



Extrusion Blow Molding of *Alcryn*®

Alcryn® melt processible rubber can be processed on a range of extrusion blow molding machines to produce a variety of hollow rubber goods at low unit cost. Due to the unique rheology of *Alcryn*®, blow-molded parts can be formed and demolded in very short cycles. Typical processing conditions for successful blow molding of *Alcryn*® are described in this guide. Parts made from *Alcryn*® look, feel and perform like thermoset rubber and provide outstanding oil, heat, and weather resistance.

Safety and Handling Precautions

All safety practices normally followed in the handling and processing of melted thermoplastics should be followed for *Alcryn*® melt-processible rubber. The material is not hazardous under normal shipping and storage conditions.

Alcryn® melt-processible rubber is supplied as pellets. Like other pelletized products, *Alcryn*® may accumulate a static charge during shipping, unloading, conveying or pouring from the bag. To avoid an explosion or fire hazard associated with a static electric discharge, adequate grounding of equipment is advised. Warehouse storage areas used for *Alcryn*® should carry appropriate warnings: In case of fire, hydrogen chloride (TLV 5 ppm) will be evolved. Protection from hydrogen chloride fumes should be provided.

For further information, refer to the *Alcryn*® Toxicity Guide.

Material Handling

Alcryn® is supplied in pellet form and is packaged in 55 lb (25 kg) multiwall bags. In most cases, *Alcryn*® may be used directly without drying. If porosity in the finished part is observed, the resin may be dried for 1 to 2 hours at 150 to 180°F (65 to 82°C).

For rubber equipment requiring strip feed, pellets can be fluxed in standard internal mixers of mills capable of 300 to 325°F (140 to 163°C) roll temperatures.

Clean dry scrap from any processing operation can be recycled several times with little change in either processing characteristics or the properties of fabricated products, provided that the scrap resin has been processed within suggested limits. Scrap can be granulated for hopper-fed equipment or recycled through the internal mixer or hot mill for strip feed operations. Dry extruded scrap also can be reused directly as strip feed. Although scrap can be recycled as 100% of the equipment feed, blending with virgin material is advisable to ensure consistent processing and finished product performance.

Polymer Rheology

The rheology of *Alcryn*[®] is advantageous in blow molding. *Alcryn*[®] does not have a crystalline melting point, but it softens enough at temperatures above 300°F (149°C) so that it will flow under shear. The pellets are readily fluxed, or plasticated into a uniform low-viscosity melt in the extruder, and the melt flows well through the die to form the parison. When shear stops on the parison is blown, the part begins to stiffen or "freeze", even though its temperature remains at 320-330°F (160-166°C). The high melt viscosity of *Alcryn*[®] permits practical blow ratios. The part quickly develops enough strength so that it can be demolded hot, without distortion, resulting in very short molding cycles.

The Extrusion Blow Molding Process

Blow molding enables the production of hollow parts of complex design and variable internal configuration from thermoplastic resins. The process involves forming a hot tube of molten or softened resin called a parison, and clamping it inside a cooled mold. As the mold closes, the parison is inflated with compressed air until it conforms to the mold cavity configurations. Thus, convolutions, texturing, and other fine details can be produced in the part. The finished part is ejected from the mold when it has developed enough strength (by cooling) to be removed without distortion.

Blow-molded parts are prepared commercially by three processes:

- Continuous extrusion blow molding
- Intermittent extrusion blow molding
- Injection blow molding

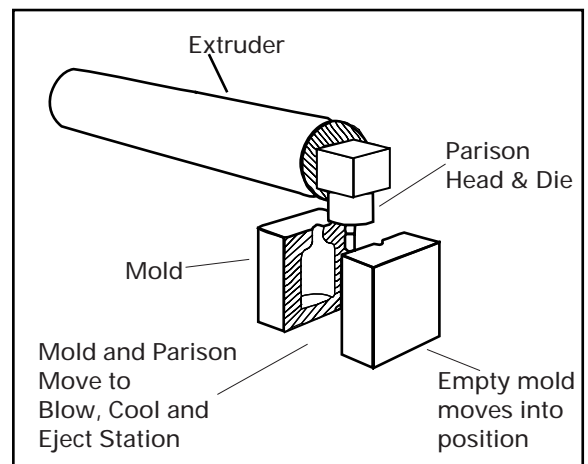
This guide covers only extrusion blow molding

Continuous Extrusion Blow Molding

In this process (Figure 1), the melt is continually fluxed (plasticated) and extruded vertically downward through the parison die. The parison is formed, the mold closes and moves automatically to another station where the parison is blown and the finished piece is cooled and ejected. Meanwhile, an empty mold moves into position beneath the parison die head, a new parison is extruded, and the cycle is repeated.

Continuous extrusion blow molding yields high production rates and is suitable for heavy weight parts. It is the preferred process for blow molding *Alcryn*[®], because there is little opportunity for the melt to hold up in the machine and degrade.

Figure 1. Continuous Extrusion Blow Molding with Shuttle Mold



Intermittent Extrusion Blow Molding

In this process (Figures 2-4), the melt is fluxed and delivered to a reservoir, or accumulator. When enough melt has accumulated a ram or plunger forces it through the parison die. When the parison is completely formed, the mold closes and the parison is blown (at the same station).

Meanwhile, the ram retracts and the extruder plasticates more melt and delivers it to the accumulator for the next shot. There are three variations of the intermittent process:

- The accumulator head system (Figure 2).
- The ram-accumulator system (Figure 3).
- The reciprocating screw system (Figure 4).

Intermittent extrusion blow molding is suitable for large parts and is economical for short production runs. It is best used with non-heat sensitive resins.

Figure 2. Intermittent Extrusion Blow Molding Accumulator Head Systems

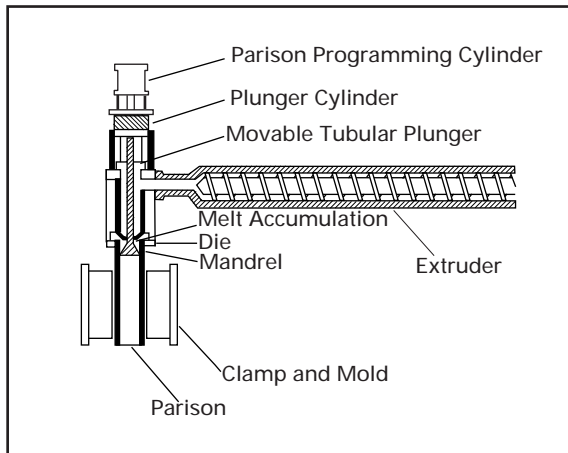


Figure 4. Intermittent Extrusion Blow Molding Reciprocating Screw System

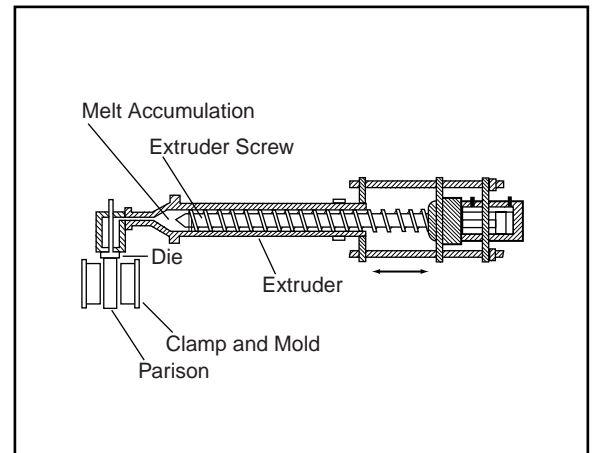
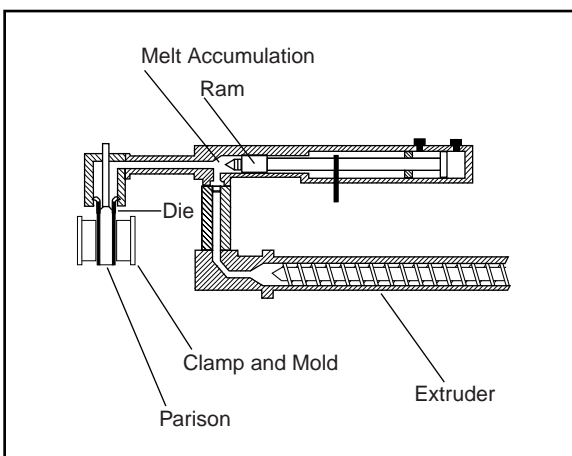


Figure 3. Intermittent Extrusion Blow Molding Ram-Accumulator System



System Preferences for Blow Molding *Alcryn*®

Systems which minimize holdup and possible degradation of the melt give the least problems when blow molding *Alcryn*®. Continuous extrusion systems are preferred. Second choice is an accumulator head system. Third choice is a ram-accumulator system. While it may be possible to satisfactorily blow mold *Alcryn*® in reciprocating screw systems, we have experienced difficulty in obtaining a uniform, well-fluxed melt.

Equipment Design Considerations

Materials of Construction

Corrosion-resistant materials, such as those typically used in equipment for processing polyvinyl chloride (PVC), chlorinated polyethylene (CPE), or chlorosulfonated polyethylene (CSM) should be used when processing *Alcryn*® to maximize equipment life.

The Extruder

Successful extrusion blow molding of *Alcryn*® depends largely upon the extruder. The extruder must be able to:

- Convert a feed of unheated pellets into a homogeneous, low viscosity melt by combination of heat and shear.
- Heat the melt to a temperature of 320 to 360°F [160 to 182°C] (measured at the extruder exit with a needle pyrometer). Melt temperature can be increased significantly by increasing shear rate through appropriate screw design.
- Meter fully fluxed melt uniformly to the accumulator or parison die.

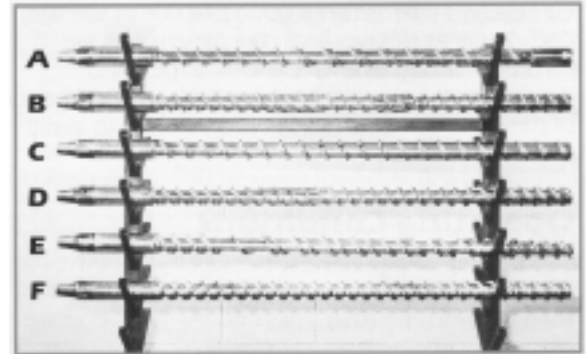
Extruders suitable for use with common thermoplastics (particularly those used with PVC) are usually suitable for *Alcryn*®. Some rubber extruders may be suitable if they are modified to provide sufficient heat and shear. Length to diameter ratios (L/D) of between 15:1 and 30:1 are usually satisfactory, with 20:1 or greater being preferred. Longer barrels provide a more uniform, well-fluxed melt.

Screw Design

Shear is necessary to produce a uniform, well-fluxed melt with *Alcryn*®. To provide the required shear, a section of the screw should have several flights which are no more than 0.100 inches (2.5 mm) deep. Any device which increases mixing and shear--such as pins, torpedoes, dams or barriers--will improve plastication and broaden the processing window. The compression ratio should be between 2.0 and 3.0. Only moderate working is necessary; high shear screws could cause overheating and polymer degradation.

Types of screws which have been found suitable for extrusion and extrusion blow molding of *Alcryn*® are described in Table 1. The screws are listed in order of preference for parison smoothness and processing latitude.

Table 1: Typical Extruder Screws for *Alcryn*®



Ranked by Parison Smoothness

- A. Moderated-Working, Continuous Barrier Screw
 - Maximum feed depth--0.50 in. (12.7 mm)
 - Shear area depths--0.175 in. (4.45 mm) and 0.035 in. (0.89 mm)
 - Optional Maddock mixing tip--0.05 in. (1.27 mm) clearance
- B. Three Stage, Double-Dam Vacuum Screw
 - Maximum feed depth--0.5 in. (12.7 mm)
 - Dam clearances--0.052 in. (1.32 mm) and 0.107 in. (2.72 mm)
- C. Step-Tapered (PVC) Screw
 - Maximum feed depth--0.40 in. (10.1 mm)
 - Minimum metering depth --0.13 in. (3.3 mm)
 - Compression ratio--3:1
- D. Two-Stage, Single-Dam, Vacuum Screw
 - Maximum feed depth--0.50 in. (12.7 mm)
 - Dam clearance--0.87 in. (2.21 mm)
- E. Low Working Continuous Barrier Screw
 - Maximum feed depth--0.45 in. (11.4 mm)
 - Shear area depths--0.27 in. (6.85 mm) and 0.12 in. (3.05 mm)

Screens and Breaker Plate

A breaker plate of streamlined design supporting two 100 mesh screens is generally used when extruding *Alcryn*®. Steamlining reduces the possibility of dead spots and subsequent polymer degradation. The screens increase back pressure, which decreases chances of porosity.

Accumulator (Head)

To maintain melt quality and uniformity, the accumulator should have as small a volume as is reasonable, smooth continuous contours, and good temperature control. Large volume heads, or heads without smooth contours, can lead to holdup of melt and subsequent polymer degradation.

Parison Die

Alcryn® is molded routinely at a blow ratio of 2:1 and has been formed satisfactorily at 3:1. Generally, it is considered good practice to size the parison die as close to final part dimensions as possible. Parison diameter and wall thickness depend on the desired diameter and wall thickness of the part. The die should be streamlined to avoid polymer holdup.

Operating Conditions

Generally, all operating variables must be optimized empirically for each machine and each part.

Extruder Temperatures

Regardless of which extrusion blow molding process is utilized, a combination of barrel heat and shear is necessary to convert pellets of *Alcryn*® into a properly fluxed, uniform melt. Melt temperature measured at the parison die or at the exit to the accumulator head should be between 320 and 360°F (160 and 182°C).

In general, barrel temperatures are set in a "reverse profile" (with the feed end set to a higher temperature than the head end) when extruding *Alcryn*®. Suggested temperature settings on the extruder are as follows:

Zone 1 (Feed) 320-340°F (160-171°C)

Zone 2 (Transition) 310-330°F (154-166°C)

Zone 3 (Metering) 300-320°F (140-160°C)

Accumulator (Head) 280-330°F (138-166°C)

Die 300-350°F (149-177°C)

Additional heat to achieve the desired melt temperature is generated by shear.

Screw Speed

Screw speed is usually adjusted to achieve the output desired. Typical screw speeds with *Alcryn*® range from 20 to 60 rpm.

Increasing screw speed with a screw suitable for *Alcryn*® will increase melt temperature due to shear heating. Barrel temperature set points may have to be lowered to maintain the desired melt temperature. This effect of shear is most noticeable with very high shear screws.

With marginally low shear screws, increasing screw speed may actually decrease melt temperature because of reduced residence time within the barrel in this case, barrel temperature settings may have to be increased to maintain the desired melt temperature.

Parison Drop Time

Drop time depends on part size, extruder size and screw speed. Typical drop time with *Alcryn*® is one to two seconds.

Blow Pressure and Blow Time

Blow pressure and blow time are functions of part size and parison wall thickness. Moderate pressures and blow rates generally yield well-defined parts while avoid blowouts. Blow pressure typically ranges between 30 and 100 psig (200-700 kPa gauge).

Mold Temperature

Chilled molds are recommended when extrusion blow molding *Alcryn*[®]. Excellent parts have been obtained with mold temperatures of 40 to 140°F (5 to 60°C). Blow-molded parts do not show anisotropic (orientation) effects.

Vent Time (Demolding Time)

Parts of *Alcryn*[®] develop strength rapidly in the absence of shear. (See "Polymer Rheology"). They generally do not stick to the mold and have enough hot strength to demold easily, without distortion, in very short cycles--typically, two to three seconds.

Shutdown Procedures

Brief shutdowns of 30 minutes or less require no special precautions, provided the measured melt temperature is no greater than 350°F (177°C). If the extruder is shut down for longer periods, the system should be purged with LDPE or other suitable purge compound. During the next startup, the initial material exiting the extruder should be discarded. Venting of off-gases is recommended for all processing operations.

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