Shape Makes a Difference

Using metallic flakes instead of powder as a feedstock might significantly improve process productivity.

Richard G. Ollila
Transmet Corp., Columbus, Ohio

A recent study[1] and early production experience have shown that the shape of the metallic particles used as feedstock in chemical processes may improve the productivity of the process by as much as 40%. This improved productivity is a combination of increased throughput of the product, reduced material costs and elimination of secondary steps and additives required in the existing process.

In the study, a simple experiment was devised to evaluate the effect of particle shape using aluminum particles. The experiment consisted of dissolving a specified mass of a wide variety of particle shapes in an aqueous sodium hydroxide solution and observing the reaction rate behavior and time for the reaction to go to completion. The results of this experiment indicated that properly sized flakes (planes) produce a more uniform and optimum reaction than powders (spheres) or chopped wire or needles (cylinders).

For more than 100 years, the chemical industry has prepared commercial products containing one or more metals by dissolving the metals from base metal stock. Metal powders, shot and chopped wire have been used as feedstock for more than 50 years. These metals were specified for use in the chemical process by particle size and purity. The shape of the particles was determined by the process to produce the particles.

Metallic Particle Chemistry

Most chemical reactions involving the dissolution of metals are exothermic in nature. The release of energy and gas requires that the processing equipment for such reactions be designed to handle and control the maximum levels of temperature and pressure for a specified throughput. Thus, the ideal situation is a reaction or dissolution rate that is constant from the time the feedstock is introduced until it is completely dissolved. This reaction would fully utilize the capital equipment and minimize the process time per unit of chemical throughput.

It has been shown that the reaction rate of a dissolution process is proportional to the total surface area of the feedstock material used in the process. For a given mass of feedstock, the initial dissolution rate is proportional to the initial surface:volume ratio of the particulates. However, as the particles dissolve and get smaller, the reaction rate changes depending on the change in the total area of the particles. Thus, the rate of dissolution is strongly influenced by the geometry of the particles and the size distribution of the particles.

With the advent of the rapid solidification process, a new dimension has been added to the chemical industry. Metal particles with fine grain structures and tailored shapes and sizes can be produced economically for the first time. Now, metal particles can be shaped to optimize the reaction rate and the output of chemical processes.

In the current study, three common shapes of feedstock material were examined: spheres (powders), cylinders (chopped wire or needles) and planes (flakes). Ideally, the