Proceedings of the 2018 Winter Simulation Conference
M. Rabe, A.A. Juan, N. Mustafee, A. Skoogh, S. Jain, and B. Johansson, eds.

SHORT-TERM FORECASTING IN OPEN PIT MINING USING SIMULATION MODELLING

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ABSTRACT

Simulation modelling has long been used to support operations strategy decisions in the mining industry. Recently, the commodity cycle and push for lower costs has driven efforts to improve operations efficiency. The use of simulation has typically been challenging in the operational time horizon due to the difficulty of initializing the system state and the sensitivity of the results to initial conditions. However, a recent explosion in data availability has made it feasible to know, in real time, the location of each piece of equipment in the fleet, what it is carrying and where it is going. This makes it possible to simulate and predict production performance within a shift and to allow testing of what-if scenarios to improve operations efficiency. In this case study we describe the approach taken, the application of simulation for short-term forecasting and the challenges faced implementing this for a global mining company.

1 INTRODUCTION

Simulation modelling has long been used to as a decision support tool in the mining industry (Sturgul, 2001). This is typically done to address issues on the strategic time horizon, with a heavy focus on experimentation and sensitivity analysis. These issues include mining equipment selection, design and operation of the mine-plant interface, testing the robustness of a mine plan (Fricke et al. 2014) and blending.

A number of changes have occurred in open pit mining over the past few years. The availability and quality of data has improved substantially. Integrated operations centers have been established to improve coordination of decisions across the value chain. The alignment between mine planning and scheduling has improved across multiple time horizons. The capability to adhere to mine plans and the potential impact of improvements to short-term decision quality has substantially improved.

Against this backdrop, simulation modelling can be used to forecast production in the short term. It can be used to test the quality of truck dispatch decisions (allocation of trucks to loaders) and evaluate the value of alternate scheduling rules. It can also be used to produce a forecast of the likelihood of achieving a shift target and allow operators to test what-if options to reduce the risk of production loss or reduce costs by putting excess equipment on standby. Being able to make these decisions with confidence helps to drive improvements in operations efficiency.

2 MODEL AND DATA

The simulation model was developed using the AnyLogic modelling software and represents the load and haul operations of an open-pit mine. The model evaluates the ability of a given set of mobile fleet to achieve a target mine schedule. It includes a discrete-event simulation of load and haul operations and is integrated with a dispatch scheduling algorithm that allocates trucks to shovels. The trucks and loaders are subject to unplanned outages. Downstream, the crushers are subject to rate limits and unplanned outages. The model was designed to be completely data driven to support real-time usage. Inputs were generated from a database containing all required data on the state of the mobile equipment (position and payload), the job

978-1-5386-6572-5/18/$31.00 ©2018 IEEE

schedule, the road network and the load and dump locations. Historical data was used to develop inputs for travel speeds and distributions for process times and payload. A Python script retrieved the required data transformed it into model inputs. The model was initialized to reflect the system state.

The time horizon of interest was typically 12 hours. The model produced a prediction of truck positions, load-haul cycles and production metrics. Multiple replications were run to estimate the likelihood that the production target for a shift could be met given equipment configuration and operating rules.

Validation was conducted by comparing actual performance over a given 12 hour shift to predicted performance. The primary metric for comparison was cycle progress, the number of load-haul cycles done for each piece of equipment. Using the mean percentage error (MPE) methodology, both initialization error and forecast error were used to compare model forecast quality.

3 RESULTS

The model was used to evaluate short-term production options for a single pit in a large iron ore mine. The production target, including individual targets for blending of ore sources over the course of the shift, was chosen to reflect a particular shift in 2017. The model was configured to represent the road networks and equipment available during the shift, including 21 trucks and 8 loaders. The model was validated against actual data for the period to assess cycle-progress prediction error and bias.

Experiments were run to assess the impact of the production levers available within the shift. These included increasing or decreasing the number of trucks available as well as changes to the balking rules at the crusher. 30 replications of each simulation were run for representative statistics.

Increasing truck numbers led to increased likelihood of achieving the plan, albeit at lower productivity. Conversely, reducing truck numbers led to reduced likelihood, higher productivity and reduced queuing time. More aggressive balking rules increased truck productivity by reducing queue time. However, this was at the cost of double handling through the run-of-mine (ROM) stockpile. Each of these results were intuitive but could not previously be quantified by a dispatch operator during live production.

4 DISCUSSION

There were a number of challenges that had to be overcome during implementation. These were primarily related to initializing system state, building a data-driven model structure, model validation and the appropriateness of sampling from independent stationary distributions. These were quite distinct from strategic time horizon simulations where initial condition error tends to 'wash out' given sufficient warm-up. The results here present an experimental design using simulation run over a single shift. This is easy for strategic time horizon questions but challenging in real-time production environments. As a result, dispatch operators have tended to rely on intuition and rules of thumb. Using a high fidelity simulation-based forecasting tool with a pre-developed experimental design allows dispatch operators to ask questions and make complex trade-offs between multiple options on the fly. It also allows demonstration of the knock-on effects of choices (such as costs) and support value-based decision making at the front line.

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