

Extrusion Troubleshooting

How Temperature Affects Surging

Good quality product requires stable output from extruders. This can be a demanding challenge when formulations are changed frequently or when there are few working instruments. We often use formulations that are very different from those for which the screw was originally designed. In many cases, a narrower operating window results. Causes for surging (unstable output) fall into 3 categories: raw material; equipment malfunctions and operating conditions. This article will focus on adjustments to operating conditions. A typical single screw extruder can exhibit the following types of surging: Feeding, Melting Rate and Melt Conveying. Operator skill is the key to stabilizing the process when surging occurs.

1) Surging in the Feed Zone

a) Raw Material

The most pragmatic approach is to eliminate the simple causes first. Formulations that have a wide range of particle size or density, such as chopped regrind, fluff or fines are common sources of problems. The screw flights push the material towards the transition (melting) zone as the screw rotates. Material must *stick to the barrel and not the screw*. Additives that reduce the coefficient of friction on the barrel surface such as slip, polybutylene (stretch film tackifier), and lubricants will reduce output capacity and may cause instability. Reducing or eliminating these material is a quick and easy solution.

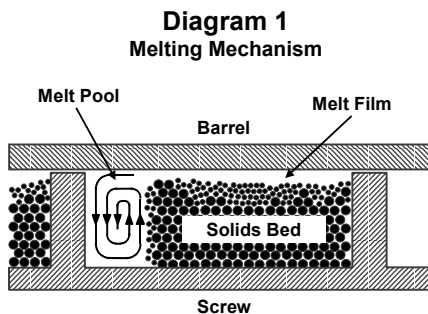
b) Equipment Malfunctions

The most common types of equipment problems are unstable drives, worn gears or bearings, bent or worn screws and barrels, and poorly tuned or defective heaters. Most of these problems can be detected with simple tests.

c) Operating Conditions

Operators will try to “make it work” without changing formulations or repairing equipment. The key controls available to them are temperature profiles and production rate. **Setting the feed zone too hot causes the vast majority of feeding related surging.** Premature melting causes material to stick to the screw until pressure from fresh raw material suddenly moves the “Melt Plug” toward the Transition zone.

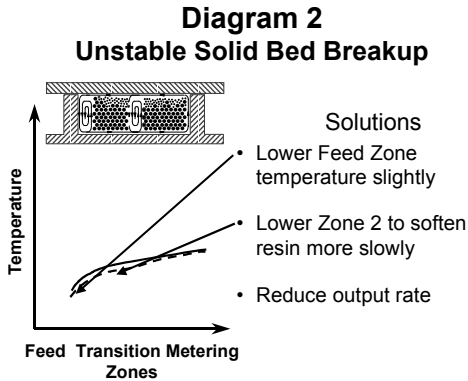
2) Melting Rate Surging in the Transition Zone



Lets assume the barrel temperature control systems are operating correctly. The screw designer makes certain assumptions concerning the particle size, density and energy required to melt the resin.

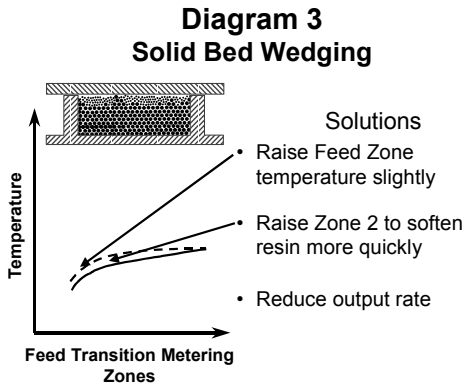
Problems occur when melting too quickly or too slowly, particularly in barrier screws. Correct melting inside screw flights in the Transition zone is shown in Diagram 1.

a) Unstable Solid Bed Breakup (melting too quickly)



Most melting takes where the Solid Bed rubs against the Barrel Wall (see Diagram 1). The Solids Bed will break up too soon if melting takes place too quickly. Less friction results in a reduced melting rate further along the screw. The simplest solution is to lower the temperature in Zones 1 and 2. If this does not work, slow down the screw speed to reduce frictional heating in Zone 2 (see Diagram 2).

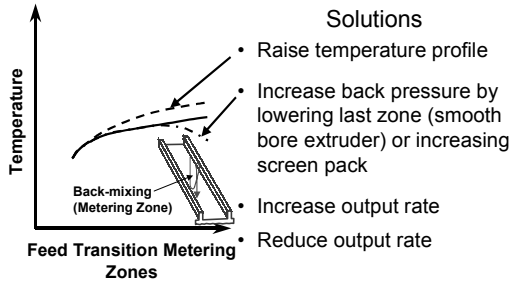
b) Solid Bed Wedging (melting too slowly)



Melting too slowly will plug the screw flight with solid material. Frictional overheating at the end of the Transition zone is a common symptom. Barrier screws are more sensitive to this problem because there are separate channels for the melted (Melt Pool) and unmelted (Solids Bed) material. Raise the temperatures in Zone 1 and 2. Raise the temperature in the Metering zone if the melt is still too cold. If this does not work, reduce screw speed to allow the resin more time to heat up before entering the Transition Zone (see Diagram 3).

3) Melt Conveying Surging in the Metering Zone

Diagram 4
Melt Conveying Surging in Metering Zone



The most common causes are Back (Head) Pressure that is too low or not enough mixing. When the Back (Head) Pressure is too low, there is not enough back-mixing to blend melt temperature non-uniformities. Symptoms include wide variation in profile caliper or film gauge, poor dispersion of pigments, gels and cyclical swings in overall dimensions.

Raise the temperature profile from Zone 2 onward to improve mixing. Lower the last temperature zone to extract heat and make the melt more viscous. Add finer mesh screens to increase Back (Head) Pressure. Increase screw speed to cause more frictional heating and increase Back (Head) Pressure. Reduce the screw speed if the melt becomes too hot. This will increase residence time and improve mixing (see Diagram 4).

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