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Beneficiation Studies of Manganese Ore of Kumsi, Shimoga, Southern India

KEYWORDS: Manganese, gravity concentration: tabling and jigging, liberation and comminution.

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ABSTRACT *beneficiation of low grade manganese ores are involving liberation of unwanted species from gangue mineral. the liberation is accomplished by comminution involving various stages of crushing of the run of mine. In the present investigation an attempt has been made to upgrade the manganese ore from the deposits. high grade ore samples are directly utilized for the preparation of electrolytic manganese dioxide (EMD). Low grade ore upgrade by gravity concentration methods that is tabling and jigging the main object is to reduce the content of silica and clay associated with the ore, the concentration obtained from the process with high grade ores of the area and utilized for the preparation of EMD.*

Introduction:

Manganese deposits of Shimoga schist belt is a broad, open trough and covers an area of about 6000sq.km. The Dharwar group in the Shimoga schist belt is represented by narrow belts of steeply dipping metasedimentary formation and volcanic rocks, including stratiform manganese iron formation, phyllite/argillite, quartzite, greywacke, metabasalt, basic and ultrabasic intrusive. They are surrounded by peninsular gneiss, which constitute the basement of the Shimoga schist belt. Enclaves of Sargur group of rocks are encountered in the peninsular gneiss. Stratigraphic successions of rock formations of the Shimoga region. (Janardhana, 1991). A brief description of the above lithounits is given here below.

Peninsular gneiss along with younger granite encompass the eastern, western and northern parts of the study region and referred to variously as Shimoga gneiss, Konandur gneiss and Saulanga gneiss respectively. The Shimoga gneiss exposed in and around Kumsi has been regarded as a domal structure having a granodiorite composition (Syed Ali and Divakara Rao, 1980). It is leucocratic, medium to coarse grained and foliated. Chitradurga group of rocks in the Shimoga area is represented by shallow water sedimentary rocks, chemical precipitates and volcano-sedimentary rocks. The chief lithounits include polymict conglomerate, current bedded quarzites, limestone/dolomites, banded iron formation, banded manganese formation, phyllites and greywackes. (Harinadha Babu et al., 1981) proposed that the polymict conglomerate bed in the Shimoga belt indicates sudden uplift of the area following cessation of Bababudan cycle and a consequent break in sedimentation. Vasudev et al., (1989) reported the presence of stratified stromatolites exhibiting columnar structures in the dolomites of the Kumsi area. The stromatolitic limestone and dolomites are succeeded by phyllites and quartzites with interbanded manganiferous formation. Manganiferous formatios occurs both as massive lensoidal bodies and also as macro/meso/micro banded layers interbanded either with phyllites or quartzites. The manganiferous formation are variably weathered along with host phyllite and quartzite. Banded iron formation alternating with bands of either chert/quartzite/ sericitic/chloritic/phyllites, overlies the manganiferous formation. The width of each band in BIF varies from less than a meter to as much as ten meters. In the study area, BIF occurs as thick discontinuous bands generally occupying the ridge portions. Greywacke-argillite-chert-volcanic suite consisting of fine grained, thin-bedded argillite is widespread in the study area. Greywacke is grey to grayish green in colour and composed mainly of quartz, chlorite, biotite and hornblende. Dolerite dykes are coarse grained and melanocratic and trend in a NW-SE direction. These dykes are well exposed to the south of Vemaligudda and northwest of Bukkivara. Chitradurga group of rocks are characterized by the presence of chlorite, muscovite, K-feldspar and garnet in pelitic and quartzo-feldspathic rocks and hornblende, diopside, sphene and epidote in the calcareous rocks and suggest greenschist to lower amphibolite facies metamorphism. Shivaprakash (1983) reported temperatures of the order of 300-400°C and pressures of 2-4 Kb corresponding to greenschist facies conditions during the metamorphism of the Chitradurga group of rocks. From the above findings, it can be concluded that the supracrustal rocks of the Shimoga area have undergone greenschist to lower amphibolite facies metamorphism.

Location:

Manganese deposits of Shimoga schist belt are encountered between the latitudes 13°50´ and 14°10´; and longitudes 75°15´and 75°30´. A large part of the study area is a fairly rugged terrain, excepting the eastern part, which is a relatively plain country. The rugged terrain is made up of linear ridges and hills consisting of schists and the low-lying areas are characterized by greywackes. The area receives moderate rainfall of 700 to 1200 mm per annum and falls under semitropical climate. There are no agricultural lands and the entire rugged area is clad with a fairly thick jungle of teak, bamboo and sandalwood trees. A large part of the area is drained mainly by Kumudvathi River and its numerous tributaries.

Beneficiation techniques can be applied to ores to know the liberation of unwanted species from the gangue mineral. The liberation is accomplished by comminution involving various stages of crushing of the run of mine (ROM) ore followed by grinding to a particles size, where the ground product consists of a mixture of relatively manganese and iron mineral and gangue mineral. This optimum particle size is determined by mineralogical investigation and may differ slightly for each deposits over grinding can be detrimental to the downstream separation processes, causing insufficient power consumption, especially in the mill and also has a negative effect on the sufficiency of the different separation processes. In gravity separation mineral of different specific gravity can be separated by their relative movement in response to gravity in conjunction with other force in viscous fluids air of water (Will, 1980).

Potkonen N.I., (2001) was reported it may eventually be possible to make use of materials from the already 92 million tons of carbonate ore and the manganese region 41 million tons of carbonate ores. However, processing these ores by traditional methods involving magnetic separation, floatation and radiometric concentration rarely yield commercial manganese concentrates having quality and cost characteris-

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tics. Trubetskoi, et al., (1999) proposed the one characteristic common to all of the carbonate concentrates obtained from the ores in the different deposits is their low metallurgical value: their manganese content lies within the range 26 – 29%, they have a high unit phosphorus content (P/ Mn >0.006), and they contain the impurities SiO_2 and Fe.

Early efforts have been made (Das et al 1992) to reduce alumina in the slim by using classification followed by separation in a hydro cyclone. They showed that it is possible to obtain a product containing 64% Fe, 1.4% silica and 3.5% alumina from a feed assaying 57% Fe, 4% silica, and 8.3% alumina, several researchers have worked on alumina reduction. The beneficiation of iron slims produced from washing plants and tailing ponds of Kiriburu mines was studied (Prasad et al, 1988) using wet high intensity magnetic separation (WHIMSs) followed by classification in hydro cyclone. They showed that a concentrate assaying 63% Fe, and 3.3% alumina could be produced with an overall iron recovery of 56%. (Das et al 1995) using classification by hydro cyclone followed by high intensity magnetic separation, their results show that it is possible to obtain a concentrate assaying 60-65% with 60-80% recovery.

In the present investigation an attempt has been made to upgrade the Kumsi manganese ore deposits. High grade ore samples are directly utilized for the preparation of EMD. Low grade ore are upgraded by gravity concentration methods that is tabling and jigging the main object is to reduce the content of silica and clay associated with the ore, the concentration obtained from the process is blended with high grade ores of the area and utilized for the preparation of EMD.

COMMINUTION:

Comminution aims in size reduction of the mine sample, size reduction involves crushing, grinding and sizing and product handling.

Samples of the ores ware carried out by coning and quartering. The samples technique involves the reduction of the samples weight in such a manner that the final fraction is truly the original part of the ore. The main aim of liberation of a mineral is to reveal the abundance of mineral at a particular size fraction. The fraction where maximum liberation is identified. The mineral is subjected to various up gradation techniques. The separation of each mineral species can be achieved by employing one or the other process depending upon the physical or chemical property of the mineral.

Gandin (1939) defined the degree of liberation as the ratio number of free particle to the number of some free and middling particle expresses as a percentage.

Total number of particle

$$\text{Degree of liberation (f)} = \frac{\text{Total number of particle}}{\text{Total number of free particles + locked particle}} \times 100$$

Janardhana (1991) reported that the late Archaean metasedimentary manganese ores of Shimoga are composed of pyrolusite and minor phyllite and lateritization of these manganese ores resulted in the formation of supergene minerals such as cryptomelane and goethite with minor hollandite, pyrolusite, ramsdellite, nsutite and lithiophorite.

Model analysis was carried out of the communition on individual sieve fraction by mounting the mineral grains on square glass plate and observed under reflected light microscope to know the degree of liberation. The results are tabulated in table1.

Table 1: Liberation of kumsi manganese ores.

Size in mesh	Total No. of particle counted	Free particles	Locked particle	Degree of liberation	liberation size
-22+44	54	12	40	23,07	23.07
-44+60	85	32	51	38.55	15.48
-60+100	73	34	30	53.12	14.57
-100+150	70	38	10	79.16	26.04
-150+200	100	58	8	87. 87	8.4
-200	105	68	8	89.42	1.6

The liberation study reveals that 100% liberation will not help sometimes maximum liberation is uneconomical. The optimum liberation is in coarser fraction. The mineral beneficiation technique jigging and tabling are sufficient to achieve 80% liberation and the low-grade ores of the present investigation are blended high-grade ores to obtain EMD grade sample. The manganese ores are associated with silica and iron. Silica can be separated by employing gravity concentration process.

The gravity concentration process makes use of specific gravity difference between silica and iron. Silica can be eliminated by jigging or tabling. The presence of iron cannot be removed by the above method. The iron can be reduced by subjected the ore to reduction roasting followed by magnetic separation or reduction roasting. Followed by chemical leaching which helps to reduce the iron content in the sample.

From the above table it is evident that the liberation of manganese is in the coarser fraction of ores. The liberation is achieved in size fraction -100+150, -150+200 mesh. The manganese ores do not get crushed to fines, which compare to the soft nature of gangue minerals.

Sizing and chemical constituents distribution:

Representation manganese ore samples are obtained by coning and quartering method. Four hundred grains of manganese ore is subjected to sizing by sieve analysis and experiments were carried out. The individual fractions are weighed and the weight percentages are determined. The sieve fraction are subjected to chemical analysis is know the percentage of individual constituents Fe_2O_3, MnO_2 and SiO_2.

The high grade manganese ores of the area under investigation reveals the content of SiO_2 is less compared to low grade ores. The ores are harder because they dominantly consist of pyrolusite. Morphologically, pyrolusite occurs as tabular, interlocked crystal aggregates, medium- to coarse- grained prismatic crystals, fine-grained and needle-like crystals. It is encountered as layers and bands admixed with clastic material, as veins and stringers, vug-fillings and detrital grains. The content of Fe_2O_3 decrease with increase in MnO_2 content. The liberation of MnO_2 is achieved more in coarser fractions than compared to fine fractions. From table1, it is evident that maximum liberation is achieved in the size range -22+44, -44+60 and -60+100 mesh; in the remaining fractions the content of MnO_2 is homogeneous.

On the basis of liberation studies the ores are amenable for beneficiation in the coarser size fraction by physical methods, based on the differences in specific gravity of MnO_2 and SiO_2. The elimination of Fe_2O_3 is not possible by gravity concentration method. Fe_2O_3 can be minimizing by reduction roasting followed by magnetic separation. The size fraction +10mm-500µ may be used for jigging operation and +100mesh for tabling.

In the present investigation size analysis was carried out on manganese ores of Kumsi. From the size analysis and the distribution of major elements in the manganese ores of Kumsi show irregular distribution of $MnO_2$and Fe_2O_3. The content of SiO_2 decrease with size reduction. High grade ore contain the SiO_2 concentration and they can be directly used for the preparation of EMD. The liberation of MnO_2 is dominant in

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size fraction -22+44 and -44+60. The concentration of MnO_2 increase with increasing size and the content of Fe_2O_3 and SiO_2 are homogeneous in nature. The results are tabulated in table 2.

The ores are subjected for tabling and jigging operations and the results are discussed as below:

Tabling method:
Tabling experiments are conducted based on the difference in specific gravity of MnO_2 and SiO_2. The ores are crushed to +100 and experiments were carried out on Willfleys table. The condition maintained was 8-10^0 slope, water is made to flow continuously on the table so that separations of mineral and the gangue can be achieved. The table vibration horizontally with bumping action the minerals get separated based in their specific gravities. The separated products concentrate tailing and middling were collected and subjected for chemical analysis contents MnO_2 Fe_2O_3 and SiO_2 were determined and recovery was calculated. The results are encouraging and tabulated in table 2 and 3.

The recovery of MnO_2 by tabling ranges from 71 % to 74 % appreciable amount of silica has been reduced in tabling operation.

Table: 2. Results of tabling experiments of Kumsi manganese ores.

Sample No.1	Feed size	+100	
	Feed assay	Mno2	72.50%
		Fe_2O_3	5.85%
		Sio_2	7.2%

Constitutients	MnO_2 %	Fe_2O_3%	SiO_2%	Recovery %
Concentrate	79%	4.20%	1.84%	71%
Middling	57.50%	6.80%	9.1%	
Tailing	44.52%	10.10%	18.4%	

Table: 3. Result of tabling experiment of Kumsi manganese ores:

Sample No 2	Feed size	+100	
	Feed assay	MnO_2	71.2%
		Fe_2O_3	6.19%
		SiO_2	8.45%

Constitutients	MnO_2 %	Fe_2O_3 %	SiO_2 %	Recovery %
Concentration	79	5	2.1	74 %
Middling	61.20	8.1	9.9	
Tailing	46.99	10.9	19.50	

Jigging method
The medium grade manganese ore deposits were beneficiated by Hartz jig. Experiments were carried out on Hartz jig. The jig consists of hopper shaped compartment with upper part subdivided by shaped longitudinal partition into screen and plunger compartment screen is used. The main aims of jigging are to reduce the content of silica. The jig was optimized for parameters like length of stroke (3cms), speed (215 rpm), depth of bed (42cm) and screen aperture (1mm).

Table: 4. jigging of Kumsi manganese ore

Size in mm	Feed %			Concentrate %			Recovery
	MnO_2	Fe_2O_3	SiO_2	MnO_2	Fe_2O_3	SiO_2	
-10+4mm	71.97	7.49	5.69	79.10	5.98	1.89	80.04
-4+2.8mm	73.10	6.79	6.79	80.79	5.73	2.09	77.00
-2.8+2mm	70.9	7.1	5018	78.74	6.09	2.34	75.00
-2+1mm	74.10	6.10	5.73	81.10	7.79	1.77	73.5
-1+500µ	69.9	7.73	6.10	78.9	5.9	1.86	70.00

Table: 5. jigging of Kumsi manganese ore

Size in mm	Feed %			Concentrate %			Recovery
	MnO_2	Fe_2O_3	SiO_2	MnO_2	Fe_2O_3	SiO_2	
-10+4mm	73.10	5.18	6.19	84.68	4.76	1.81	80.00
-4+2.8mm	71.40	6.19	6.9	78.49	5.20	2.05	77.00
-2.8+2mm	72.48	5.89	6.05	79.05	4.15	2.14	75.2
-2+1mm	74.40	5.10	5.25	81.69	4.14	1.68	73.4
-1+500µ	75.10	4.9	5.09	82.05	4.26	1.34	70.4

Jigging action comprises of sizing and sorting. The upward and downward motion of the jog in water facilitates the retention of ore on the screen. The principle is based on the difference in specific gravities of the two minerals. The results of jigging with respect to ore are quite encouraging and recovery is maximum in size range -10+4mm i.e. 80 % recovery. The results are tabulated in table as above mention. From the above investigation the tabling and jigging operation result are increasing as the recovery is 80 % in jigging and tabling 71 % to 74 % with respect to the ores.

Conclusion:
The manganese ore is beneficiated by tabling, jigging, reduction, roasting, magnetic separation and by chemical leaching. The ores can be beneficiated by employing the above methods. The results obtained reveals the manganese ores with 42.47% manganese content can be upgrade to obtained EMD powder. The manganese ores can be utilized for the preparation of EMD. From the above investigation the tabling and jigging operation result are increasing as the recovery is 80 % in jigging and tabling 71 % to 74 % with respect to the ores. Reduction roasting followed by magnetic separation, chemical leaching, phase transformation can be achieved from MnO_2 is suitable for EMD production the cost of production is Rs 25,000/ton and the market valve Rs 75,000/ton. Hence, the beneficiation of manganese of manganese ores are economical viable.

REFERENCE
Das, B., Prakash, S., Mohapatra, B.K., Bhumik, S.K. and Narasimhan, K.S., (1992). | Beneficiation of iron ore slimes using hydrocyclone." Mineral and Metallurgical Processing, 9(2), pp.101-103. | Das, B., Mohapatra, B.K., Reddy, P.S.R. and Das, S., (1995). Characteritization and | beneficiation of iron ore slimes for further processing." Powder handling and processing, 7(1), pp. 41-44. | Gandin (1939). Principles of mineral dressing, McGraw Hill, London. | Harinadha Babu,P., Ponnaswamy, M. and Krishna murthy, K.V,(1981).shimoga belt.In; | J.Swaminath and M.Ramakrishnan (Eds), Early precambrian supracrustals of Southern | Karnataka, Geol. Mag, V.2, pp.199-218 | Janardhana, M.R.,(1991). Geological setting, mineralogy, textural, geochemistry and genesis of | Shimoga manganese deposits, Karnataka. Unpublished Ph.D.thesis submitted to University of Mysore, Mysore. | Trubetskoi, K.N., Chanturiya, V.A., Vorob'ev, A.E., (1999). Manganese (In Russian), Izd. | Akadmiya Gornykh Nauk Mascow. | Prasad, N., Ponomaren, M.A., Mukherjee, S.K., Sengupta, P.K., Roy, P.K. and Gupta, S.K., | (1988). "Introduction of new technologies for beneficiation of Indian hematite ores, reduction of losses and increase in their quality." In XVI International Mineral Processing Congress, (E. Forssberg, Ed.), Amsterdam: Elsevier Science Publishers B.V., pp.1369-1380. | Potkonen N.I., (2001). "Russian Manganese: Status and prospects for exploitation and use of | domestic natural resources" mineral noe Syr'e:Ser: Geologo-Ekonom, No.10. | Shivaprakash,C.(1983). Petrology of quartzofeldspathic schist, phyllite associate with manganese | formation of Nrth Kanara and Kumsi, Karnataka, Jour, geol, Soc. India, V.24, PP.571-587. | Syed Ali and Divakara Rao, V.(1980). Geochemistry and origin of acidic rocks of Shimoga, | Karnataka. India, Jour,Geol,Soc.India, V.21, PP.91-97. | Vasudev,V.N., Naqvi, S.M., Shukla, M. and uday Raj,B.(1989). Stromotolites from the chert- | dolomites of Archaean, Shimoga schist belt, Dharwar craton, India, Jour,Geol,Soc.India, V.33, PP.201-205. | Wills, B.A., (1980). Mineral Processing Technology, 3rd edn. Applied Science Publication, | pp.827.