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Mining technology that could improve productivity in South Africa

by G. de B. VAN NIEKERK*

SYNOPSIS

This paper briefly outlines some mining technology that is used with success in Australia but is not yet fully utilized in South Africa. The following aspects are discussed: improved rotary-drill bit performance, use of trucks and load-haul-dump units underground, long-hole raising, blasting techniques, and the use of butterfly roofbolt plates for support.

SAMEVATTING

Hierdie referaat gee 'n kort uiteensetting van sommige aspekte van mynboutegnologie wat in Australië met welslae gebruik word maar nog nie werklik in Suid-Afrika aangewend word nie. Die tegnologie wat bespreek word is: die verbetering van draaiboorkop werkverrigting, die meer effektiewe gebruik van vragwaens en laeprofiellaaiers ondergrond, diepgatstyggange, skiettegnieke en die gebruik van vleuel-dakboutplate vir beskutting.

Introduction

With the aid of the Delfos & Atlas Copco travel grant, the following mines were visited in Australia: Edjudina Gold Mine, Fosters Mine, Mt Lyell Mine, CSA Mine, Elura Mine, Mt Isa Mine, and West Cliff Colliery. On account of its high labour costs, Australia has applied new technologies as one way of being competitive in world markets. Because of its high inflation rate and rising production costs, South Africa will also need to apply the latest technological developments if it is to avoid being priced out of world markets.

The purpose of this paper is not to describe all the observed technology in detail, but rather to concentrate on the technology most applicable to the South African situation. The use of this technology could reduce costs and improve productivity. Although Australian mines are relatively shallow in relation to South African gold mines, a study of their methods may reveal opportunities of improvement to the vast and varied mining industry of South Africa.

It should be understood that productivity can never be expressed as an absolute quantity but only indirectly as a relative concept in terms of the ratio of output to input. The objective in productivity improvement can be defined as follows: the optimum combination and maximum utilization of all the productive resources engaged in an undertaking so that only the economically unavoidable costs are retained and the profitability is maximized in the long term.

Rotary Drill-bit Performance

Collar Pipes

In rotary drilling, it is crucial that cuttings are prevented from re-entering the hole since they cause excessive wear of drill rods and drill bits. This can be prevented by the use of a collar pipe standing a nominal 400 mm proud. To this end, a split hard-plastic pipe with a collar to prevent it from falling into the hole seems to be the best proposition. As the diameter of the drill rods is less than the diameter of the drill bit, the pipe can be fitted as soon as the drill rod has advanced a metre into the ground. The proposed collar pipe is shown in Fig. 1.

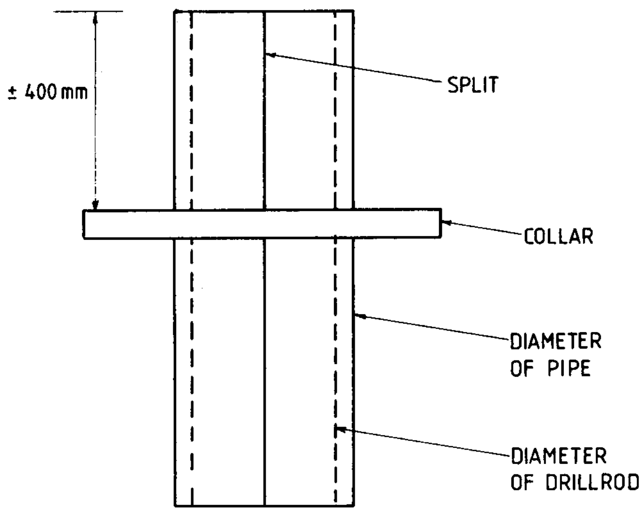


Fig. 1—Proposed collar pipe

Chip Size Analysis

The performance of rotary drills can be judged in a number of ways. An innovative means for determining the performance of rotary drills uses an analysis of the chip sizes returned at the collar. The maximum (optimum) chip size is that which equals the distance between the buttons on the bit. As the drill bit mechanically attacks the base of a hole, any reduction from this optimum size indicates that the broken material is being reground or recut.

* Chief Mining Engineer, Thabazimbi Mine, 6 Begonia Street, Thabazimbi 0380, and winner of a Delfos & Atlas Copco travel grant for mining engineers, 1987.

The occurrence of regrinding closely parallels the performance of the bit, and the regrinding of cuttings consumes additional energy. In addition, regrinding, particularly away from the toughened tungsten carbide buttons at the height of the shirt tail, dramatically increases the wear on those parts.

The analysis of the weight retained on each of four screens can be used as a guide to the performance of a drill bit, and the drill operator's logs of the applied thrust, rotation, and general geological conditions can then be compared over the known life of a bit and its mode of failure.

From the typical set of samples shown in Table I, it is obvious that something happened between the depth of 15,9 and 28,1 m, and this calls for investigation.

TABLE I
WEIGHT RETAINED (%)

Sample no.	Depth, m	Screen size, mm				
		4,75	1,7	0,85	0,425	Psing
1	3,7	10,4	38,5	20,5	14,5	16,1
2	15,9	14,9	42,0	15,3	10,0	17,8
3	28,1	4,1	30,1	21,3	18,3	26,2
4	40,3	2,3	25,7	21,3	20,1	30,6
5	52,5	1,6	20,0	22,3	22,9	33,2
6	64,1	0,7	15,9	20,0	23,7	39,7

If one determines the standard distribution for a particular drill, the influence of any change in down pressure, rotation, bailing velocity, etc. can easily be determined. It must be noted that, in determining the standard, new drill bits must be used since worn bits can drastically influence the results.

Vehicles Underground

The lack of surge capacity between load–haul–dump units (LHDs) and trucks can have a considerable effect on productivity. It was found that, even when the capacity of an ore pass is equivalent to only two truck loads, the productivity of trucks and LHDs can be improved by over 10 per cent. This is achieved by the development of a decline at an average gradient of 1 in 8 from the loading level to the bottom of the ore pass for the trucks, and the LHDs tip into the ore pass on the loading level.

The installation of a plate feeder system (Figs. 2 and 3) seems to be an outstanding success. The loading time of a 50-ton truck varies between 3 and 4 minutes. The truck driver controls the operation of the feeder with a pendant control unit, which is positioned above the truck cabin, whereas a chute-type feeder requires the employment of an orepass operator and is also susceptible to spillage problems. Another advantage of a plate feeder is that it prevents the build-up of fine toe material, and hang-up problems are therefore minimized. Although the plate feeder has many advantages, the tonnage to be handled must always be kept in mind. If the tonnage is low, the use of a chute-type feeder is more economical. Furthermore, the feeder must be designed in such a way that all the steelwork can be removed and re-assembled at another site.

Long-hole Raising

A method of raising has been developed that has achieved an advance of up to 6 m in a single blast, and such raises average 4,2 m of advance per blast. The method is a form of long-hole raising and is applicable to short raises of less than 50 m in length.

The raise pattern (Fig. 4) is based on 6 outside holes located on the points of a hexagon 2,75 m in diameter. A further 4 holes are placed within the hexagon, one centrally and the other three combining to form an offset diamond. All the holes are drilled with a nominal diameter of 165 mm. This has the advantage that any deviation can be countered by other holes in close proximity. As a general rule, the deviation occurring in a vertical hole over a distance of 50 m can approach 2 m, but the deviation is commonly limited to between approximately 0,5 and 1 m.

The geometrical design of the ten-hole pattern allows for the re-arrangement of the pattern at different horizons after a distortion caused by hole deviation. Consequently, a pattern containing holes that have deviated will usually still be regarded as satisfactory.

The delay sequence used for the long-hole raise consists of non-electric detonators in the 1 to 15 range. An idealized delay pattern for the blast-hole initiation (on the assumption that little hole deviation has occurred) would be as shown in Table II. At the stage when the blast-hole information is being prepared, the initiation sequence would be varied to compensate for any hole deviation.

TABLE II
BLAST-HOLE INITIATION

Hole no.	Delay no.	Delay time, ms
1	Uncharged relief hole	–
4	1	25
3	2	50
2	4	100
8	6	150
7	8	200
9	10	300
6	13	450
5	15	600
10	15	600

Long-hole raising for raises shorter than 50 m, if carried out in the described way, is more economical than raise-boring or the use of an Alimak raise-climber.

Blasting

Use of Anfops

Anfops is the name used for a mixture of ammonium nitrate and fuel oil (ANFO) and polystyrene. Mixtures are expressed as volume percentages of the two constituents; for example, 30 per cent ANFO by volume and 70 per cent polystyrene by volume is called Anfops 30. In all cases, the percentage refers to the ANFO content.

There are obvious cost benefits associated with Anfops because polystyrene is cheaper by volume than ammonium nitrate. Other benefits of Anfops are the reduction in blast-induced damage, which results in the following:

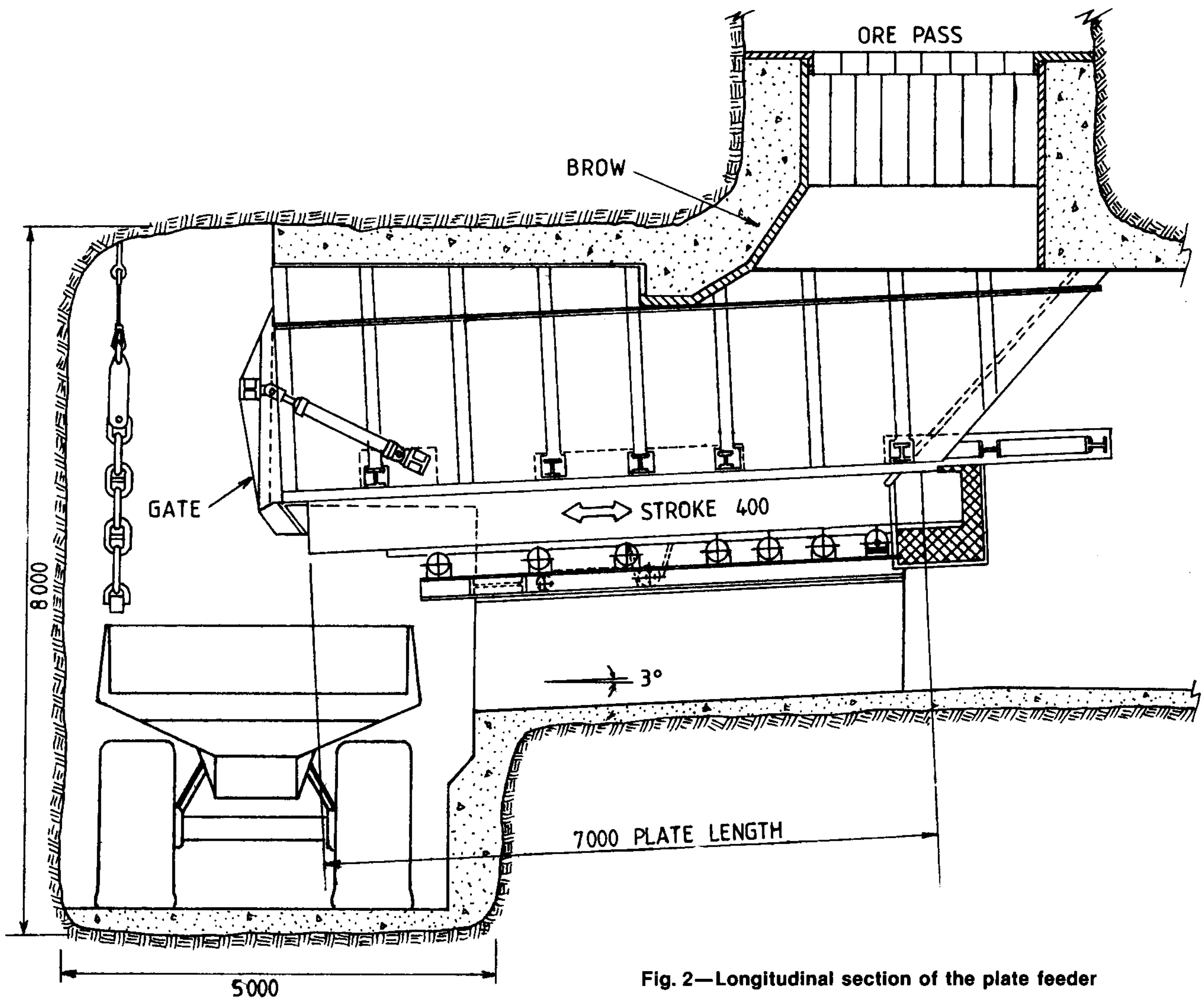


Fig. 2—Longitudinal section of the plate feeder

- the stope is inherently safer to work in;
- fragmentation in suitable ground is the same as, if not better than, Anfo because of the explosive characteristics;
- Anfops can be used successfully where poor ground conditions create problems.

Non-reactive vegetable oil is used for Anfops because the density is comparable with that of fuel oil. Polystyrene pellets of 1 to 3 mm diameter are used.

The purchase and subsequent modification of a mixer enables the manufacture of Anfops to be a controlled operation. Ammonium nitrate and polystyrene are fed separately into the mixer, and are mixed before the vegetable oil is added, which is accomplished by the use of a fine continuous spray. The feed rates of both polystyrene and ammonium nitrate must be variable so that any Anfops mixture can be produced. Vegetable oil is added at 6 per cent by weight, and coats both the ammonium nitrate and the polystyrene uniformly, giving the product a slippery feel.

Anfops can be pour-loaded into downholes with diameters of more than 70 mm, and can be blow-loaded into horizontal or inclined downholes. Polystyrene blowback is minimized if the loader is set at a reduced level. The correct setting ensures that the charge density is reasonably consistent over the length of the hole.

Experience has shown that, if Anfops 50 is adequately primed, initiation will occur and be maintained across considerable polystyrene 'pockets'. This is not surprising since polystyrene is a fuel in its own right and, when combined with vegetable oil, becomes a low-strength explosive. Although the propagation of the detonation front across the polystyrene is relatively reliable, the explosive energy tends to be concentrated in the pockets of ammonium nitrate and vegetable oil. Hence, the explosive charge is not uniform, and the merits and demerits should be assessed for the individual circumstances.

Sliderdeck System

The sliderdeck system (Fig. 5) comprises three components: a slider primer, a detonator assembly, and a detonating cord downline. Slider Primer MKIII detonators utilize the CXA delay range. Nominal firing times are given in Table III.

The principal application of the sliderdeck system is in blast-holes of large diameter where an in-hole delay is required. Bottom-of-hole initiation and sequential

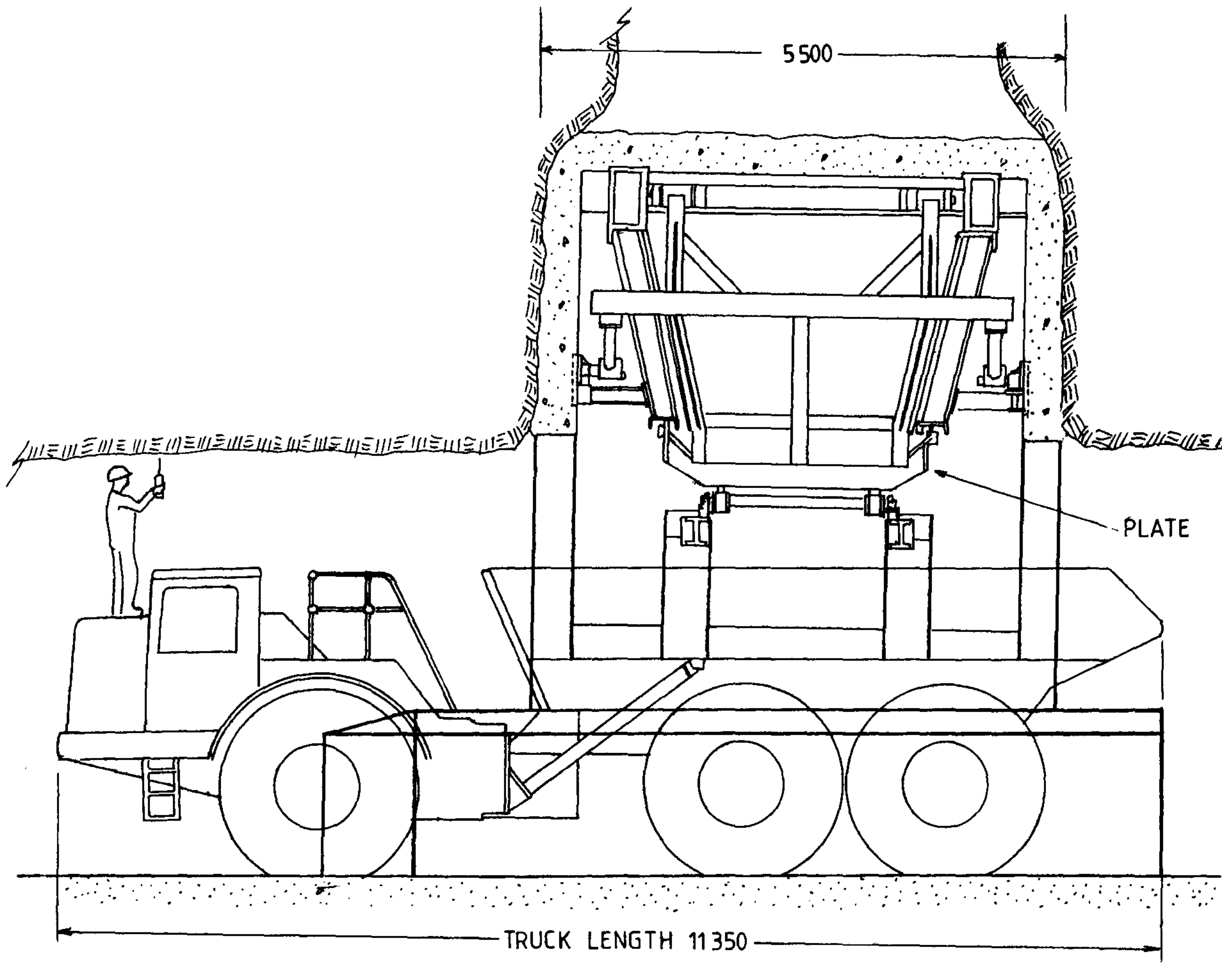


Fig. 3—Cross section of the plate feeder

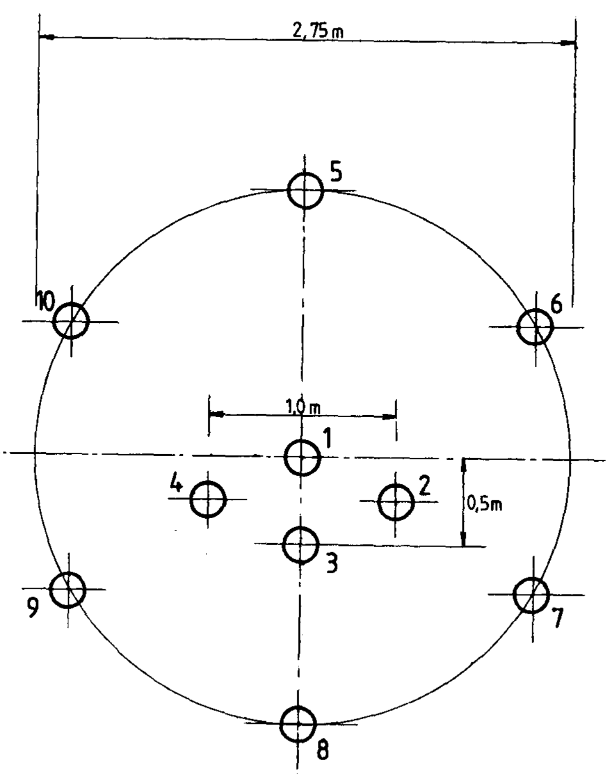


Fig. 4—Standard raise pattern (all holes 165 mm in diameter)

TABLE III
NOMINAL FIRING TIMES

Delay no.	0*	1*	2	3	4	5	6	7	8	
Firing time, ms	NA	NA	50	75	100	128	157	190	230	
Delay no.	9	10	11	12	13	14	15	16	17	
Firing time, ms	280	340	410	490	570	650	725	800	875	
Delay no.	18	19	20	21	22	23	24	25	26	
Firing time, ms	950	1025	1125	1225	1400	1675	1950	2275	2650	
Delay no.	27	28	29	30	31	32	33	34	35	36
Firing time, ms	3050	3450	3900	4350	4850	5350	5900	6550	7250	8050

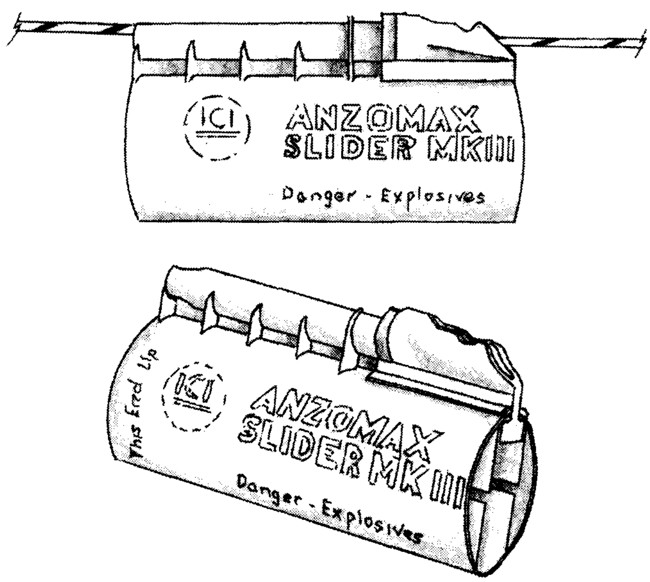
* Not available in Australia

initiation of deck charges can be obtained easily and quickly in both surface and underground blasts.

These slider primers can be used in conjunction with any blasting agents. The low (2,5 g/m) charge mass of the Slider line downline will not initiate ANFO, even if the Slider line is knotted; nor will it side-initiate or significantly damage those watergels or emulsions (including the low-density bulk Powergel used in the Powerdeck system) which are adversely affected by the detonation of detonating cords of higher charge mass.

Detonating Cord

During the adoption of a non-electrical system, a particular mine found that 5,8 g/m detonating cord downline



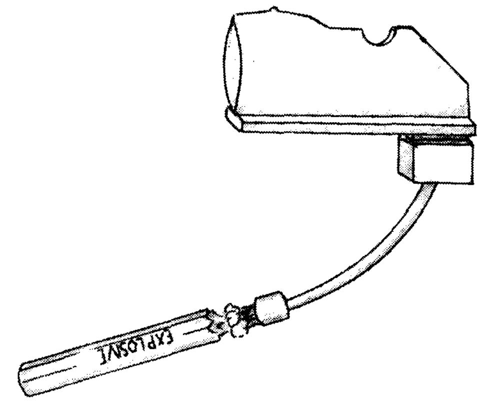


Fig. 5—Above left: Complete Sliderdeck assembly
Bottom left: Anzomax Slider Mk III primer
Above: Slider primer Mk III delay detonator

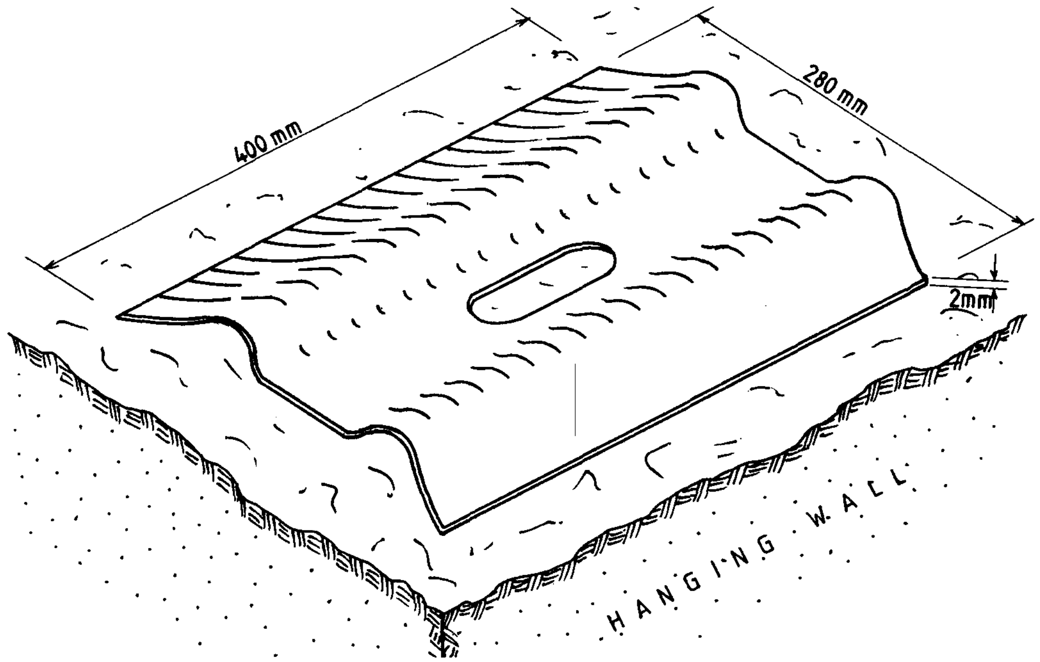


Fig. 6—Butterfly plate used with splitsets

occasionally side-initiated ANFO in a hole of 165 mm diameter. This was overcome by the use of 3,2 g/m RX Primeline, which suggests that 10 g/m Cordtex (currently used in South Africa) can side-initiate ANFO in holes of even larger diameter. To ensure that the booster detonates the charge, the use of 5 g/m Cordtex should be investigated.

Butterfly Roofbolt

The support characteristic of a splitset is improved by the use of a 'butterfly plate' (Fig. 6) with the standard flatplate. This butterfly plate is a 400 mm by 280 mm steel plate (fabricated from W-strap) 2 mm thick, with longitudinal and transverse creases that provide stiffness when the plate is pushed hard against rock. The butterfly plate is used mainly in fossile hangingwall areas, where the compressive force at the hole collar prevents 'fall-off' of scats from the region, thereby improving the stability of the hangingwall.

Conclusion

Although South Africa is one of the leading mining countries in the world, it is obvious that there is technology in other countries that could be used in South Africa to reduce costs and thereby improve productivity. Some of the items described are not available in South Africa but could be made available if there were a demand for them.

Acknowledgements

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Working conditions in the chemical industries*

Continued efforts to improve occupational safety and health and to reduce the adverse effects of shift work in the world's chemical industries were urged by a tripartite meeting that ended at the International Labour Office (ILO), Geneva, in October 1988.

Some 250 government, employer, and worker delegates from 27 countries and from concerned organizations took part in the meeting. Their conclusions will serve as guidelines for the future development of the industry and of related ILO programmes.

Shift Work

While recognizing that shift work was a very important feature of the chemical industries because it permitted fuller utilization of investments and provided increased employment, the Committee adopted conclusions that go further than those of its earlier sessions in specifying measures to avoid or reduce the impacts on the health and family life of shift workers. In addition to financial compensation—normally best decided through collective bargaining—the Committee listed measures concerning possible alternatives such as minimization of the extent of night and weekend work, reduction of hours of work and overtime, additional leave, early retirement, and priority in transfers to regular day work.

Safety and Health

The industry should continue to develop and integrate new measures of safety and health-protection practices to ensure the safe introduction of new technology and production and the use of chemicals, the Committee concluded. It stressed the importance of training and information, and re-affirmed the principle of tripartite co-operation as the most appropriate way of dealing with occupational safety and health issues.

The development of new chemical products increased the need for rapid identification and control of new hazards and for regular surveillance. Until the biological effects of new chemicals had been determined, their use should be permitted only under the most rigorously controlled conditions.

Resolutions

There were 3 main resolutions.

(1) Stressing that the stricter application of regulations in certain countries should not result in the dumping of toxic wastes in other countries with less comprehensive regulations, the first resolution invited the ILO to reinforce its activities for the creation of international guidelines in this field and to study means of strengthening the ability of developing countries to create an infrastructure for the control and treatment of wastes.

(2) Strategies to seek substitutes for the most dangerous substances was the theme of a second resolution, which called on countries to encourage the replacement, as far as possible, of high-risk production stages by less risky ones, and to ensure that information on hazardous substances was accessible to employers' and workers' representatives.

(3) The third resolution, emphasizing that delay in providing relief to victims of industrial accidents may adversely affect the chemical industries and their employees world-wide, asked the ILO to call on governments to ensure that liabilities were duly determined and that compensation was promptly granted and paid to accident victims.

* Released by the International Labour Office, CH-1211 Geneva 22, Switzerland.