guide for

extrusion blow molding

for Thermoplastic Rubbers and Thermoplastic Elastomers

- **Processing**
- **Mold Design**
- **Equipment**

Advanced Elastomer Systems

The worldwide leader in engineered TPEs

TABLE OF CONTENTS PAGE

INTRODUCTION 3
The Advantages of Extrusion Blow Molding (EBM) 3
Typical Blow Molded TPE Applications 4

PROCESSING

Processing Technologies:
Single Layer, Multi-Layer, Sequential, Flashless EBM,
Injection Blow Molding, Press Blow Molding 5
Identifying the Proper AES Grades 6
Safety Considerations 7
Temperature Recommendations/Blow Ratios 8
Process Troubleshooting 14
Dryers 17
Desiccant Drying 18
Loaders 19
Blenders 19
Regrinding 20
Grinders 21
Coloring 22

BLOW MOLDING MACHINE DESIGN

Screws 23
Barrels 25
Head 26
Parison Programming 31
Shot Size 31
Extruder Output 31

MOLD DESIGN

Cast and Machined Molds 32
Material Selection 33
Shrinkage 33
Venting 34
Mold Finish 35
Part Ejection 38
Parting Lines 39
Part Inflation 40
Inserts 41
Extrusion Dies 43
Tooling Design 44
Secondary Finishing 48
Part Cost/Weight Estimating 49

SUMMARY OF KEY PARAMETERS 50

TABLES AND FIGURES

Typical Blow Molded Applications		PAGE
Rack & Pinion Boots	Figure 1	4
Clean Air Ducts/Automobile Air Hoses	Figure 2	4
Dust Covers/Gaitors/Tubes and Hoses	Figure 3	4
Temperature Recommendations/Blow Ratios		
Typical Extrusion Blow Molding Parameters for Santoprene® Rubber	Table I	9
Typical Extrusion Blow Molding Parameters for Vyram® Rubber	Table II	10
Typical Extrusion Blow Molding Parameters for Geolast® Rubber	Table III	11
Typical Extrusion Blow Molding Parameters for Vistaflex® Elastomer	Table IV	12
Typical Extrusion Blow Molding Parameters for Trefsin® Rubber	Table V	13
Typical Moisture Pickup of Elastomers		
Typical TPE Moisture Absorption	Figure 4	17
Desiccant Drying		
Typical Desiccant Drying System	Figure 5	18
Regrinding		
Retention of Tensile Properties of Grade 201-80 Santoprene Thermoplastic Rubber	Figure 6	20
Grinders		
Standard Plastic Granulator	Figure 7	21
Scissor Type Cutting Blades	Figure 8	21
Screw Design		
Pin Mixing Screw	Figure 9	23
Two-Stage Screw	Figure 10	23
Maddock Mixing Head	Figure 11	24
Barrier Screw	Figure 12	24
Head Design		
Axial Flow Head With Uninterrupted Spider Legs	Figure 13	26
Axial Flow Head With Staggered Spider Legs	Figure 14	27
Conventional Radial Flow Head	Figure 15	28
Modified Mandrel With Heart-Shaped Channel	Figure 16	29
Typical Accumulator Head	Figure 17	30
Multilayer or Sequential Extrusion With Ram Accumulators	Figure 18	30
Material Selection		
Nominal Mold Material Properties	Table VI	33
Venting		
Parting Line Venting	Figure 19	34
Slotted Venting	Figure 20	35
Pinhole Venting	Figure 21	35
Vented Peak	Figure 22	36
Part Ejection		
Blow Pin and Bellows Article	Figure 23	38
Parting Lines		
Pinch Parting Line	Figure 24	39
Dammed Parting Line	Figure 25	39
Flat Parting Line	Figure 26	39
Part Inflation		
Blow Pin Apparatus	Figure 27	40
Hypodermic Needle	Figure 28	40
Inserts		
Molded-In Insert	Figure 29	41
Extrusion Dies		
Typical Circular Extrusion Tooling	Figure 30	43
Non-Round Head Tool, Balanced	Figure 31	44
Non-Round Head Tool, Unbalanced	Figure 32	45
Tooling Design		
Converging/Diverging Tooling	Figure 33	46
Angle Difference between Pin and Chase	Figure 34	47

INTRODUCTION

This guide is meant to provide the extrusion blow mold processor with a reference document on how to design molds, process and produce product from AES thermoplastic elastomers. It is not intended to teach extrusion blow molding. It is assumed that the reader will have a fundamental understanding of extrusion blow molding and needs only guidance on how to utilize AES thermoplastic elastomers in extrusion blow molding.

THE ADVANTAGES OF EXTRUSION BLOW MOLDING

Extrusion blow molding (EBM) is used to produce hollow parts. In the process, a molten tube, or parison, is extruded into a mold cavity and injected with compressed air; the parison expands outward, forming a hollow article in the shape of the cavity.

Traditionally, rubberlike hollow parts could only be achieved through the injection molding of thermoset rubber (TR). However, the invention of thermoplastic elastomers (TPEs) that can be extrusion blow molded, allows rubber-like articles to be produced cost effectively and with significant advantages.

Complex hollow elastomeric parts can now be extrusion blow molded:

- Flash free
- Core-less
- With sequential material construction
- With multiple layers of like materials
- With integrated components
- In sizes that range from very small to very large

Despite their complexity, extrusion blow molded TPE parts require a short mold build time. They can be produced rapidly for the following reasons:

- Thin wall construction
- No time needed for core ejection
- Rapid cooling

Rapid production translates directly into savings. Extrusion blow molded TPEs offer the following cost benefits:

- Low part weight due to thin walls
- Less expensive molds
- Reduced assembly cost

The result is complex hollow parts that can be made efficiently and affordably, with:

- Good dimensional precision
- Minor product weight variation
- Minimal deflashing and trimming operations

TYPICAL BLOW MOLDED TPE APPLICATIONS

AES TPEs can be blow molded to produce a wide variety of products with the performance of rubber and the processability of plastic. These include:

FIGURE 1: RACK & PINION BOOTS

FIGURE 2: CLEAN AIR DUCTS/ AUTOMOBILE AIR HOSES

FIGURE 3: DUST COVERS/ GAITORS/TUBES AND HOSES

PROCESS TECHNOLOGIES IN BLOW MOLDING

SINGLE LAYER

This is the simplest and most common variation of extrusion blow molding. It uses only one grade of thermoplastic rubber pellets to create a hollow part. While small parts can be extruded continuously in single layer, larger parts must be produced intermittently. Molten material must first be pushed into an accumulator before being extruded as a long parison. In both cases either standard equipment, with or without a part manipulator, or a machine with 3-D technology, can be utilized depending on the geometry of the part to be produced.

MULTI-LAYER

Multi-layer parts are generally produced via the intermittent extrusion of several materials. The process is excellent for applications requiring multi-functionality such as a barrier resin that cannot come in contact with the environment, or a combination of soft and hard materials using both rubbery and plastic properties in two different ways. If more than one material is needed, a multi-barrel machine is required.

SEQUENTIAL

Sequential parts are produced through the successive extrusion of two or more materials, or differing grades of one material. For example, hard and soft grades of Santoprene rubber can be used when mobility and sealing properties are needed in a single component. A hard grade of Santoprene rubber can also be alternated with polypropylene for applications that need both local flexibility and stiffness.

FLASHLESS EBM

A 3-D blow molding technique, flashless EBM, is now commercially available in several different variations. This technology results in multi-dimensional thermoplastic rubber parts that meet higher performance levels at a lower produced cost. These higher tolerances are achieved with a significant reduction of scrap. The technology adapts readily to AES TPEs, in both hard or soft grades. The necessary equipment will have either a parison manipulator and/or a mold manipulator, or a die manipulator.

INJECTION BLOW MOLDING

Typically, injection blow molding is suited to production of products that are light (<100gm/<.22lb), short in length (<200mm/<7.87in), small in diameter (<100mm/<3.94in), and made from a single layer of material. Usually ready for immediate use directly out of the mold, they require very little finishing. However, compared to extrusion blow molding, tooling costs on a cavity to cavity basis are higher, since blow molds, core rods and injection molds are all necessary to the process. As a result of the relatively high tooling costs, injection blow molding is typically used for large production runs. However, it is the method of choice for certain TPE applications, including small, symmetrical, convoluted parts such as those used for automotive rack and pinion boots. Critical end fit areas can be formed with injection molded tolerances, while convoluted sections can be blown, for flexibility.

PRESS BLOW MOLDING

This process variation combines injection blow molding with extrusion blow molding. Typical applications include small cylindrical and conical parts such as automotive rack and pinion boots, transmission boots or dust shields. The process provides the high control for product dimensions and wall thickness, as well as quick, efficient cycles with little scrap or mold/tool changeover. Currently, commercial equipment utilizes heads with shot sizes < 150gm (<.33lb). Press blow molding tooling requires both an injection mold and a conventional extrusion blow mold.

IDENTIFYING THE PROPER AES GRADES

Blow moldable resins must possess sufficient melt strength. They also must be capable of thinning out when molten. Consequently, we recommend the following AES families and grades for extrusion blow molding:

Santoprene® Rubber

101-64 / 201-64
101-73 / 201-73
101-80 / 201-80
101-87 / 201-87*
103-40 / 203-40*
103-50 / 203-50*

Geolast® Rubber

701-70
701-80
701-87*
703-45*
703-50*

Vyram® Rubber

9101-75 / 9201-75
9101-85 / 9201-85*
9103-45 / 9203-45*
9103-54

Vistaflex® Elastomer

641N
911B*

Trefsin® Rubber

3101-65W305 / 3201-65W305
3101-75W305 / 3201-75W305
3101-85W305 / 3201-85W305*

* Best recommended grades for blow molding.

At Advanced Elastomer Systems, we are committed to improved safety. Consequently, we urge you to observe the following practices and precautions:

IMPORTANT: Purge all acetal and polyvinyl chloride (PVC) products from the extrusion unit before processing. If necessary, mechanically clean it. Clean all upstream equipment such as the feed throat, hopper and material conveying systems as well.

FAILURE TO PURGE ACETAL AND PVC COULD RESULT IN THE PRODUCTION OF HAZARDOUS FUMES.

- Check all safety systems daily to make sure they are in good working order. This includes all electrical, hydraulic, pneumatic and mechanical systems.
- Fix all leaks in or around the machinery as soon as possible; avoid oil and water spills on the floor.
- Wear proper eye protection and safety shoe in the processing area.
- Comply completely with all the safety recommendations from the machinery manufacturer or supplier.

Remember: As with all polymer processing equipment, blow molding machinery employs powerful and potentially dangerous electrical, hydraulic, pneumatic, thermal and mechanical systems. Material temperatures can be as high as 270°C (500°F). Cooled or chilled water, hydraulic oil and compressed air may also be encountered. To avoid incident or injury, follow industrial safety practices and observe the specific safety guidelines supplied by your machine and material manufacturers.

The recommended processing temperatures for the relevant grades of AES resins are listed in Tables I-V. Follow them carefully as preliminary conditions and optimize for trouble-free operation. Low melt temperatures can cause rough surfaces, poor knit lines and blowouts; high melt temperatures can result in a high degree of parison sag, porosity and poor quality parts.

The feed zone temperature is important to the feeding process. In general, it should be cooler than all other temperature set points. However, as feeding difficulty increases, the optimum temperature also increases. Improper temperature results in lower extruder output and porosity in the parison - a problem which increases at high RPM.

Head zone temperature should approximate the desired melt temperature. Set the temperature of the die zone 5°C (40°F) higher than the upper head zone to help offset the die cooling caused by blown air.

The mold temperature should be set just above the dew point of the ambient air. This will maximize cooling and minimize surface defects, including surface blemishes from condensation. Use a cold mold to optimize cycle time. Use a warm one for the best surface appearance. In either case, be sure the coolant flow through the molds is fully turbulent at the design coolant flow rate.

Blowing and cooling times are a function of part design and wall thickness. Typically, they can range from 25 to 120 seconds. Large parts may require longer to exhaust/ depressurize the blowing air. As a result, be sure to account for the exhaust portion of the overall cycle time. Consult your local AES technical service representative for more specific information.

Table I–Typical Extrusion Blow Molding Parameters for Santoprene® Rubber

Santoprene® Grade		101-64 201-64	101-73 201-73	101-80 201-80	101-87 201-87	103-40 203-40	103-50 203-50
Feed Zone	°C (°F)	170 (340)	175 (350)	190 (370)	195 (380)	195 (380)	195 (380)
Transition Zone	°C (°F)	180 (360)	190 (370)	195 (380)	200 (390)	200 (390)	200 (390)
Metering Zone	°C (°F)	190 (370)	195 (380)	200 (390)	205 (400)	205 (400)	205 (400)
Upper Head	°C (°F)	195 (380)	200 (390)	205 (400)	210 (410)	210 (410)	215 (420)
Lower Head	°C (°F)	195 (380)	200 (390)	205 (400)	210 (410)	210 (410)	215 (420)
Die Tip	°C (°F)	200 (390)	200 (390)	205 (400)	215 (420)	215 (420)	215 (420)
Melt Temperature	°C (°F)	200 (390)	200 (390)	205 (400)	205 (400)	205 (400)	215 (420)
Blow Ratio (Typical max value)		2	2.5	3	4	4.5	5

Table II–Typical Extrusion Blow Molding Parameters for Vyram® Rubber

Vyram® Grade		9101-65 9201-65	9101-75 9201-75	9101-85 9201-85	9103-45 9203-45	9103-54
Feed Zone	°C (°F)	170 (340)	175 (350)	190 (370)	195 (380)	195 (380)
Transition Zone	°C (°F)	180 (360)	190 (370)	195 (380)	200 (390)	200 (390)
Metering Zone	°C (°F)	190 (370)	195 (380)	200 (390)	205 (400)	205 (400)
Upper Head	°C (°F)	195 (380)	200 (390)	205 (400)	210 (410)	215 (420)
Lower Head	°C (°F)	195 (380)	200 (390)	205 (400)	210 (410)	215 (420)
Die Tip	°C (°F)	200 (390)	200 (390)	205 (400)	215 (420)	215 (420)
Melt Temperature	°C (°F)	200 (390)	200 (390)	205 (400)	205 (400)	215 (420)
Blow Ratio (Typical max value)		2	2.5	3	4	5

Table III–Typical Extrusion Blow Molding Parameters for Geolast® Rubber

Geolast® Grade		701-80	701-87	703-45
Feed Zone	°C	180	195	200
	(°F)	(360)	(380)	(390)
Transition Zone	°C	190	195	200
	(°F)	(370)	(380)	(390)
Metering Zone	°C	195	195	200
	(°F)	(380)	(380)	(390)
Upper Head	°C	200	200	205
	(°F)	(390)	(390)	(400)
Lower Head	°C	200	200	205
	(°F)	(390)	(390)	(400)
Die Tip	°C	205	205	210
	(°F)	(400)	(400)	(410)
Melt Temperature	°C	200	200	205
	(°F)	(390)	(390)	(400)
Blow Ratio (Typical max value)		2.5	3	4

Table IV–Typical Extrusion Blow Molding Parameters for Vistaflex® Elastomer

Vistaflex® Grade		911-B	641-N
Feed Zone	°C	195	100
	(°F)	(380)	(212)
Transition Zone	°C	200	110
	(°F)	(390)	(230)
Metering Zone	°C	205	110
	(°F)	(400)	(230)
Upper Head	°C	210	110
	(°F)	(415)	(230)
Lower Head	°C	210	110
	(°F)	(415)	(230)
Die Tip	°C	215	110
	(°F)	(420)	(230)
Melt Temperature	°C	205	145
	(°F)	(400)	(293)
Blow Ratio (Typical max value)		2	4

Table V–Typical Extrusion Blow Molding Parameters for Trefsin® Rubber

Trefsin® Grade		3101-65 W305 3201-65 W305	3101-75 W305 3201-75 W305	3101-85 W305 3201-85 W305
Feed Zone	°C (°F)	185 (365)	190 (370)	190 (370)
Transition Zone	°C (°F)	190 (370)	195 (380)	195 (380)
Metering Zone	°C (°F)	190 (370)	200 (390)	200 (390)
Upper Head	°C (°F)	200 (390)	205 (400)	205 (400)
Lower Head	°C (°F)	205 (400)	205 (400)	205 (400)
Die Tip	°C (°F)	205 (400)	205 (400)	205 (400)
Melt Temperature	°C (°F)	205 (400)	210 (410)	210 (410)
Blow Ratio (Typical max value)		2.0	2.5	4.0

PROCESS TROUBLESHOOTING

In the production of extrusion blow molded items, defects may occur which can be eliminated with remedies suggested below. Usually, two types of problems are found when blow molding. These are either **PARISON** or **MOLDING** related.

PARISON RELATED PROBLEMS

PROBLEM	CAUSE	SOLUTION
1. Parison curls outward	• Outer skin of parison may be too cold	• Heat the die ring
2. Parison curls inward	• Outer skin of parison may be too warm	• Cool the die ring
3. Parison presents a banana shape	• Wall thickness variation through cross section	• Align the die ring
4. Parison length not controllable	• Melt viscosity too low	• Select a more viscous material
	• Processing temp. too high	• Decrease melt temperature
	• Extrusion rate too low	• Increase extrusion rate
	• Screw speed too low	• Increase screw speed
5. Counter flow marks	• Degraded material contamination	• Purge equipment
	• Wrong flow path	• Modify head design
	• Melt temp. too high	• Decrease melt temperature
6. Flow marks in flow direction	• Mandrel support too close to die	• Modify head design
7. Heterogeneous flow marks in flow direction	• Contamination	• Clean die ring • Check die ring
8. Rough inner surface	• Melt temp. too low	• Increase melt temperature
	• Die temp. too low	• Increase die temperature
	• Parison extruded too fast	• Decrease parison speed
	• Die chatter	• Check parison programming
9. Parison exhibits local discoloration	• Contamination	• Purge equipment
	• Recycling ratio	• Decrease recycling ratio
10. Parison contains brown stripes	• Melt temperature too high	• Decrease melt temperature
	• Too long residence time in screw	• Increase output
	• Too high shear rate	• Check all flow paths
	• Overheating	• Check heaters/temperatures
	• Mandrel support not streamlined	• Reposition/change mandrel support

PARISON RELATED PROBLEMS

PROBLEM	CAUSE	SOLUTION
11. Small round or lens-shaped inclusions	• Porosity	• Dry material • Dry compressed air
12. Parison falls from head before mold closes	• Extrusion tooling closing	• Increase die gap at end of shot
	• Parison too thin	• Thicken parison at end of shot
	• Wet material	• Dry material
13. Parison folds or ripples	• Too thin parison • Excessive melt temperature	• Light preblow • Reduce melt temperature
14. Bubbles	• Air entrapment	• Increase screw speed • Increase extrusion pressure • Vent the equipment

MOLDING RELATED PROBLEMS

PROBLEM	CAUSE	SOLUTION
1. Parison blows out	• Blow ratio too high • Parison walls too thin • Parison wall not uniform • Parison not correctly grasped • Blowing air speed too high • Welding edges too sharp • Welding edges do not close tightly together • Melt temperature not uniform on length	• Change die or material • Increase wall thickness • Check parison control • Check mold halves position • Reduce air speed/pressure • Check welding conditions • Check parison thickness vs. die design • Increase output/screw speed
2. Parison is not fully inflated	• Blow-up pressure is too low • Blow-up time is too short	• Increase blow-up pressure • Increase blowing time
3. Blown-up parison collapses in mold	• Blow-up air is activated too early	• Check blow-up timing
	• Blow-up air pressure is too low	• Increase blow-up pressure
4. Material sticks to edges	• Mold temperature too high • Cycle time too short	• Decrease melt temperature • Increase cycle time

PROCESS TROUBLESHOOTING
MOLDING RELATED PROBLEMS

PROBLEM	CAUSE	SOLUTION
5. Weld seam is too weak	• Melt temperature is too low or much too high	• Adjust melt temperature
	• Closing mold timing is wrong	• Adjust mold closing timer
	• Pinch-off angle is wrong	• Adjust pinch-off angle
6. Base seam displaced inwards	• Pinch-off angle too great	• Decrease pinch-off angle
	• Mold closing time too short	• Delay mold closure
7. Base seam not centered	• Parison not fully vertically extruded	• Center the parison
	• Mold halves not grasping parison evenly	• Reposition mold halves
8. Sudden changes in wall thickness	• The parison controller is defective	• Repair defective equipment
	• Lost control of melt temp.	• Regain control of melt temp.
9. Parting line protrudes	• Mold edges are damaged	• Check mold edges
	• Mold closing force is too low	• Increase mold closing force
	• Blow-up air is activated too early	• Check timing for air blowing
10. Contours of the mold are not aligned	• Mold is loose	• Check mold locating elements
11. Demolded items change shape	• Cooling time too short	• Increase cooling time
	• Blowing pressure too low	• Increase blowing time
12. Uneven appearance on mold surface	• Venting problem	• Improve venting
13. Scaly surface	• Contamination	• Clean equipment
14. Molding tears at demolding	• Degradation	• Decrease melt temperature • Check for overheating
15. Excess smoke and volatiles during extrusion	• Excessive melt temperature	• Decrease melt temperature
	• Excessive shear rate in extruder	• Check extrusion conditions
16. Poor part definition	• Trapped air	• Add/modify venting
	• Condensation on mold	• Sand blast mold with coarse grit
	• Cold mold	• Adjust temperature above dew point
	• Low blow pressure	• Increase blow pressure
17. Other problems		• Call the AES AnswerPerson from 8:00 a.m. to 6:00 p.m. U.S. Eastern Time at 1-800-305-8070 or 1-330-849-5272; or call your nearest AES representative listed on the back cover; or visit our website at www.aestpe.com.

DRYERS

Dry pellets are key to the uninterrupted production of optimum quality blow molded products. Most TPEs are slightly hygroscopic.

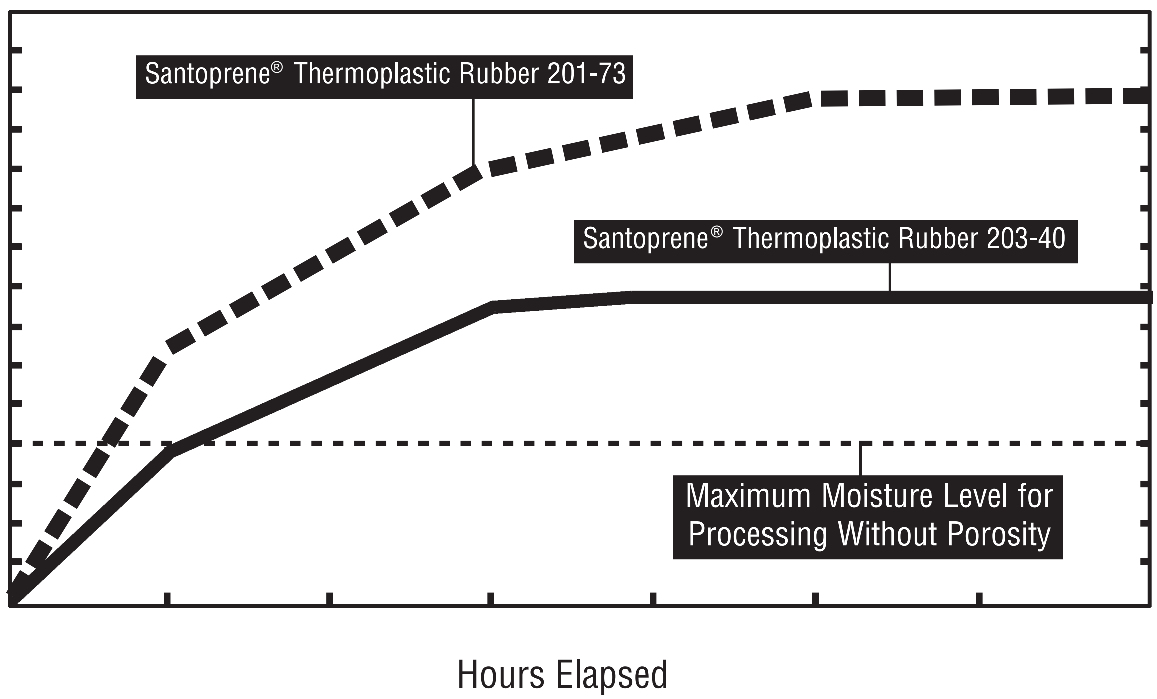
Consequently, moisture control is important. Moisture in blow molding can cause porosity in the parison, resulting in a parison blowout, surging as the parison is extruded, and poor surface quality. Rejects due to such problems can be reclaimed through regrind, drying and reprocessing. The use of a good dryer system will minimize such problems.

MINIMIZING MOISTURE PICKUP

Advanced Elastomer Systems ships all elastomers in Gaylord quantities or sealed 25 kg (55 lb) bags with a built-in moisture barrier. Once in your plant, however, you should take additional steps to control or prevent moisture absorption. In the graph below, you can see the typical moisture pickup by our TPEs under normal temperature and humidity.

Store all bags in a cool environment - sealed or securely closed - until ready for use. Open bags just prior to processing, and, at the end of a run, store any remaining elastomer in the original bag or in another clean, sealed container.

FIGURE 4: TYPICAL TPE MOISTURE ABSORPTION



Typical moisture pickup of elastomers

HOT AIR DRYING

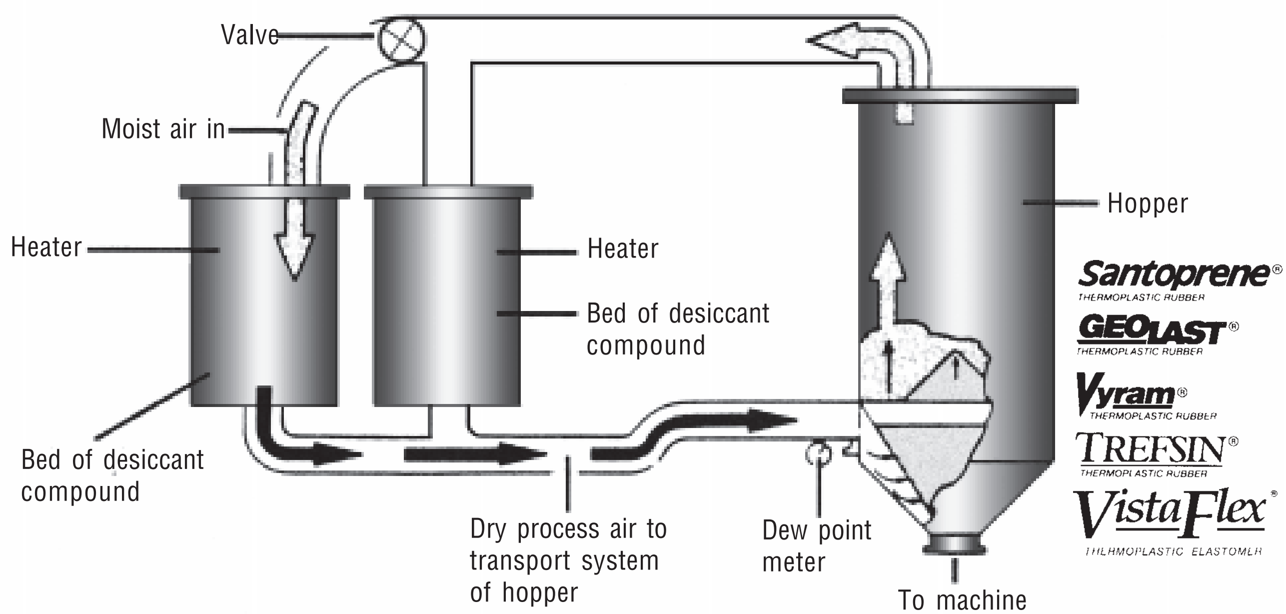
Although well suited for non-hygroscopic pellets and for removing surface moisture, we do not recommend this drying method for our TPEs.

It can produce uneven drying results, take too long for proper moisture removal, and actually increase the moisture level of the TPE in high humidity environments.

DESICCANT DRYING

This is the best way to dry AES resins. The system can be floor mounted, or hopper mounted on the machine. Either will automatically and continuously deliver low dewpoint air, below -18°C (0°F) at the correct temperature, 60-80°C (140-180°F) and flow rate, >1.5m^3/min/kg (24ft^3/min/lb), producing uniform drying irrespective of ambient conditions. Virgin material should be dried for a minimum of two hours. Reclaimed/recycled material should be dried for a minimum of four hours before processing. For continuous operation, the drying hopper should hold enough pellets for four hours of throughput.

FIGURE 5: TYPICAL DESICCANT DRYING SYSTEM



ALL AES ELASTOMERS SHOULD BE DRIED IN A DESICCANT DRYER AT 60-80°C (140-180°F) PRIOR TO PROCESSING.

BLOWING AIR DRYERS AND FILTERS

Blow air must be dried and filtered prior to using. Because it is usually taken from the factory's compressed air supply, it frequently contains lubricating oil or water condensate.

Once in the parison hollow, these contaminates can trigger localized premature wall cooling, which causes the internal surface of the blow molded article to be rough or pitted.

LOADERS

We recommend that the frame and hoses of vacuum and mechanical loaders be electrically grounded. This will prevent the electrostatic charges that build up from the rubbing motion of loading the resin into the hopper.

BLENDERS

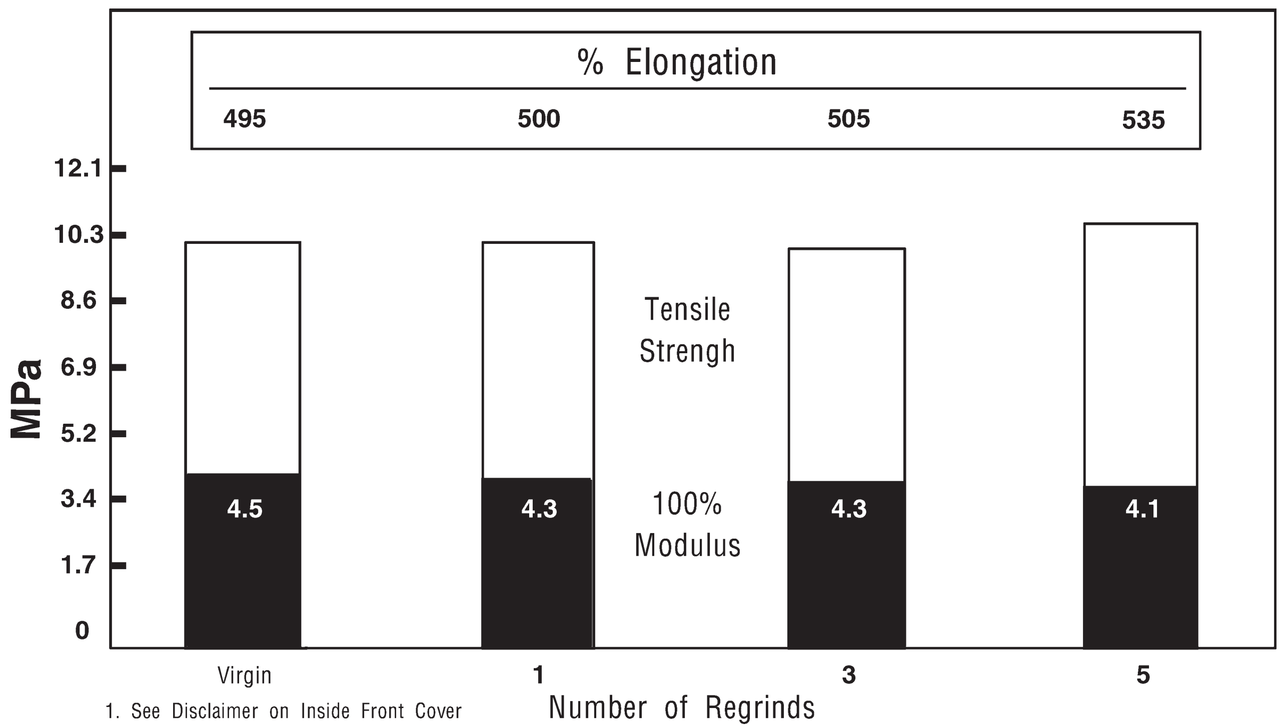
Blending can be done in a batch process via tumbling, or on-line at the machine with automatic dosing units equipped with a mixing chamber. Either is sufficient to blend color masterbatch, additives or regrind with the virgin material to create the feedstock for the machine.

REGRINDING

AES TPEs are excellent candidates for regrind as indicated by the study below. Samples taken from five extrusion paths of 100% regrind of Santoprene rubber, grade 201-80, show no significant signs of degradation. Furthermore, only a 7% reduction in viscosity was observed after this reprocessing.

While 100% regrind material can be successfully processed, lower levels of regrind can result in better control of production. Re-using the regrind gives Santoprene rubber a real edge in processing flexibility. For best results, maintain a consistent regrind level throughout the production process and make sure it is properly sized.

FIGURE 6: RETENTION OF TENSILE PROPERTIES OF GRADE 201-80 SANTOPRENE THERMOPLASTIC RUBBER



1. See Disclaimer on Inside Front Cover

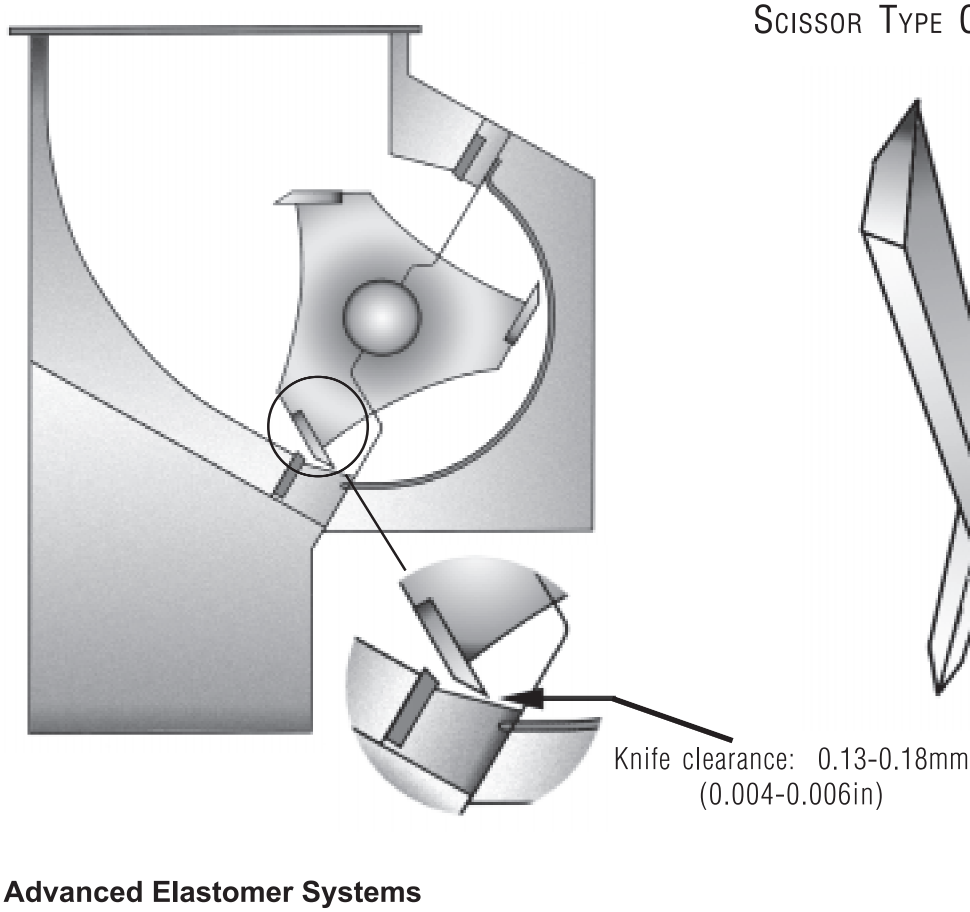
Grinders

When blow molding our resins, as with other resins, there will be some scrap from the pinch-off flashes and occasionally unusable parts. This scrap can be reused by grinding it to a suitable size and mixing it in with the virgin material. This material blend can then be fed back into the blow molding machine to fabricate good parts with little or no loss of properties or performance.

Grnder Systems

Since AES resins have grades ranging from very soft to hard, it is important to select a grinder system that can handle various durometers. We recommend a three-blade standard plastic (see Figure 7) granulator with knife clearance of 0.13-0.18mm (0.004-0.006in) and a filter screen with 10mm (0.375in) holes. For high capacity regrinding, or when reprocessing molten flash, we recommend a grinder with a water-cooled grinding chamber.

Fig. 7
Standard Plastic Granulator

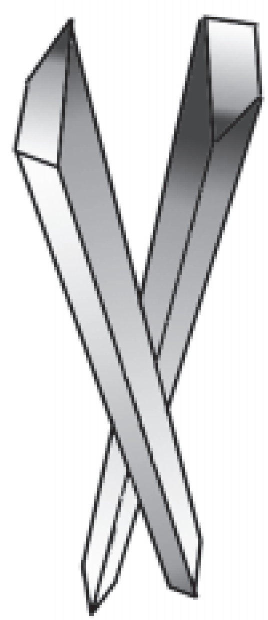


This will help prevent the granulated particles from melting and sticking together. It will also promote a more uniformly sized regrind particulate. In addition, scissor type grinders are more effective at cutting softer elastomers. (See Figure 8)

Fines

As the material is ground, small particles, or fines, are created. These fines can plug filter screens in vacuum conveying systems, eventually reducing the air velocity and preventing material transport. If the fines are allowed to reach the extrusion feed throat, they may melt, "bridging" or plugging the area. This will prevent the smooth feeding of material, causing inconsistent parisons. In extreme cases, it may stop feeding altogether. As a general rule, the fewer the fines, the fewer the handling problems. Note that blunt blades will produce more fines than sharp ones. It is also important to keep the regrind particles about the same size as the virgin pellets.

Fig. 8
Scissor Type Cutting Blades



COLORING

A major advantage of Santoprene rubber is its ability to be processed in virtually any color. Simply blend our neutral TPE pellets with the correct colorant, and you can achieve nearly any hue you want - including intense chromas, neons, metallic and a broad range of whites. Pre-colored pellets are available from several sources. Please note that AES produces resins in black and natural **only**. If a pre-colored material is required, please contact your sales/technical service representative for a recommended compounder.

COLOR CONCENTRATES

For their stability, compatibility and dispersion, solid color concentrates are the best method of coloring our TPEs. These concentrates consist of a pigment compounded with a carrier resin.

CONCENTRATES BASED ON POLYPROPYLENE ARE RECOMMENDED WITH OUR TPE'S.

Solid color concentrates are dust-free and easy-to-use. They can be tumble-blended or accurately metered into your material prior to processing. As a general rule, add solid color concentrates at a rate of 1 to 5 parts/hundred (pph), or as recommended by the colorant supplier.

Dry pigment and liquid colors can also be used but require special processing equipment as well as specific handling. For more information, contact the AES AnswerPerson from 8:00 a.m. to 6:00 p.m. U.S. Eastern Time at 1-800-305-8070 or 1-330-849-5272, or call your nearest AES representative listed on the back cover.

CHANGING COLORS

Here is an effective method for color changeover that minimizes the amount of material thrown away:

1. Empty hopper and extrude as much material as possible from the barrel.
2. Remove and manually clean the head tooling (for large machines only).
3. Feed a known amount of neutral material into the hopper. For a small machine, a bag should be sufficient. Extrude and purge until all material is clean and contaminant free.
4. Grind all purged material. Add sufficient color concentrate for the known amount of the neutral material used in purging. Use the regrind for the next run of that particular color.
5. Add one bag of neutral material to the hopper. Then add your pre-blended material on top for the next color. Extrude enough material until you achieve the proper color.
6. Regrind all intermediate material. Add the necessary concentrate for the known amount of neutral material. Blend this in with the new color blend as regrind.

DRYING

Most colorants can absorb moisture, so always follow proper drying procedures to avoid problems in your fabricated TPE part.

Equipment

Screws

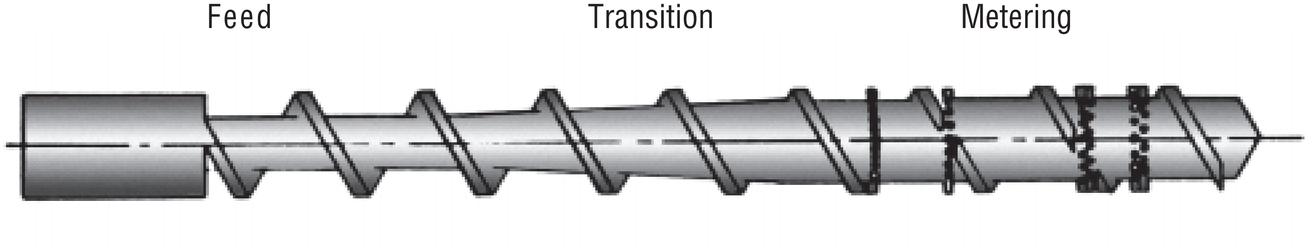
Screw Design

Because our resins are made up of dynamically vulcanized rubber particles in a plastic matrix, they require medium to high shear to plasticize. Consequently, we recommend general purpose screws of polyolefinic design with a three zone configuration: feed; compression/transition; and meter/pump. These screws should have a compression ratio ranging from 2.5:1 to 4.0:1 and a L/D ratio of 24:1 to 30:1. Screw tip cooling is not required.

.

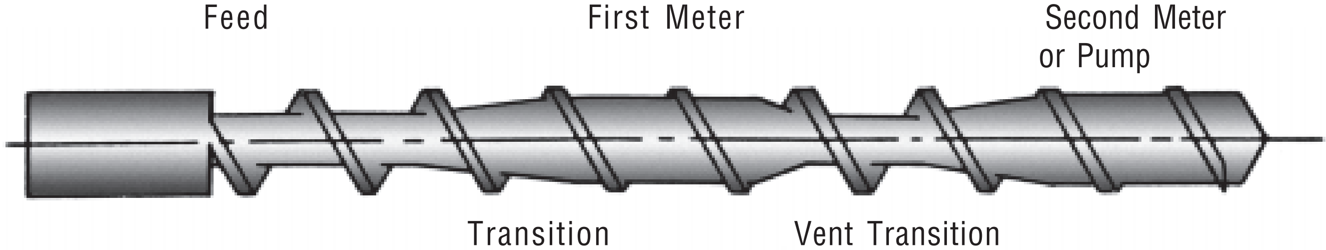
THE FOLLOWING TYPES OF SCREW VARIATIONS ARE ALSO SUITABLE FOR OUR TPES:

Figure 9: Pin Mixing Screw



A good general purpose screw with moderate shear rates. Uses pins in the metering zone to improve even mixing of the polymer melt.

Figure 10: Two-Stage Screw



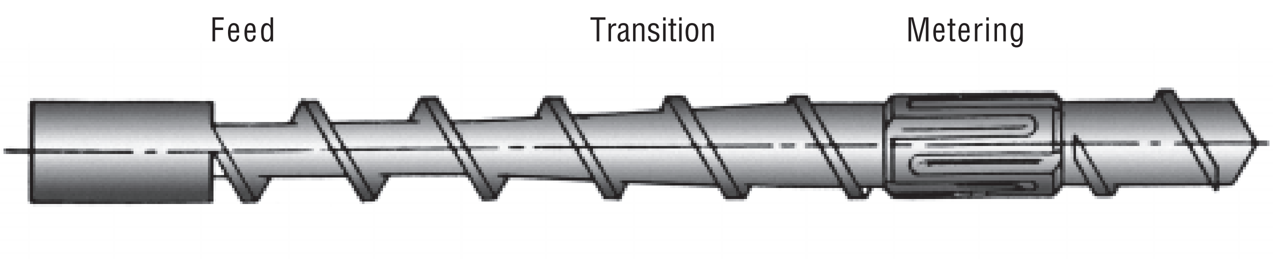
Features a decompression zone between two stages of the screw for venting volatiles and moisture. Usually uses a vented barrel. Slightly moist material may be processed without pre-drying, however extruder throughput rates are typically reduced.

Equipment

Screws

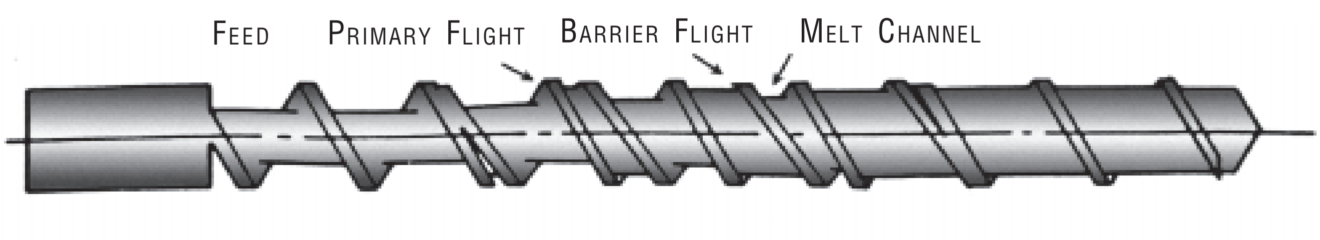
Screw Design

Figure 11: Screw with Maddock Mixer



A head design in the metering zone restricts flow and generates high shear rates, even at low screw speeds.

Figure 12: Barrier Screw



A double differential screw lead design in the transition or compression zone results in high shear mixing and plastification.

BARRELS

Extrusion blow molding requires a smooth bore barrel. Due to the viscous shear heating of the polymer as the screw rotates, barrel cooling is necessary. Usually fan cooling of the barrel is sufficient.

The feed throat section of the barrel should be equipped with water cooling channels. Room temperature water should be circulated through these channels to keep the temperature at the feed throat cool enough to prevent premature pellet melting and bridging.

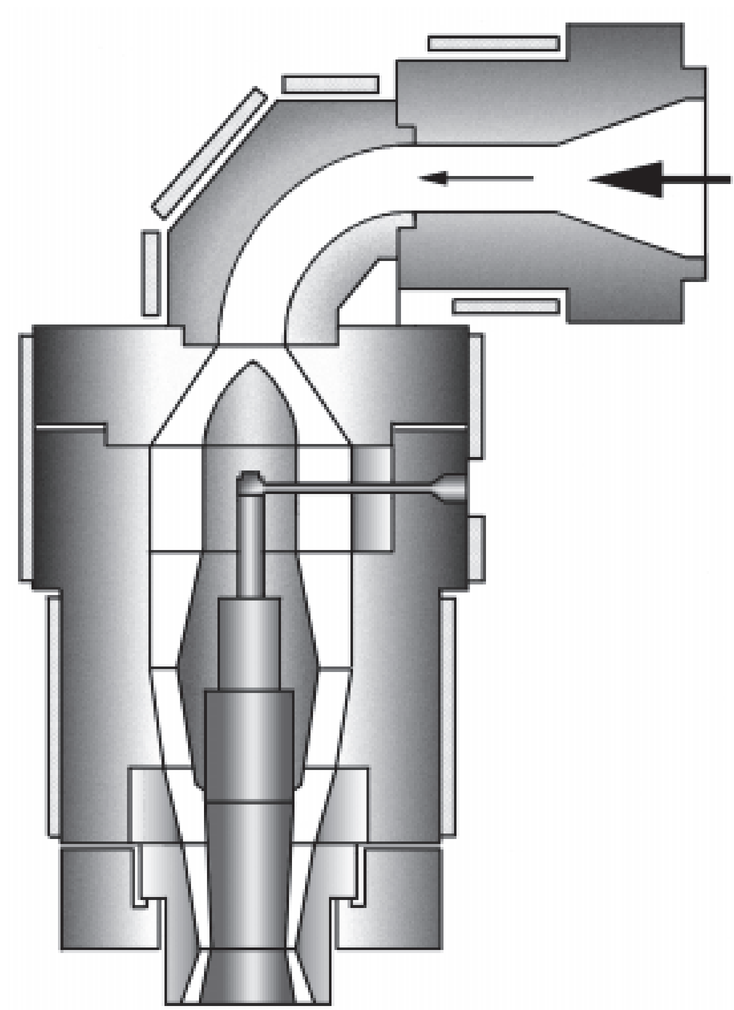
Heads

Before reaching the die area where the parison is sized and shaped, molten material must first be driven through the head from the barrel. The design of the head is critical in order to balance material flow and maximize the parison strength at the knit lines. There are several basic types of extrusion heads: the spider, or axial flow head; the side feed, or radial flow head and the accumulator. Each is illustrated and discussed below.

The Axial Flow Head

Here a central torpedo is positioned in the melt flow path, generally supported by uninterrupted spider legs. (See Figure 13 below.)

Figure 13: The Axial Flow Head With Uninterrupted Spider Legs



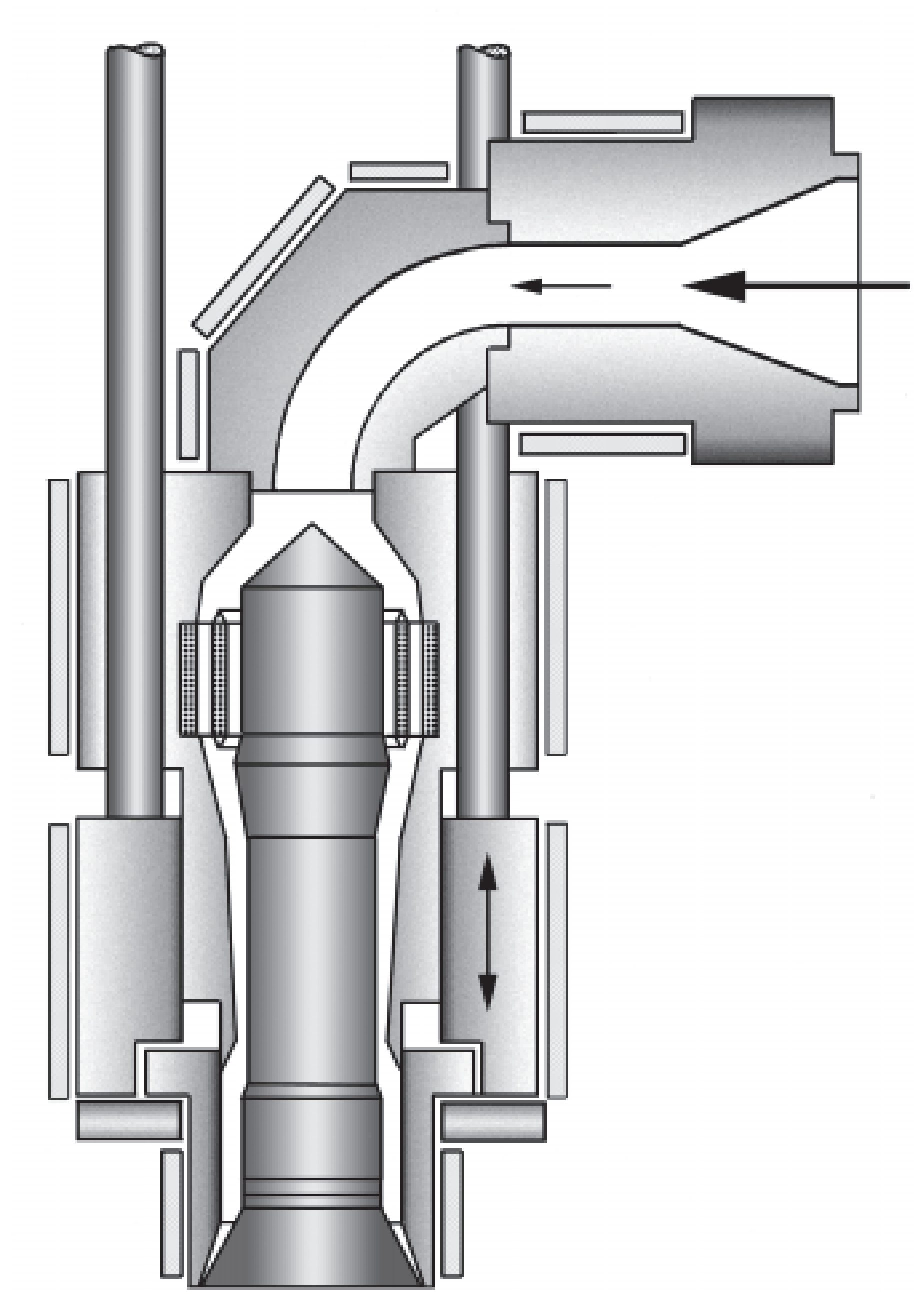
This very simple head design is currently used with a thermally sensitive material like PVC which has a low elastic memory. In it, a torpedo is centrally positioned in the melt flow path, generally supported by two spider legs.

This head design is NOT RECOMMENDED for our TPEs with high elastic memory. This axial flow head design would result in extrudates with unacceptable weld lines.

Heads

With staggered spider legs (see Figure 14 below) the resin flow is broken and a weld-free parison can be produced with our TPEs; we recommend this head design for the processing of our TPEs.

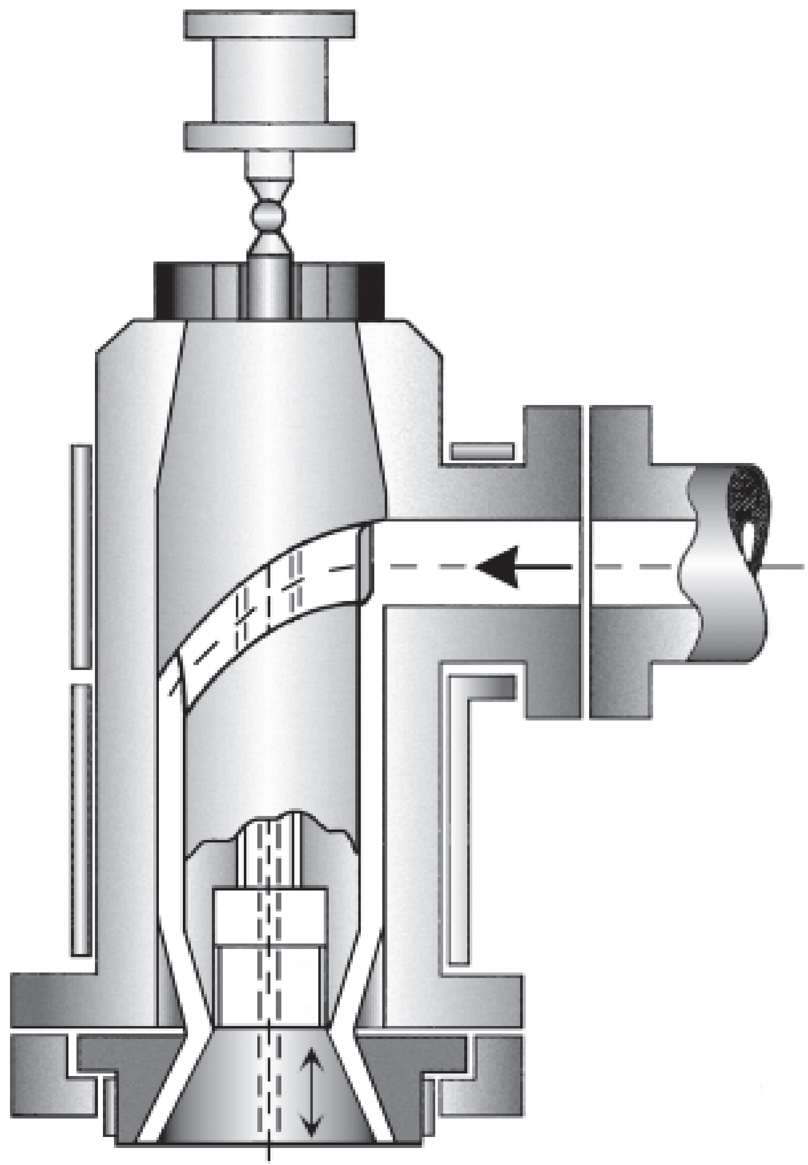
Figure 14: The Axial Flow Head With Staggered Spider Legs



Heads

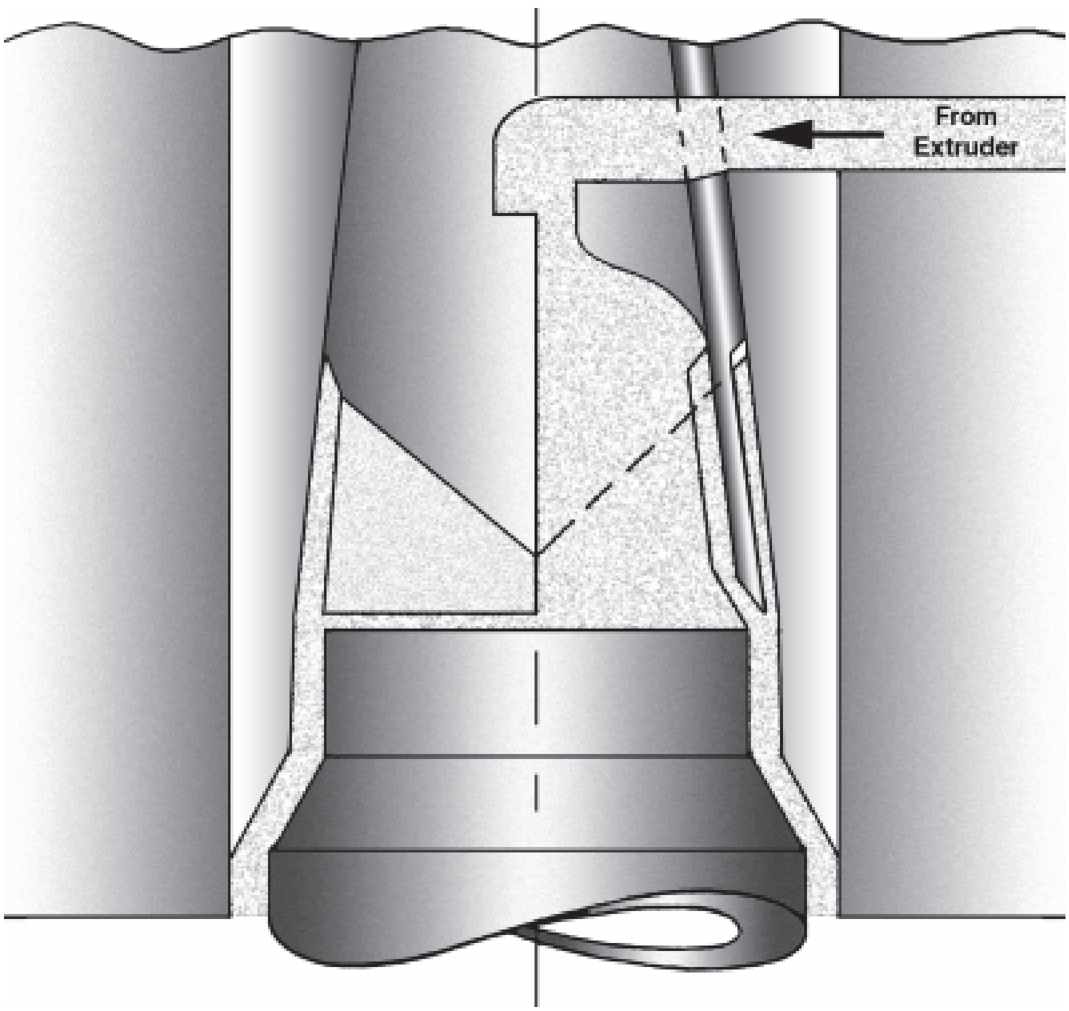
In a radial flow head design, (see Figure 15 below), the melt enters the head from the side, dividing around the mandrel and later rewelding. The downward moving melt then enters the pressuring area, creating a high back pressure, which further improves the reweld step. However, rubbery materials with a high elastic memory, such as various grades of our TPEs, need additional techniques to strengthen the weld lines. This can be achieved by using a heart-shaped mandrel (Figure 16).

Figure 15: Conventional Radial Flow Head



Heads

Figure 16: Modified Mandrel With Heart-Shaped Channel

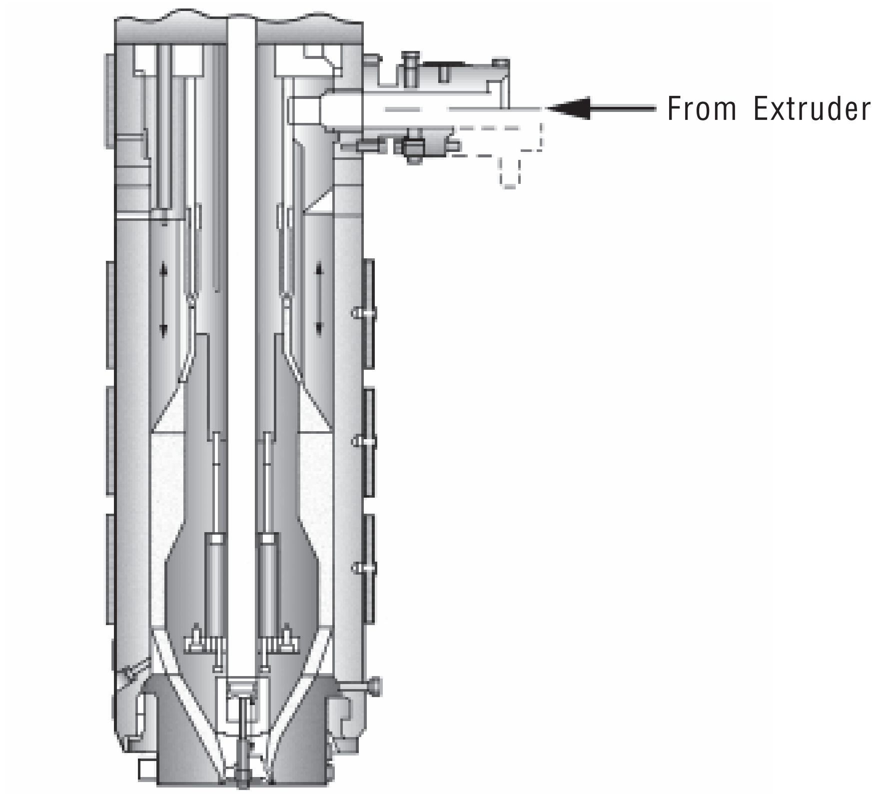


Heads

Accumulator Head / Accumulator Type

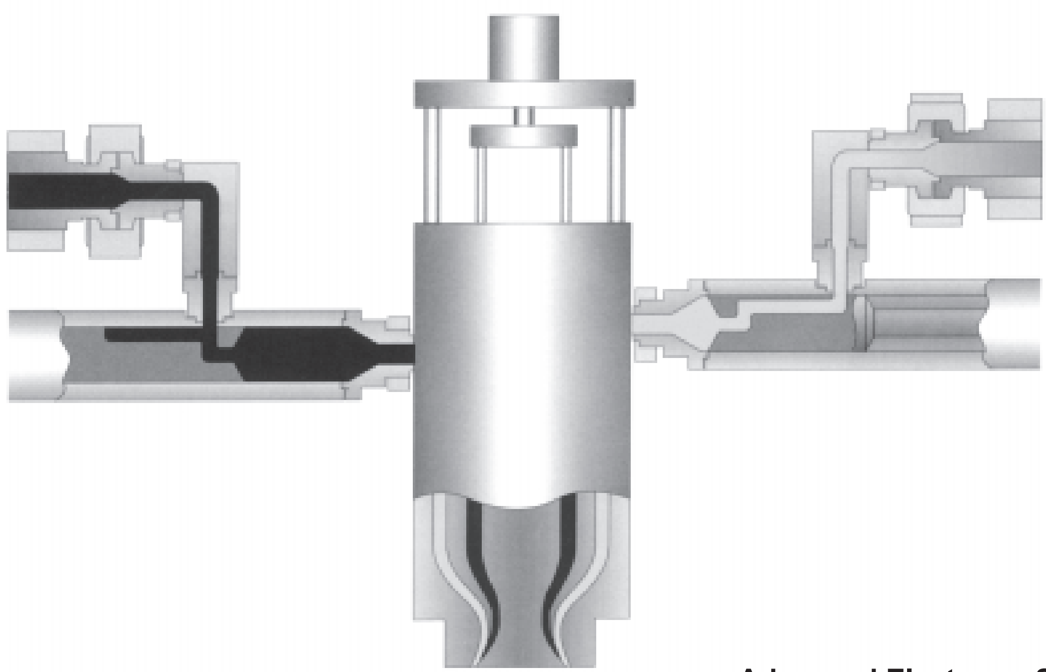
The accumulator head is considered as a sub-category of the intermittent extrusion blow molding process; it is the combination of an extrusion head with a first-in/first-out tubular ram-melt accumulator. (See Figure 17 below)

Figure 17: A Typical Accumulator Head



The accumulator head is used when long and heavy parts have to be produced. Designed to avoid the risk of parison sag, a ram accumulator style head is also used in multi-layer extrusion molding, as well as in sequential blow molding.

Figure 18: Multilayer Or Sequential Extrusion With Ram Accumulators



PARISON PROGRAMMING

Parison programming controls the wall thickness of the parison. In most cases, a 10-12 point system should be adequate. The greater the number of programming points, the greater the flexibility in tailoring wall thickness for the item to be produced. Cost and programming complexity will increase with additional programming points. Not all machines are equipped with these systems. However, third party systems, along with the necessary hydraulic actuators, are available in the marketplace for retrofit. Please contact your AES sales representative or our Marketing Technical Services Department for referral assistance.

SHOT SIZE

Shot size is defined as the amount of material needed to form a particular parison. It is an important measure, as it affects other component capacities. In blow molding machines with accumulators, accumulator volume determines shot size. The accumulator should be no less than 1.3 times the shot size, and no greater than four times the shot size. These same standards also apply to reciprocating screw volume limits and other accumulator-style machines.

OUTPUT

Specified in terms of kg/hr. or lbs/hr., extruder output combines with the length and weight of the article to be produced to determine the choice of machine. The blow molding operation should require no less than 25%, and no more than 75% of the extruder output to ensure adequate screw speed. This will allow the machine to properly plasticize and homogenize the polymer melt. It also will ensure that the machine in question has adequate capacity to form the parison within a desired time.

Mold Design

Proper mold design is critical to the success of extrusion blow molding. Extrusion blow molds can be either machined or cast, as both processes produce similar physical characteristics. The ability of the cavity to conduct heat from the part is critical for competitive processing. Extrusion blow molds can be made from cast aluminum, machined solid aluminum, or other good heat conducting alloys, such as copper bronzes.

Cast aluminum molds require that a model be built and are often useful when a representation of the product is needed before the start of major mold construction. Cut or machined molds can be made from math models and do not require the use of a physical model. The choice between cast and cut should be made on performance needs. Cast aluminum molds are a little softer and less durable than equivalent cut aluminum/alloy molds. For products with very low annual usage requirements or very large parts, a cast mold is often the best option. Cut or machined molds are typically more robust and can be modified more easily than a cast mold.

Cast Molds

Material grades for casting are typically unique to individual foundries. Common grades of aluminum include 6061 and 7075. While ferrous and copper alloys are usually not cast for the body of the mold, steel and copper alloys can be inserted as pinch edges to improve a cast aluminum mold's durability.

Machined Molds

Aluminum is the material of choice for the extrusion blow molds. For cut or machined molds, 6061-T6 or 7075-T6 grades of aluminum are commonly used. For molds that may see rigorous use or require durable pinch-off, a harder material can be substituted or inserted. Materials commonly used for this purpose include copper alloys or P-20 tool steel. Proper maintenance of ferrous alloys is required to avoid damage by oxidation.

Material Selection

The following table provides some typical property data for blow mold materials.

Table VI–Nominal Mold Material Properties

Material UNS Alloy No.	Hardness Rockwell	Density g/cm^3 lb/in^3	Conductivity W/m°K BTU/ft^2 /ft/hr/°F	Tensile Strength MPa psi
Steels:				
P-20	28-50C	7.86	38.1	1007
T51620		284	22	146
420SS	7-52C	7.75	24.9	863-1735
S42000		.280	14.4	125-250
Aluminum Alloys:				
6061-T6	60B	2.71	166.9	276
A96061		.098	96	41
7075-T6	88B	2.80	129.8	462
A97075		.101	75	67

Shrinkage

For most grades of our TPEs, mold shrinkage runs from .014-.018mm/mm (.014-.018in/in). Softer grades will exhibit slightly higher shrinkage. Your actual shrinkage will vary, depending on part shape, wall thickness and other particulars. As long as machine and molding conditions remain unchanged, any shrinkage level with a specific grade of material is repeatable - run after run.

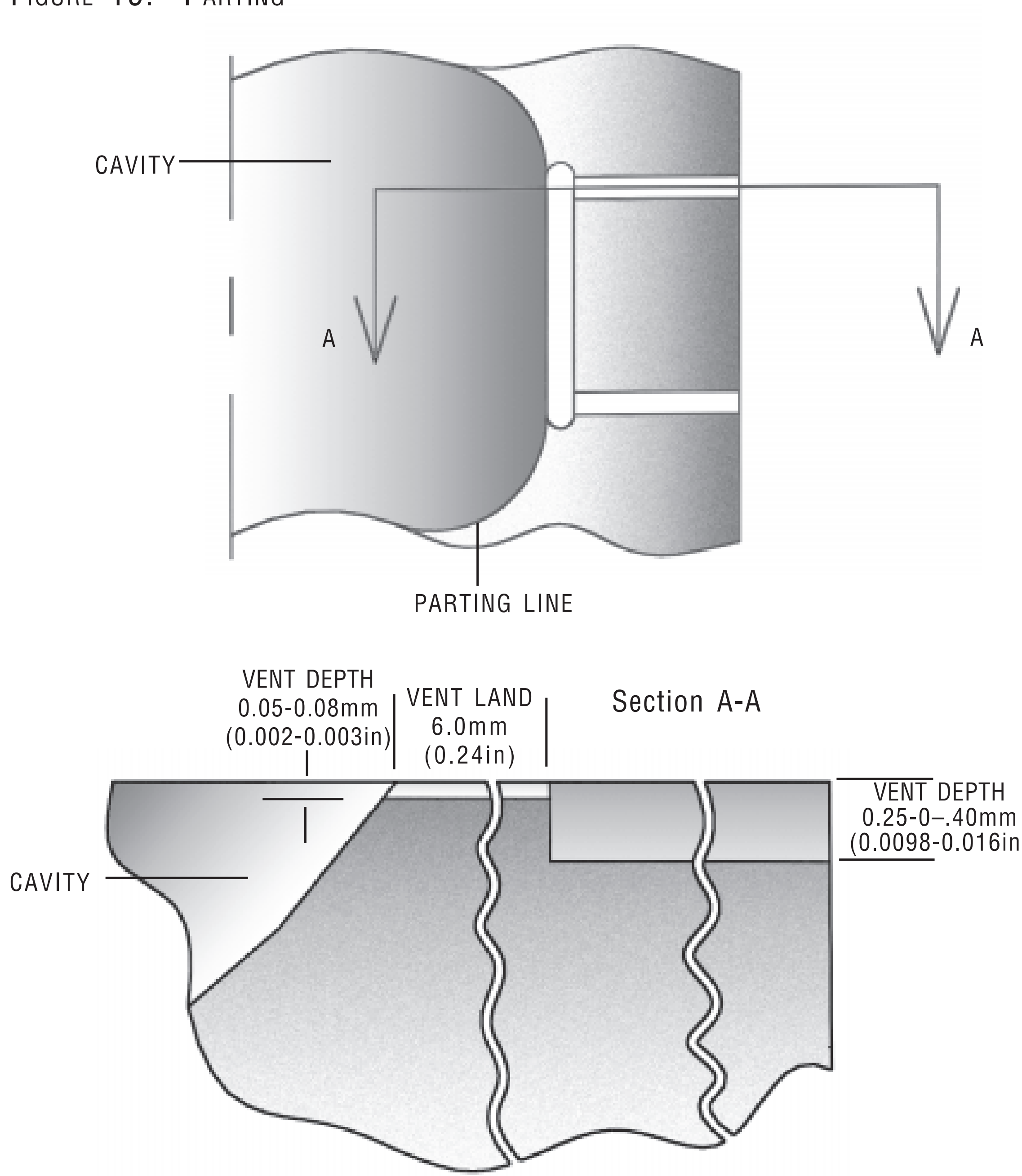
Venting

There are various ways to vent extrusion blow molds, which is critical to the success of the production process.

Parting Line Venting

Parting line venting can be added to areas of the mold containing flat parting lines. It is added to only one side of the mold. Vent depths range from 0.05-0.08mm (0.002-0.003in) with a land of 6.0mm (.24in). Beyond the land, vent depth is increased to 0.25-0.40mm (0.0098-0.016in) through channels that lead to the atmosphere.

Figure 19: Parting



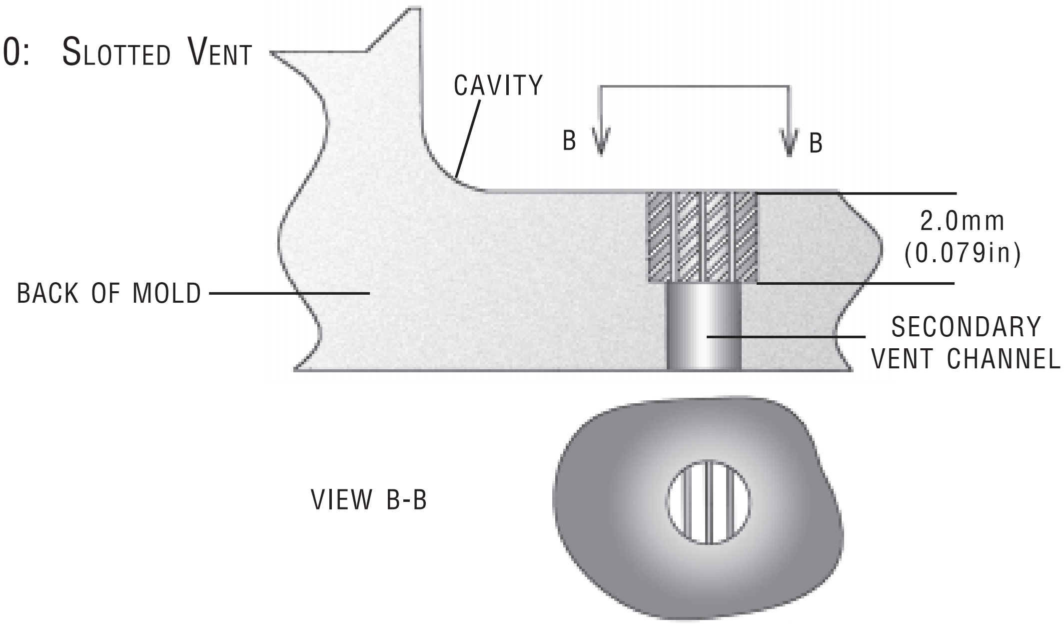
CAVITY VENTING

Cavity venting is added to areas inside the cavity containing deep draws and flat surfaces. Slotted vents are used for non-cosmetic parts.

SLOTTED VENTING

Aluminum or brass slotted vents are commercially available in a variety of sizes. They are installed from the cavity side after the cavity is cut, and they are benched to match the cavity contour. Slot widths for AES TPEs should be in the range of 0.40-1.25mm (0.016-0.49in).

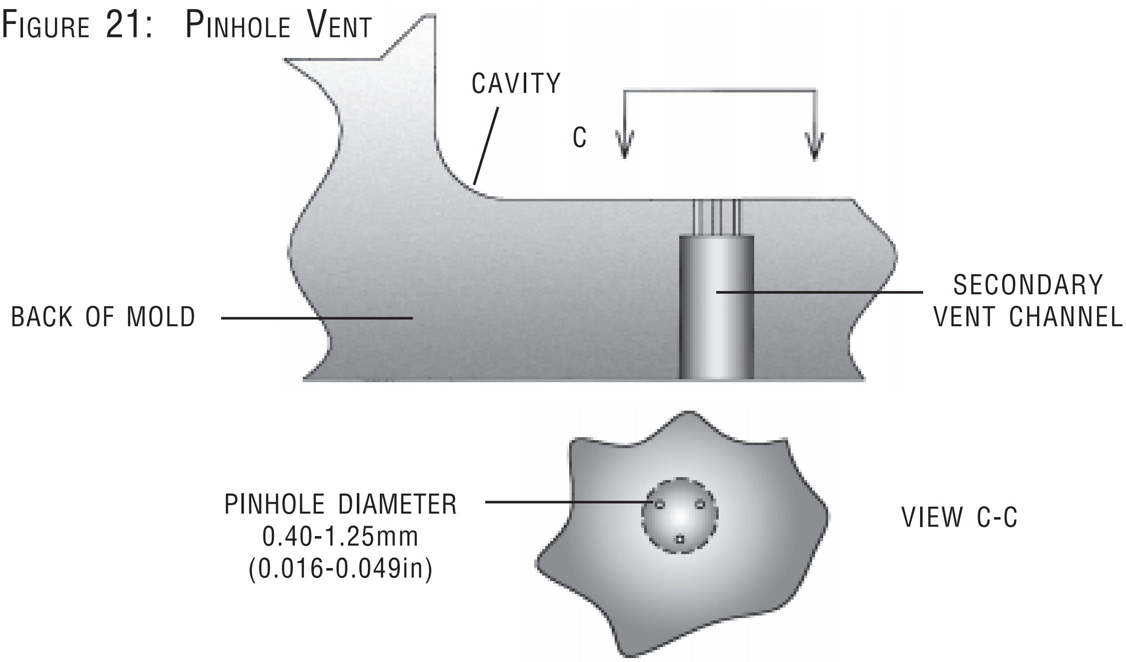
FIGURE 20: SLOTTED VENT



PINHOLE VENTING

Pinhole vents are typically used for cosmetic parts. A pinhole vent can consist of one or a group of holes anywhere from 0.40-1.25mm (0.016-0.049in). A secondary vent channel is drilled from the back of the mold block to within 2.0mm (0.079in) of the cavity surface. The pinhole vents are then drilled into the secondary vent channel from the cavity side.

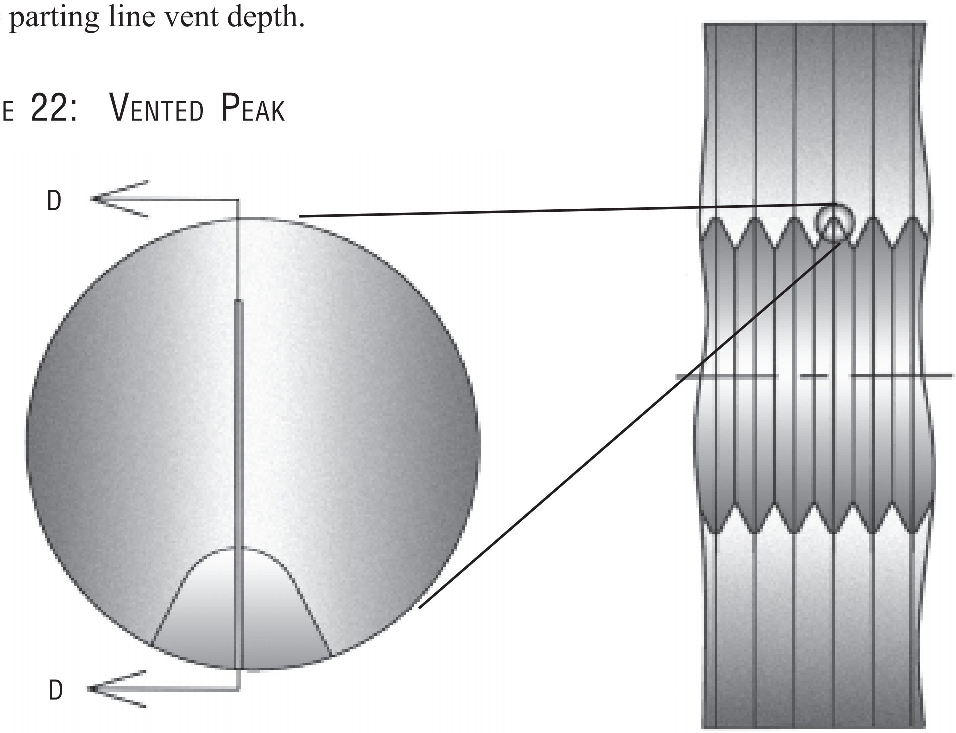
FIGURE 21: PINHOLE VENT

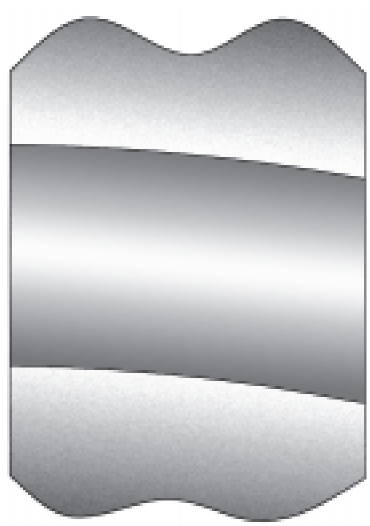


VENTED PEAK

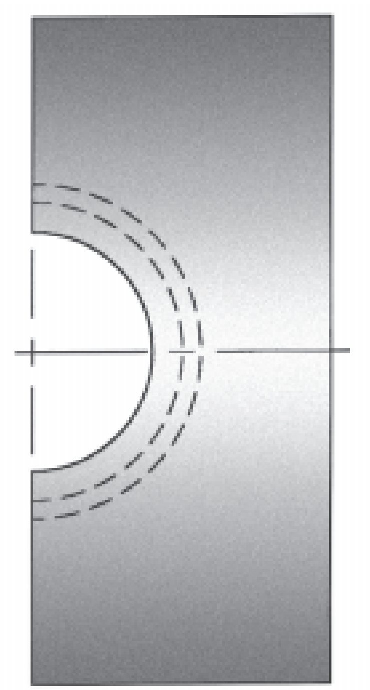
The bellows portion of a convoluted article can be built in sections. A typical section is one convolute wide-measured from peak to peak. At the apex of the convolute peak, a vent slot would be added around the entire diameter of the part. The dimensions of the vent slot are the same as that of the parting line vent depth.

FIGURE 22: VENTED PEAK





SECTION D-D



SURFACE VENTING

In order to effectively vent the air from a mold, the surface of the mold should be either sandblasted or lightly textured. This is necessary to allow the air contained between the parison and the mold surface (as the parison inflates) to migrate through the valleys of the mold surface finish and exit through the vents. In contrast, a polished mold surface may not allow air away from vents to migrate to the vents as the parison inflates. As a result, a polished surface mold may produce a part with a poor surface finish.

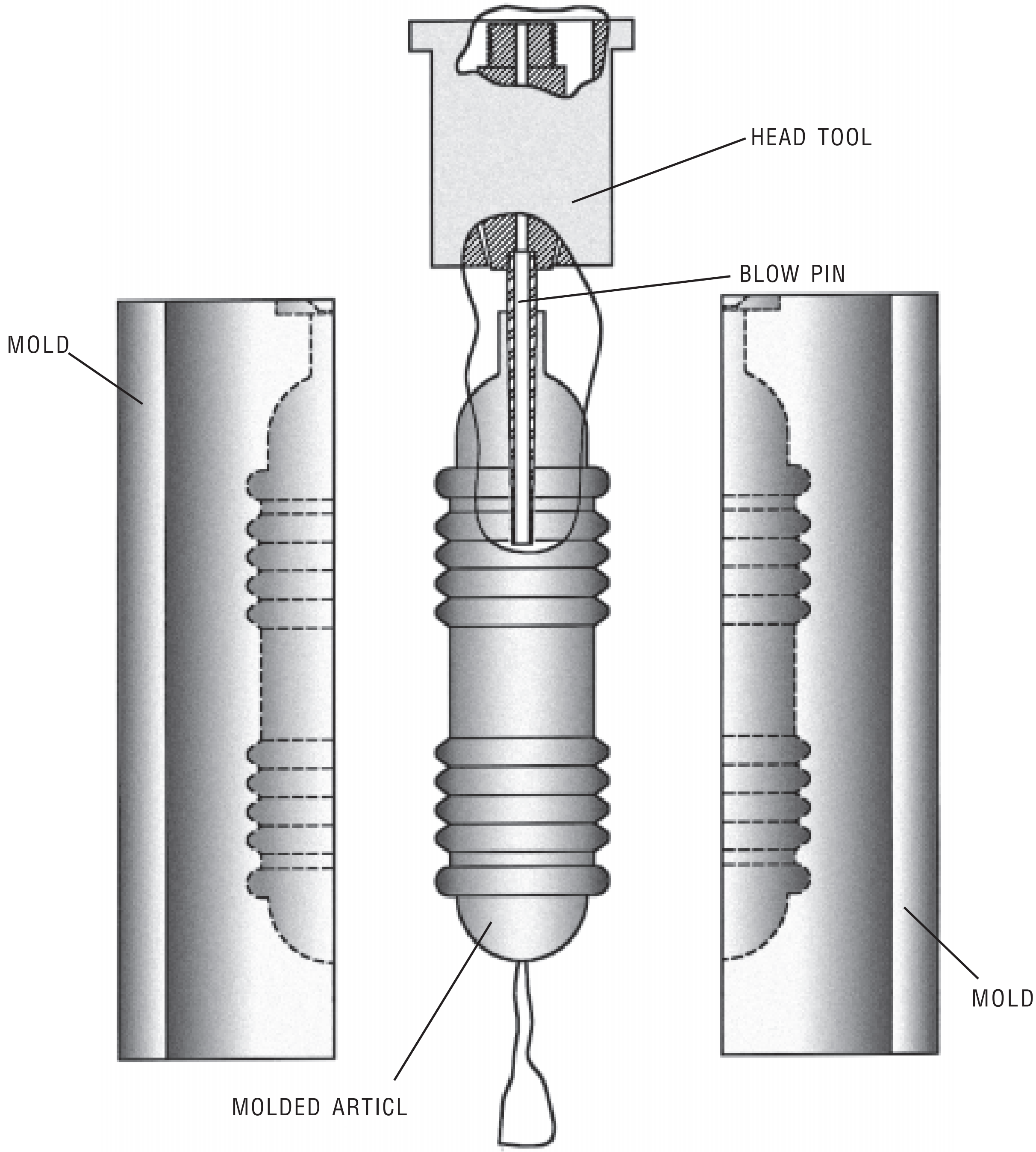
MOLD FINISH

For an untextured mold, we recommend a sandblasted finish. For aluminum molds, the use of a coarse grade of silica sand is adequate. A sandblasted finish is coarse enough to create surface venting, but not deep enough to texturize part surface. If a textured surface is desired, coarse and deeper patterns reproduce best in extrusion blow molding. Be sure to refer to extrusion blow molded sample plaques when specifying a texture. Since extrusion blow molding is a lower pressure process than injection molding, finishes cannot be easily duplicated between the two.

Part Ejection

The most popular form of part ejection uses a blow pin to "strip" the part from the mold. The blow pin can be above or below the mold, depending on the blowing source. The length and shape of the pin are a function of each specific part. A typical example of a blow pin stripping a bellows part out of a mold is shown below.

Figure 23: Blow Pin And Bellows Article



As with injection molding, pin or sleeve style ejection can also be used. This method of ejection is more successful for rigid TPEs with durometers in the Shore D scale. We recommend that pin ejectors be located on flat or smooth article surfaces, and be no smaller than 12.7/19.0mm (.5/.75in) in diameter. Maximizing the diameter of the ejector pin will minimize any part deflection during ejection.

PARTING LINES

Pinch, dammed and flat styles of parting line are used in extrusion blow molds.

FIGURE 24: PINCH PARTING LINE

Pinch parting line is employed on areas where the parison must be pinched together, creating flash. A typical pinch design is show below. Pinch land length is 0.50-0.75mm (0.02-0.03in) with a pinch angle of 45 degrees. Pinch relief depth is 1.5-2.0 times the wall thickness.

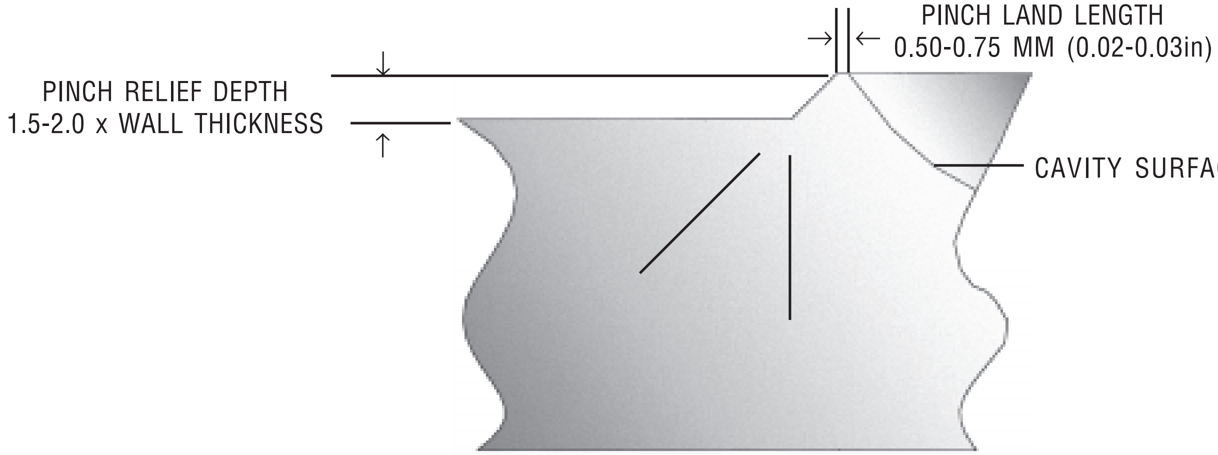


FIGURE 25: DAMMED PARTING LINE

This is used in areas where the parting line on the inside requires additional material. It is often used when an inside diameter must be machined smooth to contain no voids.

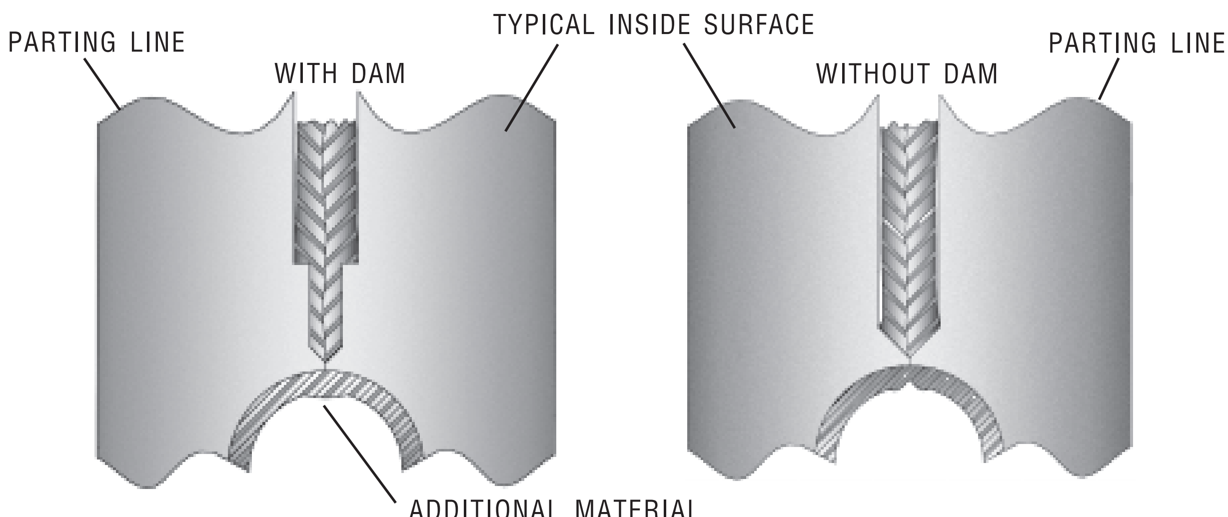
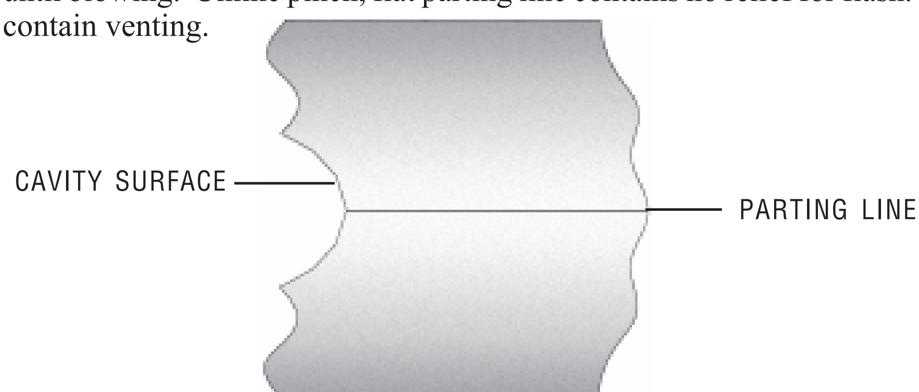


FIGURE 26: FLAT PARTING LINE

A flat parting line is used where the parison is captured inside the cavity and will not contact the parting line until blowing. Unlike pinch, flat parting line contains no relief for flash. However, flat parting can contain venting.

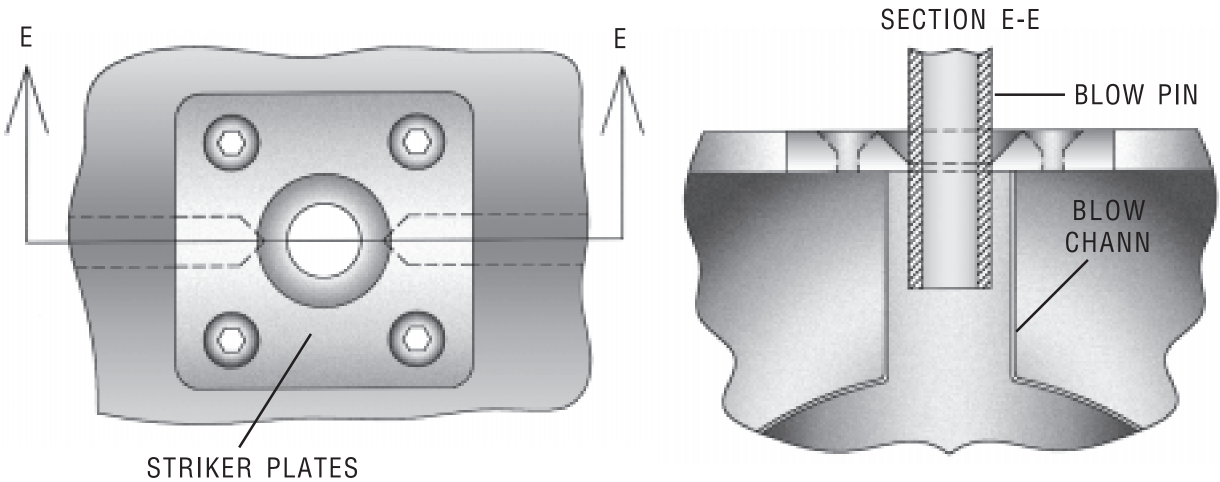


PART INFLATION

Blow Pin

Referred to as top blow, the blow pin is the most efficient way to inflate a part. It is attached to the pin portion of the extrusion tooling. The mold, which contains a blow channel, closes around the blow pin, made from Cr steel, iron pipe or brass. Size of the pin can vary, depending on the finished part requirements. The blow channel is generally 50% larger than the blow pin.

Figure 27: A Blow Pin Apparatus

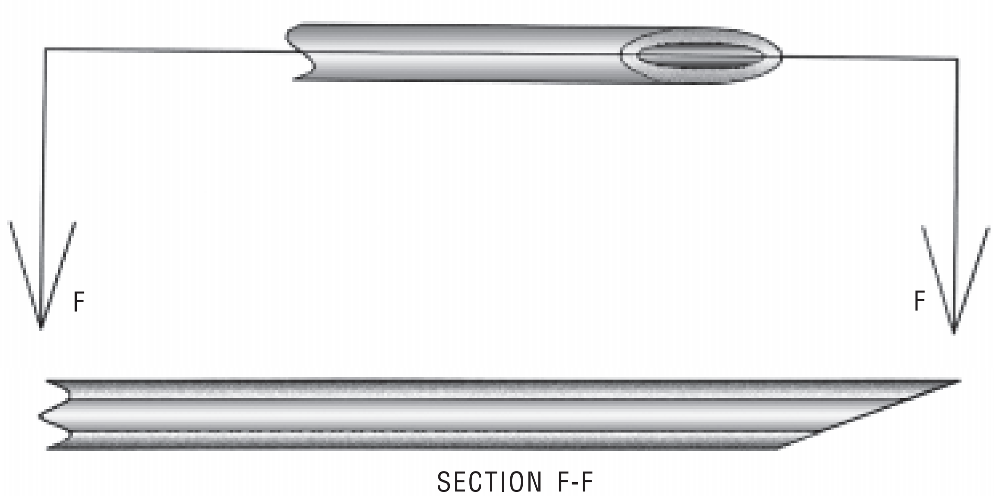


When the striker plates can be located directly adjacent to the cavity surface, the blow channel can be eliminated. This is useful when the channel is not part of the scrap and a finished hole can remain.

Hypodermic Needle

A hypodermic-style needle is another way to inflate a part. This approach is used when a discreet hole in the part is required, or when it is not feasible to use a blow pin. A needle made from small diameter steel tubing is attached to an air cylinder. Separate circuits controlling the blowing air and the needle movement are advisable.

Figure 28: Hypodermic Needle

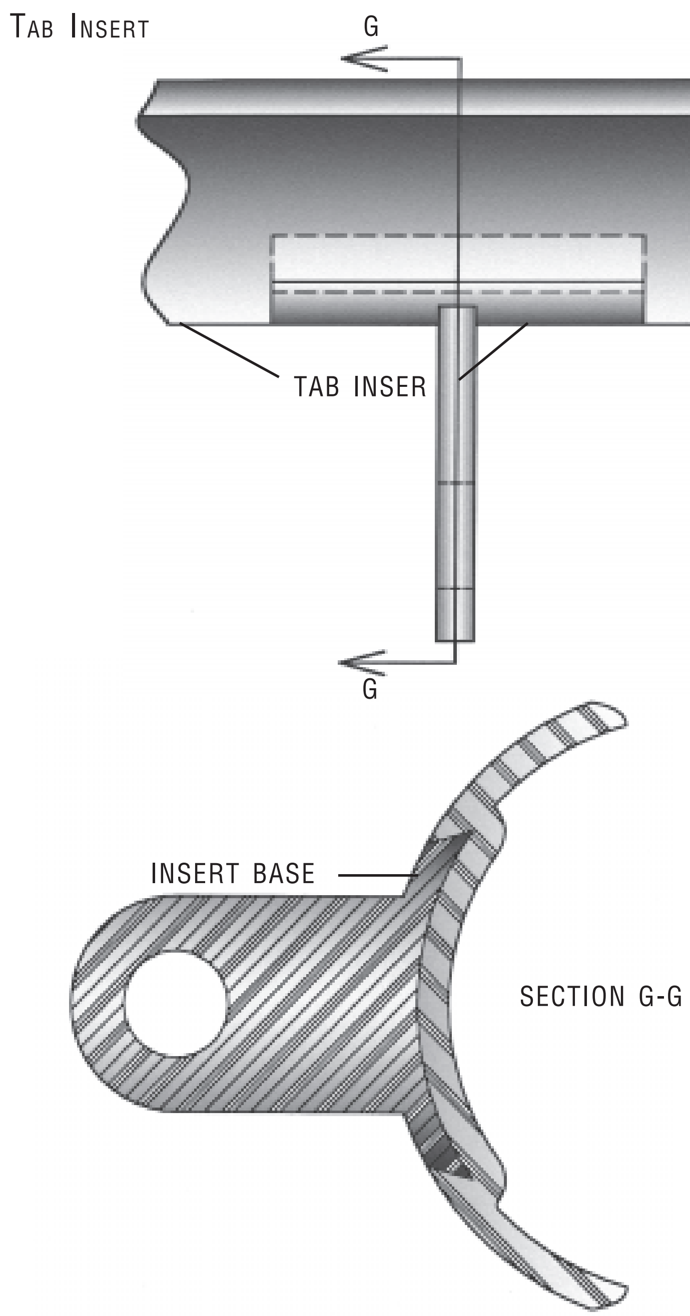


INSERTS

To accommodate inserts, extrusion molds must have receptacles to hold and allow the insert to release during part ejection. Inserts placed in a blow mold should allow the blown part to release on removal from the mold. If this is not possible, a pneumatic slide mechanism should be used. Venting around the insert is necessary to ensure consistent encapsulation. Inserts should be securely placed while the mold is closing.

Typical inserts include mounting tabs, nuts, bolts, ports and tubes. These can be added to a part by placing an insert into the mold and blowing a parison around it. Attachment to the part can be accomplished through mechanical, adhesive or thermal weld. For mechanical attachment, inserts need a large base with a design that allows for parison encapsulation, as below:

FIGURE 29: MOLDED-IN INSERT



INSERTS

For a thermal bond, the insert should be made from polypropylene or Santoprene® rubber and be heated to around 93°C (200°F) before insertion into the mold. Experiment to find the best preheat temperature.

Even if the insert is incompatible with the blow molding material, a bond can still be achieved by using an adhesive. Please refer to AES Technical Correspondence Document on adhesion. Specific information is available through the AES AnswerPerson from 8:00 a.m. to 6:00 p.m. U.S. Eastern Time at 1-800-305-8070 or 1-330-849-5272; or call your nearest AES representative listed on the back cover; or visit our website at www.aestpe.com.

EXTRUSION DIES

The die and the mandrel, or the ring and the core pin, give the final shape and size to the extruded parison. Consequently, the die assembly should be resistant to the extruded material being processed.

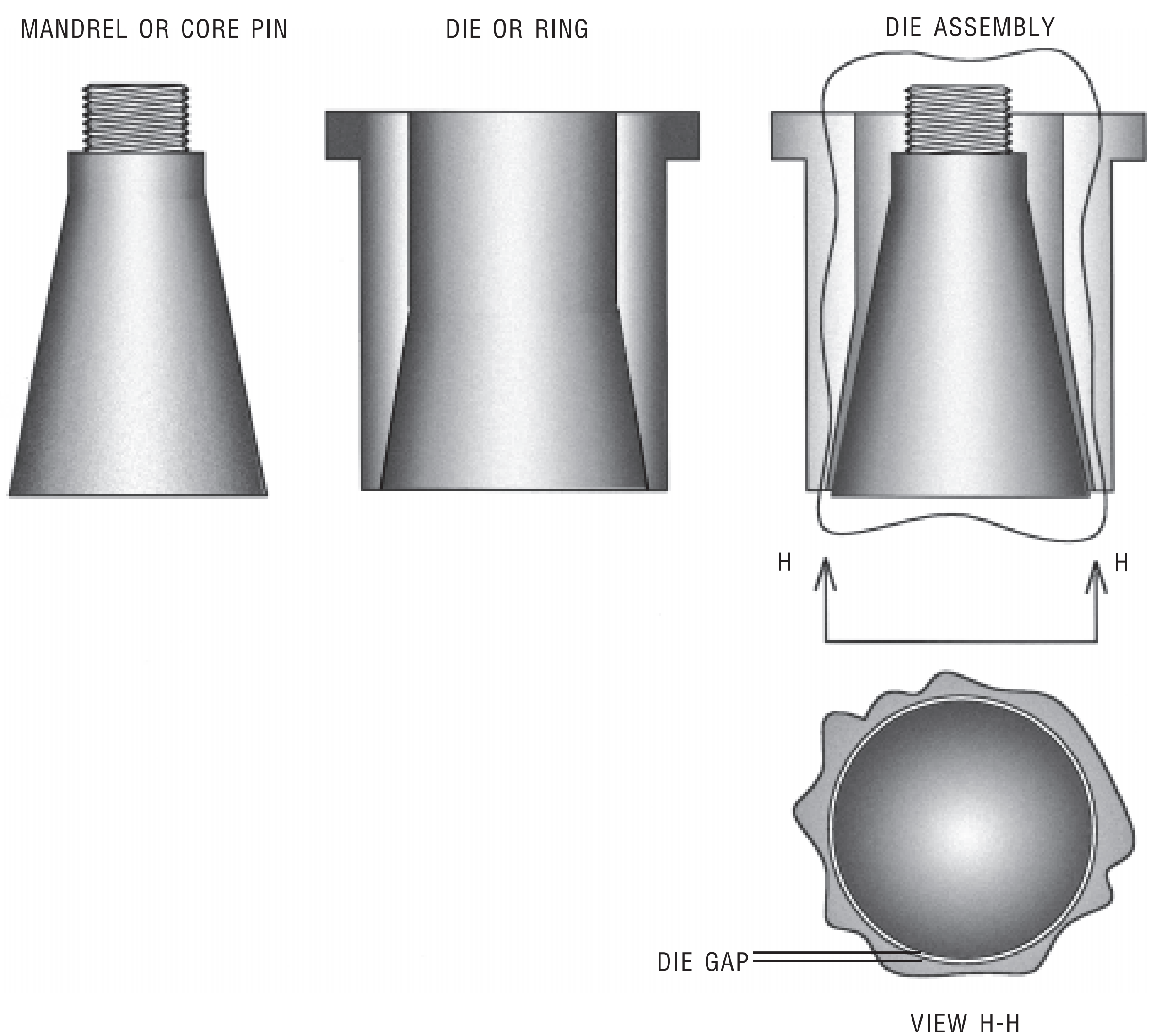
Material

We recommend the following tool steel content for producing extrusion dies for our TPEs: CO.38, Si 0.50, Mn 0.50 and Cr 13.6% (minimum chromium content.) Be sure to harden the metal used with the mandrel. It is good practice to dismantle the die after extrusion and clean it with brass tools. An anti-corrosion spray after cleaning will help maintain the life of the tools.

Style: Round vs. Oval

For products with a round cross section, use circular extrusion tooling to produce a symmetrical parison.

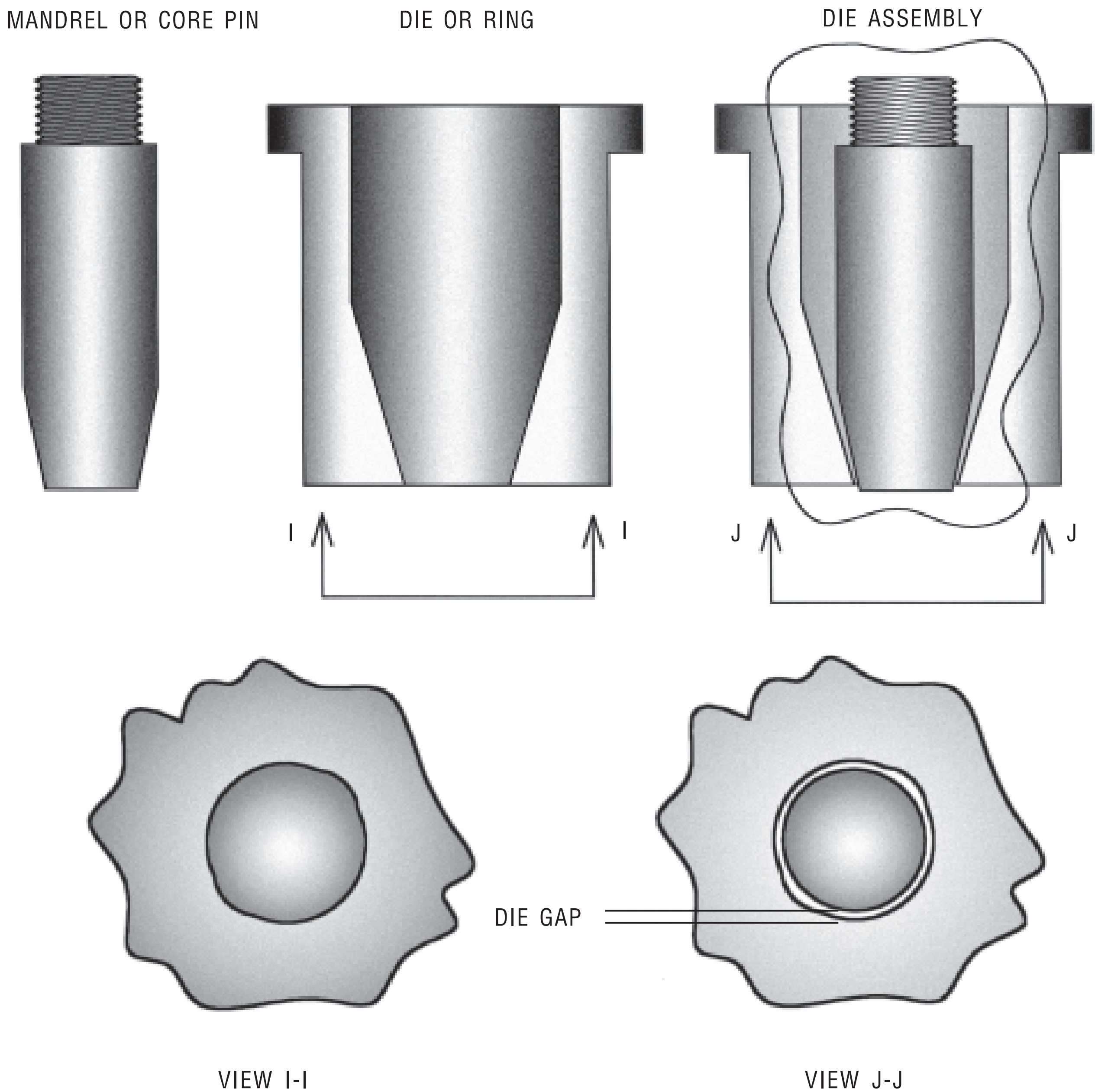
Figure 30: Typical Circular Extrusion Tooling



EXTRUSION DIES

For products with an oval cross section, it may be necessary to use non-round head tooling for uniform wall thickness.

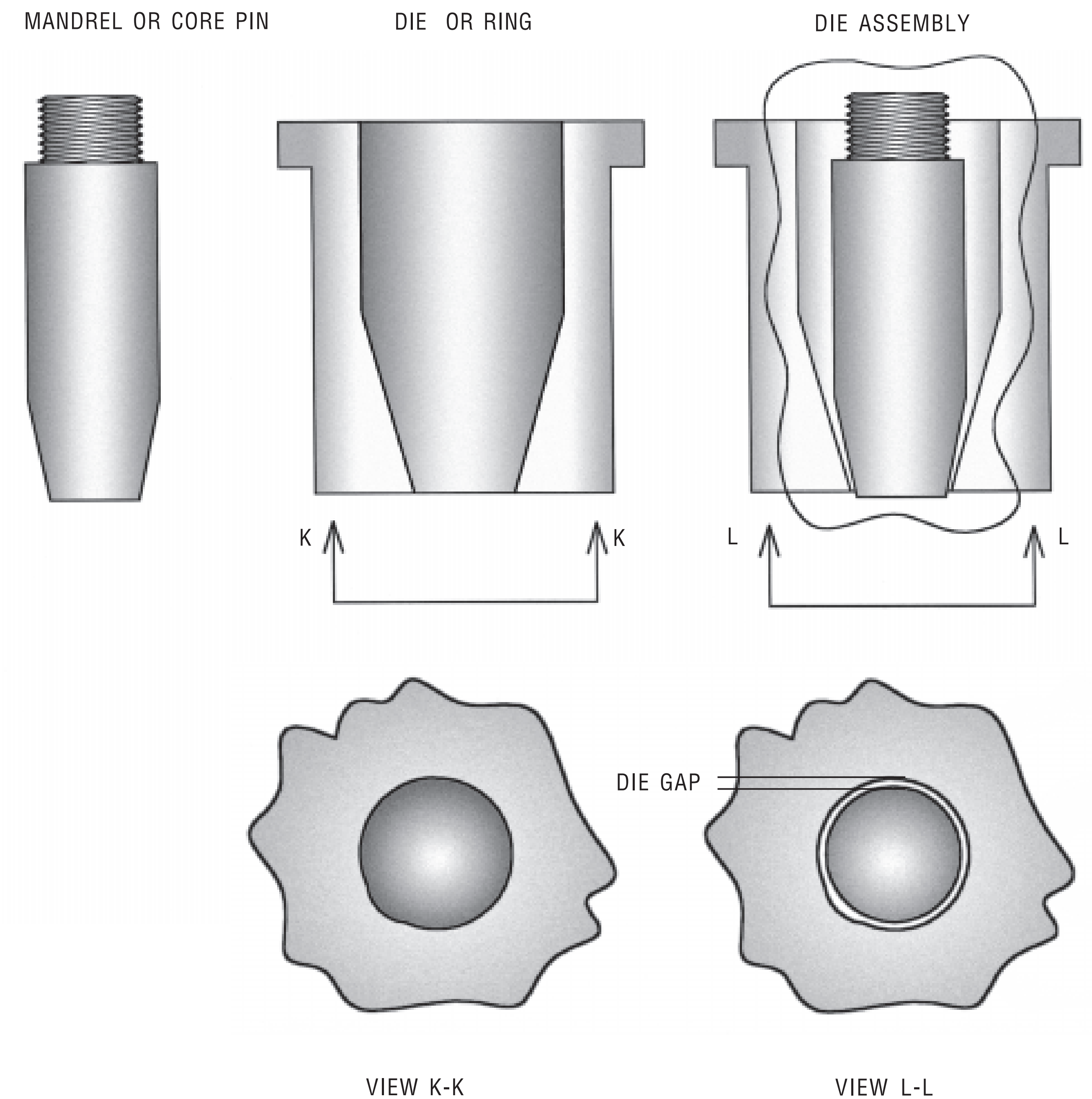
FIGURE 31: NON-ROUND HEAD TOOL, BALANCED (RECOMMENDED)



EXTRUSION DIES

For processing reasons, it is important that such tooling be balanced for flow. This is accomplished through a 2-axis symmetry. For comparison, an example of an unbalanced tool is shown below.

FIGURE 32: NON-ROUND HEAD TOOL, UNBALANCED
(NOT RECOMMENDED!)

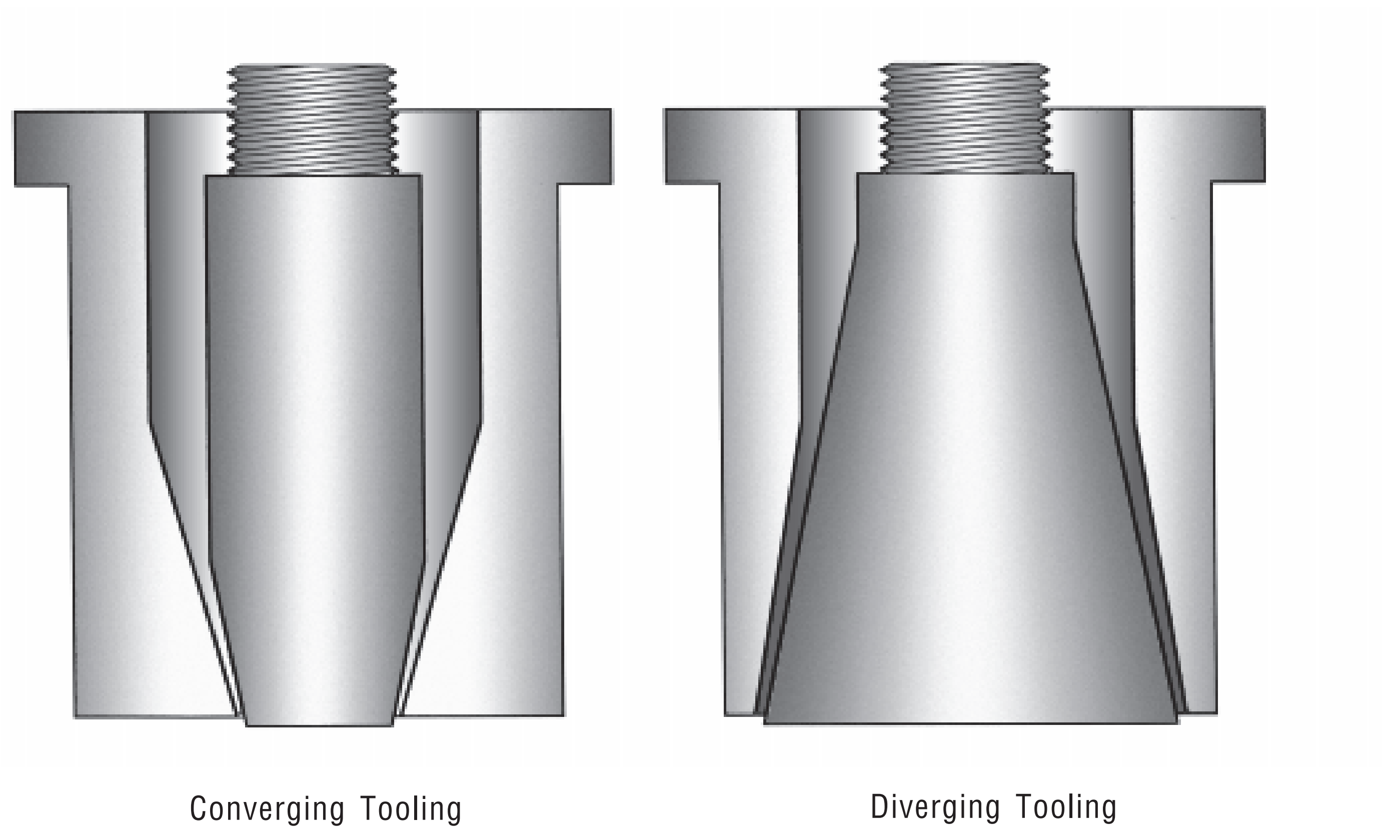


Tooling Design

Tooling Design

Die tooling for extrusion blow molding is chosen according to the size of the article being produced. Choose the maximum die size capable of producing the desired article while minimizing the blow-up ratio. The choice of converging or diverging tooling will depend upon specific process equipment. A general representation of converging tooling and diverging tooling is shown below.

Figure 33: Converging/Diverging Tooling



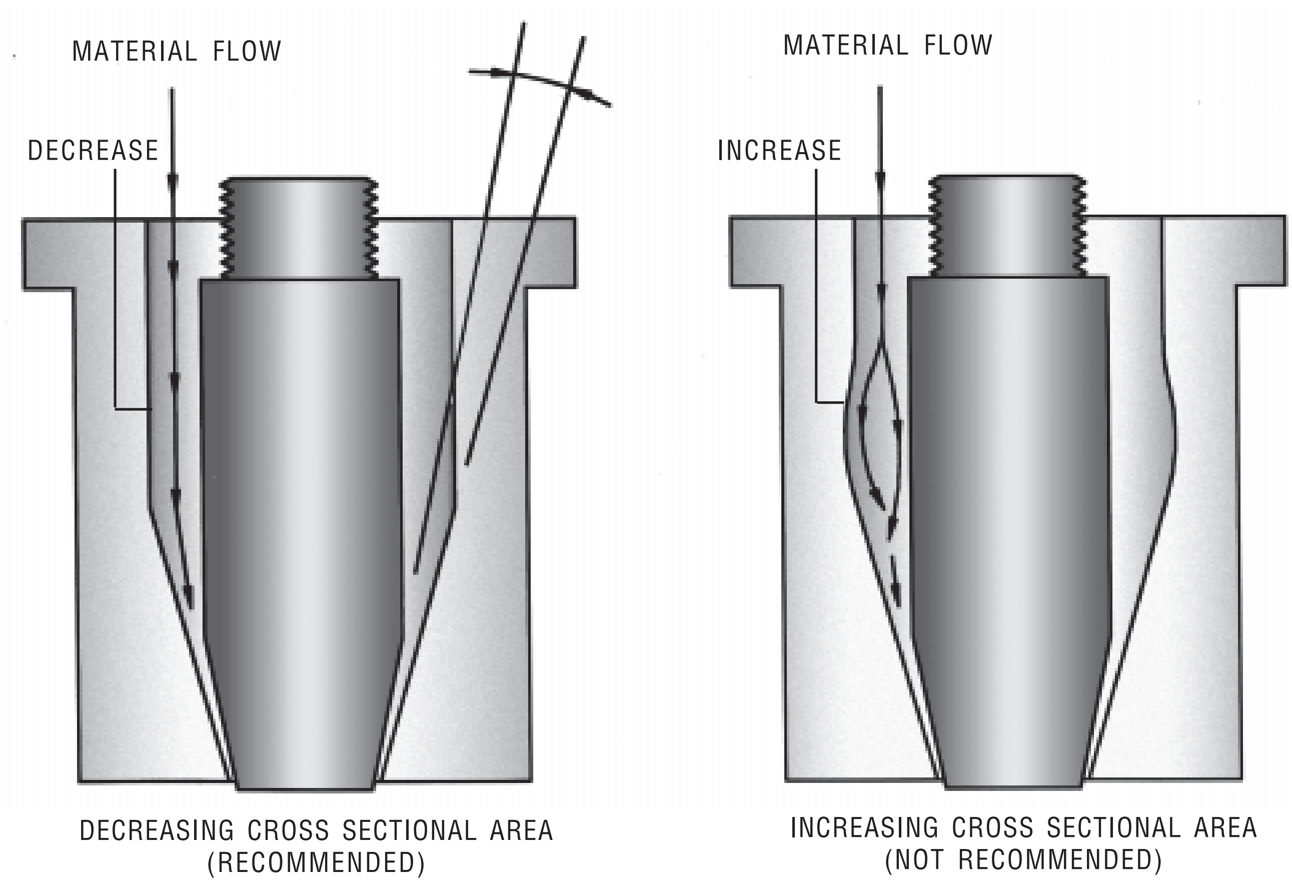
TOOLING DESIGN

Material swell is also important. Typically, our resins exhibit very low die swell. For grades with durometers in the Shore A scale, die swell will be less than 5%. For durometers in the Shore D scale, die swell will be around 10%. However, individual results will vary based on the characteristics of the equipment and the melt temperature of the material.

Either type should feature the following:

- Angle difference between the pin and the chase of 3-5 degrees; larger angle as required.
- In the direction of the material flow, the cross sectional area should be decreasing, never increasing.

FIGURE 34: ANGLE DIFFERENCE BETWEEN PIN AND CHASE
3°-5 DEGREES° IS COMMON (UP TO 6-8 DEGREES° AS REQUIRED)



TOOLING WITH DETAILS OF ANGLE DIFFERENCE AND DECREASING CROSS SECTION

SECONDARY FINISHING

BONDING

AES thermoplastic rubbers and elastomers can adhere to many substrates with chemical bonding, such as polypropylene and nylon. Please refer to AES Technical Correspondence Document on bonding. Specific information is available through the AES AnswerPerson from 8:00 a.m. to 6:00 p.m. U.S. Eastern Time at 1-800-305-8070 or 1-330-849-5272; or call your nearest AES representative listed on the back cover; or visit our website at www.aestpe.com.

DRILLING AND PUNCHING

Various methods are available to create holes in elastomeric materials. For rigid materials in the 80A and harder durometers, twist drills and forstner type cutters are more successful. Otherwise, a punch die may be used. Punch dies can create holes and other shapes in virtually any blow moldable grade AES TPE. The die should be constructed with a male and female component, and should be made to tight tolerances to ensure a clean cut. When cutting, the back side of the elastomer should be fully supported.

CUTTING/TRIMMING

While it is possible to produce hollow parts that are completely finished due to proper mold design, most extrusion blow molding requires secondary finishing. Usually the pinch-off and the flash at the neck must be removed; also the neck must often be reamed and sized to produce the finished part. Standard trimming equipment like fly cutters and guillotines, designed for fast trimming where tolerances are large, are quite successful. Trim spinning is also an option for cylindrical parts.

WELDING

Santoprene rubber can be welded to itself, as well as to polypropylene and polypropylene-based materials, using hot plate, HF, ultrasonic and spin welding methods, to name a few. For more specific information about possible welding techniques, refer to AES Technical Correspondence Document on welding.

PART COST/WEIGHT ESTIMATING

When deciding what technology to use to produce a hollow part, a part cost analysis can prove helpful.

Commonly, manufacturing (or purchase) costs of thermoset vs. thermoplastic rubber parts are compared. So are the costs of injection molding vs. blow molding.

Despite the generally higher raw material cost of thermoplastic rubber as compared to thermoset rubber, the extrusion blow molded thermoplastic part can be cheaper to manufacture for several reasons.

- The use of thinner walls.
- The resulting shorter cycle times due to less processing time, easier demolding and the absence of vulcanization.

Of course, cost comparisons have to reflect real facts from the shop floor, like cavity number and cycle time. However, we can show that Santoprene rubber parts have been produced two to three times cheaper, for example, than existing parts made with chlorinated thermoset rubber. *

That means any integration of a thermoplastic material should help to reduce the cost of the part/assembly.

When comparing injection molding to blow molding for a thermoplastic rubber hollow part, blow molding has the edge. This is based on:

- The cooling time and the demolding time, which impact the cycle time.
- The part volume and the number of cavities. The bigger the part, the higher the advantage for the blow molding process.
- The injection mold investment, which can be significant in light of demolding problems.

More information on cost analysis is available from your local Advanced Elastomer Systems service representative.

*Ask your local AES service representative for cost comparison examples of Santoprene rubber components and thermoset rubber parts.

SUMMARY OF KEY PARAMETERS FOR THE EXTRUSION BLOW MOLDING AES THERMOPLASTIC ELASTOMERS

Extruder screw:

Polyolefinic design with:
compression ratio: 2.5 to 4.0:1
L/D: 24 to 30:1
The higher the shear, the better the quality of the melt.

Extruder barrel:

Smooth surface with fan cooling but water cooling in the feed throat section.

Extruder temperature settings:

Depends on grade to process but generally between 170° and 215°C, (338° and 419°F).
(See specific conditions in relevant tables from this manual)
Melt temperature limited to 215°C (419°F) with GEOLAST Rubber.

Always purge with polypropylene after having processed acetal or PVC resins and before processing our thermoplastic rubbers.

Extruder head design:

Axial flow: use offset/staggered spider legs.
Radial flow: use a heart shaped mandrel.
Accumulator: may be necessary depending on parison length.

Extruder die:

Metal: steel with 13.6% minimum chromium content.
Design: always decrease the cross sectional area from head to die angle.
Difference between pin and mandrel: 3 to 5 degrees, typically.

Parison programming:

Highly recommended, often mandatory.

Recycled material:

Use grinders with a three-blade standard plastic granulator having a knife clearance of 0.13-0.18mm (0.004-0.006in) and a filter with 10mm (0.375in) holes; a water cooled grinding chamber is advised for high capacity regrinding.

Drying:

Always dry our material in a desiccant dryer for 3 to 4 hrs. at 60-80°C (140-180°F).

Venting:

Can be quite important; refer to relevant section in this manual.

Shrinkage:

Typically .014-.018mm/mm (.014-.018in/in), depending on part design, grade and processing parameters.

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