



## **Graceful Scale-Up of Mixing Systems – Make it Happen for You**

When acquiring a process that involves one or several mixing steps, foresight for scale-up or expansion remains to be a subtle but important factor for long-term success. As production requirements grow, your ability to shift gears smoothly, quickly and efficiently is critical because it can spell the difference between an economical transition and a financial disaster.

Many process engineers have answered the call for greater capacity while avoiding scale-up entirely by simply adding more mixers identical to the ones they already had. This strategy certainly increases production but misses to capture many economies of scale. With every square foot of floor space occupied by numerous small mixers, these associated costs go up when they really don't need to if only a larger mixer version is used instead.

The textbook concept on scalability is defined in terms of process, material and machine variables, grouped into ratios and equations establishing geometric, kinematic and dynamic similarities. But virtually all of these classic formulas apply only to simple, low-viscosity liquid-liquid mixing systems involving a single agitator. Real mixing applications of today are much more complex than that. Mixing involving multiple stages that correspond to varying levels of viscosity, density, vacuum/pressure requirements, shear-sensitivity and heat requirements cannot be neatly quantified using standard scale-up equations. Hence, for many mixing systems, traditional academic analysis provides only a starting point. From there, we rely on collective experience and our ability to identify and control the most important variables at work in a specific application. For

instance, we may narrow our focus on such variables as shear input, power density, blade or ribbon agitator tip speeds, drive requirements, batch turnover rates or flow rates.

Below are some considerations that could help your business grow while reaping the benefits of reliable scale-up and other creative ways of increasing production.

**Plan Ahead.** Set a product and package matrix that includes possible future expansion. A projection of future product and process requirements is a proactive means to build maximum flexibility. Your plan must include provisions for efficient product transfer, storage, waste management and also rework or recovery, which is desirable if not necessary for large-scale production. Because larger batches will require longer hold time, consider if this will potentially alter product quality.

**Invest in scalable mixing equipment.** As early as the R&D stage of a project, choose a manufacturer that places high priority on scalability in their mixer and blender product lines. Make sure you will have options available for scale-up, if and whenever you need them.

Truly scaleable equipment takes into account the decrease in surface area to volume ratio and provides sufficient power; shear and bulk flow of product necessary for effective heat transfer. When inadequate flow is produced, burn-on becomes a serious scale-up issue since higher temperatures are needed at the surfaces to speed up heat transfer to the product.

In the real world where fluids are imperfect and relationships are non-linear, we are left to concentrate on results. Starting with geometric similarity and calculations that help ballpark such key parameters as power input and agitator speed, you can then manipulate mixing variables until process similarity is achieved. This is where the support of an experienced partner becomes critical. Strong experience and strong information management guides you how to manage variables associated with multiple agitators in a

multi-step process and enables you to tap into the results of countless laboratory tests in similar applications.

**Consider semi-continuous processing.** Batch processing allows a high degree of control on discrete units of production. On the other hand, in an inline high shear mixer set-up, the mixing process is also tightly controlled in the sense that the number of passes through the high-shear zone can be monitored with confidence. Inline HSMs are practical solutions for tanks that are already equipped with low-shear, gentle-mixing agitators. Operators can add an inline high-shear mixer without disturbing pre-existing equipment. The inline mixer can simply be positioned on the floor alongside the tank. Product can then be tapped from the tank for processing through the high-shear rotor/stator generator and then returned to the vessel.

This configuration eliminates the difficulties of trying to squeeze a top-entering mixer into the vessel along with pre-existing mixers, baffles and other obstacles. It solves headroom issues that sometimes arise when longshafted batch HSMs are retrofitted to existing tanks. It also simplifies maintenance, since the inline HSM doesn't need to be removed from the tank for periodic maintenance.

Addition of an inline high shear mixer into a blending system improves production rates by cutting blend times. For additional efficiency, the inline mixer can be rolled up to the tank, operated for only a portion of the overall mixing cycle, and then rolled to another tank to perform a similar function. In this way, a single, portable inline mixer can serve numerous tanks rather than sit idle in a fixed installation for a substantial portion of the mixing cycle.

You should also consider whether a switch to an inline configuration would provide additional advantages of value in your application — such as the ability to inject hard to-disperse powders into your batch using the same inline mixer.

Another way of pursuing a semi-continuous process is to utilize a change can design mixer. With multiple vessels, one mix can could be at the loading stage, another under the mixer, another at the discharge step and yet another at the clean-up stage. The change can design is available for most mixing systems up to 500 gallon capacities or even larger.

**Test and See For Yourself.** Whether you are planning to invest in scalable pilot equipment, looking to increase production at minimal cost or getting ready to acquire large-capacity mixing equipment, include in your to-do list a trip to the manufacturer's laboratory. Be sure to test a variety of equipment and techniques using your own raw ingredients, simulating conditions as close to your actual process as possible. Quantitative test results provide the best assurance that you have chosen the best mixing system before you buy anything.

This strategy works best if the mixer manufacturer provides a well-equipped analytical laboratory to support a thorough mixing trial. Be there to witness the test – even the most expert of mixing engineers needs your expertise in knowing the behavior of your specific product. In turn, you will also see how to utilize the mixer and learn important processing techniques.

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