Spray Drying

A noninvasive, continuous and scalable way to convert liquids into powders

By Yamato Scientific America

History and Concept

The Spray drying technique is the method of feeding liquid materials through a heated air jacketed nozzle, resulting in a dry powder.

The method was originally developed at the end of the 19th century. Since then, the technique has significantly improved. About 70 years ago, milk was sprayed for the first time.

A self-priming peristaltic pump draws the liquid from the sample container and drives it through a small diameter jet into the main chamber. At the same time, an integral compressor pumps air into the outer tube of the jet which, due to the close proximity of the air outlet to the liquid jet, causes the liquid to emerge to a fine, atomized spray. Hot air is blown through the main chamber evaporating the liquid content of the spray and leaving the solid particles of the material, which are normally in a free flowing state, to be separated from the exhaust air flow by a cyclone and collected in the sample collector container.

Sample collector

Uniform powder Morphology

Application Areas

The area where the spray dryer is used is widespread and includes Pharmaceuticals, Food, Dairy and Beverage, Agriculture, Chemical, Biochemical, Polymer, Ceramic, Material Research, Cosmetics and Fragrances as well as other application areas and industries.

Features of Spray Drying Technique

Solution, slurry or suspension, is fed through the spray nozzle to become even, small drops which increase the area of its surface to contact hot air. Since surface to contact hot air is larger, the time required for drying is shorter. Although the travel time from the nozzle to the sample container is very short, less than 0.5 seconds, the sample is efficiently dried.

The sample is surrounded by evaporated steam or solvent vapor. Although the drop contact high heat can reach 180°C, the sample particle itself does not heat up higher than 50°C.

The liquid form is dried in the air. It does not come in contact with any surface such as heating materials. Because of this, particles with even sizes are obtained. No need for separation, condensation, filtration and contamination which might be created by other drying methods such as vacuum ovens and freeze drying.

By changing the parameters of nozzle size, inlet temperature, flow rate and sprayed pressure, the configuration of particle, particle size, shape, distribution and water content may alter.

Micro-encapsulation

Encapsulation technique is also used with spray drying by the food, feed, pharma and other industries. A substance to be encapsulated (the load) and an amphipathic carrier e.g. starch, dextrin or other modified starch, etc. are homogenized as a suspension in water slurry. The slurry is then fed into a spray dryer where the carrier forms a hardened shell around the load. The sprayed particle with its active compound is thus embedded and protected with the carrier shell.

Spray Drying Systems

Designed to be used in laboratories and for R&D purposes

Water based spray sample Systems

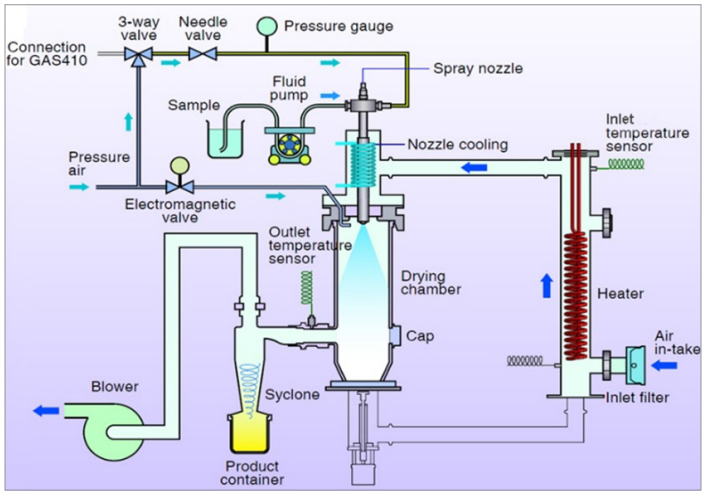
The essential elements of the spray dryer: atomizer, air dispenser, drying chamber, inlet and exhaust air handling are combined into a system that meets individual operational safety, environmental protection and powder handling requirements.

The majority of industrial safety spray dryers handle aqueous feedstock and use this system. Both direct and indirect air-heating are applicable.

For Yamato Spray Dryers all glass parts are made of Borosilicate Super Hard Glass benefitting that the spray drying operation can be visually observed.

ADL311SA Spray Dryer

Key specs of ADL311SA are 1.3 L/h water evaporation rate, 40-220°C temp control range, 26mL/min variable sample flow rate and bigger selection of available spray nozzles.



Schematic drawing of ADL311SA Spray Dryer, Yamato's most economical and affordable spray dryer

Organic Solvent based spray sample Systems

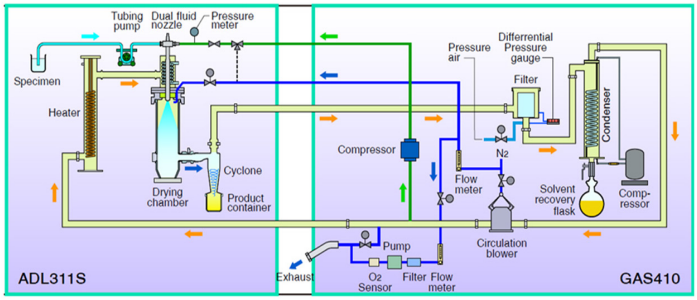
This system features spray drying in an inert gas atmosphere where nitrogen circulates in a closed loop within the spray dryer. It must be used for the spray drying of spray samples containing organic solvents or where the product must not contact oxygen during drying. Closed loop systems are gas and powder tight and are designed to the strictest safety standards to prevent external discharge when using organic solvent based spray sam-

ples. The inflammable solvent vapors are fully recovered in liquid form, thus helping to protect the environment.

The GAS410 Solvent Recovery Unit is used as an attachment to the Yamato Spray Dryer systems. When used with the ADL 311SA, GB210A or DL410, the N_2 gas and any solvent are contained in a closed system preventing any discharge to the outside environment. Flammable or toxic solvents can be processed. As the name implies, this unit is used to recover solvents in a safe and efficient manner using Nitrogen (N_2) gas by reducing the Oxygen (O_2) levels during the spray drying process. By doing so, the potential of a fire or explosion is eliminated when used properly. The drying of easily oxidized materials is also possible as this system supports low temperature drying to decrease deformities which may be caused by higher temperatures.

Yamato ADL 311SA and GAS410

Key specs of GAS410 are 0.12 to 0.65 m³/min Nitrogen circulation flow, 1.3 L/h or more recovery capacity, with integrated freezer and compressor eliminating the need for extra freezer / dehumidifier or external compressor.



Schematic drawing of Yamato ADL 311SA and GAS410 Solvent Recovery Unit

Granulation

Granulating Process

Granulation refers to the act or process in which primary powder particles are made to adhere to form larger, multi-particle entities called granules. It is the process of collecting particles together by creating bonds between them. Bonds are formed by compression or by using a binding agent.
In the pharmaceutical industry granulation is extensively used in the manufacturing of tablets and pellets.

Versatile Yamato Spray Dryer and Granulation system (2 instruments in 1 system)

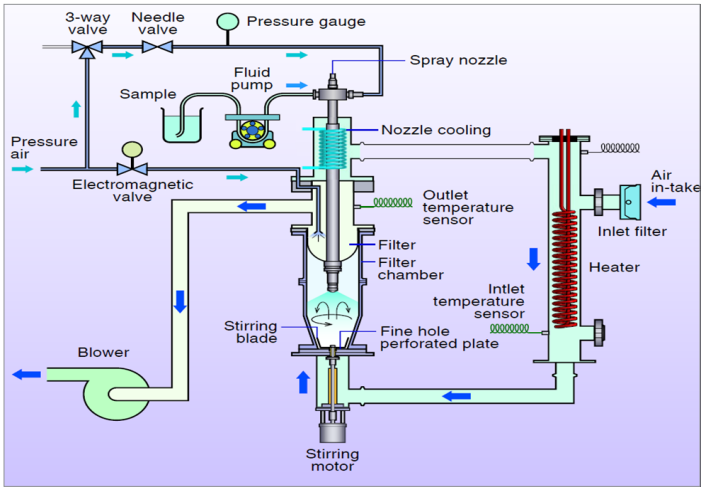
The Yamato GB-210 has a unique dual function of spray drying by using GB-210 with glassware GF300 and of a fluid bed by using GB-210 with glassware GF200 for granulating, drying and mixing. It is designed to granulate powder and dry wet powder.

This is a very simple process; either the spray dry glass chamber GF300 or the fluid bed glass chamber GF200 is placed on the stage of the basic unit GB-210. The unit has an automatic lift as a standard to enable convenient installation or removal of the glass chamber attachment.

Spray Dryer Pulvis Mini Bed GB-210B with Glassware GF200

Key specs of GB-210B are 50g to 300g processing capacity, 40 to 220°C temp control range, 26mL/min variable sample flow rate, and bigger selection of available spray and gas nozzles.

Fluid bed technique is where granular matter is floated and suspended in the air and at the same time binding agent (e.g. starch, dextrin, etc.) is fed to the granular matter to create a fluid bridge. Ultimately, the granular matter grows in size.



Schematic drawing of Yamato GB-210B Granulation Fluid Bed system with glassware GF200

Sample put in from (A)

As compared with powder, granular matter has the characteristics of better solubility, fluidity, no fugacity, less cohesion, less electric resistance and better appearance.

Fluid bed method has the advantages of:

- Mixing, stirring, particle generating and drying done by one instrument resulting to less contamination and high reproducibility
- Less time required to generate particle having high solubility
- Easier to control the size of granular matter by changing the conditions of the fluid bed

Summary

Spray drying involves the atomization of a solvent (aqueous) into tiny droplets, which then make contact with air resulting in moisture evaporation and a dry powder-like end product.

During spray – air contact, droplets meet hot air and rapid moisture evaporation takes place from the droplet surfaces.

Heat is applied as a heated atmosphere; the feed (the spray sample) is sprayed into the atmosphere.

Spray Drying Techniques

- Spray drying from solution (water, solvent or mixture of water and solvent)
- Micro-encapsulation and coating
- Improve Powder Structure
- Spray and Drying suspension solution
- Agglomeration
- Spray crystals (crystallization)
- Cooling Spray dry (i.e. par film, wax, etc.)

Advantage of Spray Drying

- When parameters are set and remain constant, the powder quality remains consistent throughout the entire drying operation (i.e., spherical shaped powder with accurate production of specific µm sized particles)
- Intuitive and easy to use interface
- Quick and simple installation and maintenance
- Applicable to both heat sensitive and heat resistant materials
- Flexible conversion to agglomeration
- Compared to freeze drying technique cost effective and time saving