**TECHNOLOGY BRIEF:**

The mixing of thermoplastic materials requires precise temperature control, sufficient shear and efficient agitation. This bulletin outlines some useful considerations for mixer selection.

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**Mixing thermoplastics**

**Thermoplastic materials**

A thermoplastic is a polymer that turns to liquid when heated and hardens when cooled. At very low temperatures, a thermoplastic may freeze to a brittle glass-like state. But when reheated sufficiently, it becomes soft and malleable, eventually returning to a flowable viscous liquid phase. This reversible process differentiates thermoplastic materials from thermosetting plastics which chemically deteriorate when reheated or will simply not re-melt. Thermoplastics are recyclable but thermosets, once they cure, tend to be more durable.

Common thermoplastics include polyethylene (PE), polyurethane (PU), polypropylene (PP), polyester, polycarbonate (PC), polyamide (PA or Nylon), acrylonitrile butadiene styrene (ABS), ethylene-vinyl acetate (EVA) and polyacrylate (acrylic). We find them everywhere, from sports equipment, toys, automobile parts, to drinking bottles, food storage containers and the ubiquitous plastic grocery bags.

**Mixing objectives**

Depending on the end use and application, a thermoplastic may be mixed with other resins, as well as plasticizers, pigments, fibers, fillers and additives to impart the desired properties in the final product. Some thermoplastics are supplied as solid pellets and others are highly viscous fluids at room temperature. They require mixing systems that can rapidly melt or dissolve the solid polymer(s), bring down viscosity through heating and/or thoroughly agitate a viscous batch to produce a homogenous blend.

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Mixer features to consider

Mixer selection is primarily based on operating viscosity and the level of shear required for a particular thermoplastic application. The starting viscosity of the resin(s) and other liquid components, the maximum viscosity reached by the mixture during processing and the final viscosity of the end product are all important considerations. Multi-shaft mixers and planetary-style mixers are commonly used in the processing of thermoplastic materials. Extremely viscous applications are now routinely produced in heavy-duty double planetary mixers in lieu of traditional sigma blade mixers (kneaders).

Since temperature plays a crucial role in establishing viscosity and dissolution rates, the mixer must be properly equipped with a jacketed mix vessel and the appropriate heating system.

While a relatively high temperature is necessary to lower viscosity and produce adequate product turnover within the vessel, extreme heat can damage the thermoplastic or other mixture components. It is usually desirable to integrate temperature control into the main mixer controls. This allows the heater to react to real time batch temperature as opposed to simply maintaining a set temperature based on the heat transfer fluid. Depending on the style of mixer, a thermoprobe can be supplied for measuring temperature from the center of the batch or from the sidewall of the mix vessel.

In a vertical batch mixer, thermal degradation can be further avoided by utilizing scrapers that will constantly remove product from the hottest parts of the mix vessel (i.e. the sidewalls and bottom).

Sample Application: Thermoplastic Modified Epoxy

A Ross VersaMix Multi-Shaft Mixer is being used to dissolve polyethersulfone (PES) into a viscous epoxy resin. The resulting thermoplastic modified epoxy is used in advanced composite systems.

Two different grades of epoxy resin are charged into the vessel and heated to 200°F. PES pellets are then added to the batch and full vacuum is established. The shear produced by the disperser blade and rotor/stator mixer breaks down the pellets into smaller pieces and accelerates dissolution. The final product is a clear amber liquid with no air voids or undissolved PES particulates. The material is discharged by gravity into release liners and allowed to cool.