Solving the Challenges of Composites Mixing

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The field of mixing has evolved in many ways over the past several years. Industries from food to automobiles have benefited from the advances in mixing technology. The composites industry is looking for ways to cut costs and increase efficiency while paying attention to the intricacies that separate composites manufacturing from other manufacturing processes. This article looks at composites mixing in general with an emphasis on continuous mixing, focusing on the available processes for the industry.

COMPOSITES MIXING

Any discussion of composites mixing centers around seven basic challenges:

- Combine resins with fillers that provide structural strength (fiberglass, wood, etc.)
- Uniformly coat or "wet" all the filler material for proper adhesion
- Consistently feed long, fluffy fibers (up to _")
- Preserve the physical properties of filler materials
- Produce a consistent product
- Provide ease of handling
- Generate economies of floor space, production labor, and simplicity

The two most common ways of meeting these challenges are batch mixing or continuous mixing.

Batch Mixing

Batch mixing is the traditional mindset when considering mixing processes - two or more ingredients are blended together until the product is uniform in consistency. As a product is mixed, the effects of shear come into play. Shear is the actual process of one material separating into small particles and dispersing throughout another. In batch mixing, shearing may be uneven - some particles are readily dispersed while others are not dispersed until the end of the mixing cycle.

Shearing requires the input of energy to separate and mix the products. Because the shearing times for particles within a mixture are not the same, their temperatures become inconsistent. Therefore, those particles that were sheared early in the mixing cycle have higher temperatures than those sheared at the end of the cycle. The effect of shear and heat on a product and the level of that effect can be gauged by its shear/heat history. The longer a product is mixed in a batch, the more pronounced its shear/heat history will be. Shear/heat history can be detrimental to heat-sensitive ingredients.

What are the potential benefits of batch mixing? Batch mixing can be applied to many different production rates, and is easy to install and implement. The process is often sufficient for small quantities or if a product requires a long reaction time, and clean-up to change to a different product color or type usually requires a simple rinse of the mix tank. However, cost-effective production may require that large quantities be produced in minimal time. Treating large volumes of product within a reasonable time is sometimes difficult in batch mixing, as it takes a long time to turn over the entire volume. Under these circumstances, batch mixing for a single product facility can become a compromise for the manufacturer. Batch mixing can also create some batch-to-batch variation, which can be debilitating to certain industries. Additionally, batch mixing sometimes fails to preserve the physical characteristics of filler materials in the "wetting" process. The longer mix cycles often degrade the size and shape of the particles, forcing companies to either trash the batch or remove the damaged filler materials and replace them. These processes create additional labor and handling costs.

Continuous Mixing

The continuous mixing process consists of a continuous mixer machine fed by dry powder feeders and liquids by the appropriate pumps. The formulation of the ingredients has been predetermined, and the pumps and feeders are set to dispense the required amounts of each ingredient. Calibration and monitoring of metering

equipment is essential for consistent product. Where possible, ingredients have been combined to reduce the number of desired feeders and pumps. Depending upon the equipment selection, the mixing time, mixing intensity, and the sequence of ingredient addition are easily changed to respond to fluctuations in production demand. Once these parameters are established, the process can run nearly unattended but not unmonitored. If additional ingredients are needed, other entry points are available by adding new feed lines. Changing the final product may require significant cleaning of lines, mixers, and feed pumps.

In a continuous mixer, mixing actually becomes a mini-production process. Three basic steps, all accomplished within the mixer, produce the accurately mixed output.

1. **Blending/Homogenization:** In a continuous mixing process, the mixture is homogenized in seconds. Blending occurs so quickly that it is almost insignificant, and the shear/heat history becomes extremely short and uniform. The remainder of the mixing time is used to develop the given temperature and shear that will give the product its unique physical and chemical properties.

2. **Shearing with Temperature Control**: Once the product is homogenized, it passes through a set of paddles for shearing. The configuration of the paddles is specifically designed to obtain the final product's desired characteristics. The paddles can be adjusted in order to perfect the results. As materials pass through the paddles for shearing, its temperature is regulated by multiple temperature controls on the outside surface of the mixer. The rapid heating and cooling significantly reduces processing time.

3. **Extruding/Grinding**: This final step in the continuous mixing process provides the product's final output. Once the product's desired physical attributes are obtained, it can be formed into bars, rods or strands, or it can be ground or pelletized. A contoured extrusion die plate at the discharge end of the mixer can be customized to produce any size or shape required for the final product.

The continuous process assures superior wetting and defibrillation of fibers without breakage. It also reduces alteration of filler materials. This is accomplished by the appropriate arrangement of paddles within the mixer, the machine characteristics, and material entry points and locations. Continuous mixers are appropriate for products with viscosities from 20,000 centipoise to 50 million centipoise.

One of the major problems facing continuous mixing of products for composites manufacturers is the uniform and consistent feeding of long, fluffy fibers, such as carbon, fiberglass, or KevlarTM. This challenge can be easily solved by determining the correct combination of feeders that will achieve a consistent product. Continuous mixing can also be a challenge if the product requires long periods of stagnation to achieve its desired composition.

It should be pointed out that mixing processes can be both mechanical and psychological. The other major challenge of continuous mixing is changing the mindset of the company and overcoming the skepticism of doing things differently.

MIXER SELECTION

In many product development or improvement scenarios, mixing is an afterthought. However, it is very important for manufacturers to consider the effects a mixer can have on their product formula. Testing of mixers is essential to determine the feasibility of production and to uncover the distinctive aspects of the product's properties. Tests might only take one or two days to complete and a mixer supplier can assist by providing facilities and equipment. During the tests, videotaping is often used to document the entire mixing process, but it is important that manufacturers be involved throughout. By participating in the tests they will learn more about their product than they ever did before. They will learn about the variables involved in mixing and develop an important understanding of how those variables affect their product, and since the test is a mini-production line setup, the manufacturer will get a better understanding of the entire process.

THE BOTTOM LINE

Manufacturing processes are not simple anymore, and new methods must be found to keep up with a changing world. To obtain the best product possible, mixing must meet the product's process, not develop it.

Manufacturers can and should find the right combination of mixers and mixing processes that will satisfy the exacting requirements of their products.

Composites manufacturers need a consistent product to bring to their customers in large volume production. Batch mixing may not offer the consistency or the volume needed for most firms. Continuous mixing, however, historically provides a uniform product 24/7, cutting costs and creating a more efficient manufacturing environment for all industries.

Mixing alternatives for the composites industry:

Comparative Factor	Continuous	Batch
Ability to provide structural strength	High	Low
Wetting Capability	Excellent	Moderate
Alteration of filler materials	Very Little	Moderate
Consistent Product Production	Always	Sometimes
Ease of Handling	Excellent	Poor
Floor Space Footprint	Moderate	Large
Ability to accept large, low desity filler materials	High	Moderate
Cost	Moderate	High
Horsepower Requirement	Low	High

CURRENT APPLICATIONS FOR CONTINUOUS MIXING WITH RESINS

Continuous mixing is currently being used by a number of diverse composites manufacturing processes:

- Automotive friction materials: The automotive indus try combines resins with copper and fiberglass fibers to produce brake linings and other abrasive materials.

- Wood composites: Sawdust, wood flour, wood chips or other wood products can be combined with resins to form various composite wood products.

- Fiberglass molded products: Combining resins with up to _" long fiberglass can yield composite roof shingles and other architectural products.

- Plastic additives: The plastics industry uses continuous mixing with resins for a large number of processes, most involving the combination of micro-spheres with resins (and with no sphere breakage).

APPLICATIONS THAT SHOULD CONSIDER CONTINUOUS MIXING

- Aerospace
- Marine
- Powder coating
- Solid surface/countertops
- Fire retardants
- Fiber reinforced calipers and many more

It really suits any industry.

For more information contact Readco Kurimoto at 717-848-2801.