Blindhole boring at Buffelsfontein Gold Mining Company Limited

by R. C. MORE O'FERRALL*, M.Sc. (Eng.) (Wits.) (Member), and W. G. GOULDING*, Pr. Eng., C. Eng., M. I. Mech. E., M. S.A. I. Mech. E. (Visitor)

SYNOPSIS

This paper describes the performance of a Robbins 52R Boxhole Borer from its introduction into the mine in July 1975 until late in 1977. As indicated by the costs involved, the performance has increased considerably and is expected to be even better once further envisaged modifications have been made. The average cost for the first half of 1977 was R275 per metre bored as against an average of R628 for 1975.

SAMEVATTING

Hierdie referaat beskryf die werkverrigting van 'n Robins 52R Boxhole-boor vanaf sy ingebruikneming in die myn in Julie 1975 tot laat in 1977. Soos die betrokke koste toon, het die werkverrigting aansienlik verbeter en dit sal na verwagting selfs nog beter wees wanneer verdere verwysigings wat beoog word, aangebring is. Die gemiddelde koste vir die eerste helfte van 1977 was R275 per meter geboor teenoor 'n gemiddelde van R628 vir 1975.

Introduction

The Robbins 52R Boxhole Borer described in this paper was introduced at Buffelsfontein Gold Mining Co. Ltd in July 1975 under the control of the Technical Services Department of General Mining & Finance Corporation. From the outset, a comprehensive set of cost and performance records were kept. These results have been invaluable in assessments of the performance of the machine and in indicating what modifications should be made to the machine to substantially improve its performance and reduce the operating cost.

This paper gives these results and the proposed modifications, which should be of considerable interest to companies embarking on a programme of boxhole boring.

General Organization

The fixed costs are high for a Boxhole Borer, with the result that operations are geared to produce the maximum possible number of metres bored, and so minimize the cost per metre drilled. The organization is therefore geared to provide the maximum possible time for boring.

The crew comprises the following:

1 foreman

4 technicians and 20 assistants

1 site-preparation timberman and 9 labourers.

To ensure that the preparation of the site is of the required standard, all the sites are prepared by the site-preparation crew, who ensure that the sites are sliped to the correct dimensions, that the face is prepared for ease of collaring, and that the foundations are cast complete with holding-down bolts in the correct position. After the foundation has been cast, the entire site is supported by bolting and meshing, and any snatching holes that may be required are drilled.

At least two complete sites are prepared ahead of the drilling operations, the layout of each site being planned to provide as smooth an operation as possible both in moving and boring. Operations take place over as many hours as are available, and, as boring often takes place in areas subjected to re-entry periods, this results in shifts of odd lengths. Crews relieve each other at the machine both in the boring and the moving operations.

The boring crew is also responsible for the removal of the spoil, and the loco driver and guard are part of the crew. A loco and a span of hoppers are allocated to the machine at whichever shaft the machine is operating. In this manner, as complete a control as possible is exercised over all the operations.

Logistics

The logistics of the Boxhole Borer are most important. Because of the quantity of ancillary equipment involved, a major proportion of the available working hours are spent moving from one site to the other. For this reason, moves between sites are planned well ahead in considerable detail. The critical item here is the 'drill string'. Each drill pipe has a length of 0,610 m and a diameter of 0,613 m, and weighs more than 220 kg, and, because of the two 'fixed' stabilizer fins, is extremely difficult to man-handle and store. Four drill pipes are carried per pipe-car, of which there are twelve. Thus, in a boxhole 72 m in length, where 118 drill pipes are required, the pipe cars have to be loaded and unloaded six times during the drilling cycle. The required storage space is considerable and must, for obvious reasons, be in close proximity to the Boxhole Borer.

Operational Analysis

Site Preparation

With the current arrangement of the machine, the foundations have had to be up to 2 m deep because the considerable overturning movement required the foundation bolts to be anchored in bed rock. This is both costly and labour-intensive, the average cost per site to date being R2262, which is equivalent to R39,00 per metre drilled.

The bolting and meshing of the site have contributed considerably to the safety of the operations. This is particularly so during collaring, when considerable vibration is imparted to the rock. This vibration has been greatly reduced by the use of pilot bit-and-button cutters.

*General Mining & Finance Corporation, Stilfontein, Transvaal.

Drilling Performance

During the period under review, twenty-one boxholes have been bored with the Boxhole Borer, ranging in length from 29,26 to 89,67 m, the average being 58 m. In all, a total of 1145 m has been bored. The original minimum guaranteed rate of advance of 1 m/h has never been achieved, except for short inconsequential periods, when a rate of more than 2 m/h was reached. The average drilling rate is 0,65 m/h, with an average of 0,8 m/h for the last three holes. The actual drilling time as a percentage of the total available time has remained disappointingly low, ranging from 9,6 to 41,9 per cent with an overall average of 24,9 per cent in any one calendar month.

Cutters

To minimize the time spent in pulling the head, it is necessary to have cutters that will complete the hole in one pass. Also, the failure of cutters has a considerable demotivating effect on the drill crew.

From the outset, it was decided to lease rather than buy cutters because of the uncertainty of cutter life, and the results showed this to be a wise decision.

The disc cutter first employed proved totally inadequate, and the quadruple centre cutter was a major problem, subject to early and complete failure. Indeed, frequent disc-cutter failure led to the pulling of the drillstring up to four times per boxhole, failures occurring after boring as little as 9,14 m.

Even after the fitting of a tri-cone pilot bit, the maximum length bored with disc cutters before failure was 38,4 m. The domed head and disc cutters were replaced by a flat head fitted with T/C button cutters. Although the initial penetration rate was 10 per cent lower, this was more than compensated for by the increased depths bored between cutter changes. To date, up to 74,4 m has been bored with a set of button cutters in a single pass.

Failure of the conical centre cutter was experienced with the new arrangement. The cutter head was then modified and a 'tri-cone' T/C button pilot bit fitted in its place. There was an immediate improvement, the cutters drilling between 138 and 151 m before bearing failure occurred. A total length of 200 m was bored with one pilot bit. This initial success was followed by early failure of the pilot bit, apparently owing to the high rock temperature, and to the fact that cooling water could not enter the pilot hole and the pilot bit overheated, thus causing bearing failure.

Deflection

Because boxholes are usually required to hole into raises where the width is frequently less than 2 m, drilling accuracy is most important. Drilling from the raise to locate the boxhole and then to effect a holing by tunnelling or winzing is difficult and adds considerably to the cost.

The first boxholes deflected badly, 6 to 7 m from the expected holing point. This resulted from the flexibility of the non-rotating drill string (only the six starter pipes being bolted together with 24 bolts at each end) and the fact that, during collaring, the roughness of the face tended to cause the machine to deflect. Once this had happened, there was little that could be done to correct it. Conditions were improved considerably by better face preparation and the fitting of the tri-cone pilot bit to the cutter head. Experience showed that the flexibility of the drill string itself caused a deflection of between 5 and 7 degrees on a 65 m boxhole. The 'dip' angle of the boxholes was corrected to compensate for this and the ability to hole was improved, the deflection amounting to between 0,3 and 1,0 m of the true line.

Breakdowns and Failures

As this was the first 52R Boxhole Borer put into service, it is quite understandable that the percentage of downtime caused by breakdowns and failures (hydraulic, mechanical, and electrical) should initially have been very high (40,4 per cent maximum). The downtime is now an average of less than 4 per cent. By far the majority of failures were hydraulic, with a very small proportion of electrical breakdowns. The crew, who in the main comprise fitters and boilermakers by trade, are capable of doing all the running repairs necessary, which contributes considerably to the efficiency of the operation.

Mining Delays

Delays caused by the interruption of essential services (water, compressed air, and power supply) and tramming delays, which originally constituted over 15 per cent of the available working hours, have now been reduced by half, the delays due to tramming hold-ups averaging 3,5 per cent. (This includes delays at the tips, derailments, unauthorized removal of the loco and hoppers assigned to the Boxhole Borer, and loco maintenance.)

Performance

The operation of the Boxhole Borer can be divided into four distinct phases.

Drilling: the addition of drill pipes to the string as the head advances

Delays: all delays and interruptions, including pulling the drill string for the purpose of working on or changing cutters during the boring cycle for one boxhole.

Breakdowns: all mechanical, electrical, and hydraulic failures to equipment, but excluding cutter failure

Moving: removal of the drill string after the completion of the boxhole, rigging down, moving all equipment to the next site, rigging up the Boxhole Borer, and preparations prior to the start of boring.

The percentage times for these activities for the period under review average out as follows:

Drilling	41,3 %
Moving	32,1 %
Delays	21,2 %
Breakdowns	5,4%.

From this tabulation it is obvious that improved logistics and a reduction in delays will make for a rewarding improvement in the time available for drilling.

Costs

As indicated by the costs involved, the operation of the Boxhole Borer has improved considerably since its introduction into the mine. The operating costs, which include all salaries or wages, consumables, cutter costs, maintenance and modifications, materials used, site preparation, tramming and moving from site to site, all of which are undertaken by the Boxhole Borer crew, have averaged out at R19 000,00 per month. The cost per metre bored has dropped from an average of R628,00 for 1975, to R359,00 for 1976, and to R275,00 for 1977 until the end of June.

Although this drop in cost is gratifying, there is room for further improvement, and it is felt that, when the major modifications are completed, a figure of R200,00 per metre will be achieved.

The current costs can be broken down as follows:

Operation and tramming	R186,00 per metre
Site preparation	R39,00 per metre
Maintenance and minor modifications	R50,00 per metre
	R275,00 per metre

Modifications

The modifications already made, together with those being implemented, are expected to have the following effects.

Site Preparation and Collaring

The erection mechanism has been altered to a push-up arrangement that eliminates the need for large foundations. This will allow the foundation to be reduced to a slab approximately 0,60 m thick. It has been calculated that this will reduce the cost of site preparation by R14,86 per metre (viz, from R39,00 to R24,14 per metre). The integral erection equipment will be used to support the Boxhole Borer while 'collaring', thus preventing the machine from being pushed off line as has happened in the past. The drilling face need not be prepared as carefully as before, which will enable the site-preparation gang to be reduced by 4 to a total of 5.

Drilling Performance

The cutter head is being modified so that high-pressure flushing and cooling water will be forced up the stem to the pilot bit and onto the cutter faces. It is expected that not only will this significantly reduce the operating temperatures and overcome the existing bearing failure problems, but the copious supply of water to the tri-cone bit will flush out the cuttings and so prevent them lodging between the cutters, which leads to jamming and early failure. There should also be an improvement in the penetration rate while drilling, and there will be no dust hazard.

A self-contained hydraulic thrust pack is being built that wills upply the necessary thrust to the cutter head. The entire output of the existing hydraulic power pack will be utilized to rotate the head, thus leading to an appreciable increase in the torque available and overcoming the frequent stalling under load that has plagued the Boxhole Borer up to the present time. This should result in improved drilling performances.

The new derrick arrangement resulting from the push-up erection will enable the drill pipes to be fed from the back of the machine, instead of the front, thus providing easier access to the operators. This and the other modifications will result in the drilling gang being reduced from 20 to 16.

The present average boring rate of 3,5 m per shift is expected to increase substantially so that, on the basis of three shifts per day, more than 1800 m per annum can be drilled by each Boxhole Borer. (An output of 100 m per month has already been achieved under existing conditions on a number of occasions while working for two shifts per day.)

Deflection, and Design of Drill Pipes

All the drill pipes are being modified and will be bolted together with three 30 mm bolts, thus greatly improving the rigidity of the drill string, which is expected to reduce the deflection problem. Further, all the pipe fins will be removable and held in place with a single bolt each. The logistics will be better as each pipe car will accept eight drill pipes, instead of four as at present, and damage to the pipe fins should be reduced considerably. The stability during collaring will also improve the accuracy of the drilling.

Moves Between Sites

The modification planned will reduce the moving time between sites by an average of at least three shifts. Manhandling will be greatly reduced, and the space required for the storage of back-up equipment will be reduced.

Savings

It has been calculated that these modifications and improvements will result in an immediate saving in labour and material of R26,00 per metre. The expected improved availability of the machine and probable higher penetration rates will result in substantial increase in metres bored per month, which should decrease the costs to around R200 per metre.