BENEFICIATION STUDIES ON IRON ORES FROM ORISSA

1. Badampahar Iron Ore

The sample, 3" to fines in size, consisted of rather soft yellowish lumps. Hematite and hydrated oxides of iron and small amounts of magnetite were the iron minerals present. Veins of psilomelane were observed in some specimens. Quartz, clay and some lateritic material constituted the gangue.

The ore assayed Fe = 54.11%, SiO_2 = 6.47%, Al_2O_3 = 4.92%, L.O.I. at 800°C = 8.54% and Mn = 1.06%. The iron minerals got fairly liberated from the gangue at about 20 mesh, with progressive increase of gangue content in the finer fractions.

The problem was removed of silica and alumina so that the concentrate would be used for direct reduction experiments to produce variable density steel.

Dry magnetic separation at −20 +48 mesh and −48 mesh sizes after desliming, was conducted. The concentrate assayed 60.12% Fe with 77.9% Fe recovery.

Tabling followed by magnetic separation at −20 mesh size yielded a combined concentrate assaying 61.31% Fe, 2.62% SiO_2, 1.81% Al_2O_3 and 7.13% L.O.I. with a recovery of 67.9% Fe.

2. Bonai Iron Ore

The sample, 6" to fines in size consisted of goethite, followed by hematite, lepidocrocite and traces of magnetite, Limonitic clay, quartz, felspar, calcite, etc. formed the gangue minerals.

The chemical analysis of the ore is given below:

Constituent	Assay %	Constituent	Assay %
Fe	59.6%	MgO	0.23%
SiO_2	2.23%	P	0.066%
Al_2O_3	4.45%	S	0.02%
TiO_2	0.14%	L.O.I.	
CaO	0.25%	at 1000°C	7.5%

The ore is to be upgraded to about 65% Fe, in connection with a new trade agreement being negotiated for export of iron ore to Japan.

The ore after crushing to −3" size was attrition ground and washed in a concrete mixer. But there was not much improvement in the grade of the coarse fraction, because of the small clay content in the ore.

Jigging and tabling of the −3 mesh crushed ore after sizing yielded a combined concentrate assaying only 62.04% Fe with a recovery of 53.9% Fe.

As goethite was the major mineral constituent in the ore heating (Calcining) of the −3" ore at higher temperature of around 650°C and soaking it for 15-30 minutes produced a calcined product assaying 64.1% Fe by expelling almost all the combined water. In practice this can be done in vertical or rotary kilns which can be advantageously used for this purpose.

3. Iron Ores from Bolani

Six different samples of Iron ore were tested in NML for beneficiation and agglomeration studies sponsored by both HSL and Bolani Ores Ltd. Iron ore from Bolani area is fed to the HSL's steel plant at Durgapur.

Sample No. 1

The sample consisted of 100 mm lumps to fines and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	56.60	P	0.06
SiO_2	5.00	S	0.20
Al_2O_3	6.30	Mn	Trace
MgO	0.51	LOI	7.3
CaO	0.60		

Mineralogical examination revealed the abundance of hematite, followed by martite, goethite, lepidocrocite and ochre. Quartz was found in the cavities, walls and crevices while kaolin and felspars filling the cavities and pore spaces. Ochres and laterite contributed the alumina content of the ore.

The ore was sampled and then different lots were crushed to 75 mm, 50 mm and 38 mm size and subjected to scrubbing and wet screening on 9 mm screen.

The washed lumps of −70 mm, −50 mm and −38 mm analysed respectively −60.82% Fe, 61.51% Fe and 61.93% Fe with respective distribution of 62.0%, 58.9% and 55.5% Fe. The SiO_2 content varied from 1.44% to 1.59% while alumina varied from 4.06 to 4.33%.

Further treatment of the washed lumps after sizing by Heavy Media Separation at Sp. gr. 3.0 yielded a combined concentrate for −75 mm, −50 mm and −38 mm assaying 62.81% Fe with 51.0% Fe distribution, 63.87% Fe with 48.0% Fe distribution and 63.0% Fe with 47.1% Fe distribution in them respectively.

The −9 mm sand portion was screened on 6 mm screen and −9 mm +6 mm portion was treated by HMS at Sp. gr. 2.9 the product obtained from −75 mm, −50 mm and −35 mm respectively analysed 63.5% Fe, 63.1% Fe and 63.3% Fe with Fe distributions of 6.7%, 7.2% and 9.4% respectively.

Jigging tests with the −6 mesh portion from −50 mm crushed ore produced a concentrate assaying 60.6% Fe with a further recovery of 7.2% Fe in it.

In another series of tests the R.O.M ore was screened on 63 mm screen. The +63 mm protion was separately crushed to −63 mm and wet screened on 9 mm screen. The +9 mm lumps analysed 62.5% Fe with 36.9% Fe distribution in it.

The −63 mm lumps were subjected to scrubbing and wet screening on 9 mm screen. The washed −63 mm+6 mm lumps analysed 60.30% Fe with 31.2% Fe distribution in it. The combined wet screened and washed lumps analysed 61.28% Fe, 1.78% Sio_2 and 4.78% Al_2O_3 with 68.1% Fe distribution in it. The combined −9 mm sand analysed 57.72% Fe with 37.5% Fe distribution.

When the washed lumps and the −9 mm+6 mm sand were subjected to HMS at Sp. gr. 3.0, and the −6 mm fines to jigging and the concentrates combined with the respective wet screened products (+ 63 mm portion), the lumps analysed 62.9% Fe, 1.35% SiO_2 and 3.74% Al_2O_3 with 49.0% Fe distribution. The combined sand analysed 61.67% Fe, 2.24% Sio_2 and 4.17% Al_2O_3 with 22.6% Fe distribution. This product was taken up for the production of sinters.

Sintering tests were conducted with −9 mm wet and dry screened fines and the jig concentrates. The other raw materials used for sintering were — fluedust from Durgapur steel plant assaying 23.4% Fe, 7.56% Sio_2 and 8.03% Al_2O_3, coke breeze from Durgapur steel plant assaying 70.3% F.C., 26.6% Ash and 2.6% V.M., lime stone from Purnapani area assaying 45.9% CaO, 3.6% MgO and 8.32% SiO_2, Limestone concentrate from Purnapani limestone assaying 50.43% CaO, 5.3% MgO and 2.06% SiO_2 and Dolomite from Rourkela Steel Plant assaying 29.35% CaO, 21.55% MgO and 2.48% SiO_2.

Good quality sinters were produced under the optimum conditions of 7.0% water, 4.0% Coke, and 20% of return fines in the sinter mix.

Self fluxing sinters were produced varying the basicity from 0.8 to 1.4 using 4 : 1 mixture of limestone and dolomite.

Sample No. 2

The 500 tonne sample received consisted of 460 mm lumps down to fines and had the following chemical analysis :

Constituent	Assay %	Constituent	Assay %
Fe	56.89	P	0.05
SiO_2	5.23	S	0.03
Al_2O_3	7.10	Mn	0.08
MgO	0.40	LOI	7.40
CaO	0.20		

Mineralogical examination of the sample revealed the presence of hematite followed by minor amount of goethite, lepidocrosite and ocher. Quartz and laterite contributed silica and alumina.

The ore was crushed to 50 mm size and two different washing tests were conducted using a cyclone and a spiral classifier to deslime the fines.

The washed and wet screened −50 mm+9 mm portion analysed 60.59% Fe with 70.0% Fe distribution. The −9 mm+3 mm sand portion analysed 54.53% Fe and after further treatment in Harz Jig yielded a concentrate assaying 58.5% Fe with 11.6% Fe distribution in it. The −3 mm fines were deslimed in a 150 mm cyclone and the underflow was further treated in a Denver mineral jig producing a concentrate assaying 60.92% Fe with 6.8% Fe distribution in it. The combined jig concentrate analysed 59.37% Fe with 18.4% Fe distribution in it.

The washed lumps when further treated by HMS at Sp. gr. 3.0, the concentrate analysed 63.8% Fe with 54.4 Fe distribution in it.

In the second tests where the cyclone was replaced by a spiral classifier, the washed −50 mm+9 mm lumps analysed 60.65% Fe with 70.8% Fe distribution. The −9 mm+3 mm sand analysing 56.50% Fe and the classifier sand analysing 52.6% Fe when combined analysed 55.2% Fe with 22.3% Fe distribution.

Treatment of the −3 mm fines in Humphry's spiral and further treatment of the spiral tails on Wilfley's table yielded a concentrate assaying 54.2% Fe only.

Investigation was conducted to produce a high basicity sinter from the beneficiated −9 mm fines obtained from Bolani Ore. The ore fines were also mixed up with ore fines received from M/s. MMTC.

The iron ore fines from Bolani ore and those received from M/s. MMTC respectively analysed 59.0% Fe and 56.2% Fe. The mill scales and iron scrap fines respectively analysed 42% Fe and 38.7% Fe respectively. The coke breeze analysed 68% F.C. and 23.7% Ash. The lime stone from Birmitrapur quarries analysed 46.0%, CaO, 4.6% MgO and 7.42% SiO_2. The dolomite analysed 28.6% CaO, 20.2% MgO and 3.4% SiO_2. The burnt lime analysed 90.76% CaO.

Sinters having a very high basicity of 4.0 to 4.5 were produced under the optimum conditions of 8% water, 4% Coke, 25% return sinter fines. Use of freshly prepared burnt lime produced better results. Upto 2% of fine scrap also may be added to the sinter mix which will be of some advantage.

Sample No. 3

The sample was collected from reject fines dump and was taken up to discard the claying matter from the sample. It consisted of 12 mm lumps down to fines and analysed as given under :

Constituent	Assay %	Constituent	Assay %
Fe	62.8	Mn	Trace
SiO_2	3.5	S	0.037
Al_2O_3	2.8	P	0.03
CaO	0.2	LOI	3.20
MgO	Trace		

The sample predominantly composed of hematite in the form of blue dust. Limonitic and clayey matter coating over the ore grains was responsible for the sticky nature of the fines. Quartz, kaoline and mica contributed the insolubles.

Scrubbing followed by wet screening on 9 mm screen produced a coarser fraction assaying 64.0% Fe with 23.2% Fe and a finer −9 mm fraction assaying 63.5% Fe with 53.9% Fe distribution. The washing slimes when treated in hydrocyclone produced an underflow assaying 63.2% Fe with 15.1% distribution in it.

Wet screening tests on 9 mm screen produced a coarser fraction assaying 63.6% Fe and a finer portion assaying 63.1% Fe. The slimes analysed 60% Fe thereby indicating non suitability of this method.

Sizing the sample on 20 mesh screen followed by jigging of the +20 mesh portion and tabling of the −20 mesh portion respectively yielded concentrates assaying 61.9% Fe with 35.1% Fe

distribution and 63.6% Fe with 22.3% Fe distribution.

Sample No. 4

The 60 tonne ROM sample received, consisted of 200 mm lumps to fines and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	63.50	P	0.09
SiO_2	2.83	CaO	0.29
FeO	0.54	MgO	Trace
Al_2O_3	2.00	TiO_2	0.04
S	0.06	LOI	3.13

Examination of the sample under microscope indicated the heterogeneous association of hematite, hydrohematite, lepidocrosite, hydrogoethite, ocher and laterite along with argilaceous and arenaceous matter filling the pores and crevices etc.

Wet screening of the sample after crushing to −50 mm produced −50 mm+10 mm lumps assaying 62.8% Fe with 34.0% Fe distribution and −10 mm fines assaying 63.40% Fe with 35.2% Fe distribution. The slimes analysed 64.34% Fe with 30.8% Fe distribution.

Scrubbing followed by wet screening produced −50+10 mm lumps assaying 62.6% Fe, −10 mm fines assaying 63.94% Fe and a slime assaying 64.34% Fe with respective Fe distributions of 30.6%, 39.5% and 29.9%.

Dryscreening the 50 mm crushed on 25 mm screen followed by washing of the −25 mm lumps produced a combined product (+25 mm unwashed and −35+10 mm washed lumps) assaying 62.8% Fe, with 32.2% Fe distribution. The classifier sand and slime respectively analysed 63.5% Fe and 64.4% Fe. All these test results indicated that the slimes always assayed 64% Fe due to the presence of blue dust.

Treatment of the slimes in cyclone from various operations, produced an underflow assaying 67.4%.

Sample No. 5

60 tonnes of ROM sample consisting of lumps upto 200 mm was received for beneficiation tests. The sample analysed as under :

Constitutent	Assay %	Constituent	Assay %
Fe	58.46	P	0.05
SiO_2	3.52	CaO	Trace
Al_2O_3	6.14	MgO	Trace
S	0.087	LOI	4.93

Wet screening of the ore after crushing to 50 mm size produced −50+10 mm lumps assaying 60.4% Fe with 70.6% Fe distribution and −10 mm sand assaying 59.1% Fe with 23.2% Fe distribution in it. The slimes analysed 39.0% Fe. After scrubbing and wet screening, the −50+10 mm lumps analysed 61.0% Fe with 67.5% Fe distribution and the −10 mm fines analysed 59.4% with 23.8% distribution. The slimes analysed 42.71% Fe.

Washing of the −25 mm portion only produced a grade of 59.3% Fe for the −25 mm+10 mm lumps and when this product was combined with the unwashed −50+25 mm lumps, product analysed 60.4% Fe with 72.8% Fe distribution in it. The −10 mm fines analysed 58.9% Fe with 21.6% Fe distribution. The slimes analysed 41.2% Fe.

Scrubbed and wet screened −50+10 mm lumps when subjected to H.M.S. at Sp.gr. 2.9, the sink product analysed 63.0% Fe with 57.2% Fe distribution. The slimes when treated in cyclone, produced an underflow assaying 53.6% Fe with 5.8% Fe distribution in it. Washing, HMS and cyclone treatments produced an over all Fe recovery of 84.0% in the sample.

4. Barsua Iron Ore

The 100 tonne ROM sample consisted of 100 mm lumps to fines and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	52.18	P	0.07
SiO_2	4.80	S	0.48
Al_2O_3	11.34	Mn	Trace
MgO	0.84	LOI	9.08
CaO	0.42		

Washing tests were conducted with the sample after crushing to 75 mm, 50 mm, and 25 mm sizes.

Washed −75+10 mm lumps analysed 55.73% Fe with 64.2% Fe distribution and the −10 mm sand analysed 51.11% Fe with 29.0% − Fe distribution in it. HMS tests with the washed lumps at Sp.gr. 3.0 produced a sink product assaying 63.06% Fe with 46.8% Fe distribution in it.

Sizing of the −10 mm sand on 6 mm screen followed by HMS at Sp.gr. 3.0 of the coarser product produced a grade of 61.7% Fe with 8.7% Fe distribution. This when combined with the −6 mm fines, the product analysed 53.68% Fe with 22.8% Fe distribution in it.

−50 mm ore after washing produced a −50 mm+10 mm lumps assaying 56.26% Fe with 62.6% Fe distribution in it. The −10 mm sand analysed 57.37% Fe with 29.0% Fe in it. HMS at Sp.gr. 3.0 with washed lumps produced a sink product assaying 62.52% Fe with 47.4% Fe distribution. Similar treatment of the −9 mm +6 mm portion of the sand product produced a concentrate assaying 63.3% Fe with 8.1% Fe distribution. The combined HMS conc and the −6 mm fines analysed 53.74% Fe with 21.7% Fe distribution in it.

25 mm crushed ore after washing produced a grade of 57.46% Fe for the −25+10 mm lumps with 52.6% Fe distribution. The −10 mm sand analysed 52.81% Fe with 38.1% Fe distribution HMS of the washed lumps at Sp.gr. 3.0 yielded a sink product assaying 62.6% Fe with 45.5% Fe distribution in it. Treatment of the −10+6 mesh sand by HMS produced a concentrate at Sp.gr. 3.0 analysing 63.1% Fe with 13.7% Fe distribution. −6 mm fines when treated in a jig produced a concentrate assaying 58.5% Fe with 8.3% Fe distribution. The combined −10 mm HMS and jig concentrates assayed 61.27% Fe with 22.0% Fe distribution in it.

Sinters were prepared using the −10 mm washed fines as well as treated fines obtained from 25 mm crushed ore.

The other raw materials for sintering were (1) flue dust from HSL Rourkela assaying 18.7% Fe, 13.74% SiO_2 and 28.37% Fe, (2) Coke breeze from Durgapur assaying 70.4% F.C., and 26.6% ash (3) Lime stone concentrate assaying 49.84% CaO, 3.37% MgO and 2.3% SiO_2 and (4) dolomite from HSL analysing 29.31% CaO and 21.55% MgO.

Good sinters were produced under the optimum conditions of 7% water, 25.0% return fines, 5.2% Flue dust and 4.0% Coke. Self fluxing sinters were also produced using limestone concentrate and dolomite fines upto basicity of 1.6.

5. Kiriburu Iron Ores

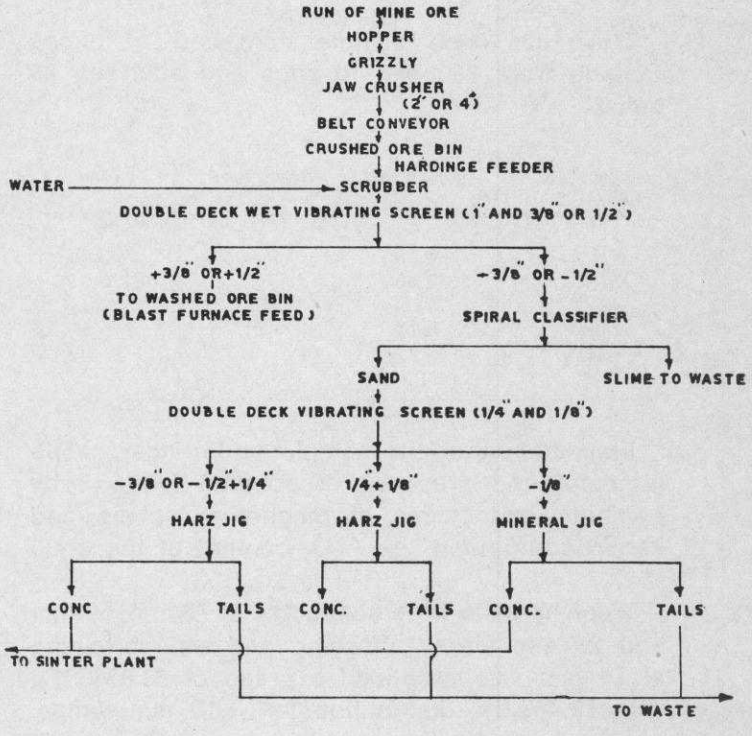
A large number of iron ore samples from different parts of the Kiriburu mines were tested for beneficiation and agglomeration of the ore fines. (Flowsheet 2.3).

Two iron ore samples were received from Kiriburu mines project NMDC for screening tests. Ore was of + 100 mm size lumps and other was 12.5 mm fines. Screen analysis and chemical analysis of these two samples was determined as desired.

Sample No. 1

The lump ore assayed 65.2% Fe, 0.92% SiO_2 and 0.88% Al_2O_3. Screening tests indicated that all the + 12.5 mm fractions constituting 99.0% by wt. were almost similar and the − 12.5 mm fractions which was only 1% by weight assayed 63.01% Fe, 2.76% SiO_2 and 1.56% Al_2O_3.

Flow Sheet 2.3 Beneficiation of Kiriburu Iron Ores



The fines sample assayed 63.3% Fe, 2.52% SiO_2, 1.57% Al_2O_3. Screen analysis of the sample indicated that the total insoluble contents in the fractions gradually increased with fineness upto +14 mesh, with less than 4.0% of total insolubles in each of them. The combined −12.5 mm+14 mesh product constituting 61.2% by weight assayed 64.7% Fe, 1.46% SiO_2 and 0.88% Al_2O_3 with a recovery of 62.6% Fe, whereas the −14 mesh fraction would assay 61.1% Fe and 6.85% total insolubles. This product will require to be beneficiated before mixing with the +14 mesh material prior to sintering.

Sample No. 2

Crushing tests on a sample of iron ore received from Kiriburu Mines of N.M.D.C. were undertaken in a Jaw crusher set at 95 mm, 62 mm and 50 mm jaw settings to find out how much of over sizes and −12.5 mm size products are produced at each setting. The results indicated that the oversizes produced were 13.0%, 23.4% and 33.4% and undersize of 12.5 mm produced were 10.2%, 13.1% and 16.3% respectively at each of the above three settings. A good amount of oversize material was resulted due to dropping of flat pieces mostly through the discharge opening everytime the movable jaw receded.

Sample No. 3

The 100 tonne sample consisted of lumps ranging from 200 mm to fines and analysed as below :

Constituent	Assay %	Constituent	Assay %
Fe	60.96	P	0.08
SiO_2	2.40	S	0.03
Al_2O_3	4.50	Mn	Trace
MgO	0.15	LOI	5.30
CaO	0.62		

Examination of the sample under microscope indicated the presence of goethite followed by hematite and traces of magnetite; ochers and kaolin contributed the Al_2O_3 content of the ore.

Washing tests were conducted at 75 mm, 50 mm and 25 mm sizes. Washing and wet screening at 75 mm size produced a grade of 63.83% Fe with 79.4% Fe distribution for +10 mm lumps. The −10 mm sand analysed 56.46% Fe with 15.3% Fe distribution in it. Heavy media separation of the washed lumps at Sp.gr. 2.9 produced a sink product assaying 65.57% Fe with 72.3% Fe distribution in it. When the −9 mm+6 mm fines were treated for HMS at Sp.gr. 2.9, the concentrate analysed 65.8% Fe with 3.4% Fe distribution. The combined −9+6 mm HMS conc and the untreated −6 mm fines when combined, the product analysed 57.55% Fe with 15.3% Fe distribution in it.

Washing tests at 50 mm size, produced +10 mm lumps assaying 64.18% Fe with 78.0% Fe distribution and −10 mm fines analysing 57.37% Fe with 16.3 % Fe distribution in it. HMS of the washed lumps at Sp.gr. 2.9 produced a sink product assaying 65.88% Fe with 67.9% Fe distribution in it. HMS concentrate of the −10+6 mm sand portion at 2.9 Sp.gr. analysed 62.9% Fe with 4.4% Fe distribution. Treatment of the −6 mm fines in jig yielded a concentrate assaying 59.6% Fe with 6.3% Fe distribution. The combined −10 mm HMS and jig concentrate product analysed 60.88% Fe with 10.5% Fe distribution in it.

Washed −25 mm+10 mm lumps analysed 64.28% Fe with 67.2% Fe distribution and improved to 66.04% Fe when subjected to HMS at Sp.gr. 2.9 with 61.4% Fe distribution. The −10 mm washed sand analysed 59.07% Fe with 26.5% Fe distribution. HMS tests with −9 mm +6 mm sand at Sp.gr. 2.9 yielded a sink product assaying 66.34% Fe with 4.3% Fe distribution in it. The combined −10+6 HMS concentrate −6 mm fines analysed 59.88% Fe with 22.6% Fe distribution in it.

Sintering tests were conducted with −10 mm washed sand (56.46% Fe) obtained with −75 mm crushed ore. The other raw materials in the sintering were (1) flue dust from Rourkela Steel Plant assaying 18.7% Fe, 23.37% F.C. and 13.74% SiO_2, (2) Coke breeze from Durgapur Steel Plant assaying 70.4% F.C., and 26.1% Ash, (3) Limestone from HSL assaying 45.4% CaO, 3.6% MgO and 2.48% SiO_2 and (4) dolomite from Rourkela Steel Plant assaying 21.25% MgO and 29.31% CaO.

Under the optimum condition of 7.0% water, 4.0% coke, 25.0% return sinter fines and 5.3% fluedust, good grade of sinters were produced. Self fluxing sinter having a basicity upto 1.4 were

produced with these fines using a limestone dolomite mixture in the ratio of 4 : 1.

Sample No. 4

This sample was prepared by blending 80 tonnes of ROM ore from the upper portion of the main haulage road and 20 tonnes of the ROM ore from the bench No. 3 of Hill No. 1 of Kiruburu Iron ore mines. The composite test sample had the following complete chemical analysis :

Constituent	Assay %	Constituent	Assay %
Fe	60.43	CaO	Trace
SiO_2	2.78	MgO	Trace
Al_2O_3	5.23	Mn	Trace
P	0.049	TiO_2	Trace
S	Trace	LOI	4.9

Hematite was the chief mineral followed by appreciable amounts of goethite, laterite material, lepidocrosite and trace of magnetite. Alumina and silica are contributed by the lateritic matter only.

Scrubbing and wet screening tests were conducted at 50 mm and 25 mm sizes. The washed, scrubbed and wet screened −50 mm +13 mm lumps analysed 62.62% Fe with 67.1% Fe distribution and the −13 mm sand analysed 59.63% Fe with 27.3% Fe distribution in it. Wet screening tests at −50 mm sizes followed by wet screening at 13 mm size, the lumps analysed 63.41% Fe with 66.8% Fe distribution and the −13 mm sand assayed 59.9% Fe with 26.7% Fe distribution.

When the washed −25 mm ore was sized on 10 mm screen, the lumps analysed 63.4% Fe with 65.8% Fe distribution and the −10 mm sand assayed 59.79% Fe with 29.6% distribution in it. The sand product when subjected to jigging after sizing, the combined jig concentrate analysed 62.1% Fe with 22.0% Fe distribution in it.

Sinters were prepared from both treated and untreated −10 mm sand from 50 mm crushed ore using (1) Flue dust from Rourkela Steel Plant assaying 24.3% Fe, and 11.5% SiO_2, and (2) Coke from Durgapur Steel Plant assaying 70.4% F.C., and 26.6% ash, (3) Limestone from HSL assaying 46.96% CaO, 2.68% MgO and 8.16% SiO_2, (4) dolomite from TISCO assaying 20.56% MgO, 28.56% CaO and 5.04% SiO_2 and (5) Blue dust from Noamundi Iron ore mines assaying 68.6% Fe and 0.66% SiO_2.

Under the optimum conditions of 4.5% coke, 5% fluedust 7.0% water and 25% return fines sinters having good porosity and shatter strength were produced; using limestone and dolomite with sinter mix good self fluexed sinters having basicity upto 1.4 were produced. Replacement of return fines with blue dust upto 30% was also quite successful without hampering the sinter quality. 30% of the coke consumption was reduced when the coke in the mix was reduced and the combustion gas (coke oven gas) was allowed to flow with the sinter.

Sample No. 5

This sample was prepared by mixing the ROM samples from Hill No. 1, bench No. 2 and Hill No. 2, bench No. 1 in equal proportions. The composite sample had the following chemical analysis.

Constituent	Assay %	Constituent	Assay %
Fe	57.90	TiO_2	0.26
SiO_2	3.00	CaO	Trace
Al_2O_3	7.00	MgO	Trace
P	0.047	LOI	7.6
S	Trace		

Hematite and goethite formed the bulk of the ore followed by minor amounts of lepidocrosite and magnetite.

Wet screen tests at −100 mm size produced −100+13 mm lumps assaying 61.10% Fe with 65.8% Fe distribution and −13 mm sand assaying 56.69% Fe with 29.5% Fe distribution in it. Washing tests at 100 mm size produced a grade of 61.51% Fe with 62.8% Fe distribution for the +13 mm lumps while the −13 mm sand analysed 56.4% Fe with 34.8% Fe distribution in it.

Jigging tests with the −13 mm wet screened product after sizing produced a combined concentrate assaying 59.7% Fe with 24.2% Fe distribution in it.

Scrubbing and wet screening tests at −50 mm size produced −50+10 mm washed lumps

assaying 61.16% Fe with 62.2% Fe distribution and the −10 mm sand analysed 56.24% Fe with 29.0% Fe distribution in it. Sizing followed by jigging of the −10 mm sand produced a combined concentrate assaying 59.47% Fe with 23.0% Fe distribution in it.

Sinters were produced both with wet screened −13 mm sand and washed −9 mm sand portions using the raw materials used as in case of the earlier sample (i.e. upper portion of the main haulage road and Hill No. 1 bench No. 3). Good quality sinters produced under the optimum conditions of 7.0% water, 5% flue dust, 5.0% coke and 25% sinter fines in the sinter mix. Self fluxing sinters of good quality and strength were produced having a basicity of 1.4 to 1.6. Blue dust was used in place of ore fines conveniently upto 30% of the mix.

Sample No. 6

Two samples of iron ore crushed to 200 mm and 100 mm, after removing the −13 mm fines were received at NML by road to study the amount of fines that will be produced during handling; the test conditions were simulated to be similar to those the ore would suffer at the ore handling plant at Visakhapatnam port. The 200 mm and −100 mm samples contained 7.5% and 10.3% of −13 mm fines respectively. These were produced during the transit and handling at the mine head as well as at the Pilot plant. The test procedure consisted of the following steps:

(i) The −200 mm +9 mm lumps to be dropped twice on a M.S. plate from a height of 1.83 meters and to determine the −9 mm fines produced. (ii) The −200 mm +9 mm from the test to be dropped twice on M.S. plate from a height of 3.66 meters and the amount of −9 mm fines produced to be determined. By this test 6.5% of −9 mm fines were produced. (iii) The −200 mm +13 mm lumps to be tested as in case of −200 mm +9 mm sample and after the two drops from 3.66 meter height, the −200 +13 mm lumps to be dropped once from height of 10.98 meters and the quantity of −13 mm fines to be determined.

After two drops each from a height of 1.83 meters and 3.66 meters, 6.9% of −13 mm fines were produced and additional 7.0% of −13 mm fines were produced from the 10.98 mtrs. drop test.

(iv) The −200 mm+100 mm lumps from the ROM sample were crushed to 100 mm top size and tested as indicated in steps 1, 2 and 3. For the two drops from a height of 1.83 meters, 5.9% of −9 mm fines and additional amount of 4.9% for the two drops from 3.66 meters height were produced. 6.8% of −13 mm fines were produced for single drop from 10.98 meters height.

(v) Tests conducted after crushing the −200 mm +50 mm lumps to 50 mm size. The −9 mm fines produced for 1.83 mtrs. and 3.66 meters heights drops were 2.7% each. No shatter tests were conducted with this sample from a height of 10.98 meters.

Sample No. 7

This was a composite sample prepared by mixing 10% ore from Bench No. 3 of Hill No. 1, 10% of ore from the upper part of the main haulage road and 80% from the lower portion of the main haulage road. The sample had the following complete chemical analysis:

Constituent	Assay %	Constituent	Assay %
Fe	60.50	TiO_2	0.08
SiO_2	3.90	MgO	Trace
Al_2O_3	5.30	S	Trace
CaO	0.20	FeO	Trace
P	0.06	LOI	4.90

The ROM sample consisted 200 mm lumps down to fines. Due to practical difficulties the ore was dry screened at −100 mm size and the two sized portions were separately washed and wet screened.

Wet screened −200 mm +100 mm lumps analysed 64.2% Fe with 23.5% Fe distribution in it and the slime analysed 55.0% Fe. The −100 mm ore was washed and wet screened on 40 mm and 10 mm screens. The +40 mm lumps analysed 63.8% Fe with 18.7% Fe distribution and the +10 mm lumps analysed 60.5% Fe with 30.9% Fe distribution. The −10 mm sand and slime analysed respectively 57.5% Fe and 45.4% Fe with 19.2% Fe and 7.0% Fe distribution in them.

Sizing and jigging of the −10 mm washed sand produced a combined concentrate assaying

61.7% Fe with 15.6% Fe distribution in it. Crushing of the +40 mm washed lumps to 40 mm size produced an additional quantity of 9.8% of −10 mm fines assaying 62.2% Fe on dry screening. The +10 mm portion was further stage crushed to −10 mm size and then wet screened for desliming. The wet screened −10 mm sand portion analysed 64.6% Fe.

A representative portion of the washed +40 mm lumps were crushed to 40 mm and then wet screened on 40 mm and 10 mm screens. The +40 mm lumps analysed 64.8% Fe and the +10 mm lumps analysed 64.4% Fe. The −10 mm sand and slime analysed 62.7% Fe and 57.7% Fe respectively. Stage crushing of the +10 mm lumps to 10 mm size followed by desliming produced a sand assaying 64.8% Fe and the slime analysed 57.7% Fe. Sintering tests were conducted with the −9 mm jig concentrate and −9 mm washed fines using (1) Limestone from Bhawantapur quarries assaying 45.19% CaO, 5.1% MgO and 6.6% SiO_2, (2) Dolomite from TISCO assaying 20.56% MgO, 28.56% CaO and 5.04% SiO_2, (3) Flue dust from Rourkela Steel Plant assaying 24.8% Fe, and 11.5% SiO_2, (4) Coke breeze from Durgapur assaying 68.18% F.C., and 23.7% Ash and (5) Mill Scales from Durgapur assaying 71.8% F.C.

High basicity sinters were produced using limestone and lime stone dolomite mixtures under the optimum conditions of 20 to 25% of return fines, 4.5 to 5.7% water, and 6 to 8% coke breeze. Basicity of the sinters was varied from 1.0 to 2.4. Sinters at basicity 1.4 to 1.6 were rather poorer in strength.

Sample No. 8

The test sample was prepared by mixing 40% of porous laminated ore, 20% each of hard laminated ore and soft biscuity ore, 10% of lateritic ore and 5% each of laterite and blue dust ores. Complete analysis of the test sample is as follows :

Constituent	Assay %	Constituent	Assay %
Fe	61.6	S	0.036
SiO_2	1.3	Mn	Trace
Al_2O_3	4.2	TiO_2	0.2
CaO+MgO	Trace	LOI	5.4
P	0.10		

The ROM composite sample composed of 200 mm to fines was sized on 100 mm screen and the +100 mm (23%) lumps were divided into two parts.

The 1st part of the +100 mm lumps was crushed in a jaw crusher to 64 mm size and wet screened. The −64 mm+10 mm lumps analysed 64.7% Fe with 9.5% Fe distribution with reference to the total feed. The −10 mm sand analysed 62.6% Fe with 1.7% Fe distribution (w.r.o). Second portion of +100 mm lumps was crushed to 38 mm top size in a jaw crusher and then wet screened. The −38 mm+10 mm washed lumps analysed 65% Fe with 8.8% Fe distribution (w.r.o) and the −10 mm sand analysed 62.8% Fe with 4.2% Fe distribution.

The original −100 mm ore was scrubbed and wet screened. The −100 mm+10 mm lumps analysed 63.4% Fe with 45.2% Fe distribution and the −10 mm sand analysed 62.7% Fe with 20.7% Fe distribution in it. The slimes analysed 50.0% Fe while the slimes from the wet screening alone of the +100 mm lumps analysed 52.0% Fe.

All the washed lumps were combined and crushed to 38 mm. The combined −38 mm washed lumps represented 58.2% of the feed and analysed 63.9% Fe with 60.4% Fe distribution. The −10 mm sand represented 27.45% of the feed assaying 62.7% Fe with 27.9% Fe distribution and the combined slimes analysed 50.3% Fe.

Sample No. 9

The ore fines received from the Kiriburu Iron ore mines for sintering studies had the following chemical analysis :

Constituent	Assay %	Constituent	Assay %
Fe	63.40	CaO	0.16
SiO_2	1.10	MgO	0.11
Al_2O_3	3.50	FeO	0.12

The sample was said to be of −10 mm+3 mm but contained 8.7% of +10 mm fines and 34.5% of −3 mm fines in it. Sintering tests were conducted with the sample using the following raw materials.

(i) Limestone from Bhavantapur qarries assaying 44.4% CaO, 5.50% MgO and 6.0% SiO_2, (ii) Dolomite supplied by Bokaro Steel Plant assaying 30.0% CaO, 20.5% MgO and 2.6% SiO_2 (iii) Manganese ore from Mansar mines assaying 33.63% Mn, 29.14% SiO_2 and (iv) Coke from TISCO assaying 68.9% F.C. and 25.7% ash

Good quality sinters were produced under the optimum conditions of 7.0% water, 6.5% Coke and 30% return fines. Self fluxing sinters were prepared varying the basicity from 1.1 to 1.9 but the sinters having a basicity of 1.5 showed good shatter stability and porosity. Extended firing tests helped in reducing the coke consumption upto 20%. Addition of 11.0% of Manganese fines helped in increasing the degree of oxidation although the strength was lowered.

Sample No. 10

The sample consisted of −10 mm fines and also contained 1.4% of −100 mesh fines and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	63.62	S	0.04
SiO_2	1.12	P	0.09
Al_2O_3	3.65	TiO_2	0.11
CaO	0.17	LOI	4.50
MgO	0.11		

Sintering tests were conducted using the same raw materials as in case of −10 mm +3 mm fines. Optimum conditions were determined to be 7.0% water, 5.5% coke, and 32.5% return fines for the production of good quality of sinters. Variation of basicity for the production of self fluxing sinters from 1.1 to 1.9 indicated 1.5 to be optimum. Use of dolomite along with the limestone in case of self fluxing sinters had showed a slight increase in the strength.

Sample No. 11

The ore fines were of 3 mm top size and contained 16% of −65 mesh although the sample was said to be comprised of −3 mm +65 mm sized fines only. Complete chemical analysis of the sample was as given under :

Constituent	Assay %	Constituent	Assay %
Fe	62.80	CaO	0.34
SiO_2	1.16	MgO	0.70
FeO	0.31	TiO_2	0.11
Al_2O_3	5.83	P	0.10

All the raw materials used for sintering were the same as used in the earlier cases. The optimum conditions determined for sintering of the ore fines were 6.5% water, 6.0%, coke, and 30% return fines in the sinter mix. A basicity of 1.5 was determined to be optimum for the self fluxing sinters. Upto 10% Mn fines were used without any adverse effect on the sinter quality. Addition of dolomite with limestone helped in increasing the strength of the sinter.

6. Meghatburu Iron Ores

Meghatburu iron ores deposit is actually the extension of Kiruburu iron ore deposits and NMDC is developing the mines to feed the Bokaro Steel Plant.

Sample No. 1

The 100 tonnes sample from Meghatburu mines comprised of 175 mm top size lumps to fines and analysed as under.

Constituent	Assay %	Constituent	Assay %
Fe	61.87	CaO	Trace
SiO_2	2.08	S	Trace
Al_2O_3	4.00	P	0.04
FeO	0.72	TiO_2	0.07
MgO	Trace	LOI	5.70

The sample was stage crushed to 50 mm size and with different lots of the crushed ore dry screening wet screening and washing followed by wet screening tests were conducted.

Dry screening of the −50 mm crushed ore produced a grade of 62.5% Fe distribution for the −50 mm +10 mm lumps. The fines analysed 58.4% Fe. Wet screening tests yielded −50+10 mm lumps assaying 63.5% Fe with 76.6% Fe distribution and −10 mm fines assayed 59.36% Fe with 18.9% Fe distribution while the slimes assayed 46.2% Fe.

Scrubbing followed by wet screening improved the grade of −50+10 mm lumps to 63.6% Fe with 73.3% distribution and the −10 mm sand analysed 60.48% Fe with 21.5% Fe distribution. The slimes analysed 48.72% Fe.

Jigging tests with the −10 mm washed sand after sizing produced a combined concentrate assaying 62.5% Fe with 18.7% Fe distribution.

Sintering tests were conducted with the jig concentrate of −9 mm washed fines. The raw materials used for sintering were (1) Flue dust from Rourkela Steel Plant assaying 24.8% Fe, and 11.5% $Si0_2$, (2) Coke from TISCO assaying 68.7% F.C., and 25.7% ash and (3) Limestone from Nandini mines of HSL assaying 41.6% CaO, 8.5% MgO and 5.26% SiO_2. 7.0% water, 4.5% coke and 25% return sinter fines were found to be optimum in the sinter mix for the production of good sinters. Self fluxing sinters having a basicity range of 1.0 to 2.4 were produced successfully.

Sample No. 2

The sample was prepared by mixing 17.6% Lateritic/Limonitic ore, 13% hard laminated ore 69% powdery ore (55% high silica and 45% high alumina) and 0.4% of blue dust ore, complete chemical analysis of the test sample was as under :

Constituent	Assay %	Constituent	Assay %
Fe	61.15		
SiO_2	3.12	MnO	0.022
Al_2O_3	2.92	P	0.075
FeO	0.65	S	0.012
CaO	0.112	TiO_2	Trace
MgO	Trace	LOI	6.3

Mineralogical examination revealed the presence of goethite, hematite, as major constituents followed by limonite, lepidocrosite and ochre.

The ore was crushed to 75 mm top size and wet screened on 30 mm and 10 mm screens. The slimes were treated in a cyclone. The −70+30 mm lumps were reduced to pass 30 mm screen and were wet screened on 10 mm screen. These slimes were also treated in cyclones. The combined −30+10 mm lumps analysed 62.18% Fe and the −10 mm sand analysed 61.16% Fe. The cyclone underflow analysed 63.22% Fe and the overflow analysed 51.72% Fe.

Washing tests with −75 mm ore followed by sizing on 30 mm and 10 mm screens and reducing the +30 mm lumps to 30 mm top size and wet screening as with the earlier case, produced −30+10 mm lumps assaying 62.17%, while the −10 mm fines analysed 62.12% Fe. The cyclone underflow and overflow analysed 63.78% Fe and 51.39% Fe respectively.

Wet screening of the test sample at 30 mm top size followed by sizing on 10 mm screen and cycloning of the slimes produced −30+10 mm lumps assaying 62.7% Fe. The cyclone underflow analysed 63.52% Fe.

Washing tests at 30 mm size produced a grade of 62.83% Fe for +10 mm lumps and the −10 mm fines analysed 61.4% Fe. while the cyclone under flow and overflow respectively analysed 63.52% Fe and 50.69% Fe.

Another wet screening test conducted with −70 mm on 40 mm and 10 mm screens yielded a grade of 62.5% Fe for both +40 mm and +10 mm lumps. The slimes when treated in cyclone produced an underflow assaying 64.24% Fe and an over flow assaying 51.00% Fe. The −10 mm sand analysed 60.73% Fe. These test results were taken as optimum for the treatment of composite type of ore from Meghataburu mines.

7. Agglomeration of L. D. Dust

At Rourkela Steel Plant L.D. converters are used for steel making and about 60 tonnes of dust comprising of rich oxides of iron ore produced every day. Complete agglomeration tests were taken up at NML with the L.D. dust sample. The L.D. dust contained 30.0% of −325 mesh material and analysed as under :

Constituent	Assay %	Constituent	Assay %
Fe	49.60	CaO	13.71
Fe_2O_3	71.08	MgO	0.92
FeO	1.62	MnO	1.57
Met. Fe	Trace	P	0.13
SiO_2	4.2	S	Trace
Al_2O_3	1.00	Basicity ratio	2.72

Briquettes were prepared using varying combinations of Bentonite, Lime, cement, starch, sulphite lye and molasses. Out of all the combinations 3.5% each of lye and molasses yielded good briquettes having a compression strength of 14.6 Kg/Br.

Alternately pelletizing was also attempted as the sample was readily suitable for pelletization, using varying combination of limestones, molasses, bentonite with water. Pellets prepared with 1% bentonite and 13.6% of water produced a green strength of 3.7 Kg/pellet and 180 Kg/

pellet after heat hardening in pot grate furnace at temperature of 1135°C.

In addition to briqeuetting and pelletization, sintering was also tried with preballed feed. Under the optimum conditions of 13% water, 5% coke and 20% return fines good grade sinters were produced which had a basicity ratio of 2.25.

8. Studies on the Screenability of Composite Iron Ore Samples from Meghataburu Mines, N.M.D.C. Ltd.

Four types of Iron ore samples from Meghataburu Mines designated as (i) High alumina variety (ii) High Silica variety (iii) Compact laminated variety and (iv) Blue dust were received for screening studies with different moisture contents as to pose the screening problem of the ore during monsoon seasons. Screen analysis of the R.O.M. samples is given in Table 2.36.

TABLE 2.36—SCREEN ANALYSIS OF THE R.O.M. SAMPLES

Ore type	High silica	Blue dust	High alumina	Compact Laminated
+30 mm	25.5	4.0	22.4	29.0
—30+10 mm	10.4	6.2	14.9	43.8
—10 mm	64.1	89.8	62.7	27.2
Total	100.0	100.0	100.0	100.0

It is contemplated to prepore a composite sample basically of high alumina and high silica varieties in proportion of 60-70 : 40-30, and also a composite sample along with some amount of the other two varieties.

It was observed during tests that upto 5% moisture, the ore was quite free flowing but with a lot of dust flying. When it is increased around 9%, the dust problem was not there and the handling was easy. With moisture 10% and beyond, there are occassional jamming of chutes, launders, and feeders and blinding of 10 mm screen from 40% to 90%. Hence it was concluded that handling of the Meghataburu iron ore samples were quite normal upto 9% moisture content but started giving trouble with its increase.

9. Pilot Plant Studies on the Flowability and Screenability Characteristics of Iron Ore Samples from Meghataburu Mines, N.M.D.C. Ltd.

Five samples of iron ores from Meghataburu Mines of NMDC were studied for their flowability and screenability characteristics. The samples were composed of Siliceous and Aluminous ores at varying proportions and their screen analysis given a Table 2.37.

TABLE 2.37—SCREEN ANALYSIS OF SAMPLES AS RECEIVED

Sample No. 1 (Sil : Al = 80 : 20)	Sample No. 2 (Sil : Al = 90 : 10)	Sample No. 3 (Sil = 100)	Sample No. 4 (Sil = 100)	Sample No. 5 (Sil = 100)
Size :				
+40 mm	21.2	21.8	20.2	20.2	20.2
—40+10 mm	30.2	23.5	24.1	24.1	24.1
—10 mm	48.6	54.7	55.7	55.7	55.7
Total	100.0	100.0	100.0	100.0	100.0

As desired by the sponsors, each sample was crushed to —40 mm size and flowability and screenability charactersitics of each sample were determined at specific moisture content. The tests indicated that (1) Sample 1 showed poor flowability and screenability at, 7.5% moisture ; (2) The 2nd and 3rd samples showed better flowability and screenability with 7.5% and 8.5% mioisture respectively ; (3) The fourth and Fifth samples (100% siliceous ore) had operational difficulty at 9.5% moisture ; (4) and dry screening with the 100% siliceous ore at 10.5% moisture was found to be very difficult.

These results were attained under controlled laboratory conditions which might be different in actual plant practice.

10. Pelletization Studies on Bolani and Gua Iron Ores Fines Concentrates from Mecon

Reject fines from Bolani and Gua iron ore mines were recieved from MECON-Ranchi for the preparation of heat hardened, ordinary and self fluxing peilets. Various samples and their analysis are as under.

Constituent	Bolani fines		Gua fines		Blue dust
	Current %	Dump %	Current %	Dump %	%
Fe	60.42	61.58	57.82	59.77	63.38
SiO_2	2.60	2.11	2.60	3.06	1.20
Al_2O_3	4.22	3.57	4.88	4.45	5.48
LOI	4.66	4.10	6.58	5.48	3.03

Pellets were prepared from sample with three different compositions by mixing some amount of Blue dust after their beneficiation. (1) All the four samples (2) Gua fines alone and (3) Bolani fines alone. Analysis for the pelletisation feed was as under.

Constituent	Composite II (All the fines) %	Type III (Bolani fines) %	Type IV (Gua fines) %
Fe	60.20	60.76	60.62
SiO_2	4.10	3.80	4.40
Al_2O_3	4.48	4.40	4.49
LOI	5.22	4.90	6.16

Analysis of bentonite and limestone used for the tests was as under :

Constituent	Bentonite %	Limestone %
CaO	3.40	49.50
MgO	2.80	3.35
SiO_2	45.60	4.08
Al_2O_3	26.40	1.92
Fe_2O_3	0.40	1.36
S	—	0.05
LOI	12.30	39.50

Pellet feed was ground to 70-75% -325 mesh and 85-90% -325 mesh levels although dry and wet grinds both in open and closed circuits were tried, it was observed that closed circuit dry grinding yielded better results. A series of tests conducted under different conditians indicated that 1% bentonite and 8 to 9% moisture were optimum for the production of pellets. Limestone upto 10% was added for the production of fluxing pellets. These pellets had an average green strength of 1 Kg/pellet and after heat-hardening (in a pot grate furnace) drying at 380°c to 400°c and in duration at 1200°C to 1250°C.

The pelletising feeds were prepared from the three samples as follows :

The composite II after beneficiation and mixing with blue dust had been made into two samples internal and export grades for detailed pelletization studies. The type III had been amenable for beneficiation resulting in good grade without addition of blue dust. The Type IV sample on the other hand is poorer and for export grade of concentrates, were after addition of about 50% blue dust analysed 2.54% Al_2O_3. The analysis of the feeds is given below.

	Composite II		Type III		Type IV	
%	Internal	Export	Internal	Export	Internal	Export
Fe	62.72	64.4	62.5	64.6	62.1	63.3
FeO	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
SiO_2	2.32	1.74	2.73	1.83	1.85	1.3
Al_2O_3	2.72	2.22	2.38	1.68	3.45	2.54
LOI	40.95	4.0	4.75	4.26	5.10	4.01

In the heat hardening process, though drying and preheating were critical at around a temperature of 380°C, when pronounced bursting tendency was observed. This bursting was almost avoided by careful dehydration, or preheating of the feed beyond 400°C before grinding and balling when the goethite converts into iron oxide losing its water of hydration as well. The pellets produced had very high strength of 298 Kg/ pellets and abrasion resistance of 3.2%.

Test results of the various ore samples are given In the Table 2.38.

Table 2.38—Summary of the Results of Beneficiation Studies on Iron Ore Samples of Orissa

Locality	Feed Assay (%)	Beneficiation Methods	Conc. Assay	Dist. %	
(1)	(2)	(3)	(4)	(5)	
(1) Badampahar	54.11 Fe 6.47 SiO_2 4.92 Al_2O_3	Crushing to 20 mesh, followed by sizing, tabling and mag. separation	61.31% Fe	67.9% Fe	
(2) Bonai iron ore	59.60 Fe 2.23 SiO_2	Crushing to 3 mesh followed by jigging and tabling	62.04	53.7 Fe	
	4.45 Al_2O_3	Calcination at 650 °C for 30 mts.	64.1		
Bolani Iron ores	56.6 Fe	Test at —75 mm size			
Sample No. 1	5.0 SiO_2 6.3 Al_2O_3	Washing +9 mm lumps	60.82 Fe 1.44 SiO_2 4.33 Al_2O_3	62.0 Fe	
		Sizing & HMS of washed lumps	62.81 Fe	51.0 Fe	
		Sizing & HMS —9 mm+6 mm Sand	63.5 Fe	6.7	
		Tests at —50 mm size washing +9 mm lumps	61.5 Fe	58.9 Fe	
		Sizing & HMS of washed lumps	63.81 Fe	48.0 Fe	
		Sizing & HMS washed Sand	60.6 Fe	7.2 Fe	
		Jigging of —6 mm sand	60.6 Fe	7.2	
		Tests at —50 mm washing +9 mm lumps	61.93 Fe	55.5 Fe	
		Sizing & HMS washed lumps	63.0 Fe	47.1 Fe	
		Sizing & HMS of —9+6 mm sand	63.3 Fe	9.4 Fe	
		Test at 63 mm West screening +9 mm lumps	61.2 Fe	58.1 Fe	
		Sizing & HMS of —9+6 mm sand	61.67 Fe	22.6 Fe	Sintering feed
Sample No. 2	56.89 Fe 5.23 SiO_2 7.10 Al_2O_3	Washing at 50 mm size +9 mm lumps	60.6 Fe	70.0 Fe	
		Jigging of .... 9+3 mm sand	58.53 Fe	11.6 Fe	Sintering feed
		Desliming and jigging —3 mm sand	60.92 Fe	6.8 Fe	
		HMS of washed lumps	63.8 Fe	54.4 Fe	
Sample No. 3	62.8 Fe	Washing +9 mm lumps	64.0 Fe	23.2 Fe	
		—9 mm lumps	63.5 Fe	53.9 Fe	
	3.5 SiO_2	Cyclone underflow of slimes	63.2 Fe	15.1 Fe	
	2.8 Al_2O_3	Wet screening +9 mm lumps	63.6 Fe		
		—9 mm lumps	63.1 Fe		
Sample No. 4	63.5 Fe	Dry and wet screening at 25 mm size			
	0.54 SiO_2	—25+10 mm	62.8 Fe	32.2 Fe	
	2.83 Al_2O_3	—10 mm	63.5 Fe		
		Slime	64.4 Fe		
		Wet screening —50+10 mm	62.8 Fe	34.0 Fe	
		—10 mm	63.46 Fe		
		Slimes	63.34 Fe		
		Washing and wet screening			
		—50+10 mm	62.6 Fe	30.6 Fe	
		—10 mm	63.94 Fe	39.5 Fe	
		Slimes	64.34 Fe	39.5 Fe	
		Cyclone treatment of slimes underflow	67.4 Fe		

Table 2.38 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
		+6 mm HMS conc+6 mm jig conc	60.88	10.5 Fe
		Washing at 25 mm —25+10 mm	64.28	62.7 Fe
		—10 mm	59.07	26.5 Fe
		HMS with +10 mm	66.04	61.4 Fe
		+10+6 mm sand	66.34	4.3 Fe
		+6 mm HMS conc+ —6 mm fines	59.88	22.6 Fe
Sample No. 4	60.43 Fe	Washing at 50mm size —50+13 mm	62.62 Fe	67.1 Fe
	2.78 SiO_2	—13 mm	59.63 Fe	27.3 Fe
	5.23 Al_2O_3			
		Wet screening —50 +25 mm +		
		washing of —25+13 mm	63.14 Fe	66.8 Fe Sintering tests
		—13 mm	59.9 Fe	26.7 Fe with both the
		Washing at 25 mm size —25+10 mm	63.4 Fe	65.8 Fe sand products
		—10 mm	59.79 Fe	29.6 Fe were
		Sizing and jigging of —10 mm sand	62.1 Fe	22.0 Fe conducted
Sample No. 5	57.9 Fe	Wet screening at 100 mm		
	3.0 SiO_2	—100+13 mm	61.1 Fe	65.8 Fe
	7.0 Al_2O_3	—13 mm	56.69 Fe	29.5 Fe
		Washing at 100 mm size		
		—100+13 mm	61.5 Fe	62.8 Fe Sintering tests
		—13 mm	56.4 Fe	34.8 Fe with —13 mm
		Jigging with —13 mm (wet screened)	59.7 Fe	24.2 Fe and —10 mm
		Washing at 50 mm size —50+10 mm	61.16 Fe	62.2 Fe sands were
		—10 mm	56.24 Fe	29.0 Fe
		Sizing and jigging of —10 mm	59.47 Fe	23.0 Fe conducted
Sample No. 6		Ore handing tests to determine the fines expected to produce in shifting		
Sample No. 7	60.50 Fe	Wet screened —200 +100 mm	64.2 Fe	23.5 Fe Sintering with
	3.9 SiO_2	Washed —100 mm lumps		untreated and
	5.3 Al_2O_3	—100+40 mm	63.8 Fe	18.7 Fe treated
		—40+10 mm	60.5 Fe	30.9 Fe —10 mm sand
		—10 mm	57.5 Fe	
		Sizing and jigging of —10 mm sand	61.7 Fe	15.6 Fe
Sample No. 8	61.6 Fe	Crushing the +100 mm (ROM) to 64 mm and wet screening —64		
		+10 mm	64.7 Fe	9.5 Fe ⎫
	1.3 SiO_2	—10 mm	62.6 Fe	1.7 Fe ⎪ Dist. %
	4.2 Al_2O_3	+100 mm (ROM) crushed to and		⎭ w.r.o.
		screened —38+10 mm	65.8 Fe	8.8 Fe ⎫
		—10 mm	62.8 Fe	4.2 Fe ⎭
		Washing of —100 (ROM) —100		
		+10 mm	63.4 Fe	45.2 Fe
		—10 mm	62.7 Fe	20.7 Fe
Sample No. 9	63.4 Fe	—10 mm+3 mm fines		
	1.1 SiO_2			

Table 2.38 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
Sample No. 5	58.46 Fe 3.52 SiO_2 6.14 Al_2O_3	Wet screening at —50 mm+10 mm	60.4 Fe	70.6 Fe
		—10 mm	59.1 Fe	23.2 Fe
		Slimes	39.0 Fe	
		Washing and wet screening —50+10 mm	61.0 Fe	67.5 Fe
		—10 mm	59.4 Fe	23.8 Fe
		Slimes	42.71 Fe	
		Washing of 25 mm from 50 mm Combined =10 mm	60.4 Fe	72.8 Fe —50+25 mm lumps unwashed
		—10 mm	58.9 Fe	21.6 Fe
		HMS of washed —50+10 mm lumps at 2.9	63.0 Fe	57.2 Fe
		Cyclone treatment of slimes underflow	53.6 Fe	5.8 Fe
Barsua Iron Ore	52.18 Fe 4.80 SiO_3 11.34 Al_2O_3	Washing at 75 mm		
		—75 mm + 10 mm	55.73 Fe	64.2 Fe
		— 10 mm	51.11 Fe	29.0 Fe
		HMS at 3.0 with lumps (washed)	63.00 Fe	46.8 Fe
		HMS at 3.0 with —10+6 mm	61.70 Fe	8.7 Fe
		—10+6 mm HMS conc. + —6 mm fines	53.68 Fe	22.8 Fe
		Washing at 50 mm		
		—50 mm +10 mm	56.26 Fe	62.6 Fe
		—10 mm Sand	57.37 Fe	29.0 Fe
		HMS with —50+10 mm washed lumps	62.52 Fe	47.4 Fe
		—10+6 mm Sand	63.30 Fe	8.1 Fe
		—10+6 mm HMS conc. + —6 mm fines	53.74 Fe	21.7 Fe
		Washing at 25 mm		
		—25 mm +10 mm	57.46 Fe	52.6 Fe
		—10 mm	52.81 Fe	38.1 Fe
		HMS with washed —25+10 mm at Sp. gr. 3.0	62.6 Fe	45.5 Fe Sintering tests
		HMS with —10+6 mm	63.1 Fe	13.7 Fe were
		Jigging with —6 mm fines	58.5 Fe	8.3 Fe conducted
		—10+6 HMS conc+ —6 mm jig conc.	61.27 Fe	22.0 Fe with —10 mm washed fines
Kiriburu Iron Ores	65.2 Fe			
Sample No. 1	0.92 SiO_2 0.88 Al_2O_3	Screening only lumps		
	63.3% Fe	Crushing and Sizing tests		
	2.52 SiO_2	—13 mm —14 mesh	64.7 Fe	
	1.57 Al_2O_3	—14 mesh	61.1 Fe	
Sample No. 2				
Sample No. 3	60.96 Fe 2.40 SiO_2 4.50 Al_2O_3	Washing at 75 mm size		
		—75+10 mm	63.83 Fe	79.4 Fe
		—10 mm	56.46 Fe	15.3 Fe
		HMS at 2.9 washed —75+10 mm lumps	65.57 Fe	72.3 Fe
		—10+6 mm sand	65.8 Fe	3.4 Fe
		+6 mm HMS conc + —6 mm fines	57.55 Fe	15.3 Fe
		Washing at 50 mm size —50+10 mm	64.18 Fe	78.0 Fe
		—10 mm	57.37 Fe	16.3 Fe
		HMS at 2.9 with washed +10 mm	65.88	67.9 Fe Sintering tests
		—10+6 mm	62.9	4.4 Fe with —10 mm
		Jigging of —6 mm	59.6	6.3 Fe washed sand

Table 2.38 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
Sample No. 10	63.32 Fe 1.12 SiO_2 3.65 Al_2O_3	—10 mm fines		
Sample No. 11	62.81 Fe 0.31 SiO_2 1.16 Al_2O_3	—3 mm+65 mesh		
Meghataburu Iron Ores				
Sample No. 1	61.87 Fe 2.08 SiO_2 4.00 Al_2O_3	Dry screening at 50 mm size —50+10 mm —10 mm Wet screening at 50 mm —50+10 mm —10 mm Washing at 50 mm —50+10 mm —10 mm Sizing & Jigging of —10 mm	 62.5 Fe 58.4 Fe 63.5 Fe 59.36 Fe 63.6 Fe 60.48 Fe 62.5 Fe	 81.3 Fe 18.7 Fe 76.6 Fe 18.9 Fe 73.3 Fe Sintering tests 21.5 Fe were 18.7 Fe conducted with jig conc.
Sample No. 2	61.15 Fe 0.65 SiO_2 3.12 Al_2O_3	Wet screening at —75 mm followed by crushing to 30 mm wet screening —30+10 mm —10 mm Cyclone treatment of slimes underflow Washing at 75 mm followed by crushing and wet screening of +30 mm —30+10 mm —10 mm Cycloning of slimes underflow Wet screening at 30 mm —30+10 mm —10 mm Cyclone underflow of slimes Washing at 30 mm —30+10 mm —10 mm Cyclone underflow of slimes Wet screening at —70 mm —70+40 mm —40+10 mm Cyclone underflow of slimes	 62.18 Fe 61.16 Fe 63.22 Fe 62.17 Fe 62.12 Fe 63.78 Fe 62.7 Fe 61.42 Fe 63.52 Fe 62.83 Fe 61.49 Fe 63.52 Fe 62.55 Fe 62.55 Fe 64.24 Fe	
Meghataburu Iron Ore Mines, from N.M.D.C.	Composite of (1) High Alumina (2) High Silica (3) Compact Laminated (4) Blue dust.	Screenability test of R.O.M.	5% moisture 9% moisture 10% moisture & beyond Optimum moisture	Free flowing with loto flying dust. No dust. Handling very easy. Blinding of screens, Tarceming of Chutes, launders etc. %—9% from the above tests.
Meghataburu Iron Ore Mines, from N.M.D.C.	Five sample prepared from siliceous and Aluminous ores mixed in different ratios.	Flowability & screenability characteristics after crushing to —40 mm. —40 mm	*Sample 1* *Sample 2*	(Sil:Al-80:20)—Poor flowability & screenability at 7.5% moisture. (Sl:Al-90:10)—Better

Table 2.38 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
			Sample 3	flowability and screenability at 7.5% moisture. (Sil:100)—Better flowability and screenability at 8.5% moisture.
			Sample 4 & 5	(Sil-100)—Operational difficulty at 9.5% moisture.
			Dry screening of 100% siliceous ore at 10.5% moisture was found very different.	
Magnetite from Bharat Coking Coal Ltd., Ranchi.	Fe-59.48%	Tabling at —48mes Tabling at —65mes High intensity wet magnetic separation	Fe-68.13% Fe-69.23%	Fe-84.17% Fe-79.1%
		at —48 mesh at —65 mesh (opt.) at —100 mesh (opt.)	Fe-69.52% Fe-70.1% Fe-70.17%	Fe-90.2% Fe-88.3% Fe-82.1%

Reject Fines from Bolani Iron Ores Mines and Gua Iron Ore Mines.	*Bolani Mines*	Fe	SiO_2	Al_2O_3	LOI	Pelletisation, and heat hardening for preparation of ordinary and self fluxing pellets using, bentonite (binder) and limestone (flux). The optimum conditions are :
	(a) Current	60.42	2.6	4.22	4.66	
	(b) D mp	61.58	2.11	3.57	4.10	
MECON—Ranchi.	*Gua Mines*					
(a) Current	(a) Current	57.82	2.60	4.88	6.58	Pellet feed : 70-75%—325 mesh
(b) Dump	(b) Dump	59.77	3.06	4.45	5.48	Bentonite -1%
	Blue dust	63.38	1.2	5.48	3.03	Moisture -8-9%
						Limestone -10%

	Composite samples prepared with the above for internal use and export grade.	Drying and preheating-380°C Induration temp.1200°C-1250°C Green strength attained-1 Kg/pellet Heat hardened pellets strength-298 kg/pellet.

References

1. Dressing of low grade iron ore from Badampahar—NML IR No. 106/57 by N. N. Subramanyan & P. I. A. Narayanan.
2. Beneficiation of Iron ore sample from Bonai—Orissa NML IR No. 119/58—by G. P. Mathur, B. L. Sengupta & P. I. A. Narayanan.
3. Pilot Plant studies on beneficiation and sintering of Bolani Iron ore for Durgapur Steel Plant of HSL—NML IR No. 220/61 by S. B. Dasgupta, S. K. Banerjee, P. V. Raman, G. P. Mathur, G. V. Subramanya & P. I. A. Narayanan.
4. Further Pilot Plant studies on beneficiation of Iron ore from Bolani for Durgapur Steel Plant of HSL—NML IR No. 276/63 by M. V. Ranganathan, A. Peravadhanulu, S. B. Dasgupta, G. S. Ramakrishna Rao, G. P. Mathur & P. I. A. Narayanan.
5. Studies on the production of high basicity sinters from the beneficiated Bolani Iron ore fines, for Durgapur Steel Plant—NML IR No. 309/64—by P. K. Sinha, G. V. Subramanya & P. I. A. Narayanan.
6. Beneficiation studies on Bolani ore fines received from M/s. Bolani Ores Ltd., Orissa—NML IR No. 634/71 by B. L. Sengupta & G. P. Mathur
7. Pilot Plant studies of the beneficiation of iron ore sample I received from Bolani Ores Ltd.—Orissa NML IR No. 720/73—by R. K. Kunwar, V. K. Sharma, S. C. Maulik, B. L. Sengupta & G. P. Mathur.
8. Pilot Plant studies sample II—Orissa NML IR No. 740/73—by S. C. Maulik, R. K. Kunwar, B. L. Sengupta & G. P. Mathur.

9. Pilot Plant studies on beneficiation and sintering of Barsua Iron Ore for Rourkela Steel Plant of HSL—NML IR No. 236/62—by P. V. Raman, S. K. Banerjee, S. B. Dasgupta, G. P. Mathur, G. V. Subramanya & P. I. A. Narayanan.

10. Screen analysis and chemical analysis of Iron ore samples from Kiriburu—NML IR No. 184/60—by S. K. Banerjee, B. L. Sengupta & P. I. A. Narayanan.

11. Crushing tests with a sample of iron ore from Kiriburu—NML IR No. 204/61—by S. B. Dasgupta, G. P. Mathur & P. I. A. Narayanan.

12. Pilot Plant studies on beneficiation and sintering of Kiriburu Iron Ore for NMDC Ltd.—NML IR No. 244/62—by S. B. Dasgupta, P. K. Sinha, S. K. Banerjee, G. P. Mathur, G. V. Subramanya & P. I. A. Narayanan.

13. Further Pilot Plant studies on beneficiation and sintering of a mixed iron ore sample from (1) upper portion of the main haulage road and (2) Bench No. 3 of Hill No. 1 of Kiriburu mines of NMDC Ltd.—NML IR No. 286/64—by M. V. Ranganathan, A. Peravadhanulu, S. B. Dasgupta, G. S. Ramkrishna Rao, G. P. Mathur & P. I. A. Narayanan.

14. Pilot Plant studies on beneficiation and sintering from Hill No. 1, Bench No. 2, and Hill No. 2 Bench No. 2 of Kiriburu iron ore mines of NMDC Ltd.—NML IR No. 288/64—by A. Peravadhanulu, Y. A. Joglekar, S. B. Dasgupta, G. S. Ramakrishna Rao, G. P. Mathur & P. I. A. Narayanan.

15. Investigation on the generation of fines from Kiriburu Iron ore during transport and handling—NML IR No. 318/65—by S. K. Dhar, G. P. Mathur & P. I. A. Narayanan.

16. Pilot Plant studies on (1) Beneficiation of an iron ore sample from Kiruburu Mines of NMDC, (2) Production of additional —10 mm fines and (3) Production of high basicity sinters for Bokaro Steel Plant—NML IR No. 325/65—by R. K. Kunwar, A. Peravadhanulu, N. Chakravarthy, G. S. Ramakrishana Rao, G. P. Mathur & P. I. A. Narayanan.

17. Studies on crushing and washing of a mixed iron ore sample from Kiriburu mines of NMDC for supply of ore to Bokaro Steel Plant—NML IR No. 511/69—by R. K Kunwar, P. K. Sinha, G. P. Mathur & P. I. A. Narayanan.

18. Studies on the production of fluxed sinters with the —10+3 mm iron ore fines from Kiriburu Iron ore mines for Bokaro Steel Plant—NML IR No. 682/72 by P. K. Sinha, P. V. Raman, B. L. Sengupta, S. K. Banerjee, & G. P. Mathur.

19. Studies on the production of fluxed sinters with the using —3 mm +65 mesh iron ore fines from Kiriburu Iron Ore mines for Bokaro Steel Project—NML IR No. 702/72—by H. B. Barari, B. L. Sengupta, S. K. Banerjee & G. P. Mathur.

20. Studies on production of fluxed sinters using —10 mm +65 mesh composite iron ore fines from Kiriburu Iron ore mines for Bokaro Steel Project—NML IR No. 683/72—by R. Ganesh, B. L. Sengupta, S. K. Banerjee & G. P. Mathur.

21. Beneficiation and sintering studies on a sample of Iron ore from Meghataburu mines of NMDC—NML IR No. 363/66—by M. V. Ranganathan, N. Chakravorthy, B. L Sengupta, G. S. Ramakrishna Rao, G. P. Mathur & P. I. A. Narayanan.

22. Pilot Plant beneficiation studies on a composite sample of iron ore from Megahtaburu mines of M/s. NMDC Ltd. NML IR No. 810/74—by R. K. Kunwar, S. C. Maulik, Joga Singh, B. L. Sengupta & G. P. Mathur.

23. Agglomeration studies on L. D. Dust from Rourkela Steel Plant of HSL—NML IR No. 701/72—by H. Patnaik, B. L. Sengupta, S. K. Banerjee & G. P. Mathur.

24. Studies on the Screenability of Composite Iron Ore samples from Meghataburu Mines—N.M.D.C. Ltd., by P. D. Prasada Rao, B. L. Sengupta & G. P. Mathur—IR No. 817/75.

25. Pilot Plant Studies on the flowability and screenability Characteristics of iron ore samples from Meghataburu Mines, N.M.D.C. Ltd.,—by R. K. Kunwar, P. K. Sinha, S. K. Banerjee and G. P. Mathur—IR No. 838/75.

26. Studies on pelletisation characteristics of Iron ore fines concentrates from Bolani and Gua Mines sponsored by MECON for central pelletisation Project in the Bihar-Orissa Region—by N. Chakravarthy, H. Patnaik, R. K. Kunwar & G. P. Mathur IR No. 861/76.