JMME. Vol. 11 September 2018 *ISSN: 2006-1919*
pp. 18-22

DETERMINATION OF THE WORK INDEX OF ZURAK LEAD –ZINC ORE, PLATEAU STATE, NIGERIA

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ABSTRACT

The work index of Zurak Lead-Zinc ore deposit in Plateau State of Nigeria was determined using the modified Bond's method. The sample of the ore used for the test was sourced from Zurak village in Wase LGA, using the grab and trench sampling technique. The reference ore (Iron ore) was also sourced from Itakpe village in Kogi State. The reference and test ores of equal and known weights were ground using a rod mill under the same grinding conditions respectively. The grinding was conducted dry. The size analyses of the rod mill feed and discharge for both the reference and test ores were also carried out respectively. The reference ore (Itakpe Iron ore) of work index 8.71kWh/ton was used to calculate the work index of the test ore (Zurak Lead-Zinc) and was found to be 11.41kWh/ton. The work index value of the Lead-Zinc ore obtained agreed favourably with the ones cited in the literature.

Key words: Zurak Lead-Zinc, reference ore, test ore, work index.

1.0 INTRODUCTION

Grinding characteristics of an ore refers to the ease with which the ore can be comminuted. It is an important factor in estimating the power requirement of industrial grinding operations. A generally accepted method of determining the work index is the method of Barry and Bruce, otherwise known as the Modified Bond's Method. The method requires the use of a reference ore whose work index is known, and using the Bond's Energy Equation (Wills, 2006).

$$\mathrm{W} = \frac{10\mathrm{W}_i}{\sqrt{\mathrm{P}}} - \frac{10\mathrm{W}_i}{\sqrt{\mathrm{F}}}$$

Where, W = Work input, W_i = Work index, P = product, F = feed

The work index of the unknown ore is determined when the work input (W) is the same for the identical weights of the reference and unknown ore, ground under the same conditions in the same laboratory ball mill. The energy input of the unknown ore therefore equals that of the reference ore.

For the above conditions where r and u denote the reference and unknown ores respectively, the following holds according to Wills (2006):

$$E_r = E_u = W_{ir}\left[\frac{10}{\sqrt{P_r}} - \frac{10}{\sqrt{F_r}}\right] = W_{iu}\left[\frac{10}{\sqrt{P_u}} - \frac{10}{\sqrt{F_u}}\right]$$

Where, E_r is the energy input in grinding the reference ore,
E_u is the energy input in grinding the unknown ore,
W_{ir} is the work index of the reference ore,
W_{iu} is the work index of the unknown ore,
F_r is the 80% passing feed of reference ore,
F_u is the 80% passing feed of unknown ore,
P_r is the 80% passing product of reference ore,
P_u is the 80% passing product of unknown ore.

Therefore, the work index of the unknown ore is:

$$W_{iu} = W_{ir}\frac{\left[\frac{10}{\sqrt{P_r}} - \frac{10}{\sqrt{F_r}}\right]}{\left[\frac{10}{\sqrt{P_u}} - \frac{10}{\sqrt{F_u}}\right]}$$

This method is relatively simple and is called the comparative method of determining the work index.

2.0 MATERIALS AND METHODS

50Kg of the Lead-Zinc ore sample was collected from the deposit site at Zurak using the grab and trench sampling techniques.

1.7kg of the reference and test ores were each ground dry, in a Bico Rod mill for 30minutes and their power consumptions recorded. The samples were further split using a Jones Riffle.

500g of the product samples were sieved for 30minuteson an Endecott sieve shaking machine to determine the particle size at 80% passing.

The appropriate sieve aperture sizes ranging from 1700µm to 63µm were used based on the square root of 2 (√2 = 1.414) method.

Sieve analysis was carried out to determine the particle size distribution of the ore in each sieve size fraction. 637.83g of the ore was ground for 10minutes in a Bico Pulverizer and sieved for 30minutes. Sieve aperture sizes ranging from 500µm to 63µm were used. Each sieve size fraction obtained was weighed and recorded.

3.0 RESULTS AND DISCUSSIONS

The reference ore used was Itakpe Iron ore whose work index is 8.71Kwh/tonne (Smith & Lee, 1968 in Sirajo, 2008). The grinding was conducted dry.

Table 1: Feed to the rod mill of reference ore (Itak peIron ore)

Sieve size (**µ**m)	Weight retained		Cumulative weight (%)	
	(g)	(%)	Retained	Passing
+1700	83.12	17.27	17.27	82.73
+1168	72.03	14.96	32.23	67.77
+1000	90.13	18.72	50.96	49.04
+699*	50.12	10.41	61.37	38.63
+500	33.41	6.94	68.31	31.69
+350*	12.27	2.55	70.86	29.14
+250	43.31	9.00	79.86	20.14
+180	29.11	6.05	85.91	14.09
+125	21.10	4.38	90.29	9.71
+90	26.41	5.49	95.78	4.22
+63	12.22	2.54	98.31	1.69
-63	8.12	1.69	100.00	-
	481.35	100.00		

Table 2: Rod mill discharge of reference ore (Itakpe Iron ore)

Sieve size (μm)	Weight retained		Cumulative weight (%)	
	(g)	(%)	Retained	Passing
+699	-	-	-	-
+500	20.43	4.79	4.79	95.21
+350	40.17	9.42	14.21	85.79
+250	79.44	18.64	32.85	67.15
+180	43.11	10.11	42.96	57.04
+125	109.44	25.68	68.64	31.36
+90	60.41	14.17	82.81	17.19
+63	49.34	11.58	94.39	5.61
-63	23.91	5.61	100.00	-
	426.25	100.00		

Table 3: Rod mill feed of test ore (ZurakLead-Zinc)

Sieve size (μm)	Weight retained		Cumulative weight (%)	
	(g)	(%)	Retained	Passing
+1700	57.06	11.54	11.54	88.46
+1168	35.91	7.26	18.80	81.20
+1000	32.63	6.60	25.40	74.60
+699	81.32	16.45	41.85	58.15
+500	21.61	4.37	46.22	53.78
+350	74.13	14.99	61.22	38.78
+250	41.75	8.45	69.66	30.34
+180	15.68	3.17	72.84	27.16
+125	47.63	9.63	82.47	17.53
+90	14.28	2.89	85.36	14.64
+63	41.96	8.49	93.85	6.15
-63	30.41	6.15	100.00	-
	494.37	100.00		

Table 4: Rod mill discharge of test ore (ZurakLead-Zinc)

Sieve size (µm)	Weight retained		Cumulative weight (%)	
	(g)	(%)	Retained	Passing
+699	-	-	-	-
+500	-	-	-	-
+350	24.93	5.23	5.23	94.77
+250	56.40	11.84	17.07	82.93
+180	35.71	7.50	24.57	75.43
+125	145.04	30.45	55.02	44.98
+90	56.51	11.86	66.89	33.11
+63	122.73	25.77	92.66	7.34
-63	34.96	7.34	100.00	-
	476.28	100.00		

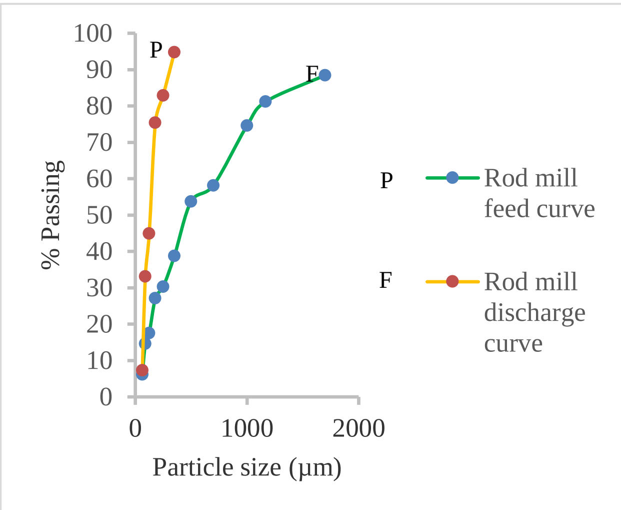

Figure 2: Plot of cumulative sieve analysis for the test ore (Zurak Lead-Zinc)

From table 1, the cumulative weight percent passing against particle size for the reference ore (Itakpe Iron ore) were obtained:

80% passing of feed size, F_r = 1650µm; 80% passing of product size, P_r=325µm

Work index of the reference ore W_i = 8.71Kwh/tonne

The energy expended in grinding the Iron ore from 80% passing feed (1650µm) to 80% passing product (325µm) using the Bond's energy equation is given by:

$$E_r = 10W_i\left(\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right) \text{ Kwh/tonne}$$

$$= 10 \text{ x } 8.71\left(\frac{1}{\sqrt{325}} - \frac{1}{\sqrt{1650}}\right)$$
$$= 87.1(0.05546 - 0.02462)$$
$$= 2.6863\text{Kwh/tonne}$$

Since the grinding was conducted dry, the energy expended in grinding the Iron ore from 80% passing feed (1650µm) to 80% passing product (325µm) using the Bond's energy equation is multiplied by a factor of 1.30. Thus,

$E_r = 1.30 \text{ x } 2.6863 = 3.4922\text{Kwh/tonne}$

Also, from Figure 2, the cumulative weight percent passing against particle size for the test ore (Zurak Lead-Zinc ore) were obtained:

80% passing of feed size, F_t = 1100µm; 80% passing of product size, P_t =215µm

The energy consumed in grinding the test ore is given by:

$$E_t = 10W_i\left(\frac{1}{\sqrt{215}} - \frac{1}{\sqrt{1100}}\right) = 0.306W_i$$

Since the same amount of energy was consumed in grinding both the Iron ore (reference ore) and the Lead-Zinc ore (test ore).

Then:

$$0.306W_i = 3.4922\text{Kwh/tonne}$$

Solving for W_i,

$$W_i = 11.41\text{Kwh/tonne}$$

The work index of the test ore (Zurak Lead-Zinc) is 11.41Kwh/tonne.

4.0 CONCLUSION AND RECOMMENDATIONS

The determination of the work index of Zurak Lead-Zinc ore was conducted using the modified Bond's method. The work index was found to be 11.41Kwh/tonne. This means that at an average cost of N30.00 per Kwh of power in Nigeria, it will cost N342.30 to comminute one tonne of Zurak Lead-Zinc to 80% passing 215µm.

Therefore, it is recommended that further work should be done to determine the reserve estimate of the Zurak Lead-Zinc deposit for the benefit of investors and other stakeholders in the minerals industry.

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