The hydraulic cleaning of stopes

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SYNOPSIS

Union Corporation are experimenting with a high-pressure water jet to remove blasted rock from short panels. The advantages are that the jet provides a highly efficient, flexible, and mobile cleaning tool that eliminates much of the lashing. Cost estimates show it to compare favourably with the existing system, with potential savings of 30 cents per ton milled.

Equipment and method trials are continuing with the ultimate objective of eliminating hand lashing entirely while retaining the flexibility of the present method of mining.

SAMEVATTING

Union Corporation eksperimenteer met 'n hoëdrukwaterstraal om losgeskiete rots uit kort panele te verwyder. Die voordele is dat die straal 'n baie doeltreffende buigsame en mobiele skoonmaakwerktuig verskaf wat baie van die wegruiming uitskakel. Kosteramings toon dat dit gunstig met die bestaande stelsel vergelyk met 'n moontlike besparing van 30 sent per ton gemaak.

Die proewe met die toerusting en metodes word voortgesit met die uiteindelike oogmerk om handwegruiming geheel en al uit te skakel en terselfdertyd die buigsaamheid van die huidige mynboumetode te behou.

Introduction

The centre gully–strike track mining method as practised on Union Corporation Group Mines is labour-intensive, and the mining output is tied more closely to the labour productivity than to any of the mechanical devices in use. One of the major limiting factors is the amount of rock that a labourer can lash and tram in a shift, and it is essential to keep this figure as high as possible. Each labourer is confined to a relatively small face length, and physical constraints make it uneconomic to increase this labour density much beyond the present level.

During the preparatory planning for the new Unisel mine, it was apparent, from the predicted stoping width of 2,0 m, that the output per labourer would have to be substantially higher than for the existing mines if similar rates of face advance were to be achieved. A new method of cleaning was therefore desirable, and accordingly a number of tests were conducted in a trial stope. In common with other trials current in the industry, the main line of thought was directed towards mechanization.

Various methods and devices were tested, including some of those already established in other groups. One of the less traditional methods tried was the application of water under pressure, directed from a hose, to propel the broken rock from the face into a suitable collection point (strike or diagonal gully).

This aspect of the trials, its subsequent development, and the results to date are discussed in this paper.

Present Method of Mining

The gold mines of the Union Corporation Group generally follow the system of centre gully–strike track mining.

A raise, developed on reef along the line of true dip, becomes the centre gully of a stope. The stope boundaries are generally defined by the lines of intersection with successive levels and by the midpoint lines between successive raises. Each stope has two faces, one on each side of the centre gully, which are carried approximately 70° overhand and advanced for a distance of about 90 m. (Raises are developed at roughly 180 m intervals.) The method of mining is to divide each face into short panels of 9,0 m with a strike track on the down-dip side of each panel. An average stope with 180 m of face on each side of the centre gully would therefore have 20 tracks and panels on each side. Advanced strike-track cuttings are carried a few metres in advance of the face on the bottom tracks to provide a breaking face for blasting. Each track is equipped with rails and a 0,75 t end tipper.

A cycle generally follows the pattern of drill, blast, bar down, temporary support, clean, permanent support, and equip, and the work progresses sequentially round the available face. After a blast, the ore is divided between a concentration on the track of each panel and a distribution along the length of each panel. The proportions depend upon the dip, stoping width, and efficiency of the blast.

The ore that is on the track is lashed directly into the end-tipping car, and is trammed and tipped into the centre gully, where a scraper pulls all the ore into an ore pass at the bottom of the stope. The ore that lies on the panel has to be lashed down to the track before it can be loaded into the end-tipping car.

For a 9,0 m panel with an average stoping width of 1,2 m and an advance per blast of 0,9 m, the amount of ore to be cleaned per blast would be 26 t. At a dip of 25° this quantity is split roughly into 13 t on the track and 13 t scattered over the panel. The 13 t on the track can be cleaned at the rate of 40 standard minutes per ton in a time of 520 minutes. The 13 t scattered over the panel, however, requires 80 standard minutes per ton and takes 1040 minutes.

The physical characteristics of the working place limit the amount of labour that can usefully be employed to one labourer per track, so that, at 100 per cent performance, the track cleaning takes one shift, and the panel cleaning two shifts, owing to double handling of stuff.

Hydraulic Cleaning

The use of a hosepipe during sweeping operations is not unique, and the idea of washing down blasted rock was a

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natural extension of this practice. In order to test the idea it was necessary to provide both the equipment and an acceptable method. The trials were aimed at proving and refining both aspects.

In the first trials, a small positive displacement pump was mounted on a sled, equipped with switchgear, and installed in the stope. A flexible hose with a trigger-operated gun was connected to the pump outlet, and was used to move ore at up to 45 m from the pump. The pump was serviced from a trailing power cable with a flexible 50 mm water hose connected to the stope water supply. The sled had to be dragged manually around the stope to cover all the working areas.

These trials were not very successful for two main reasons. Firstly, the pump did not prove to be very reliable, and maintenance was both difficult and unpopular because the pump was situated in the stope. Secondly, the pump was difficult to manoeuvre around the stope, and the potential working time was reduced quite considerably. These two major problems conspired to reduce management's confidence, and the poor equipment availability made it extremely difficult to operate any laid down method in a satisfactory manner.

Notwithstanding the above, the system was studied for sufficient operating time to provide data on the effect of the system whilst working. The output pressure was varied between 5,0 and 34,0 MPa, and various flow-rates were tried ranging up to 5 l/s.

At pressures between 7,0 and 10,0 MPa and with flow-rates of about 3 l/s, the effect of the jet was visibly impressive. Experiments with nozzle sizes showed that this was the correct output range. A reduction in the pressure or flow-rate caused a disproportionate increase in rock-movement times; an increase in the pressure or flow-rate produced an unacceptable risk of accident and increased the spattering of fines onto the hanging and support.

Sufficient results were obtained to show that the jet had the potential to move stuff off a 15 m panel at the rate of 20 t/h with a true dip of about 30°. It could move unexpectedly large rocks, leaving behind only those that would have required man-handling under shovel or even scraper methods. Calculations of the economics showed that, although the system resulted in a slight improvement in labour productivity, it would still be more expensive to operate than a conventional manual system, but calculations were made difficult by the unreliability of the equipment.

Despite the unfavourable conclusion, the method had the following advantages.

(1) Cleaning is not confined to a single path as with a scraper.
(2) Broken ore can be cleaned around sticks or support packs without much difficulty.
(3) The jet can be used to 'bar' the face to some extent.
(4) The footwall does not require much subsequent cleaning to complete sweeping operations.
(5) The jet has the potential to open the face rapidly after a blast.

Current Trials and Results

A new series of trials was started at Bracken Mines in June 1977. The experience gained in the first trials led to the following revisions in both the equipment and method.

(a) A more reliable positive displacement pump was obtained.
(b) The pump was mounted on a hopper chassis and installed in a suitable cubby adjacent to the stope crosscut.
(c) A 50 mm high-pressure column was led from the pump down the centre gully of the stope with laterals provided on every third track.
(d) The laterals and flexible high-pressure hose were fitted with quick-release couplings.
(e) The design of the gun was improved.

The method of operation was as follows.

(i) After the blast, water down and make safe; open all blasted faces for a distance of 2,0 m back.
(ii) Start cleaning from the nearest established rib wall, moving progressively towards the face. (This had the effect of creating a rolling scatter-pile between the face and the nearest rib wall.)
(iii) After the construction of the new rib wall, break down the previous rib wall and hydraulically clean up to the new wall.

It should be noted that 'rib wall' in this context refers to a heaped blast barricade comprising reef and waste constructed along successive lines of matpacks at 3,0 m intervals.

The advantages of the revised pump installation were that maintenance was no longer a difficult task, and that, in the event of a major breakdown, the pump could be brought to surface very easily. The delay in moving the pump around the stope was eliminated and replaced by the task of pulling the flexible hose from one track to the next.

The laid-down method provided the miner with a means of drilling his newly blasted faces within the period of a day and the potential to increase face advance. It also provided the shiftboss with a means of control in which he could use the jet to sweep all the panel dirt onto the track in a very short time and stop further blasting until the tracks were cleaned.

No attempt was made to replace the lashing labour. Efforts were directed towards the removal of all the stuff to a position where it could be lashed directly into the end tipper.

The stope had an average stoping width of 1,11 m, an average dip of 29°, and average panel lengths of 9,0 m. Studies showed that it took an average of 35 minutes to clean all the dirt off a panel into the strike track. Included in this period is the time for the manipulation of the hose around the panel.

In practice, all the lashing labour started track cleaning in the first shift after the blast. As soon as possible the jet operator started on the bottom blasted panel and cleaned a 2,0 m wide area of the panel all the way up the face. This operation pushed the dirt to one side rather than moving it down to the track, and took about 10 minutes per panel. The lashing labour withdrew from the working place while jetting was taking place in the vicinity, and then returned immediately the jet had moved sufficiently far away. The jet operator did not return to a panel until the initial track cleaning was complete. Track cleaning took about a shift to complete.

Rib walls were built between alternate rows of mat packs on dip and acted as blast barricades. Once the track was clean, the jet was used to clean as much dirt as possible off the panel onto the track, starting at the rib wall and moving towards the face. Average removal rates of 20 t/h over the 9,0 m panels were achieved regularly. At the most, this secondary jetting took only 40 minutes and was arranged so as not to interfere with the drilling of the panels.

The equipment still proved to be unreliable, and there were many breakdowns that could be attributed to under-design. Detailed experiments showed that the relationship between pressure, flow-rate, and nozzle diameter was critical, and sufficient data were obtained for the prediction of the optimum values.

Costing exercises showed the likely effect to be at least a break-even situation with the system in that form, and predicted savings of up to 30 cents per ton with some minor modifications to methods and better equipment.

When the figures obtained from this trial are superimposed on those for the basic method outlined earlier, 13 t in the track are still removed at 40 standard minutes per ton, whilst the 13 t in the panel are now moved down to the track at the rate of 3 minutes per ton, and then cleaned at the same rate as the initial track tonnage, i.e. 40 minutes per ton. Hence the time required to clean the 26 t with hydraulic panel cleaning is now

$$\left(26\ \text{t}\times 40\ \frac{\text{std min}}{\text{t}}\right)+\left(13\ \text{t}\times 3\ \frac{\text{min}}{\text{t}}\right)$$
$$=1079\ \text{min}.$$

This compares directly with the 1560 min for the same quantity of stuff without hydraulic cleaning.

The trial, although reasonably positive regarding the method, still showed the equipment to be highly suspect. However, there was sufficient justification for the preparation of further trials using different equipment, and these include both the use of loaders to clean strike tracks and alterations to stope layouts. It is still too early to comment on this third series of trials.

Dispersal of Fines

When water is applied to broken gold-bearing ore, there is always concern that gold fines might be washed into crevices in the footwall and never regained. An argument raised during the experiments was that the output from the jet was only at the rate equivalent to ten drilling machines, and was not of long duration. Losses should therefore hardly be much greater than those under present methods. As far as can be ascertained, there was little discernable change in the gold balance.

Environmental Cooling

Although it was new mine requirements that largely prompted these developments, it will be apparent that hydraulic cleaning appears to have an application at dips much flatter than those expected at Unisel. Future trials have been designed to exploit this. However, for a deep mine, another factor must be brought into account, and that is in respect of the cooling of hot stopes.

Because of the thermal environment[1], cooling will be applied by the delivery of chilled water in some form to stopes. If chilled water is used as the input to the pressure pumps, it can be dispersed without the need for any special equipment.

As the dip increases, the double-lashing content reduces to a theoretical zero when the dip just exceeds the angle of repose (about 38°). In practice, this situation is rarely achieved because of rough footwall, but steep dips give the potential for an increase in panel lengths with the knowledge that, although material remains on the panel, it is relatively easy to remove.

Conclusion

The trials on hydraulic cleaning are by no means complete; nor have they been conducted over a sufficient range of conditions to be conclusive. Despite this, they have been sufficiently promising for the pressure-jetting of rock from the face to be regarded as one of the methods for consideration in the design of stope layouts. It can also complement a system using chilled water for environmental cooling.

Acknowledgement

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Reference

1. Howes, M. J. Paper no. 22, Eleventh Commonwealth Mining and Metallurgical Congress.

Materials in South African industry

A symposium entitled 'Materials in South African industry — needs and training' is to be held in the Auditorium, National Institute for Metallurgy, 200 Hans Strijdom Road, Randburg, on Wednesday, 13th June, 1979.

The programme includes talks by leading figures in South African industry on the need for materials scientists and engineers and on aspects of the optimal use of materials and the potential of new materials. These talks will be followed by reviews of the courses of training in material science and technology offered by universities and colleges of advanced technical education, and suggestions for alternative courses of specialized training. The symposium will end with a panel discussion under the title 'Where do we go from here?'

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