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Ball mill

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Abstract

A ball mill is a type of grinder, in a cylindrical device used in grinding or mixing materials like ores, chemicals, ceramic raw materials and paints. Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium. Different materials are used as media, including ceramic balls, flint pebbles and stainless steel balls. The objective of Bond ball mill test is carried out to determine the standard work index which is defined as the specific power required to reduce material from a notional infinite size to 80% passing screen. In this experiment, time of milling effect on particles size have been shown, So that the longer the time the better size reduction. A known weight of oil shale is crushed to retain in 63μm sieve size. The product is screened by using different size of sieve starting from 500μm, 250μm, 125μm, 90μm and lastly with 63μm. The product from the sieves were weighted and classify according to the size range of above 63μm.

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Results

Table (1): Raw data.

	Sample #1	Sample #2	Sample #3
Feed particle size (µm)	1400-850	1400-850	1400-850
Weight of sample (g)	100	100	100
Time (min)	5	10	15
Rotation speed (rpm)	250	250	250
Power consumption (W)	10	10	10

Table (2): Results of Bonds' law.

	Feed particle size	Weight of sample (ton)	Time (hr)	Feed rate(tons/hr)	Power consumption (kW)	Work index (KW.hr/ton)	Error (%)
Sample # 1	1125	0.0001	0.0833	0.0012	0.01	51.1	193.17
Sample # 2	1125	0.0001	0.1667	0.0006	0.01	49.57	184.4
Sample # 3	1125	0.0001	0.25	0.0004	0.01	48.1	176
theoretical Work index (KW.hr/ton)	17.43						

Table (3): Results of Sample #1 at time = 5 min.

Sieves size(µm)	Average screen opening(µm)	Mass collected on sieve (g)			
		Mass retained (g)	Mass retained (%)	Accumulative mass retained (%)	Accumulative mass passing (%)
x ≥500	500	82.8010	82.7993	82.7993	100.0000
500 > x >250	375	7.7000	7.6998	90.4992	17.2007
250 > x >125	187.5	2.8020	2.8019	93.3011	9.5008
125> x >90	107.5	1.4190	1.4190	94.7201	6.6989
90> x >63	76.5	1.5800	1.5800	96.3001	5.2799
63 ≥x	63	3.7000	3.6999	100.0000	3.6999
Total		100.0020	100.0000		

Table (4): Results of Sample #2 at time = 10 min.

Sieves size (µm)	Average screen opening(µm)	Mass collected on sieve (g)			
		Mass retained (g)	Mass retained (%)	Accumulative mass retained (%)	Accumulative mass passing (%)
x ≥500	500	72.1370	72.1363	72.1363	100.0000
500 > x >250	375	10.4630	10.4629	82.5992	27.8637
250 > x >125	187.5	5.8590	5.8589	88.4581	17.4008
125> x >90	107.5	2.8900	2.8900	91.3481	11.5419
90> x >63	76.5	3.2460	3.2460	94.5941	8.6519
63 ≥x	63	5.4060	5.4059	100.0000	5.4059
Total		100.001	100.000		

Table (5): Results of Sample #3 at time = 15 min.

Sieves size (µm)	Average screen opening (µm)	Mass collected on sieve (g)			
		Mass retained (g)	Mass retained (%)	Accumulative mass retained (%)	Accumulative mass passing (%)
x ≥500	500	57.8360	57.8366	57.8366	100.0000
500 > x >250	375	14.0750	14.0751	71.9117	42.1634
250 > x >125	187.5	7.0340	7.0341	78.9458	28.0883
125> x >90	107.5	4.5140	4.5140	83.4598	21.0542
90> x >63	76.5	3.9500	3.9500	87.4099	16.5402
63 ≥x	63	12.5900	12.5901	100.0000	12.5901
Total		99.9990	100.0000		

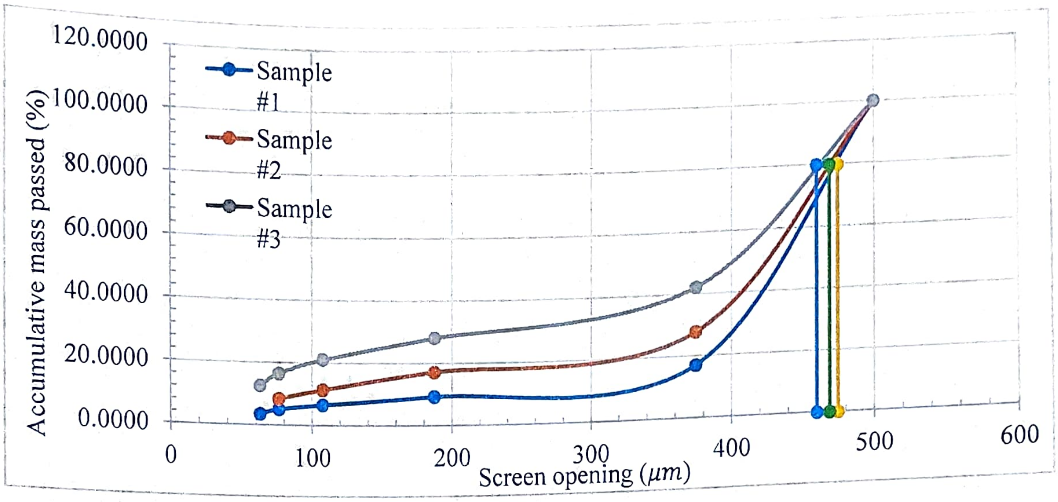

Figure (1): Relation between accumulative weight percent of product passed with screen opening

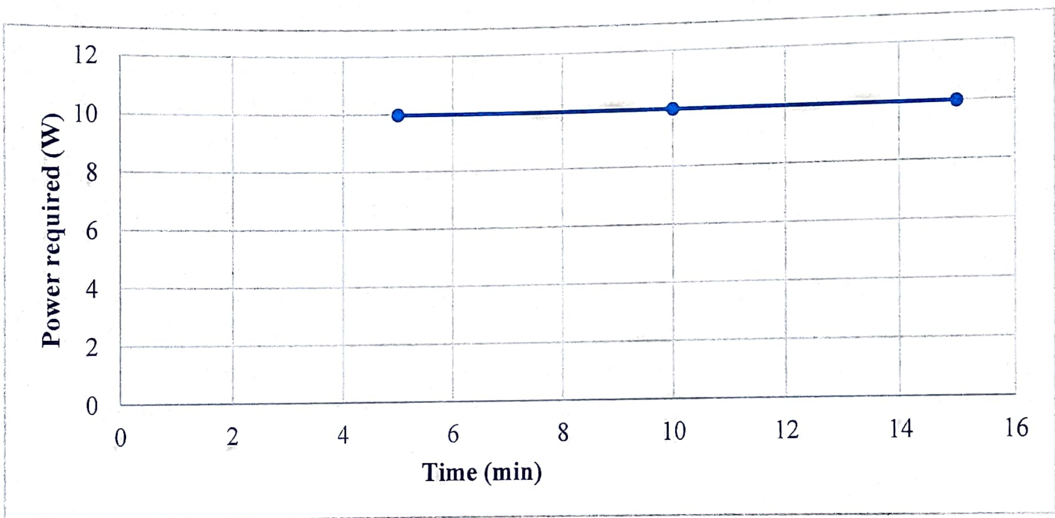

Figure (2): The behavior of power required along varies time applied

Discussion

When researching the oil shale particle milling procedure With the exception of milling time, which has a variable impact on particle size, all other variables are constant. Where the number of balls within the cylinder and the rotation's speed are two variables that never change. In order to improve the milling process since the driving power will be greater, start by placing oil shale with an average diameter of 1125 micrometers within the cylinder. Then, add metal balls of various sizes inside. Five minutes are spent on the first sample, 10 minutes on the second, and fifteen minutes on the last one.

After the milling process is finished, the product is put through sieves to determine the size of the particles remaining after the grinding process and then calculate Accumulative mass passing against screen operating as shown in figure (1) and from it get practical size of product which represent 80% of particle passing screen as shown in figure (1), it observed from the data as we increase time of milling as increase size reduction.

As seen from the data there is percentage error between experimental and theoretical bond work index because the grinding conditions are different, also it have been noted as the time of milling increase bond work index decrease because by definition of bond index is a measure of ore resistance to crushing and grinding as the time took longer the partials size reduction increase and therefore less resistance.

Finally, because some particles were left in the ball mill, the weight achieved after milling is lower than before milling. Not all particles can be extracted from the ball mill Due to the volatilization of some milling dust and its adherence to the cylinder walls and the outer surfaces of the balls used in the milling process, there is a small amount of inaccuracy in the measurements

Conclusion

- Size reduction rises as ball milling time increase.
- To produce a full curve of particle size distribution, wider aperture meshes should be employed in sieving.
- A lower weight was acquired after ball milling since some particles were lost during the process of removing them, when screen opening increases, the cumulative weight percentage of the product is determined.
- There are some variables affect crushing process such as: Initial material size, time & the Properties of material to be ground (hardness, brittleness, viscosity).

References

1. McCab, W.L., and Smith, J.C., Unit Operation of Chemical Engineering, McGraw Hill, Inc, 3rd ed., (1976).

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3. Greek Document.Bond work index tables (wi) from various sources.Retrived December 28, 2022 , from https://fdocument.org/document/bond-work-index-tables-wi.html?page=7

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1. McCab, W.L., and Smith, J.C., Unit Operation of Chemical Engineering, McGraw Hill, Inc, 3rd ed., (1976).

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3. Greek Document.Bond work index tables (wi) from various sources.Retrived December 28, 2022 , from https://fdocument.org/document/bond-work-index-tables-wi.html?page=7

Appendix:

Sample of calculation, taking the first row:

From Table (2):

Sample #1:

1. Feed particle size:

   $L_1 = \frac{850+1400}{2} = 1125\ \mu m.$

2. Weight of sample (ton):

   $m = 100\ g.$

   $m = \frac{100\ g}{1000\ g} * 0.001\ ton = 0.0001\ ton.$

3. Time (hr):

   t: $5\ min.$

   t (hr): $\frac{5\ min}{60\ min} * 1\ hr = 0.0833\ hr.$

4. Feed rate (ton/hr):

   $\dot{m} = \frac{\text{weight of sample (ton)}}{\text{time (hr)}} = \frac{0.0001\ ton}{0.0833\ hr} = 0.0012\ ton/hr.$

5. Power (kW):

   $P = 10\ W.$

   $P = \frac{10\ W}{1000\ W} * kW = 0.01\ kW.$

6. Bonds' work index (kw.hr/ton):

   Applying bonds' law:

$$\frac{p}{\dot{m}} = 0.3162\ W_i \left(\frac{1}{\sqrt{L_2}} - \frac{1}{\sqrt{L_1}}\right)$$

$$\frac{0.01}{0.0012} = 0.3162\ W_i \left(\frac{1}{\sqrt{470 * 10^{-3}}} - \frac{1}{\sqrt{1125 * 10^{-3}}}\right)$$

$$W_i = 51.1$$

From Table (3), taking the second row:

Sample #1:

1. Average screen opening:
   $d = \frac{500+250}{2} = 375\ \mu m$.

2. Actual sample weight:
   $wt = 82.801 + 7.700 + 2.802 + 1.419 + 1.580 + 3.700 = 100.002\ g.$

3. Mass fraction %:
   $= \frac{7.700}{100.002} * 100\% = 7.700\%$

4. Accumulative weight percent of product:

   $= 82.799 + 7.700 = 90.499\%$

Ball Mill Data Sheet -8-

	Sample #1	Sample #2	Sample #3
Feed particle size (µm)	1400-850	1400-850	1400-850
Weight of sample (g)	100	100	100
Time (min)	5	10	15
Rotation speed (rpm)	250	250	250
Power consumption (W)	10	10	10

	Mass collected on sieve (g)					
Sieves size	**Sample #1**	**Mass fraction %**	**Sample #2**	**Mass fraction %**	**Sample #3**	**Mass fraction %**
500	82.801		72.137		57.836	
250	7.7		10.463		14.075	
125	2.802		5.859		7.034	
90	1.419		2.89		4.514	
63	1.58		3.246		3.95	
< 63	3.7		5.406		12.59	
Total						

Instructor sign: [signature]	
Date: 21/12/2022	