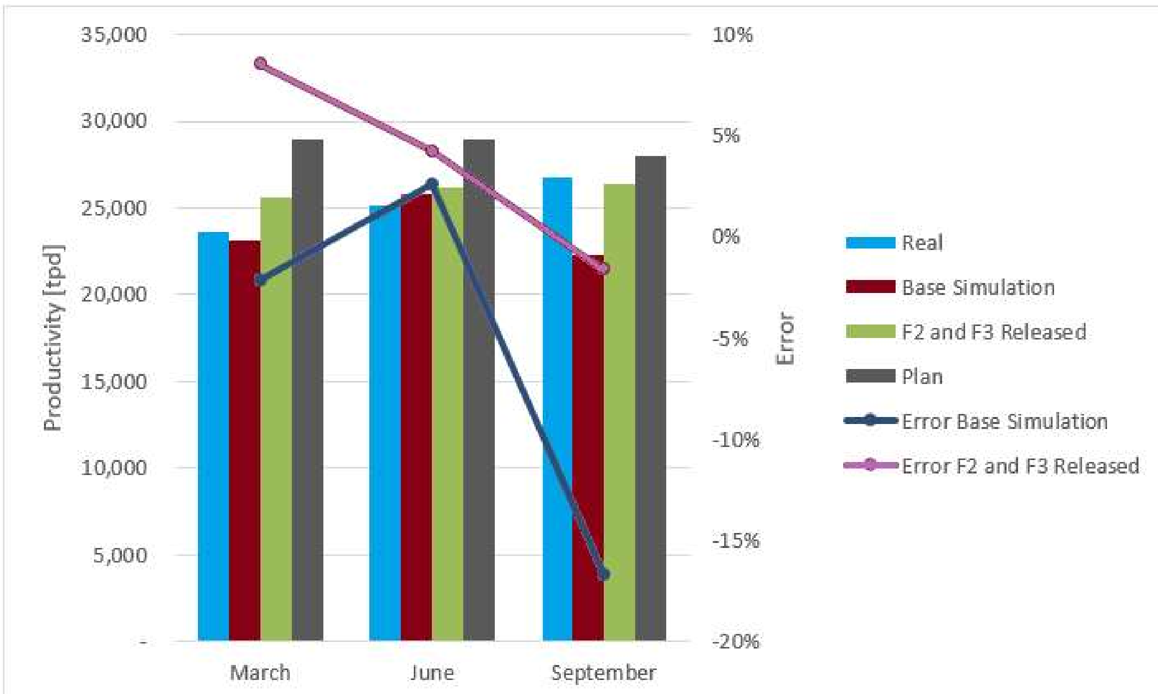

Figure 4 Calibration and validation results

The simulation without constraints to phase 2 and 3 has greater stability over the months and a maximum absolute error of 2,000 tpd in March, which represents an absolute error of 8.5% in relation to the real extraction, this difference could decrease because the actual production could have been greater if there had not been a fire that stopped material handling throughout the mine in February 2015.

Figure 5 compares the average absolute errors of the streets of the two models generated, it is observed that the average absolute error increases as the months of the year progress, which must occur due to the errors or variability that goes accumulating throughout the year, which force the operation to decide to exploit other streets for reasons such as: Availability of staff, availability of equipment, street work, street repair, etc.