Oxygen enrichment of the converter air at Rustenburg Platinum Mines

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SYNOPSIS

An account is given of the adoption of oxygen enrichment to accelerate converting operations and so permit the handling of larger quantities of feed materials. In addition to achieving its object, the use of oxygen-enriched air (6 per cent oxygen by volume) results in an increase in the concentration of sulphur dioxide in the converter off-gas. The slags have the same composition as those produced without oxygen enrichment, and the operation of the converters is easily controlled.

SAMEVATTING

Daar word verslag gedoen oor die gebruik van suurstof-verryking om die omsitbewerkings te versnel en so die hantering van groter hoeveelhede voermateriaal moontlik te maak. Benewens die bereiking van die oogmerk daarvan, lei die gebruik van suurstofverrykte lug (6 persent suurstof volgens volume) tot 'n toename in die konsentrasie van swaweldioksied in die gas wat die omsetter afgee. Die slakke het dieselfde samestelling as dié wat sonder suurstofverryking verkry word en die werking van die omsetters word maklik beheer.

Oxygen-enriched atmospheres have been used for many years in non-ferrous pyrometallurgy, notably by the Japanese and by concerns such as International Nickel in Canada. Our experience at Rustenburg with oxygen enrichment of the converter air blast is typical of that recorded at the Copper Cliff Smelter of International Nickel and presented in a paper to the American Institute of Mining and Metallurgy in 1965. In consequence, I shall concentrate on the practical application of oxygen enrichment to a particular installation, Rustenburg Platinum Mines.

The main advantage derived from the use of oxygen on the converters at Rustenburg is the greater flexibility it gives to the operation. The ability to use oxygen if desired makes it possible to schedule alternative methods, for the treatment of various feed-stock materials to suit prevailing circumstances. To explain this more fully, it is necessary that I describe the Rustenburg establishment (see Fig. 1).

Ore from the mine is processed in one of three concentrating plants producing a flotation concentrate assaying some 5 to 6 per cent Cu and Ni, 16 per cent Fe, 10 per cent S, 18 per cent CaO and MgO, and 25 per cent SiO_2. This concentrate is filtered, dried, and pelletized, and is then charged with limestone to one of two 19,5 MV.A Elkem furnaces. The semi-dried pellets and limestone flux are choke-fed along the side walls of the electric furnace and are fed manually around each electrode. The furnaces are rectangular with six-in-line electrodes operating in pairs, each pair supplied by a separate transformer. Matte at a temperature of 1150 to 1250 °C is tapped from the front of the furnace as required for the converters; slag is tapped continuously from the rear of the furnace, being granulated directly in water, and then milled and treated in a flotation circuit for the recovery of any entrapped particles of matte before it is discarded on a tailings dam.

Furnace matte, having an approximate analysis of 9 per cent Cu, 16 per cent Ni, 37 per cent Fe, and 25 per cent S, is transferred by ladle and overhead crane to Peirce-Smith converters. The converters are 10 ft in diameter by 20 ft long, and are equipped with 28 tuyères (of which 24 are used) punched automatically by Kennecott pneumatic punching machines. The converters oxidize the iron sulphide to iron oxide and sulphur dioxide. The oxide is fluxed with quartzite, skimmed off, and returned molten to the furnaces. Converter matte, analysing 30 per cent Cu, 49 per cent Ni, 20 per cent S, and less than 1 per cent Fe, is cast into moulds, crushed, and sent for further processing.

These facilities are virtually duplicated at Union Section, some 80 km to the north of Rustenburg, where two concentrators serve one 19,5 MV.A electric furnace. Union Section, however, have no converters, and crushed furnace matte is trucked to Rustenburg for converting. It was intended that this material be used as cold dope in our converting operations but, with the commissioning of Union Section furnace last year, we found that attempts to treat it in this way led to excessive blowing times and a resultant loss in converter capacity. In consequence, use had to be made of the electric furnaces for re-melting the Union furnace matte prior to converting.

Thus, in circumstances of constrained converter capacity, having increased quantities of cold dope to be treated and knowing that a sulphuric acid plant would be commissioned in the near future operating on converter off-gas, we were receptive to an approach from Air Products about the feasibility of oxygen enrichment of the converter air blast. At this time, though accepting that the use of oxygen would accelerate the reactions taking place in the converter, and that the consequently proportionately lower ratios of nitrogen would make more heat available for the smelting of cold charge, we were concerned with the safe application of the process, the control of the reactions, and the possible adverse effects on converter refractories. We agreed, however, that equipment be installed to enable us to do testwork on one converter.

This equipment (Figs. 2 and 3) consisted of a 10-ton liquid-oxygen storage tank, vaporizers, and a 2-inch oxygen delivery line delivering oxygen through a control

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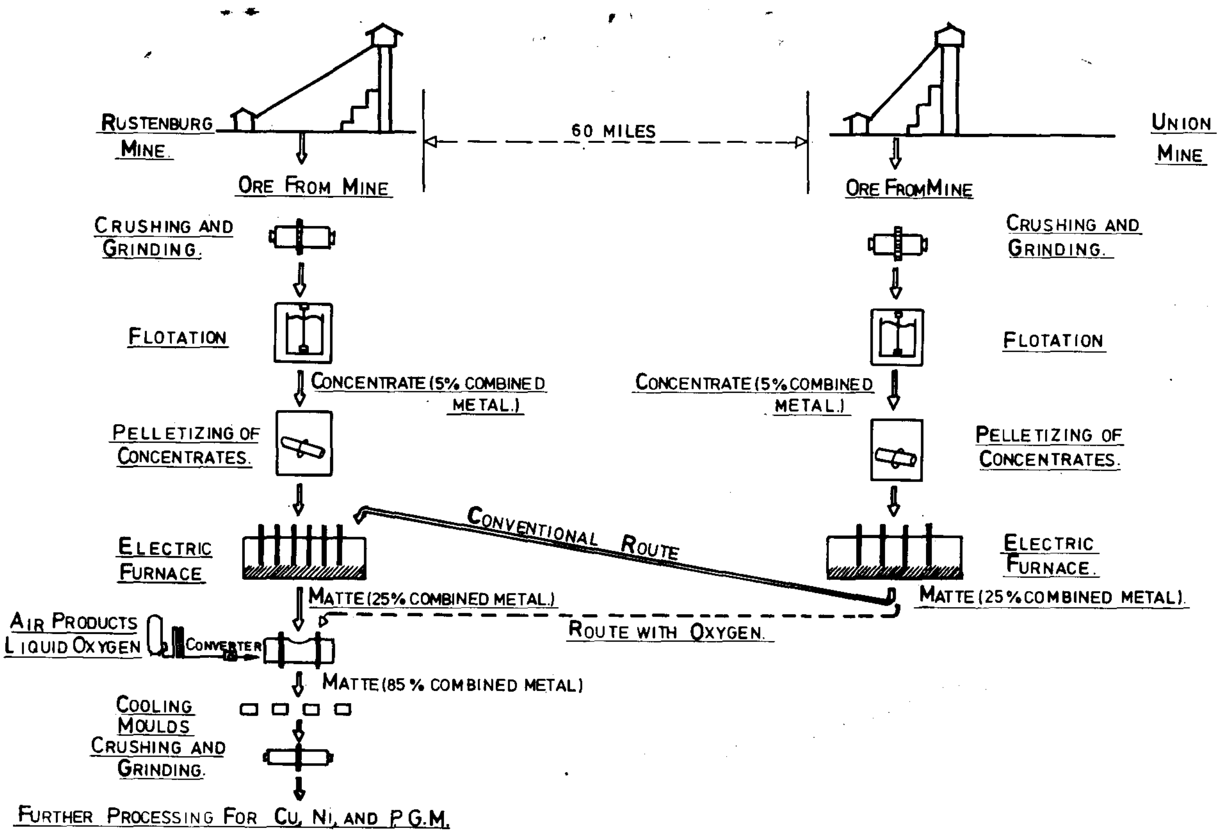

Fig. 1—Flowsheet at Rustenburg Platinum Mines

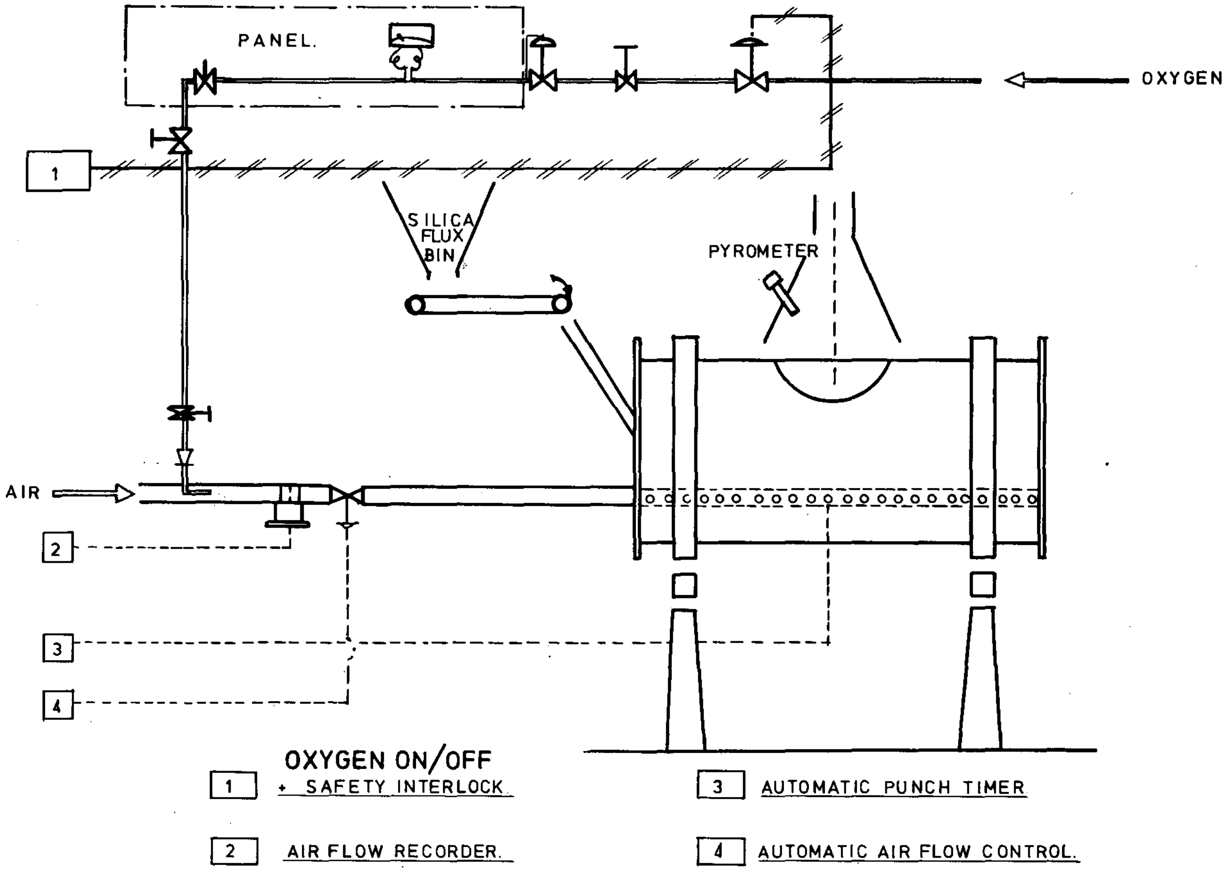

Fig. 2—Peirce-Smith converter with oxygen enrichment. 1 Oxygen on-off and safety interlock. 2 Air-flow recorder. 3 Automatic punch timer. 4 Automatic air-flow control

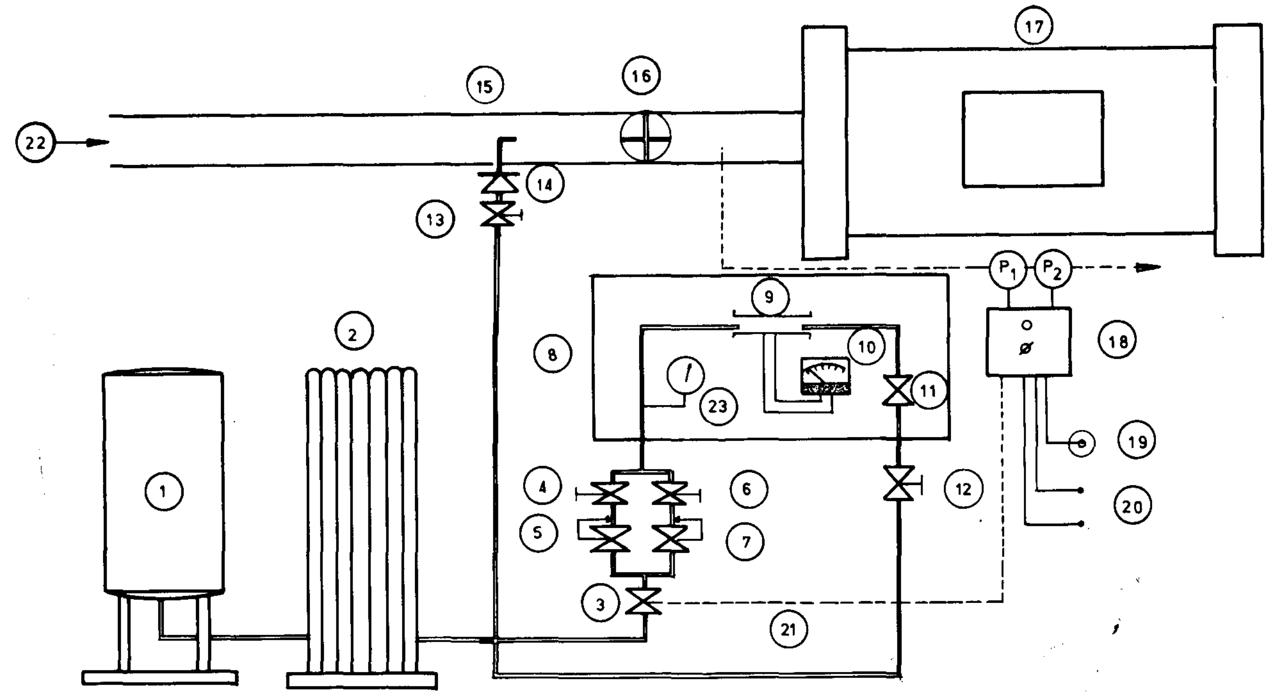

Fig. 3—Schematic diagram of the oxygen-control system. 1. Cryogenic storage vessel for liquid oxygen. 2. Vaporizers. 3. Pneumatically actuated ball valve (safety interlock). 4. Isolation valve. 5. Pressure regulator. 6. Isolation valve. 7. Pressure regulator. 8. Lockable control panel. 9. Amber element. 10. Eagle-eye differential pressure gauge. 11. Maximum flow control valve. 12. Flow control valve. 13. Isolation valve. 14. Non-return valve. 15. Oxygen diffuser. 16. Air shut-off valve. 17. Peirce-Smith converter. 18. Safety interlock panel. 19. Air supply. 20. Air line. 21. Electrical supply to pneumatically actuated ball valve. 22. Air supply to Peirce-Smith converter. 23. Pressure gauge. P1. High-pressure switch. P2. Low-pressure switch

panel to a diffuser located in the main air-supply column some 12 pipe diameters up-stream of the converter to allow adequate mixing. The oxygen control system is made up of a primary pneumatically operated ball valve, a pressure regulator, a pressure gauge, a flow meter, a maximum flow control valve (pre-set and locked), a manual control valve, and a non-return valve immediately ahead of the diffuser. High- and low-pressure switches, located down-stream of the diffuser, and the electrical supply are interlocked with the oxygen on-off switch operating the primary pneumatic ball valve. The system thus fails to safety in the event of an electrical failure, blocked tuyères giving rise to pressure increase, or the turning of the converter into the skimming position.

Additionally, the converter is equipped with the following instrumentation and equipment:

Flux and cold dope storage bins

Flux and cold dope addition timers, tonnage indicator, and recorder

Blower air-pressure indicator and recorder

Tuyère pressure indicator and recorder

Temperature indicator and recorder.

Initial testwork covered a period of three months and proved sufficiently encouraging to have the installation extended to equip all the converters for oxygen enrichment (Fig. 4). The extended facility has been available to us for five months.

Starting tentatively with an air blast enrichment of 3 per cent by volume of additional oxygen while we were feeling our way, this was soon increased to a 6 per cent additional oxygen level. This was found sufficient to give all the effect we were looking for, principally that of successfully blowing cold dope and molten furnace

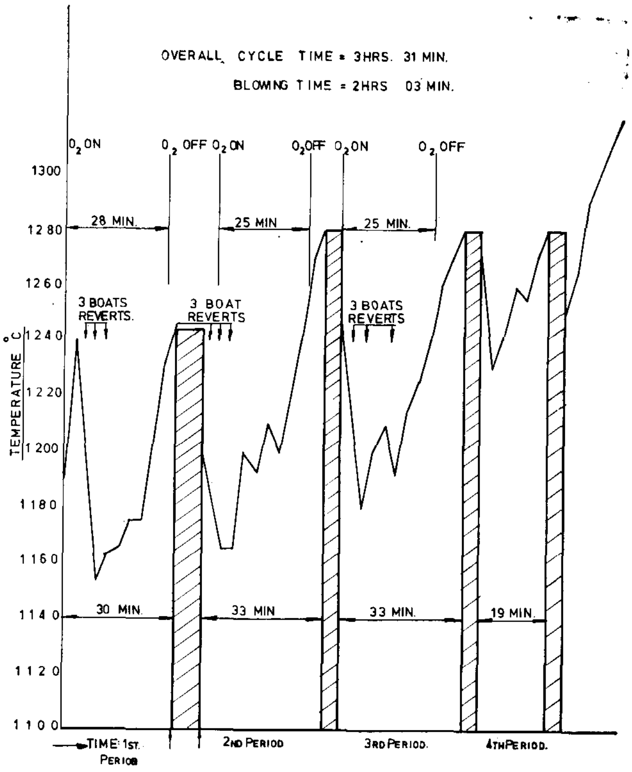

Fig. 4—The effect of oxygen blowing

matte in the ratio of 1 to 1, and all subsequent work has been carried out at this level of enrichment. This work has consisted both in the use of oxygen throughout the complete blowing cycle and in the intermittent use of oxygen at the beginning of the blow and after additions of cold dope to the converter. The effects recorded for both methods of oxygen usage are as follows.

When enriched air was used throughout the blow, it was found possible to treat all the Union furnace matte and cold dope material available directly in the converters, and additionally to increase the converter capacity by some 15 per cent, blowing times being reduced from a normal 13 minutes per ton of converter matte to an average 11,1 minutes. In these tests, an average ratio of 4 tons of cold dope to 1 ton of oxygen was recorded.

Intermittent use of oxygen for short periods during the blow is sufficient to permit treatment in the converters of all the cold dope materials available, provided normal converter capacities are acceptable. In these circumstances, average consumption ratios are of the order of 9 tons of cold dope to 1 ton of oxygen.

Comment on some of the subsidiary information gathered during the testwork may be of interest.

(1) The use of air enriched by 6 per cent oxygen results in an increase in the concentration of sulphur dioxide in the converter off-gas. This increase is about 10 to 12 per cent and could be of importance to us in the near future when we commission the sulphuric acid plant.

(2) Though our records concerning the effects of oxygen usage on converter refractories are necessarily rather meagre owing to the limited time that testwork has been in progress, we are thoroughly convinced that no adverse effects are evident. In fact, results to date show a small positive trend. Although this is possibly a little illogical, we consider it derives from the situation that converter operators are unable to judge temperatures from the converter flame and are forced to rely on the instrumentation provided.

(3) In general, an examination of the slags produced when oxygen is used shows no significant difference between their composition and that of normal slags. Some attempt was made to use pelletized concentrate instead of cold dope for temperature control, but the tests were unsuccessful, resulting in very mushy slag conditions. This work has not been pursued because it holds no real interest for us at this time.

(4) We have found converter operation with oxygen to be completely controllable and responsive. Any indication of temperature over-shooting can immediately be corrected by switching off the oxygen supply. In support of this, operator attitudes can be used as illustration. These have changed from an unequivocal 'You're absolutely mad' attitude at the outset of the testwork to a reluctance to blow without oxygen. In no small measure this has been due to the effective wet-nursing carried out by the personnel of Air Products during the early experimental programme.

In conclusion, I would like to touch on the economics of oxygen usage. Though I am not permitted to quote actual cost figures, we estimate that the use of oxygen throughout the converting operations would increase converter costs by 15 to 20 per cent. Partial utilization of oxygen will obviously have considerably less effect. However, in our case, economics still favour the use of the electric furnaces for the remelting of matte, provided the capacity is available. Thus, oxygen enrichment offers convenient advantages to short-term limitations of capacity. Long-term constraints on capacity would have to be examined more critically.

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