IRON ORES OF MADHYA PRADESH

Large deposits of iron ore are located at Bailadila and Dali-Rajhara, which are being worked at present for export and to meet the requirement of Bhilai Steel Plant respectively. Bailadila ore being quite rich only a few samples were tested, particularly for the utilization of the —9 mm fines. A large number of samples representing different parts of the deposit from Rajhara mines were also tested.

Bailadila Iron Ores

1. Sample No. 1

The sample was drawn from Deposit No. 14 and consisted lumps upto 200 mm and fines. Complete chemical analysis of the sample was as follows :

Constituent	Assay %	Constituent	Assay %
Fe	66.9	CaO	Trace
FeO	Trace	P	0.049
SiO_2	1.5	S	Trace
Al_2O_3	1.8	TiO_2	0.04
MgO	Trace	LOI	1.70

Microscopic examination of the sample indicated the presence of Hematite followed by minor amounts of goethite, lateritic material and ocher ; well developed crystals of quartz were also noticed occasionally in the cavities of the ore.

The sample was crushed to 152 mm size and washed in a log washer and then sized on 9.5 mm screen. The —152 mm +9.5 mm portion analysed 68.47% Fe, 0.53% SiO_2 and 1.32% Al_2O_3 with 91.8% Fe distribution in it.

The —9.5 mm sand analysed 55.7% Fe, 7.0% SiO_2 and 6.0% Al_2O_3 with 7.4% Fe distribution in it. This product when treated in jig after sizing, produced a combined concentrate assaying 66.0% Fe, 2.8% SiO_2 and 1.9% Al_2O_3 with 6.4% Fe distribution in it. This concentrate was taken for Agglomeration by sintering.

The slimes analysed 29.1% Fe, 28.0% SiO_2 and and 10.5% Al_2O_3 with 0.8% Fe distribution in it.

Sintering tests were conducted with the —9.5 mm jig concentrate employing flue dust (Rourkela) assaying 24.8% Fe, 11.5% SiO_2 and 7.2% Al_2O_3 coke from Durgapur assaying 70.4% F.C. and 26.6% Ash, limestone from Durgapur assaying 46.96% CaO and 2.68% MgO ; and Dolomite from TISCO assaying 28.56% CaO and 20.56% MgO.

Tests indicated that 7.0% water, 4.5% coke 25% return sinter fines and 5.7% flue dust were optimum for the production of good quality of sinters. Self fluxing sinters having a basicity of 2.0 were also produced using requisite amount of lime to the sinter mix. Addition of freshly prepared burnt lime upto 3% increased the rate of sintering considerably. It was also found out that the coke consumption may be reduced upto 40% by substituting gaseous fuel.

2. Sample No. 2

The sample was drawn from Deposit No. 5 and consisted of 200 mm lumps to fines. Complete chemical analysis of the sample is as follows :

Constituent	Assay %	Constituent	Assay %
Fe	68.38	P	Trace
FeO	0.94	S	Trace
SiO_2	0.94	CaO	0.18
Al_2O_3	1.00	LOI	0.88

Minerological examination revealed the presence of hematite (Massive and blue dust type)

and minor amounts of goethite. Lateritic material was found as thin encrustation on the ore lumps.

Wet screening tests were conducted after crushing the sample to 150 mm and 100 mm size. The ROM sample containing 2.0% of —12.7 mm fines increased to 5.9% when crushed to 150 mm size and 6.7% when crushed to 100 mm size.

After wet screening at 9.7 mm size the —150+9.7 mm lumps analysed 68.35% Fe, 0.92% SiO_2, and 2.08% Al_2O_3 with 97.2% Fe distribution in it. The —9.7 mm sand analysed 64.4% Fe, 2.8% SiO_2, and 2.08% Al_2O_3 with 2.6% Fe distribution. The slimes analysed 49.9% Fe with 0.2% Fe distribution in it.

Wet screening tests conducted at 100 mm size produced —100+6 mm lumps assaying 68.37% Fe, 0.88% SiO_2, and 0.97% Al_2O_3 with 96.2% Fe distribution in it. The —6 mm sand analysed 65.8% Fe 2.72% SiO_2 and 1.04% Al_2O_3 with 3.5% Fe distribution. The slimes analysed 50.96% Fe with 0.3% Fe distribution in it.

Drop shatter tests conducted with wet screened —150+9.7 mm lumps from 2 m, 6 m, and 10 m heights for three times on a steel plate produced respectively 1.8%, 3.1% and 6.5% of —9.7 mm fines. Similar tests conducted with —100+6 mm material produced similar results.

Rajhara Iron Ores

Rajhara iron ore is being used by the Bhilai Steel Plant and a large number of samples from different zones of the deposit were tested in N.M.L.

1. Sample No. 1

The sample was received from the Indian Bureau of Mines, Nagpur, at the instance of the Russian experts and consisted of 62 mm lumps to fines. Complete analysis of the sample was as follows :

Constituent	Assay %	Constituent	Assay %
Fe	54.80	TiO_2	0.28
FeO	0.86	CaO	0.15
Fe_2O_3	77.36	P	0.073
SiO_2	11.16	LOI	0.96
Al_2O_3	4.46	MgO	Trace
Mn	0.03		

Mineralogical examination of the sample indicated the presence of the fine grained porous type hematite with appreciable amounts of hydroxides of iron. Small amounts of magnetite and quartz were also observed. Clayey matter and mica flakes were also observed in the sample.

The sample was screened on 12.5 mm screen for the separation of the coarse and fine portions. The +12.5 mm portion analysing 59.4% Fe was washed in a log washer and then sized on 30 mm screen. The +30 mm lumps analysed 61.25% Fe with 10.8% Fe distribution. The —30 mm lumps analysing 60.8% Fe were subjected to H.M.S. tests at medium sp. gr. 2.8 when the sink product analysed 61.1% Fe having 26.6% Fe distribution. The washed slimes analysing 38.4% Fe were treated on a table which yielded a concentrate assaying 61.3% Fe with 1.1% Fe distribution in it. The combined concentrate from the +12.5 mm portion analysed 61.15% Fe with 38.5% overall Fe distribution in it.

The —12.5 mm fines which analysed 52.74% Fe were scrubbed in a ball mill without balls and were separated into sand and slime portions. The slimes assaying 37.5% Fe were screened and were treated by two methods. When the thickened slimes were treated on table, the concentrate analysed 64.7% Fe with 4.7% Fe distribution in it. Alternatively when subjected to flotation followed by one cleaning, the concentrate analysed 64.4% Fe with 5.9% Fe distribution in it. The tabling and flotation tails respectively analysed 22.06% Fe and 11.1% Fe.

The sand portion obtained after scrubbing analysed 59.8% Fe. This product when screened on 6 mesh screen, the +6 mesh portion analysed 60.05% Fe with 25.9% Fe distribution and was taken as acceptable grade. The —6 mesh fines were beneficiated by 3 different methods. Jigging of the —6 mesh fines produced a concentrate assaying 62.5% Fe with 16% Fe distribution in it. High intensity magnetic separation tests yielded a magnetic concentrate assaying 63.1% Fe with 17.9% Fe distribution in it. Tabling tests yielded a concentrate of 61.3% Fe with 19.3% Fe distributions. The rejects of jigging, magnetic separation and tabling tests respectively analysed 51.1% Fe, 42.31% Fe and 34.14% Fe. The combined concentrate obtained from the —12.5 mm portion analysed 61.3% Fe with 50% Fe distribution in it. The overall grade of the

combined concentrate was 60.73% Fe with 91.0% Fe distribution in it.

2. Sample No. 2

The 60 tonne representative sample received at NML consisted of 200 mm lumps down to fines and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	56.25	MgO	0.75
SiO_2	7.17	P	0.076
Al_2O_3	6.39	Mn	0.10
CaO	0.68	LOI	5.30

Mineralogical examination of the sample indicated the presence of hematite, goethite, lepidocrocite, and magnetite in their order of abundance. Quartz, clay, red and yellow ochers and lateritic matter formed the gangue.

The ore was initiably crushed to 50 mm and screened on 12.5 and 9.7 mm screens. The +12.5 mm lumps analysed 62.05% Fe, 3.96% SiO_2 and 5.56% Al_2O_3 with 67.1% Fe distribution in it. The +9.7 mm and —9.7 mm portions respectively analysed 58.7% Fe and 49.5% with 7.9% Fe and 25.0% Fe distribution in it.

Washing tests were conducted at 75 mm, 50 mm, and 25 mm size in a blade washer and wet screened on 9.7 mm screen. The fines and the wash slimes were separated in a spiral classifier. The washed —75 mm +9.7 mm lumps analysed 60.75% Fe, 3.35% SiO_2 and 5.53% Al_2O_3 with 78.2% Fe distribution. —25 mm +9.7 mm washed lumps analysed 61.56% Fe, 3.05% SiO_2 and 4.81% Al_2O_3 with 59.2% Fe distribution. The sand portions obtained respectively analysed 50.77% Fe, 52.31% Fe and 54.94% Fe.

Heavy Media Separation tests conducted with the washed lumps at sp.gr. 2.9 produced a grade of 63.72% Fe, 64.03% Fe and 64.37% Fe with 65%, 63.9% and 51.7% Fe distribution respectively for 75 mm, 50 mm and 25 mm sizes.

The sand portions obtained from washing test screened on 6 mesh screen and the coarser portions were treated by H.M.S. The sink obtained at sp.gr. 2.9 feed from the sands of 75 mm, 50 mm and 25 mm size tests respectively analysed 60.43% Fe with 5.21% Fe distribution, 59.44% Fe with 6.52% Fe distribution and 62.18% Fe with 4.29% Fe distribution in them.

Treatment of the —6 mesh fines in jig produced a grade of 61.52% Fe with 6.7% Fe distribution in it. The combined —9.7 +6 mm HMS concentrate and the —6 mesh jig concentrate formed feed for the sinter plant.

Sintering tests were conducted to find out the optimum sinter mix for both fluxing and non-fluxing sinters. Fluedust from Rourkela assaying 18.7% Fe, 28.37% F.C. and 5.6% MgO, Coke from Durgapur Steel Plant assaying 70.4% F.C. and 26.4% ash, limestone from HSL assaying 45.9% CaO were used for sintering tests. 7% water and 4.0% of coke were found optimum for the sinters.

However the coke consumption varied from 3.5% to 6.0% as the basicity of the self-fluxing sinter varied from 1.0 to 2.5.

3. Sample No. 3

This was mixed sample prepared by mixing 20% of massive type ore assaying 66.0% Fe, 34% of compact laminated type ore assaying 66.45% Fe, 43% of laminated type assaying 58.3% Fe and 3% hydroxide type ore assaying 49.6% Fe. The composite sample analysed as follows :

Constituent	Assay %	Constituent	Assay %
Fe	62.54	MgO	0.20
FeO	Nil	P	0.027
SiO_2	2.59	S	0.06
Al_2O_3	4.30	TiO_2	0.26
CaO	0.06	LOI	3.90

Microscopic examination of the four different types of ore samples indicated the presence of hematite followed by goethite which was maximum in case of hydroxide type ore. Ochers and laterite material were present in the sample.

The sample was crushed to 50 mm size and washed in a blade washer provided with water sprays. The washed ore was wet-screened on vibrating screen fitted with 12.5 mm screen.

The unwashed —50+12.5 mm lumps analysing 64.21% Fe with 75.5% Fe distribution when wet screened, improved the grade to 64.68% Fe with 71.9% Fe distribution in it. After scrubbing and wet screening, the product analysed 65.15% Fe, 1.97% SiO_2 and 3.14% Al_2O_3 with 70.6% Fe dis-

tribution in it. The —12.5 mm sand analysed 60.90% Fe with 25.7% Fe distribution in it.

Treatment of —12.5 mm sand in jig after sizing produced combined concentrate assaying 64.6% Fe, 1.98% SiO_2 and 3.27% Al_2O_3 with 20.9% Fe distribution in it. Further attempts to recover some more from the washing slimes were not successful.

Self fluxing and non fluxing sinters were prepared from the —12.5 mm sand concentrate employing flue dust from Rourkela assaying 28.37 F.C. and 24.8% Fe, coke from TISCO assaying 68.9% F.C. and 25.7% Ash and limestone from Nandini Quarries of HSL assaying 41.6% CaO and 8.5% MgO 7.0% water and 4.5% coke were found to be optimum for making unfluxed sinters. For the self fluxing sinters for the basicity range of 1.0 to 2.4 the coke consumption varied from 3.5 to 5.0%. It was also observed that 40% coke may be replaced by gaseous fuel — cokeoven gas in this case.

4. Sample No. 4

The sample was designated as laminated variety of iron ore (one of the constituent in the mixed sample mentioned as sample No. 3) and consisted of 200 mm lumps down to fines. Complete chemical analysis of the sample was as below :

Constituent	Assay %	Constitue4t	Assay %
Fe	58.30	P	0.042
SiO_2	4.10	S	0.076
Al_2O_3	7.40	TiO_2	0.06
CaO	0.10	FeO	Trace
MgO	0.10	LOI	5.2

Mineralogical examination of the sample indicated the presence of hematite followed by goethite and traces of magnetite ; lateritic matter and siliceous matter formed the gangue.

Dry and wet screenings and washing followed by wet screening tests were conducted after crushing the ore to 50 mm top size and discarding the —12.5 mm fines.

Dry screening tests produced —50+12 mm lumps assaying 59.1% Fe with 63.7% Fe distribution while the wet screening tests produced —50+12.5 mm lumps assaing 59.75% Fe with 63.9% Fe distribution in it. 2.2% of total Fe was lost in the wash slimes.

Scrubbing and wet screening tests produced a grade of 61.5% Fe for the —50+12.5 mm lumps with 62.6% Fe distribution and the slimes carried 3.9% of the total Fe.

The —12.5 mm washed portion was treated in Harz Jig after sizing. The combined jig concentrate assayed 63.2% Fe with additional recovery of 27.0% Fe in it.

Sintering tests were conducted with —12.5 mm jig concentrate for the production of fluxed and nonfluxed sinters. The other constituents used for sintering were (1) Flue dust from HSL Rourkela assaying 24.8% Fe, 28.37% F.C. and 11.5% SiO_2, (2) —8 mesh coke from TISCO assaying 68.9% F.C. and 25.7% ash, and (3) Limestone from Nandini Quarries of HSL, Bhilai assaying 41.6% CaO, 8.5% MgO and 5.36% SiO_2.

Good grade and quality sinters were produced under the optimum conditions of 6.0% water and 4.5% coke, employing 25% of the return sinter fines.

Fluxed sinters having a basicity of 1.4 and using 30% of the return fines were produced. Coke consumption was lowered upto 30% by using the coke oven gas during sintering (Mixed firing).

5. Sample No. 5

The sample was designated as "Massive Type" and had the following analysis :

Constituent	Assay %	Constituent	Assay %
Fe	66.00	TiO_2	0.02
SiO_2	2.30	CaO	0.20
Al_2O_3	2.10	MgO	Trace
P	0.02	FeO	Trace
S	Trace	LOI	1.90

As the sample was of high grade, and contained low amounts of insolubles only dry and wet screening tests were conducted.

Dry screening tests with 50 mm top size crushed ore after discarding the —12.5 mm fines produced —50+12.5 mm lumps assaying 67.5% Fe with 78.6% Fe distribution in it. Wet screening tests produced a grade of 67.6% Fe with 77.2% Fe distribution in it. 2.7% of total Fe was lost in slimes.

Sintering tests were conducted with the

—12.5 mm wet screened fines assaying 62.4% Fe, 3.14% SiO_2 and 4.24% Al_2O_3.

The fluedust from Rourkela assaying 28.37% F.C., 24.8% Fe and 11.5% SiO_2, limestone from Nandini Mines assaying 41.6% CaO, 8.5% MgO and 5.26% SiO_2, and coke from TISCO assaying 68.9% F.C. and 25.7% ash were used for the production of sinters.

Good quality nonfluxing sinters were produced under the optimum conditions of 6% water, 4.5% coke and 30% of return sinter fines.

Coke quantity was reduced to 3.5% in case of self fluxing (1.00 basicity) sinters due to fusion of the fines. However, good grade of sinters having a basicity upto 1.3 were produced; use of coke oven gas during sintering helped in the reduction of 20-30% coke.

6. Sample No. 6

The sample was designated as "Compact laminated type" and had the following chemical analysis:

Constituent	Assay %	Constituent	Assay %
Fe	66.45	CaO	0.04
FeO	Trace	P	0.028
SiO_2	1.94	S	0.06
Al_2O_3	2.00	TiO_2	0.10
MgO	0.04	LOI	1.70

The sample in its "as received" state contained 200 mm lumps down to fines and was crushed to 50 mm top size for the tests. As the sample was of high grade in nature, only dry and wet screening rests were conducted.

After dry screening and removing the —12.5 mm fines, the —50+12.5 mm lumps analysed 67.5% Fe with 77.7% Fe distribution in it. The —12.5 mm fines analysed 61.3% Fe. Wet screened —50+12.5 mm lumps analysed 68.2% Fe with 76.3% Fe distribution and the —12.5 mm fines analysed 64.7% Fe with 22.7% Fe distribution in them. Only 1.0% of total Fe was lost in the slimes.

Sintering tests were conducted with the —12.5 mm fines obtained from wet screening employing (1) Flue dust from Rourkela Steel Plant assaying 28.37% F.C. 24.8% Fe and 11.5% SiO_2, (2) Limestone from Nandini Mines of HSL assaying 41.6% CaO, 8.5% MgO and 5.20% SiO_2 and (3) Coke breeze from TISCO assaying 68.9% F.C. and 25.9% ash.

Good sinters were produced under the optimum conditions of 7.0% water, 4.5% coke breeze, and 25.0% return sinter fines along with the ore fines. Self fluxing sinters having a basicity range of 1.0 to 2.4 were produced all of which had good shatter stability. Mixed firing was also successful in producing quality sinters wherein the coke consumption was reduced upto 30% in case of fluxed sinters.

7. Sample No. 7

This sample was designated as hydroxide type due to the presence of large quantities of goethite and other iron bearing lateritic material; complete chemical analysis of the sample was as follows:

Constituent	Assay %	Constituent	Assay %
Fe	49.60	MgO	0.20
FeO	Trace	P	0.075
SiO_2	7.60	S	Trace
Al_2O_3	11.30	TiO_2	0.04
CaO	0.20	LOI	10.20

This sample analysed poorest iron and highest insoluables against the other three samples i.e. Massive, Laminated and massive-laminated types of ores received from Dalli mines. The ROM contained 27.3% of —12.5 mm fines which increased to 45.7% when the sample was crushed to 50 mm size.

Scrubbing and wet screening improved the grade of the —50+12.5 mm lumps to 52.5% Fe with 58.7% Fe distribution in it. The —12.5 mm fines analysed 48.2% Fe with 34.2% Fe distribution in it. 7.7% of total Fe was lost in the slimes.

Dry and wet screening tests produced a grade of 51.7% Fe and 52.0% Fe for the —50+12.5 mm lumps. 4.8% of total Fe was lost in the slimes of wet screening.

The —12.5 mm fines obtained after scrubbing and wet screening were treated in Harz Jig after sizing. The combined jig concentrate analysed 53.7% Fe with 12.4% Fe distribution in it. This jig concentrate was used for the production of fluxing and non-fluxing sinters.

Sinters were produced on bench scale employing (1) flue dust from Rourkela assaying 28.37% F.C., 24.8% Fe and 11.5% SiO_2 (2) Coke from TISCO assaying 68.90% F.C. and 25.7% Ash and (3) Limestone from Nandini Quarries of HSL assaying 41.6% CaO, 8.5% MgO and 5.26% SiO_2.

Under the optimum conditions of 7.0% water, 5.0% flue dust and 4.5% coke good quality sinters were produced. Self-fluxing sinters having a basicity of 1.09 to 1.51 were produced which had good shatter stability. Further increase in the basicity lowered the strength of the sinter. Mixed firing tests indicated possibility of reducing the coke consumption by 20-30%.

8. Sample No. 8

The sample was prepared by mixing three different types of iron ore samples viz. soft laminated type and compact laminated type drawn from different parts of the mines. The mixed sample taken up for beneficiation studies analysed as below :

Constituent	Assay %	Constituent	Assay %
Fe	62.20	P	0.08
SiO_2	3.65	S	0.04
Al_2O_3	3.47	TiO_2	0.12
FeO	Trace	LOI	4.50
MgO	Trace		

Hematite was the chief iron mineral followed by minor amounts of goethite and magnetite. Silica, aluminious matter and laterite formed the gangue.

The ROM sample contained 200 mm lumps down to fines and was reduced to 50 mm top size for beneficiation tests.

Dry screening tests with washed ore on 9.5 mm screen ($\frac{3}{8}$") produced —50+9.5 mm lumps assaying 63.8% Fe with 48.0% Fe distribution in it. The fines analysed 60.8% Fe.

Scrubbing and wet screening tests improved the grade —50+9.5 mm lumps to 64.2% Fe with 43.1% Fe distribution. The —9.5 mm fines analysed 63.5% Fe with 41.8% Fe distribution. The slimes contained 15.1% of the total iron.

Jigging tests with the sized —9.5 mm fines produced a combined concentrate assaying 65.00% Fe with 28.2% Fe distribution in it. Jig tails contained 13.6% of the total Fe.

The washing slimes analysing 53.79% Fe when treated in cyclone at 10% solids and 7032 kg/sq.m. pressure produced an underflow product assaying 63.55% Fe with an additional recovery of 12.4% Fe in it.

Sintering tests were conducted with both beneficiated and un-beneficiated —9.5 mm fines employing flue dust from Rourkela assaying 24.8% Fe, 11.5% SiO_2 and 28.37% F.C., coke breeze from TISCO assaying 70.4% F.C. and 25.8% ash and limestone from Nandini Quarries of HSL assaying 41.68% CaO, 8.5% MgO and 5.26% SiO_2. Under the optimum conditions of 7% water, 4.5% coke, and 25% of return sinter fines, best quality of sinters were produced.

Self fluxing metallurgical grade sinters having basicity upto 2.4 were produced with the un-beneficiated fines where as in case of the beneficiated fines the basicity was reached upto 2.7. It was observed althrough that the beneficiated fines produced sinters with greater strength.

9. Sample No. 9

The sample was a blend comprising 55% of the laminated type ore blend mentioned above (Sample No. 8) and 45% of massive type ore from Rajhara Mines. The sample had the following analysis :

Constituent	Assay %	Constituent	Assay %
Fe	65.60	FeO	Trace
SiO_2	2.10	TiO_2	Trace
Al_2O_3	2.51	P	0.06
CaO	Trace	S	0.03
MgO	Trace	LOI	2.70

The prepared blend contained 29.8% —9.5 mm fines in it. The ore was reduced to 50 mm top size and then sized on 9.5 mm screen. The —50+9.5 mm lumps analysed 67.0% Fe with 64.7% Fe distribution while the —9.5 mm fines analysed 63.0% Fe with 35.3% Fe distribution in it.

Scrubbing followed by wet screening of the crushed sample improved grade of the —50+9.5 mm lumps to 67.5% Fe with 61.2% Fe distribution. The fines analysed 65.7% Fe with 30.0% Fe distribution in it. The slimes

analysed 54.04% Fe with 8.8% Fe distribution in them.

Treatment of the wash slimes in hydrocyclone at 10% solids and 10 lbs/sq. inch pressure yielded an underflow assaying 64.95% Fe with 7.0% Fe distribution in it.

Sintering tests were conducted with the washed —9.5 mm fines employing flue dust from Rourkela Steel Plant assaying 24.8% Fe, 11.5% SiO_2 and 28.37% F.C., coke breeze from TISCO assaying 70.4% F.C. and 25.8% ash and limestone from Nandini Quarries assaying 41.6% CaO, 8.5% MgO and 5.20% SiO_2.

Good grade metallurgical sinters were produced under the optimum conditions of 7.0% water, 5.0% coke and 25.0% of return sinter fines.

In case of self-fluxing sinters 5% coke was found to fuse the sinter mix. Hence the coke was reduced to 3.5%. Sinters with good shatter stability were produced upto a basicity of 2.2.

Pilot Plant Beneficiation studies Composite sample from Deposit 4 N.M.D.C.

The sample was prepared by mixing steel and massive grey lumpy hematites 15%, 14%, laminated ore 21%, lateritic ore 16% and blue dust 34% and had the following chemical analysis :

Constituent	Assay %	Constituent	Assay %
Fe	64.6	P	0.045
FeO	0.2	LOI	1.60
SiO_3	2.4	sp. gr.	4.95
Al_2O_3	3.5	TiO_2 ⎫	
CaO	0.21	Na_2O ⎬	Trace
MgO	0.12	MnO ⎭	

Crushing the ore to 150 mm followed by dry screening on 40 mm and 10 mm screens produced +40 mm analysing 64.9% Fe and +10 mm lumps assaying 65.1% Fe. The —10 mm lumps analysed 63.8% Fe, 3.4% SiO_2 and 3.6% Al_2O_3. When the +40 mm lumps were crushed to 40 mm screen and sized on 10 mm screen, the lumps and fines respectively analysed 65.1% Fe and 64.1% Fe. The alumina content was 3.4% and 4.0% respectively. The combined +10 mm lumps analysed 65.1% Fe 1.6% SiO_2 and 3.4% Al_2O_3 with 54.1% Fe distribution and the —10 mm fines analysed 63.9% Fe, 3.2% SiO_2 and 3.7% Al_2O_3 with 45.9% Fe distribution in it.

Crushing the ore to 150 mm followed by wet screening on 40 mm and 10 mm screens produced +40 mm lumps analysing 65.1% Fe and +10 mm lumps 65.4% Fe. When the +40 mm lumps were reduced to 40 mm and then sized on 10 mm screen, the lumps analysed 65.5% Fe and the fines analysed 63.7% Fe. The combined —40+10 mm lumps analysed 65.5% Fe, 1.45% SiO_2 and 3.3% Al_2O_3 with 53.6% Fe distribution. The —10 mm fines assayed 64.2% Fe, 3.0% SiO_2 and 3.3% Al_2O_3 with 38.1% Fe distribution in it.

The washing slimes when treated in cyclone, the under flow analysed 63.3% Fe, 6.7% SiO_2 and 1.0% Al_2O_3 with an additional recovery of 7.3% Fe. Only 1.0% Fe was lost in the rejected cyclone over flow.

The —40+10 mm lumps obtained from wet screening can be directly used for Blast Furnace, while the under flow from hydrocycloning of slime could be mixed with classified sand and used for agglomeration.

The Bulk density and angle of repose results on sample crushed —150 mm are as under :

Moisture %	0	3	5	7.5
Bulk density T/M	2.89	2.95	2.98	3.31
Angle of repose (in degrees)	34.0	43.3	46.0	44.3

The shatter test results showed that in the first stage —10 mm fraction increased from 37.3% to 44.4% and increase of 7.1% of fines after 3 drops were produced. In the second stage it was increased to 51.4% (increase of fines 14.1%) and in the last stage the +40 mm fraction from stage 2 was crushed to —40 mm size and screened on a 10 mm screen. The total amount of —10 mm fraction was found to be 57.4% by weight.

Decrepitation test on Bailadila Iron Ores deposits No. 4 and No. 5 for Vizag Steel Plant.

Eight type samples from Bailadila deposits No. 4 and 5 after washing were crushed to —25 mm size. The —25+12 mm fraction of each was tested for decrepitation characteristics both, under stagnant as well as under reducing atmospheres.

It was observed from these studies that decrepitation temperature for deposit No. 4 varied from 418°C to 440°C and from 385°C to 415°C for stagnant (no reducing gases) and reducing atmospheres generating fines below 6 mm from 0.5 to 3.1% and from 2.1 to 15.2% respectively.

In the case of deposit No. 5 it varied from 415°C to 445°C and from 400°C to 410°C for stagnant and reducing tests generating fines (—6 mm) from 0 to 1.3% and from 1.8% to 9.1% respectively, depending on the type of the ore samples resulting in maximum temperature and minimum fines with steel grey hematite variety and minimum temperature and maximum fines with lateritic limonitic ore. The other two varieties tested were Blue massive hematite and laminated hematite with lateritic material which were intermediate.

The optimum test results of the various ore samples from Madhya Pradesh are given in Table 2.40.

TABLE 2.40—SUMMARY OF THE RESULTS OF BENEFICIATION STUDIES ON IRON ORE SAMPLES FROM MADHYA PRADESH

Locality	Assay % (Feed)	Beneficiation Method	Product	Assay % conc.	Dist %	Remarks
1	2	3	4	5	6	7
Bailadila						
(1) S. No. 1	66.9 Fe 1.5 SiO_2 1.9 Al_2O_3	Washing at 152 mm followed by jigging of —9.5 mm sand	Lumps Sand	68.47 Fe 66.90 Fe	91.8 Fe 6.4 Fe	Sintering test with sand conducted
(2) S. No. 2	66.38 Fe 0.94 SiO_2 0.94 Al_2O_3	Wet screening at 100 mm Wet screening at —150 mm size	+6 mm lumps —6 mm sand +9.5 mm lumps —9.5 mm sand	68.37 Fe 65.80 Fe 68.35 Fe 64.40 Fe	96.2 Fe 3.5 Fe 97.2 Fe 2.6 Fe	
Rajhara Iron Ores						
(3) S. No. 3	54.80 Fe 11.60 SiO_2 4.64 Al_2O_3	Scrubbing and washing after sizing at 12.5 mm size	—30 mm washed lumps	61.25 Fe	10.8 Fe	
		HMS for washed —30+12.5 mm lumps	—30+12.5 washed lumps after HMS	61.10 Fe	26.6 Fe	
		Tabling of the washed slimes.	Table conc.	61.30 Fe	1.1 Fe	
		Scrubbing of —12.5 mm fines followed by tabling of slimes	Table conc.	64.7 Fe	4.7 Fe	
		Sizing of the sand on 6 mesh and washing	Washed +6 mesh	60.05 Fe	25.9 Fe	Over all 60.73% Fe
		Jigging of —6 mesh fines	Jig conc.	62.5 Fe	16.0 Fe	with 91.0%
		Magnetic separation	Mag. conc.	63.1 Fe	17.9 Fe	Fe dist.
		Tabling	Table conc.	61.3 Fe	19.3 Fe	
(4) S. No. 2	56.25 Fe 7.17 SiO_2 6.39 Al_2O_3	Crushing to 50 mm and sizing on 12.7 and 9.7 mm sizes	+12.5 mm lumps —12.5+9.5 sand —9.5 sand	62.05 Fe 58.7 Fe 49.5 Fe	67.1 Fe 7.9 Fe 25.0 Fe	
		Washing at —75 mm	+9.5 mm lumps —9.5 mm sand	60.75 Fe 50.77 Fe	78.2 Fe	
		Washing at 50 mm	+9.5 mm lumps Sand	61.05 Fe 52.31 Fe	71.5 Fe	
		Washing at 25 mm	+9.5 mm lumps —9.5 mm sand	61.56 Fe 54.90 Fe	59.2 Fe	

Table 2.40 (*Contd.*)

1	2	3	4	5	6	7
		HMS at sp. gr. 2.9 with +9.7 mm lumps	+75 mm	63.72 Fe	65.0 Fe	
			+50 mm	64.03 Fe	63.9 Fe	
			+25 mm	64.37 Fe	51.7 Fe	
		HMS with washed +6 mesh sized at sp.gr. 2.9	75 mm	60.43 Fe	5.21 Fe	
			50 mm	59.44 Fe	6.52	
			25 mm	62.15 Fe	4.29	
		Jigging with —6 mesh fines (combined)	Jig conc.	61.52 Fe	6.7 Fe	
(5) S. No. 3	62.54 Fe 2.59 SiO_2 7.30 Al_2O_3	Crushing & sizing at 12.5 mm size and washing	Dry screen +12.5 lumps	64.21 Fe	75.5 Fe	
			Washed & screened +12.5 lumps	64.68 Fe	71.9 Fe	
			Scrubbed wet screened +12.5 lumps	65.15 Fe 1.97 SiO_2 3.14 Al_2O_3	70.6 Fe	
			Scrubbed —12.5 sand	60.90 Fe	25.7 Fe	
		Sizing & Jigging of scrubbed —12.5 mm sand	Jig conc.	64.6 Fe 1.98 SiO_2 3.27 Al_2O_3	20.9 Fe	Sintering tests were conducted
(6) S. No. 4	58.3 Fe 4.1 SiO_2 7.4 Al_2O_3	Crushing and sizing at 12.5 mm size	Dry screened +12.5 lumps	59.1 Fe	63.7 Fe	
			Wet screened +12.5 lumps	59.75 Fe	63.9 Fe	
			Scrubbing & wet screening +12.5 lumps	61.5 Fe	62.6 Fe	
		Jigging with —12.5 mm sand from scrubbing	Jig conc.	63.2 Fe	27.0	Sintering tests were conducted
(7) S. No. 5	66.0 Fe 2.3 SiO_2 2.1 Al_2O_3	Crushing to 50 mm and sizing at 12.7 mm	Dry screened +12.7 mm lumps	67.5 Fe	78.6 Fe	
			Wet screened +12.7 mm lumps	67.6 Fe	77.2 Fe	
			—12.7 mm fines	62.4 Fe 3.14 SiO_2 4.24 Al_2O_3		Sintering tests were conducted
(8) S. No. 6	66.45 Fe 1.94 SiO_2	-do-	Dry screened +12.7 mm lumps	67.5 Fe	77.7 Fe	
			—12.7 mm fines	61.3 Fe	20.4 Fe	
			Wet screened +12.7 mm lumps	68.2 Fe	76.3 Fe	
			—12.7 mm fines	64.7 Fe	22.7 Fe	
(9) S. No. 7	49.6 Fe 7.6 SiO_2	Scrubbing & wet screening at +50 mm sizing at 12.7 mm	—50+12.7 mm lumps	52.5 Fe	58.7 Fe	
			—12.7 mm fines	48.2 Fe	34.2 Fe	
	11.3 Al_2O_3	Wet screening	—50+12.7 mm	52.0 Fe		
			—12.7 mm	51.7 Fe		
		Jigging of the 12.7 mm	Jig conc.	53.7 Fe	12.4 Fe	
(10) S. No. 8	62.20 Fe 3.65 SiO_2	Crushing to 50 mm & dry screening at 9.5 mm	+9.5 mm lumps	63.8 Fe	48.0 Fe	
			—9.5 mm fines	60.8 Fe	52.0 Fe	
	3.47 Al_2O_3	Scrubbing and wet screening	+9.5 mm lumps	64.2 Fe	43.1 Fe	
			—9.5 mm fines	63.5 Fe	41.8 Fe	
			Slimes	53.79 Fe	15.1 Fe	
		Jigging tests with —9.5 mm washed fines	Jig conc.	65.0 Fe	28.2 Fe	Sintering tests were conducted
		Cycloning treatment	Underflow	63.55 Fe	12.4 Fe	

Table 2.40 (*Contd.*)

1	2	3	4	5	6	7
(11) S. No. 9	65.60 Fe	Crushing to 50 mm size	+9.5 mm lumps	67.0 Fe	64.7 Fe	
	2.10 SiO_2	and sizing at 9.5 mm	—9.5 mm fines	63.0 Fe	35.3 Fe	
	2.10 Al_2O_3	Scrubbing and wet screening	+9.5 mm lumps	67.5 Fe	61.2 Fe	
			—9.5 mm fines	65.7 Fe	30.0 Fe	
			Slimes	54.04 Fe	8.8 Fe	
		Cyclone treatment of slimes	Under flow	64.95 Fe	7.0	

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