Beneficiation of low grade manganese ore fines

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ABSTRACT

The availability of ferro-manganese grade ore is limited in India while the requirement of this grade of ore is expected to increase manifold, considering the projected steel production of about 30 million tons by 2000 A. D. To meet the growing demand of manganese ore, to improve the metallurgical and economic performance of the operating mines and also to extend the life of limited manganese ore reserves in the country, it is imperative to install suitable beneficiation and agglomeration facilities.

A recent innovation in the field of heavy media separation of mineral fines is the Dyna Whirlpool process. The paper examines the feasibility of adopting the process for the beneficiation of low grade manganese ore fines based on the experience of this process in Brazil and the amenability of Indian ores to this process, as established by pilot plant tests conducted in foreign laboratories. It also reviews the performance of a manganese ore sintering plant designed, fabricated and installed by an Indian agency at Chandrapura, Maharashtra.

Introduction

Manganese ore and its alloys play an important role both in the metallurgical and non-metallurgical industries. Metallurgical applications probably account for 97 to 98 per cent of the total manganese ore consumption while the rest is being used in the manufacture of dry cell batteries and chemicals.

It may be pointed out that steel, no matter what grade or type, cannot be made and shaped without the appropriate amount of manganese in it; and there is no satisfactory substitute for manganese. It is estimated that about 95 per cent of the total manganese ore is ultimately consumed in the production of iron and steel, either directly as ore in the blast furnaces or as ferro-manganese and metal in steelmaking.

Manganese ore is mined by both underground and surface methods depending upon the geological setting of the deposits. The manganese ore is usually hand sorted into lump ore and fines. The manganese content in the lump ore is higher compared to that of the fines. At present, the manual sizing and sorting of manganese ore practised in India give an yield of about 30 to 55 per cent of saleable manganese ore from the r.o.m. ore and the ore fines are being stockpiled at the mines, since there is no market for the same.

Taking into consideration the relevant factors in the Indian situation, namely manganese being an essential ingredient for steelmaking, limited reserves of proved manganese ore, low

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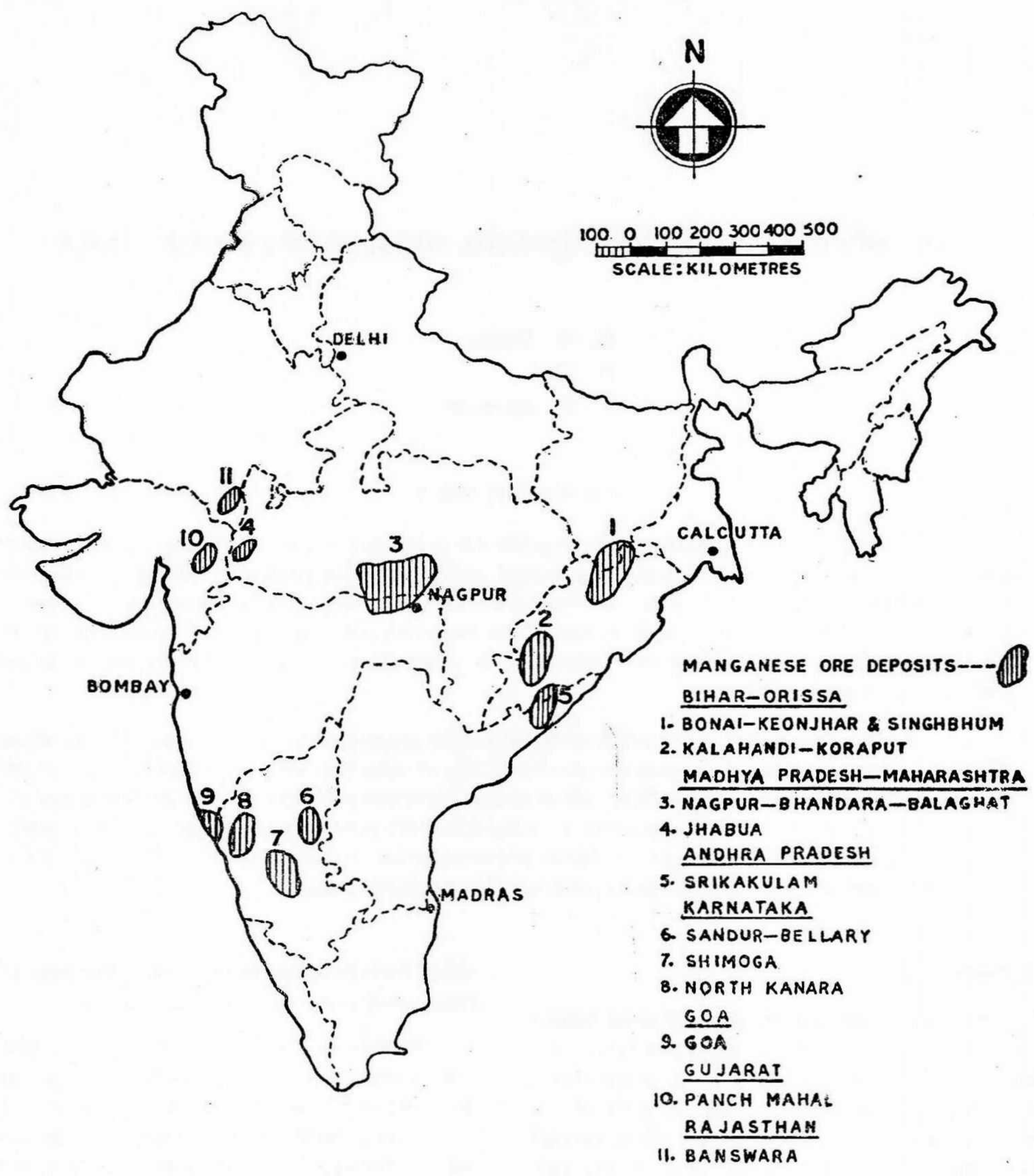

FIG. - 1 DISTRIBUTION OF MANGANESE ORE DEPOSITS IN INDIA

recovery of saleable ore and progressive growth of steel production of the country, the installation of suitable beneficiation including agglomeration facilities to beneficiate the low grade manganese ore fines and agglomerate them and also to improve the lump recovery, is considered absolutely nccessary for the conservation of the country's limited reserves.

This paper briefly reviews India's manganese ore reserves, grade, production, future anticipated demands etc and examines the feasibility of adopting Dyna Whirlpool Process, a recent innovation in the field of heavy media separation, for the beneficiation of low grade manganese ore fines as well as sintering of the concentrate.

Manganese Ore Deposits

The manganese ore was first produced in Visakhapatnam district, Andhra Pradesh in 1892. India was the largest manganese ore producer in the world until 1912, when the USSR overtook her, followed by South Africa, Australia, Brazil, Gabon etc.

The manganese ore deposits, confined entirely to the rocks of Pre-Cambrian age, are scattered throughout the country as can be seen from Fig. - 1. They mostly occur in Maharashtra, Madhya Pradesh, Andhra Pradesh, Bihar, Orissa, Karnataka, Goa and Gujarat. The main deposits are located in the Nagpur-Bhandara-Balaghat belt of Maharashtra and Madhya Pradesh.

Mineralogically the deposits are characterised by the presence of primary minerals like braunite, bixbyite with/without hollandite, jacobsite and hausmannite Pyrolusite, psilomelane and cryptomelane are the secondary minerals; while quartz, biotite, rhodonite, tourmaline, piedmontite etc constitute the gangue minerals.

Reserves : The recoverable reserves of manganese ore in India have been placed at 80 million tons, consisting of only about 12 million tons of proved, 18 million tons of probable and the rest as possible reserves. The zonewise, categorywise and gradewise recoverable ore reserves of India as on 1.1.75 are given in Table-1.

TABLE — 1

Zonewise, Categorywise and Gradewise recoverable manganese ore reserves of India as on 1-1-75

		Recoverable reserves estimated by GSI & IBM (million tons)				Gradewise recoverable reserves (million tons)			
Zone	State	Measured	Indicated	Inferred	Total	+46%Mn	35 to 46%Mn	25 to 35%Mn	Total
A.	Bihar-Orissa	5.95	5.78	19.26	30.99	4.62	8.41	17.96	30.99
B.	M.P.-Maharashtra (including Adilabad Dist. of A.P.	5.92	6.11	8.60	20.63	12.66	6.32	1.65	20.63
C.	Andhra Pradesh (Garividi/ Chipurapalle)	—	0.88	0.37	1.25	—	—	1.25	1.25
DI.	Karnataka (Bellary-Hospet including Sandur)	—	1.83	11.63	13.46	—	4.90	8.56	13.46
DII.	Karnataka (Hassan, Shimoga, Tumkur, Chitradurg)	—	—	2.48	2.48	—	0.22	2.26	2.48
E.	N. Kanara including Kalindi area of Karnataka	—	—	4.19	4.19	—	—	4.19	4.19
F.	Goa	—	3.28	—	3.28	—	—	3.28	3.28
G.	Gujarat, Rajasthan & other states	—	—	3.22	3.22	—	3.03	0.19	3.22
	TOTAL	11.87	17.88	49.75	79.50	17.28	22.88	39.34	79.50

Source : Indian Bureau of Mines.

TABLE — 2

Typical Chemical Analyses of Indian Manganese ores

	Mn%	Fe%	Mn+Fe%	SiO_2+ Al_2O_3%	P%
Madhya Pradesh/Maharashtra					
Standard peroxide	58.50	2.75	—	2	0.32
Dongri ore	51.00	6.50	—	4	0.30
Oriental mixture	49 25	7.50	—	15	0.15
Other high grades	46/48	9.00	—	15	0.15/0.20
Medium grade - I	44/46	12.00	—	15	0.15/0.18
Medium grade - II	38/40	12.14	—	15	0.15/0.18
Karnataka					
High grade	46/48	10	—	14	0.10
Medium grade	44 46	10/12	—	15	0.10
Low grade	30/30	16/17	48/50	15	0.08
Orissa/Bihar					
High grade	46/48	9/10	—	12	0.10
Medium grade	44/46	9/10	—	12	0.10/0.12
Low grade	30/30	18/20	48/50	15	—
Goa					
Medium grade	38/40	15/16	—	15	0 08
Ferruginous manganese ore	28/30	18/20	50	15	0.10
Manganiferous iron ore	15/18	28/31	50	16	0.10
Black iron	7/10	42/45	52	12	0.08

Source : "Manganese : The other uses", A study of the non-steelmaking applications of manganese — Stanley A. Weiss.

Grade : On the basis of their chemical characteristics and commercial uses, the manganese ores produced have been classified as follows :—

i) Manganese dioxide ore

ii) High grade ore (Mn content 46% and above)

iii) Medium grade ore (Mn content below 46% and upto 35%)

iv) Low grade ore (Mn content below 35% and upto 25%)

v) Below 25 per cent Mn.

Quality requirement : The main factors governing the suitability of manganese ore for the production of high-carbon ferro-manganese are the manganese to iron ratio (Mn:Fe) and the phosphorus content of the ore.

Typical chemical analyses of Indian manganese ores are given in Table - 2.

The Mn:Fe ratio is important in view of the lower manganese yield in metal as compared to iron. In smelting the recovery of iron in alloy is about 90 per cent while that of manganese is only about 68 to 80 per cent. The Mn:Fe ratio generally specified in the ore is 7:1 for high-carbon ferro-manganese containing 75 per cent manganese.

In order to reduce the slag volume, the manganese content in the ore should be as high as possible. Silica and alumina are the slag forming constituents and higher contents of these

TABLE — 3

Categorywise and Statewise production of manganese ores in 1979

(in tons)

State	High grade +48%Mn	High grade 46-48%Mn	Medium grade 35-46%Mn	Low grade 25-35%Mn	Below 25%Mn	Total
Orissa	15,417	69,879	161,105	382,405	3,566	632,372
Bihar	12	139	825	7,971	—	8,947
Madhya Pradesh	133,769	34,729	66,802	27,287	169	262,756
Maharashtra	58,741	64,901	17,827	60,482	1,915	203,866
Karnataka	350	1,343	138,937	313,163	4,897	458,690
Andhra Pradesh	—	12,348	14,793	43,656	38,201	108,998
Goa	1,415	2,101	5,367	52,261	15,687	76,831
Gujarat	—	—	3,370	—	—	3,370
All India (Total)	209,704	185,440	409,026	887:225	64,435	1,755,830

Source : Indian Minerals Year Book 1978 & 1979, IBM, 1982, P. 757.

in the ore lead to greater slag formation, resulting in higher energy consumption due to the heat carried away by the slag Hence, the combined silica and alumina in the ore should preferably not exceed 10 to 11 per cent. Further, if the alumina content in the ore exceeds 4 per cent, the slag becomes viscous and creates difficulties during tapping.

Taking the abovs factors into consideration, it is desirable to use manganese ores conforming to the following specification, for ferro-manganese production :

		Percentage
Mn	...	48 (min)
Fe	....	6 to 7
SiO_2	...	6 (max)
Al_2O_3	....	4 (max)
P	...	0 15 (max)

Production · The categorywise and statewise production of manganese ores in 1979 is given in Table - 3. It can be seen from the table that Orissa produces the maximum quantity of medium and low grade ores while Madhya Pradesh produces the maximum quantity of high grade ores, followed by Maharashtra.

Future anticipated demand : The annual production of crude steel for 1980-81 with the corresponding consumption of manganese ore and equivalent manganese and also the projected annual requirements corresponding to the projected steel production of 22 and 30 million tons per annum by 1990 and 2000 A. D. respectively are given in Table - 4.

It will be clear from Table 4 that consumption of mananese ore will go up by about 3 and 4 times at the 22 million and 30 million-ton stages of steel production, resulting in the faster depletion of our reserves.

Considering the proved reserves and progressive increase in consumption of manganese ore in iron and steel industry, it is imperative to install beneficiation facilities to improve the recovery of saleable ores ; and to upgrade the low grade fines and agglomerate them for use as feed material for ferro-manganese production.

Manganese Ore Beneficiation

There is a growing demand for richer ore with stringent stipulation of size in the domestic and international market. This has resulted in accumulation of large quantities of inferior grade ore fines at the mines because of limited de-

TABLE — 4

Projected Annual Demand of Manganese Ore by 1990 and 2000 A. D.

(Thousand tons)

Crude steel production[1] capacity	Consumption/requirement		Total consumption/requirement[4]	
	Manganase ore	Ferro manganese	Manganese	Manganese ore
7,546[2]	477[3]	111[3]	226	755
22,000	1,391	324	660	2,200
30,000	1,896	441	900	3,000

NOTES :

1) The figures for curde steel production do not include productions from Mini Steel Plants. (Ref. IIM Report on Utilisation Planning of Country's Limestone & Dolomite Resources for Iron & Steel Industry, March 1980, p 6.2).

2) Actual figure for 1980-81 as indicated in Indian Iron & Steel Statistical Bulletin, Annual Vol. 1981, published by Indian Institute of Metals, p. 2.

3) Ibid, p. 38.

4) Computed on the basis of 30% manganese in ore and 75% manganese in Fe-Mn.

mand. In order to put these inferior grade ore fines to productive use and make them saleable, systematic beneficiation of the fines followed by agglomeration of the concentrate is gaining greater importance in the manganese ore-producing countries all over the world.

Beneficiation of ores may be defined as the method of upgrading and enriching the useful mineral content of the ores, by removing undesirable and deleterious components. The processes adopted depend on the physical and chemical characteristics of the ore minerals, to take advantage of properties like specific gravity, magnetism, surface characteristics etc. The beneficiation processes normally employed are washing ; gravity concentration - jigging, heavy media separation, spiralling and tabling ; and magnetic separation and floatation.

Most of the manganese ores are being presently subjected to beneficiation ranging from simple crushing, classification, washing and jigging to heavy media separation, also known as sink-float separation, to achieve higher recovery of saleable ore and to obtain a high grade concentrate. There have been significant developments in recent years in sink-float separation technology.

Two main types of sink-float separation are practiced currently. In the first type, the separation is conducted in a relatively quiescent medium. This type of separation is termed as "static" and typified by cone and drum separators. The second type employs centrifugal force to assist the separation and is termed as "dynamic". The dynamic heavy media devices are typified by hydrocyclone and the Dyna Whirlpool separator. The Dyna Whirlpool process is briefly discussed below.

Dyna Whirlpool Process

The Dyna Whirlpool (DWP) process was originally developed for coal washing, but has since found extensive applications in the treatment of metallic minerals such as iron, manganese and chromite ores ; tin and tungsten ores ; and non-metallic minerals, namely fluorspar, gypsum, barite etc because of the following techno-economic advantages :

i) it can be adopted for more effective mineral concentration at a lower cost, wherever there is a difference in specific gravity between the valuable constituents and worthless gangue ; and

ii) it has extended the heavy media process, the most efficient of the gravity methods, to the treatment of fine sized materials, which was not possible earlier with the available equipment.

In view of these advantages, the process has become popular and today there are about two hundred DWP separatory vessels in operation all over the world.

DWP separatory vessel : The heart of the DWP process is the separatory vessel. The separatory vessel is a straight-walled cylinder of standard length and diameter. It is fitted with a head at each end and is operated in an inclined position at various angles. The DWP separatory vessel is shown in Fig. 2.

The heavy medium used in the process is finely ground magnetite or ferro-silicon or a mixture of the two, according to the density of medium required for optimum economic separation. These two solid substances are used as media because they possess the required physical characteristics, such as resistance to corrosion, adequate specific gravity, reasonable cost, and ease of separation and concentration.

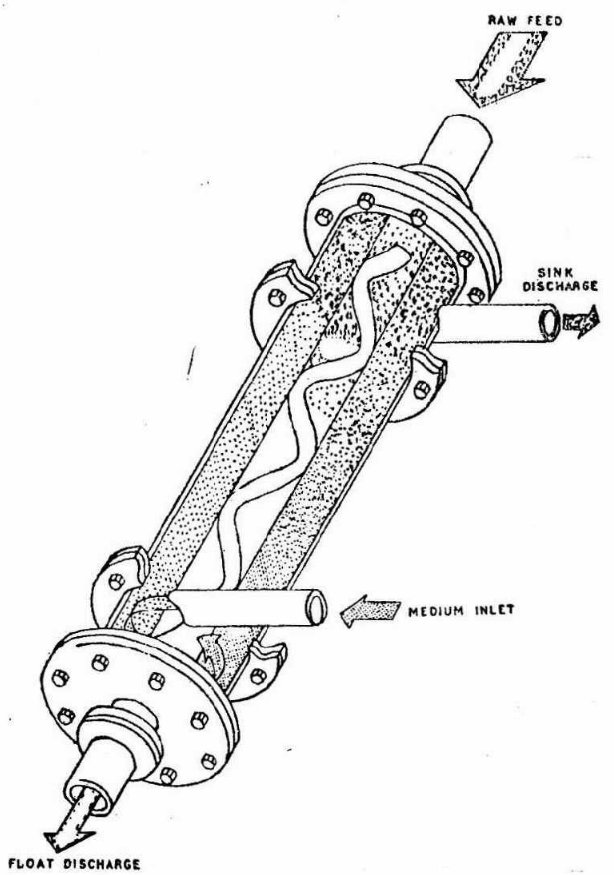

FIG. 2 - DYNA WHIRLPOOL SEPARATORY VESSEL

The laboratory analog of heavy media separation is heavy liquid separation. The heavy liquid tetrabromethane or a mixture of tetrabromethane and chloroethane is used as separation media to ascertain the effective separation gravity to be used as inlet media gravity which would ensure optimum recovery of useful mineral components as well as stipulated grade of concentrate.

The separator can treat materials containing particles of sizes ranging from 50 mm to 65 mesh. However, the material of 6 mm to 28 mesh is considered as the optimum feed for the effective operation of DWP separator.

The prepared feed is sluiced into the device with some of heavy medium through the feed pipe. The centrifugal forces generated by the medium, which is pumped tangentially under pressure into the vessel through an inlet pipe near the lower end of the cylinder, cause the heavy mineral particles to be forced towards the wall of the vessel, and these are removed as the "sink" product through a tangential pipe located near the top of the cylindrical section, together with a portion of the medium. The light minerals are carried downwards in the inner section of the separator and are discharged at the bottom of the vessel along with the medium, as the "float" product.

The sink and the float materials are delivered to a drain and spray screen which is provided with a partition to receive sink and float products separately. The discharge end of the screen is equipped with water spraying arrangement.

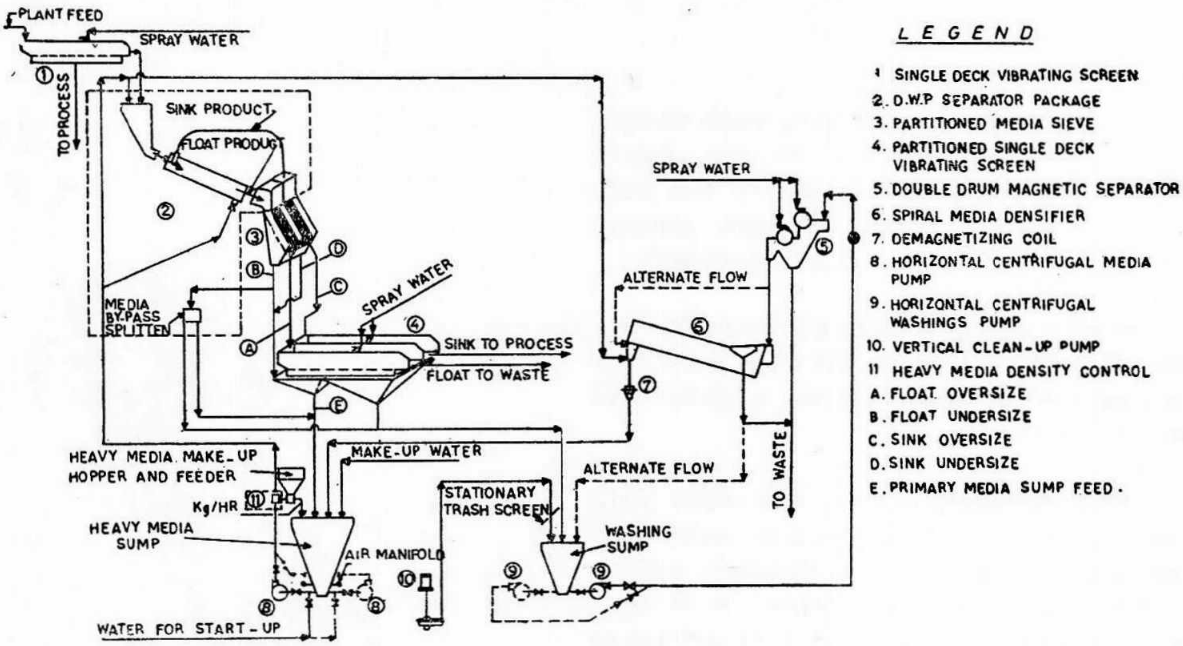

FIG. 3 — DYNA WHIRLPOOL HEAVY MEDIA SYSTEM PROCESS FLOWSHEET

The underflow obtained from the feed end of the screen is collected in a dense medium sump fitted with a pump which delivers the medium to the DWP vessel at a predetermined pressure. The underflow of the discharge end of the screen is collected in a separate dilute medium sump fitted with a vertical pump. The dilute medium solution is fed into a double drum magnetic separator equipped with permanent magnets having field strength between 900 and 1000 gauss. The medium recovered by magnetic separation is treated in a densifier and returned to the dense medium sump for re-use. A typical Dyna Whirlpool process flowsheet is shown in Fig. - 3.

DWP Plants for Manganese ore Beneficiation

The Dyna Whirlpool plants for beneficiation of manganese ore fines have been installed by ICOMI in Brazil and Cia. Minera de Autlan in Mexico.

ICOMI DWP Unit

The ore characteristics, operating parameters and the results obtained from the Dyna Whirlpool unit installed by ICOMI in Brazil for the beneficiation of manganese ore fines are presented below to highlight the suitability of the process for the beneficiation of low grade manganese ore fines.

ICOMI (Industria e Commercio de Minerios, S. A.) is the largest manganese ore producer in Brazil. The mining operation was started in 1957 at Serra do Navio deposits in Ampa. The estimated reserves amount to about 16 million tons having more than 45 per cent manganese.

Mineral composition : These deposits, like the Indian deposits. belong to Pre-Cambrian age. The ore consists primarily of the manganese minerals cryptomelane and pyrolusite with subordinate manganite; alumina minerals - clay and hydrated aluminium silicate; and iron minerals - goethite.

Washing plant : The ore is mined by opencast mining method and the r c m. ore analysing 41 per cent manganese, 7.5 per cent iron, 9.5 per cent alumina and 6.4 per cent silica, is fed to the washing plant. The washing plant is

TABLE — 5

Chemical analyses of washing plant products including sizes

Products	Size in mm	Mn%	Fe%	SiO_2%	Al_2O_3%	Ratio Mn/Fe
Lump :						
Grosso	75 to 13	48.5	5.8	2.5	5.2	8/1
Bitolado	13 to 8	48.0	6.0	2.2	5.0	8/1
Fines :						
Miudo	8 to 0.833	43.0	8.0	5.0	7.0	5/1
Fino	0.833 to 0.15	31.0	10.0	14.0	12.0	3/1

TABLE — 6

Chemical analyses of feed and concentrate

Description	Size in mm	Chemical analyses				Ratio Mn/Fe
		Mn%	Fe%	SiO_2%	Al_2O_3%	
Feed	6 to 0.833	43.3	7.7	4.8	8 4	5.6/1
Concentrate	6 to 0.883	45.4	6.4	3.3	7.1	7.1/1

equipped with a gyratory crusher, a four-stage screening, a scrubber and a set of rake classifiers. The chemical analyses of washing plant products including sizes are given in Table - 5.

The ore fines continued to be stockpiled in the mines, since they were not saleable in the world market. ICOMI, therefore, decided to install a concentration plant comprising a Dyna Whirlpool unit and Humphrey spiral unit to beneficiate the fines by removing Al_2O_3 and SiO_2 from Miudo (8 to 0.833 mm) and Fino (0.833 to 0.15 mm) respectively.

Two DWP units of abour 395 mm diameter were successfully commissioned in March 1972. They operate in parallel and can handle about 160 tons per hour. Ferro-silicon slurry is used as separating heavy medium and the separating density of 2.8 to 3.2 gm/cm^3 is used depending on the fines grade. medium is pumped at a pressure of 0.5 to 0.7 kg/cm^3. The weight and manganese recoveries of about 70 and 80 per cent respectively are achieved in the plant. The ferro-silicon consumption is about 0.35 to 0.50 kg/ton. The chemical analyses of feed and concentrate are given in Table 6.

ICOMI have also installed a pelletising plant of 220,000 tons capacity per year. The pellet feed is prepared by reduction roasting and magnetic separation of a mixture of concentrates obtained from DWP and Humphrey spiral units. The plant produces pellets analysing 55.1 per cent manganese and Mn:Fe=8.7:1.0.

In this context, it may be pointed out that the representative samples collected from two of our manganese ore mines have already been subjected to Dyna Whirlpool tests in the laboratories of internationally reputed agencies and the results obtained are extremely encouraging, in respect of higher recovery of saleable ore and appreciable upgrading of manganes ore fines.

Preliminary capital and production costs : The capital investment required for installation of a 395 mm (15.5″) Dyna Whirlpool separatory vessel with ancillaries, namely screens, magnetic separator, densifier, pumps etc capable of processing about 275,000 tons of low grade manganese ore fines per year would be around Rs. 1.5 crores of which about 20 per cent will be in foreign exchange.

Considering 70 per cent weight recovery, the production cost per ton of concentrate excluding cost of raw material and fixed charges would amount to about Rs. 20.00.

Agglomeration : The concentrate produced by the beneficiation of low grade manganese ore fines cannot be directly used in the smelting furnaces because of its fineness. Therefore, to make the concentrate suitable for the furnace feed, it has to be agglomerated. Commercially proven agglomeration processes are pelletising, briquetting and sintering. As mentioned earlier, a pelletising plant for agglomeration of manganese ore concentrate has been installed by ICOMI, Brazil. Sintering plants for the agglomeration of manganese concentrate/fines have been installed in a number of countries, namely Japan, Australia, Hungary, India etc; and a briquetting plant at Tempico, Mexico, by Cia Minera Autlan.

Pelletising : The finely ground manganese ore concentrate is amenable to pelletising and the pellets produced are physically and chemically superior to lump ore. But pelletising of manganese ore is not economically viable, because of higher capital investment and higher operating cost due to fine grinding required for balling and fuel oil required for induration.

Briquetting : It is possible to agglomerate the manganese ore fines/concentrates by briquetting process, but the briquettes produced by using a number of binders, namely molasses, hydrated lime, bentonite, sodium silicate, portland cement etc and their mixtures are not

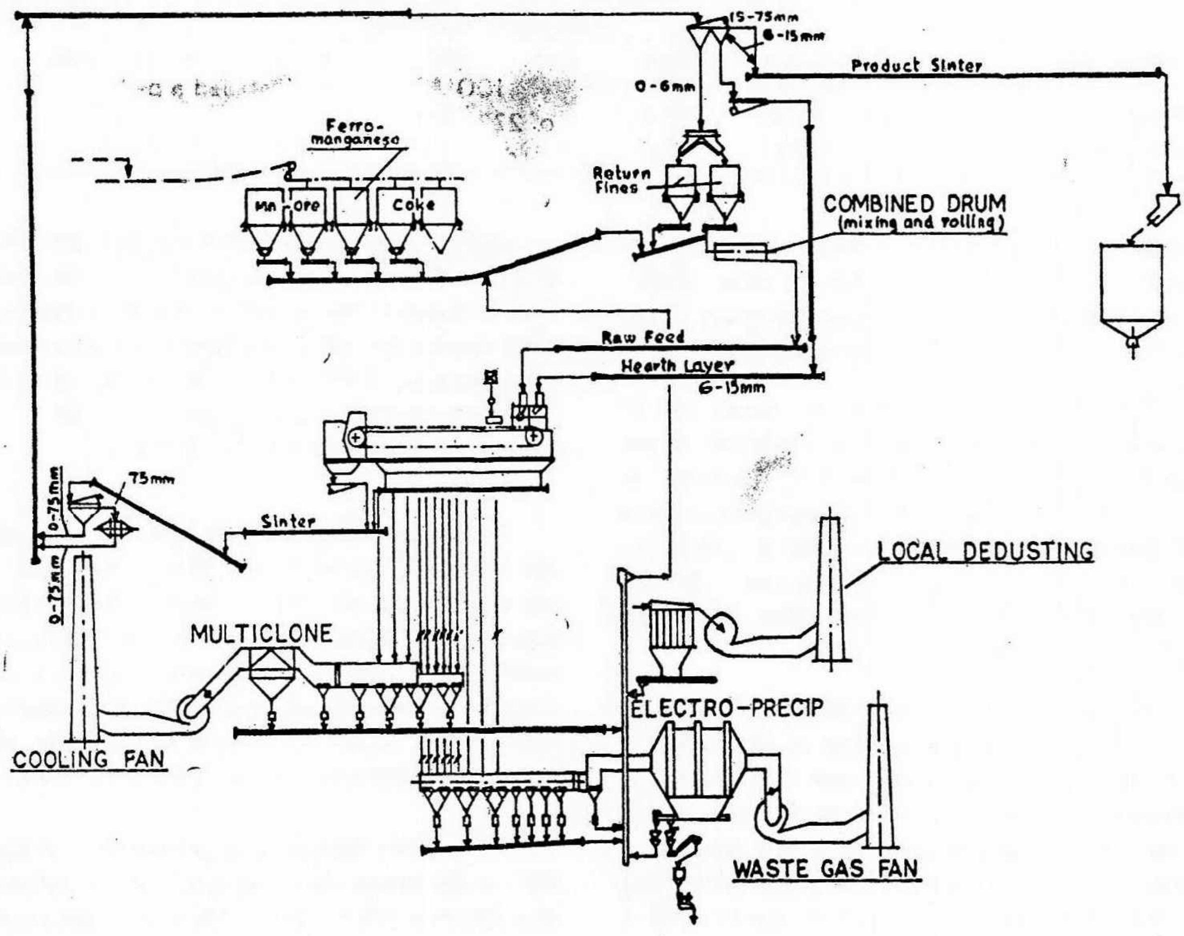

FIG. 4 — SINTERING PLANT — TYPICAL PROCESS FLOWSHEET

suitable for use as feed material for the smelting furnaces, because of not having adequate heat resistance and handling properties.

Sintering : Operating experience in a number of commercial sintering plants spread all over the world has established that the sinter produced from mixtures of manganese ore fines/concentrates, coke breeze and fluxes is physically and chemically suitable for ferro-manganese production. Further, it may be pointed out that the inclusion of sinter as part of the charge in the production of ferro-manganese considerably improves the operating conditions and performance of the smelting furnaces. A typical flowsheet of a sintering plant is given in Fig. 4.

Maharashtra Elektrosmelt Ltd. (MEL) in their ferro-manganese plant at Chandrapura got installed a sintering plant of 15,000 tons per year capacity to utilise lump ore screenings generated during the preparation of raw materials prior to charging of the electric smelting furnace. The sintering unit was designed, erected and successfully commissioned by M/s. Paramount Sinter Pvt. Ltd., Nagpur who can also supply sintering plant with annual capacity of 50,000 tons or more. The major facilities and operating parameters including unit consumption of water, power etc of Chandrapura sinter plant are furnished in Table 7.

The trial run of the plant was started in February 1981 and regular production in May 1981.

Raw material and sinter quality : The chemical analyses of raw materials and sinter produced are given in Table 8.

The installation of sintering plant has enabled MEL to utilise waste materials namely manganese ore fines and coke breeze for ferro-manganese production.

TABLE — 7

Major facilities and operating parameters of Chandrapura sinter plant

Sl. No.	Description		Size/operating parameters
1.	Sinter strand capacity, tons/yr	....	15,000*
2.	Grate area, sq m	...	3.0
3.	Grate speed, mm/min	...	600 to 800
4.	Vacuum below the grate, mm W. G.	...	150-200
5.	Bed heights :		
	Hearth layer, mm	...	25
	Sinter mix layer, mm	....	125
6.	Rate of sintering, mm/min	...	12 to 16
7.	Sinter mix :		
	Return sinter fines, %	....	30 to 35
	Coke breeze, %	...	5 to 10
	Moisture, %	....	5 to 10
	Mn-ore fines, %	...	Balance
8.	Yield, percent of the mix	....	50
9.	Water consumption, l/ton of sinter	...	200
10.	Power consumption, kWh/ton of sinter	....	45
11.	Fuel oil consumption, l/ton of sinter	...	15
12.	Manpower strength	...	50

* 85 per cent of the installed capacity.

TABLE — 8

Chemical analyses of raw materials and sinter

	Chemical analyses			
	Mn%	Fe%	SiO_2%	P%
Manganese ore fines	38.61	10.00	12.00	0.16
Sinter	40.59	11.20	12.24	0.17
	F.C.%	Ash%	VM%	P%
Coke breeze	65.00	32.00	3.00	0.15

Conclusion

In early years, India had very little domestic use for manganese ore and most of its production was exported. In view of the changed situation, namely the increasing demand by the growing domestic production of steel coupled with limited reserves, it is considered advisable to adopt beneficiation process for manganese ore to achieve higher recovery of saleable ore and to upgrade low grade manganese ore fines, and to agglomerate the concentrate. In this context, it may be pointed out that unless timely action is taken, the supply of high grade ores required for ferro-manganese production in future may pose problem. The compelling factors for the early setting up of beneficiation and agglomeration plants are :

a) Increasing domestic demand and additional requirements for the expansion of the existing steel plants and setting up of new plants.

b) Rapid depletion of existing resources and the need to extend the life of proved reserves in view of the limited resources.

c) Obviating the need for imports of manganese ore in future, thus saving regular and continuous drainage of foreign exchange.

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Discussion

S. Jayaram, TISCO, Joda

What is the Mn : Fe ratio in the two ore samples tested from this country by D. W. P. process, as also the SiO_2, Al_2O_3 content? What is the yield and Mn : Fe ratio in the concentrate produced and the size range of the concentrate ?

Answer

The Mn : Fe ratio in the two ore samples tested was 7.3:1 and the same in the concentrates produced was 8.3:1. The recovery as weight percentage was 85% and expressed as metal percentage was 95%. The size range of the concentrate produced was - 6 mm to 28 mesh.

O. Seetharamayya, FACOR, Shreeramnagar

Is there any reduction in SiO_2 content by this process and what would be the capital cost required for a beneficiation and agglomeration plant with a minimum capacity ?

Answer

Yes, there was a reduction in SiO_2 content. Capital cost of a beneficiation plant is given in the paper.

S. Rafiuddin, NML, Jamshedpur

The D. W. P. process can remove silicious gangues and not iron. Then how did the Mn/Fe ratio increase in the concentrate ? Please elucidate.

Answer

Iron mostly comes from tourmaline and braunite. Alongwith quartz, braunite, tourmaline, & biotite etc. are removed. Hence the increase in manganese, iron ratio.

A. K. Tripathy, RRL, Bhubaneswar

Can phosporus be removed by this process ?

Answer

Phosphorus cannot be removed by this process.

P. D. Prasada Rao, NML, Jamshedpur

In your paper you have mentioned about the improvement of Fe/Mn ratio by heavy media process for Brazilian Mn ores. Can you kindly mention the mineralogy of the ore and the analysis of manganese, iron and silica ?

Answer

Brazilian deposits belong to pre-cambrian age like Indian deposits. The ore consists primarily of manganese minerals cryptomelane (A potassium Mn oxide of variable composition and pyrolusite (MnO_2) with subordinate manganite (Mn_2O_3 H_2O). Chemical analysis of the fines is as follows. Mn-43.3%, Fe-7.7%, SiO_2-4.8%.

A. Peravadhanulu, NML, Jamshedpur

What is the size of the sink and float concentrate used for sintering operation ?

Answer

Feed size is 6 mm to 28 mesh.