Melt Filtration Options and Alternatives

Issue: *The quality of clean PET regrind has steadily improved with advances in PET collection programs and intermediate processing. However, the quality requirements for most recycled PET applications are highly demanding. The acceptable level of particulate contaminants for many end-products is less than 100 parts per million (or 0.01% by weight). Particulate impurities can also plug or damage equipment during manufacturing. Today's state-of-the-art separation technology still may not be able to remove these particulate contaminants from recycled PET to these extremely low levels. Melt filtration is one possible option for ensuring contaminant removal and a high quality product.*

Background: Particulate contaminants in recycled PET flake are small, non-melting materials that, in many cases, are incompatible with PET. The most common contaminants are aluminum from caps and foil labels, other metals, dirt, glass, and paper. These contaminants must be reduced below 100 parts per million to avoid the following major problems:

1) Inferior Properties: Particulate material can cause haze, visible defects, and reduced mechanical properties.
2) Plugged Orifices: Particles entrained in melted PET can plug small openings in converting equipment (e.g., nozzles in molding machines).
3) Surface Defects: When these contaminants migrate to the surface, manufactured parts will have surface defects.
4) Inconsistencies: Solid materials can act as nucleators in PET, causing the finished part to have different and inconsistent properties.

Extrusion equipment is used to manufacture many plastic products. An extruder melts, mixes, and conveys the resin through a die plate to produce the desired shape, or conveys the material to melt pumps for further processing. Extrusion allows conversion of recycled PET into pellets, and/or incorporation of recycled PET into end-products such as strapping, fibers, sheet, and film. Engineered PET resins are also extruded when various ingredients are compounded into the resin. PET bottles are not commonly extruded, but are injection molded into preforms and subsequently blown into the desired shape. For injection blown bottles, the recycled PET is melt filtered in a separate step before the blow molding process.

Melt filtration is commonly used to remove particulate contaminants. It generally occurs in extrusion equipment, where melt flow is continuous and pressures are relatively low and constant. Melt filtration is desirable at the reclaimer level when specialized grades of

recycled PET, such as solid stated resin, blends and alloys, or compounds, are produced. Extrusion of recycled PET is required to manufacture these value-added grades.

During extrusion, solid contaminants are mechanically screened out of the recycled PET just before the melt exits the extruder. This screening is usually achieved with a breaker plate and wire mesh screen. A breaker plate consists of a steel plate securing multiple screens (referred to as a screen pack) installed on the plate's upstream face. When the pressure drop across the filter gets too high as a result of contaminants clogging the screen, the screen-pack assembly must be removed and cleaned.

Often, the screen pack consists of several progressively finer screens, starting at 40 mesh (removing particles larger than 0.014 inches) and ending at 200 mesh (removing particles greater than 0.003 inches). Finer filtration screens are used when product clarity is extremely critical, such as for PET overhead transparencies, or when the product is very fine, such as certain polyester fabrics. Supporting screens of a stronger gage wire and wider mesh opening may be positioned last for additional support to the fine screens. Also, different weave arrangements, such as a square weave, or a dutch weave, may be employed to serve specific functions.

There are several configurations available for melt filtration. Manual screen packs are used when the quality of the incoming feed is very high and, therefore, the changeout interval is long. In this case, filtration is used as a finishing step to remove the occasional impurity and protect downstream equipment. The screen is changed on a regular schedule or when the pressure drop becomes excessive. Changeout may be triggered by manual monitoring of the pressure drop, or by an automated pressure sensor system.

Continuous screen changers are used when the level of impurities is high and frequent extruder shutdowns are impractical. Changeout typically is initiated when the pressure drop across the screen exceeds an acceptable level. A fresh screen is automatically substituted for the clogged screen by various mechanisms. Continuous screen changers include double piston, slide gate, belt, and rotary disc units. Each design has various pros and cons, but all function to minimize any disruption in the extrusion operation. The range in cost for melt filtration units is from $2,000-$3,000 for manual types to $35,000 for the top-of-the-line automatic units (1,2).

The decision to melt filter clean PET regrind is relatively straightforward for extrusion-based processes. However, melt filtration involves considerable expense beyond the cost of the filtration unit in cases where a separate extrusion step is required, such as for injection molded preforms or products. Commercial scale extruders cost several hundred thousand dollars, installed, when all the associated material handling, drying, weighing, and finishing equipment is considered.

Best Practices: Options and Alternatives. The decision to melt filter PET flake is dependent on the end use application, budget considerations and whether a higher market value can be received for the filtered product. Therefore, the first Best Practice for reclaimers considering melt filtration is to carefully analyze the market specifications of their customers and determine if, for their customer mix, the investment makes economic sense.

On one hand, all else being equal, clean flake has a higher intrinsic viscosity and better optical properties than pellets and is widely accepted by end-product manufacturers purchasing recycled PET. If, however, the recycled PET is converted to pellets for the end-product manufacture, a primary advantage of melt filtration is that particulate contaminants essentially are removed as the flake is melted and extruded. For flake that is converted to pellets after filtration, improved flow properties for end-product manufacturers and a higher bulk density than clean flake is achieved. These trade-offs must be evaluated for each individual case.

For most reclaimers, it is unlikely that melt filtration will make economic sense. As stated earlier, the majority of end-product manufacturers melt filter recycled PET when they produce the finished product. For example, in blow molding, the recycled PET is melt filtered in a separate step before the injection molding of the preform. Therefore, it is redundant for the reclaimer to melt filter clean flake, as this adds an unnecessary heat history.

If melt filtration is being considered because a recycled PET flake product exceeds contaminant specifications, it is advisable as a first step, to work with suppliers to minimize or eliminate the contaminant source and/or make appropriate improvements in the separation process. If the contamination source(s) can be identified, the supplier must improve the quality of his product to correct the problem. If the source cannot be identified, incoming quality specifications may have to be tightened. Each sorting and separation stage also should be audited to correct operating inefficiencies.

If these steps do not correct the contaminant problem, additional separation equipment (such as an electrostatic precipitator, eddy current unit, or flake sorter) may also improve product quality so that filtration is not necessary. The choice of separation equipment is a function of the types of remaining contaminants and a cost comparison between this and the use of filtration to remove contaminants.

Benefits: If melt filtration is deemed a cost-effective alternative to minimize or eliminate undesired particulate contaminant in recycled PET, the results will ensure a higher quality product, and will avoid equipment damage or clogging during manufacture.

References:

1. Galli, Ed. "Are You Ready for Melt Filtration?", Injection Molding, October 1994.
2. Ling, Fuhua. "Continuous Models Offer Maximum Benefits to High Volume Processors," Modern Plastics Encyclopedia, November 1996.

Contact: For more information, contact CWC at (206) 443-7746 or e-mail at info@cwc.org.

Issue Date / Update: January 1998