Notes on Polyethylene Extruder Surging

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The polyethylene range of materials are usually quite resistant to extrusion rate surging. The materials normally feed very well.

Principal factors that can cause rate surging are additives, material melting point and coefficient of friction, screw design and operating practices.

Screw Design
Polyethylene screws with L/D ratios of 24:1 to 32:1 are usually designed with feed sections of 5 to 7 turns in length, transition sections of 3 to 10 turns and the remainder of the length in meter and mix sections. The taper of the transition section should be matched to the melting rate of the polymer. Hard low coefficient of friction materials such as HDPE usually require a long transition to avoid jamming of the pellets at the end of the transition section.

Jamming at any point along the screw can cause sections down stream toward the die to alternately fill and empty to create output surging. Jamming at the end of the transition section can starve the meter section.

Melt plugs at the end of the feed section and the beginning of the transition section can stare the forward sections of the screw.

If the screw design is not too mismatched with the polymer, operating conditions can be adjusted to work around the problem with some success.

Specific screw designs are required for each area of application such as blown film, cast film, or extrusion coating, etc.

Operating Conditions
In the case of a melt plug, it is important to prevent the condition. Melt plugs can form from allowing the rear sections of the extruder to run too hot. Hopper section, screw cooling in the screw feed section, and first zone temperatures can all be used to keep the rear section feeding.

In higher temperature operations such as cast film or extrusion coating, prolonged periods of drooling at low rpm can allow heat to transfer from the front of the screw to the rear causing polymer in the feed section or start of the transition section to melt prematurely and adhere to the screw root section forming a plug. Chunks of extrudate dropped in the hopper will sometimes clear the blockage. Often the screw must be pulled and cleared.

Low level rate surging can be monitored by immersion melt thermocouples and pressure traces. The best information is obtained from sensors inserted into the melt stream downstream from the breakerplate toward the die. This avoids pulsations from screw flights passing the sensor probes.

Rate surging can be detected and measured by measurement of machine direction, part thickness variation or consecutive part weight measurements.

Frequently low level rate surging can be minimized with a preferred temperature profile on the extruder barrel and pressure of operation. Each screw design and material combination will have an optimum barrel setting profile for best operation. Barrier screws often respond to a reversed temperature profile with 1.0 melt index LLDPE film resins. Where the first zone is kept relatively low, the second zone is set at the highest temperature and slopes down toward the front zones next to the die. Alternatively, ULDPE resins which have high coefficients of friction and seem to melt early in the screw respond to a low temperature profile which is relatively flat from the back of the extruder to the front.

Additives
Rate surging can be caused by the lubricity of additives such as slip or tackifier. High levels of slip can cause the for

warding polymer to slip on the barrel wall rather than adhering. Rates may simply be reduced to lower levels or as the offending additive is increased in concentration alternate starving and forwarding can cause major fluctuations in output. Again, cooling is a first line of action. Test variations in the temperature profile in increments of in crease or decrease may need to be achieve a suitable profile.

The addition of polybutene tackifiers to stretch cling films will affect rate to varying levels depending on the molecular weight of the polybutene, where it is added to the extruder, and the level of addition. Addition by dripping into the hopper section can reduce rate by as much as 50%. Four percent is a common level of addition at the hopper. When injecting the tackifier through the screw or the barrel much higher levels have been achieved depending on the polymer of choice, the screw design, and the injection point along the screw.

Regrind
The addition of regrind with a low bulk density can cause rate surging compared with 100% virgin feed. Increasing concentrations of regrind normally increase rate variation. Deeper feed sections may be needed to balance feed section forwarding with the subsequent screw sections. The presence of large amounts of fines and fluff generated in bulk handling systems can cause similar raze variations.

Pellet Size
Pellet size is an often discussed issue in extrusion rate stability. This often needs to be treated on a case by case basis. The more or less standard industry one eight inch pellet works very well for a wide range of extruders. At the extremisms small extruders may run best on smaller pellets and large six and eight inch extruders may per form better with somewhat larger pellets. Some skepticism should be exercised until a definite cause and effect relationship with pellet size and geometry is defined.

Powders may melt earlier than pellets and may need to have a lower temperature profile than a pelletized form of the same product for optimum feed rate.

—Earl Veazey

See also:

- Causes of extruder surging
- Correcting flow instability in coextrusion
- Extruder surging
- Extrusion evaluation through pressure and melt temperature analysis
- HDPE LDPE properties
- Linear low density polyethlyene

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