Middle East Technical University

Department of Metallurgical and Material Engineering

Mete215 – Materials Processing Laboratory

Experiment 1: Particle Size Reduction and Analysis

Instructor: Prof. Dr. Yavuz Topkaya

Assistant: Y. Tütel

Experiment Date: 21.11.2019

Submission Date: 1.12.2019

Name: Doruk Sınayuç

No: 2379808

Group Members: Murathan Cugunlular, İklim Ozturk, Melisa Yildirim, Ezgi Eylen, Mehmet Oguz Yavuz, Darin Azzam Ahed Alaryan, Bahattin Emre Boran, Ekin Kursun, Arslan Korcan Ozal, Olgu Cagan Ozonuk, Bahadir Akman, Onur Das

ABSTRACT

The ore that was picked undergone a crushing process first with the use of a dodge type jaw crusher and then with roll crusher. The reduction ratios of these two processes were calculated. A sample was taken from the crushed ore and after weighing it they undergone screening process as to determine the weight distribution of the ore particles. 7 different numbered meshes were used and the shaking was done with vibratory screen shaker for about 15 minutes. The total weight of the specimen was measured before and after the screening process. An increase of total weight was observed and discussed. 3 different plots were drawn with the use of the data gotten from screening analysis. These plots helped understand the distribution of the ore particles.

INTRODUCTION

Comminution can be said to be the reduction of size of the materials in preparation for further processes. (Centre for Mineral Research, n.d). There are several reasons as to why comminution is done. First of all, if the particles of minerals want to be separated than the mineral has to first be liberated (Barry A. Wills, 2016). Also, it has been mentioned that Comminution result in the reduction of the materials. This allows the ease of transportation.

The reducing of size is done in two main steps. Namely, crushing and grinding. Crushing is done by compressing the material that is on a non-moving. It is the primary stage of comminution where the crushers can be categorized into 3 categories; jaw, gyratory and cone crushers which are based on the way that the crushing occurs (Neikov, 2019). The crushing does not have to happen in only single step. More than 1 step of crushing can be done to get a desired level of initial reduction. Generally, 3 steps which are primary, secondary and tertiary can be done to get a final result of size that is less than half of a centimeter.

Jaw crusher reduce the size of the material by doing a force to the material that is fixed between a moving plate and a fixed plate where the force is done by the moving plate (Ashok Gupta, 2016). There are several types of jaw crusher based on where the plates are pivoted on. They are blake type, dodge type and universal type. In the experiment dodge type jaw crusher was used as it can be seen in figure 1. In dodge type jaw crusher, the moving plate is pivoted in the bottom part of the crusher which can also be seen in figure 1.

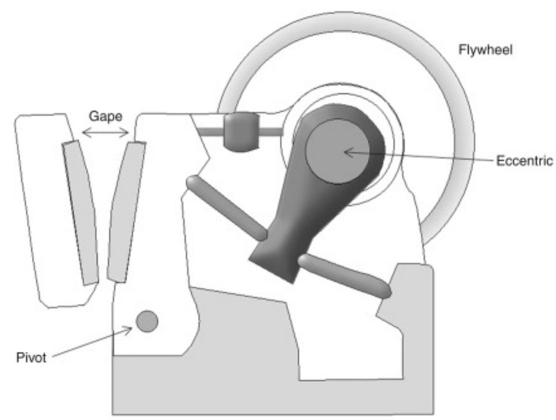

Figure 1. Dodge type jaw crusher (Ashok Gupta, 2016)

The reduction ratio can also be found in the process of crushing. The ratio Gape/Set is the theoretical value of the reduction ratio. To figure out what the actual reduction ratio is Max feed size is dived to the Max product size which gives a calculated reduction ratio. Generally, it is expected for a ratio in the range of 3 to 7 is expected. Moreover, the theoretical capacity of the jaw crusher can be determined by multiplying width and set and 0.6. It is important to note that while finding the capacity the width and set values should be in inches.

The amount of energy that is used in the duration of crushing also depends on some factors. To give an example, if a big rock which is hard is to be crushed than relatively more energy will be consumed.

It has been mentioned that usually the crushing process can reduce the size of the material to 0.5 cm but there are times that smaller sized particles are wanted. To do this the grinding process is done. The process can be done with the use of either balls, rods or pebbles that is moving in the mill body (Neikov, 2019). It is important on which media is picked for the grinding process as the rotation speed of the mill body as well as the medium can change the amount of reduction that can occur.

Sampling and screening are two important topics which was used on the experiment. Sampling is the gathering of a small sample which can represent all of the pile that the sample was gotten from. This is highly important as it is not always realistic to analyze an entire pile of material. Therefore, a representative sample is gathered and the conclusions are made from this sample. Screening is a method to observe the distribution of the particles. It is simply the procedure where what can be considered as sieves with different sized holes are put on top of each other. The holes size is known as the mesh number.

EXPERIMENTAL

Equipment

- Jaw crusher
- Roll crusher
- Riffle sampler
- US standard screens
- Vibratory screen shaker
- Balance

Sample

- Any ore that is available

Procedure

In the beginning of the experiment after a suitable ore has been chosen the first step was to measure the dimensions of the rock that will go under crushing process. Three values were measured and the middle value was taken as the length of the ore. After the measurements were taken the ore was first put into the dodge type jaw crusher. The crushed ore was then again measured. This was the end of the crushing with the jaw crusher. The crushed ore then underwent a crushing process again but this time with the use of a roll crusher. The measurement of the ore was again taken after the crushing process with the roll crusher. When this was over we went back to the lab. In the lab the crushed ore was shaped to be cone like and the sharp tip of the cone was flattened. Now, it was separated into 4 parts with the help of a riffle sampler. From one of these 4 parts a sample was gotten and with the help of a separator it was roughly evenly separated. This was done to get a more homogenous distribution. The weight of one sample that was just before separated into two was measured. After, it went through a screening process. A total of 7 meshes was used. For the shaking vibratory screen shaker was used for approximately 15 minutes. To end the experiment every ore particle in different sieve sections were weighed and noted.

RESULT

US mesh	Opening Size(mm)	Weight(g)	Actual wt.%	Cumulative wt.% oversize	Cumulative wt.% undersize	Log size(μ)	Log cumulative wt.% undersize
8	2.36	54.86	28	28	72	3.37	1.86
10	2	12.75	6.5	34.5	65.5	3.30	1.82
14	1.4	24.70	12.6	47.1	52.9	3.15	1.72
20	0.85	25.44	13	60.1	39.9	2.93	1.60
30	0.6	14.91	7.6	67.7	32.3	2.78	1.51
35	0.5	6.89	3.5	71.2	28.8	2.70	1.46
45	0.355	10.58	5.4	76.6	23.4	2.55	1.37
-45	-	46	23.4	-	-	-	-
total		196.13	-	-	-	-	-

Table 1. Data of the screen analysis

	Before process length(cm)	After Process length(cm)
Jaw Crusher	6	1.5
Roll crusher	1.5	0.6

Table 2. the length of ore before and after certain crushing process

The theoretical reduction ratio has been mentioned above and in this experiment a dodge type jaw crusher was used with a gap value of 4 inches as well as a set value of 0.5 inches. Therefore;

$$\text{Theoretical reduction ratio} = \text{Gape} / \text{Set} = 4 / 0.5 = 8$$

To calculate the actual reduction ratio for the jaw crusher process;

Calculated reduction ratio = Max. feed size / Max. product size = 6 / 1.5 = 4

To calculate the actual reduction ratio for the roll crusher process;

Calculated reduction ratio = Max. feed size / Max. product size = 1.5 / 0.6 = 2.5

	Before screening	After Screening
Weight (g)	194.3	196.13

Table 3. The total weight of sample before and after screening

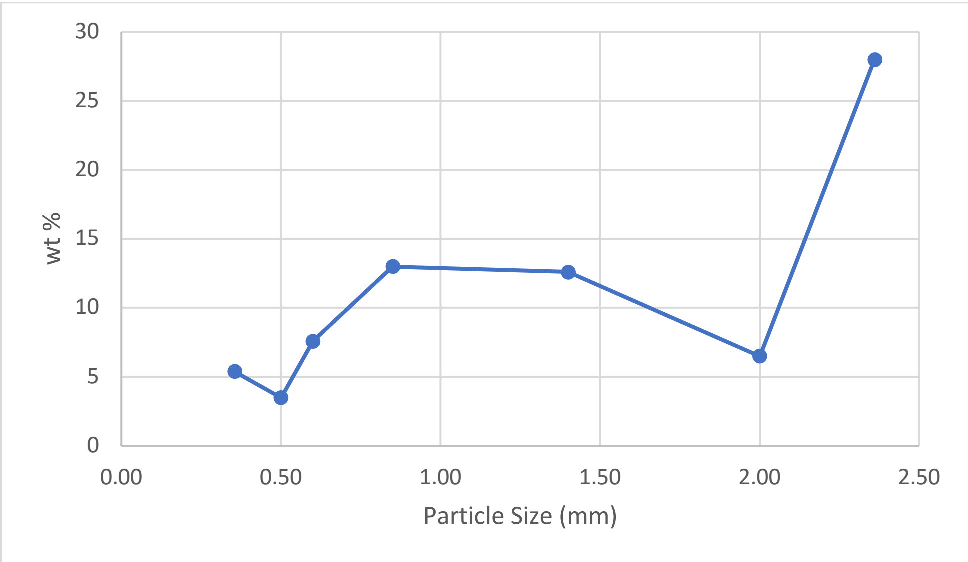

Figure 2. particle size graph vs actual wt. %

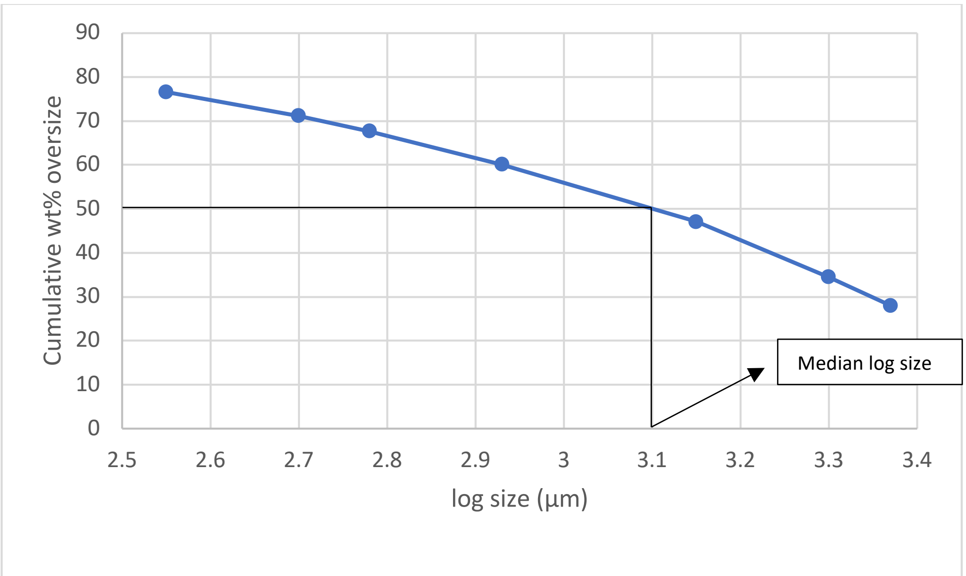

Figure 3. log size vs cumulative wt. % oversize

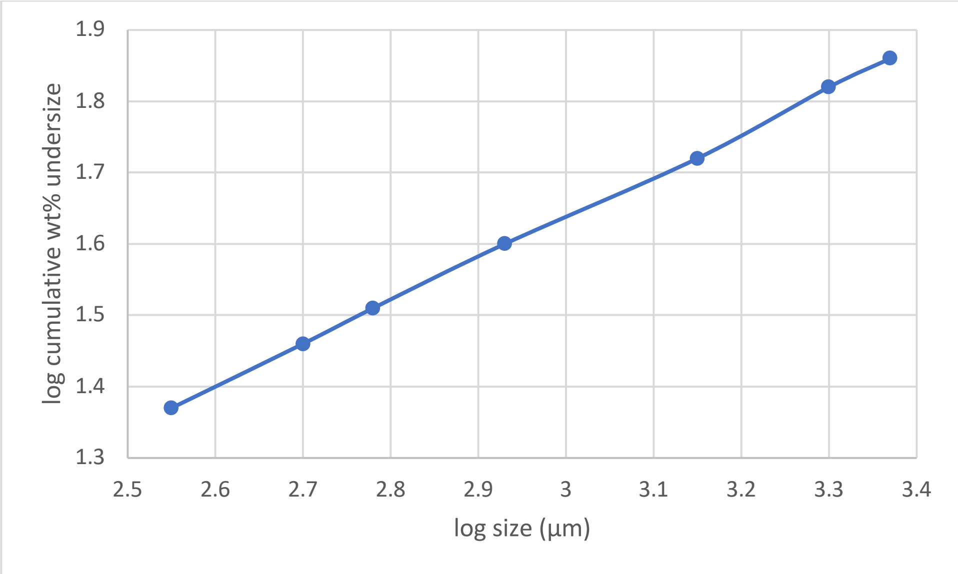

Figure 4. log size vs log cumulative wt. % undersize

Figure 1 till 3 show different kind of plots where the data that has been used can be seen in table 1. Figure 4 is also called the gates-Gaudin-Schuhmann plot. As can be seen in figure 3, the median log size is 3.1 µm meaning that median is $10^{3.1}$ = 1259 µm.

DISCUSSION

In this experiment different sieves with different mesh numbers and opening sizes were used. This is called as the screening process and with this a distribution data was obtained. By using this data different types of data were calculated. Namely, actual wt. %, cumulative wt.% oversize, cumulative wt.% undersize, log size and log cumulative wt.% undersize. Using these data three different kinds of plots were drawn.

In figure 2 the wt. % distribution is illustrated. Note that the distribution is not a gaussian distribution as the data we have gotten increases, decreases and again decreases which does not make a gaussian distribution. From figure 2 it can be concluded that most of the ore has length higher than 2 mm which means that it was not so homogenous. In figure 3 the graph of cumulative wt. % oversize with respect to log size can be seen. Notice that the log size has been converted into micrometer. This was done as to not work with negatives. In figure 3 the median size can also be found as 3.1 micrometer. This means that the average oversize ore in the specimen is of this length. Moreover, in figure 3 a decrease can be seen with the increase of log size. Figure 4 shows the change of log cumulative wt. % undersize with respect to log size. This plot is also called the gates-Gaudin-Schuhmann plot. In this plot it can be seen that there is generally a linear increase. This plot is drawn by using log of certain data's as it is possible to calculate some values such as the amount of weight % if there was a sieve of certain opening size.

Theoretical reduction as well as calculated reduction has been shown. The theoretical value is found as 8 for the jaw crusher where the actual value is found as 4. This is in our expectations as a reduction ratio from 3 to 7 is expected. However, there may be some mistakes in calculating the maximum product or feed size as the measurements were done by a ruler.

One important thing to note that is before the screening process the weight is 194.3 grams however when the weight is calculated after the screening process an increase of weight can be seen. During the process of the screening, it was observed that some particles stuck to the sieves. Therefore, it can be said that the extra weight might have come from these extra particles that were already there due to prior experiments. It was also observed that some particles were dropped to the ground during the weighing process. This means that the number of particles lost did not single out the particles that were added and there has been an increase of the total weight.

CONCLUSION

In this experiment the process of comminution was observed. This process that is aged very far back in modern history can be considered as an important way to reduce the size of materials. With the size of materials decreasing the liberation of certain materials can occur as well as transportation becomes much easier. The material also gets prepared for any hydrometallurgy process that may come. The crushing process was done by the help of a dodge type jaw crusher. It was learned that there are many ways for the crushing process to occur. The second step of comminution which is the grinding step also allows the further reduction of size of the material. In this experiment, three different plots were drawn and these plots helped explain the distribution of the ore with respect to weight.

REFERENCES

Ashok Gupta, D. Y. (2016). *Mineral Processing Design and Operations* . Elsevier.

Barry A. Wills, J. A. (2016). *Wills' Mineral Processing Technology* . Butterworth Heinemann.

Centre for Mineral Research. (n.d). *University of Cape Town*. Retrieved from Centre for Mineral Research: http://www.cmr.uct.ac.za/cmr/ra/comminution

Neikov, O. D. (2019). *Handbook of Non-Ferrous Metal Powders.* Kiev: Elsevier.

APPENDIX

The table of the plots can be found in results parts as table 1.