Abstract

Comminution and leaching unit processes play a major role in extracting valuable minerals from ore. Most of the research reported in the literature has focused on optimising individual unit operations rather than on integrating the whole process. This thesis develops an integrated approach to mineral processing systems and flow sheets and is intended to create a methodology for process synthesis that can be applied throughout the extractive metallurgical industry. This could lead to improved efficiency in the overall process by obtaining optimum recovery and, most important, a reduction in energy and material costs. In order to illustrate the methodology a particular example was chosen, namely optimizing the joint comminution and leaching of a particular gold ore.

In this investigation laboratory scale grinding and leaching profiles for a gold feed sample (1700–850 µm) were measured. In a laboratory mill various combinations of grinding media, filling level and ball size were investigated, and of the three ball sizes used (10, 20 and 30mm) breakage was most pronounced for the 20 mm. Thus for instance it was also established that when using a higher filling (J=30%) and a ball size of 30 mm, more energy was consumed but less liberation occurred, thus a lower amount of gold was extracted during a 24-hour leaching period. Finally, the breakage kinetics of the gold ore was looked at. Using a standard population model the breakage and selection function parameters were successfully calculated.

An investigation into the dissolution kinetics of gold ore in a solution of NaCN was also done. These were found to depend on the stirring rate, reaction temperature,

particle diameter and the concentration of the leachant. The rate increased with the stirring speed, reaction temperature and leachant concentration, but decreased when the particle size was greater. The activation energy for the dissolution was estimated at about 3 kcal/mol. Furthermore, the linear relationship between the rate constant and the reciprocal of the square of the particle size is a strong indication that the gold dissolution process is diffusion-controlled. The experimental results were well-fitted to a shrinking core model.

In attempting to understand the results, the researcher carried out a number of experiments that involved an investigation into the relationship between comminution and leaching in terms of energy usage and particle size, the former to establish the most efficient application of energy, and the latter to identify the degree of fineness that would ensure optimal recovery.

The Attainable Region (AR) method was then used to establish ways of finding the leaching and milling times required to achieve minimum cost (maximise profit). No work on utilizing the AR technique to minimise the cost of milling and leaching on a real industrial ore has previously been published. The investigation aims to show how the AR technique can be used to develop ways of optimising an industrial process that includes milling and leaching. The experimental results were used to show how this method could be successfully applied to identifying opportunities for higher efficiency when performing these operations.

The approach however is general and could in principle be used for any two or more unit operations in determining how the product from one unit should be prepared to feed to the next unit so as to optimize the overall process.