The University of Jordan

School of Engineering

Chemical Engineering Department

lab (2)
section 2

Chemical Engineering Laboratory (II) 0915461

Experiment Number (6)

Jaw Crusher

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Abstract

Almost all process industries employ size reduction or comminution to produce solid particles of desired shape, size or size ranges, to separate unwanted particles effectively, to improve handling characteristics, and to increase of the surface area of solid materials used especially for chemical reactions or unit operations such as leaching, drying, adsorption and the like. Size reduction can be carried out in stages using different types of equipment depending on the characteristics of the feed and the product to be obtained. These equipment vary in their mechanical action to give different kinds of motions and force that would result in the fracturing of the solid particles into smaller sizes.

In this experiment have been shown comminution behavior of oil shale using Jaw crusher and the effect of specific factor such initial material size on power requirements. In experiment, Jaw crusher have been used. Used to reduce the run-of-mine ore down to a size suitable a then we used a sieve shaker. In result the bigger particles need more power for crushing and grinding

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Results

Table (1): Properties for crushing coarse size particles and power required.

coarse size						
Dimension of feed particles	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	d_v (mm)	d_{80} (mm)
	2.5	1.5	1	3.75	19.83	1.3
	2	1.5	2	4.5		
	2	2	1	4		
				Avg=4.0833		
weight of sample	348.214 g = 0.000348214 ton					
Time needed for crushing	1.12 min = 0.01867 hour					
feed flow rate (ton/hr)	0.018651					
power (KW)	0.0608					

Table (2): Cumulative distribution for coarse size.

Coarse size				
Sieves size	davg(mm)	Weight(g)	Weight (%)	Weight cumulative (%)
x ≥1.4mm	1.4	163.554	47.16	100
1.4mm> x >850 μm	1.125	66.371	19.14	52.84
850 μm > x >500 μm	6.750E-01	43.93	12.67	33.7
500 μm > x >355 μm	4.275E-01	18.194	5.25	21.03
355 μm > x >250 μm	3.025E-01	17.172	4.95	15.78
250 μm > x >180 μm	2.150E-01	6.684	1.93	10.83
180 μm > x >90 μm	1.350E-01	9.227	2.66	8.9
90 μm ≥ x	9.000E-02	21.642	6.24	6.24
Total		346.774	100.000	

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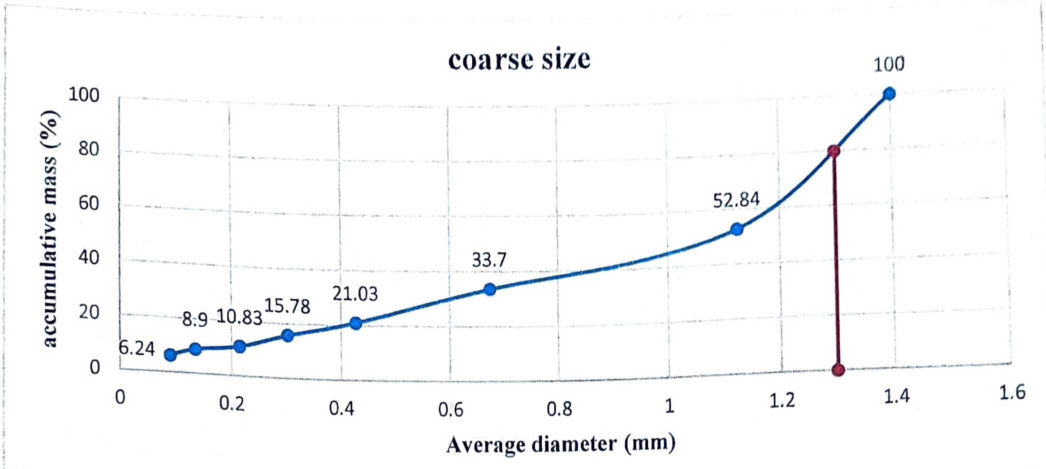

Figure (1): Accumulative mass percent against average opening diameter for coarse size

Table (3): Properties for crushing intermediate size particles and power required.

intermediate size						
Dimension of feed particles	length (cm)	Width (cm)	height (cm)	volume (cm^3)	d_v (mm)	d_{80} (mm)
	1.5	1	0.7	1.05	12.78	1.3
	1.5	1.2	0.4	0.72		
	1.8	1.2	0.7	1.512		
				Avg=1.094		
weight of sample	346.347 g = 0.00034635 ton					
Time need for crushing	1:07 min = 0.017833 hour					
feed flow rate (ton /hr)	0.019422					
power (KW)	0.05796					

Table (4): Cumulative distribution for intermediate size.

Intermediate size				
Sieves size	d_{avg}(mm)	Weight(g)	Weight%	Weight cumulative (%)
x ≥1.4mm	1.4	178.161	51.578	100.00
1.4mm> x >850 μm	1.125	62.15	17.993	48.42
850 μm > x >500 μm	6.750E-01	39.559	11.452	30.43
500 μm > x >355 μm	4.275E-01	16.407	4.750	18.98
355 μm > x >250 μm	3.025E-01	15.202	4.401	14.23
250 μm > x >180 μm	2.150E-01	6.054	1.753	9.83
180 μm > x >90 μm	1.350E-01	8.216	2.379	8.07
90 μm ≥ x	9.000E-02	19.67	5.695	5.69
Total		345.419	100.00	

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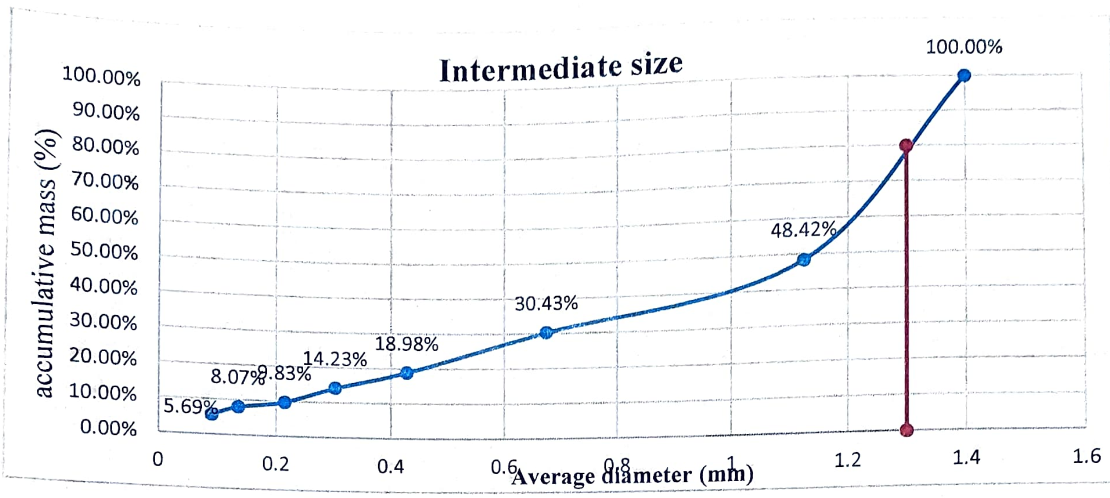

Figure (2): Accumulative mass percent against average opening diameter for intermediate size.

Table (5): Properties for crushing fine size particles and power required.

Fine size						
Dimension of feed particles	**length (cm)**	**Width (cm)**	**height (cm)**	**volume (cm^3)**	**dv (mm)**	**d_{80} (mm)**
	1	0.5	0.3	0.15	7.115	1.3
	1.2	0.8	0.4	0.384		
	0.4	0.4	0.2	0.032		
				0.1887		
weight of sample	346.927 g = 0.00034693 ton					
Time need for crushing	1 min = 0.01667 hour					
feed flow rate (ton/hr)	0.02081					
power (KW)	0.0522					

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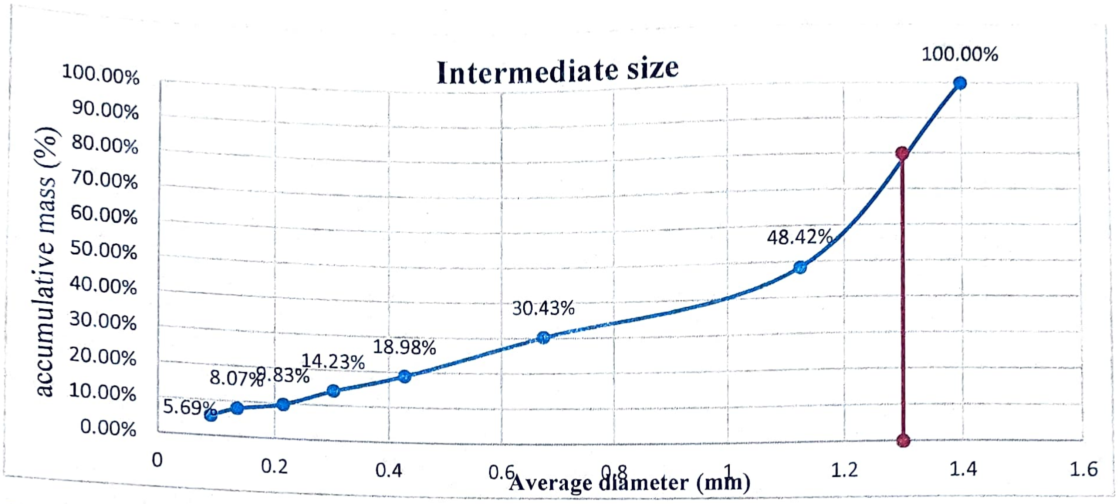

Figure (2): Accumulative mass percent against average opening diameter for intermediate size.

Table (5): Properties for crushing fine size particles and power required.

Fine size						
Dimension of feed particles	**length (cm)**	**Width (cm)**	**height (cm)**	**volume (cm^3)**	**d_v (mm)**	**d_{80} (mm)**
	1	0.5	0.3	0.15	7.115	1.3
	1.2	0.8	0.4	0.384		
	0.4	0.4	0.2	0.032		
				0.1887		
weight of sample	346.927 g = 0.00034693 ton					
Time need for crushing	1 min = 0.01667 hour					
feed flow rate (ton/hr)	0.02081					
power (KW)	0.0522					

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Table (6): Cumulative distribution for fine size.

Fine size				
Sieves size	d_{avg}(mm)	Weight(g)	Weight%	Weight cumulative (%)
x ≥1.4mm	1.4	185.583	54.159	100.000
1.4mm> x >850 μm	1.125	60.272	17.589	45.841
850 μm > x >500 μm	6.750E-01	37.37	10.906	28.252
500 μm > x >355 μm	4.275E-01	15.026	4.385	17.346
355 μm > x >250 μm	3.025E-01	14.122	4.121	12.961
250 μm > x >180 μm	2.150E-01	5.58	1.628	8.840
180 μm > x >90 μm	1.350E-01	7.514	2.193	7.211
90 μm ≥ x	9.000E-02	17.196	5.018	5.018
Total		342.663	100.000	

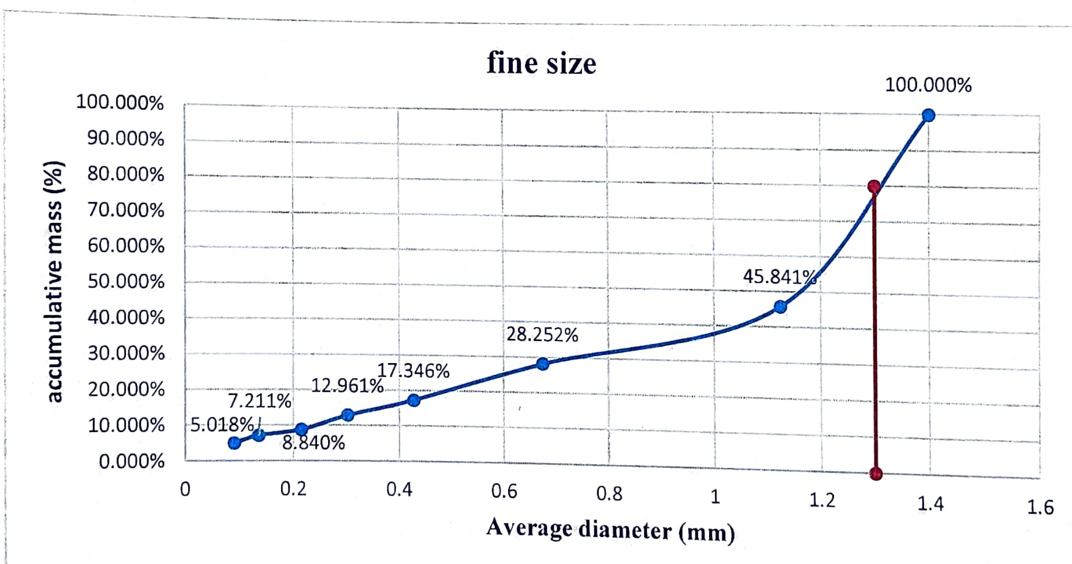

Figure (3): Accumulative mass percent against average opening diameter for fine size.

Table (7): Different particles size of product and feed and power required for crushing.

	weight of sample (ton)	time need for crushing (hr)	feed flow rate (ton/hr)	feed particles size L_1 (mm)	feed particles size L_2 (mm)	work index (kw.hr/ton)	power(KW)
coarse size	0.000348214	0.01867	0.018651	19.83	1.3	15.8	0.0608
intermediate size	0.00034635	0.017833	0.019422	12.78	1.3	15.8	0.05796
fine size	0.00034693	0.01667	0.02081	7.115	1.3	15.8	0.0522

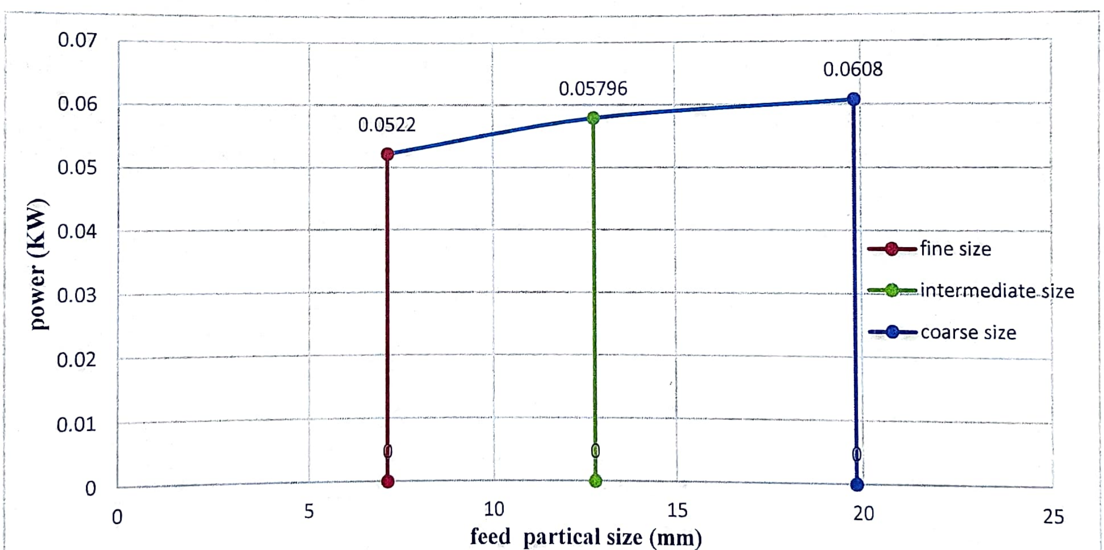

Figure (4): power required for crushing against varies feed particles size.

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Discussion

when studying crushing process on oil shale particles All factors will be constant except initial material size(coarse ,intermediate, fine particles) of crushing process, also studying how initial material size will effect on power requirement Where other process variable (Jaw gap setting , type of material) remain constant .Initially, introduce oil shale in jaw crusher, This apparatus has two Jaws. The rock or stones are held in the jaws of one of them, which is movable, until they are tiny enough to fit through the space at the bottom of the jaws, at which point we utilized a sieve shaker. A sieve shaker automates the agitation of particles for particle separation and size distribution for a range of materials to meet the demands of quality control and quality assurance. Shakers provide consistency, precision, and repeatable separations as compared to hand sieve shaking techniques for particle size. In storage, sieves are organized according to aperture size. The first sample (coarse particles) with average particle size (19.83 mm) it take 1.12 minutes, in the second sample (intermediate particles) with average practical size (12.87mm) it take one minutes and the last one (fine particles) with average particles size (7.115 mm) take one minutes.

After the crushing process is completed, we will put the product in the sieves to calculate the size of the particles 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 that the bigger particles need more energy to reach a specific size as shown in table (7).

Due to the volatilization of some grinding dust and its adherence to the walls of jaw device, there is a small amount of inaccuracy in the measurements.

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Conclusion

- The larger particles require more energy to grow to a certain size.
- The relationship between crushing force and material crushing strength is essentially linear.
- The crushing process is affected by a number of factors, including: Size of the raw material, setting of the jaw gap, and crushing technique

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References

1. Lowrison, C.C., "Crushing and Grinding" Butterworths (1974).

2. McCabe, W.L. and Smith, J.C,"Unit Operation of Chemical Engineering ", 3rd edition, McGraw – Hill.

3. Coulson J.M and Richardson J. F., "Chemical Engineering", Volume 2,2nd edition, Pergamon pre

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Appendix

Sample of calculation, taking the first row from Table (1): Coarse size

1. Average volume particles size (V_{avg}): 4.0833 cm^3.
2. Equivalent volume diameter (d_V)= $\left(\frac{6*Vavg}{\pi}\right)^{\frac{1}{3}} = 1.983cm = 19.83mm$
3. Weight of sample (ton):
   $m = 348.214\ g.$
   $m = \frac{348.214\ g}{1000\ g} * 0.001\ ton = 0.000348214\ ton.$
4. Time (hr):

   t: $1.12\ min.$

   t (hr): $\frac{1.12\ min}{60\ min} * 1\ hr = 0.01867\ hr.$

5. Feed rate (ton/hr):
   $\dot{m} = \frac{\text{weight of sample (ton)}}{\text{time (hr)}} = \frac{0.000348214\ ton}{0.01867\ hr} = 0.018651\ ton/hr.$

6. Bonds' work index (kw.hr/ton): 15.8

   Applying bonds' law:

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

$$\frac{P}{0.018651} = 0.3162 * 15.8\left(\frac{1}{\sqrt{19.83}} - \frac{1}{\sqrt{1.3}}\right)$$

$$P = 0.0608\ KW$$

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From Table (2), taking the third row:

1. Average screen opening:

$$d = \frac{850+500}{2} = 675\ \mu m = 0.675 mm\ .$$

2. Actual sample weight:

$$wt = 163.557 + 66.371 + 43.93 + 18.194 + 17.172 + 6.684 + 9.227 + 21.642 = 346.774\ g.$$

3. Mass fraction %:

$$= \frac{43.93}{346.774} * 100\% = 12.67\%$$

4. Accumulative weight percent of product:

$$= 6.24 + 2.66 + 1.93 + 4.95 + 5.25 + 12.67 = 30.7\%$$

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Jaw crusher Data Sheet -6-

	Coarse size	Intermediate size	Fine size
Dimensions of feed particle	(2.5)*(1.5)*(1)	(1.5)*(1)*(0.7)	(1)*(0.5)*(0.3)
	(2)*(1.5)*(1.5)	(1.5)*(1.2)*(0.4)	(1.2)*(0.8)*(0.4)
	(2)*(2)*(1)	(1.8)*(1.2)*(0.7)	(0.4)*(0.4)*(0.2)
Weight of sample	348.214 g	346.347 g	346.927 g
Time need for crushing	1:12 min	1:07 min	0.59 min

	Mass collected on sieve (g)		
Sieves size	Coarse size	Intermediate size	Fine size
x >1.4mm	163.554	178.161	185.583
1.4mm> x >850µm	66.371	62.150	60.272
850 µm > x >500 µm	43.930	39.559	37.370
500 µm > x >355 µm	18.194	16.407	15.026
355 µm > x >250 µm	17.172	15.202	14.122
250 µm > x >180 µm	6.684	6.054	5.580
180 µm > x >125 µm	9.227	8.261	7.514
125 µm > x	21.642	19.670	17.196

Instructor sign :	
Date : 28/12/2022	

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