Minerals Engineering 49 (2013) 103–108

Contents lists available at SciVerse ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Comparison of different breakage mechanisms in terms of product particle size distribution and mineral liberation

Ozgur Ozcan *, Hakan Benzer

Hacettepe University, Mining Engineering Department, 06800 Beytepe, Ankara, Turkey

ARTICLE INFO

Article history:
Received 12 July 2010
Accepted 4 May 2013
Available online 9 June 2013

Keywords:
Liberation
Breakage
Impact breakage
Compressed bed breakage

ABSTRACT

The comminution process is still governed by a large number of factors that influence the liberation of the valuable components in the ore. A better understanding of these basic factors will provide more certainty about the design of equipment in order to achieve the best liberation and energy efficiency.

Impact and bed breakage mechanisms were investigated as two distinctly different modes of breakage. Standard drop weight tests and hydraulic piston-die press tests were conducted with different energy intensities on samples.

This paper describes the work carried out for the comparison of mineral liberation and particle size distribution in the particle bed breakage with impact breakage of two different copper ores. Ground products from these two different modes of breakage were screened into size fractions which were analyzed for the particle size distributions by sieve analysis and the degree of liberation by an image analysis system. The results of these analyses were statistically compared to make inferences in relation to the stated objective of the work. Test results indicated that compressive bed breakage mechanism gives finer product particle size distribution and provides better mineral liberation compared to impact breakage mechanism.

1. Introduction

Comminution is the essential step in mineral processing where the run of mine ore is broken in order to expose the valuable particles that are recovered in different down stream processes. There are four basic mechanisms employed to reduce the size of the material; impact, abrasion, shear and compression, and most of the crushers employ a combination of all. In crushing terminology, impact refers to the sharp, instantaneous collision of one moving object against another. As the name implies, crushing by compression is done between two surfaces, with the work being done by one or both surfaces (Loveday, 2004).

There is an important difference between the states of material crushed by pressure and impact. There are internal stresses in material broken by pressure which can cause later cracking. Impact causes immediate fracture with no residual stresses. It may be that very rapid shock is transmitted so quickly that the lattice has little time to absorb strain energy and so cannot nucleate new cracks by relaxation after impact Lewis et al. (1976).

There is some evidence in the literature that particle bed breakage occurring in the high pressure roll press has the potential to enhance liberation of minerals through preferential breakage of composite mineral particles along grain boundaries. It is evident from studies of Hoşten and Özbay (1998), that particle bed breakage achieved in the piston-die press produced significantly better chromite liberation than rod-mill grinding for particles of the same size fraction. The liberation enhancement is in the range of about 3–16%, depending on the size and applied pressure. The percent degree of liberation of chromite increased with the higher pressure in the case of piston-die press tests.

South African researchers found that comminuting kimberlite in a particle bed, compared to conventional crushing, could result in a better liberation of diamonds with a much lesser amount of diamond breakage. (Kellerwessel, 1996).

After the introduction of HPGR, various circuit configurations have been developed for energy efficient cement grinding. Wustner (1986) showed that 30% reduction was achieved after conversion of closed circuit ball mill circuits to a semi-finish grinding circuit including HPGR. Applications of HPGR in different circuit alternatives have resulted in 10–50% energy savings when compared with closed circuit ball milling operations (Aydoğan et al., 2005).

The optical microscope is most commonly used in the earlier stages of a mineralogical study in order to identify areas for more detailed study with other instruments (Petruk, 2000).

In the optical microscope systems mineral liberation analyses are conducted by an image analysis system composed of the units

* Corresponding author. Tel.: +90 3122977600.
E-mail address: ozgozcan@hacettepe.edu.tr (O. Ozcan).

0892-6875/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.mineng.2013.05.006

Table 1
Sizes and specific energies of drop weight and bed breakage tests.

Sample 1		Sample 2	
Size (mm)	Specific energy (k W h/t)	Size (mm)	Specific energy (k W h/t)
−3.35 + 2.36	0.34–0.63–0.90–1.11	−3.35 + 2.36	0.37–0.70–1.068
−1.18 + 0.850	0.37–0.66–0.97–1.23	−1.18 + 0.850	0.37–0.70–1.068
−0.600 + 0.425	0.42–0.77–1.09–1.44	−0.600 + 0.425	0.37–0.70–1.068
−0.300 + 0.212	0.50–0.91–1.30–1.68	−0.300 + 0.212	0.37–0.70–1.068

of high-performance color camera, zoom stereo microscope and an image analysis software. Procedure is based on grain counting of all the free particles and estimating the area occupied by mineral in each locked particle in a polished section image.

Other important liberation analysis systems are X-ray diffractometer and SEM based mineral identification systems.

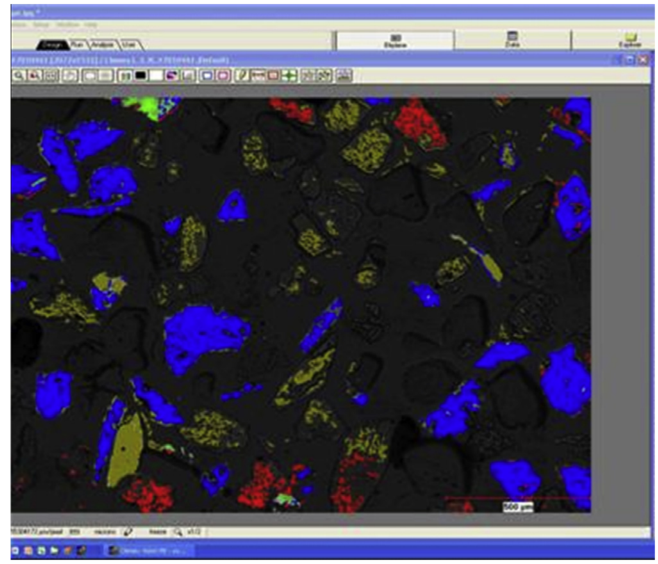

Fig. 3. Display image during the liberation analyses.

2. Experimental procedure

Two different copper ore samples were used in the study. The principal minerals of the Sample 1 are chalcopyrite, pyrite, covellin and host rock basalt. The principal minerals of the Sample 2 are chalcopyrite, pyrite, sphalerite and host rock basalt. The samples were dry screened to obtain required size fractions for crushing tests. Samples were prepared as narrow size fractions. For the

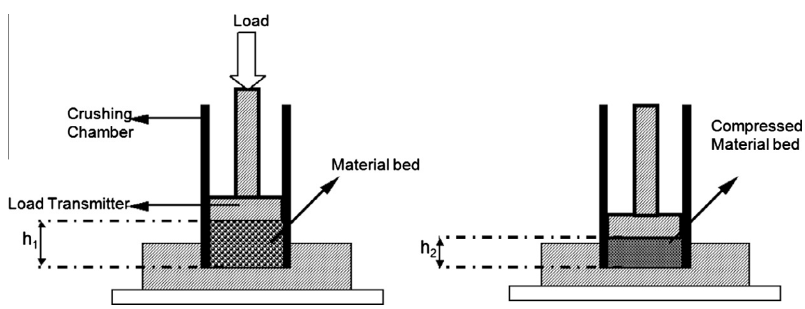

Fig. 1. Schematic view of the piston-die test equipment.

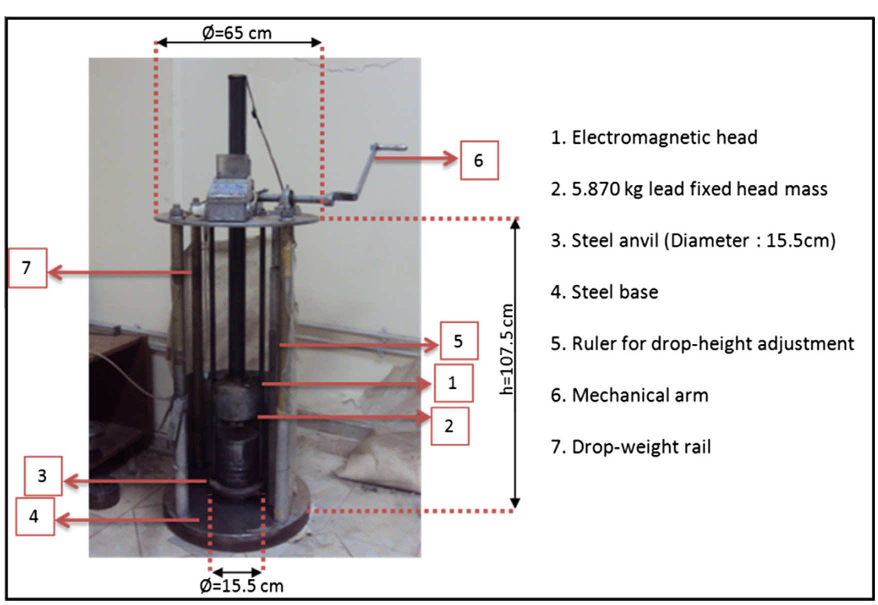

Fig. 2. Photograph of the drop weight test apparatus.