Technology Brief

POST-CONSUMER RESIN SCREW DESIGN

Manufacturers utilizing both post-consumer resins (PCRs) and virgin resins often have difficulty producing a homogenous materials mix. The ability to obtain a homogeneous PCR/virgin mix is affected by such PCR materials characteristics as varying melt points, viscosity levels, densities, and form (flake or pellet). An often overlooked remedy to a poor materials mix is to change the screw design of the machine being used in product manufacture.

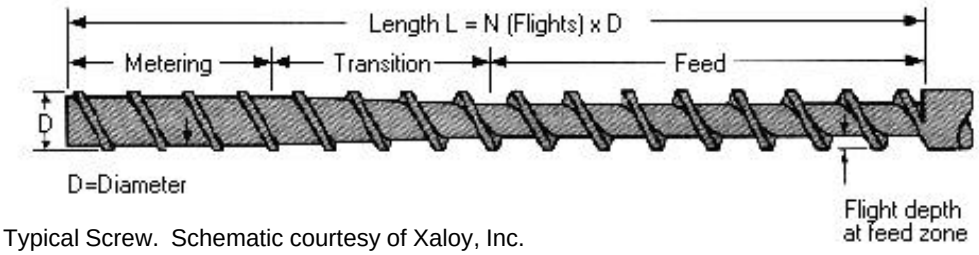
Optimizing the screw design for use with PCR materials enables manufacturers to obtain consistent processing characteristics and contributes to maximizing material properties. This may result in improved output, increased recycled content, or better performance properties.

This technology brief provides background information on plastics processing screws and highlights the important points to consider when evaluating screw design for use with PCR materials.

Key Words	
Materials:	Plastics or Post-Consumer Resins.
Technologies:	Extrusion; injection molding; blow molding.
Applications:	Plastics products.
Market Goals:	Optimize plastics manufacturing with recycled resins.
Abstract:	Design considerations in selecting a screw for plastics processing.

The Plastic Screw

The plastic screw is an essential part of all extrusion, injection and blow molding machines. The screw is a helically flighted shaft that rotates within a cylindrical housing called a barrel. The screw's purpose is to mechanically mix, melt and advance the material being processed into a mold or die (2).



Typical Screw. Schematic courtesy of Xaloy, Inc.

The typical screw is composed of three sections, each designed for a specific purpose. The *feed section* contains deep channels between the flights to begin the process of melting and mixing, and to make sure the material constantly moves forward into the next section. The *transition section* gradually decreases the flight depth to further compact, melt, and mix the material. Finally, the *metering section* further reduces the flight depth to create compression and finalize the melting process. The melted material is then pumped forward, often through a screen, into the mold or die (5).

Preventing Material Degradation

During resin processing, low shear and controlling melt temperature are important factors in preventing degradation of PCR/virgin materials mixes. Because PCRs have already undergone multiple heat histories, preserving melt quality by preventing excessive heating is essential. Poor melt quality can lead to insufficient materials properties and poor surface quality of the final product.

Materials degradation also occurs when maximum shear rates are exceeded within the screw and barrel. Shear rate is defined as "the surface velocity at

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the barrel wall divided by flight depth." All plastics have maximum allowable shear rates. Many PCR materials are heat sensitive and have lower permissible shear rates than do virgin materials. Since flight depth is inversely proportional to shear rate, PCR materials may require deeper screw channels than virgin materials to lower shear rates and prevent degradation. Deeper screw channels also have the added benefit of allowing a larger volume of material to be processed and a greater output (2).

However, deeper flight depths increase the probability of poor circulation of material within the screw. If PCR materials are to be used in combination with virgin materials, processors should select a PCR material with shear rates closely resembling virgin resins. Processors should also select a flight depth to optimize mixing ability and output.

Better Mixing

There are many mixing devices that can be used to ensure material homogeneity. Generally employed at the discharge end of the screw, these devices seek to achieve the desired quality of the materials mix while minimizing the rise in melt temperature. Common mixing device designs include parallel interrupted mixing flights, pins protruding from the root, helical grooved channels, and fluted constructions (1, 2).

Some plastics reclaimers use extruders with two screw diameters to reduce the need for pre-processing. A larger screw with deep channels serves to densify the material. The smaller screw melts, mixes and conveys the material. The screws can be combined into one long shaft to function as a single unit (3).

Ogando cites a number of approaches to obtain low temperature, low shear mixing in blown film applications. The first involves the use of extruders in the 30:1 length/diameter (L/D) range. Average L/D for blown film extruders is 25:1. The longer-than-average extruders blend materials better than shorter extruders, and have the flexibility to process more types of material. The second method emphasizes the use of shorter extruders, 20:1 L/D, in order to decrease the residence time (and potential degradation) of the material (4).

Barrier screws provide another method to obtain optimal mixing. Barrier screws are designed to accommodate blends of multiple materials. In the proper application, barrier screws serve to minimize melt temperature, improve output rate, maximize output stability and maintain acceptable melt quality levels.

Contaminant Control

Screw design also plays an important role in removing unwanted vapors during material processing. PCR materials may possess high moisture levels or contain contaminated materials that release volatiles. Excessive moisture levels can cause splay leading to poor surface finish. Volatiles may complicate processing and create voids that lower product performance. To remove moisture and volatile elements from the melt, processors may employ two-stage screws in vented-barrel extrusion or molding equipment. These screws have a barrel with an opening to the atmosphere or a vacuum source that can remove moisture, air, and/or other volatiles (1,2).

PCR materials may contain contaminants such as metals or pebbles that can wear and even break screws in extreme conditions. Screws can be coated with harder wear-resistant alloys, such as Colmonoy 83, in order to provide additional protection (3).

Conclusions

In situations where potentially dissimilar materials such as PCR and virgin resins are blended, selecting the correct screw design is an important step in optimizing materials processing and maximizing materials properties. Any company purchasing new equipment, or established processors, that intend to use PCR materials should benefit from a screw design evaluation.

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For More Information

For a copy of the report, *Post-Consumer Resin Screw Design (PL-95-1)*,use the CWC Publication Order Form. For more information call CWC at (206) 443-7746, email info@cwc.org, or visit the CWC Internet Website at www.cwc.org.

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