Note: Hydraulic rockdrills and their effect on the underground environment

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In any situation where hydraulic rockdrills are used underground, it is evident that an amount of heat equivalent to the total electric input to the power pack would enter the ventilation air. Some concern has been expressed in certain quarters about the effect of this thermal problem. On the other hand, the compressed air used with pneumatic rockdrills has a cooling effect. It is necessary, therefore, to evaluate the magnitude of the effect that the introduction of hydraulic rockdrills would have on the underground thermal environment.

THE COOLING EFFECT OF PNEUMATIC ROCKDRILLS

The hand-held rockdrills that are in common use in stopes in South African gold mines consume air at a rate[1] of about 0,06 m^3/s. If the standard density of air is 1,2 kg/m^3, this corresponds to an air mass flowrate of 0,072 kg/s.

The compressed air in the pipes of the mine reticulation system has a moisture content of typically 6 g/kg, and enters stopes at a temperature of about 35°C. This air, when returned to an ambient stope air pressure of say 110 kPa and 35°C dry bulb, will have[2] a wet-bulb temperature of about 19°C, with a corresponding energy content (sigma heat) of about 50 kJ/kg.

The ventilation air leaving hot stopes is typically at a wet-bulb temperature of about 32°C, and has a sigma heat of about 100 kJ/kg; the expanded air from a rockdrill will rise in temperature and sigma heat to these values. Hence, the cooling effect when a pneumatic rockdrill is operating is about $0{,}072 \times (100 - 50) = 3{,}6$ kW.

It is important to realize that this is the net cooling effect regardless of the efficiency of the rockdrill. Although it is true that the air leaving a rockdrill may be cooler than indicated above, both as a result of doing work in the rockdrill to move the piston and as a consequence of accelerating the air so that it leaves the exhaust ports with high velocity, all this energy is ultimately dissipated as heat in the stope. All the work done by the piston on the rock through the drillsteel is removed as heat by the flushing water (as is evident to anyone who has observed how quickly a drillsteel gets hot if the water supply fails), and, as the air leaving the exhaust ports slows down in the surrounding atmosphere, its kinetic energy is converted back into sensible heat.

The number of rockdrills in stopes is typically from three to five for a face 40 m in length. The cooling effect of rockdrills occurs only when air is being consumed (that is, only for the 2 to 3 hour period during which drilling takes place) and amounts to between 11 and 18 kW for a 40 m panel, or 270 to 450 W per metre of face length. This must be compared with the heat flow from the rock into a stope, which is typically 2 kW per metre of face and which takes place continuously over the full 24 hours of each day. Hence, the cooling effect of pneumatic rockdrills, while being of benefit to the rockdrill operator, has a relatively small effect on the overall thermal environment in mines.

THE EFFICIENCY AND WORK OUTPUT OF PNEUMATIC ROCKDRILLS

The efficiency of pneumatic rockdrills can be estimated from the temperature of the exhaust air stream after it has slowed down some distance from the exhaust port of the rockdrill.

Table I (which is derived from previously published information[3]) indicates the ideal isentropic work rate per unit mass of air as a function of pressure, and the efficiency of rockdrills as a function of the exhaust air temperature. It would seem that a typical rockdrill has an efficiency of about 10 per cent.

On the assumption of typical average flowrates of 0,048 kg/s, 0,072 kg/s, and 0,096 kg/s for the three different gauge pressures, Table I also shows that the rate at which rockdrills work ranges between 0,49 and 2,97 kW. In stopes, air pressures are usually between 400 and 500 kPa, so it would seem that hand-held rockdrills have a work output of only about 1 kW.

TABLE I

EFFICIENCY AND POWER OUTPUT OF PNEUMATIC ROCKDRILLS (WITH COMPRESSED AIR SUPPLY AT 30°C, BAROMETRIC PRESSURE 100 kPa)

Assumed air-gauge pressure, kPa	300			500			700		
Isentropic work rate at an air flowrate of 1 kg/s, kW	102			125			139		
Assumed exhaust temperature, °C	20	10	0	20	10	0	20	10	0
Efficiency of rockdrill, %	10,1	20,2	30,3	8,3	16,5	24,8	7,4	14,8	22,2
Assumed air flowrate, kg/s	0,048			0,072			0,096		
Work rate at the assumed exhaust temperatures, kW	0,49	0,98	1,48	0,74	1,48	2,23	0,99	1,98	2,97

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ELECTRIC POWER USED TO COMPRESS THE AIR

The electric power consumed by the compressors to provide compressed air can be estimated from published information[4], which indicates that 13,2 m^3 of free air (at a surface density of 1 kg/m^3) can be compressed to a pressure of 600 kPa with 1 kWh of electric energy. Thus, the power needed to provide compressed air at a rate of 0,072 kg/s is

$$0{,}072 \times 3600 / 13{,}2 = 20 \text{ kW}.$$

This power is consumed only while the rockdrills are in use, which is during the peak-demand period of the day.

From these figures it will be apparent that, with pneumatic rockdrills, a power input to the compressor of 20 kW is required in order to obtain about 1 kW of mechanical work output at the hammer of the rockdrill. This represents an overall efficiency of only 5 per cent.

HYDRAULIC ROCKDRILLS

Since hydraulically powered rockdrills should have an overall efficiency of about 33 per cent, the electric-power input that would be needed to achieve the same work rate as the pneumatic rockdrill (1 kW) would be 3 kW. As was mentioned earlier, all of this 3 kW would end up as heat in the ventilation air. It should be recalled that hydraulic rockdrills would also be able to complete the drilling cycle in less than two hours, so that this additional heating effect would be of relatively short duration compared with the 24-hour influx of heat from the rock.

In order to counter the heating effect of hydraulic rockdrills, it would be necessary for the size or cooling effect of refrigeration plant in the mine to be increased by 3 kW for each such rockdrill. The additional electric power needed by the refrigeration plant to provide this cooling would be only about 1 kW per rockdrill, assuming an overall refrigeration coefficient of performance of 3.

Hence, the total electric demand if hydraulic rockdrills are to be introduced and if the thermal environment is not to suffer will be $3 + 1 = 4$ kW. This is but a fraction of the electric-power demand when pneumatic rockdrills are used, so that the resulting reduction in the peak demand for, and the cost of, electric power would be considerable. Furthermore, a refrigeration plant having been installed, its cooling effect would be available throughout the 24-hour day, and not only during the drilling shift.

STOPE COOLING WITH MACHINE WATER

Where refrigeration is installed, it would be a relatively simple matter to add a water-to-water heat exchanger adjacent to each air-cooling coil, in order to cool the machine water to about 26 °C before this water enters the stope. This would provide the additional cooling necessary to remove the heat generated by the hydraulic rockdrills and power pack. Since each rockdrill requires about 0,2 l/s of water during drilling operations, the cooling effect of this cold water in the stope would be about

$$0{,}2 \times 4{,}18 \times (30 - 26) = 3{,}3 \text{ kW}.$$

Of course, the cooling effect of chilled water need not be limited to that necessary to compensate for the heat generated by the hydraulic rockdrills. The machine water could be cooled to between 20 and 15 °C, giving a cooling effect in the stope of 8 to 12 kW.

For the remaining 20 to 22 hours a day when not required for drilling, this water could be allowed to continue running, perhaps through suitable sprays located at convenient places in the stope, so as to provide continuous cooling. The extra cost of this additional flow of water will be small in relation to all the other costs of stoping, and in relation to the cost of alternative methods of cooling in the stopes.

CONCLUSION

The above discussion relates to only one aspect of hydraulic rockdrills, and indeed there are many other factors to be considered. Hydraulic rockdrills must be evaluated on their ability to increase stope and labour productivity and to reduce overall mining costs, and not on their initial cost or on their small adverse effect on the thermal environment underground. The main conclusion to be drawn from the calculations outlined above is that mines need not be overly concerned about the thermal problem when consideration is being given to the possible introduction of hydraulic rockdrills. The thermal problem can be overcome with little difficulty, and the additional costs of doing so will be more than countered by savings along other lines.

REFERENCES

1. Mine Ventilation Society of South Africa. *The ventilation of South African gold mines.* 1974. p. 439.
2. Whillier, A. Psychrometric charts for any barometric pressure (SI units). *Journal of the Mine Ventilation Society of South Africa,* vol. 24. 1971. pp. 138-143.
3. Mine Ventilation Society of South Africa, *op. cit.,* p. 176.
4. *Ibid.,* p. 438.

Book review

Australian Mineral Industry 1972 Review. Australia, Department of Minerals and Energy.

For those interested in facts, figures, and developments in the Australian minerals industry in relation to the world situation, this annual review, which has been published regularly since 1948, holds a wealth of information in its 411 pages. The latest issue provides statistical data for the calendar year 1972, while updating general developments to mid-1973. For the first time, statistics are declared in metric units to conform with international standards. The information is clear, authoritative, and amply supported by statistical tables and illustrations.

Part I is a review of the current world mineral scene in general, and the Australian mineral industry in particular. Relevant information is supplied on the latest developments in mineral exploration, and a useful summary is given of Government taxation, assistance, and control.

Part II comprises a more detailed review of 106 individual mineral products compiled by authoritative authors in the relative fields. Each mineral product is discussed under the general headings of domestic production, overseas trade, consumption, prices, and new developments, and a short resume is given of the relevant world situation with respect to the mineral concerned.

Part III and Part IV are essentially composite statistical tables of relevant data on mining establishments; labour; mineral stocks, production, and value; rent and leasing expenses, and fixed capital expenditure.

Two appendices give useful information regarding the principal mineral producers classified under product type; ore-buyers and mineral dealers; Government mining services; industrial and professional organizations and development associations.

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NIM report

The following report is available free of charge from the National Institute for Metallurgy, Private Bag 7, Auckland Park 2006.

Report no. 1691

The determination of zirconium and aluminium by 14MeV neutron-activation analysis.

Aluminium and zirconium were determined in alloys, slags, and fumes by 14 MeV neutron-activation analysis. After corrections for density variations and mutual interferences had been made, the data agreed well with those obtained by chemical analysis, precisions of less than 1,8 per cent being obtained. The method is capable of a through-put of 10 to 12 samples, in duplicate, per man-day, and is non-destructive.

Automation in Mining, Mineral, and Metal Processing

The International Federation of Automatic Control (IFAC) is to hold its second symposium on the above subject in Johannesburg on 13th to 17th September, 1976. Persons knowledgeable in the field are invited to submit papers on the following topics:

Mining

Prospecting; survey and mine design techniques; materials handling; transportation; mining equipment and methods; environmental control.

Mineral Processing

Grinding and flotation; agglomeration; beneficiation; blast furnaces; direct reduction.

Metal Processing

Steelmaking; non-ferrous metal production; reheat furnaces; rolling mills; electrolysis.

Computers and Control Equipment

System design techniques; equipment design; application of microprocessors; control software; case studies of computer control systems.

On-line Instrumentation

Measurement techniques for the above processes.

Theory

Identification, optimization and modelling; control algorithms relevant to the above processes.

General

Economics of computer control; reliability; human factors.

Further information is available from the Secretariat, IFAC Symposium on Mining, Mineral, and Metal Processing, Conference Division (S. 100), Council for Scientific and Industrial Research, P.O. Box 395, Pretoria 0001 (telephone 746011 ext. 2077 or 2100).

V Simpósio de Mineracão

A symposium is being arranged for 6th to 9th August, 1975, in Ouro Preto, Brazil. The matters to be discussed include the following: Mineral Research, Mineral Political Economy, Mine, Mineral Treatment, and Extractive Metallurgy. Further information is obtainable from Centro Moraes Rego, Departamento de Engenharia Metalurgica — EPUSP, Cidade Universitaria — Sao Paulo — Capital, 05508, Brazil.

ACHEMA 1976

The 18th Chemical Engineering Exhibition—Congress and European Meeting of Chemical Engineering will be held in Frankfurt from 20th to 26th June, 1976, and the Chemical Engineering World Congress ('Chemical engineering in a changing world') in Amsterdam from 28th June to 1st July, 1976. Further information on both these events is available from DECHEMA, D-6000 Frankfurt (Main), P.O. Box 97 01 46.

Sixth Underwater Mining Institute

The above Institute will be held on the main campus of the University of Wisconsin in Madison, U.S.A., on 2nd and 3rd October, 1975. The programme will include presentations by leading industrial and academic workers on such topics as the following: Minor metals of economic interest in ferromanganese nodules; Mining of seafloor phosphorite deposits; New U.S. regulations for mining on the outer continental shelf; Profits in nodule mining: the corporate approach; Advances in research on ferromanganese nodules; Sources of risk and venture capital for underwater mining; New geophysical systems for the locating of mineral deposits on the seafloor; Exploration of marine placers: gold, platinum, and tin; Economic processing of marine deposits.

Further information is obtainable from Dr Gregory D. Hedden, Program Co-ordinator, Sea Grant Advisory Services, University of Wisconsin, 610 Langdon Street, Madison, WI 53706, U.S.A.

Company Affiliates

The following members have been admitted to the Institute as Company Affiliates.

AE & CI Limited.
Afrox/Dowson and Dobson Limited.
Amalgamated Collieries of S.A. Limited.
Apex Mines Limited.
Associated Manganese Mines of S.A. Limited.
Blackwood Hodge (S.A.) Limited.
Blyvooruitzicht G.M. Co. Ltd.
Boart & Hard Metal Products S.A. Limited.
Bracken Mines Limited.
Buffelsfontein G.M. Co. Limited.
Cape Asbestos South Africa (Pty) Ltd.
Compair S.A. (Pty) Limited.
Consolidated Murchison (Tvl) Goldfields & Development Co. Limited.
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East Driefontein G.M. Co. Limited.
East Rand Prop. Mines Limited.
Free State Saaiplaas G.M. Co. Limited.
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President Steyn G.M. Co. Limited.
Pretoria Portland Cement Co. Limited.
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Rustenburg Platinum Mines Limited (Union Section).
Rustenburg Platinum Mines Limited (Rustenburg Section).
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Shaft Sinkers (Pty) Limited.
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Stilfontein G.M. Co. Limited.
The Griqualand Exploration and Finance Co. Limited.
The Messina (Transvaal) Development Co. Limited.
The Steel Engineering Co. Ltd.
Trans-Natal Coal Corporation Limited.
Tvl Cons. Land & Exploration Co.
Tsumeb Corporation Limited.
Union Corporation Limited.
Vaal Reefs Exploration & Mining Co. Limited.
Venterspost G.M. Co. Limited.
Vergenoeg MiningCo. (Pty) Limited.
Vlakfontein G.M. Co. Limited.
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West Driefontein G.M. Co. Limited.
Western Deep Levels Limited.
Western Holdings Limited.
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