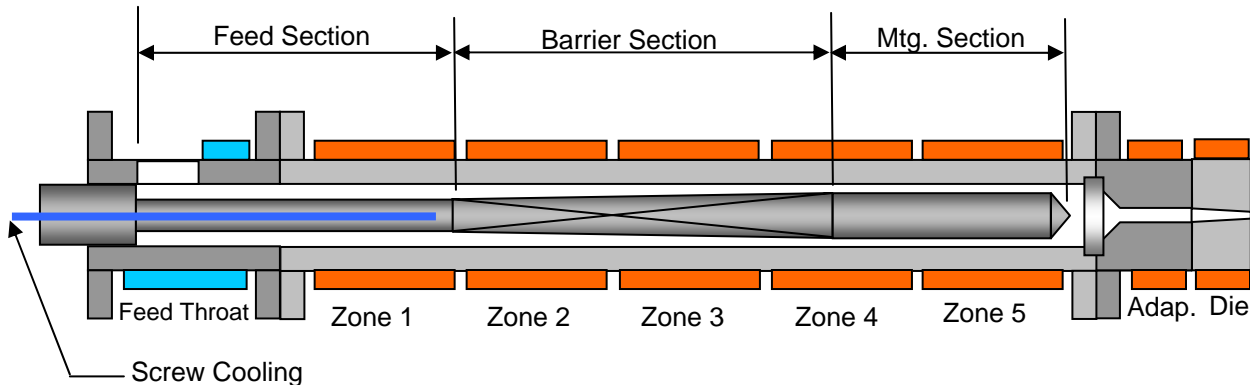


Barrel Temperature Profiles for Barrier Type Screw

(the “hump back” temperature profile)

By
Timothy W. Womer



<u>Resin Type</u>	<u>Melt Index</u>	<u>Density</u>	<u>Melt Temp Target - °F</u>
Z-N LLDPE	1.0	0.918	400 to 430
EXCEED® mLLDPE	1.0	0.918	390 to 420
EXACT® Plastomer	1.2	<0.910	370 to 390

Introduction

More often than not, extrusion operators do not critique the barrel zone temperatures to the resin when being processed when using a barrier type extrusion screw. Typically, it is not uncommon to see the extruder barrel zones set at temperatures lower than the desired melt temperature. When this type of operating condition is used, the control of the extrudate temperature is totally dependent to the screw geometry and the viscous heat it develops from the shear rates that are generated by the channel depths, flight clearances and screw speed.

By studying the heater zone layout and how they are located in reference to the different sections of the screw this will help determine the proper zone setting. This paper will first give the reasoning of the process, based on the general configuration shown above, then suggested zone settings for the resin listed above will be recommended.

Starting with the Die

Based on the resin manufacturers recommended melt temperature for the resin being processed, the die zones and adapter should be set at this recommended temperature.

Feed Throat Section

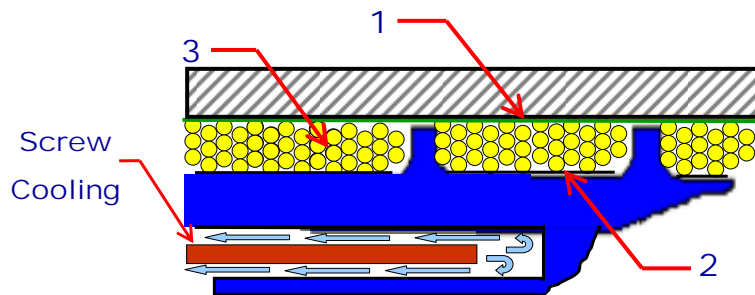
The feed throat section should be set to a temperature where it is “warm to the touch”, which is somewhere between 110°F and 120°F. This is warm enough to help pre-heat the material as it enters the extruder, yet cool enough to prevent bridging in the feed throat of the extruder.

A good means of monitoring the feed throat temperature is to install an immersion thermometer in the return line of the feed throat cooling water. By installing a Tee fitting in the line, the immersion thermometer can be fitted; and by placing a globe valve after the thermometer, the water chamber of the feed throat can be kept full and eliminate cavitation of the system.

Screw Cooling

There are basically three Coefficients of Friction that take place in the feed section of the screw, (1) between the barrel and the pellet, (2) between pellet to pellet, and (3) between the root of the screw and the plastic pellet.

Coefficient of Friction (in the feed section of the screw)



1. Pellet to the barrel wall
2. Pellet to the root of the screw
3. Pellet to Pellet

5

Screw cooling on the feed section core of the screw should always be installed. In most cases, screw cooling will be a benefit to the process. It will give the operator another “zone” of control of the extruder. The main theory of “solids conveying” is that the resin must “stick to the barrel” and “slip on the screw”. By cooling the root of the screw it will reduce the Coefficient of Friction between the steel of the screw and the plastic pellet.

Feed Section (Zone 1)

By cooling the root of the screw and the feed throat section, now Zone 1 can be set to a temperature that will maximize the coefficient of friction at the barrel wall, there in turn maximizing the solids conveying of the resin. For most polyolefin resins, Zone 1 should be set between 300°F and 400°F. The higher the final recommended melt temperature the higher Zone 1 can be set. Therefore, this zone needs to be set as high as possible as long as it does not cause bridging in the feed throat section. As long as sufficient cooling is used in the feed throat casing, higher temperatures can be used.

Metering Section (Zone 5)

This zone should be set approximately 10°F to 25°F below the recommended melt temperature that the resin supplier suggests or as mentioned earlier 10°F to 25°F below the adapter and die zone settings.

Zone 2

This zone should be set between 125°F and 175°F higher than Zone 1. This elevated zone temperature will not cause a higher melt temperature because the resin is still in a pellet form at this point in the screw geometry. The phenomenon that will happen by using the increased temperature in this zone is that it will put more energy into the resin and in turn help in the melting process of the polymer.

To melt plastic it requires energy. The energy can be induced into the resin either via mechanical energy from the extruder drive or via electrical energy via the heaters. One of the values in calculating the power needed to melt plastic is referred to as the “Specific Heat” of the plastic. Specific Heat has SI units of “BTU/lb/°F. BTU (British Thermal Units) is a form of energy which can be expressed as horsepower, joules, watts, etc. So, typically, by inducing large amounts of heat via the barrel zones in the rear of the extruder, the drive load or amperage will be reduced.

The remaining zones (Zones 3 & 4)

The remaining zones, which in this example there are two zones, should be evenly split between Zone 2 and Zone 5. For example, if there is 60°F difference between Zone 2 and Zone 5, then Zone 3 will be set 20°F below Zone 2 and Zone 4 will be set 20°F below Zone 3.

Examples of resins listed

The following are starting barrel, adapter and die zones settings for the resins which were listed at the beginning of the paper. With the return water on the screw cooling and feed throat housing set between 100°F and 120°F, the remaining zones should be set as follow:

<u>Resin Type</u>	<u>Tm</u>	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>	<u>Zone 4</u>	<u>Zone 5</u>	<u>Adap.</u>	<u>Die</u>
Z-N LLDPE	415	350	465	445	425	405	415	415
EXCEED® mLLDPE	405	325	450	430	410	390	405	405
EXACT® Plastomer	380	300	415	400	385	370	380	380

Conclusion

The temperature settings suggested in this paper are starting point settings which will best process the resins mentioned here. These barrel zones are specifically recommended for barrier type screws and will condition the resin in a less stressful manner and help reduce screw and barrel wear due to forcing too cold resin into the barrier section of the screw.