Truck Haulage Improvements at the Phu Kham Mine – the Journey to 97 per cent Utilisation of Availability

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ABSTRACT

Reducing metal prices have forced mining operations to become more efficient and innovate in order to do more with the existing base. Much of this effort has focused on improving the efficiency of load and haul operations. The key to this is to understand and quantify where delays and missed opportunities exist. Metrics such as utilisation of availability, efficiency utilisation and asset availability are helpful indicators of performance; however, uptime-based time usage models and performance analysis tools using productive operating time models help to identify additional improvement opportunities.

Phu Kham is a copper-gold mine operated in the Lao People's Democratic Republic (Laos) since 2008 by PanAust Limited. The mine is a single large open pit of 450 m depth, running a fleet of 51 100 t class rigid dump trucks and 300 t and 200 t shovels controlled with the aid of a fleet management system in order to achieve ex-pit material movements of 56 Mt/a.

Commencing in late 2014, a range of initiatives were implemented in order to improve the efficiency of the mine haulage fleet. These include hot seating of all operator changeouts via changeout ramps, split shifting of crews to minimise queuing delays, maximising blast volumes and minimising blast event days to reduce blast exclusion delay events including opportune refuelling of equipment during blasting events, inspections of trucks during refuelling events, implementation of a dedicated haul road services team to help reduce wet weather related delays and infrastructure development for haul path efficiency improvements.

These and other initiatives have allowed the mine haulage fleet utilisation of availability (UofA) to be sustainably increased from 85 per cent to 97 per cent (see Figure 1), efficiency utilisation to increase from 85 per cent to 90 per cent, and productive operating time (POT) to increase from 73 per cent to 84 per cent. The corresponding increases in efficiency of the haulage fleet has allowed an equivalent reduction of eight haul trucks from the fleet to meet continuing life-of-mine production requirements.

INTRODUCTION

The Phu Kham open pit copper-gold mine, located in the northern part of Lao People's Democratic Republic (Laos), was developed and is operated by PanAust Limited's joint venture company, Phu Bia Mining Limited. PanAust is the majority joint venture shareholder with a 90 per cent holding and the remaining ten per cent held by the Government of Laos. Operations commenced production in 2008. There are two other large-scale international mining operations in Laos, being PanAust's other operation, the Ban Houayxai gold-silver mine located approximately 30 km from Phu Kham and MMG's copper-gold Sepon mine.

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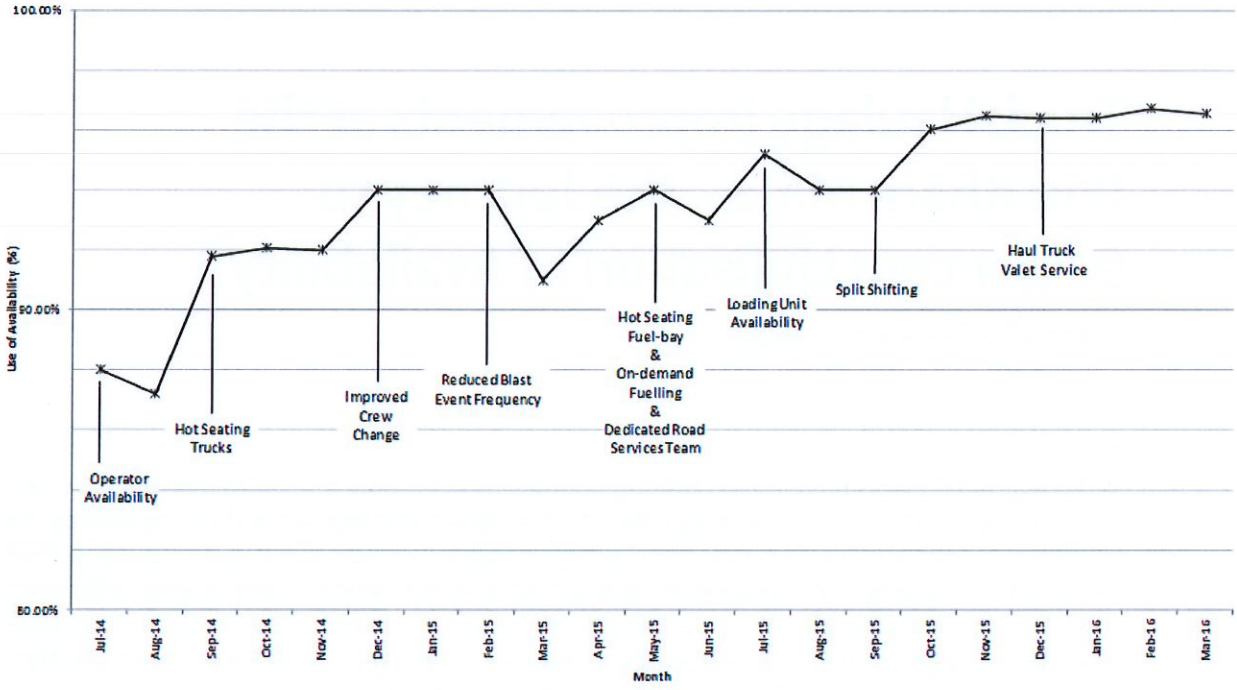

FIG 1 – Phu Kham haul fleet performance.

Over time the milling and concentrator capacity was progressively upgraded from 12 Mt/a through to 19 Mt/a, with the mining fleet more than doubling in size. The mine consists of a single large pit of 450 m depth, and currently runs a fleet of 51100 t class rigid haul trucks and 300 t and 200 t shovels, controlled with the aid of an automated fleet management system in order to achieve ex-pit material movements of 56 Mt/a. The workforce comprises over 90 per cent Laos nationals, with 70 per cent of mine production operations personnel coming from surrounding areas, of which the previous primary skills base was subsistence farming, predominantly rice farming.

In 2014, the company adopted a production loss accounting standard (PanAust Group) and time usage model premised on effective performance measurement, analysis and action. These elements would be fundamental to standardising performance measurement and management, and improving production outcomes over time. The time usage model uses uptime as a basis, and is defined as:

$$Uptime = \frac{Valuable\ operating\ time}{Valuable\ operating\ time + losses}$$

Adoption of the uptime based model led to justification and design of a whole of business reporting platform. A graphical representation of the time usage model is shown in Figure 2.

The fleet management system (FMS) in use at Phu Kham operation, had technical limitations which made the immediate use of uptime as a measure for the mining fleet impractical. A decision was made to use productive operating time (POT) as the primary key performance indicator (KPI) until system enhancements could be incorporated. FMS enhancements are due to be completed in the first half of 2016 and will enhance the operations data collection and analytical capability.

An update of the life-of-mine plan and the truck haulage simulation model confirmed that mining production would continue to be truck constrained, and that improvements in haul truck POT from the baseline of 73 per cent to increase to over 82 per cent would be necessary in order to meet material movement targets in following years. The necessary efficiency improvements for haulage fleet would go hand in hand with the need to boost efficiencies across the business in a volatile and declining metal price environment. These conditions have driven a belief in the possibility of the development of a business case for sustainable change, which would justify the efforts required to implement.

In adopting the standard, Phu Kham mining operations have been able to effectively focus on improving the utilisation performance of the mine truck haulage fleet by identifying primary

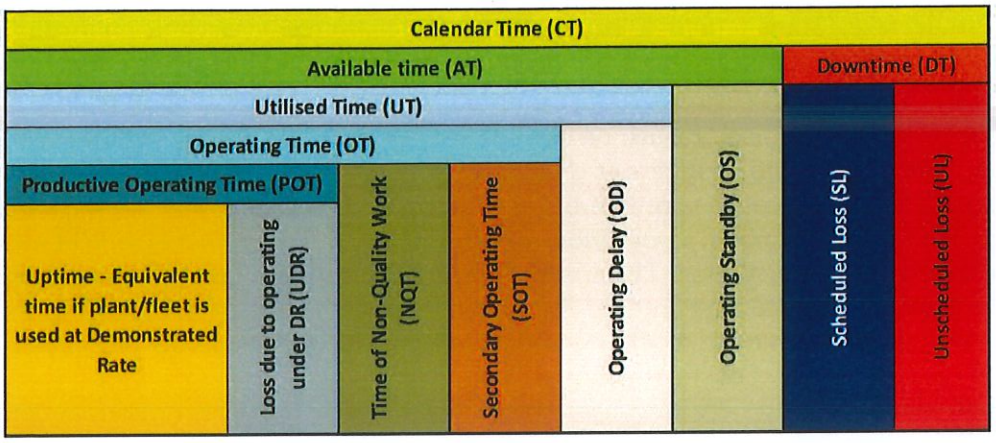

FIG 2 – PanAust time usage model.

loss contributors on a shift by shift basis. This has led in turn to the systematic minimisation of the most significant causal factors. This was seen as creating upside, which could translate into improved production and cost outcomes for mining operations.

DATA COLLECTION AND ANALYSIS

Phu Kham and Ban Houayxai mining operations both utilise an automated FMS. The FMS reporting of mining fleet performance is in real time and is consistent with time usage model classifications. A standardised set of reason codes has been mapped to the time usage classifications allowing a detailed drill down into secondary metrics, particularly into delay and standby codes. The ability to drill down into the detail of each of the classifications enabled productive discussions between operations and maintenance personnel. A POT driver tree was developed and updated on a daily basis with data sourced from the FMS. 'Lost' productive fleet hours were converted into an estimate of last tonnage by multiplying payload by the number of cycles per hour based on average cycle time for the day (waste and ore):

$$Lost\ tonnes = Rated\ truck\ payload \times \frac{average\ cycle\ time\ minutes}{60}$$

This assisted in monitoring and drawing attention to factors which negatively impacted fleet performance and allowed operations, planning and maintenance teams to develop a deeper understanding of the most likely target areas for improvement. These efforts culminated in a series of workshops which resolved to focus on five key areas with the aim of increasing fleet availability (primarily a maintenance activity) and utilisation and efficiency (operations and planning).

REDUCING STANDBY

Hot seating

The initial focus for increasing the utilisation of available haulage fleet capacity centred around ensuring that hot seating of trucks were efficiently maximised. Prior to the project kicking off the truck haulage fleet had been averaging 86 per cent utilisation of availability (UofA), with maintenance availability averaging 88 per cent. Half of the truck haulage fleet were using the existing two boarding ramps at the go-line for hot seating, with the remaining fleet changing operators in-pit which was assumed to be more efficient compared to utilising the go-line boarding ramps which are at the pit crest. The reality was that the in-pit changeover was not efficient and relied on additional transportation from the go-line to the pit benches as well requiring compliant operator behaviour rather than the simpler process of using the boarding ramps.

A change management process was undertaken and trials were performed changing overall haulage trucks through the go-line boarding ramps, including hot seat change overs for all end of shift, meal and fatigue breaks. This also meant that the normal operator prestart check of each machine couldn't be undertaken as per previously; however, this was resolved by the full maintenance

inspection undertaken at the refuelling bay by the mobile maintenance technician during refuelling events which occurred on average once per shift. Together with the shift change standby reduction initiative, the hot seating improvements helped to increase the haul fleet UofA from 86 to 92 per cent.

To further improve the productivity of the hot seating process, a split shifting initiative was introduced. This involved 40 members of each crew commencing (and finishing) work 30 minutes earlier than the remainder of the crew in order to decrease congestion and subsequent delays at the two go-line boarding ramps. Congestion occurred when the entire haulage fleet attempted to changeout over a short time period. This initiative helped to decrease production related delays by over 50 per cent and boosted first and last hour productivities to consistently achieve the material movement rate, as well as having the flow on effect of ensuring ore feed to the primary crusher was maintained regardless of end of shift or shift change.

Crew change

Phu Kham operations crews work a three-panel 14/7 roster of seven days, seven nights and seven days off. At the weekly crew change for the outgoing night shift and incoming day shift, there had been interchange delays resulting from the extra time taken to reorient the incoming crew. In addition the outgoing crew was required to complete their shift earlier than normal in order to fit in with site's scheduled transport which drops employees on rostered break at local villages and various drop-off points between Phu Kham and the company's transport facility in Vientiane. These two shift change related standby events were costing more than 30 minutes of overall fleet production per week. A more efficient shift change process was adopted utilising 'return to work' presentations displayed on TV screens at the go-line, helping to reduce the amount of time required to update the incoming crew on safety and operational status of mining operations before commencing work. The outbound transportation timetable for the outgoing crew was also delayed by 30 minutes in order to allow for continued hot seating of the haulage fleet. These two initiatives eliminated all production losses related to the weekly operator shift change

Operator availability

Manning for the haulage fleet is budgeted at 1.2 people per machine to offset operator planned and unplanned absences from work including annual leave, sick leave and maternity leave. This also provides an opportunity for multiskilling across the auxiliary fleet to help balance requirements during hot seating. An issue discovered early in the efficiency project was that additional delays were occurring due to a lack of skilled operators. The shortfall was attributed to lag between the time an operator left the organisation to the time a replacement operator could be recruited and fully trained. The average time to train a green new hire for competent operation of a haul truck averaged a little over three months. To resolve this issue, a training pool of 30 operators or ten per crew was created to assist in reducing the delay in replacing operators. This initiative, together with an increased focus on targeted multiskilling across the haulage and ancillary fleet, was effective in helping to reducing the downtime of the haulage fleet caused by a lack of skilled operators. This delay was reduced by over 90 per cent when compared with the previous baseline.

Loading unit availability

Although there is surplus loading capacity at the Phu Kham mine (PKM), truck haul fleet downtime was experienced due to loading unit availability. This was a combination of loading unit hot seating processes not matching the increasingly efficient haulage fleet hot seating performance and a suboptimal daily servicing schedule program of the fleet.

Between the mobile maintenance and mine operations group an optimal day and night servicing schedule was developed which included a larger service on night shift of each loading unit when the truck fleet reduces efficiency due to rolling operator fatigue breaks after midnight as well as smaller duration servicing events during day shift closer to lunch time when the trucking fleet also experiences less efficiency. The run-of-mine (ROM) wheel loader was also repositioned to follow the shovel servicing crew, swapping out each shovel for production at its dig face as it would go down for servicing. This had the added benefit of reducing ROM ore rehandling requirements as well as reducing truck relocations from individual loading units being unavailable. The hot seating efficiency of the loading fleet was also improved.

These initiatives have helped to increase the loading fleet UofA from a baseline of 86 per cent to a sustainable level of 94 per cent, which in turn has reduced the standby as a result of 'no loading unit available' by 70 per cent.

Blasting events

During blasting events the required personnel and equipment exclusions would result in between 40 to 60 minutes of lost production over a portion or sometimes all of the load and haul fleet. Previously blasting events occurred five or six times per week, causing an average loss of ex-pit production of 8000 t for each day of blasting despite efforts to reduce the blasting exclusion window. The move was then made to maximise blast volumes and minimise blasting event days by sleeping shots overnight where possible. This caused blasting events day to occur three to four times per week, and helped to reduce blast exclusion related delays by 40 per cent.

Also linked to this initiative is the refuelling of haul trucks at either the refuelling bay or with service trucks dispatched to meet haul trucks on the waste dump in order to use the blast exclusion related delays as productively as possible.

Maintenance interaction

A single mobile maintenance organisation is responsible for providing fleet maintenance services at both Phu Kham and Ban Houayxai operations, with haul truck maintenance availabilities continuing to average over 90 per cent availability. The adoption of the one team approach between operations and maintenance departments has been beneficial in improving delivery to the customer – the mine delivering quality ore feed in the required quantity to processing, and mobile maintenance delivering well-maintained assets to mining. Two areas in which this has been measurably successful have been the hot seating of the fuel bay and the return of trucks after service to the mining go-line by maintenance personnel, known as the 777 valet service.

As there is only one dedicated haul truck fuel bay at PKM, for the FMS fuel on demand logic to work effectively, the fuel bay was needed to be hot seated in order for refuelling related delays to be minimised. This also included the need for an efficient weekly shift change process for mobile maintenance personnel to allow complete 24/7 maintenance ability. Once the maintenance hot seating initiatives were implemented there was a sustainable reduction in refuelling related delays by 85 per cent compared to the previous baseline. Together with effective implementation of fuel on demand logic, the truck waiting without fuel delay was completely eliminated, and the number of haul truck refuelling events were decreased by 14 per cent per shift.

The second initiative focused on reducing the time taken for haul trucks to be put back into operation once completed maintenance scheduling. Previously the process involved a notification being sent to the FMS dispatcher officers that the haul truck was ready to be put back into service, and the dispatcher would then need to arrange for an operator to be transported up to the workshop in order to pick up the haul truck to get it back into operation. Despite efforts to improve the efficiency of this released to operations process, there was an average of 127 hours per month of haul truck standby. An initiative was implemented called the 777 valet service, which involved maintenance personnel to be able to drive the haul trucks from the workshop directly down to a demarcated area at the mining go-line where an operator would be able to immediately utilise the truck. A number of maintenance personnel from each shift were trained in restricted haul truck operations (an expansion of the move and test certification), and the emphasis then moved onto ensuring that the maintenance driver was given a lift backup to the workshop in a timely fashion. The 777 valet service initiative was particularly effective, reducing the released to operations standby by 50 per cent.

Wet weather

Phu Kham experiences average annual rainfall of approximately 2.7 m, with the annual monsoon season falling between June and October. In the past, poor mine road conditions have led to reduced ex-pit production rates during the wet season. In late 2014 a dedicated road services team was formed specifically to address the quality of in-pit and waste dump term haul roads and ramps. The initial focus of road services operations was to ensure that roads and ramps were bought up to the standard defined in the 'Phu Kham Mine Haul Road and Ramp Design Standard' which was published in June 2014 (PanAust Group). This standard defined the requirements for design,

construction and maintenance of mine roads based on the configuration of the pit taken from the life-of-mine plan and on a detailed knowledge of locally available construction materials. Once roads met the requirements of the standard, the focus of the team moved to the maintenance of running surfaces and surface water management.

Improved haul road quality was a significant contributor to a reduction in wet weather delays of 95 per cent as measured in 2015 and compared with previous wet seasons. The ongoing efforts in maintaining quality roads has had additional benefits with average haul truck tyre life increasing from 5300 hours to 7600 hours.

REDUCTION IN NON-QUALITY AND SECONDARY WORK

In addition to increasing the POT of the haulage fleet via increased UofA, added focus was applied to reducing ore re-handle related activities. This was the primary cause of non-quality time events and secondary operating time (SOT). SOT events are defined as all work not contributing directly to the primary activity KPIs (eg a production haul truck is transporting road base material etc).

While direct dumping of ore into the crusher is the preferred scenario for short-term planning, there is often a need to stockpile material at the ROM to facilitate blending. The drivers for blending crusher feed include ore grade, material properties, primarily hardness and proportion of clays, and the presence of secondary elements, particularly sulfur and arsenic. A large low-grade stockpile has been depleted over the course of 2015 and 2016 in order to supplement ore feed during periods of more intensive waste stripping. With the removal of the last of this material, as well as the previously mentioned loading unit availability initiatives, the impact of SOT has been significantly reduced.

Mining schedules are increasingly focused on the steady-state delivery of direct feed ore in order to meet process throughput and site metal production targets. Non-quality and SOT events will continue to be a focal point for loss elimination activities as they represent waste in the haul cycle.

IMPLEMENTING AND SUSTAINING CHANGES

The successful implementation of these initiatives has been assisted by the development of a strong reporting and analysis culture throughout the operations supervision and technical teams. A new presentation format was developed for crew prestart meetings showing performance for the past shift and week to date. These presentations are formatted and delivered in Laos to ensure maximum comprehension. In addition, operations supervisors receive SMS message updates of shift to date performance against target on a three hourly basis within the shift. Over time this has proved to have a flow on effect throughout the mining group with a greater awareness of the current state of the operation being well understood by operations and maintenance personnel alike. Further improvements focused on the reduction of heavy equipment incidents, especially those related to reducing operator fatigue related issues and incidents, drill and blast improvements and shovel productivity improvements are all also well underway and are assisting in gaining further ground in the aim to obtain optimal efficiency from the mine production fleet.

NEXT STEP – EFFICIENCY FOCUS

The metrics

While UofA is a useful metric for measuring the ability to keep mining equipment moving, it does not measure how efficient the fleet is moving within that space. Overall fleet ex-pit tonnage per hour against demonstrated rate and overall fleet cycle times continue to be useful metrics for monitoring and analysis. Recently the truck productivity effective flat haul metric has been adopted for analysis, however this metric is likely more suited to operations that don't have average haul lengths that vary from period to period such as us Phu Kham.

Obviously, utilisation does not provide an overall picture as an idle truck or truck travelling off-cycle does not add any value. Efficiency utilisation examines only those parts of the haul cycle during which a truck is doing useful work and is defined as follows:

$$Efficiency\ utilisation = \frac{(Dumping + travel\ empty = loading + haul\ full + spot)\ times}{(Total\ cycle\ time)}$$

This metric has also been tracked to help aid in the goal of improving the overall efficiency of haulage operations (see Figure 3). Improving efficiency utilisation included a focus on training techniques such as targeting self spot double-side loading to reduce spotting time, engineering ramp and haul road design to help reduce the impact of a deepening pit as well as the various other initiatives detailed in this report. While there has been an increase in efficiency utilisation from an average of 85 per cent to 90 per cent, there is more work to be done in this space. For example, an upcoming initiative is the implementation of an additional mobile hot seating facility to decrease the amount of off-cycle travel as a result of truck operators needing to utilise the current hot seating facility for all meal, coffee and toilet breaks.

Haul path efficiency improvements

Two major projects to decrease the waste haulage cycle were identified and actioned during 2015. This included the construction of a cut and cover tunnel linking the pit to the waste dump and tailings storage facility (TSF) (see Figure 4). The tunnel reduced the waste haulage path by 500 m and 3.5 minutes per cycle, with the waste haulage efficiency gains directly allowing for three additional haul trucks to not have to be purchased to maintain future required production levels. It was the first tunnel constructed in Laos, and was built together by the site Projects and Mining departments.

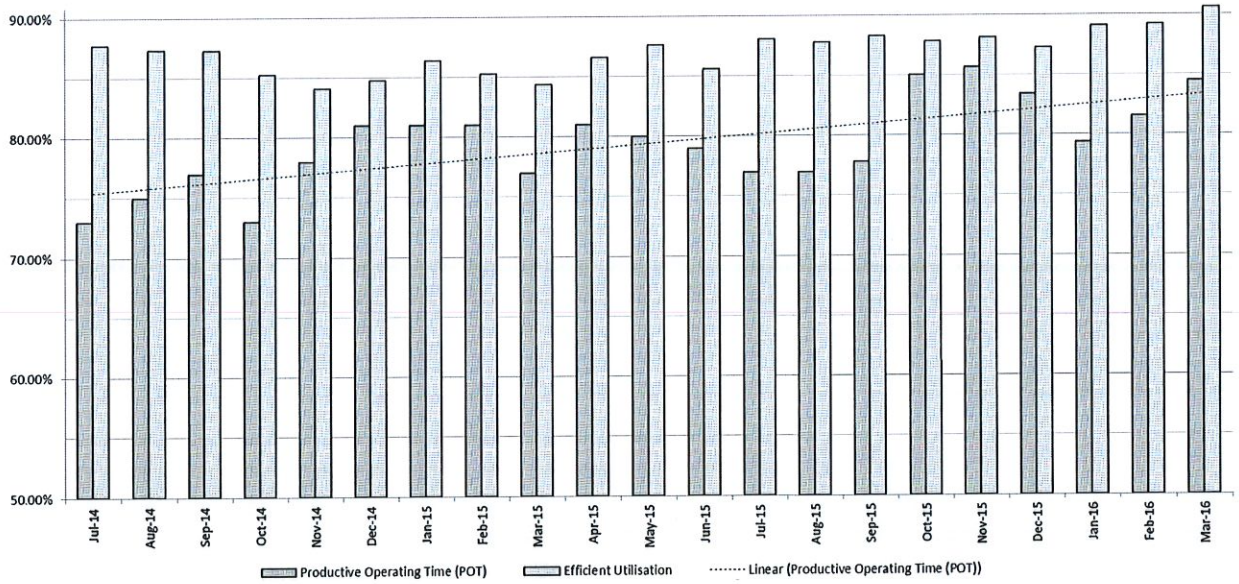

FIG 3 – Haul fleet productive operating time and efficient utilisation.

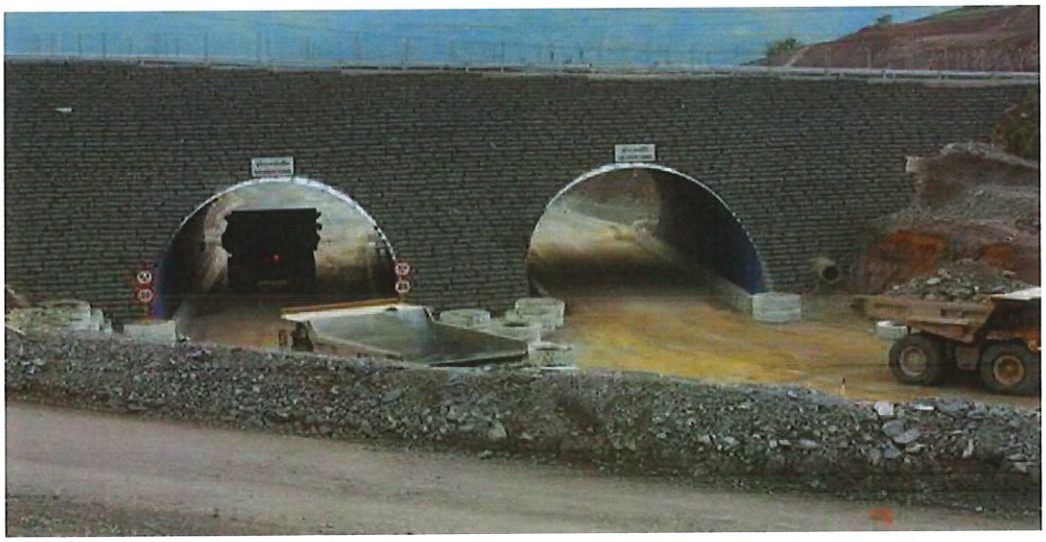

FIG 4 – Phu Kham mine waste haulage tunnels.

An additional haulage path efficiency project involved removing infrastructure from the waste dump area in order to construct a straight truck highway linking the pit exit through the waste dump to the tailings storage facility. This highway reduced the waste haul path by 220 m and allowed the haulage fleet to travel at an average of 41 km/h as compared to the previous haul road which averaged 22 km/h, an overall saving of 2.4 minutes per cycle for all TSF bound waste trucks and an equivalent reduction of 1.5 additional haul trucks from the fleet.

Operator buy-in

Getting operator buy-in into the continuing focus to improve efficiencies is obviously just as important as getting the initiatives and processes in place. Given the general lack of large-scale mining and business leadership experience in the country, especially in the areas surrounding the Phu Kham mine, obtaining sustained operator buy-in and compliance to more efficient outcomes has been a major project in itself. Various initiatives have been put in place with varying levels of success; however, the reduction in fleet management direction non-compliances, heavy equipment incidents and equipment damage events indicate that the workforce is increasingly motivated to succeed.

CONCLUSIONS

Key to improving the performance of a mine haulage fleet includes a combination of education, motivation and an effective production reporting system. Engagement and empowerment of supervisors in utilising data to drive performance improvement will be a difficult, but not insurmountable, cultural obstacle for the operations management team.

Enhanced measurement and modelling tools will continue to drive an improved understanding of the drivers of fleet efficiency and prioritisation of future initiatives. Various initiatives were put into place in late 2014 in order to lift the UofA of the truck haulage fleet from 85 to 97 per cent sustainability, as well other efficiency and performance metrics; however, as demonstrated in this paper, it possible to develop a business case and implement and sustain change over time, thus justifying the efforts made with the help of measurement systems and improvement management behaviours.

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