International Journal of Scientific Engineering and Technology ISSN :2277-1581
Volume No.4 Issue No.7, pp: 392-396 01 July 2015

Responses of Ka'oje Metallurgical Manganese Ore to Gravity Concentration Techniques

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Abstract: ***Metallurgical manganese ore samples from Ka'oje (Nigeria) were enriched to higher Metallurgical grades during wet gravity separation techniques which included Jigging and Tabling operations. As-mined samples S1 (36.83%MnO), S2 (47.85%MnO), S3 (58.85%MnO) and S4 (54.96%MnO) were dressed and screened to -780+500 µm, -500+355µm, -355+250 µm, -250+192 µm and -192 µm particle size ranges. Obtained Jigging test concentrates assayed 51.54% MnO minimum recovery level with an enrichment ratio (ER) of 1.02; while Tabling operation concentrates assayed 91.11% MnO maximum recovery and 1.14 ER value. These responses demonstrated the suitability of the two techniques in raising the enrichment levels of the ores for better applications and higher economic gains.***

Keywords: Metallurgical, concentrates, enrichment ratio and recovery

INTRODUCTION

The suitability of gravity concentration methods in ore enrichment processes largely depends on the ore minerals' specific gravity gradients and solubility, Olubambi and Potgieter (2005). The Ka'oje metallurgical grade manganese samples were subjected to Jigging and Tabling operations in wet condition for value addition; owing to great deal of price differences (gains) existing between equal tonnage of raw manganese ore and value added manganese concentrates as stated by Corathers (2007). In first quartal of 2014, manganese (Mn) concentrate with 52% Mn cost $328.11per metric ton while same one ton of Mn ore having 33-36% Mn cost $148-162, Dewitt (2014). Ores are dressed through comminuting, liberation, sizing and screening operations to separate valuable minerals from gangue minerals. During comminuting, intertwined valuable minerals and unwanted ore constituents are unlocked by sequence of crushing and grinding processes. Specific gravities of the major minerals in the ores, according to Abubakre et al (2010), are presented in Table 1. Distinct variations in specific gravities among the minerals signaled achievable separation using gravity method. Little overlapping could however occur in the processes in the wake of valuables cleft away with gangues during comminution, which will result to generation of some middlings.

Table 1: Specific gravities of manganese ore major constituent minerals

Mineral	MnO_2 (Pyrolusite)	Fe_2O_3 (Hematite)	SiO_2 (Quartz)	Al_2O_3 (Corundum)
Specific Gravity	4.6	5.3	2.65	3.69

EXPERIMENTAL METHOD: As-mined ore samples of 20Kg (labeled S1, S2, S3 and S4) were crushed and ground on 5Kg per sample basis. The grounding was carried out in a laboratory ball-mill for 8 minutes per batch and products were subjected to screening to generate particle size ranges within +780 - 192µm.

Jigging process

i) Some 50g from each sieve fractions -780+500µm (-20+30 BSS), -500+355 µm (-30+44BSS), -355+250 µm (-44+60BSS), -250+192 µm (-60+80BSS) and -192 µm (-80BSS) was weighed as head/feed materials.

ii) Feed materials were fed into the compartment of the Denver jig and mixed with water at constant dilution ore: water ratio of 1:3 by weight percent. Jigging proceeded for three minutes at constant jigging time, dilution ratio, medium speed and stroke.

iii) Products were separately collected as underflow (concentrates) and overflow (tailings). Both were dried, weighed and recorded.

Tabling operation:

a) Some 50g from each fractions -780+500 µm (-20+30 BSS), -500+355 µm (- 30+44BSS), -355+250 µm (-44+60BSS), -250+192 µm (- 60+80BSS) and -192 µm (-80BSS) was weighed as feed materials.

b) Pulp of 25% solid by weight and 75% liquid (water) by weight was prepared for each size range.

c) Wilfley shaking table was adjusted to 195 strokes per minute, 23^o tilt angle and 10 lit/3 minutes wash water flow rate.

d) Shaking went on in maximum of five minutes per batch.

e) The three products, concentrates, middling and tailings were collected in separate launders. The products were dried, weighed and figures recorded. ED-XRF analysis was carried out on the products to determine their respective chemical compositions. The determination of valuable mineral recovery, concentration ratio and enrichment ratio were carried out to assess the effectiveness of technique.

RESULTS

Jigging operation:

The Jigging operation generated underflow and overflow (Table 2) as concentrates and tailings respectively. Particle sizes -190 µm favoured highest enrichment while highest recovery was attained with particle size range -500+355 µm. and particle sizes -190 µm recorded highest ER.

Table 2: Jigging test result of sample S4(AT LAST)

ISSN :2277-1581
01 July 2015

Tabling Operation: The separation and displacement of the particles during Tabling are presented in the Plates 1. While Tables 7 to 11 present the numerical Tabling results.

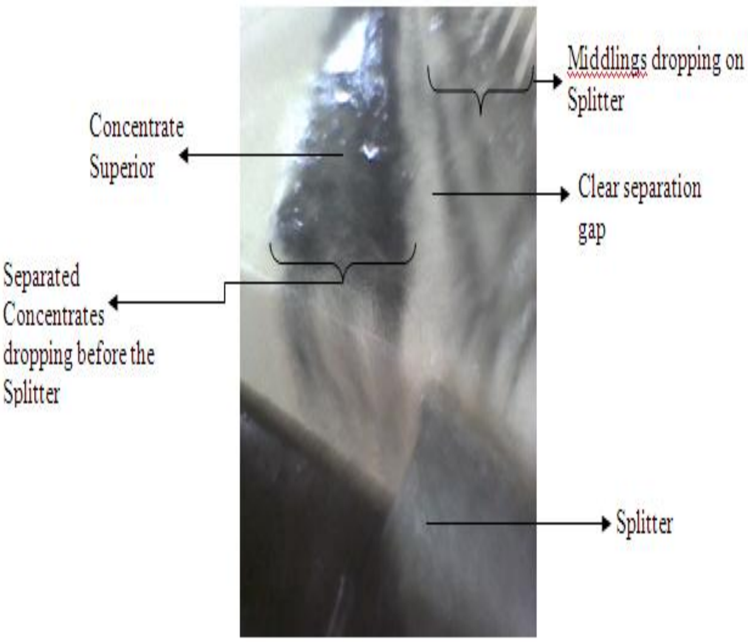

Plate 1: Middling dropping on the splitter clearly separated from the concentrate.

The effect of ore particle size on concentration ratio is presented in Figure 1. Particle size reduction down to 380 µm did not significantly liberate valuable mineral (MnO_2), hence little or no change in the CR. Further reduction in particle size below 380 µm however resulted in a significant valuable mineral liberation which resulted to high increase in concentration ratio. Products were generated as concentrates, middlings and tailings (Plates 1; Tables 3,4 and 5). Sieve sizes -780+500 µm and -500+355 µm favoured generation of more middlings than tailings while -355+250 µm, -250+192 µm and -192 µm generated more tailings than middlings. The Tabling operation proved more efficient as the feed materials got more spread out and stratified for better sensitivity to particles' specific gravities during Tabling operation. Particle size range -355+250 µm, however, generated more middlings in samples S1 and S4. This was due to aggregation of the valuables in finer shapes in the bulk sample. Tabling of S2 recorded 51.39% valuable assay with lowest recovery level of 72.49% as much valuables were lost to tailings. The S2 tabling results showed that top ER was recorded with particle sizes -192 µm with reduced silica content, as similar to what occurred in the tabling of sample S4.

Table 3: Tabling results of sample S2(AT LAST)

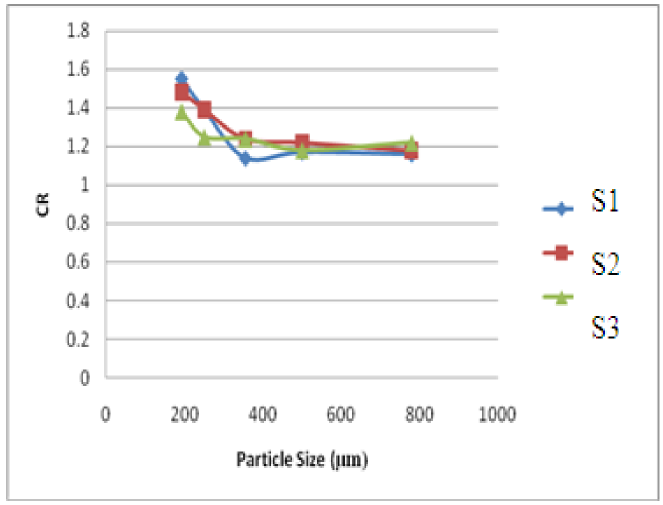

Figure 1: Relationship between particle and concentration ratio.

Table 4: Tabling results of sample S3(AT LAST)

Table 5: Tabling results of sample S4(AT LAST)

All the generated concentrates were far below 6000 µm (6 mm) particle size required in a furnace operation; this necessitated cold-bond agglomeration of the products (Plate 2) using natural resin (Gum arabic) and 5% Portland cement as binders in a lab-size pelletizer. The Resin serves as a precarbonization material while the cement serves as pre-flux material should the agglomerates be used for production of ferro-manganese. Average compressive strength of resin bonded pellets was 9.74KN while that of cement bonded pellets was 10.78KN; this is in consonance with the standard according to Lotosh (1999).

Plate 2: Agglomerates of 9-21 mm. Pellets 'A' and 'B' are fine concentrates and natural resin bonded while pellets 'C' and 'D' are coarse contrates and cement bonded.

Cost Analysis

Cost analysis of concentrating the manganese ore is presented in Table 12.

Table 12: Ore Concentration Cost Analysis

S/N	Item Description	Quantity	Cost ($)
CONSUMABLES			
1	Ore Comminution	20Kg	0.08
2	Jigging Test	10Kg	1.43
3	Tabling Operation	10Kg	2.40
4	Potable Water	300 Liters	0.47
Sub-Total 1 = $4.38			
CAPITAL EXPENDITURE			
4	Holman- Wilfley Shaking-Table Model 8000, (2,500Kg/h)	One set	3,000.00
5	Denver Jig	One set	1,200.00
6	Overhead for two personels in ten years	At $1,800 per head per month	432,000.00
7	Pelletizer	One set	900.00
8	Portland Cement	2,520 metric ton	567,000.00
Sub-Total 2 = $1,004,100.00			

Consum. total expend. for 1000Kg = 50 × 4.38 = $219.00
Cost of 1000Kg raw manganese ore (26% Mn) = $ 102.00
Cost of 1000Kg concentrate (52% Mn) = $ 358.11
Cost difference = $256.11
Net gain = $(256.11-219)
= $37.11

Wilfley table of model 8000 operation capacity is 2,500Kg per hour. The gain per hour equals $92.78; eight hours per day working principle produces $742.2 per day gain. The twenty one working days principle earns $15,586.2 while a year operation earns $187,034.40 gross profit. For ten years shelf life, the Wilfley Table would have earned $1,870,344.00 gross gain having processed 50,400 metric ton.

The Net Gain per decade = $ (1,870,344 – 1,004,100) = $866,244

Net gain per year = $86,624.4
Net gain per month = $7,218.7

CONCLUSIONS

The Jigging and Tabling tests successfully upgraded the Ka'oje metallurgical ore to feeds usable in ferro-manganese production cycles. Jigging test concentrates assayed 51.54% MnO minimum recovery level with an enrichment ratio(ER) of 1.02; while concentrates from Tabling operation assayed 91.11% MnO maximum recovery with 1.14 ER value. Tabling operation however proved more suitable in raising the enrichment levels of the ores and a net gain of $86,624.40 a year. .

REFERENCES

i. *Abubakre, O.K., Muriana, R. A. & Arogundade, A. I. (2010). Petrological and Mineralogical Characterization of Ka'oje (Kebbi State, Nigeria) Manganese Ores. Journal of Eng. Research, Uni. of Lagos, 15(3) . 20-28.*

ii. *Corathers, L.A. (2007). Manganese. USA Geological Survey Minerals Year Book. USA.*

iii. *Dewitt A. (2014). Metal-pages. Argus Media, Washington DC. USA.*

iv. *Lehne, R.W. (2006). Treatment and Microscopy of Gold and base metal ores.*
   a. *Retreived from www.isogyre.com*

v. *Lotosh V.E (1999). Cold-Bond Pelletizing of Iron-containing Wastes of a Metallurgical Enterprise on Calcium Containing Binder. Journal of Steel in Transaction, 29(12). Pp6-10.*

vi. *Malayoglu U. (2010). Study on the Gravity Processing of Manganese Ores. Asian Journal of Chemistry. Vol. 22, No4. Pp 3292-3298.*

vii. *Olsen S.E., Tangstad M. and Lindstad T. (2007). Production of Manganese Ferroalloys. SINTEF and Tapir Academic Press, Trondheim . 1st edition.*

viii. *Olubambi, P.A. & Potgieter, J.H. (2005). Effectiveness of Gravity Concentration for the Beneficiation of Itakpe (Nigeria) Iron Ore Achieved Through Jigging Operation. Journal of Minerals and Materials Characterization and Engineering, 4, (1), 21-30, Issue4-1P21-30. U.S.A. Retreived from http://www.jmmce.org.*

ix. *Subrata R. (2009). Recovery improvement of Fine Iron Ore Particles by Multi Gravity Separation. The Open Mineral Processing Journal. Vol. 2, Pp 17-30.*

x. *Wills,B.A,(2005).MineralProcessingTechnology.NewYork:ThePergamonLtd,SeventhEdition.*

Table 2: Jigging test result of sample S4

S/N	Sieve Size Range (µm)	Feed (g)	Underflow					Overflow			% losses [50-(x+y)]
			Wt (g) x	% MnO	% SiO_2	E.R	Recovery (%)	Wt (g) Y	% MnO	% SiO_2	
1	-780+500	50	45.51	57.87	6.33	1.05	95.84	3.65	35.78	34.20	1.68
2	-500+355	50	42.93	60.18	6.35	1.10	94.01	5.87	39.07	31.20	2.40
3	-355+250	50	39.91	61.87	6.21	1.13	89.86	7.93	35.14	36.72	4.32
4	-250+192	50	40.13	60.12	5.97	1.09	87.79	6.85	36.54	36.89	6.04
5	-192	50	37.48	63.09	5.37	1.15	86.05	9.42	34.68	31.15	6.20

Table 3: Tabling results of sample S2

S/N	Sieve Size Range (µm)	Feed (g)	Assay of feed		Product	Weight of Product (g)	Assay of Product		Recovery (%)	E.R	C.R
			% MnO	% SiO_2			% MnO	% SiO_2			
1	-780+500	50	47.85	14.80	Concentrate Middling Tailing	42.53 05.11 01.36	50.41 38.36	14.09 21.70	89.61	1.05	1.18
2	-500+355	50	47.85	14.80	Concentrate Middling Tailing	40.93 07.05 00.89	50.55 40.72	13.10 20.50	86.48	1.06	1.22
3	-355+250	50	47.85	14.80	Concentrate Middling Tailing	40.36 01.97 06.67	50.52 40.87	13.20 19.30	85.22	1.06	1.24
4	-250+192	50	47.85	14.80	Concentrate Middling Tailing	35.87 00.33 13.80	50.03 41.34	14.52 19.15	75.01	1.04	1.39
5	-192	50	47.85	14.80	Concentrate Middling Tailing	33.75 00.30 14.19	51.39 45.38	12.67 16.90	72.49	1.07	1.48

Table 4: Tabling results of sample S3

S/N	Sieve Size Range (μm)	Feed (g)	Assay of feed		Product	Weight of Product (g)	Assay of Product		Recovery (%)	E.R	C.R
			% MnO	% SiO_2			% MnO	% SiO_2			
1	-780+500	50	58.85	8.78	Concentrate Middling Tailing	41.10 07.23 00.67	65.02 38.34	10.20 23.30	90.81	1.11	1.22
2	-500+355	50	58.85	8.78	Concentrate Middling Tailing	42.50 05.77 00.73	62.99 34.27	06.36 25.90	90.98	1.07	1.18
3	-355+250	50	58.85	8.78	Concentrate Middling Tailing	40.37 01.68 06.95	64.73 38.09	6.04 22.60	88.80	1.10	1.24
4	-250+192	50	58.85	8.78	Concentrate Middling Tailing	40.03 01.07 07.20	66.98 29.73	4.07 30.10	91.11	1.14	1.25
5	-192	50	58.85	8.78	Concentrate Middling Tailing	36.15 01.90 11.05	67.93 44.04	4.50 25.00	83.46	1.15	1.38

Table 5: Tabling results of sample S4

S/N	Sieve Size Range (μm)	Feed (g)	Assay of feed		Product	Weight of Product (g)	Assay of Product		Recovery (%)	E.R	C.R
			% MnO	% SiO_2			% MnO	% SiO_2			
1	-780+500	50	54.96	10.65	Concentrate Middling Tailing	42.08 06.85 00.61	58.46 38.59	5.90 32.40	89.52	1.06	1.19
2	-500+355	50	54.96	10.65	Concentrate Middling Tailing	40.65 08.08 01.20	58.53 39.75	5.88 31.60	86.57	1.06	1.23
3	-355+250	50	54.96	10.65	Concentrate Middling Tailing	38.95 07.10 03.95	59.77 38.02	4.92 32.70	84.72	1.09	1.28
4	-250+192	50	54.96	10.65	Concentrate Middling Tailing	38.05 02.84 08.66	59.12 46.00	3.95 23.30	81.88	1.08	1.31
5	-192	50	54.96	10.65	Concentrate Middling Tailing	35.20 02.31 11.85	60.30 44.16	4.01 24.80	77.26	1.10	1.42