LyondellBasell Technical Tip

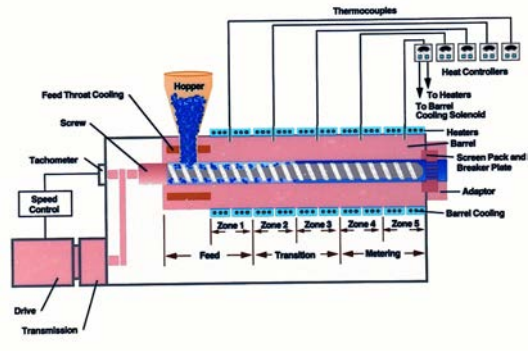
tech.topic

The Extruder

Blow molding lightweight polyethylene milk bottles call for an understanding of every element of the process, starting with the extruder where the resin is melted or plasticized.

Function of the Extruder

The basic components of the extruder are shown in Figure 1. High density polyethylene (HDPE) pellets are fed into the feed throat from the hopper by gravity. As the unmelted resin exits the feed throat, it comes into contact with a rotating screw driven at a desired speed by an electric or hydraulic motor through a gearbox. The extruder screw is contained in a barrel maintained at a hotter temperature than the screw. Since HDPE tends to stick to hotter surfaces, the unmelted resin sticks to the barrel and slides on the screw. This action pushes the polyethylene forward by the flights of the rotating screw. As the polyethylene moves forward, it is heated by the barrel along with the frictional heat generated by the compounding and compression action of the screw. By the time the resin leaves the screw barrel, it has been melted, compressed and mixed into a homogenous melt.



In some cases a screen pack and breaker plate are positioned at the end of the barrel to filter out foreign contaminants that may have entered the hopper. The screen pack also increases backpressure in the barrel, contributing to a homogenous melt and steady flow. The breaker plate holds the screens, gives them support and contributes to the backpressure.

There are basically two types of extruders – the continuous type and the reciprocating type. The continuous extruder delivers a constant flow of resin as the screw turns, while the reciprocating screw moves not only in a circular motion, but also horizontally within the barrel. As the screw turns, it fills the barrel with polyethylene, thus pushing the screw backwards. When the backward motion of the screw reaches a predetermined distance, a hydraulic cylinder is actuated pushing the screw forward. This forward motion delivers a flow material and the process is started over once again.

The Screw

The most important part of the extruder is its screw. The screw is divided into three sections — feed, transition and metering — with the flow of the resin as follows:

Feed Section: a resin enters the deep channels of the rotating screw and is fed forward to the hotter barrel zones.

Transition Section: resin enters this section at the point where the screw channel depth starts to decrease. The primary function of the transition section is to compress and melt the resin. Any air carried along into this section is forced back to the feed section. Resin should be molten by the time it leaves the transition section.

Metering Section: the channel depth of this screw section is shallow and constant, permitting the melt to be homogenized and metered or pumped out the end at the constant rate with a minimum of surging.

Standard, single-stage, metering polyethylene screws generally have the following features:

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1. A length of 20-to-30 times the diameter of the screw (L/D 20-30:1)
2. A ratio of 3-4:1 for the depth or volume of the flights in the feed section to the depth or volume of the flights in the metering section (compression ratio).
3. A constant distance between flights (pitch) equal to the diameter (square pitch)
4. A mixing device at the end of the metering section to promote homogeneity.

The Barrel

The extruder barrel is also divided into sections identified as feed, transition and metering (see Figure 1). The feed section contains a hopper-cooling jacket designed to prevent premature melting of the polyethylene pellets. After the feed throat, all sections of the barrel are wrapped with a bank of heater bands. There may be several zones of heater bands to each section of the barrel. The temperature of each zone is controlled by a proportioning heat controller and sensed by a thermocouple inserted into the barrel wall. The barrel also incorporates a hardened liner or sleeve to increase wear life.

The barrel heaters are generally of two types — band or cast. While the band type is used for heating only, the cast type has channels to accommodate a flow of a cooling medium, and thus it can be used for both heating and cooling. The cooling medium can be water or preferably oil that can be tempered to prevent thermal shock to the barrel.

A general heat profile for an extruder running high-density polyethylene is as follows:

Zone 1 = 325°F
Zone 2 = 325°F
Zone 3 = 350°F
Zone 4 = 375°F
Zone 5 = 375°F

Actual temperature profiles may vary, depending on grade of resin used, extruder screw design (high output), extruder output, overall cycle, etc.

Screw and Barrel Wear

It is often difficult to determine when to replace or repair a worn screw and/or barrel. The most obvious method to determine wear is to physically measure the screw and barrel, but this may be impractical due to the necessity of shutting down production. However, there are several areas that can be monitored and these are listed. Any of these conditions could indicate a wear problem assuming other process conditions remain the same.

1. Decreasing extruder output
2. Increasing cycle times
3. Increasing heat profiles
4. Increasing screw speeds
5. Varying shot size
6. Deterioration of melt properties, i.e. lack of color dispersion, degradation, physical and cosmetic defects, etc.

Probably the most reliable indicator of wear is extruder output. If the output is considerably less than previously recorded data or published information, this usually indicates a feeding problem or worn screw and/or barrel. A feeding problem can on occasion be corrected by changes in the barrel temperature profile. If this cannot be accomplished, a check of the screw and barrel is necessary.

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The Extruder *(continued)*

The following are some of the major causes affecting screw and barrel wear:

1. Screw, barrel and drive alignment
2. Straightness of the screw and barrel
3. The material being processed (i.e. abrasive filters, reinforcing agents, pigments, contamination, etc.)
4. Screw and barrel material
5. Improper barrel support

Extruder-Related Problems

Blow molding product and processing problems can be directly related to the extrusion process. Some of the most common problems and their causes are listed in the table below.

PROBLEM	CAUSE
Surging (varying shot weights)	Insufficient Back Pressure Partially Bridged or Collared Screw Variable Screw Speed Hot Feed Section Variable Regrind/Virgin Mix
Bubbles	Wet Material Cold Feed Throat Hot Feed Section Insufficient Back Pressure
Cold Spots	Insufficient Back Pressure Low Extruder Temperatures Mixture of Dissimilar Materials
Overriding Temperatures	Malfunctioning Temperature Controller Insufficient Cooling to Zone Excessive Frictional Heat Build-Up

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