The characteristics study of sphalerite tailings by using MLA

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Abstract

Sphalerite tailings contains large amount of ferric sulfide and some sphalerite which need to be recovered to further use for the utilization of resource. The characteristics study of the tailings is necessary to the treatment of tailings. Mineral Liberation Analysis (MLA) is the effective modern method to analyze the mineral properties, especially the liberation of minerals which very important to the separation of different minerals. The sample was classified to -0.045mm, +0.045–0.063mm and +0.063mm to the MLA research. The model of mineralogy of different minerals was obtained which can easily observing the dissemination properties of minerals and the association of minerals. The particle distribution and the mineral grain distribution for three classes and the combine one were shown in figures. The liberation of pyrite, sphalerite and arsenopyrite and the relation between cumulative mass recovery and liberation class were clearly demonstrated. This information is very helpful to choose the fitful treatment technique to effectively recovery the valuable material in the tailings.

Keywords: sphalerite tailings; MLA analysis; mineral properties; ferric sulfide

1. Introduction

There are more than 300 sulfide tailing dams contained more than 2.2 billion tons of tailings and the amount is continuously increasing at about 140 million tons a year. The reuse of the tailing was only 8.2%. The tailings dam not only occupied farmland and had potential safety hazard, but also contaminated the environment and wasted resources. The early sulfide tailing dams contain large amount of useful mineral, such as sphalerite tailing contains...
pyrite and some of sphalerite and galena and some harmful mineral like arsenopyrite. In order to reuse this tailing, the mineral analysis must be carried out to recognize the characteristics of different minerals and the occurrence of them to provide information for the next separation process. The JKMRC Mineral Liberation Analyzer (MLA) was a new development in the field of SEM-based automated mineral measurement tools. It represented a unique method of combining BSE image analysis and X-ray mineral identification to provide automated quantitative mineral liberation characterization. The advanced analysis techniques implemented by the MLA today are presented, as are the many methods of combining them to provide targeted and optimized, automated mineralogical information.

2. Material and equipment

The sphalerite tailing comes from Nandan county of Guangxi autonomous region of China. The tailing was preconcentrated and the element content was shown in table 1. The sample was classified into three particle fractions, that is +0.063mm, -0.063 +0.045mm and -0.045mm to make the analysis more precise.

| Element | S     | Cu    | Fe     | Mn    | Ca     | Mg     | Al2O3 | SiO2 |
|---------|-------|-------|--------|------|-------|-------|-------|------|
| Content/%| 28.56 | 0.033 | 49.09  | 0.048| 0.81  | 0.27  | 0.95  | 7.09 |

| Element | Pb    | Zn    | Au/(g/t) | Ag/(g/t) | As | P | K2O | Na2O |
|---------|-------|-------|----------|----------|----|---|-----|------|
| Content/%| 0.016 | 0.47  | 0.053    | 4.9      | 0.51| 0.13| 0.25| 0.15 |

The MLA system consist of the SEM (JSM-6510, Nippon Tekno Co.,Ltd) and energy spectrometer (EDAX Inc.) with the version 2.9 software. The three classified samples was mixed with some binder and polished for SEM observation after it solidified.

3. Results and discussion

3.1. the SEM image of different size particles

The SEM images of three classification samples were shown in Fig. 1. The particle size, shape, the minerals was presented at different colors for easier recognition. Fig. 1 a shows that the main mineral is pyrite, some of the pyrite is liberated and some of the pyrite particles are locked with quartz and other mineral. there are little sphalerite and arsenopyrite particles in class. Fig. 1 b shows that the most of the pyrite particles are liberated and sphalerite, arsenopyrite and galena particles are shown in this class. Fig. 1 c shows that the liberation rate of different mineral particles is increased, but there are a lot of locked particles. It means that the further milling will be needed if the high recovery of minerals wanted.
3.2. The particle image of combined of different minerals

Three are a lot of particles consisted of different minerals except for some fully liberation particles in Fig. 1. In order to clearly know the minerals in particles, some of the typical particles which consisted of different minerals are shown in Fig. 2. It is shown that the particle is consisted of two, three or four different minerals. It include pyrite and quartz and others, sphalerite and quartz and others, sphalerite and arsenopyrite and others, arsenopyrite and galena and quartz, pyrite and quartz enclosed in sphalerite, pyrite and Fe2S and others, arsenopyrite and pyrite and quartz and others. It means that it is hard to separate those minerals from each other at present particle size and it needs more milling to separate those minerals.

3.3. the liberation of main minerals in different particle class

It is shown in Fig. 1 and Fig.2 that different type particles such as liberated, binary and ternary or greater are existed in this sample. Fig. 3 to Fig. 5 show the results of recovery of total mineral of liberated, binary and ternary or greater particles of +0.063mm, -0.063+0.045mm and -0.045mm.
Fig. 3 the mineral locking situation of +0.063mm particles of pyrite, sphalerite and arsenopyrite
The liberation rate will increase with the particle size decline generally. But the liberation rate of this sample does not follow this role from Fig. 3 to Fig. 5 results. The recovery of liberated particles is between 85% to 90% and the recovery of binary is around 10% and the recovery of ternary or greater particles is less than 5% in those three classes’ particles. It indicates that the recovery of the mineral will not increase even more milling is done. So the suitable milling must be determined both for recovery and cost.
3.4. the particle size distribution of three class particles

The particle distribution of three classes’ samples are shown in Fig. 6. Because of the sample is classified by sieving, the distribution of the particle size is fit to the sieving results. This distribution result can be used to compare the mineral grain size distribution.

Fig. 6 the particle size distribution +0.063mm, -0.063+0.045mm and -0.045mm classes

3.5. mineral grain size distribution of three class particles

The mineral grain size distribution of pyrite, sphalerite, aresenopyrite and quartz are shown in Fig. 7. It is shown that the mineral grain size distribution is different from the particle size distribution and different minerals has different grain size distribution curve. With the particle size descent, the grain size distribution of pyrite, arsenopyrite and sphalerite are closer but the grain size distribution of quartz becomes finer. It shows that even the
particle size declined the grain size of minerals such as pyrite, arsenopyrite and sphalerite are not changed because of most of them are locked together. This results shows that the milling work is totally used to grind quartz particle to smaller size and have no use to separate the locked minerals. It is the waste of energy to reduce the particle size.

Fig. 7 the mineral grain size distribution +0.063mm, -0.063+0.045mm and -0.045mm classes

3.6. The relation of liberation classed to cumulative mass recovery

The suitable particle sizes influenced the liberation of pyrite, sphalerite and arsenopyrite and further the recovery of those minerals in the subsequent flotation process according to above results. The prediction of mineral mass recovery at different liberation rate is presented in Fig. 8.
Fig. 8 shows that if all the mineral are liberated the theoretical recovery of minerals will less than 80%, 85% and 75% at the particle size at +0.063mm, -0.063+0.045mm and -0.045mm respectively. If the high recovery needed, the liberation rate of minerals will decrease and the grade of concentration will decrease at the same time. The best result needs the comprehensive consideration of all the factors.
4. Conclusion

(1) The composition of this sphalerite tailing is complicated, the further analysis of the minerals and the relationship of different mineral is necessary.

(2) A large number of SEM image of tailing particles are obtained which clearly shows the types and shapes and the combined situation of minerals which very useful for the data excavation.

(3) The main minerals in this tailing are pyrite, sphalerite, arsenopyrite, galena, and quartz and little chalcopyrite.

(4) The liberation rate of pyrite, sphalerite, arsenopyrite is not increase with the particle size decline which means that even more milling is done which need a lot of energy, the liberation rate can not increase.

(5) The MLA is the efficient method to recognize the characteristics of tailings and it can predict the recovery of minerals and guide the following separation process.

Reference

[1] Yan Sun, Hefeng Liu, et al. Current problem in the design of nonferrous metals tailings. Metal Mine 151 (2009):6-10.
[2] Garcia, C., et al. "Pyrite behaviour in a tailings pond." Hydrometallurgy 76.1 (2005): 25-36.
[3] Rodriguez, L., et al. "Heavy metal distribution and chemical speciation in tailings and soils around a Pb–Zn mine in Spain." Journal of Environmental Management 90.2 (2009): 1106-1116.
[4] Lu, Jimnei, et al. "Evaluation of the application of dry covers over carbonate-rich sulphide tailings." Journal of Hazardous Materials 244 (2013): 180-194.
[5] Grangeia, C., et al. "Mine tailings integrated investigations: the case of Rio tailings (Panasqueira Mine, Central Portugal)." Engineering Geology 123.4 (2011): 359-372.
[6] Vizcarra, T. G., et al. "The effect of breakage mechanism on the mineral liberation properties of sulphide ores." Minerals Engineering 23.5 (2010): 374-382.
[7] Celik, I. B., and M. Oner. "The influence of grinding mechanism on the liberation characteristics of sulphide ores." Cement and Concrete Research 36.3 (2006): 422-427.
[8] Sperner, Blanka, Raymond Jonckheere, and Jörg A. Pfänder. "Testing the influence of high-voltage mineral liberation on grain size, shape and yield, and on fission track and 40Ar/39Ar dating." Chemical Geology 371 (2014): 83-95.
[9] Fandrich, Rolf, et al. "Modern SEM-based mineral liberation analysis." International Journal of Mineral Processing 84.1 (2007): 310-320.
[10] Gu, Ying, Robert Schouwstra, and C. Rule. "The value of automated mineralogy." XXVI International Mineral Processing Congress-IMPC 2012. Technowrites, 2012.

Electronic Age, E-Publishing Inc., New York, 1999, pp. 281–304.