Agglomeration — The Practical Alternative

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ABSTRACT

Various methods of agglomeration are offered as viable alternatives to spray drying. Equipment used includes horizontal mixers, orbital screw mixers, batch drum mixers, continuous two-stage rotary drum mixers, V-shaped twin shell batch mixers, and continuous zig-zag mixers.

Ever since the first synthetic detergents appeared on the market, manufacturers have been searching for practical methods for compounding laundry and dishwashing detergents. The trend was set by the wealthy nations in their use of marketing gimmicks designed to capture the consumer. Light-density products in the range of 0.2 to 0.5 kg/liter were needed to fill the ever-growing boxes being sold in the supermarkets.

The solution was the spray tower, where the detergent components are mixed as a paste or slurry, which can be injected into a vertical chamber. The droplets are dried by a current of hot air and discharged as dry detergents, granules, or beads. The water content of the slurry is between 35% and 45%, depending on the results required.

The spray-drying process is excellent for controlling product quality and is widely used by major detergent manufacturers. The problem with spray drying, however, is its cost. Both equipment and operating expenses have sky-rocketed in the past 4 years, mainly because of the rapidly rising price of energy.

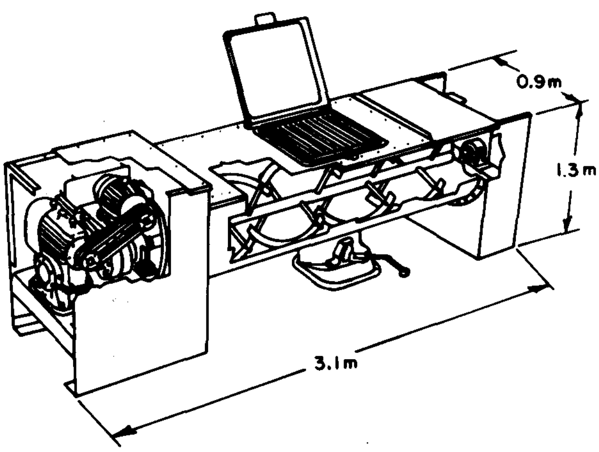
Manufacturers throughout the world have been looking for alternate methods to produce less expensive detergents. Dry formulations with pregranulated ingredients have been tried, but problems with varying densities and wide ranges of particle sizes, plus government regulations, were too much to overcome.

Semi-dry formulas with 22% or lower moisture content seemed to be the answer. Pharmaceutical manufacturers and other processors have used the granulation method for many years to homogenize their products, and when proper equipment is used, it can produce high-quality products similar to spray-dried detergents.

The granulated product is an agglomerate of particles that itself behaves as a particle. The agglomerate is usually formed by blending solids with liquids that serve as adhesive agents. But a lump-free liquid-solids blend is often a difficult task to produce. Solids, consisting of several different materials, must be precisely blended in the dry-particle state. While an initial small amount of liquid may be helpful, it will usually be impossible to remedy serious nonuniformity after the liquid-solids blend has been completed. Adding substantial amounts of liquid tends to lock in whatever nonuniformity exists.

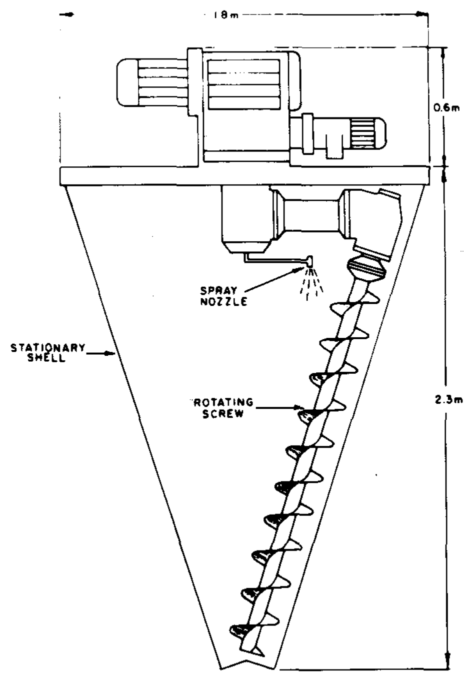
A lump-free blend of liquid and solid particles or a controlled agglomerate size requires fine liquid droplets. Contact of liquid with inner walls of the vessel during blending must be prevented. Liquid reaching the wall surface before touching a particle will adhere to the wall and encourage a build-up of solids. Temperature also affects liquid-solids blending. Surfaces of solids can harden due to chemical reactions and change the capacity of solids to absorb moisture.

There are three basic requirements for uniform



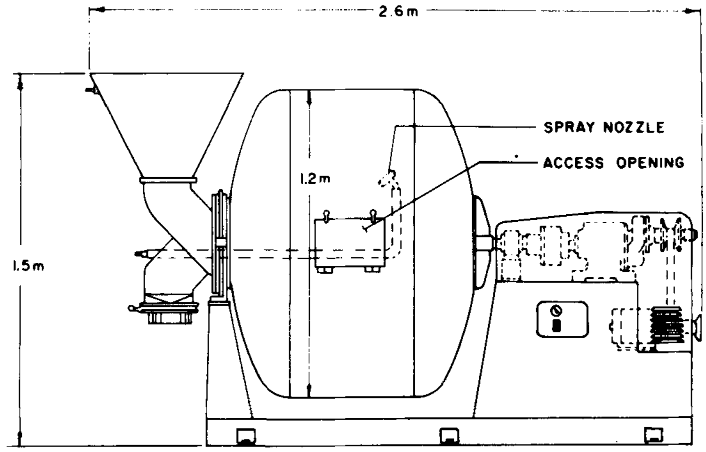
TYPE	BATCH
DRIVE	10 HP
CAPACITY	300 Kg/BATCH
PRICE	U.S. $ 8,000

FIG. 1. Horizontal mixer.



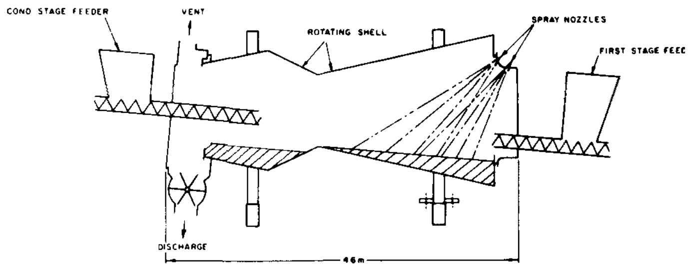
TYPE	BATCH
DRIVE	7.5 HP
CAPACITY	300 Kg/BATCH
PRICE	U.S. $ 19,000

FIG. 2. Orbital screw mixer.



TYPE	BATCH
DRIVE	5 HP
CAPACITY	300 Kg./BATCH
PRICE	U.S. $ 29,000

FIG. 3. Spray mixer.



TYPE	CONTINUOUS
DRIVE	7 1/2 HP
CAPACITY	4 TONS / HOUR
PRICE	U S $ 49,000

FIG. 4. Continuous two-stage mixer.

liquid-solids blending or for agglomeration:

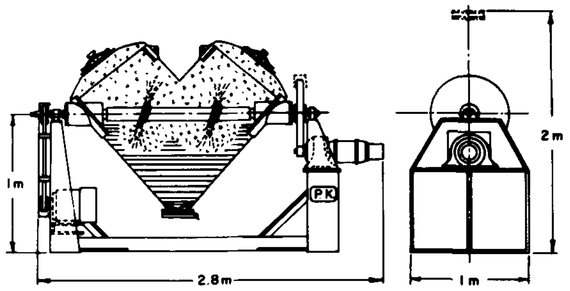
1. liquid must be finely divided,
2. both liquid and solid must be suspended in space, and
3. liquid and solid must be kept in motion so that fresh material is continually exposed.

Modern equipment can meet such requirements. Agglomeration can be predictable and can be used with almost any detergent formulas with minor modifications. For example, when the spray-dried formula uses a liquid surfactant, the agglomerated formula may substitute a dry surfactant in order to reduce density. The following no-phosphate laundry detergent can be agglomerated to 0.45 kg/liter density: 30% soda ash, 19.4% sodium sulfate, 19.4% dry Na DDBS (90% active), 0.25% CMC, 0.08% Tinopal, and 27.9% sodium silicate of 2.9 ratio. The finished product is granular and meets all detergent specifications.

When using this process, care should be exercised in selecting the proper equipment to assure that the finished product will appear, perform, and be reproduced according to product specifications. There are many batch and continuous mixers/blenders on the market. They can be classified into (a) stationary mixers, (b) rotating mixers with spray nozzles, and (c) rotating blenders with liquid dispersion bars.

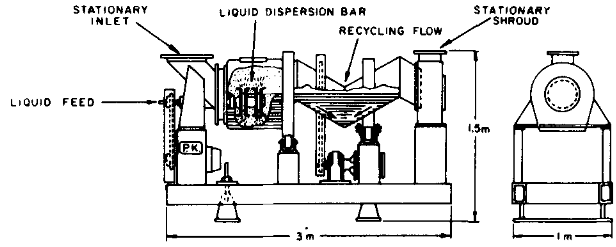
STATIONARY MIXERS

Stationary mixers have a "U" shaped trough (Fig. 1), a cylindrical vessel, or cone (Fig. 2). They are fitted with spiral agitators, interrupted spiral agitators, or plows. These



TYPE	BATCH LIQUID-SOLIDS
DRIVE	2 HP SHELL, 5 HP BAR
CAPACITY	300 Kg / BATCH
PRICE	U.S. $ 16,600

FIG. 5. Batch type detergent blender.



TYPE	CONTINUOUS LIQUID-SOLIDS
DRIVE	2 HP SHELL, 5 HP BAR
CAPACITY	4 TONS / HOUR
PRICE	U.S. $ 37,000

FIG. 6. Continuous detergent blender and agglomerator.

tools can vary from manufacturer to manufacturer, but the basic principle remains the same. The agitators must push through a static mass and move the material from top to bottom, left to right, and expose the batch to the liquid-spray system.

When liquids, especially sodium silicates, are being added to powders, the flow properties are constantly changing, and the forced agitation becomes unpredictable. Some designers are using multiple spirals to improve the flow, but the primary problem still remains: the exposed surface to the spray nozzle is relatively small compared to the total mass. The effective spray area becomes less and less as the mixer volume is increased. Therefore, the liquid dispersion time must be increased or the product quality will suffer. Stationary mixers should be used for simple liquid-solids mixing, such as nonionic and perfume mixing into detergents.

ROTATING MIXERS WITH SPRAY NOZZLES

Rotating mixers with spray nozzles are manufactured in many shapes. There are drum types (Fig. 3), cone or double cone shapes, or any other geometry (Fig. 4) based on the imagination of the designer. The rotating mixers employ gravity within the shell to move the product. Sometimes internal baffles are used to assist the flow. A rotating mixer may be effective on dry mixes and may be inexpensive to operate, but as a liquid-solids mixer, it is limited because it cannot mix ingredients with more than 6% water or sodium silicate. Positioning of the spray nozzle is critical, since the cascading material could bury the nozzle. The spray surface is small and the lack of agitation tends to promote lumps especially when viscous liquids, such as sodium silicates or surfactants, are used.

The continuous two-stage drum mixer (Fig. 4) may be used for up to 12% liquid addition when the spray is extended over a long surface. However, the length of the mixer becomes unproportional to the rate being handled. Caking of the product on the walls of the mixer can be a

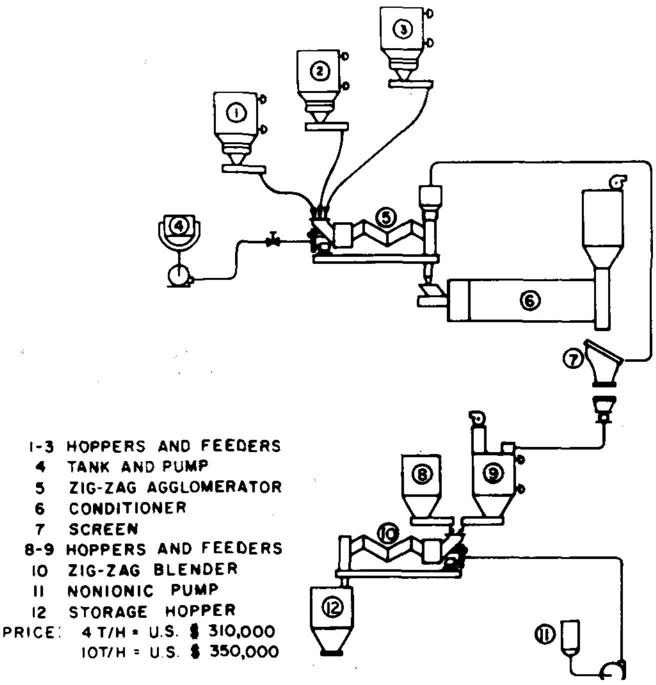


FIG. 7. Detergent plant.

problem. In fact, one dishwashing detergent manufacturer uses air hammers to chip off the caked-on product.

ROTATING BLENDERS WITH LIQUID-DISPERSION BARS

Rotating blenders with liquid-dispersion bars are the ultimate solution for the process of agglomerating detergents. These machines combine the proper material flow with high-speed bar agitation to accelerate blending and dispersing liquids into an area where the displacement of solids is rapid. The V-shaped twin shell blenders (Fig. 5) and the zig-zag continuous blenders (Fig. 6) were pioneered by the Patterson-Kelley Company in the U.S., and the patented features of both blenders include the unique liquid-dispersion bar. Both designs are used in the detergent industry.

Twin Shell Blender

The twin shell blender is batch type equipment (Fig. 5) where the V-shape achieves a precision blend through a divergent flow and by the intermeshing action when two inclined cylinders combine their flows. Material is rotated close to the axis, reducing power requirements. As the blender rotates, liquid is sprayed into the material through a high-speed liquid dispersion bar located concentric to the trunnion axis. The blades on the bar aerate the material to increase the speed and thoroughness of the blend. Liquid is dispersed through disc apertures in a controlled pattern and extended to all solids throughout the blend. Complete agglomeration and controlled chemical reaction is the number one reason why the liquid-solids twin shell is the most reliable batch blender and used in place of the spray tower. Up to 1500 liter capacity, the twin shell blender is used for adding 22% water to sodium tripolyphosphates or for agglomerating detergents with up to 35%, 50° Baume sodium silicates.

Continuous Zig-Zag Blender

The continuous zig-zag blender (Fig. 6) rotates between a stationary inlet and stationary discharge shroud and offers the same accuracy as the twin shell, but on a continuous basis. Uniform blends are obtained by agitation and multiple recycling. At each half-turn, part of the material moves forward, part of it backward. Random splitting, merging, tumbling bring particles into contact with each other and with the liquid. One or more liquids can be injected into the suspended mass through the liquid-dispersion bar. The metered liquid is discharged centrifugally as a mist of controlled droplet size. It impinges on particles but never reaches the walls of the blender. Pilot testing establishes the desired blend characteristics which dictates the size of production equipment. Blending time is the same in the zig-zag regardless of the unit's size. Scale-up is direct; therefore, chemical reactions can be predicted and controlled. Detergent blending and agglomeration usually require only 90 seconds retention time in the zig-zag. After discharge, however, the material must be kept moving and be conditioned until the chemical reaction is complete, which takes ca. 15 to 20 minutes. The conditioner is a simple rotating drum utilizing some air flow to carry off the heat generated during the chemical reaction.

The zig-zag continuous blender can blend or agglomerate up to 100 tons per hour of detergent products. Typical liquid-solids applications include 22% water addition to sodium tripolyphosphate, 12% surfactant to sodium tripolyphosphate, 8% sulfanic acid to soda ash, or 35% sodium silicate dispersion into detergent blends.

Detergent manufacturing plants similar to the schematic shown in Figure 7 have been operating for many years in the U.S. and in Europe. They use many processing steps which include:

1. hydration of sodium tripolyphosphate,
2. dry neutralization of soda ash,
3. blending and agglomerating dishwashing compounds,
4. blending and agglomerating laundry detergents,
5. coloring (speckling) detergents,
6. blending dry hand cleaners,
7. agglomerating spray tower fines.

The cost of agglomeration is understandably much lower than spray drying and when the zig-zag of twin shell blenders are used, the product is always uniform and performs as well as the product formed by the wet process.

When using the proper formula and the right equipment design, the agglomerated detergent product could be directly compared to the spray-dried formula. The agglomerated particles are like fused clusters held together by the silicates as binders and are nonsegregating even after repeated handling. The conditioned detergent is free-flowing and easily dissolved in water. At the present time, laundry detergent formulas are being agglomerated to reasonably low densities, such as 0.45 kg/liter.

Agglomeration is a practical alternative to spray drying and should be investigated by all detergent manufacturers, regardless of the size and nature of their operations.