Benefits and techniques of vacuum mixing

Laboratory Dual-Shaft Mixer with Vacuum Pump (plumbed to the mixer, pre-wired to the control panel and installed on the bottom shelf of the mixer bench).

Why vacuum mixing?

Vacuum refers to space in which pressure is lower than atmospheric pressure. In other words, it contains less gas molecules per unit volume compared to ambient air.

Vacuum environments accomplish a number of mixing goals that vary from one application to another. For some, it is a matter of aesthetics, like in the case of coatings, personal care products or molded composites. A void-free mixture also contributes to the strength and precision of specially engineered parts. In other products, vacuum is applied to remove oxygen and prevent decomposition of sensitive ingredients or thwart unwanted chemical reactions and microbial growth. Minimizing oxygen content in beverages, for example, is a single important factor in maintaining consistent high quality during shelf life.

Applying vacuum also improves product handling and performance. Certain gels and pastes are mixed under vacuum to prevent defects in syringe filling or printing. Finally, vacuum mixing allows drying processes to proceed faster and at lower temperatures. This is an excellent method for drying heat-sensitive materials without fear of thermal degradation.
Vacuum-capable mixers

Almost all batch mixer configurations can be built for vacuum operation, from single-shaft devices such as high speed saw-tooth dispersers or rotor/stator mixers used for making low viscosity formulations to multi-agitator or planetary mixing systems used in batching high viscosity, high density compounds or even blending equipment used in drying operations such as vertical cone screw blenders or horizontal ribbon blenders. Many of these mixers are supplied with a built-in vacuum pump pre-wired to the mixer’s control panel.

Useful techniques

Make sure you have the right type of vacuum pump to handle the level of vacuum and the operating conditions that your process requires. For example, a rotary vane pump may allow you to draw a deeper vacuum (29.5-29.8” Hg) than a liquid ring pump. However, a liquid ring pump may better accommodate condensate from the batch. Do use the appropriate filter and/or condenser before the pump to protect it from contaminants.

Always visually monitor the contents of your vessel as you apply vacuum. Use a sight glass to watch for bubbling and changes in volume. Include a separate “break valve” in your vessel design. This will allow you to pull vacuum, start the mixer and close off the chamber once the desired level of vacuum is achieved in the batch. By isolating the mix chamber and turning off the pump at this point, you avoid drawing out volatile constituents and upsetting the formulation. Once an agitation phase is completed, you can then bleed air or inert gases back into the chamber gradually.

To accelerate the mix cycle, you can utilize vacuum to inject raw materials into the batch. Sub-surface addition is a convenient way of incorporating large amounts of liquids and it also prevents “dusting” and floating of lightweight powders, thus promoting better dispersion. Overall processing time is shortened as well because a separate post-mixing deaeration step becomes unnecessary.

Sample Applications: Epoxy- and Polyester-based Composites

Deaeration is a key factor in the processing of cast epoxy resin. The sample on the left was mixed in a Double Planetary Mixer under vacuum; while the one on the right was prepared in a similar fashion except vacuum was not applied.

These 20x micrographs compare a filled polyester resin mixed under vacuum (A) and under atmospheric pressure (B). Entrapped air can lead to a high rate of rejects and, in many applications, premature product failure under load.