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Achieving gentle mixing with a horizontal rotary drum mixer

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Unlike ribbon mixers and other mechanical batch mixers with impellers, a horizontal rotary drum mixer provides gentle gravity flow of the ingredients to achieve a homogeneous blend. After outlining mixing basics and how the horizontal rotary drum mixer is applied and operates, this article covers factors to consider in selecting the unit for your batch application. Related information provides general batch mixer selection tips.

Batch-mixing fragile, friable, or heat-sensitive ingredients requires gently achieving a homogeneous blend without damaging the particles. A horizontal rotary drum mixer is ideal for gentle batch mixing because it has no impellers to grind or smear particles or generate heat during mixing. But before examining the horizontal rotary drum mixer's operation, it will be helpful to look at some mixing basics.

Mixing basics: Defining a homogeneous blend

In a homogeneous blend of dry bulk ingredients, the particles are randomly distributed. This requires that all particles have uniform mobility and equal opportunity to flow at random during mixing so they can move freely about the mixer vessel.

Various forces can prevent random particle flow during mixing, including heat and energy, compaction, particle degradation, atmospheric conditions, liquid addition, and static electricity. You need to consider each of these forces when selecting a batch mixer, especially for materials that require gentle handling.

Heat and energy. The wiping action of a mixer with an impeller can generate heat. Such energy can't be created or destroyed, only transferred into the mixer itself or into the particles. In the latter case, the heat can prevent the particles from flowing freely.

Compaction. Particles can compact during mixing due to contact with the impeller or heat generation. This inhibits particle flow, causes bridging, and agglomerates particles, thus preventing random particle flow.

Particle degradation. Particles can degrade when pinched, smeared, or ground by an impeller sweeping against a stationary mixer surface. This action is especially harmful to crystals or other fragile particles because they're reduced to a size that doesn't flow as freely.

Atmospheric conditions. Conditions such as temperature and humidity outside the mixer can change the particles' flowability. For instance, humidity can cause hygroscopic particles to cling together rather than flow freely.

Liquid addition. Adding liquids to dry particles can cause agglomeration. While this is useful in applications that require agglomeration, during mixing, liquids can cause particles to clump together and impede free particle flow. [***Editor's note:*** Find more information on controlling liquid addition later in this article.] Particle flow during mixing can also be affected by the liquid addition rate, the liquid droplet size, and the particles' ability to absorb the liquid.

Static electricity. Static electricity from the particles' motion during mechanical mixing charges the surfaces of some particles so that they resist aeration. This prevents the particles from flowing randomly and promotes tight particle packing, which can cause demixing. A fine particle coating on the mixer's interior wall can indicate static electricity.

Gentle batch blending in a horizontal rotary drum mixer

A horizontal rotary drum mixer blends particles by gravity flow rather than with an impeller, reducing shear forces and eliminating heat for gentle handling of fragile particles. The mixer is suited to mixing batches of free-flowing materials. For instance, the mixer handles food products such as soup mixes and cereals, which are fragile and subject to breakage; thermoplastics, which are extremely heat-sensitive; ceramics, which can

Some tips:

How to select a batch mixer

Selecting a mixer for any batch application requires a good understanding of your batch requirements and your ingredients and operating conditions.

Batch requirements. Consider the maximum load volume the mixer will require per batch. This depends on the density (in pounds per cubic foot) of your total blended batch before packaging and your projected output (in pounds per hour). The mixer volume required per batch (in cubic feet) is the batch size (in pounds per batch) divided by the average finished batch density (in pounds per cubic foot).

Also consider what degree of mixing accuracy you need based on sieve analysis, coefficient of variance, or standard deviation and analytical information about the mixture's chemical and physical properties. Determine which mixing characteristics —such as shorter mixing times, gentle mixing, or dust-tight handling — are most important for your application. Consider whether you can combine another process step — such as agglomerating or drying — with mixing in the same equipment. This can reduce equipment costs and eliminate problems associated with processing and handling a batch twice. Also determine how the mixer will integrate with other equipment and how much floor space and headroom is available for the mixer.

Ingredients and operating conditions. Analyze your ingredients. What is the particle size range? What are the particles' flow properties, including the angle of repose? Identify other properties, too: Are the particles abrasive? Corrosive? Hygroscopic? Temperature sensitive? Friable? Aerated? Compacted? Also consider your atmospheric conditions. What's the temperature in the mixing area? Will ambient humidity change with the season? ***—D.C. Callaghan Jr.***

degrade and produce fines if roughly handled; and refractories and minerals, which can wear and break the impellers in other mixers. However, because it has no impeller, the horizontal rotary drum mixer is generally not suited to blending slurries, pastes, or extremely sticky or hard-to-flow materials, such as some resins.

How the horizontal rotary drum mixer works. A standard horizontal rotary drum mixer typically consists of a horizontal drum-shaped carbon or stainless steel housing supported by roller assemblies mounted on trunnions; this arrangement allows the drum's rotation. Several flights or chutes line the interior drum walls. A feed inlet is located at the mixer's upper front (one end of the drum) or top. The discharge is typically located on the upper front and can be the same opening as the inlet. A chute or slide from the outlet can lead to a discharge gate; some models have a discharge auger that extends from the drum center through the discharge outlet to promote cleanout. The drum's rotation is typically powered by an electric motor located below the mixer; a mixer with a discharge auger can require an additional motor. The mixer is typically available in working capacities up to 300 cubic feet. Depending on the application, the mixer can also be jacketed for cooling or drying, have liquid spray attachments, or be integrated with an electronic scale system.

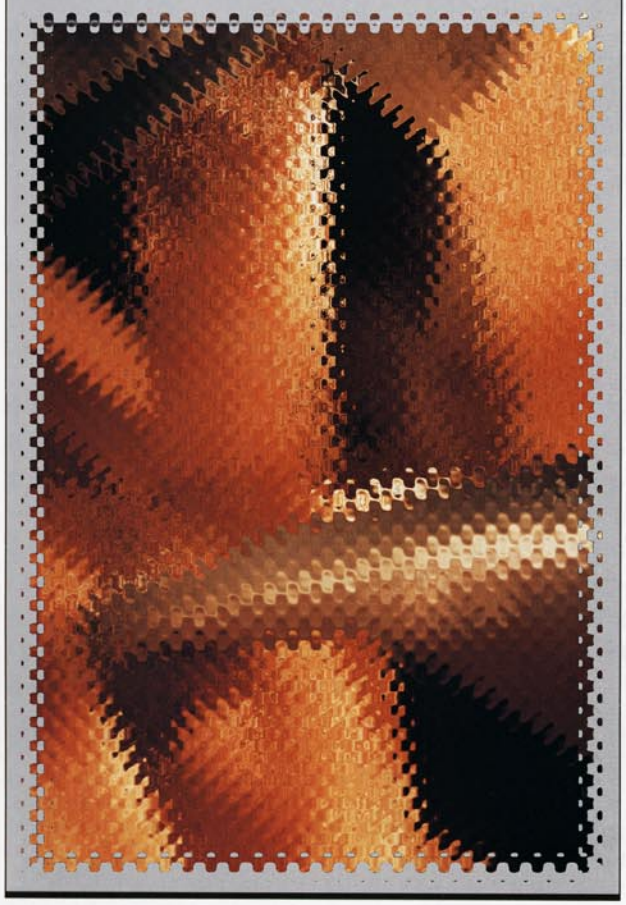
In operation, ingredients are fed by an auger or auxiliary handling equipment into the mixer's front inlet or by gravity into the top inlet. As the drum rotates, typically no faster than 15 rpm, the particles are gently carried by gravity through the drum walls' flights or chutes. The flights or chutes fold, cut, and turn the flowing material to increase mixing efficiency without compacting or forcing the material against mixer surfaces and without creating friction or heat buildup. If a liquid is added to blend with or agglomerate the dry ingredients, the liquid is typically sprayed into the mixer through one spray nozzle aimed at an area along the interior wall. Uniform mixing can take less than 2 minutes or as much as 5 to 8 minutes. When mixing is complete, the blended batch is discharged — typically either by gravity through the discharge gate or with the aid of the discharge auger — for packaging or storage. Some units must reverse rotation to discharge the batch. An access door for cleaning and maintenance is typically located on the drum.

Some variations. Other horizontal rotary drum mixer models are similar to a standard unit with some component and operating differences; the following descriptions concentrate only on these models' differences from the standard unit. One model[1] that is also mounted on trunnions has the inlet and discharge outlet at opposite ends of the drum. The mixer's internal lifters and baffles gently tumble, turn, cut, and fold ingredients as they flow by gravity. The unit rotates at about 7 rpm and typically achieves a uniform blend in 14 to 21 revolutions (2 to 3 minutes). Liquids can be added through a spray nozzle that directs the spray at material flowing over an internal baffle.

Another model[2] consists of a rotating drum suspended from a shaft fixed between two pillow block bearings; the bearings are supported by an independent frame. The solid cold-rolled steel shaft runs through the drum's center. During each rotation, the mixer's interior proprietary arrangement of flights and chutes divides the batch 25 times per drum revolution into continuous rivers of particles that randomly flow into and through each other (Figure 1). The ingredients gently free-fall as the mixer rotates at about 3 rpm, achieving uniform mixing typically in 6 to 9 revolutions (2 to 3 minutes) and in some cases less than 1 minute. The flights and chutes have no acute angles or pockets to create hangup points or hamper complete discharge. The drum has a viewing window to monitor mixing or agglomeration progress as well as several access doors at the top, bottom, sides, front, and rear for cleaning and maintenance. The unit can be equipped with liquid spray lances with up to 12 spray nozzles; the liquid droplets impact the particles individually as each particle in the cascading curtain of flowing material is ex-

Figure 1

Rivers of particles randomly flowing into and through each other inside one horizontal rotary drum mixer model[2]



posed to the spray. An intensifier assembly can also be added to increase shear forces and reduce particle size in some applications. Compared with other horizontal rotary drum mixers of the same capacity, this model requires about one-fifth the horsepower; the mixer is available in working capacities up to 1,500 cubic feet.

Selecting a horizontal rotary drum mixer

For basic advice on choosing a batch mixer, see the related information elsewhere in this article, "Some tips: How to select a batch mixer." But if your free-flowing batch ingredients are fragile, friable, or heat-sensitive and you're selecting a horizontal rotary drum mixer, you need to consider several additional factors. They include mixing speed, shear, turndown, energy requirements, inlet and discharge location, system integration and flexibility, cleanout and accessibility, maintenance, liquid addition, startup under full load, scaleup ease, electrostatic charge hazards, and cost.

Mixing speed. Depending on the model and application, the horizontal rotary drum mixer can provide uniform mixing in periods ranging from less than 1 minute to as long as 5 to 8 minutes. Some models divide the particle flow more often during one drum revolution, which increases the mixing speed but can also increase the unit's cost. If, for instance, your packaging operation requires high throughput rates, a faster mixer will keep the operation at full capacity without delays. If your process doesn't require fast mixing, you may be able to select a less expensive mixer.

Shear. A horizontal rotary drum mixer provides low-shear mixing action for gentle blending, so if you also need size reduction during some batches, select a unit that can be equipped with an intensifier assembly to increase the shear forces.

Turndown. If you'll be running batches of widely different size in the same horizontal rotary drum mixer, select a unit with a large turndown ratio — that is, one that doesn't require a specific load volume to operate. The maximum available turndown ratio is 10:1. For instance, a model[2] with this turndown ratio and a 1,000-cubic-foot maximum capacity can uniformly mix a 100-cubic-foot batch at the same speed.

Energy requirements. Because the horizontal rotary drum mixer relies on gravity flow and has no impellers, it's more energy efficient than other batch mixers. However, some models with a discharge auger require an additional motor that can slightly increase the energy requirements. Also check the relationship of working capacity to horsepower requirements for the various horizontal rotary drum mixer models.

Inlet and discharge location. Consider which horizontal rotary drum mixer has inlet and discharge locations that will best integrate with your existing equipment and meet your operator access and space requirements. The mixer's high inlet permits gravity feeding. The high discharge (on the unit's upper front or top in most models) allows the blended batch to discharge typically by gravity, eliminating the need for additional handling equipment. If your batch will be packaged directly from the mixer, the high discharge also allows the operator to work safely in front of the mixer rather than underneath it. The high discharge also minimizes the distance between the inlet and discharge points, which reduces the mixer's headroom and floor space requirements.

System integration and flexibility. To directly integrate your packaging or handling operations with a horizontal rotary drum mixer, select a unit with gravity discharge rather than a discharge auger. This avoids the need for intermediate handling equipment that can demix the blended batch during discharge. If you need more operating flexibility, select a model with optional components that allow the mixer to serve as a packaging hopper, soft granulator or agglomerator, surface coater, impregnator, dedusting unit, cooler, or dryer.

Cleanout and accessibility. Some horizontal rotary drum mixers have hard-to-clean angles or other areas that can collect particles and hamper full cleanout. If you're concerned about

cross-contamination between batches, select a unit without these hard-to-clean areas and, if you need to access the mixer from all sides for cleaning and maintenance or to access related equipment, choose a unit with multiple access doors.

Maintenance. Because the horizontal rotary drum mixer's maximum rotation speed doesn't usually exceed 15 rpm, the mixer's internal components and drum wear slowly and require little maintenance. The mixer's lack of an impeller eliminates the need to adjust impeller-to-wall tolerances. A horizontal rotary drum mixer mounted on trunnions requires tolerance adjustments due to wear from drum rotation. As the trunnions wear, the drum settles, widening the original tolerance and potentially causing material leaks. A mixer mounted on pillow block bearings has no such tolerances to maintain.

Liquid addition. If you need to add liquids during mixing, choose a horizontal rotary drum mixer equipped with liquid addition components. Select a spray nozzle aperture size that produces the droplet size you need. Droplets smaller than the particle size allow the liquid to blend with the particles without balling or clumping; droplets larger than the particle size agglomerate the particles. For maximum uniformity in droplet dispersion, select a unit that sprays the droplets against a cascading curtain of particles so that each is individually exposed to the liquid. Also be aware that during liquid addition in a mixer equipped with a discharge auger, the auger can become coated with wet particles, bind, or create condensation inside the drum.

Startup under full load. To make formula corrections during mixing, you need to stop the mixer to take samples for lab analysis and then start the mixer under full load. And when your plant experiences power outages, you must either start the mixer under full load or clean it out before starting it, which can waste product and slow production. Few batch mixers with impellers can start under full load without damaging the impeller and requiring costly repairs or replacement. When selecting a horizontal rotary drum mixer for this situation, consider a model with a solid cold-rolled steel shaft.

Scaleup ease. For some horizontal rotary drum mixers, a lab-scale unit can be scaled up in direct 1:1 proportion to a production-size unit. This isn't always true for mixers with impellers, such as ribbon blenders. One reason is that the lab unit's impellers have a relatively greater surface area than those in a production-scale unit, which makes scaleup results harder to predict.

Electrostatic charge hazards. If your ingredients are prone to electrostatic charging, minimize associated hazards by choosing a horizontal rotary drum mixer that bleeds off the charges. A model equipped with a steel shaft mounted on pillow block bearings draws electrostatic charges from the particles out of the drum and toward the shaft ends. The ends can also have carbon brushes to bleed off electrostatic charge on the particles.

Cost. The capital and operating costs of horizontal rotary drum mixers vary by model, working capacity, and optional components. A model that achieves uniform mixing at lower rotation speeds is generally more expensive to purchase; however, a model that requires significantly less horsepower per cubic foot of working capacity has lower operating cost.

Running mixer tests

Once you've selected a mixer, work with the mixer manufacturer to arrange a mixing test of your batch ingredients. You'll need to send a sample of your ingredients with appropriate Material Safety Data Sheets to the lab. (Be aware that the lab typically isn't equipped to handle hazardous materials.) The lab staff will adjust the feeding and discharge systems used with the lab mixer depending on how you handle your ingredients — for instance, in small bags, bulk bags, or barrels — to contain dust.

The test will simulate an actual production run. Plan to observe the test so you can see how accurately the lab mixer blends your ingredients and how your batch is handled during and after mixing. The lab staff can help you optimize the mixer's operation for your batch requirements and scale up the unit to production size. **PBE**

Editor's note

For more information about mixing equipment, check the articles listed under "Mixing and blending" in *Powder and Bulk Engineering*'s comprehensive "Index to articles," December 1995. Also attend industry trade shows to see how new equipment can meet your mixing needs.

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