Benefits of simulation modelling to the mining **industry**

Dr Alexander A Lebedev ❖ Xcel

Applications of computer modelling for the mining industry have been known since the early 1960s. With the development of specialist simulation software tools in the last 10–15 years which have simplified the process of model building and improved accuracy, scope for the application of simulation modelling for mines and other large industrial systems has increased dramatically. Simulation has become an extremely helpful tool to select and interface equipment, predict the throughput of a mine, size buffers and stock of material, find and minimise bottlenecks, analyse the effect of breakdowns and solve many other problems. Numerous papers have been published on successful applications of computer simulation — both in the designing of new mines and in the process of operating existing mines.

Simulation modelling has the advantage of being able to incorporate the various uncertainties and dynamics of a system's behaviour in the model: the yield of a mine can change, the probability of breakdowns can escalate, and it may be necessary to quantify the performance of a mine over its entire life cycle. A good simulation model can solve these and other similar problems in a matter of hours, with the necessary level of detail.

To illustrate, three case studies of simulating operational mines in South Africa are presented, highlighting just a few of the many benefits available to the industry.

Simulation modelling can identify bottlenecks, reduce production losses, and improve mine delivery. The resulting reductions in risk, and savings in capital and operating expenditure can be substantial.

Case study 1: controlling underground bunkers and trunk belts

In an underground mine, coal is mined in a number of mining sections, loaded onto shuttle cars of different sizes and tipped into feeder-breakers. From there, material is conveyed to sectional conveyors feeding bunkers. There are 12 sectional conveyors in total, ten of which feed five underground surge bunkers and two that directly feed trunk conveyors, each one consisting of four belts. The last belts in the trunk conveyor lines can feed two main bunkers on an alternate basis. Coal is conveyed from the main bunkers to the surface.

Each bunker is provided with four individually controlled vibrating feeders, two for each trunk belt, and the level of the material in bunkers is continuously monitored. Current flow rate of the conveyor belts is also monitored by belt weighers.

The colliery's problem was caused by lack of control over the operation in the mining sections, and discharge rate from the surge bunkers on the trunk belts, resulting in overflow of bunkers and conveyors. Every time a trunk belt was overloaded, a stoppage of about six hours was incurred to clean up, and if a surge bunker was overflowing the corresponding mining sections had to be shut down. Loss of production due to overflow of bunkers and spillage from conveyor belts was more than 40 per cent.

The objective of the simulation study was to develop and verify a control algorithm to avoid over-flow of the surge bunkers and eliminate excessive feeding of the trunk conveyor belts, thus minimizing blockages.

Logging of the number of tips into each feeder-breaker was carried out to quantify production in each mining section and the feed rates of sectional conveyors. A detailed simulation model of the underground operation was built incorporating real equipment capacities and sizes, breakdown profiles, operational shift patterns and other available data. It is worth mentioning that virtually no fixed values were used in the model; all parameters, such as feed or discharge rates, mean time between failures, and other model variables were sampled from proven statistical distributions to bring the model closer to the real world.

A simple yet robust control algorithm was designed to maintain the total discharge rate of the material from the surge bunkers on each of the two trunk belts within a specified limit to accommodate parcels arriving from uncontrollable conveyors, and to delay the tipping of shuttle cars in the mining sections if there was a risk of overflow. The algorithm used readings from the belt weighers and level monitors in the bunkers as inputs to generate control actions, and also took care of breakdowns in the trunk belts.

The efficiency of the control algorithm was verified with the simulation model, and the results of experimentation proved that the objectives of the study had been achieved. The algorithm was then implemented in a new PLC control system installed in the mine and, according to feedback from the operators, surge bunkers have been running at 70 per cent above average, and no overloading of the trunk belts has occurred. The model also illustrated a method of increasing productivity in the mining sections, as the bottleneck caused by the surge bunkers overflow interrupting injection of coal into the system was removed.

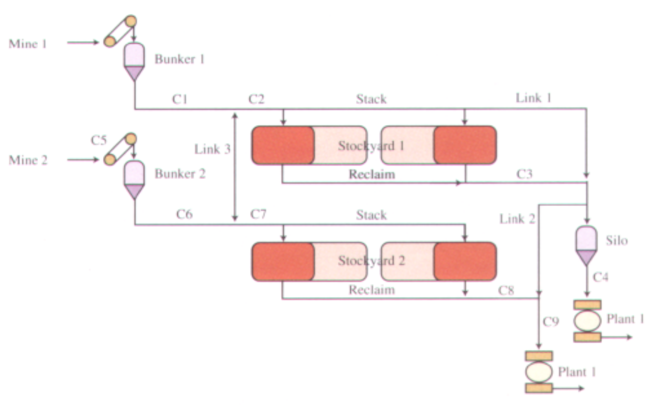

Figure 1. Material flow chart

Case study 2: sizing stockyard

In this project, material from existing Mine 1 was conveyed into Bunker 1, then via conveyors C1 and C2 into existing Stockyard 1, comprising two stockpiles (see Figure I). From the stockyard material was then reclaimed find conveyed via C3 to a silo, feeding it to processing Plant I via conveyor C4, and directly to Plant 2 via Link 2, C9.

The mine was considering establishing a new underground operation (Mine 2) deploying 6-16 mining sections and a new incline conveyor (C5), as well as an entire new surface infrastructure comprising Bunker 2, an overland conveyor (C6) and either a new stockyard or the existing stockyard, whose capacity may have been upgraded to accommodate supply from the new mine. The plan was to supply Plant 2 primarily from the new mine, and Plant I from Mine 1. However, Link 2 had to be retained to maintain feed to Plant 2, it needed, due to its higher priority.

The objectives of the simulation study were: to quantify a number of new mining sections to meet an increased demand; to size new surge Bunker 2 and all new conveyor belts: and to configure and size the stockyard to accommodate increased supply from the two mines and provide as uninterrupted a feed as possible into Plants I and 2.

The required number of underground mining sections, capacities of the new incline, overland conveyors, and the size of the new surge bunker were quantified using a simulation model. This showed that the existing stockyard, at its original capacity, would maintain increased annual production it the existing stacker and reclaimer were replaced with machines of a 200 per cent higher capacity The time and expense avoided are clear.

Case study 3: improving underground mine performance

This case study was concerned with an operating underground coal mine consisting of three shafts, each comprising a few seams. Various mining methods and a large conveying system of 51 units, including two feeding coal to a customer, were employed on the mine. Conveyor belts ranged from 1000 to 2000t/hr in capacity, and from 100 to 4000m in length. A number of underground and surface bunkers/silos With vibrating or belt feeders were installed in the colliery.

The task of the project was to evaluate the possibility of increasing production and accommodating a new client. To meet increased coal demand five alternative coal mining scenarios were drawn up for analysis and simulation modelling by the engineers. The object of the simulation exercise was to verify sufficiency and, if necessary, recommend upgrading or replacement, of: existing overland conveyor system from shafts 2 and 3; all existing underground bunkers and surface silos; new underground surge bunker proposed to shalt 1; and all underground conveyors.

The simulation study proved that the mine had enough capacity to increase production and provide extra coal feed to new and existing customers in all proposed operational scenarios. A set of detailed recommendations was worked out to upgrade rather than replace, equipment conforming to the new production target and avoid installation of a new underground bunker in Shaft 1.

Author

Dr Alexander A Lebedev is Senior Consultant at Xcel