International Fine Particle Research Institute

Project Brief

Mass Fabrication of Particles with Uniform Size and Shape

In industry, powders are produced by a myriad of processes that can be categorized as "bottom-up" (e.g. crystallization, spray drying, granulation) or "top-down" (e.g. crushing and grinding). In either type of process, particles with broad size distributions are often produced, and particle shape is typically uncontrolled and random. It is common, therefore, to classify the powders by size and shape, and either recycle or dispose of a significant fraction of the powder. One example of this is the grinding of granite by 3M that produces only 52% yield of the desired product, with the remainder of the fines being discarded. To date no use for these fines has been found.

The ability to produce particles with tightly controlled size and shape at scale would have substantial benefits for industries that manufacture particulate products or otherwise process powders by improving process efficiency and improving product functionality and reproducibility.

In an IFPRI-funded project [1], Karen Hapgood used 3D printing to produce particles with controlled size, shape, and internal structure. The intent of this project was to produce particles with reproducible mechanical properties which could be used to test models of agglomerate mechanical properties. While the particles were quite large (mm-scale primary particles and cm-scale agglomerates), the work demonstrated the application of 3D printing for making small numbers of identical particles. A recent development in 3D printing called 'necroprinting' has identified mosquito probosces as useful nozzles able to produce details as small as 20 microns [2], suggesting that 3D printing can be used to make particles of industrially relevant size.

3M and others have used replication techniques to produce metric tons of 75-micron shaped abrasive particles, but the technique has not been applied in other fields or with other materials [3, need reference].

IFPRI wishes to fund a project to explore particle replication techniques for producing 25-200 micron particles from structured surfaces. Potential approaches include, but are not limited to:

- Compaction
- Slurry filing
- Necroprinting

- Additive manufacturing
- Xerography

The objective is to demonstrate proof of concept of one or more particle replication methods. The project should focus on the process fundamentals, with particular attention paid to the forming and release of particles from the surface. While scale-up of the process is not in scope, it is hoped that the formation method(s) will have potential to be commercially viable.

In scope are the production of organic (e.g. food, pharmaceutical), inorganic (e.g. metal, metal oxide), and polymer particles. Granulation, suspension or emulsion polymerization, or atomization techniques for the formation of particles are not in scope.

[1] Ge, R., et al., Deformation of 3D printed agglomerates: Multiscale experimental tests and DEM simulation, Chemical Engineering Science, 217, https://dx.doi.org/10.1016/j.ces.2020.115526

[2] Puma, J., et al., 3D necroprinting: Leveraging biotic material as the nozzle for 3D printing, Science Advances, 11(47), https://doi.org/10.1126/sciadv.adw9953

[3] G. L. Holmes, et al., "Precisely Shaped Particles and Method of Making the Same"; US Patent 5,500,273.