A GUIDE TO UNDERSTANDING AND MIXING THICKENERS

Rheology modifiers, commonly referred to as thickeners or viscosifiers, are ever-present in most products. The use of these additives cut across several process industries including food, pharmaceuticals, cosmetics and personal care, adhesives, textile, ceramics, paper, detergents, paints, inks and coatings, among others. They serve the purpose of not just altering the viscosity of the formulation but also that of providing specific functionality to the product. This could range from improving mouthfeel, body, texture, moisture retention and suspendability of soluble ingredients to increasing stability and dry strength, inhibiting syneresis, resisting bacterial attack, preventing shrinkage and controlling crystal ice formation.

Thickeners come from both natural and synthetic sources. Naturally occurring polymers comprised of polysaccharide or amino acid building blocks, and are generally water-soluble. Common examples are starch, cellulose, alginate, egg yolk, agar, arrowroot, carageenan, collagen, gelatin, guar gum, pectin and xanthan gum.

On the other side, synthetic acrylic-based polymers are conveniently grouped into three general classes: alkali-swellable (or soluble) emulsions (ASE's) hydrophobically modified alkali-swellable emulsions (HASE's) and hydrophobically modified, ethoxylated urethane resins (HEUR's).

HASE's are modifications of ASE's following an addition of hydrophobic functional groups. These are commonly known as associative thickeners. In its simplest form, an associative thickener is a water-soluble polymer containing several relatively hydrophobic groups. HEUR's also belong to the category of associative thickeners. But unlike HASE's, HEUR's are nonionic substances and are not dependent on alkali for activation of the thickening mechanism. Typically in the form of white, fluffy, dry powder, popular varieties of synthetic thickeners include carbomers, sodium carboxymethylcellulose (CMC) and fumed silica.

THE PLOT THICKENS

Rheology modifiers alter a system's viscosity through a combination of mechanisms. Addition of alkali to an emulsion consisting of tightly coiled polymers generates anionic charges along the chains. Like charges repel each other and the polymers swell and uncoil occupying more volume within the solution. Also, hydrophobic groups form domains along other water-hating groups, ultimately reducing overall free energy and manifesting as a more structured, less fluid system. Lastly, particle-to-particle interactions between thickener and charged surfaces of system components bring about changes in rheological properties.

The ease by which thickeners are effectively dispersed or dissolved in the solvent chemically depends on particle size, molecular weight and structure (average number and distribution of hydroxyl groups per compound) and also the presence of a surfactant.

The primary objectives of the mixing step are to provide a homogenous mixture and to expose as much surface area of the additive particles. To achieve this goal mechanically, the system is subject to high shear mixing conditions. Simply adding powders on top of an agitated batch used to be the only way to introduce thickeners. However, most thickeners, due to their hydrophobic groups, resist wet-out upon contact with water and could float on the surface for hours. Mixing operators are then forced to carefully sift and add powders only as fast as the liquid will take them.

Adding powders slowly into a small batch of vigorously agitated liquid may provide enough time for individual solid particles to hydrate. But in a full-scale production setting, this method of addition is very costly and time-consuming.

Moreover, if powders are added too slowly, an uncontrolled viscosity build-up can occur mid-processing thus preventing the rest of the solids to be fully dissolved.

In contrast, manually adding the powders too fast can cause particles to clump up. The clumps solvate to form a tough outer layer that prevents complete wetting of the interior particles. This can result in solution defects such as grainy texture, reduced viscosity, or the presence of insoluble particles resembling "fish eyes." The high shear conditions usually needed to break up these agglomerations can also overshear the already hydrated particles resulting in a permanent viscosity loss.

While thickeners of different varieties and origins offer numerous benefits, their incorporation into any liquid formulation requires certain processing techniques in order to reveal full functionality.

THE ROSS VERSAMIX SOLUTION

The Ross VersaMix is a multi-agitator mixer consisting of any of three agitators or combinations thereof:

- Anchor Agitator
- High Speed Disperser
- High Shear Mixer

The Anchor agitator rotates at relatively low rpm, providing radial and axial movement to the batch. Scrapers can be mounted to the arms and wings of the Anchor to remove any constituents from the vessel walls. This promotes batch homogeneity and improves thermal transfer when a heating or cooling jacket is used.

The High Speed Disperser with the modified sawtooth blade is commonly used to disperse solids into viscous liquid vehicles. In conjunction with the anchor agitator, the high-speed disperser can be used in viscosities up to several hundred thousand centipoise.

The High Shear Mixer consists of a four-blade rotor rotates at high speed and at close clearance to a stationary stator head. The high-speed rotor draws formulation components from the bottom, and then expels the components radially through openings in the stator.

The Ross VersaMix has been highly successful at producing high quality thickened solutions. For example, a Carbopol solution can be produced in the VersaMix in considerably less time than in conventional mixers. A typical mixing procedure is as follows:

- Water is added to the vessel of the VersaMix.
- Agitators are turned on and the speeds are adjusted to create the proper flow patterns and vortex.
- It is essential that the Carbopol powder is drawn immediately below the surface and dispersed by the High Speed Disperser and High Shear Mixer.
- The rotor/stator is run until all of the Carbopol has been dispersed and then it is turned off. Running the High Shear Mixer for an extended period of time can damage the Carbopol polymer, reducing its thickening efficiency.
- Vacuum processing techniques can be employed to eliminate air in the finished product, yielding a smoother, air-free gel.

Some of the recommended features for VersaMix units used for the dispersion of Carbopol solutions include:

• **Vacuum capability** - allows the removal of air from the product, resulting in a smoother air-free gel.

• **Variable speed control** - of each agitator (mechanical variable speed drives or AC variable frequency inverters) enables the user to fine tune the flow patterns and optimize the vortex for charging purposes.

• **Jacketing of the mix can** - lets the user control the temperature of the batch. Heating of the water can accelerate the rate of dispersion; however, this also makes the solution more sensitive to agglomeration formation during powder charging. Cooling of the batch can aid in keeping the solution below 70C (158F), the temperature at which a permanent loss of viscosity can occur.

• **Teflon scrapers** - staggered on the arms and wings of the Anchor, can be hinged or fixed, and are used to scrape materials from the sides and bottom of the mix can. This promotes batch homogeneity and improves heat transfer when the jacket is used.

• **Sight ports and charging port**s - allow the operator to view the batch and to add Carbopol without raising the agitators.

• **Probe type Thermocoup**le - can be used to monitor batch temperature.

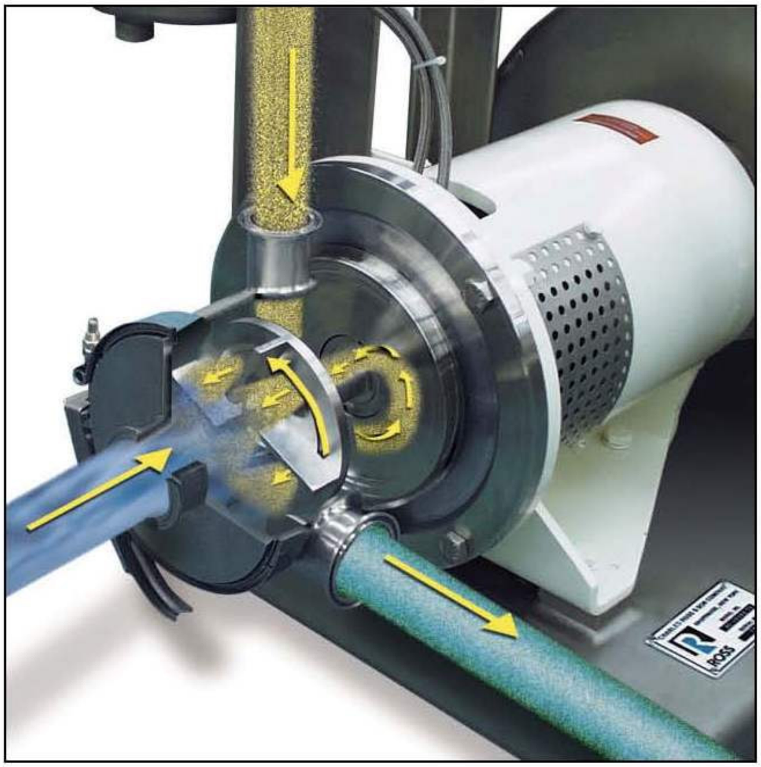
• **Flush mounted ball valve** - in the bottom of the mix can facilitates the discharge of the Carbopol solution with minimal dead space between the Anchor and bottom of mix can.

• **Caster wheels** - on the mix can promote easy movement of the mix can in and out of the mixing position.

THE ROSS SLIM SOLUTION

For a long time, improvements to first generation high shear mixers have been confined to different stator designs and multi-stage assemblies. Recent advances though, take the conventional rotor/stator to a higher level of use and purpose. Charles Ross & Son Company has developed the Solids/Liquid Injection Manifold (SLIM) Technology, based on the standard four-blade rotor and stationary head.

Illustration of SLIM System



The rotor and stator mixing arrangement of a SLIM-modified High Shear Mixer is specially designed and engineered to create negative pressure (vacuum) behind the rotor, which is used as the motive force to suck powdered (or liquid) ingredients directly into the high shear zone. The resultant powder/liquid mixture is expelled centrifugally through the openings in the fixed stator. Solids are wetted instantly and a smooth, lump-free solution is produced at a rapid and cost-efficient rate. In many applications, the SLIM system shortens mixing cycles by more than 50%.

The SLIM technology is available in both batch and inline Ross High Shear Mixers. The inline SLIM system eliminates the need to dump solids directly into an open batch vessel and virtually eliminates "dusting," too. This has led to a significant reduction in the volume of airborne particles in plants that have switched to the new induction system. In addition, it does not use an eductor to create the suction, thereby making the inline SLIM more tolerant of flow and viscosity changes

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Ross Inline SLIM Systems, in Hopper Arrangement (left) and
Hose & Wand Arrangement (right)

For batch-style operations, the Ross VersaMix with SLIM System is considered one of the most efficient mixing systems of today. It combines the bulk flow-inducing capability of the anchor agitator, the dispersing action of the sawtooth blade, and the homogenizing and powder induction functions of the SLIM-modified rotor/stator assembly. Mixing of rheology additives is made simpler and faster, thereby activating full functionality in the end product.

UNLIMITED ROOM FOR GROWTH

Much as thickeners are already widely used at present, a steadily increasing number of researches are continuously studying these polymers and their unique properties. This, together with advances in mixing technology, suggests that the use and potential of thickeners in general will be even more significant in future.

Ross 100-Gallon VersaMix with SLIM

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