

The effect of the reactivity of lime on desulphurization efficiency in the basic oxygen furnace

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SYNOPSIS

The iron charged to the basic oxygen furnace at the steel plant of Highveld Steel and Vanadium Corporation has a relatively high sulphur content. Considerable emphasis is therefore placed on the reactivity of the lime. An investigation of the lime used at the steel plant showed that its reactivity had deteriorated considerably both during transport from the supplier (Northern Lime Company) and during storage and handling at the steel plant. The deterioration on the steel plant is the more severe, and is due to hydration and carbonation. Rapid deterioration is a characteristic of highly reactive lime when exposed to the atmosphere.

Plant tests showed that the desulphurization efficiency decreases with a decrease in the reactivity of the lime. The addition of slag rich in manganous oxide to the furnace considerably improved the efficiency of desulphurization that can be achieved with limes of lower reactivity and with lime that has deteriorated. A decrease in particle size of lime of lower reactivity greatly increased the desulphurization efficiency.

Less lime of higher reactivity is required for the same degree of desulphurization to be achieved. Lime of higher reactivity gives rise to slags with lower ferrous oxide contents and hence the steel yield is increased.

SINOPSIS

Die yster wat gebruik word in die basiese suurstofhoogoond by die staalinstallasie van „Highveld Steel & Vanadium Corporation” het ’n relatiewe hoë swawel-inhoud. Gevolglik word daar baie klem gelê op die reaktiwiteit van die kalk. ’n Ondersoek het getoon dat die kalk wat gebruik word, se reaktiwiteit aansienlik verswak met die vervoer vanaf die verskaffer (Northern Lime Company) en ook as gevolg van die opberging en hanteering by die staalinstallasie. Die verswakking by die staalinstallasie was egter die meeste en dit was as gevolg van hidratering en karbonering. Een van die eienskappe van hoë reaktiewe kalk is dat dit vinnig verswak as dit aan die atmosfeer blootgestel word.

Toetse by die installasie het getoon dat die ontswaelingsvermoë verminder as daar ’n afname in die reaktiwiteit van die kalk is. Die byvoeging van slak wat ryk is aan mangaanhoudendeoksied in die hoogoond het ’n verbetering getoon in die ontswaelingsvermoë wanneer kalk met ’n laer reaktiwiteit en kalk wat reeds verswak het, gebruik word. Met die verkleining in korrelgrootte van die kalk wat ’n laer reaktiwiteit het, het die ontswaelingsvermoë grootliks verbeter.

Minder kalk met ’n hoër reaktiwiteit is nodig om dieselfde graad van ontswaeling te bewerkstellig. As kalk met ’n hoër reaktiwiteit gebruik word word slak met ’n laer ysteroksiedinhoud verkry en sodoende word die opbrengs verhoog.

INTRODUCTION

In the production of vanadium-rich pig iron and titaniferous slag from the titaniferous magnetites of the Bushveld Igneous Complex, the ore is pre-reduced in rotary kilns before being charged to electric smelting furnaces. The hot metal is then transferred to a shaking ladle in which, by suitable additions, top oxygen blowing concentrates the vanadium in the slag. This partially blown hot metal is converted to steel in a basic oxygen furnace (B.O.F.) and is subsequently transferred to a continuous casting plant.

Because of its high titanium dioxide content (about 30 per cent), the slag

produced in the electric smelting furnaces is of low basicity and hence the sulphur capacity is also low, and rather high sulphur levels can therefore be expected in the hot metal.

The silicon and manganese contents of the partially blown metal charged to the B.O.F. are very low. In addition, considerable fluctuations occur in its carbon content, which is generally lower than that of typical iron produced in a blast furnace. Ferrosilicon has therefore to be added to the B.O.F. so that the desired quantity of scrap can be charged to the furnace.

The production of steel of low sulphur content (less than 0,04 or 0,05 per cent, depending on grade) presents difficulties under these conditions. It is believed that lime, as the most important slag-forming agent, plays a very important role in steel production and that its role

depends on its reactivity. This reactivity is a function of the degree of burning, being higher for ‘soft burnt’ than for normally burnt lime. It is generally accepted that lime of high reactivity dissolves more easily and rapidly, thus promoting the formation, at the start of the blowing period, of a slag relatively high in calcium oxide, which assists in rapid desulphurization and dephosphorization. A further advantage of highly reactive lime is that its consumption is lower and the slag is decreased, resulting in smaller losses of ferrous oxide in the slag and higher yields of steel. Also, early dissolution of the lime means that refractory attack is reduced.

DETERIORATION OF REACTIVITY OF LIME

The lime that is specifically burnt for use in the B.O.F. at Highveld

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Steel and Vanadium, when dispatched from the Northern Lime Company's plant at Lime Acres, Cape Province, is generally of high reactivity. However, because of the considerable distance (some 800 km) between the lime producer and the steel plant, and the time taken for the journey, the lime can deteriorate in the railway trucks, although these are covered with tarpaulins. Also as a result of this long rail haulage, considerable bunker capacity for lime has to be provided at the steel plant to ensure a continuous supply, and lime can be stored there for several days before use. Further deterioration of reactivity can occur during this period. Before the effects of lime reactivity on desulphurization in the B.O.F. could be studied, the deterioration of reactivity during railage and storage had to be investigated.

Measurement of the reactivity

The two tests most commonly used in determinations of the reactivity of lime are the coarse-grain titration and the slaking test. In the titration test, the rate at which 50 g of lime between 10 and 1 mm (between $\frac{3}{8}$ inch and 16 mesh) in particle size dissolves in 2 litres of water at 40°C is measured by the continuous neutralization of the resultant solu-

tion with hydrochloric acid. An essential condition of the titration is that the solution should always remain alkaline (above a pH value of 8) to ensure that only dissolved calcium hydroxide is neutralized and that solid calcium oxide is unaffected.

In the DIN slaking test (similar in principle to the Beachville and American reactivity tests), 150 g of lime between 5 and 1 mm (between 4 and 16 mesh) in particle size is placed in 600 ml water at 20°C. The reactivity is obtained from a measure of the time required for the solution to reach a predetermined temperature. The reactivity values quoted in this paper were determined from slaking tests by use of the formula

$$R = \frac{240}{t} \times 10,$$

where

R = reactivity of lime, and

t = time in seconds for a temperature of 60°C to be reached.

Experiments had indicated that the slaking test was more suitable than the titration test for rapid quality control in a plant, and both the lime producer and the steel plant employ this technique.

Deterioration of reactivity during transport

During August 1970, the lime that arrived at the steel plant was sampled

in the rail trucks at 10 cm intervals from the surface, three samples being taken from each 10 cm level. The results are presented in Table I. As can be clearly seen, the reactivity of lime in the upper layers had deteriorated considerably, and this deterioration increased with time, as shown by the first three trucks, which were sampled twice, i.e., on arrival at the steel plant and after having stood on the rail siding for a week. If this deterioration of the upper layers is expressed as deterioration of the total contents of the truck, the decrease in reactivity of the lime during rail haulage varies from 4,0 to 20,0 per cent. It should be pointed out that the weather conditions were dry and windy.

Deterioration of reactivity during storage and handling in the steel plant

In a determination of the extent of the deterioration occurring on the steel plant, a programme of sampling was conducted during August and September, 1970. The results are shown in Table II, which, for comparison, also indicates the deterioration attributable to transport by rail. It can be seen that the reactivity values of the lime were drastically reduced as a result of storage in the bunkers and handling on the steel plant.

TABLE I
REACTIVITY OF LIME AT VARIOUS DEPTHS IN RAIL TRUCKS, AS SAMPLED AT WITBANK

| Date — August, 1970 | | Truck number | Reactivities at various levels from the surface of the consignment in the truck, RDIN | | | | Average reactivity of consignment RDIN | Decrease in reactivity due to deterioration of upper layers % |
|---------------------|-------------------|--------------|---|-------------|-------------|-------------|--|---|
| Arrival at Witbank | Sampling of truck | | 0 to 10 cm | 10 to 20 cm | 20 to 30 cm | 30 to 40 cm | | |
| 19th | 20th | 151146 | 39 | 91 | 107 | 120 | 100 | 8,5 |
| | 26th | 151146 | 11 | 37 | 69 | 118 | 97 | 17,9 |
| 19th | 20th | 112801 | 120 | 126 | 133 | 145 | 139 | 4,0 |
| | 26th | 112801 | 25 | 45 | 67 | 130 | 105 | 19,5 |
| 16th | 17th | 186875 | 39 | 51 | 115 | 120 | 106 | 11,6 |
| | 24th | 186875 | 13 | 63 | 83 | 120 | 102 | 15,0 |
| 16th | 17th | 163248 | 100 | 105 | 141 | 141 | 134 | 5,0 |
| 16th | 17th | 162139 | 40 | 100 | 120 | 149 | 126 | 11,6 |
| 19th | 20th | 67728 | 44 | 77 | 100 | 150 | 126 | 16,0 |
| 3rd | 7th | 115211 | 52 | 80 | 90 | 120 | 93 | 10,5 |
| 3rd | 11th | 134987 | 5 | 26 | 120 | 126 | 105 | 16,5 |
| 3rd | 14th | 113605 | 5 | 14 | 56 | 104 | 86 | 20,5 |
| | 14th | 137311 | 9 | 68 | 75 | 120 | 101 | 15,8 |
| | 14th | 122557 | 13 | 68 | 96 | 109 | 95 | 12,1 |
| 15th | 17th | 150774 | 17 | 52 | 105 | 110 | 96 | 12,5 |
| 11th | 17th | 115346 | 2,5 | 30 | 45 | 86 | 67 | 18,5 |
| 12th | 21st | 153745 | 4 | 44 | 65 | 80 | 69 | 13,6 |
| 11th | 21st | 162491 | 4 | 12 | 14 | 15 | 14 | 9,5 |
| 12th | 21st | 151782 | 7 | 63 | 70 | 127 | 106 | 16,4 |
| 11th | 21st | 163973 | 10 | 120 | 142 | 150 | 142 | 5,5 |
| 31st | 31st | 150144 | 68 | 77 | 104 | 114 | 106 | 7,3 |
| 31st | 31st | 222671 | 52 | 89 | 133 | 133 | 105 | 7,4 |
| 31st | 31st | 138933 | 31 | 63 | 83 | 100 | 89 | 11,0 |

TABLE II
DETERIORATION OF THE REACTIVITY OF LIME IN THE RAIL TRUCK AND AT THE STEEL PLANT

| Date | Reactivity of lime (DIN) | | |
|---------------|---|---|----------------------------|
| | Sample taken below upper deteriorated levels in truck | Estimated bulk reactivity of truck load | As fed to B.O.F. converter |
| 6th August | 102 to 115 | 88 to 100 | 48 |
| 7th August | 106 | 93 | 38 |
| 8th August | | | 20 |
| 10th August | | | 15 |
| 11th August | | | 27 |
| 12th August | | | 48 |
| 13th August | 36, 21 | | |
| 14th August | 122 | 108 | 15 |
| 15th August | | | 10 |
| 16th August | | | 13 |
| 17th August | | | 23 |
| 18th August | 115 | 100 | 22 |
| 19th August | | | 14 |
| 20th August | 73 | 64 | 12 |
| 21st August | | | 18 |
| 23rd August | 132 | 115 | 12, 9 |
| 24th August | | | 8 |
| 25th August | 120 | 104 | 13 |
| 26th August | | | 20 |
| 27th August | | | 33, 34, 37 |
| 28th August | | | 43, 44, 38 |
| 29th August | 128 | 111 | 31 |
| 31st August | | | 13 |
| 1st September | | | 28 |
| 2nd September | 116 | 101 | 21, 22 |
| 3rd September | | | 12 |
| 4th September | | | 11 |

sults, which are shown in Fig. 1, are similar to those obtained by Anderson and Vernon¹.

EFFECT OF REACTIVITY OF LIME ON DESULPHURIZATION

As indicated earlier, the partially blown metal fed to the B.O.F. is relatively high in sulphur but low in silicon and manganese and exhibits considerable fluctuations in carbon content. Although lime of high reactivity is dispatched from the lime producer, the lime fed to the furnace is generally of low reactivity because of deterioration during railage and storage. Because these factors made the attainment of the required sulphur levels in the steel rather difficult, the practice of adding a slag high in manganous oxide (derived from an adjoining ferroalloy producer), which would induce early and rapid slag formation, was introduced. The effect of the reactivity of lime on desulphurization and of the slag addition was evaluated in an extended test campaign.

Operating practice in the basic oxygen furnace

Of the two B.O.F. vessels, only one is in operation while the other is being reconditioned. The water-cooled lances have three 0.028 6 m

Discussion

Of the deterioration of reactivity occurring during railage and during storage and handling at the steel plant, the latter is the greater. It was shown that considerable attrition of the lime occurred during storage and handling at the steel plant, this disruption of the particles producing an increased rate of deterioration because new surfaces became exposed to the atmosphere.

The degree of deterioration was shown to be related to the increase in hydrate and carbonate content of the lime, the hydrate content being the more important factor. Hence, the deterioration can be correlated with loss on ignition values. As confirmation of this contention, samples of lime supplied by the Northern Lime Co. were exposed to atmospheric conditions as a single layer of lumps. At selected time intervals, the increase in carbon dioxide and water content and the loss on ignition were determined. The re-

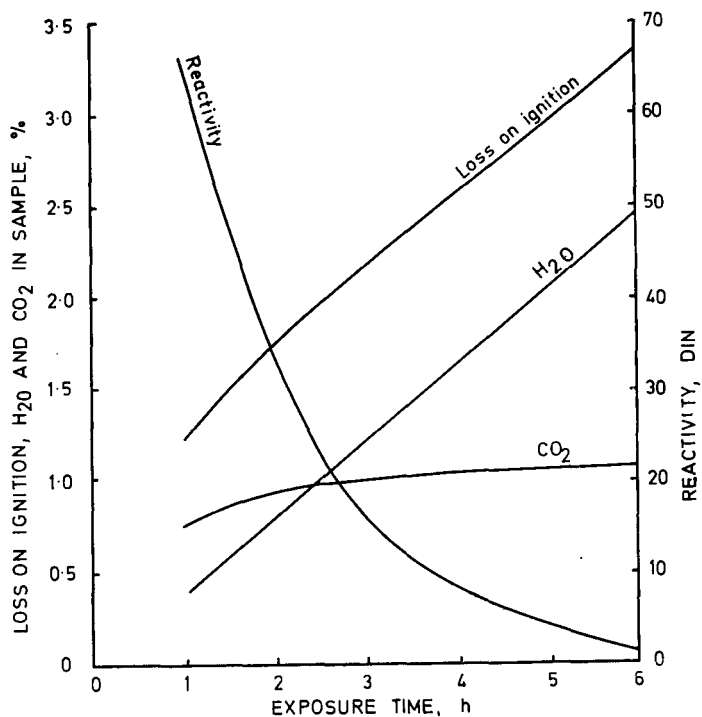


Fig. 1—Change in the composition and reactivity of lime on exposure to the atmosphere

(1½ in) de Laval type of nozzles inclined at 10° to the vertical and operate at a pressure of 1,034 to 1,172 MPa (150 to 170 lb/in²), with maximum oxygen flowrates of 2,83 m³/s (6 000 ft³/min).

The major proportion of steel produced is in the 0,15 to 0,25 per cent carbon range, and the desired production technique is the 'catch carbon' practice. To permit this practice, a thermally balanced charge is required. Early slag formation and the correct total oxygen input are essential, and lance height and flow-rate are adjusted for slag conditioning.

The B.O.F. is charged with 4,5 to 9 t (5 to 10 sh. ton) of scrap, followed by 54,5 to 59 t (60 to 65 sh. ton) of partially blown hot metal. The converter is turned into the vertical position, the lance is lowered to the required height above the metal surface, and blowing is commenced. The ferrosilicon addition and the first lime addition are then made. The lime is charged in separate batches of 454 to 794 kg (1 000 to 1 750 lb).

The amount of lime to be added is based principally on the ferrosilicon addition and a basicity ratio (calcium oxide to silica) in the slag of 3,5 to 4,0. At the first 'turn-down', the bath temperature is measured and, after a sample has been analysed, blowing conditions are adjusted for carbon elimination or sulphur removal. The required temperature and composition should be attained at the second turn-down. If the metal has had to be overblown so that sulphur contents will be sufficiently low, recarburization is achieved by the addition of anthracite to the steel ladle. A short, second reblow is often required for the adjustment of final steel composition.

Plant test

The tests were so planned that information would be obtained on the relation of desulphurization and other metallurgical factors to lime with low, intermediate, and high reactivity when a slag rich in manganese oxide had been added and when it was absent. Also, since lime that has been burnt to possess a high reactivity but that has deteriorated is generally charged to the B.O.F., this lime was treated as a

TABLE III
RELATION BETWEEN THE REACTIVITY OF LIME AND THE EFFICIENCY AND KINETICS OF DESULPHURIZATION AND DEPHOSPHORIZATION

| No. of test series | Reactivity of lime | | Addition of MnO-rich slag t | Initial S concentration % | Desulphurization efficiency | | Rate of S removal | | Phosphorus content of blown metal % | Dephosphorization efficiency | |
|--------------------|--|---------------------------------------|-----------------------------|---------------------------|-----------------------------|---------|---|---|-------------------------------------|------------------------------|---------|
| | on arrival at steel plant R _{DIN} | as charged to B.O.F. R _{DIN} | | | To first turn-down % | Total % | To first turn-down % min ⁻¹ X 10 ⁻³ | Between first turn-down and end of blow of 10 ⁻³ | | To first turn-down % | Total % |
| 1 | 97 | 22 | 1,13 | 0,099 | 26 | 52 | 1,85 | 7,50 | 0,066 | 64 | 82 |
| 2 | 90 | 75 | 1,13 | 0,095 | 26 | 43 | 1,64 | 3,12 | | | |
| 3 | 85 | 75 | 1,13 | 0,104 | 33 | 55 | 3,09 | 6,43 | 0,068 | 56 | 76 |
| 4 | 80 | 25 | 2,27 | 0,094 | 25 | 48 | 1,29 | 5,25 | | | |
| 5 | 78 | 50 | 1,13 | 0,088 | 23 | 55 | 1,35 | 6,25 | | | |
| 6 | 72 | 27 | 1,00 | 0,085 | 31 | 51 | 1,45 | 7,00 | | | |
| 7 | 33 | 22 | 1,13 | 0,093 | 18 | 42 | 1,19 | 6,89 | | | |
| 8 | 32 | 13 | 1,36 | 0,086 | 17 | 41 | 1,10 | 8,40 | | | |
| 9 | 32 | 18 | 1,13 | 0,091 | 13 | 50 | 1,07 | 8,50 | 0,072 | 42 | 85 |
| 10 | 8 | 4 | 1,13 | 0,083 | 7 | 39 | 0,45 | 7,42 | 0,056 | 32 | 75 |
| 11 | 83 | 25 | * | 0,084 | 17 | 44 | 7,67 | 3,75 | | | |
| 12 | 90 | 60 | † | 0,100 | 34 | 52 | 2,33 | 6,52 | | | |
| 13 | 72 | 27 | † | 0,090 | 13 | 46 | 0,68 | 7,15 | | | |
| 14 | 32 | 18 | † | 0,088 | 12 | 47 | 0,87 | 6,25 | 0,066 | 26 | 82 |
| 15 | 55† | 11 | 1,13 | 0,102 | 34 | 54 | 2,59 | 7,28 | | | |
| 16 | 7† | 5 | 1,13 | 0,093 | 23 | 55 | 0,92 | | | | |

†No addition of MnO-rich slag

*Instead of additions of MnO-rich slag, 0,23 to 0,46 t of iron ore and 0,11 to 0,22 t of CaF₂ were charged to B.O.F.

‡Lime of reduced particle size.

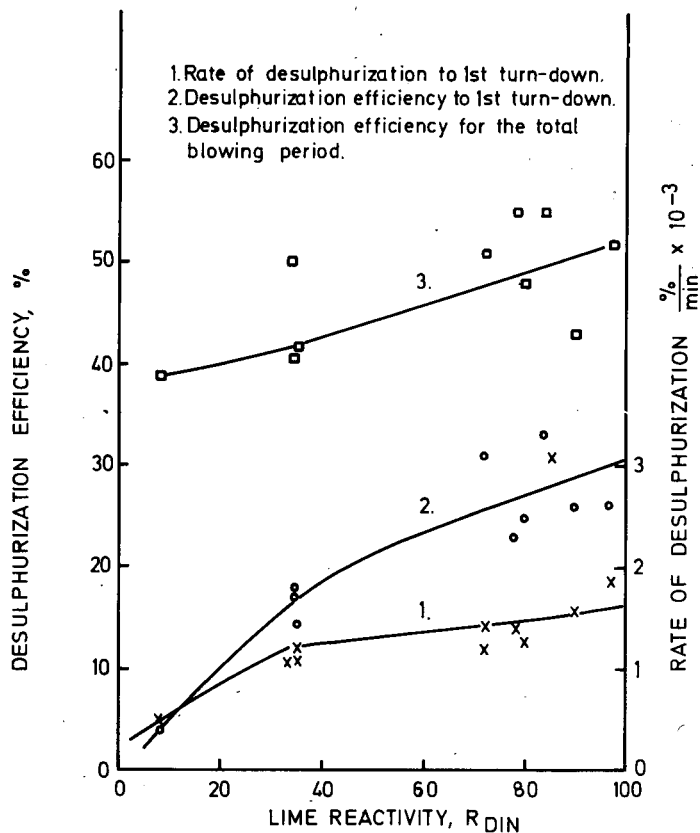


Fig. 2—Desulphurization efficiency and rate of desulphurization as functions of lime reactivity

separate type from the above three types. The results in Table III are the average results of each test series which consisted of from 25 to 300 heats. The results of these tests in which additions of slag rich in manganous oxide were made are plotted in Figs. 2 and 3.

Discussion

Fig. 2 clearly shows that, in the presence of slag rich in manganous oxide, as the reactivity of the lime is decreased, the desulphurization efficiency up to the first turn-down also decreases. The reactivity value plotted is that measured on arrival at the steel plant. The rate of desulphurization up to the first turn-down decreases similarly, although this value incorporates the effect of variation in time during the first blowing period. Very little desulphurization is obtained when 'dead-burnt' lime is used. Interestingly enough, lime of high reactivity that has deteriorated behaves effectively like lime that has not deteriorated.

The final desulphurization value obtained is far less affected by the

reactivity of the lime, but the trend is for lower reactivity values to be associated with lower final desulphurization values.

In those tests in which no additions of slag rich in manganous oxide were made, it can be seen that, provided the initial reactivity of the lime and the reactivity when charged to the B.O.F. is high, good desulphurization is obtained in the first blowing period. Lime of intermediate reactivity and lime that had deteriorated from a high reactivity did not exhibit good desulphurization capacity. When reactivity values were low, it was not practically possible to conduct a test series consisting of many blows because the first blow resulted in very poor desulphurization efficiency.

Series 15 and 16 were conducted with lime of reduced particle size — between 0,019 and 0,006 4 m (between $\frac{3}{4}$ and $\frac{1}{4}$ in) — instead of the material generally used, which was between 0,038 and 0,019 m (between $1\frac{1}{2}$ and $\frac{3}{4}$ in). Even with 'dead-burnt' lime of very low reactivity, good desulphurization was achieved

during the first blowing period.

Fig. 3 shows the effect of lime reactivity on dephosphorization. As for desulphurization, the trend is rather pronounced up to the first turn-down, whereas, for the whole blowing period, the reactivity has very little effect on the removal of phosphorus from the metal. It may be noted that because of the very low phosphorus content of the iron, dephosphorization has never been a serious problem in Highveld's B.O.F. operation.

Slag formation

Fig. 4 illustrates the fields of the Highveld B.O.F. slags in the $(CaO + MgO + MnO) - FeO - SiO_2$ pseudo-ternary diagram for two lime reactivity ranges, viz., 88 to 115 R_{DIN} , (field 2) and 30 to 35 R_{DIN} , (field 1). The slags were analysed after completion of the blowing period. As can be concluded from the graph, as lime reactivity decreases, the field of slag formation definitely moves up towards the heterogeneous phase boundary, which was drawn according to Bardenheuer et al.² for three different temperatures. As the reactivity decreases, the rate of dissolution of lime in the slag also decreases and the slag gradually becomes saturated with calcium orthosilicate. This will result, in addition to the presence of undissolved lime, in the precipitation of solid dicalcium silicate, the formation of which may be further increased by relatively low temperatures at the start of the blowing period or by local areas of low temperatures caused by charging of large amounts of cold lime.

In Fig. 5, total desulphurization efficiencies are plotted against the ferrous oxide contents of the slag for the above lime reactivities. For the lime of lower reactivity, the sulphur transfer to the slag first decreases with increase in ferrous oxide, reaches a minimum value, and then increases again with further increase in ferrous oxide content. This behaviour accords with the findings of Bardenheuer and Oberhauser³. Fig. 5 also indicates that, for the same degree of desulphurization, lime of lower reactivity is associated with higher losses of ferrous oxide in the slag.

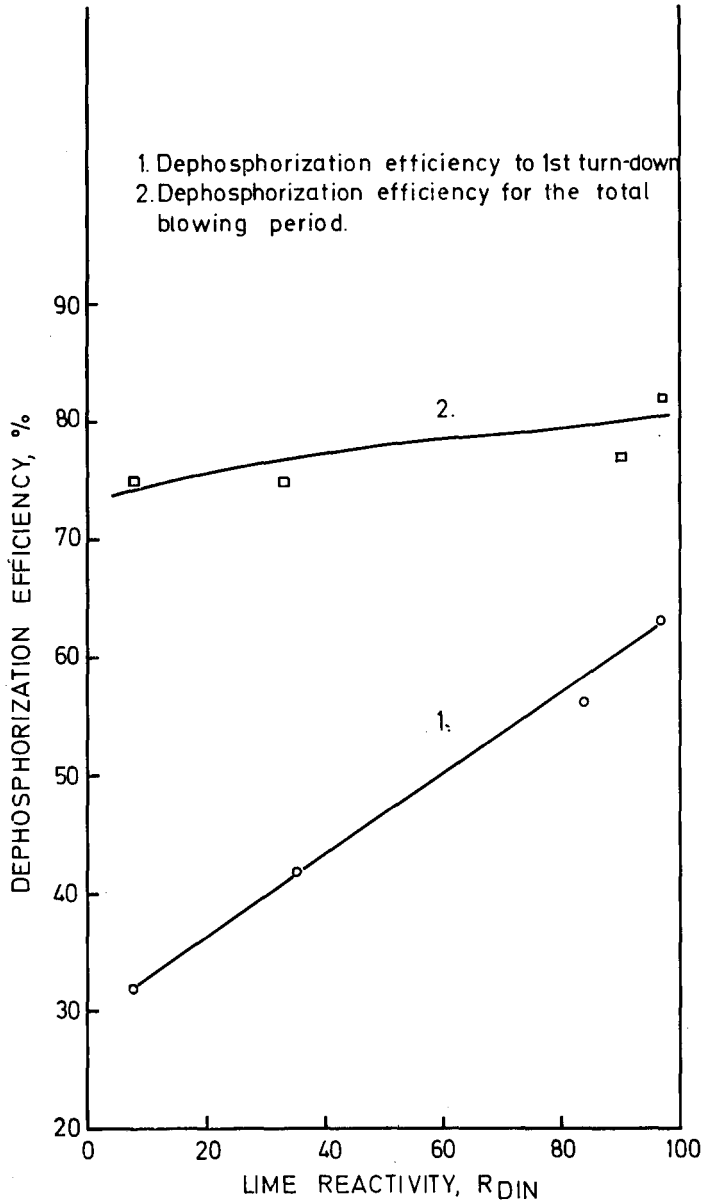


Fig. 3—Dephosphorization efficiency as a function of reactivity of lime

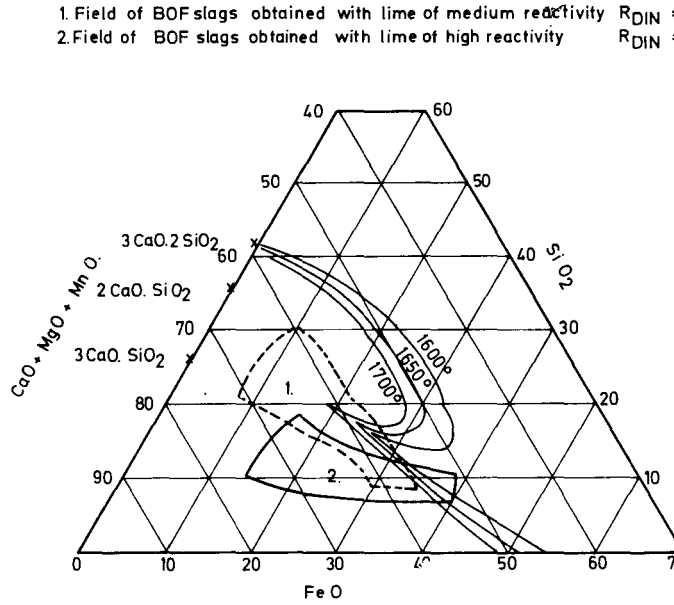


Fig. 4—Effect of reactivity of lime on the composition of the slag

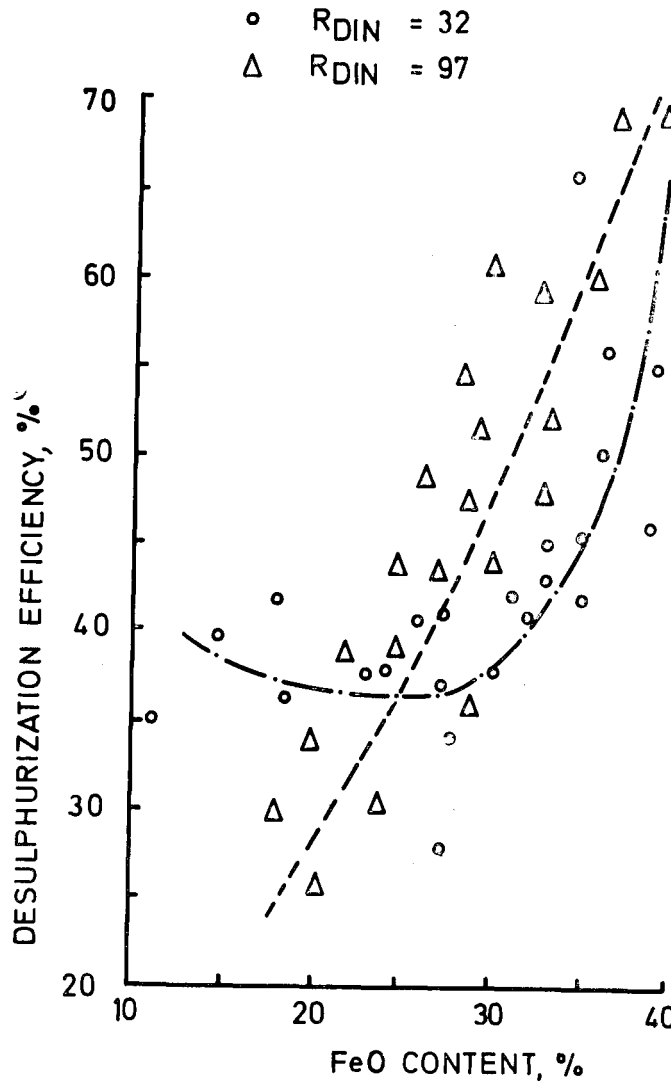


Fig. 5—Effect of ferrous oxide content of the slag on the desulphurization efficiency of lime possessing high and medium reactivity

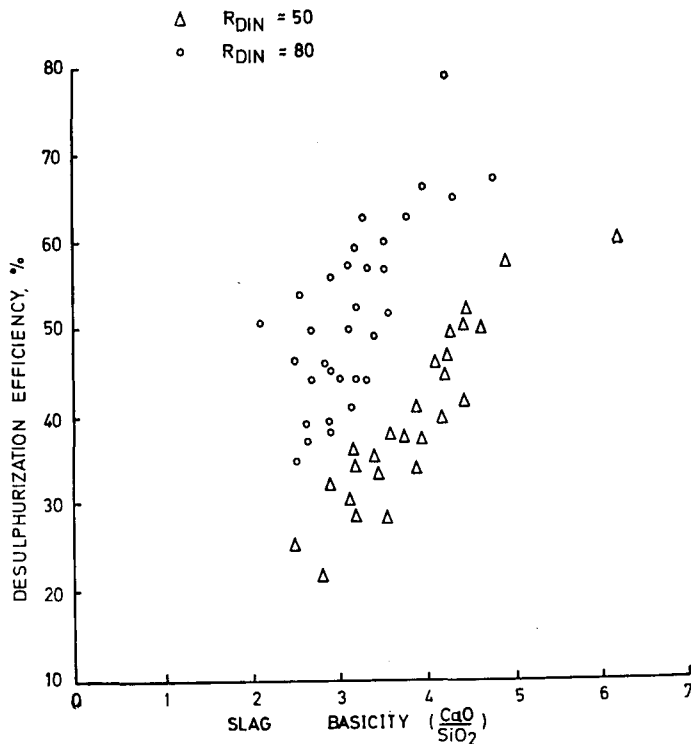


Fig. 6—Effect of slag basicity on desulphurization at various reactivities of lime

Effect of reactivity of lime and slag basicity on desulphurization efficiency

Another effect of the reactivity of lime is shown in Fig. 6, in which the desulphurization efficiency is plotted as a function of slag basicity. In the period of this test series, the average reactivity of the lime supplied was 83. However, at times the values were lower, i.e., 50 to 65. It can be concluded from Fig. 6 that lime of higher reactivity gives rise to better desulphurization efficiency at all slag basicities, an increase in slag basicity being accompanied by an increase in desulphurization efficiency. Behrens et al.⁴ obtained similar results for the relations between sulphur distribution and slag basicity, from which they concluded that, for identical slag basicities, the sulphur distribution is better in heats using soft-burnt lime than in heats using hard-burnt lime. Linear regression analysis between desulphurization efficiency and basicity of the slag for the two types of lime gave the following expressions:

$$\% \eta_s = 20,33 \left(\frac{CaO}{SiO_2} \right) - 14,5$$

for the higher-grade lime, and

$$\% \eta_s = 12,86 \left(\frac{CaO}{SiO_2} \right) - 11,0$$

for the lower-grade lime.

Gas-phase desulphurization

Based on calculations of sulphur balance, an investigation of gas-phase desulphurization was made for lime of three reactivities. The results are summarized in Fig. 7. It is apparent that the use of the two highly reactive limes results in very similar desulphurization characteristics, viz., desulphurization occurs

mainly via the slag phase. With the lime of lower reactivity, gas-phase desulphurization becomes far more significant. Irrespective of the reactivity of the lime, an increase in the initial sulphur content of the iron is associated with an increase in the proportion of sulphur removed via the gas phase.

Lining wear

The magnesium oxide content of the slag is almost totally derived from the attack on the magnesia refractory lining of the vessel, and the degree of refractory attack can therefore be assessed in terms of the magnesium oxide in the slag. From the available plant data, the magnesium oxide content could be correlated with the ferrous oxide content and the basicity ratio of the slag:

$$\% (MgO) = 2,69 - 0,179 \left(\frac{CaO}{SiO_2} \right) + 0,027 (\% FeO).$$

Therefore, to ensure a low magnesium oxide content in the slag (i.e., low refractory consumption), the ratio of calcium oxide to silica should be high and the ferrous oxide content should be low. Since higher reactivities of lime will promote quicker slag formation and thus result in higher slag basicities at the early stages of the blow, thereby restricting the level of ferrous oxide in the slag, the beneficial effect of lime of higher reactivity becomes apparent. This confirms the findings

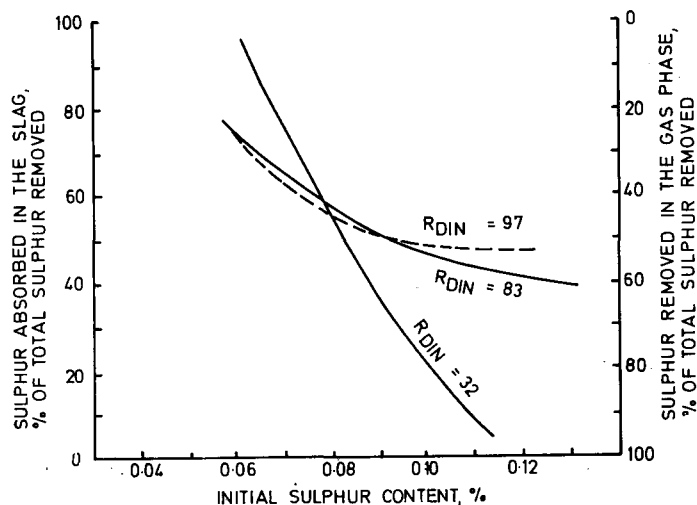


Fig. 7—Desulphurization in the slag and gas phase as a function of sulphur load at various reactivities of lime

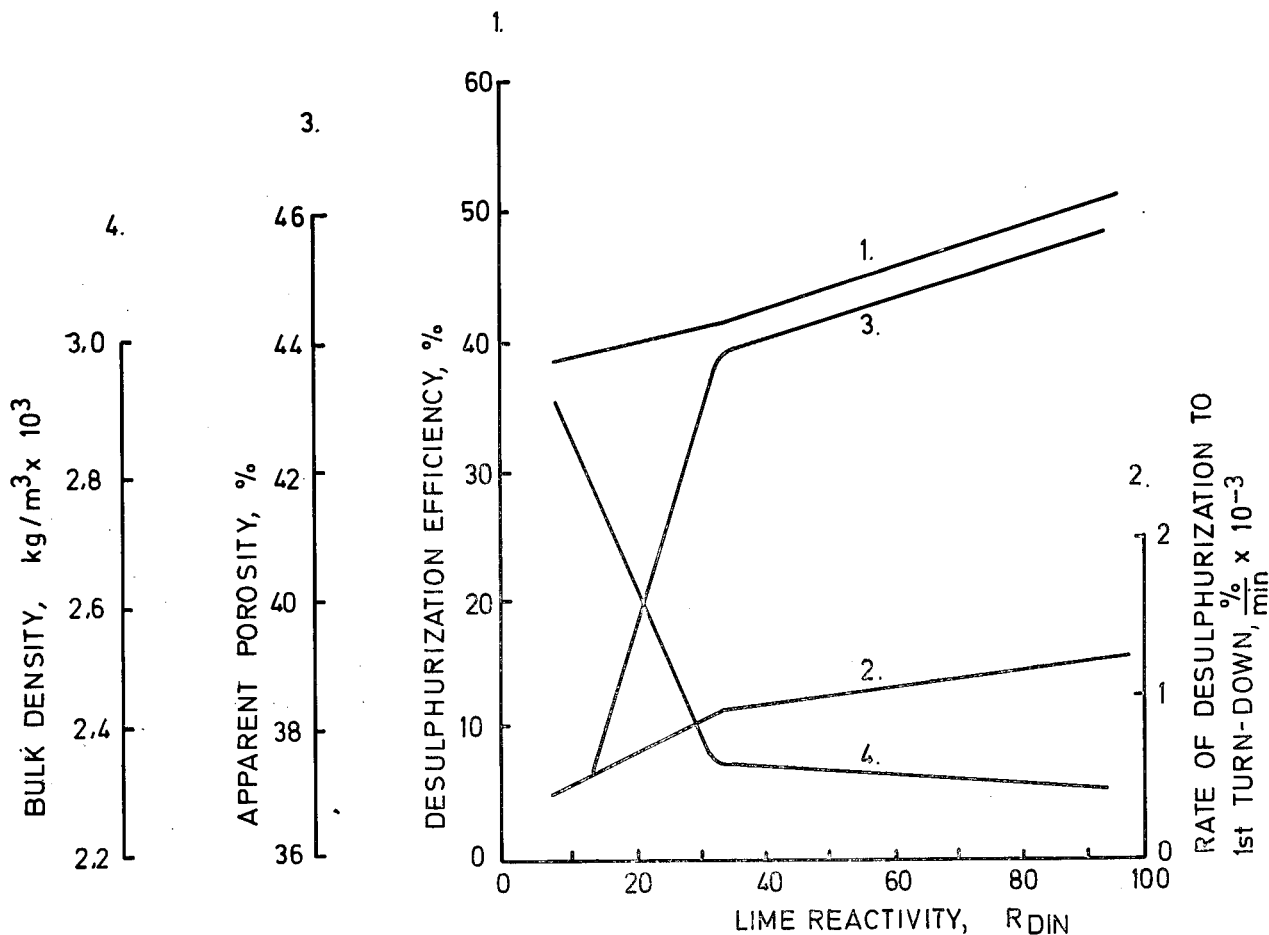


Fig. 8—Relation between desulphurization and lime characteristics at various reactivities of lime

of Kriek⁵ and Limes⁶, who emphasize the importance of the role played by ferrous oxide in lining wear.

Reactivities of lime measured in the laboratory and those evaluated in B.O.F. operations

There has been a great deal of controversy in the literature about how far the reactivity of lime, as determined in aqueous media, can be related to its behaviour in the B.O.F. Gregory et al.⁷, for example, found that the lime used in a pilot-plant converter behaved in a manner exactly opposite to that expected from laboratory reactivity tests.

This aspect was investigated in the light of the available data from Highveld's operation, and the results are summarized in Fig. 8. The graph shows the relation between reactivity as determined in the

laboratory and desulphurization efficiency in the B.O.F. The latter was regarded as the actual measure of the reactivity of lime under working conditions. Fig. 8 indicates that the DIN reactivity test appears to be a satisfactory measure of the reactivity that can be expected from B.O.F. operation. The figure also indicates that, below a reactivity of about 30 to 35 DIN, there is a noticeable decrease in the desulphurization efficiency.

CONCLUSIONS

The reactivity of lime deteriorates considerably both during rail transport and during storage and handling at the steel plant. The deterioration on the plant is the more severe and is caused by hydration and carbonation, the former being predominant.

Tests conducted on the plant with

four groups of limes when slag rich in manganous oxide was added to the B.O.F. and when it was absent indicated the following:

- (1) Good desulphurization is obtained with lime of high reactivity, even in the absence of slag rich in manganous oxide.
- (2) Lime of medium reactivity can be used, but the operation becomes more difficult and the desulphurization efficiency is reduced, especially when slag rich in manganous oxide is not added.
- (3) Lime of low reactivity in the conventional size range is not suitable for desulphurization. However, if this lime is added at smaller particle size, good desulphurization is obtained in the presence of slag rich in manganous oxide. Smaller particle size was also highly beneficial

in the lime of medium reactivity. (4) If additions of slag rich in manganese oxide are made, lime that was burnt to possess a high reactivity but that has deteriorated behaves like a lime of high reactivity with respect to its desulphurization potential in the B.O.F.

Correlation of the laboratory slaking method for the determination of the reactivity of lime with the desulphurization efficiency of the lime in the B.O.F. appears to be valid, except when lime has deteriorated from a high reactivity value.

A comparison of limes of different reactivity confirms that a lime of low reactivity does not dissolve as rapidly or as completely in the slag as a lime of high reactivity. Further, lime of low reactivity gives rise to

slags with higher ferrous oxide contents, and the steel yield is consequently decreased. For the same basicity, sulphur is removed better when lime of high reactivity is used, i.e., less lime of high reactivity is required to achieve the same degree of desulphurization. As the reactivity of the lime is decreased, the proportion of sulphur removed in the gas phase is increased. In addition, it appears that lime of higher reactivity is associated with lower rates of lining wear.

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THE SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY

COLLOQUIUM ON TRACKLESS MINING

A one-day colloquium is being arranged by the South African Institute of Mining and Metallurgy on the above subject, to be held on May 16th, 1973, in Kelvin House.

Papers dealing with their respective trackless-mining methods will be presented by the following:

Mr C. F. Hews of the International Nickel Co., Canada; Mr A. Winther, of Kiruna Mine, Sweden; Messrs M. P. Grobler and P. J. Constancon, of Prieska Copper Mine; Mr S. Watson, of Thabazimbi; Mr Maibaum, of Demag; Mr Mantell, of Oamites Mine, South West Africa; and Mr J. Hoatson, of Rokana Division, Nchanga Copper Mines Limited, Zambia,

Members of the Institute who would like to contribute to this Colloquium are invited to submit their suggestions to the Secretary, South African Institute of Mining and Metallurgy, as soon as possible.