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# Iron-ore sinter produced from a mix containing waste materials

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**SYNOPSIS**

The production of iron and steel generates various types of waste materials containing oxides, carbon, and flux material. Usually, these materials are land-filled at the plant site or are hauled away for disposal. Some of these waste materials are hazardous, and they must therefore be recycled or disposed of properly.

The influence of different waste materials in iron-ore sinter blends on the quality and operational parameters in sinter production is described. The recycling of waste materials such as dolochar, scrap fines, mill scale, electric-arc-furnace slag, basic-oxygen-furnace mud via the sintering process can achieve a saving in the cost of the raw materials (for example, fuels and flux) and a reduction in pollution.

A comparison of a typical sinter with a sinter produced through the utilization of waste materials shows a distinct correlation between certain types of waste material and some metallurgical properties and operational parameters. Dolochar (and arc-furnace slag) in a sinter blend acts as part of the fuel and flux that are normally added to a sinter mix. In general, dolochar improves the quality of the sinter and decreases the consumption of coke. Other waste materials adversely influence the quality of the sinter, but not necessarily the operational parameters such as the production rate.

At Vanderbijlpark, approximately 15 kt of various waste materials per month are successfully recycled in the sinter plant. Investigations into the handling and recycling of other waste materials may indicate that even more waste materials can be utilized.

**SAMEVATTING**

Die produksie van yster en staal genereer verskillende soorte afvalmateriaal wat oksiede, koolstof en smeltmiddelmateriaal bevat. Hierdie materiale word gewoonlik vir grondopvulling op die terrein van die aanleg gebruik, of weggery om weggedoen te word. Sommige van hierdie afvalmateriale is gevaarlik en moet dus hersikleer of behoorlik weggedoen word.

Die invloed van verskillende afvalmateriale in ystererts-sintermengelinge op die gehalte en bedryfsparameters in sinterproduksie word beskryf. Die hersiklering van afvalmateriaal soos dolomietverkoolsel (dolochar), fynafval, walsskaal, elektrieseboogoondslak, basiesesuurstofoondslik, via die sinterproses kan 'n besparing in die koste van die grondstowwe (byvoorbeeld brandstowwe en smeltmiddel) en 'n vermindering van besoedeling bewerkstellig.

'n Vergelyking van 'n tipiese sinter met 'n sinter wat met die benutting van afvalmateriaal geproduseer is, toon 'n duidelike korrelasie tussen sekere soorte afvalmateriaal en sommige metallurgiese eienskappe en bedryfsparameters. Dolomietverkoolsel (en boogoondslak) in 'n sintermengeling dien as deel van die brandstof en smeltmiddel wat gewoonlik by 'n sintermengsel gevoeg word. Oor die algemeen verbeter die dolomietverkoolsel die gehalte van die sinter en verlaag die verbruik van kooks. Ander afvalmateriaal het 'n nadelige uitwerking op die gehalte van die sinter, maar nie noodwendig op die bedryfsparameters soos die produksietempo nie.

By Vanderbijlpark word daar ongeveer 15 kt van verskillende afvalmateriale maandeliks suksesvol in die sinteraanleg hersikleer. Ondersoeke na die hantering en hersiklering van ander afvalmateriaal kan toon dat nog meer afvalmateriale benut kan word.

## INTRODUCTION

The production of iron and steel generates several types of waste materials in large quantities, such as dolochar, electric-arc-furnace slag, scrap fines, mill scale, and basic-oxygen-furnace mud. In the past, these materials were land-filled at the nearest site or dumped in neighbouring dump sites with little or no consideration of their effect on the environment. Some of the waste materials contain toxic substances that can create serious environmental problems, which become worse if the materials are leached out by contact with rain or ground water. Therefore, these types of materials must either be recycled without creating an environmental problem or disposed of properly.

However, waste materials can contain valuable components like iron, fuel, and fluxes, which can be recycled. Several dedicated processes for the disposal and utilization of waste material in special furnaces are being evaluated at present[1-5], but the use of these processes entail additional costs to the iron-and-steel producer.

The aim of the study described here was to investigate the feasibility of utilizing waste materials in a sinter mix without adversely affecting the quality of the sinter product and the operational parameters. The use of waste materials in this manner should not necessarily entail additional costs, and should reduce environmental hazards in that no stockpiling or special processing of the waste materials would be required. By determination of the metallurgical properties of the sinter product and the operational parameters, the quality of a sinter can be evaluated in relation to the addition of waste materials to sinter blends.

## BACKGROUND

A sinter is a mixture of raw materials and fuel and, in this case, also waste materials, which is ignited with a flame and sintered at approximately 1350°C to form a partly reduced product for use in blast-furnace operations. The basicity of a sinter is expressed as the ratio of CaO to $SiO_2$.

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The metallurgical and physical properties of a sinter are defined as follows:

- reducibility index (RI) — percentage loss of oxygen per minute in a reducing atmosphere at 950°C
- reduction disintegration index (RDI) — determined at 500°C in an atmosphere of $CO_2$, followed by tumbling and screening of the plus 3,15 mm fraction
- cold strength — percentage of plus 6,30 mm fraction remaining after tumbling for 8 minutes.

These indices indicate the quality of a sinter. The higher the value of the index, the better the quality of the final sinter product.

## EXPERIMENTAL PROCEDURES

The sinter-pot tests described here were conducted at Iscor's pilot plant, where a batch of up to 100 kg of a specific sinter product can be produced at a time. The sinter-pot test[6] was designed according to the requirements of real plant conditions, and a schematic diagram of the sintering apparatus is shown in Figure 1.

The typical mean particle size and chemical composition of the raw materials used in the sintering process are given in Tables I and II. The mineralogical compositions of the waste materials were also determined. The following waste materials were tested: fine (–1 mm) and coarse (+1 mm) dolochar (a byproduct from the direct-reduction kilns), electric-arc-furnace slag, scrap fines, mill scale, basic-oxygen-furnace (BOF) mud, and blast-furnace mud. An additional test featured the waste materials mentioned, together with the following waste materials: direct-reduction product dust, direct-reduction furnace dust, arc-furnace dust, and ferrous oxide pellets. In this test, the BOF dust and blast-furnace dust were added to the BOF mud and blast-furnace mud respectively. Two series of tests were conducted on each of the sinter mixes: in one series, the waste materials were used as produced; in the other, the waste materials were crushed progressively to a particle size of minus 3 mm. The purpose of this was to show the influence of particle-size distribution on the sinter quality and the operational parameters.

The total amount of waste material added to a sinter mix varied between approximately 3 and 20 per cent by weight. The compositions of the sinter mixes are shown in Table III. The basicity of the experimental sinters was approximately 1,7 in the two series of tests.

The experimental sintering process was evaluated by a simulation of actual operational conditions. The physical and metallurgical properties of the product were determined according to procedures described elsewhere[6].

## RESULTS AND DISCUSSION

Although the quality of a sinter depends on the physical and metallurgical properties of the sinter product, the operational parameters (production rate, coke consumption, etc.) are also of utmost importance. Here, the quality of the sinter is discussed and, in some cases, reference is also made to operational parameters and to the mineralogical composition of the waste materials and sinter products.

### Mineralogical Composition

The chemical and mineralogical composition of Iscor's waste materials, which varies from day to day, gives rise to difficulties in quality control. Typical mineralogical

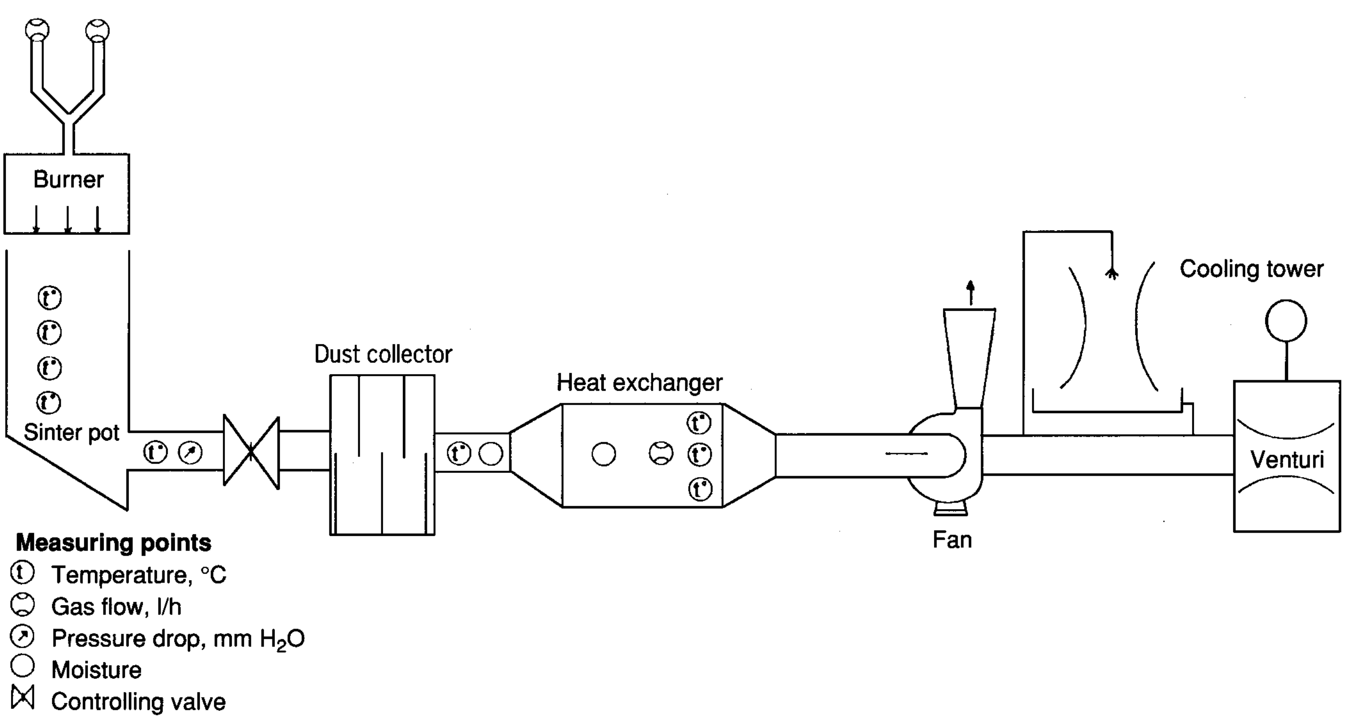


**Figure 1—The sintering apparatus**

**Table I**

**Chemical analyses of raw materials and mean particle size[7]**

| Chemical component | Iron ore | Limestone | Dolomite | Coke breeze | Silica sand |
|---|---|---|---|---|---|
| $SiO_2$ | 3,16 | 0,74 | 1,49 | 51,2 | 93,2 |
| $Al_2O_3$ | 1,72 | 0,32 | 0,35 | 27,5 | 2,15 |
| $Fe_2O3$ | – | 0,65 | 0,95 | 9,34 | – |
| Fe | 65,2 | – | – | – | 1,79 |
| $TiO_2$ | – | – | – | 1,91 | 0,05 |
| CaO | 0,10 | 52,1 | 29,5 | 4,46 | 0,11 |
| MgO | 0,26 | 2,26 | 20,1 | 1,21 | 0,07 |
| $Na_2O$ | 0,023 | 0,06 | 0,06 | 0,73 | – |
| $K_2O$ | – | 0,90 | 0,06 | 1,54 | 0,37 |
| MnO | 0,05 | – | – | – | – |
| $P_2O_5$ | 0,01 | – | – | 0,95 | – |
| S | 0,029 | – | – | 0,80 | – |
| C | – | – | – | – | – |
| Moisture | – | – | – | 4,8† | – |
| Volatile matter | – | – | – | 0,0† | – |
| Ash | – | – | – | 16,9† | – |
| Loss on ignition | 1,05 | 42,5 | 45,9 | – | 0,0 |
| Total | 71,90* | 99,53* | 98,95* | 99,64* | 97,74* |
| Mean particle size, mm | 2,83 | 1,26 | 0,92 | 0,84 | – |

* Balance is oxygen as $Fe_2O_3$

† Not part of the total

compositions of the waste materials tested are given in Table IV.

The dolochar, which also acted as part of the fuel in the sintering process, consisted of devolatilized dolomite and coal, representing the non-magnetic fraction from the direct-reduction process. This material also contained some metallic iron, known as sponge iron, with carbonaceous material (coke and char), quartz, periclase, oldhamite, and lime, as its main components. Minor components were calcite and cristobalite ($SiO_2$).

The mill scale consisted of various iron oxides, mainly wustite, minor quantities of magnetite, and traces of quartz. The BOF mud and dust contained, in addition to the latter components, metallic iron, carbonaceous material, and minor quantities of calcite, lime, sphene, and silicon (BOF mud). On the other hand, the blast-furnace mud and dust consisted mainly of hematite, magnetite, and quartz, with minor amounts of lime, calcite, and dolomite.

Of the other waste materials, the electric-arc-furnace slag was predominantly of a glassy nature and contained only minor quantities of crystalline calcium silicate and iron oxides (wustite and magnetite). The scrap fines consisted of metallic iron, iron oxides, and calcium-bearing components such as calcite and portlandite, while the ferrous oxide pellets consisted of wustite. The direct-reduction product and furnace dust contained large quantities of carbonaceous material. The crystalline material consisted mainly of magnetite, hematite, and quartz, with minor amounts of calcite, dolomite, and hercynite.

The mineralogical composition of the waste materials had a large influence on that of the sinter product produced from the waste materials in the sinter blend. There was also a relationship between the mineralogical composition of the sinter product and its metallurgical properties[6,7]. Therefore, the quantities of waste materials that can be recycled via the fine-ore blending bed are limited.

Specific types of relict particles from the waste material, such as electric-arc-furnace slag and mill scale, could still be identified in the final sinter product. In some cases, particles of mill scale that had not been completely assimilated during the sintering process had adhered to sinter particles. This shows that the mean particle size of the mill scale prevented its assimilation during the sintering process, with a direct influence on the metallurgical properties of the sinter product.

In the case of the dolochar, the inorganic portion could not be distinguished from the flux materials, e.g. dolomite and limestone, which are normally included in sinter blends. The carbonaceous material is normally burnt off, and products of the reaction of lime and magnesia with iron oxide and silica are commonly found in typical sinters.

The small particle size (on average smaller than 0,15 mm) of the muds and dusts (from the BOF and blast furnace, as well as from the direct-reduction product and furnace dust) led to complete assimilation of these materials by sinter particles.

Except for the electric-arc-furnace slag and mill scale, relict particles of other types of waste material could not be identified with certainty in the sinter product.

## Metallurgical Properties

The metallurgical and physical properties of the prepared samples are given in Table III. It was found that, except for a sinter produced from a mix containing dolochar, the addition of the waste materials to the sinter blends resulted in a decrease in RI.

## Table II

**Mean particle size and chemical composition of waste materials (in percentages by weight)**

| Material | Coarse (+1 mm) dolochar | Fine (–1 mm) dolochar | EAF slag | Scrap | Mill scale | BOF mud | BF mud | BOF dust | EAF dust | BF dust | DR product dust | DR furnace dust |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean particle size, mm | 3,063 | 0,653 | 3,204 | 2,558 | 1,009 | 0,388 | 0,027 | 0,143 | 0,050 | 0,153 | 0,250 | 0,068 |
| $SiO_2$ | 22,18 | 19,00 | 14,00 | 0,94 | 1,62 | 3,59 | 7,91 | 2,29 | 3,72 | 7,15 | 18,10 | 10,50 |
| $Al_2O_3$ | 8,91 | 9,91 | 4,34 | 0,18 | 0,82 | 0,17 | 2,44 | 0,91 | 0,43 | 3,35 | 11,00 | 6,73 |
| Fe | 8,79 | 2,19 | 19,10 | 74,00 | 73,8 | 71,10 | 24,90 | 22,40 | 37,61 | 24,56 | 10,42 | 36,68 |
| $TiO_2$ | 0,32 | 0,35 | 0,33 | 0,00 | 0,16 | 0,06 | 0,63 | 0,29 | 0,102 | 0,63 | 0,41 | 0,41 |
| P | 0,05 | 0,07 | 0,27 | <0,01 | 0,025 | 0,07 | 0,06 | 0,03 | 0,137 | 0,036 | 0,15 | 0,15 |
| CaO | 8,30 | 8,38 | 38,90 | 0,07 | 1,84 | 7,02 | 10,60 | 33,40 | 10,50 | 4,73 | 3,49 | 5,26 |
| MgO | 5,22 | 5,04 | 6,44 | 0,09 | 0,28 | 1,17 | 2,22 | 1,45 | 4,73 | 1,44 | 1,30 | 1,04 |
| $Na_2O$ | 0,08 | 0,17 | 0,29 | 0,02 | 0,19 | 0,42 | 0,65 | 8,30 | 5,83 | 0,16 | 0,25 | 0,20 |
| $K_2O$ | 0,32 | 0,44 | 0,16 | <0,10 | 0,025 | 0,21 | 0,94 | 0,20 | 4,18 | 0,72 | 0,47 | 0,32 |
| MnO | 0,25 | 0,23 | 3,32 | – | 0,72 | 9,10* | 0,67 | 0,22 | 4,11 | 0,33 | 0,06 | 0,05 |
| FeO | – | – | 6,18 | 63,00 | 41,3 | 42,00 | 2,38 | 2,83 | 1,69 | 5,21 | 3,73 | 4,19 |
| C | – | – | 1,28 | – | – | 1,30 | 24,40 | 5,16 | 0,84 | 45,20 | 43,50 | 20,30 |
| S | 1,30 | – | 0,16 | 0,03 | 0,03 | 0,06 | 0,69 | 2,98 | 1,06 | 0,58 | 0,78 | 0,36 |

*Abbreviations:*

* In metallic iron
BOF Basic oxygen furnace
BF Blast furnace
DR Direct reduction

## Table III

**Metallurgical and physical properties of the experimental sinters and constitution of the sinter mixes (in percentages by mass)**

| Sample no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Metallurgical and physical properties* | | | | | | | | | | | | | | | | | | | |
| Reducibility index* | 1,08 | 1,15 | 1,00 | 1,16 | 1,10 | 1,09 | 0,97 | 1,03 | 0,94 | 0,99 | 0,89 | 0,94 | 0,84 | 0,76 | 0,83 | 1,02 | 0,99 | 0,88 | 0,91 |
| Reduction disintegration index† | 77,4 | 81,8 | 92,3 | 77,2 | 70,1 | 69,8 | 72,5 | 77,3 | 78,0 | 76,8 | 87,4 | 89,2 | 89,3 | 91,5 | 91,1 | 75,9 | 76,9 | 86,5 | 87,0 |
| Cold strength† | 66,1 | 66,0 | 72,7 | 67,9 | 68,5 | 68,7 | 68,0 | 65,6 | 67,8 | 70,1 | 63,4 | 61,3 | 64,2 | 61,7 | 60,9 | 68,5 | 68,9 | 71,5 | 68,0 |
| *Constitution of sinter mixes* | | | | | | | | | | | | | | | | | | | |
| Ore | 54,9 | 54,1 | 57,1 | 55,1 | 55,5 | 54,5 | 53,3 | 52,5 | 50,4 | 50,0 | 52,1 | 51,3 | 47,0 | 46,6 | 46,6 | 46,7 | 46,7 | 40,4 | 28,3 |
| Return fines | 17,0 | 18,0 | 16,5 | 18,0 | 17,6 | 18,9 | 18,0 | 19,0 | 18,2 | 18,7 | 18,7 | 19,8 | 21,0 | 21,5 | 21,5 | 18,0 | 18,0 | 25,8 | 32,7 |
| Limestone | 7,6 | 7,5 | 7,7 | 7,6 | 7,6 | 7,5 | 3,1 | 3,0 | 4,1 | 4,0 | 3,0 | 2,9 | 2,8 | 2,8 | 2,8 | 3,9 | 3,9 | 4,2 | 3,6 |
| Dolomite | 8,7 | 8,5 | 7,2 | 7,2 | 7,2 | 7,1 | 6,5 | 6,3 | 7,6 | 7,6 | 5,8 | 5,7 | 5,6 | 5,5 | 5,5 | 7,6 | 7,6 | 6,6 | 5,6 |
| Coke breeze | 5,8 | 5,8 | 4,4 | 4,4 | 4,4 | 4,4 | 5,8 | 5,8 | 5,8 | 5,8 | 4,4 | 4,4 | 4,4 | 4,4 | 4,4 | 3,4 | 3,4 | 3,0 | None |
| Silica | 0,9 | 0,8 | 0,9 | 0,3 | 0,3 | 0,3 | 0,1 | 0,1 | 0,4 | 0,4 | 0,8 | 0,9 | 3,3 | 0,8 | 0,8 | 0,7 | 0,7 | None | None |
| Dolochar, coarse | None | None | 3,3 | 3,3 | 2,7 | 2,7 | None | None | None | None | 3,3 | 3,3 | 3,3 | 3,3 | 3,3 | 2,6 | 2,6 | 0,95 | None |
| Dolochar, fine | None | None | None | None | 0,7 | 0,7 | None | None | None | None | None | None | None | None | None | None | None | None | 0,41 |
| Arc-furnace slag | None | None | None | None | None | None | 8,3 | 8,3 | 8,3 | 8,3 | 8,3 | 8,3 | 8,3 | 8,3 | 8,3 | 6.4 | 6,4 | 4,5 | 3,3 |
| Scrap | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | 0,5 | 0,5 | 0,4 | 0,3 |
| Mill scale | None | None | None | None | None | None | None | None | None | None | None | None | 3,3 | 3,3 | 3,3 | 2,6 | 2,6 | 3,7 | 2,8 |
| BOF mud | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | 2,6 | 2,6 | None | 2,4 |
| BF mud | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | 4,3 | 7,5 |
| DR product and furnace dust | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | 6,0 |
| Arc-furnace dust and ferrous oxide pellets | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | None | 0,8 |

* Standard deviation = 1,5% of mean value of two replicates

† Standard deviation = 2% mean value of two replicates

**Table IV**

**Mineralogical composition according to XRD* analyses of the waste materials used, the crystalline components being listed in decreasing order of abundance**

| Material | Main component >10% | Minor component <10% | Traces <3% |
|---|---|---|---|
| BOF dust | mag, hem, quz | fe | por, Sph, lim |
| Arc-furnace dust | mag | hem | quz, fay, lim |
| Blast-furnace dust | hem, quz | mag | dol, wue |
| DR furnace dust | mag, hem | quz | cc |
| DR product dust | quz | mag | hem, dol, cc, her |
| Ferrous oxide pellets | wue | | |
| Coarse dolochar | quz | per, lim, fe | cc, old, cri, por |
| Fine dolochar | quz | per, old, lim | cc, fe, cri, por |
| EAF slag | lar | quz, bro | cc, may, mag |
| Scrap | mag, fe, hem | quz, dol | cc |
| Mill scale | wue | mag | hem, quz |
| BOF mud | fe, wue | mag | cc, hem, quz, Si |
| BF mud | hem, lim, cc | quz | mag, per |

* X-ray-diffraction

*Legend*

| | | |
|---|---|---|
| EAF | Electric-arc furnace | |
| BOF | Basic-oxygen furnace | |
| BF | Blast-furnace | |
| DR | Direct-reduction | |
| bro | Brown millerite | $Ca_4Al_2Fe_2O_{10}$ |
| cc | Calcite | $CaCO_3$ |
| cri | Cristobalite | $SiO_2$ |
| fe | Metallic iron | Fe |
| hem | Hematite | $Fe_2O_3$ |
| lar | Larnite | $Ca_2SiO_4$ |
| lim | Lime | CaO |
| mag | Magnetite | $Fe_3O_4$ |
| may | Mayenite | $Ca_{12}Al_{14}O_{33}$ |
| old | Oldhamite | CaS |
| per | Periclase | MgO |
| por | Portlandite | $Ca(OH)_2$ |
| quz | Quartz | $SiO_2$ |
| wue | Wustite | FeO |
| dol | Dolomite | $CaMg(CO_3)_2$ |
| her | Hercynite | $FeAl_2O_4$ |
| fay | Fayalite | $Fe_2SiO_4$ |
| Sph | Sphene | $CaTiSiO_2$ |
| Si | Silicon | $Si^{\circ}$ |

The RDI values of the sinters containing dolochar and/or electric-arc-furnace slag and/or mill scale and/or blast-furnace mud were high, compared with that of a normal production sinter. Additions of other waste materials (except for direct-reduction product and furnace dusts) together with the latter materials (dolochar, electric-arc-furnace slag, mill scale, and blast-furnace mud) to blends produced sinters with lower RDI values. These values were in the same range as those for normal production sinters. Upon the further addition of waste materials like direct-reduction product and furnace dust, arc-furnace dust, and ferrous oxide pellets, the RDI increased.

The cold strength of the sinters produced from mixes containing only dolochar and/or blast-furnace mud as the waste material was higher than that of a normal production sinter or a sinter with additions of some other waste materials. When all the available waste materials were mixed into the sinter blend, the cold strength increased (sample number 19, Table III) in comparison with a normal production sinter (sample number 1, Table III).

The comparison of a typical sinter with a sinter containing waste materials shows a distinct correlation between certain types of waste material and some metallurgical properties and operational parameters. This is discussed in detail below.

The values for the RDI and RI of a typical sinter are increased by the use of progressively crushed fuel (coke), which means that the metallurgical quality of the sinter improves. However, no change was found in the cold strengths. Dolochar in a sinter blend acts as part of the fuel and flux normally added to the sinter mix. The addition of coarse dolochar to the sinter blends led to an increase in the cold strength and the RDI of the sinter product. There was virtually no change in the RI as a result of the addition of coarse dolochar but, where progressively crushed dolochar was used, the RI increased. When coarse dolochar was used, the production rate decreased somewhat, but a saving of 50 per cent in the coke consumption was noted. When fine dolochar was used, the RDI and the cold strength decreased, which is in contrast to a typical sinter.

The comparison of a typical sinter with a sinter containing electric-arc-furnace slag shows that the RI and the RDI decreased. The reason for the decreasing quality is that the electric-arc-furnace slag contained calcium silicates and calcium iron oxides together with residual glass, which directly influenced the quality of the sinter product. However, the cold strength increased.

A combination of electric-arc-furnace slag and coarse dolochar resulted in a decrease in the RI, cold strength, and production rate, but the RDI was higher than that of a typical sinter. The use of dolochar in this case also led to a lower coke consumption, and therefore a saving in fuel costs. Additional mill scale in the latter sinter mix lowered the RI but raised the RDI by a few percentage points. The lower reducibility is a result of incompletely assimilated particles of mill scale in the final sinter product. The cold strength remained unchanged. The production rate was of the same order as that for a typical sinter. When coarse and fine dolochar, electric-arc-furnace slag, mill scale, scrap fines, and BOF mud were combined in a single sinter blend, the sinter produced had a slightly lower RI and RDI, and a slightly higher cold strength, than those of a typical sinter. Fine material (BOF mud) in the sinter blend increased granulation effects in the sinter mix, and the production rate increased by a substantial amount. The addition of progressively crushed dolochar and electric-arc-furnace slag to the mix resulted in virtually no change in metallurgical properties and operational parameters.

The waste materials combined in the previous sinter mix with the exception of the BOF mud, which was replaced by approximately double the amount of blast-furnace mud, produced a sinter with a higher RDI and cold strength, but a slightly lower RI, than those of a typical sinter. The larger quantity of blast-furnace mud (instead of BOF mud) resulted in a substantially higher production rate.

All the waste materials used in this study (approximately 17 per cent of the total sinter mix), with the exception of coarse dolochar, produced a good-quality sinter, although the production rate decreased slightly in comparison with that of a typical sinter. It must also be mentioned that this particular sinter mix did not include any of the fuel that is normally used (coke and coarse dolochar) in a sinter blend. This leads to a big saving in fuel costs. The only problem in the use of all the waste materials mentioned is that the chemistry of the final sinter product may not be within the required specification because of the variable chemical composition of the different waste materials. Therefore, the quantity of some waste materials utilized in the sinter blend must be limited.

The RI was lower when the sinter contained any one of the waste materials, with the exception of coarse dolochar. The RDI was higher when the sinter mix consisted of electric-arc-furnace slag, mill scale, dolochar, blast-furnace mud, direct-reduction product, and direct-reduction furnace dust. The cold strength was higher when dolochar, electric-arc-furnace slag, blast-furnace mud, direct-reduction product, and direct-reduction furnace dust were included in the sinter mix.

Some of the benefits arising from the sintering of waste materials are savings in fine iron ore, fuel (coke), and fluxes (calcite and dolomite) when these are partly replaced with waste materials containing iron and carbonaceous- and lime-bearing material. The use of fine waste materials such as BOF and blast-furnace mud increases the granulation effect of the sinter mix and, therefore, also the production rate. Another benefit is that such recycling of waste materials eliminates the need to land-fill materials at the plant or to haul them away for disposal, so reducing the risk of pollution.

A drawback in the use of waste materials via the sintering process is that the chemical composition of the waste materials varies from day to day and control of the sinter quality is therefore difficult. Because of this, the quantity of some types of waste materials to be recycled via the sintering process is limited.

At Vanderbijlpark, approximately 15 kt of varying waste materials per month are successfully recycled via the sintering process. Further investigations on a pilot scale have already indicated that the recycling of waste materials can be increased to approximately 40 kt per month.

## CONCLUSIONS

- The mineralogical composition of a sinter is determined by the type of waste material added to the sinter blend and, in turn, determines the metallurgical properties (quality) of the sinter product. Owing to the chemical and mineralogical composition of some of the waste materials, the quantities of material that can be recycled via the sintering process are limited.
- The particle-size distribution of the waste materials used in sintering are of utmost importance in assuring complete assimilation during the sintering process, and has a marked influence on the quality of the sinter product.
- The work described in this paper shows that some of the waste materials making up the sinter blend can yield a good-quality sinter at an acceptable production rate.
- The advantages arising from the utilization of waste materials in the sintering process are savings in fine iron ore, fuel, and fluxes, as well as an increase in the production rate and a reduction in pollution.
- A disadvantage is the difficulty of quality control in the process because of the varying chemical and mineralogical compositions of the waste materials used.

The work described shows that the addition of waste materials to a sinter blend can produce sinters with acceptable metallurgical properties and operational parameters. However, the composition of a sinter blend has to be controlled so that the final sinter quality can be optimized. Investigations into the handling and recycling of other waste materials may indicate that even more waste materials can be utilized.

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## INFACON BURSARY AWARD

Please note that the closing date for the Infacon Bursary Award has been extended. Applications should reach the committee before 31st March 1993. Applications should be submitted to:

INFACON Bursary Committee
The South African Institute of Mining and Metallurgy
P.O. Box 61127
Marshalltown 2107.

# Honorary Life Membership

Honorary Life Membership is the highest award the Associated Scientific and Technical Societies (AS&TS) can offer to any of its members. It has been granted to only eight people since 1920. They are Mr Percy Cazalet, Sir Lionel Phillips, Sir Evelyn Wallers, H.R.H. Prince Arthur of Connaught, Mr J.H. (Paddy) Scott, Mr L.T. Campbell, Mr S.L. Craib, and Mr E. Boden.

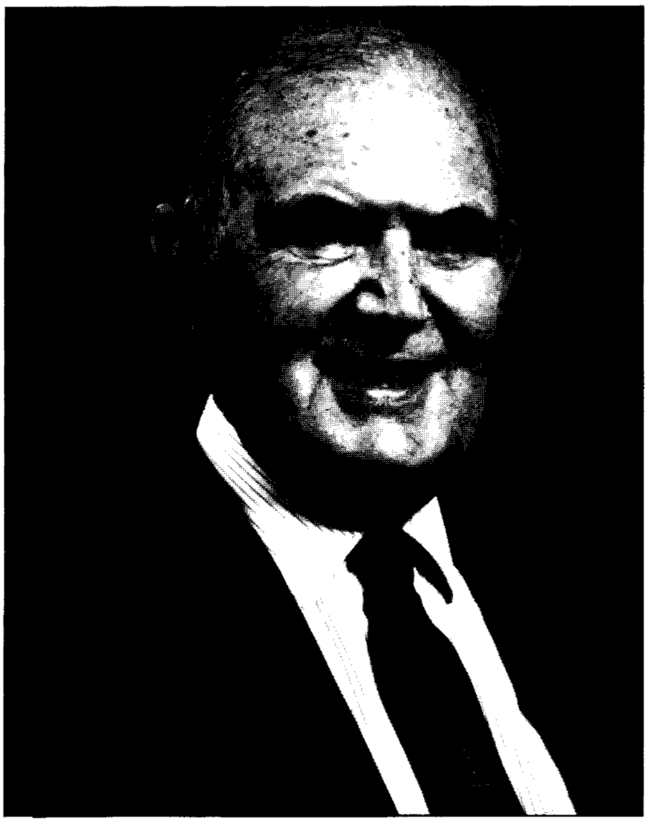
At the meeting held on 29th October 1992, the Controlling Executive elected Mr P.W.J. van Rensburg an Honorary Life Member of AS&TS in recognition of his unstinting efforts and his dedicated service to the AS&TS over many years.

Pieter van Rensburg was born 72 years ago in Cradock in the Cape, and was educated at St. Andrew's College in Grahamstown. After completing a B.Sc. (Eng.) in Mining *(cum laude)* at the University of the Witwatersrand in 1942, he served in the armed forces until the end of World War II.

On his return to South Africa, he joined the Gold Fields Group as a graduate learner. This was the start of a long and very distinguished career, culminating in senior technical and management positions, among them Deputy Chairman and Executive Director. He has also served as Director of subsidiary companies, and as Chairman of many others.

In the SAIMM he filled many management and executive positions, serving on the Council for many years. He was also the Journal Editor at one time. He is a Past President and Honorary Life Fellow, and is now a 'Senator' whose advice is invaluable. He has been consulted in the organization of a number of international conferences, and is a very astute businessman.

He first joined AS&TS in 1974, as the SAIMM representative on the Controlling Executive. He was Honorary Treasurer from November 1985 until March 1988. In June 1986 he was appointed Treasurer of the AS&TS Trust, a position he still holds today, and was also elected a member of the Trust in June 1988.



**Mr P.W.J. van Rensburg**

The interests of the AS&TS are very close to his heart. He takes a deep interest in its day-to-day activities, and is always ready to see how the Trust can help ease the tasks of the AS&TS management.

# Education, technology and South Africa's economic future

Mr Cliff McMillan, President of the Associated Scientific and Technical Societies of South Africa (AS&TS), delivered his Presidential Address on 'Education, Technology and South Africa's Economic Future' at the AGM on Thursday, 21st January. AS&TS is the voice of science, engineering and technology in South Africa; it consists of 16 member Societies representing about 30 000 individuals.

Mr McMillan referred to South Africa's economic predicament, stressing the need for outward-looking, production and manufacturing oriented economic strategy, and the strong correlation internationally between successful economic performance and a commitment to technology, particularly in the education system'.

According to Mr McMillan, South Africa compared particularly badly with other countries where production of the necessary school-leavers and graduates was concerned. 'We have inherited the worst of both worlds—the British classical approach in education policy and apartheid's deliberate denial of proper education to the majority of the population', he said.

Performance in maths and science is therefore deplorable in most schools in South Africa, and the proportion of engineering graduates has dropped from 9 to 5 per cent in 10 years.

To address these issues, AS&TS have embarked on an initiative known as the Education Policy for Technology. 'We want to be in a position to articulate positive policy proposals for inclusion in a restructured education system for South Africa', said Mr McMillan. He called for the establishment of a National Education Forum to involve all interested parties, including AS&TS, industry and trade unions, to thrash out a policy.

'We must develop the technological skills to make our industry internationally competitive, as well as to solve the immense domestic problems such as infrastructure and housing. Science, maths and language abilities form the backbone of human development in a modern society', he said.

Mr McMillan announced that the Technological Human Resources for Industry Programme, initiated last year as a joint venture between industry, government and the profession, had been allocated Government funds to focus on the more effective development of these skills. This was on the understanding that the private sector would contribute on a 2:1 basis.

He called for the establishment of a permanent high-level National Educational Council for science, engineering and technology, with appropriate broad representation, to advise on education policy in the future and to ensure that specific funds were focused on science and engineering at post-school level.