ISSN 2229-5518

Determination of Bond Index of Wasagu Manganese Ore in Kebbi State, Nigeria.

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ABSTRACT - In this study, the work index of Wasagu Manganese Ore deposit in Kebbi State of Nigeria was determined using the modified Bond's Method of determining work index also known as Berry and Bruce method. Sample of Manganese ore was sourced using random sampling method. Reference mineral (Granite) of known weight and work index (15.14 Kwh /tone) was ground for 30 minutes at a particular speed and power consumed was determined from the power rating of the ball mill. An identical weight of Wasagu Manganese ore whose work index was to be determined was ground in the same ball mill under same condition as that of reference mineral. Size analysis of the ball mill under same condition as that of the reference mineral. Size analysis of the ball mill feed and discharge for both the ores was carried out and 80% passing particle size of the ball mill feed and discharge for the two ores were estimated using semi-logarithm plots. The work index of the Wasagu Manganese ore was determined by equating the power consumed in the two indexes of the ore was found to be approximately 10.24Kwh/tones which is within the range 10 - 15.14 indicated in literatures as standard.

Key words: Bond Index, Wasagu manganese ore, Modified, Reference Mineral, Mineral Processing.

1. INTRODUCTION:

Bond index in other word called ore grindability is refers to the ease with which the mineral ore can be comminuted- useful in designing of grinding system in mineral processing [6], for a newly discovered ore it is very important to determine its hardness and grinding characteristics so that suitable power can be selected for its communition [5].

Communition in mineral processing plant or mill takes place as a sequence of crushing and grinding processes. Crushing reduces the particle size of run-off mines ore to such a level that grinding can be carried out on the mineral and gangues are substantially produced as separated particles [8].

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The choice of appropriate communition equipment is very important because communition is energy intensive operation. In fact it has been established that 50% of the energy used in processing of ore mineral in united state mills is consumed at the communition stage [9].

The most widely used parameter to measure ore grindability is the bond work index , wi [3].Numerically the work index is the energy required in Kwh/short tones to reduce a given material from theoretical infinite size to 80% passing of `100microns [4].

The earlier methods of grindability test were the simple open circuit batch test; this method was found to be only suitable for materials which are homogenous e.g coal because the grindability of the ore was reported as either harder or softer than the required reference ore which has undergone the same processes [6].

Closed circuit grindability test were later introduced to overcome the problems of the open-circuit test. The grindability was given as the rate of production of net grains of under-size passing a specific mesh of grinding per unit time [7].

The development of Bond's theory in 1952 and his methods of determining grindability of ore which are similar to closed circuit grindability test. The grindability was empirically modified to be the work index (wi) of the ore [2].

A number of methods of grindability test which are simper and faster and at the same time produced comparative results with choice of Bond's were device. One of these methods was derived by [1].

The determination of work index using modified Bond's method can be compared to method of determining it by Berry and Bruce in 1966.This method requires the use of a reference ore of known grindability. In this research work the Berry and Bruce method is used because of its advantages outlined.

Bond's developed an equation which is based on the theory that the work input into either a crusher or grinding mill is proportional to the new crack tip length produced during the particle breakage which also equals to the work represented by the product minus that represented by the free Bond's equation given by:

$$W = 10wi/\sqrt{P} - 10wi/\sqrt{F}$$

$$= 10wi\,(1/\sqrt{P} - 1/\sqrt{F})$$

Where wi = work index of the material being broken

P=the diameter in micron meter with 80% of the product passes

F=the diameter in micron meter which 80% of the feed passes

W= Work input in Kilowatt hour per short tonne.

The objective of this research work is to determine the grindability of Wasagu Manganese ore deposit located a mineral site located in Kebbi state of Nigeria using modified Bob's Method.

2. Material and Methods

Representative sample of Manganese ore (Test ore) were obtained from Wasagu manganese ore deposit Located between Bena town and Zuru in kebbi State of Nigeria. Granite (Reference ore) from Jiche Village opposite Hill Station Hotel, along Tudun wada in Jos North Local government. Jos, using random sampling method. The samples were collected at various spot of the mining site, 3 meters a part, 50kg of each material was obtained for the study.

Samples were broken manually with a sledge hammer to provide the required size acceptable to laboratory Denver Jaw crusher, then to cone crusher and finally Roll crusher. The samples were crushed and pulverized, part of pulverized samples were weighed for sieve analysis. The modified Bond's method of determining the net work index of ore involving the use of reference ore of which grindability is known. The procedure is as follows:

1.100g each of the ore under test and the reference ore were crushed and pulverized in the laboratory ball mill for an hour.

2. The samples of test and reference ores were taken and seized by sieving into a number of size fraction using the automatic sieve shaker for 3o minutes.

3. Each size fraction of the test and the reference ores were weighed and the value noted "feed"

4. The "feed" test and reference ores were each gathered together and introduced into the laboratory ball milling machine and mill for 30 minutes.

5. The test and the reference ores from the laboratory ball mill machine were sized and each sieve fraction was weighed and the value noted as the product or discharge.

6. Sieve analysis. The ground samples were sieved into the following sieve size fractions;+1400 µm,+1000 µm,+710 µm,+500 µm,+355 µm,+250 µm,+180 µm,+125 µm,+90 µm,+63µm,-63µm using automatic Denver sieve shaker for 30 minutes.

The weights of materials retained on each sieve were then tabulated against the sieve size for both the reference ore (Granite) and the test ore (Wasagu manganese ore).the results of the test are given below in tables 1 to 4

3. Results and Discussion

Tables 1, Below Shows The Sieve Analysis Result of the feed to ball mill of reference mineral (Granite).

Table 1: The Feed to ball mill of reference mineral (granite)

Sieve size(μm)	Wt (g) retained	Wt% retained	Cumulative wt% retained	Cumulative wt% passing
+1400	22.54	22.61	22.61	77.39
+1000	14.75	14.80	37.41	62.59
+710	14.90	14.95	52.36	47.64
+500	13.90	13.94	66.30	33.70
+355	7.77	7.79	74.09	25.91
+250	8.70	8.73	82.82	17.18
+180	6.88	6.90	89.72	10.28
+125	4.02	4.03	93.75	6.25
+90	3.96	3.92	97.67	2.33
+63	0.92	0.92	98.59	1.41
-63	1.34	1.34	100.00	0

Table 2, below shows the sieve analysis of product of reference material (Granite)to ball mill.

Table2: The Product of reference material (Granite) of the ball mill.

Sieve size(μm)	Wt (g) retained	Wt% retained	Cumulative wt% retained	Cumulative wt% passing
+1400	-	-	-	-
+1000	-	-	-	-
+710	0.27	0.27	0.27	99.73
+500	19.47	19.64	19.91	80.09
+355	0.39	0.39	20.30	79.70
+250	52.24	52.71	73.01	26.99
+180	15.91	16.05	89.06	10.94
+125	2.82	2.85	91.91	8.09
+90	6.12	6.18	98.09	1.91
+63	0.90	0.91	99.00	1.0
-63	0.98	0.99	100.00	0.0

Table 3, below shows the sieve analysis of the feed of test ore to ball mill.

Table3: The Feed of test ore to ball mill

Sieve size(μm)	Wt (g) retained	Wt% retained	Cumulative wt% retained	Cumulative wt% passing
+1400	33.08	33.09	33.09	66.91
+1000	8.48	8.48	41.57	58.43
+710	7.72	7.72	49.29	50.71
+500	7.25	7.25	56.54	43.46
+355	5.93	5.93	62.47	37.53
+250	5.77	5.77	68.24	31.76
+180	6.81	6.81	75.05	24.95
+125	6.89	6.89	81.94	18.06
+90	7.84	7.84	89.78	10.22
+63	7.79	7.79	97.57	2.43
-63	2.41	2.41	100.00	0

Table4, below shows the sieve analysis of the product of test ore (Manganese) of the ball mill.

Table 4: The product of Test ore of the ball mill

Sieve size(μm)	Wt (g) retained	Wt% retained	Cumulative wt% retained	Cumulative wt% passing
+1400	-	-	-	-
+1000	-	-	-	-
+710	-	-	-	-
+500	9.67	9.67	9.67	90.33
+355	9.97	9.97	19.64	80.36
+250	40.15	40.17	59.81	40.19
+180	21.39	21.40	81.21	18.79
+125	6.25	6.25	87.46	12.54
+90	6.21	6.21	93.67	6.33
+63	3.47	3.47	97.14	2.86
-63	2.85	2.85	100.00	0

Figure 1: Semi logarithm plot of the cumulative percentage passing against particle size for the granite (Reference mineral).

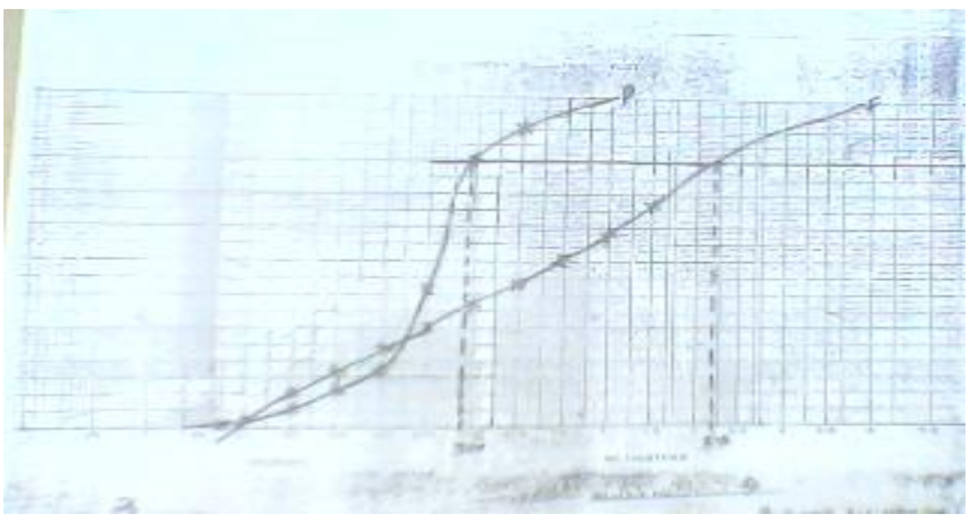

Figure 2: Semi logarithm plot of the cumulative percentage passing against particle size for the Wasagu manganese ore (Test ore).

4. Calculation

Bond's Equation states that:

W = Wt= Wir $(10/\sqrt{Pr} - 10/\sqrt{Fr}) = Wit(10/\sqrt{Pt} - 10/\sqrt{Ft})$ [2]

From the plot of cumulative wt% passing against particle size of the reference ore figure 1,the followings were obtained.

80% passing feed size= 1700 µm

80% passing of product= 460 µm

Work index of the reference ore (Granite) = 15.14Kwh/tonne

The energy expended in grinding the ore from 80% passing feed (1500 µm) to 80% passing product (430 µm)

using Bond's energy equation is given by :

W_f= 10w(1/√P_f-1/√F_f) Kwh/tonne

=10x15.14 (1/√460-1/√1700)

=1514(0.047-0.024)

=3.4822 Kwh/tonne

For the test ore given by figure 2, the following were obtained

80% passing feed size =2200 µm

80% passing Product size = 325 µm

The energy consumed in grinding the test ore is given by

W_t = 10w_i (1/√325 -1/√2200) Kwh/tonne

Since the same energy was consumed in grinding both the reference material and test ore, then

10w_i (1/√325 – 1/√2200) = 3.4822 Kwh/tonne

10w_i (0.055 – 0.021) = 3.4822 Kwh/tonne

Solving for w_i in the above relationship

Therefore W_i =10.24Kwh/tonne

Tables 1 to 4 are the results of the particle size analysis of both the reference mineral (Granite) and the Test ore (Wasagu manganese ore).figures 1 and 2 are the semi logarithm plot of the cumulative percentage passing against particle size. Semi-logarithm plot was chosen to avoid congestion of points in the region of finer apertures sizes.

From the plots, the 80% passing feed and product size for both reference mineral (Granite) and test ore (Manganese ore) were estimated. These values were then used in calculating the amount of energy expended in grinding the reference ore using Bond's equation and was found out that the energy required is approximately 3.4822 Kwh/tonne. This amount of energy expended in grinding the reference ore was then used in determining the work index of the Wasagu manganese ore, which was calculated to be about 10.24 Kwh/tonne.

The value of the work index obtained for the manganese ore may be said to be valid only over the size range of particle considered. This is because breaking characteristic of most ores varies with particle size [6]. And this brings about variation in the work index with particle size. For instance when a mineral breaks easily at the grain boundaries, but the individual grains are tough, then its grindability is bound to increase with fineness of grind [6].

5. Conclusion and Recommendation

The value of the work index of the ore obtained in this work is approximately 10.24 Kwh/tonne. This value of the work index means that 10.24 Kilowatts hour of energy is required to reduce one tonne of the manganese ore from 80% passing particle size of 2200 µm to 80% passing particle size of 325 µm. The work index of 10.24 Kwh/tonne value obtained when granite was used as reference ore and Wasagu manganese as the Test ore is within the standard limit of work index of some manganese ore (10 - 15.14Kwh/tonne) in Nigeria [9]. It can then be concluded that Wasagu manganese ore is of average resistance to grinding.

It is here by recommended that the value of work index obtained (10.24 Kwh/tonne) in this study should serve as a guide for designing grinding plant for Wasagu Manganese ore in Kebbi state, Nigeria.

Acknowledgment

The authors wish to thank The National Metallurgical Development Centre, Jos, Plateau State, Nigeria; for allowing the use of their laboratories and facilities in the cause of this research work.

References

1. Berry T.F and Bruce R.W (1966): A simple method of determining the grindability of ores, Canadian Mining Journal (July).
2. Bond, F.C. (1961); Crushing and Grinding Calculation, Bulletin 07R9235B.
3. Magdalimovic N.M (1989): Calculation of energy required for grinding in a ball mill, Journal of Mineral Processing 25, (Jan) 41.
4. Onemine (2010): Summary and Determination of the Bond Work index using an ordinary Laboratory Batch Ball Mill, Http;//www.onwmine.org/search/summary.cmf
5. Olatunji K.J., Durojaiye A.g.,(2010);Determination of Bond Index of Birnin – gwari Iron ore in Nigeria, Journal of Minerals and Materials characterization and Engineering, Vol.9,No.7,Pp.637 – 642,jmmce.org,USA.
6. Yaro S.A.,(1996);Grindability test for Ririwai Lead-Zinc complex ore; Journal of Nigeria Mining.
7. Weiss,N.F. (1985); Mineral Processing Handbook,Society of Mining Engineers,AIME Volume 1,Pp3A – 24.
8. Wills, B.A (2006); Mineral Processing Technology, 3rd Edition, Pergamon Press,Pp182 – 185.
9. Wills B.A. Napier-Munn J.T. (2006); Wills' Mineral Processing Technology. Elsevier Science and Technology.7th Edition Books. Pp 111.