Mission Impossible?

Not at All.

Today's mixing systems empower process engineers to solve immediate mixing challenges while also addressing the needs of the overall business.

BY KEN LANGHORN, CHARLES ROSS & SON CO.

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Staring into a mix vessel, watching stubborn agglomerates of calcium phosphate swirl in a liquid batch with slow agitation, refusing to break down and disperse—clearly, you have a mixing problem.

This particular challenge can certainly be solved by switching to more advanced rotor/stator mixing technology. Still, although high-speed, high-shear dispersion will prevent those agglomerates from forming, is this really the best possible solution? Not necessarily.

Years ago, when markets were less competitive and production less demanding, process engineers could afford to think of individual process steps—like mixing—distinctively rather than in a broader context. Back in the day, engineers narrowly defined their mixing challenges as "the dispersion of calcium," for example, or "the emulsification of flax seed oil." They focused on flow rates, the application of shear, controlling heat buildup, and achieving a tight particle-size distribution.

Today, competitive pressures require us to think of mixing as a component of a much bigger picture. Our goal is not just to disperse calcium without creating agglomerates, or to emulsify flax or fish oil without damaging the omega-3 fatty acids within. Instead, we must think about what the needs of the overall business are—for every batch henceforth. We need to accomplish those process steps perfectly and *exactly the same way every time,* with:

- Complete control over the process and for all of the company's recipes
- Relentless effort to prevent microbiological contamination
- An equipment solution that benefits multiple process lines when possible
- Airtight documentation and accountability for every batch leaving the plant

If these requirements sound familiar, they should. Essentially, these are what current Good Manufacturing Practices (cGMPs) are all about.

For forward-thinking manufacturers, cGMPs aren't just about compliance; rather, they are part and parcel to developing superior manufacturing practices that will benefit the company overall in the long run.

Good mixing strategies not only make production more consistent and reliable, they also ensure an end-product that is safer and more likely to be effective and pleasing to consumers. Making strategic equipment choices is all about looking forward and turning the expense of compliance into an investment in the future.

Two Perspectives on Mixing

To optimize the mixing process and derive the greatest possible competitive advantage from a process change, you must examine every mixing challenge on your process line from two perspectives:

1. **Close-up perspective:** What are we trying to accomplish at the point of mixing, where agitators contact ingredients? What specific mixing or blending challenges must we overcome? Which combination of mixing technology and technique is most likely to meet our process goals?

2. **Wide-angle perspective:** What opportunities and added features are available to optimize this mixing process, integrate it into surrounding process functions, help satisfy regulatory requirements, and deliver a business advantage?

These perspectives are distinctly different, but they are not independent. We often choose between several promising mixing strategies based on the value they offer in a larger business context.

Where Two Perspectives Merge

All manufacturers in natural foods share a common future: evolution will continue to advance toward more disciplined and sophisticated production, more pressure to comply with cGMPs, and more intense competition.

Yet every manufacturer is unique. For example, each manufacturer must find a balance that matches the company's production goals as well as its culture and business environment, weighing the value of absolute repeatability versus the value of human judgment and direct control on the process line.

Finding the right balance is vitally important—and this is why every equipment choice must be considered carefully from both a close-up perspective and wide-angle, business-savvy perspective.

The three processing scenarios illustrated on the following pages, drawn from in-plant trials, field experience, and tests conducted in the Ross Test & Development Center, reflect two of the most common mixing and blending challenges that manufacturers in natural foods face today: high-speed dispersion of hard-to-disperse powders and high-speed blending of high-value, shear-sensitive ingredients.

Scenario 1

Your Mission: Eliminate the formation of agglomerates in a fine-dispersion, medium-viscosity product

Product: Liquid dietary supplement for bone and joint support

Major Dry Ingredients: Calcium, glucosamine, chondroitin, magnesium, inulin

Minor Dry Ingredients: Iron, zinc, manganese, copper, silica, boron, chromium, selenium, vanadium, vitamin D3, molybdenum, iodine, stevia (leaf extract)

Major Liquid Ingredients: Water, glycerin, flax seed oil

Minor Liquid Ingredients: Flavors, colors

Mixing Challenge:

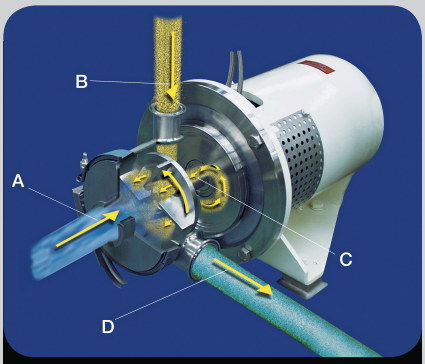
- Calcium and other minerals in a dry state form agglomerates in a liquid batch with low-speed, low-shear agitation.
- Inulin is an oligo-fiber that also requires accelerated dispersion to prevent formation of floating agglomerates.
- Flax seed oil requires emulsification at lower temperatures to prevent polyunsaturated fats from oxidizing.
- Also, all liquid flavors and colors are made in an alcohol or glycerin base and require emulsification to disperse properly.

Close-Up View:

A high-shear rotor/stator mixer is a logical choice, as both dispersion and emulsification require particle-size reduction. The intense mechanical and hydraulic shear applied by a rotor/stator generator breaks down agglomerates and droplets much more quickly than traditional alternatives such as propellers, turbine agitators, and even high-speed sawtooth dispersers.

Thanks to the new generation of multistage rotor/stator generators developed in recent years, many configurations of rotor/stator design are available, including various combinations of size and tip speed, shear rate, and flow rate. The best choice depends on the ingredients involved and the level of shear required to reach the target particle-size distribution quickly, without degrading shear-sensitive ingredients.

Fine dispersions often present the additional challenge of dispersing powders such as soluble fibers, gums, non-calorie sweeteners, and minerals into a liquid batch while preventing the formation of agglomerates or "fish eyes." Agglomerates and fish eyes are notorious for forming when powders are simply



In the SLIM (Solid/Liquid Injection Manifold) powder-injection system, a liquid stream (A) enters the high-speed rotor. Drawn into the mixer by a powerful vacuum, the powder (B) is injected through the ported rotor (C) directly into the high-shear zone, where it is subjected to intense shear. With particles instantly dispersed, the resulting product is ejected from the mixer (D).

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poured into a liquid batch, even when the batch is vigorously agitated. Once formed, agglomerates and fish eyes can be extremely difficult to break apart and disperse completely, requiring a long mix cycle—in this case, overnight, requiring a third shift in the plant!—and driving up costs.

A rotor/stator mixer can provide the necessary shear to accomplish the goal of fine dispersion without agglomerates. Switching to a rotor/stator mixer equipped for inline powder injection can accelerate the process dramatically. By injecting hard-to-disperse powders directly into a liquid stream in the high-shear zone of a rotor/stator generator, solids are dispersed instantly—and agglomerates and fish eyes never have a chance to form.

Wide-Angle View:

- **Portability** – Because a SLIM (Solid/Liquid Injection Manifold) device can disperse fine powders so quickly, the unit does not have to be dedicated to a single process line. Configured in a self-contained, portable package, a single SLIM unit can serve multiple process lines. The one pictured at right is easily moved from line to line. It also includes a recirculating tank that provides the option to disperse ingredients in multiple passes through the high-shear generator for a highly controlled mix before diverting the material into a larger vessel for further mixing or pumping downstream.

- **PLC Control (Programmable Logic Controller)** – The design of the on-board control system provides another opportunity to boost product consistency and lower the risk of operator error. The value of a PLC-based control rises as the complexity of the process rises and operators are increasingly challenged to keep up. A PLC control with an intuitive touch screen interface can easily accommodate many mixing steps and frequent changeovers from one line to another, while reducing the burden on operators to get every process step exactly right.

A portable, self-contained powder injection system can serve multiple process lines instead of just one.

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"THINK BIG WHILE YOU'RE STILL SMALL"

By Sonja T. Sladic, Chairman of the Board, Zane Product Development Inc.

As the market for natural foods continues to grow, competition will become even more intense. In this environment, small, entrepreneurial manufacturers are racing to develop their products, expand their distribution, and build their customer base. The main focus varies from company to company—some concentrate on R&D, for example, while others devote more energy to retail marketing and channel development. But despite those differences, virtually all manufacturers have this in common: they are thinking like small companies and putting off essential management development until later.

Many believe that such cGMP-driven practices as process validation, batch controls, rigorous sanitation, QA/QC control, and front-end documentation of all incoming ingredients are what big companies do. But the truth is that developing all those standards and processes is *much* easier if you start now, when you're working with a relatively small number of ingredients and the scale of your production is limited. Here are some strategies—for both processes and equipment—to help you think big while you're still small.

- Automate your production to reduce the risk of human error.
- Enclose your mix vessels. Monitor temperature and other parameters with sterile probes within the vessel instead of sampling manually and risking contamination.
- If you're working with temperature-sensitive natural ingredients like fish oil, flax oil, pine bark extract, or ginger root extract, equip your mix vessel with a thermal jacket for precise heating and cooling during the mix cycle. Use digital controls to ensure that you will never overcook your ingredients and diminish the nutritive value of your end-product.
- Buy mixing equipment that offers great versatility. Multi-agitator mixers with separately controlled agitators allow you to complete multiple mixing steps in a single unit—without having to transfer the product from one piece of equipment to another. This lowers the overall cost of equipment, helps prevent contamination during the transfer, speeds up the end-to-end process, and makes your process line more flexible.
- Make sure your controls are designed for robust data capture so you can document every batch and sail through your next FDA inspection with no problem!

Think holistically. Don't focus on product development or marketing at the expense of production. You must develop your production, too, and the best time to start is right now. It will be much harder and more costly to do so later on, when you're not a "small company" anymore.

PHOTO COURTESY OF CHARLES ROSS

Scenario 2

Your Mission: Eliminate the formation of agglomerates in a fine-dispersion, low-viscosity mix of heat-sensitive, high-value ingredients

Product: Liquid "mood food"

Major Liquid Ingredients: Water, mangosteen, and elderberry juice concentrates

Major Dry Ingredients: Vitamin/mineral blend

Minor Dry Ingredients: Malic acid, citric acid, acetyl L-carnitine, and plant extracts: Pycnogenol, 5-HTP (*Griffonia seed extract*), *Bacopa monnieri*, luo han guo, chamomile flower, lemon balm, and ginger root extracts

Mixing Challenge:

- Dry vitamin/mineral blend forms agglomerates in a liquid batch with low-speed, low-shear agitation.
- Proper temperature control is needed to avoid overheating polyphenols, bioflavonoids, and other heat-sensitive components.
- To ensure that each serving delivers proper amounts of vitamins, minerals, and active ingredients, homogeneous mixing is critical.

Close-Up View:

Botanical extracts are used for their antioxidative and bioactive properties to support good mood and brain health. Because of their low density, standardized botanical extracts such as Pycnogenol, lemon balm, and luo han guo require accelerated dispersion to prevent these very fine particles (<100–125 um) from forming agglomerates.

Botanical extracts are also heat sensitive and must be kept in a "Goldilocks" zone during manufacturing. If the temperature is too high, the extracts will be degraded and lose their potency.

The multi-agitator, high-shear sanitary mixer used during manufacturing is configured with a jacketed vessel that provides close control of heat in the batch. A temperature probe within the closed vessel collects data for display on the main control panel.

Wide-Angle View:

There are no contamination challenges during the mix cycle because the whole process takes place in an enclosed and controlled environment.

All food-contact surfaces and mixer wetted parts are built of Type 316 stainless steel and are easy to clean and sanitize. This allows for less downtime between production runs—and greater production.

A fully enclosed multi-shaft mixer provides increased control over critical process parameters such as temperature and pressure. Because the agitators are independently driven, the unit can operate with various combinations of high-shear and low-shear agitators in process. Numerous operations can be accomplished in a single unit—eliminating the time, expense, and risk of contamination associated with transfers between several single-agitator mixers.

Scenario 3

Your Mission: Blend fragile, high-value ingredients

Product: Trail mix

Major Ingredients: Nuts, dried fruit, seeds, oats

Minor Ingredients: Honey, natural oils, flavor extracts, salt

Mixing Challenge:

- Blending fragile ingredients quickly, without damage

Close-Up View:

The strong preference for natural ingredients in this market presents many formidable challenges on the process line. Many of the high-value ingredients we see in retail products like energy bars, trail mixes, and fortified cereals are fragile. Exposed to high-energy blending, dried berries, apricots, and cherries are easily crushed. Macadamia nuts, pine nuts, pistachios, pumpkin seeds, toasted oats, banana chips, coconut grates—and many other nuts, seeds, and grains—are easily chipped. The trick is to find the delicate balance between applying enough energy to fluidize the mix and achieve homogeneity, without damaging the ingredients.

In most cases, the answer to this challenge is a sanitary paddle blender equipped with electronic variable speed control, not just an on/off switch. Contemporary Variable Frequency Drives (VFD) provide the flexibility to vary speed easily, while main-

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taining constant torque over a wide speed range—typically from 8-40 rpm. A VFD also provides "soft start" capability, which is essential to motivate a batch of dense materials. Load and voltage feedback allows you to adjust overload and voltage thresholds to protect against phase failure and under-voltage.

A ribbon blender engineered for sanitary applications includes high-grade stainless steel construction, a sanitary finish, close tolerances, and design details that eliminate corners and crevices where batch material might collect.

Wide-Angle View:

In most process environments like this one, versatility is extremely valuable. Blenders should be configured to accommodate multiple products—including those with very different ingredients and wide-ranging blending needs.

A paddle blender is often the optimal choice for blending heavy, fragile ingredients. But by providing ribbon agitators that are interchangeable with the unit's paddle agitators, the same blender can be reconfigured in minutes to blend hardier ingredients—such as cinnamon, cloves, and ginger—that might comprise a spice blend.

For fast changeover with minimal risk of cross-contamination, a sanitary finish provides radiused internal corners, meticulously smoothed internal welds, and a 150-grit internal polish. All of this contributes to homogeneous blending, complete discharge, and fast cleaning during changeover.

As any business grows, recipes quickly become more complex, and ingredients seem to increase exponentially. So, your PLC-based control should be designed to facilitate growth. This requires effective communication with your control system architects so they can specify the processors, on-board memory, and I/O capabilities you will need *tomorrow*. The better they understand your current process environment, your future process needs, and your blending equipment, the better your control system will perform over the long term.

This laboratory ribbon blender is equipped with a PLC-driven control system with a touch screen interface. As product development proceeds, every process variable is controlled, and each batch is documented.

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*Author and technical director **Ken Langhorn** holds multiple patents for innovations in high-shear and high-viscosity mixing. He also manages the Ross Test & Development Center, where he oversees testing for customers.*

"AUTOMATION MAKES THE OPERATOR'S ROLE MORE MEANINGFUL"

By Gary Barber, General Manager, Ross Systems & Controls

Many people believe the goal of automation is to eliminate human operators in a production environment. This is not true. Well-designed controls take over the repetitive tasks humans don't do very well, while allowing them to do more of what they do best. A control system gathers data and executes a multistep process exactly the same way every time, shift after shift, without risk of fatigue, distraction, and occasional mistakes. Released from these chores, human operators are free to monitor the process, spot irregularities, and make judgments based on experience.

The goal in control design is really to optimize both machine operation and human operation. In each case, we ask, "What is the optimal role for operators in this case, and how can the control system help achieve this goal?" We adapt to the complexity of the process and the skill level of the operator. For example, we may provide on-screen instructions for an operator to take a sample, interpret the results, and manually continue the mixing cycle. Or we might automate the entire sampling process and simply report the results.

The value you can expect from your control system in day-to-day production goes up as you invest more energy and thought in your control strategy. Think of your control as a powerful tool that will help ensure greater product quality, more reliable production, and easier compliance with cGMPs. N