AP42 Section:	11.7
Background Chapter:	2
Reference:	6
Title:	Operating the Spray Dryer, G. Smith *Ceramic Industry*, 140 (6): 54-56, Business News Publishing Company, Troy, MI, June 1993.

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Traditional Ceramics

Operating the Spray Dryer

Notes and observations during spray dryer operation at Mannington Ceramic Tile

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Spray drying slip produces a perfectly homogeneous powder, having spherical particle shape, with correct granulation and moisture necessary for the pressing phase. The process itself is simple, consisting mainly of spraying slip against a hot air counter current.

A volumetric pump sends the slip to a set of lances placed inside the dryer. At the lances' extremity, the slip is atomized by nozzles that have been designed to function with liquids containing a high percentage of solids.

Atomized in fine particles, slip is sprayed toward the top of the drying chamber against a countercurrent of descending hot air, heated by a gas-fired burner. Drying is immediate since the fine nebulization of product and high turbulence of hot air allows a high coefficient of heat exchange.

The spray-dried powder falls to the bottom of the dryer where it is unloaded by means of a pendular valve.

Exhaust air, pulled by a centrifugal fan, typically goes through a set of cyclones to recycle the small quantity of fine powder it contains, then to a venturi scrubber for further cleansing before it is expelled from the stack as steam.

Granulation

The required powder granulation may be obtained by regulating: slip specific gravity; slip viscosity; pump pressure; diameter of nozzle outlet hole; thickness and type of swirl in the nozzle; and spray dryer type.

The water content in the slip determines how easily it can be sprayed from the nozzles. Generally, an increase in water content: improves spraying efficiency; produces smaller drops—finer grain size; and decreases thermal efficiency.

An increase in slip viscosity produces larger drops (larger grain size). A typical maximum viscosity is 165-180 Cp. If the viscosity is too low (70 Cp), the cloud of drops will shift to the sidewalls and/or cone, greatly decreasing the thermal efficiency.

Pump pressure influences the outlet angle of the particles sprayed from the nozzles. Generally, a decrease in pressure produces larger drops. If the pump pressure is held constant, nozzles with a large orifice supply powders with a large grain size.

The swirl sets the slip in rotating motion. The swirl thickness influences the trajectory of the particles, their dimensions and height of spray cloud.

Generally, given the same outlet diameter, an increase in swirl thickness yields a spray cloud located higher in the chamber, which causes the formation of larger drops and increases grain size. An increase in swirl thickness will increase the output of the spray dryer—typically 15-20%/2 mm increase in swirl thickness.

Spray dryers equipped with a large drying tower produce larger grain sizes since the higher quantity of slip sprayed means larger drops within the spray cloud.

Residual humidity

Correct residual humidity can be achieved by regulating inlet temperature, outlet temperature and pump pressure.

If everything else is held constant, an increase in inlet temperature will decrease the moisture content of the powder. Similarly, an increase in outlet temperature will decrease the moisture content. An increase in pump pressure will increase the moisture content of the powder.

Residual humidity should be checked a minimum of once every 30 min to ensure proper dryer operation and homogeneous product.

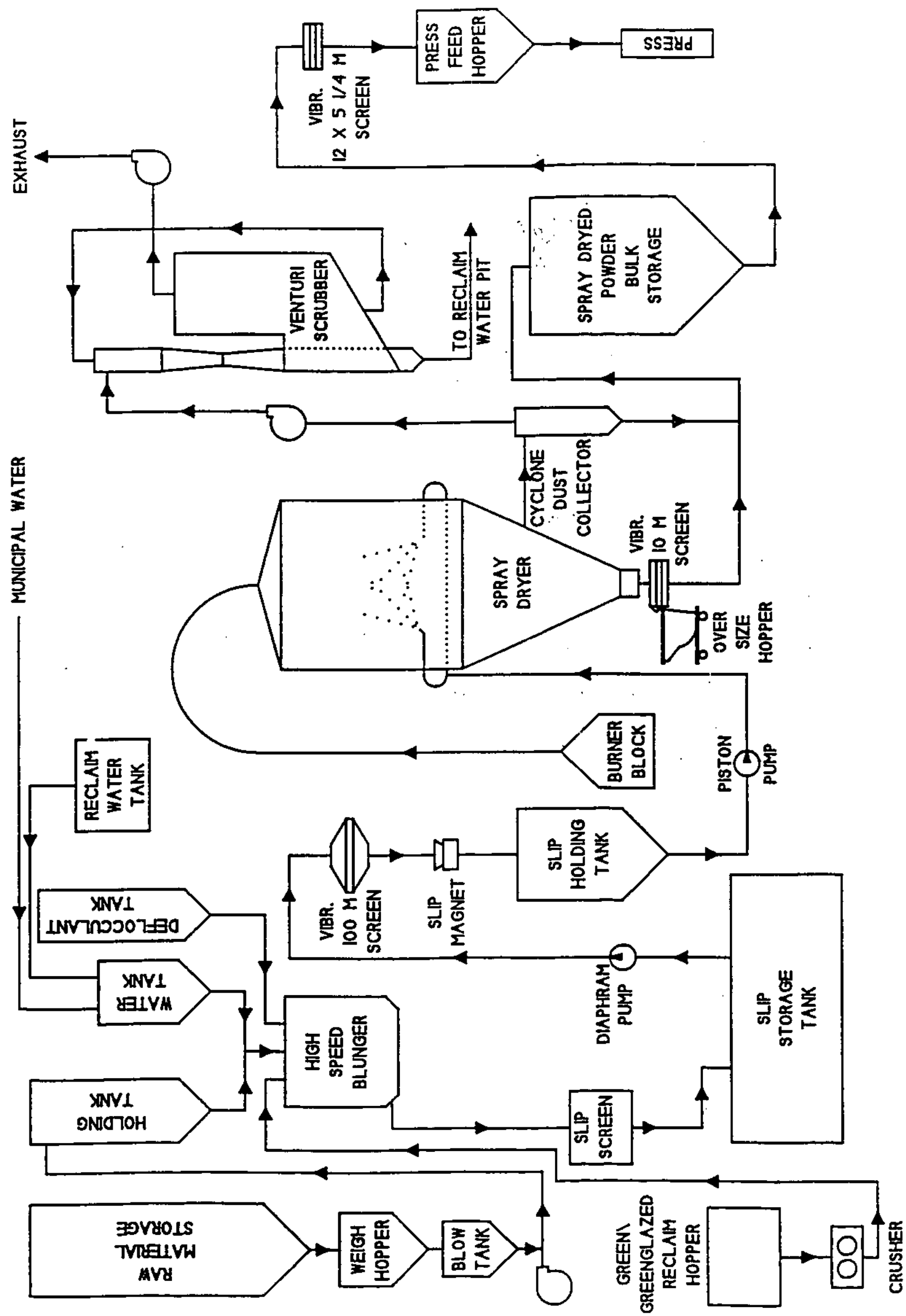
Operating notes

Inlet/outlet air temperatures. Inlet air temperature should be maintained at the highest possible compatibility with the characteristics of the product. Care should be taken not to exceed the required temperature in order to ensure long life for the hot-air piping.

Outlet temperature should be maintained as low as possible, in accordance with the humidity required in the powder—the higher the outlet temperature, the lower the moisture content of the powder.

Once the optimum inlet temperature and corresponding outlet temperature have been established, both should be kept constant during op-

Typical Body Preparation Process Incorporating a Spray Dryer



eration to maximize thermal efficiency and to obtain a homogeneous powder humidity.

Outlet temperature can be regulated by adding or reducing the number of spray nozzles working in the drying chamber. If the inlet temperature is constant and the number of working nozzles is increased, the outlet temperature will be reduced, and vice versa.

If the temperature in the drying chamber is too low, humid powder may be deposited on the interior walls. Typical drying chamber temperature range is 110-130°C.

Drying air. To obtain a constant moisture content of the powder, the outlet air temperature must be altered daily. The absolute humidity of the drying air varies daily because it is dependent upon the temperature and relative humidity of the ambient air. The higher the absolute humidity of the drying air, the less water this air can remove from the product.

Slip properties. The dry material content of the slip supplied to the spray dryer must be kept as constant as possible. A variation in specific gravity, while inlet temperature and pump delivery are kept constant, will result in a variation in the humidity of the powder.

Slip viscosity is determined and/or controlled by: the % solids present in the slip; the amount of deflocculant added to the slip; and slip temperature. Typically, slip viscosity is maintained between 70 Cp and 180 Cp.

As slip viscosity increases, larger drops are formed in the atomized spray—which will dry less quickly—resulting in powder with a higher moisture content.

Surface tension varies from slip to slip. Generally, surface tension values are too low to influence atomization and/or drying; therefore, surface tension is much less significant than viscosity.

However, if surface tension is sufficient to have an influence, then low surface tension yields small spray droplets. Thus, particle size distributions tend to become wider, and bulk densities increase. High surface tension slips are more difficult to atomize.

Deflocculant. Deflocculant agents are used to obtain acceptable viscosity levels with a low percentage of water in the slip. The amount and deflocculant type (organic or inorganic) used depends upon the type of clay and the drying process as a whole.

When using deflocculants to adjust the viscosity of the slip, use only the predetermined amount. Otherwise, over- deflocculation may result in: reversed effects (viscosity increases); a dilatant solution; rapid and uncontrollable settlement of the solids suspended in the slip.

Drying chamber pressure. To promote the best possible thermal efficiency, the drying chamber pressure should be maintained as low as possible, while yielding an acceptable product. As the internal pressure increases, the heat of vaporization of the water being evaporated increases. The result: decreased thermal efficiency and higher operating temperatures.

The operating chamber pressure also controls the powder/air loading in the exhaust air. The internal pressure should be such that the optimum dust-to-exhaust air loading is achieved for the greatest dust collection efficiency in the cyclones. The drying chamber pressure is regulated by a servo-driven damper in the exhaust duct.

Nozzles. To maintain nozzle performance, periodic cleaning is essential. Clogging, irregular spray patterns and/or reduction in throughput is likely to result if nozzles are not cleaned. If the nozzle is not to be reassembled immediately, the parts should be submersed in clean water. It is advisable to keep a set of clean, assembled nozzles on hand at all times.

Troubleshooting

Insufficient and/or erratic evaporative capacity. Check the slip piston pump; make sure the pump is not exceeding the normal pressure and is operating properly. Manually increase the inlet temperature, and check the powder moisture. If moisture content is still too high, verify inlet/outlet temperature T/Cs and controller calibration, and check fuel consumption.

If the inlet/outlet temperatures and fuel consumption have been verified and are correct, the air delivery/exhaust may be at fault. Check the following: position of the exhaust damper; antivibration joints in the dust system, making sure they are in good condition, correctly mounted and are not leaking; doors and portholes on the drying chamber should be tightly closed.

If the inlet temperature does not reach its normal operating value, check the burner block for blocked flame ports.

Check the viscosity of the slip. An excessive viscosity can decrease considerably the evaporative capacity.

Powder deposits in the drying chamber. Causes and cures:

- Incorrect dryer start-up procedure. During start up, the outlet temperature should be high enough to ensure the slip is sufficiently dried to prevent sticking. All nozzles should not be opened at once during start up.
- Inadequate slip-pump pressure. If too low, the spray angle of the nozzles will be too narrow, and slip will be deposited on the top of the drying chamber.
- Worn nozzle and/or orifice. May cause a deflection of the spray, resulting in slip being sprayed directly on the drying chamber walls. Drips formed at the nozzles result in dried slip stalagmites and periodic avalanches of moist product.
- Excessive slip viscosity. Detrimental to the spray pattern, it results in undried slip expelled in the chamber and onto the walls.

Last, but not least, establish a preventive maintenance schedule. □

Editor's Note: This article was adapted from a presentation at the 1992 joint fall meeting of the Southeast and Southwest Sections of The American Ceramic Society at Nashville, Tenn.