Feed screw temperature control (S.T.C.) in the single screw extruder

This adjustment of the extrusion process is one of the least understood and most misused of any temperature control. S.T.C., like die temperature, is often misapplied.

The reason for using screw temperature control is to maintain a particular flow characteristic of plastic along the screw surface. If either the screw design or the plastic is changed, the S.T.C. should probably be changed or eliminated. Most extrusion operations do not require it. To eliminate the S.T.C. the rotary union should be removed and the screw drained.

The S.T.C. will have different effects on the extruder operation depending on where the control takes place and whether heat is added or removed from the screw. Large quantities of heat transfer will have a much stronger effect than small quantities. Temperature changes should be made gradually. The time required to stabilize will be longer than for barrel temperature changes.

Let’s look at a single stage metering screw and use it as an example for discussing the S.T.C. results. It will have a deep feed section, a tapered transition section and a shallow metering section.

Starting at the discharge end of the screw we have the metering section. This is the shallowest part of the screw. The plastic in this section is generally melted and at a relatively high temperature. If the screw is cooled here the melt passing along the screw surface will be cooled. Its viscosity will increase and its passage will slow. Since plastic is not a good conductor of heat, only a thin layer of plastic will be cooled. However, in a shallow metering section this highly viscous layer is thick enough to reduce the effective depth of the screw flight. The shallower flight will reduce the output rate per revolution of the screw and increase the work on the plastic. When a screw is cooled through the metering section, the rate is reduced and the temperature of the plastic is increased. You get more intensive mixing but you suffer in rate and temperature.

Screw tip cooling, sometimes used with rigid PVC, maintains the screw tip at a temperature slightly below the melt temperature. This prevents plate out and burning on the tip. It is very useful when a blunt nose is on the screw.

The action of the feed section of the screw will be greatly affected by the screw surface temperature. In this area the plastic will be solid powder, pellets, or flakes. It will stick to hot surfaces and slide on cool surfaces so it is important to keep the barrel hotter than the screw. If the barrel is too hot a low viscosity film will form and the plastic will slip on this film. It is sometime necessary to cool the screw in the feed area to maintain the barrel-screw relationship. Many of us have seen powdered plastic and additives adhering to a hot screw. One way of preventing this is to block the screw downstream of the problem spot and cool that section of the screw.

A problem encountered in the transition section is the infamous melt block. One explanation of this is that a small amount of plastic melts and leaks over the top of the flight at a location where the solid feed has not generated enough pressure to wipe the melt off the trailing edge of the screw flight. The melt cools and builds up until it blocks the flight and interferes with forwarding. In effect, the plastic is melting too early in the extruder. If the screw is cooled from the feed section into the problem area of the transition section (no further) it will cool off the melt film and prevent it from leaking over the flight. The melt will stay on the pushing side of the flight where pressure is exerted. In addition, the cooling in the feed section will result in more pressure generation as described in the paragraph above. This combined action along with reducing the zone one barrel temperatures invariably prevents melt block.

This article goes into some detail on a few examples of S.T.C. The problem that you face may be considerably different. If you analyze S.T.C. by examining the effect at the screw surface, remembering that plastic is a pretty good insulator, you will probably be able to derive a correct solution.

- William S. McCormick

See also:

- Heat transfer in extruders - an introduction
- Melt block problems
- On/off barrel cooling control
- Single screw feeding
- Temperature control

Return to Consultants' Corner