Comparison of the energy breakage efficiency of high compressive breakage with drop weight impact breakage

Research Report

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Abstract

Ore particle size reduction is a process that has to be undertaken for valuable mineral liberation from host rock. In these comminution processes, appreciation of energy employment is required. Particle breakage is a function of the loading conditions as well as the particle properties. The loading conditions refer to the magnitude of the forces, loading velocity, temperature and the comminution tool properties while the particle properties refer to the particle shape, mechanical properties, size and internal structure

Mechanical processes, causing particle breakage, can be distinguished on the basis of the rate and direction in which the load is applied as well as the type of contact established. This is because of the stresses introduced, which may be localized, or distributed. The material hardness refers to the material's ability to withstand deformation while toughness is the material's ability to withstand stress without fracture and this is of great interest in comminution. Generally, brittle materials do not exhibit plastic deformation and rather exhibit a linear stress-strain relationship.

Particle breakage can occur in different ways as a function of the breakage mechanism and material properties. Material breakage behavior is important in the selection of size reduction equipment and is generally defined by breakage distribution functions. Single particle breakage is commonly used to determine particle breakage behavior for materials. As new surface is formed, the material behavior is observed to change since the change in size changes the particle behavior in terms of apertures it can accommodate, the downstream treatments it can be subjected to and such separation techniques as flotation and methods of particle handling.

When a particle is impacted, in the case of drop weight tests, it can never be pre-determined, with any certainty that it will actually break. However, what is known is that the probability of fracture is related to the amount of energy absorbed by the particle during impact. High pressure breakage also demonstrates similar behaviors, whereby a particle will experience fracture when subjected to increasing pressure. The main difference will, however, be in the conditions of the particle breakage since the impact breakage is an instantaneous process while the high pressure breakage is conducted at a slower rate and the particles receiving the pressure are retained in an enclosure.

Mechanisms of particle breakage investigated included the drop weight impact and high pressure compression tests. The impact drop weight test was conducted from two drop heights on individual and collections of particles while the high pressure compression was conducted at two compression forces on particles of a single layer and those in a multiple layer setting. Particle breakage from the tests was found to be influenced by several factors, namely the particle size, the input energy, stress distributions and the number of particles subjected to the breakage.

The impact tests indicate that less unit breakage energy is required for the single particle as compared to that required for a bed of particles of a similar size. Particle shape and size can affect breakage due to their influence on the resultant fragments obtained from the breakage, which has been indicated by the variation in the fragments obtained from breakage of particles of different sizes. The drop weight tests indicated that reducing the drop height resulted in a difference in the breakage energy used and

single particles depicted higher breakage efficiency at both energy inputs analyzed in the test work, when compared to the single layer drop weight test.

The high pressure test indicated that the change in the energy input does have an effect on the degree of breakage obtained and the number of particles subject to the breakage also affects the degree of particle breakage. The increase in the input force resulted in a higher breakage of the smaller sized particles at the single layer set-up when compared to the multiple layers setting. As the particle layers increased, the resultant particle breakage is reduced due to the drop in the direct particle contact to the applied pressure as a result of the number of particles present in the system. The initial particle breakage also causes an effect on the particle breakage efficiency in a multiple particle layer set-up because of the particle re-arrangement which occurs between the adjacent particles as well as between the particle layers. An increase in the input energy resulted in a finer product particle size distribution when compared to that obtained from a lower input energy breakage. The effect could be noted on different size classes, where the d_{80} obtained from the breakage was finer when an increased energy was input into the system.

Looking at both the drop weight test and the high pressure test the highest particle breakage efficiency was obtained with the high pressure single layer test at 80kN. In this setting, more particle breakage was obtained. Random particle breakage can be summarized as "the independence of breakage from ore properties and mechanical properties during comminution." Evans C.L, *et al* [16]. This was seen in the energy utilization obtained from both the high pressure compression and drop weight impact tests. The energy utilization varied for the impact test to that of the high pressure compression test. Looking at the energy used per mass of particles subject to breakage it indicated for both tests that more energy is used for the small particle size breakage. This was seen in the energy utilization obtained from both the high pressure compression and drop weight impact test.

The high pressure compression test results in greater effectiveness in achieving particle breakage as could be seen from the daughter fragments produced. The specific energy employed for the high pressure test was the highest for the smaller particle sizes and decreased with increasing particle size. This value was higher for each particle size when 80kN of force was applied compared to the 50kN-applied force. The energy unitization and distribution is better controlled between the particles in the high pressure test due to the confined set-up. In the drop weight test, particles are less confined and this results in the more 'erratic' particle behavior as soon as it has been impacted. However, the specific energy use displayed a similar trend as that obtained in the high pressure test with the smallest particle size using the highest amount of energy