Polycarbonate Extrusion

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Successful extrusion of polycarbonate into sheet, tube or profile requires equipment reasonably approximating the some what narrow limits of conditions under which polycarbonate can be successfully processed. The following sections give the most important requirements for screw dimensions, drying, and the polishing stack.

A. Screw Dimensions Polycarbonate is best extruded with a dual transition metering screw. An ex ample of a screw for a two-inch machine which might be used for profiles would have a metering section depth of 0.150" and a feed section depth of about 0.600". A screw for a 20:1 extruder should have a feed Section of about 5 to 8 diameters long, a transition section at least five diameters or more, and a metering section would make up the balance, but should be at least four diameters long. On a 24:1 machine, equal division of the length of the screw into feed transition, and metering sections has been very satisfactory.

For larger diameter extruders, the feed/meter depth ratio should be lower than on small machines. For example, on an extruder with an L/D of 24:1, optimum dimensions are about 0.250" for the metering depth, and 0.750" for the feed depth. Again, 8 diameters each of feed, transition, and metering sections is good. Compression ratios as low as 2:1 can be used, especially at screw speeds under 50 rpm.

Vented extruders should have the first section (from the feed throat up to the vent) designed about as one would use on a non-vented machine. The depth in the area of the vent should be at least 1.5 times the depth of the feed section. In addition, from the vent toward the die, there should again be a gradual transition back up to a second stage metering section of at least four diameters which has a depth at least 1.4 times the depth of the first metering section. Vented extruders provide the ultimate in a quality melt for any production, but learning to operate a vented barrel routinely on polycarbonate requires a major effort to develop start-up procedures, temperature profiles, and speed which will avoid vent flow while producing the output which is needed to turn a profit.

B. Drying The plastics literature is replete with articles on drying, yet this aspect of processing polycarbonate remains a major contributor to extrusion problems. If a run on polycarbonate is contemplated, your dryer should have a dew point of 10°F. or lower. A frequent malfunction of the typical dual desiccant bed dryer is failure of the regeneration heaters or switching system so that the molecular sieves commonly used do not get regenerated. Also, one should check the condition of the molecular sieves since they do deteriorate with time. The sieves, which are ceramic beads about 1/8" in diameter, are easy to replace, and should be replaced at least every three years in continuously operating equipment.

One key characteristic of polycarbonate is its need to be dried prior to processing. The typical pellet does not get adequately dry in a short time. As a rule of thumb, the dryer plenum should hold a minimum of four hours running time. That is, if you are trying to make polycarbonate tubes at 150 pounds per hour, the dryer should hold at least 600 pounds, and a 1,000 pound dryer system would not be too large. Once extruded in the wet state, the material is irreparably damaged, and can not be recovered, so it is very important to avoid drying problems. Signs of drying problems include small bubbles and streaks in the extrudate. If the product is sheet, these bubbles and streaks will migrate to the edges of the web.

Incidentally, if bubbles appear uniformly distributed in the web, and you are drying the material correctly, there is probably air entrapped in the material. Check the material feed pellets to see if they are hollow. In a non-vented extruder, hollow pellets can limit the speed to very slow rates in an effort to avoid air entrapment.

C. The Polishing Stack Polycarbonate has been successfully extruded into sheet using the conventional three roll polishing stack. However, the temperature requirements of the center roll are high: about 265 to 275°F for the circulating water in the roll. Such a temperature requires that the circulating loop be pressurized to about 100 PSIG to avoid cavitation in the circulating pump. Such conditions demand high quality rotating seals.

The melt strength of polycarbonate is not exceptionally high. For this reason, it is most desirable to have the lips of the die very close to the point of the nip. Extended die lips are required if melt temperatures are to be high enough to at tempt to extrude optical grade sheet, and the distance from the end of the lip to the point of the nip should be no more than five or six inches. The top roll of the stack is usually held down against stops to form the desired sheet thickness. The rolls must be mechanically heavy duty to avoid bending under the loads imposed by the material. In addition, the air cylinders or other means used to hold down the top roll must exert a force equal to about 300 pounds per inch of web width. That is, if the web is 52" wide (to make 48" wide sheet), then the hold down force must be about 15,600 pounds. This would require 10" diameter cylinders with an air supply of about 100 PSIG minimum. Two cylinders are usually used, one on each end of the roll.

The water temperature in the top roll should be about 265°F, and that in the bottom roll as high as 310°F. The top roll controls the nip and the bead of material behind it, and the bottom roll serves to flatten the sheet. The bottom roll should float on the web, and not be up tight against the middle roll.

End effects on cooling rolls are a problem unless the rolls are several inches longer than the width of the web being extruded. For example, in trying to make 48" wide sheet, a web with of perhaps 52" would be extruded, and the length of the rolls should be at least 60" for such a web if end effects on the rolls are to be avoided.

In summary, polycarbonate extrusion requires careful attention to the details of each component of the extrusion line if the run is to be successful. However, the application of good technique will be re warded with a good product. Other articles previously published describe further the correct methods to be used with polycarbonate, and technical assistance is available either from the resin suppliers, or from independent consultants.

- William E. Foster, Mitchell Plastics, Inc.

See also:

- Polymer drying
- Sheet/film coextrusion grows
- Some considerations in drying

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