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<p>(54) Title: MINERAL PROCESSING</p>		
<p>(57) Abstract</p> <p>A process for sintering an iron ore blend of hard/dense ores, such as hematite ores, and soft/porous ores, such as Yandi ores, is disclosed. The process comprises, forming a green mix of the iron ore blend and fluxes having a coarse particle size distribution in which at least 50 % of the particles are greater than 1 mm in diameter, granulating the green mix, and sintering the granulated green mix.</p>		

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MINERAL PROCESSING

5 The present invention relates to sintering an iron ore blend, and in particular an iron ore blend containing porous reactive ores, such as pisolite ore.

10 The term "sintering" as used herein in relation to an iron ore blend describes a process whereby a green mix of iron ore particles, fluxes (e.g. limestone, dolomite, and serpentine), fuel, and plant fines (eg. mill scale, blast-furnace dust, and returned sinter fines) are converted into an agglomerate called "sinter". The process comprises the following basic steps:

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(i) granulation of the green mix with water at room temperature to form granules comprising a relatively large core or nucleus of particles coated with a layer of finer adhering material;

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(ii) charging the granules onto a strand to form a bed;

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(iii) ignition of the surface of the bed;

(iv) sequential combustion of the fuel in horizontal layers down the bed, generating heat which is sufficient to cause a liquid melt to form from the adhering fines layer of the granules;

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(v) reaction at high temperatures involving the liquid melt and the cores or nuclei of the granules resulting in partial dissolution of the solids;

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(vi) cooling and solidification of the liquid melt; and

(vii) crushing.

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The international iron ore trade has been dominated for several decades by high-grade, relatively dense predominantly hematite (Fe_2O_3) ores (hereinafter referred to as "hematite ores") from Australia, Brazil, and
10 India.

The hematite ores are formed from banded iron formations - ferruginous sedimentary rocks that consist of fine, alternating layers of magnetite and quartz - by
15 natural enrichment during geological time. The enrichment process involves the removal of silica and addition of iron to produce large hematite ore bodies, many of which have a very high iron grade.

20 The fluxes used in sintering blends of hard/dense hematite ores typically comprise limestone, dolomite and serpentine, and in accordance with the usual practice, for optimum sinter plant productivity, the particle size distribution of the fluxes is selected to be minus 3 mm
25 with a considerable proportion of the particles being minus 1 mm material.

The Pilbara region of Western Australia has considerable reserves of porous reactive iron ores, which
30 are softer and more porous than hematite ores, and increasingly the porous reactive iron ores are being included in iron ore blends with the hard/dense hematite iron ores.

35 The porous reactive ores (hereinafter referred to as "soft/porous ores") include (a) pisolite ore, such as Yandi ore, which is composed predominantly of goethite

(FeO.OH) with only minor amounts of hematite; (b) porous hematite ores, such as Carajas ore; and (c) hematite-goethite ores such as Marra Mamba ore.

5 It has been found that the soft/porous ores currently mined in significant quantities reduce sinter plant productivity. The reduction in productivity is conventionally thought to be due to the soft/porous ores reacting/assimilating readily to form large melt volumes
10 and thereby reducing the permeability of the high temperature zone of the sintering bed and increasing substantially the sintering time required to complete steps (iv) and (v) noted above.

15 However, against this disadvantage, it has been found that sinter formed from blends of soft/porous ores and hematite ores has the advantages of improved reducibility and low-temperature reduction degradation index compared with sinter formed from blends of hematite
20 ores only. The improved reducibility is thought to be due to the soft/porous ores forming an extremely open structure composed of fine hematite grains during sintering.

 There have been a number of proposals for
25 improving sinter plant productivity for blends of soft/porous ores, in particular pisolite ore, with hematite ores.

 By way of example, Japanese patent 58-55221
30 entitled "Method of Pre-processing Sinter Raw Materials" in the name of Nippon Steel Corporation and Nisshin Steel Technical Report 1988, December, No. 59, 68-75 entitled "Increase of Sinter Productivity by Pre-granulation Process" proposes coating the surface of particles of
35 pisolite ores with serpentine prior to granulation with hematite ores and other components to form a green mix. The purpose of the serpentine coating is to alter the

assimilation behaviour of the pisolite ore particles during sintering and thereby improve sinter plant productivity.

Further, Japanese patent 58-141341 entitled
5 "Preliminary Treating of Ore containing Limonite for Sintering" in the name of Nippon Steel Corp. proposes coating the surface of particles of pisolite ores with fine ores (greater than 80% of the fine ore particles less than 0.25 mm) prior to granulation with other components to form
10 a green mix. The purpose of the fine ore coating on the pisolite ore particles is to alter the assimilation behaviour of the pisolite ore particles during sintering and thereby improve sinter plant productivity.

15 An object of the present invention is to provide an alternative process of sintering iron ore blends containing soft/porous ores to achieve higher sinter plant productivity to a productivity level up to or better than that obtained using known processes of sintering iron ore
20 blends containing predominantly hematite ores.

According to the present invention there is provided a process for sintering an iron ore blend containing soft/porous ores comprising:

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- (a) forming a green mix of the iron ore blend and a flux, the flux having a coarse particle size distribution in which at least 50% of the particles are greater
30 than 1 mm in diameter;
- (b) granulating the green mix; and
- (c) sintering the granulated green mix.

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It is preferred that the flux be selected from the group comprising limestone, dolomite and serpentine.

It is preferred that at least 60% of the flux particles be greater than 1 mm in diameter.

5 It is preferred particularly that at least 70% of the flux particles be greater than 1 mm in diameter.

It is preferred more particularly that at least 80% of the flux particles be greater than 1 mm in diameter.

10 It is preferred that at least 50% of the limestone and dolomite flux particles be greater than 2 mm in diameter.

15 It is preferred particularly that at least 50% of the limestone and dolomite flux particles be greater than 3 mm in diameter.

It is preferred that the iron ore blend comprises more than 10 wt. % soft/porous ores.

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It is preferred that the soft/porous ores comprise pisolite ore.

25 The present invention is based on the realisation that the sintering behaviour of soft/porous ores such as pisolite ore can be altered advantageously to cause an improvement in sinter plant productivity by using coarser flux size distributions, compared to that currently being used for sintering hematite ores.

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In particular, on the basis of a series of sinter tests by the applicant on Yandi soft/porous ores, the applicant believes the coarser flux distributions, particularly for limestone and dolomite, improve the green bed permeability and that this parameter is a more
35 important factor to sinter plant productivity of iron ore blends containing soft/porous ores than the

melting/assimilation behaviour of the soft/porous ores.

An important advantage of the present invention over the alternative proposals for improving sinter plant productivity disclosed in Japanese patents 58-55221 and 58-141341 and Nisshin Steel Technical Report 1988, December, No. 59, 68-75 is that the present invention does not involve an additional step, such as pre-granulation, in the sintering process.

The present invention is described further hereinafter by reference to the series of sinter tests carried out by the applicant noted above.

The sinter tests were carried out using a pilot-plant sinter pot sintering facility at the Newcastle Laboratories of the applicant. The sinter pot used had an area of 0.09 m² and was operated with a material bed height of 500 mm. The total granulated mix charge weight for each sinter test was approximately 70 kgs. The sintering facility and operating parameters are described in detail in a paper entitled "Positioning coke particles in iron ore sintering" by C.S. Teo, R. Mikka and C.E. Loo published in ISIJ Int. 32, 10, 1992, 1047-1057, and the disclosure in the paper is incorporated herein.

In summary, the aim of the sinter tests was to obtain a return fines balance of between 0.95 and 1.05. In each sinter test a sinter mix of around 100 kg of iron ore and fluxes was granulated in a batch granulation drum of 1.1 m in diameter. Water was sprayed onto the sinter mix as sprays as the sinter mix cascaded in the drum. After 10 minutes of granulation, the drum was tilted and the charge emptied directly into a hopper. The standard method for loading the sinter pot involved placing the hopper directly above the sinter pot and opening the sliding valve at the bottom of the hopper to discharge its contents. A straight

edge was then used to level the bed and the permeability of the in-situ bed was determined using an anemometer, which measured gas velocities at 5 fixed locations on the top surface of the bed at 6kPa fan suction (4 around the circumference and 1 in the centre). The 4 measurements around the circumference of the pot were found to be very comparable, but the reading obtained at the centre of the pot had a slightly lower value. The conditions used for sintering are summarised in Table 1.

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Table 1 Sinter test conditions

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Ignition temperature	1200°C
Ignition suction	6kPa
Ignition time	1.5 min.
Sintering suction	16kPa
Cooling	Downdraft at 16kPa
Shatter for stabilisation	Four drops from 2 m
Sinter product	+ 6.4 mm

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The sinter tests were carried out on:

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- (a) a sinter mix of:
 - (i) a base iron ore blend, as a reference, and
 - (ii) fluxes, and;
- (b) a sinter mix of:
 - (i) the base iron ore blend of (a) above diluted with 15 wt. % and 30 wt. % soft/porous ores (Yandi ore), respectively; and
 - (ii) fluxes.

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The base iron ore blend contained ores that were selected on the basis of chemical composition and in suitable proportions to achieve a target sinter chemical composition of: 55.7% Fe; 5.29% SiO₂; 1.88% Al₂O₃; 9.53% CaO; and 1.6% MgO. The base iron ore blend was predominantly hard/dense hematite with approximately 10 wt. % soft/porous ore (Robe River ore).

The fluxes comprised limestone, dolomite and serpentine. The chemical analysis of the "as-received" fluxes is shown in Table 2 .

Table 2 Chemical composition of fluxes

	Limestone	Dolomite (Series 1)	Dolomite (Series 2 and 3)	Serpentine
SiO ₂	0.4	1.10	1.10	39.10
Fe ₂ O ₃	0.16	6.70	1.30	5.00
Al ₂ O ₃	0.20	0.20	0.32	1.00
TiO ₂	<0.02	0.02	<0.02	0.03
P ₂ O ₅	<0.02	<0.02	<0.02	<0.02
MnO	<0.02	0.24	0.18	0.11
CaO	55.1	28.0	30.0	1.7
MgO	0.34	18.6	20.6	37.1
LOI	43.3	44.3	46.1	12.4

The sinter mix was prepared by thoroughly mixing together the iron ore blend and fluxes. The addition of limestone was controlled to obtain a sinter lime-to-silica ratio of 1.8 and the addition of serpentine and dolomite, in a ratio of 3:1, was controlled to obtain the 1.6 MgO% component of the target sinter chemical composition.

The results of the sinter tests are detailed in Table 3.

Table 3 Sintering results using flux materials of different size distributions

Test	Mix moisture (%)	Return fines (% ore mix)	Sintering time (mins.)	Productivity (t/m ² .d)	Coke rate kg/t	Tumble index (% plus 6.4mm)
Base blend As-received fluxes	5.3	40	21.7	38	63	67
Plus 1 mm limestone	5.3	40	20.3	39	65	65
Plus 2 mm limestone and plus 1 mm serpentine	5.3	40	20.0	41	65	65
15% Yandi As-received Fluxes	5.4	40	24.6	32	61	68
Plus 1 mm limestone	5.2	40	20.5	38	65	67
30% Yandi As-received fluxes	5.1	40	29.0	27	66	72
As-received fluxes	5.4	40	24.4	32	61	69
Plus 1 mm limestone	5.4	40	22.0	34	66	68
Plus 2 mm limestone	5.2	40	21.9	35	66	72
Plus 1 mm serpentine	5.1	45	22.6	34	59	68
Plus 1 mm limestone and plus 1 mm serpentine	5.2	45	21.3	35	65	68

Plus 2 mm limestone and plus 1 mm serpentine	5.3	45	18.2	41	64	67
Plus 2 mm limestone and plus 1 mm serpentine	5.1	45	18.3	42	63	68

The references in the preceding discussions and the table to "as-received" fluxes refer to fluxes having the chemical analysis detailed in Table 2. Such "as-received" fluxes are typical of the fluxes used to sinter hematite ores, and therefore have only a relatively small proportion of the particles being minus 1 mm. The references in the table to "plus 1 mm limestone", "plus 2 mm limestone", "plus 1 mm serpentine", "plus 1 mm limestone and plus 1 mm serpentine", and "plus 2 mm limestone and plus 1 mm serpentine" refer to fluxes in accordance with the present invention in which a significant proportion, i.e. at least 50%, of the particles are in excess of 1 mm.

With reference to Table 3, the use of plus 1 mm limestone did not have a significant effect on sintering behaviour of the base blend. There was a decrease in sintering time because of improved bed permeability but this was off-set by a deterioration in sinter strength. The 15% Yandi level sintered with "as-received" fluxes produced an increase in sinter strength over that of the base blend but this was off-set by a decrease in productivity. However, when plus 1 mm limestone was used instead of "as-received" fluxes most of the losses in productivity were recovered. The 30% Yandi level sintered with "as-received" fluxes produced a further deterioration in productivity compared with that of the base blend. However, when plus 1 mm material was used instead of the "as-received" fluxes the

losses in productivity were recovered. By way of particular example, a very significant increase in productivity was obtained when plus 2 mm limestone and 1 mm serpentine were used. Specifically, the productivity was significantly higher than for that of the base blend while maintaining comparable sinter strength and coke rates.

In summary, the results shown in Table 3 indicate that the use of a coarser particle size distribution for fluxes in accordance with the present invention produced higher sinter plant productivity than that obtained with the conventional finer particle size distribution.

Many modifications may be made to the present invention as described above without departing from the spirit and scope of the present invention.

CLAIMS:

1. A process for sintering an iron ore blend containing soft/porous ores comprising:
 - (a) forming a green mix of the iron ore blend and a flux, the flux having a coarse particle size distribution in which at least 50% of the particles are greater than 1 mm in diameter;
 - (b) granulating the green mix; and
 - (c) sintering the granulated green mix.
2. The process defined in claim 1, wherein at least 60% of the flux particles are greater than 1 mm in diameter.
3. The process defined in claim 2, wherein at least 70% of the flux particles are greater than 1 mm in diameter.
4. The process defined in claim 3, wherein at least 80% of the flux particles are greater than 1 mm in diameter.
5. The process defined in any one of claims 1 to 4, wherein the flux is selected from the group comprising limestone, dolomite and serpentine.
6. The process defined in claim 5, wherein at least 50% of the limestone and dolomite flux particles are greater than 2 mm in diameter.
7. The process defined in claim 6, wherein at least 50% of the limestone and dolomite flux particles are greater than 3 mm in diameter.
8. The process defined in any one of the preceding claims, wherein the iron ore blend comprises more than 10 wt.

% soft/porous ores.

9. The process defined in claim 8, wherein the soft/porous ores comprise pisolite ore.

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. ⁵ C22B 1/16, 1/14 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC : C22B 1/16, 1/14, 1/18 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU : IPC as above Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT : IPC as above and (iron: or ferr: or flux:)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	Patent Abstracts of Japan, C-151, page 104, JP,A, 57-192228 (SHIN NIPPON SEITETSU KK) 26 November 1982 (26.11.82) Abstract	1-6
X	Patent Abstracts of Japan, C-240, page 137, JP,A, 59-83727 (SHIN NIPPON SEITETSU KK) 15 May 1984 (15.05.84) Abstract	1-6
X	Derwent Abstract Accession No. 89-003931/01, Class M24, JP,A, 63-282216 (NIPPON KOKAN KK) 18 November 1988 (18.11.88) Abstract	1-7
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	Patent Abstracts of Japan, C-635, page 121, JP,A, 01-152223 (NKK CORP) 14 June 1989 (14.06.89) Abstract	1-7
X	Patent Abstracts of Japan, C-653, page 40, JP,A, 01-201427 (NIPPON STEEL CORP) 14 August 1989 (14.08.89) Abstract	1-7
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A	Derwent Abstract Accession No. 54232C/31, Class M24, JP,A, 55-79837 (KAWASAKI STEEL KK) 16 June 1980 (16.06.80) Abstract	1-7