Technical Data Sheet

Extrusion Blow Moulding of Grilamid and Grilon

EMS-GRIVORY

Contents

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1. EMS-GRIVORY extrusion blow moulding materials

The blow moulding process has been employed since about 1950, though its application to polyamides came much later. In recent years the development of technical blow moulding materials has been pushed ahead, so that there are now a considerable variety of them.

With Polyamide 6 there are now types ranging from good to very high impact strength. The reinforced types are being produced with 15 % and 20 % glass fibre reinforcement.

Polyamide 12 is now available unreinforced or with 20 % glass fibres, possessing good and very high impact strength. The available types all feature very good resistance to hot water and coolants.

Table 1:

Designation	Glass content	Impact strength	Melt strength
Grilon EB50 H	—	good	high
Grilon EB50 HDZ	—	high	high
Grilon R50 HNZ	—	very high	high
Grilon EBV-15H	15 %	good	high
Grilon EBV-2H	20 %	good	very high
Grilon RVZ-15H.1	15 %	high	high
Grilon ELX 40 HNZ	—	very high	high
Grilamid L20 ANZ	—	high	high
Grilamid L25 ANZ	—	very high	very high
Grilamid LV-2 ANZ	20 %	good	very high

2. Processing behaviour of polyamide in extrusion blow moulding

2.1. Melt strength

Very exacting requirements are imposed on the material when processing polyamide by extrusion blow moulding. One of the most important properties is the melt strength.

The term melt strength describes the "stability" of the parison. With higher melt strength it remains dimensionally stable, whereas with low melt strength it elongates more.

Consequently, materials with high melt strength are needed for extrusion blow moulding.

For this EMS-GRIVORY has developed its own procedure to assess the melt strength. A tube is continuously extruded and the time taken by the tube to cover the distance (1 metre) from nozzle to floor is measured.

The melt strength is always measured with an output of 100 cubic centimetres per minute and a fixed temperature profile.

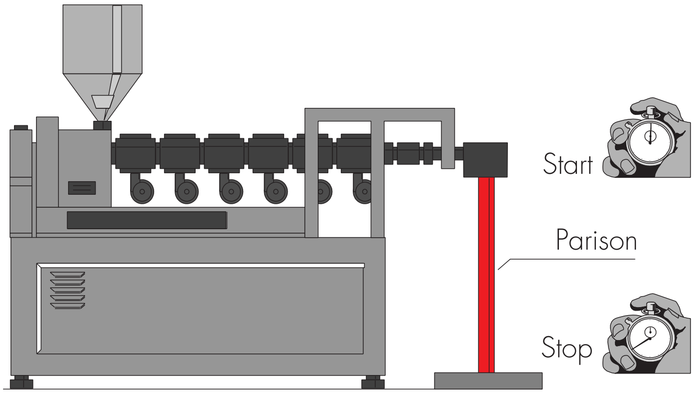

Fig. 1: Device for determining the melt strength by the EMS-GRIVORY method.

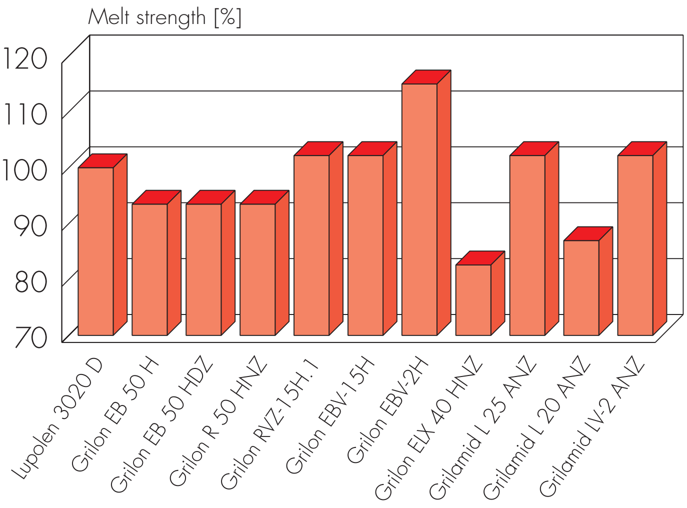

Fig. 2: Comparison of a standard PE-LD (at 210 °C melt temperature) with the EMS-GRIVORY blow moulding types (at 270 °C melt temperature).

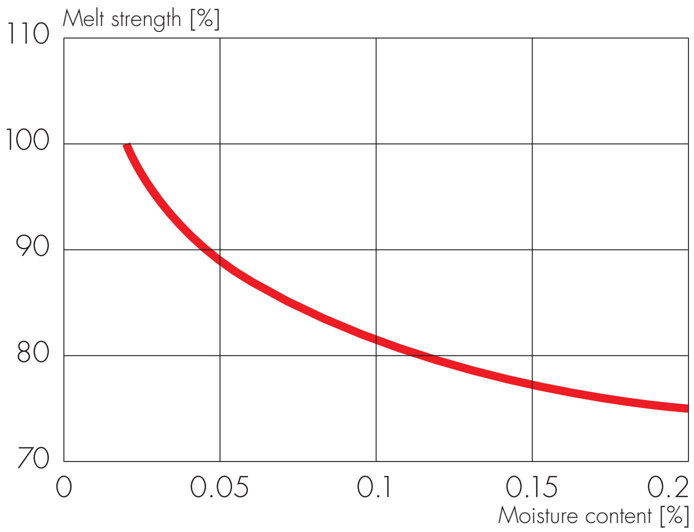

Fig. 3: Melt strength versus moisture content in the granulate.

2.2. Drying

Polyamides are hygroscopic (moisture absorbing) and take up moisture from the ambient air during storage. The moisture absorption rate depends on the relative air humidity. Only 30 minutes exposure to ambient air at 23 °C/50 % r.h. may cause difficulties in processing.

EMS-GRIVORY blow moulding materials are supplied with a moisture content below 0.06 %. It is important to avoid damaging the containers during storage and handling. They also should not be opened in a cold state, otherwise a condensation on the granulate will take place. This happens especially during winter, when cold material is brought to the machine. To prevent this problem, about 24 hours before processing the material should be placed in a room with the same temperature as the production hall.

For blow moulding, the granulate must have a residual moisture content less than 0.1 %. Make sure in particular that the moisture content is kept at the same level, to ensure constant processing. With more than 0.15 % moisture, bubbles arise in the parison, leading to rejects. Moreover processing with elevated moisture content reduces the melt strength. This means that if the material is processed with varying moisture and hence different melt strengths, constant process control and constant quality will not be attained.

Dry-Air dryers with a dew point of at least –25 °C have proved themselves suitable for drying polyamides. Drying temperatures from 60 °C to 80 °C are applied for 4 to 8 hours. If the material has been exposed to the ambient air for several days or weeks, it has to be dried for at least 10 hours.

When using regrind, grinding must be done right at the blowing machine, followed by immediate reuse. If nevertheless the regrind or the flashes to be reground are exposed to the ambient air longer than 20 – 30 minutes, they must be dried again, just like granulate from bags.

After drying, the material must not be allowed to take up moisture again before processing. This may be ensured by taking following precautions:

- Keeping small material quantities in the hopper or using small hoppers generally
- Keep the hopper always closed
- Transport dried material with dry air

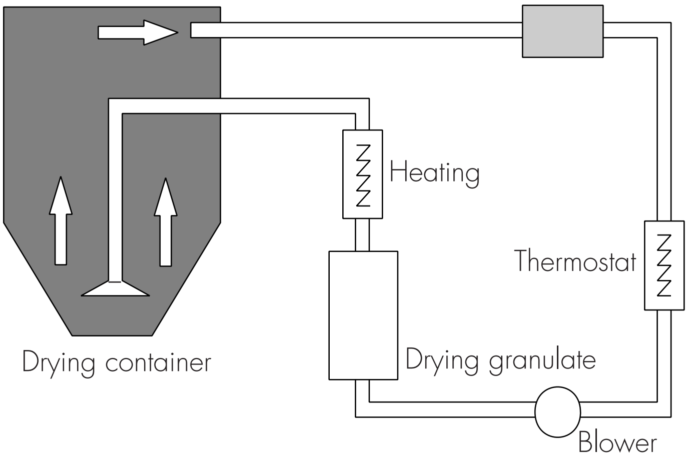

Fig. 4: Schematic dry air dryer

As a rule of thumb, the dryer volume should be 6 to 10 times the hourly material throughput. For example with a throughput of 40 kg/h the dryer volume should be at least 400 litres. The throughput multiplier depends on the particular process, how long the regrind has been exposed to the ambient air, and whether the virgin material is in undamaged bags. To obtain constant material drying, the used dryer should preferably operate continuously. There are dry air dryers that adapt the drying temperature automatically to the material throughput, keeping the residual moisture more constant than conventional equipment.

2.3. Processing temperatures

Polyamide blowing grades are generally tolerant in processing with regard to the temperature control. Of course, the melt strength is lowered by higher processing temperatures. The standard processing temperatures are set out in Table 2.

Feed zone temperatures:

By using a grooved feeding zone, temperature control should run with oil. If the machine has a smooth feed, a temperature of 60 – 80 °C at the hopper may be run.

To ensure proper material conveying, a high feed zone temperature must be chosen. Accordingly, the rule is: the deeper the grooves, the higher the temperature should be. However, if the extruder still blocks, the material must be fed in slowly or preheated (about 120 to 130 °C).

Cylinder temperatures:

The cylinder temperatures must be selected so that the melt temperature does not have a bigger difference than 10 – 15 °C. If deviation exceeds 15 °C, the cylinder temperature must be brought into line. Generally speaking, very good results can be achieved with an elevated cylinder temperature at the first zone followed by a constant temperature profile. This temperature profile may differ depending on the screw geometry, but it must be optimized.

Head temperatures:

The head temperatures must be set according to the melt temperature. To check the parison swelling at the die, a temperature lower or higher than the melt temperature may be run. It should, however, not be too low if a good surface quality is to be assured.

Mould temperatures:

Owing to the molecular chains of the extrusion blowing types, crystallization generally proceeds very slowly. Therefore blow moulding polyamides can be processed with low mould temperatures and still achieve good product quality. Moreover, due to the unilateral one-side cooling in the mould, a slower cooling than in injection blow moulding and hence an adequate crystallization can be attained.

Table 2:

Material	Melt temperature [°C]	Grooved/Feeding Zone [°C]	Cylinder [°C]	Head [°C]	Mould [°C]
Grilon EB50 H	240–250	120–160	240–260	230–250	40–80
Grilon EB50 HDZ	240–250	120–160	240–260	230–250	40–80
Grilon R50 HNZ	240–250	100–160	240–260	230–250	40–80
Grilon EBV-15H	250–260	120–180	250–260	230–250	40–90
Grilon EBV-2H	250–260	130–180	250–260	230–250	40–90
Grilon RVZ-15H.1	250–260	100–160	250–260	230–250	40–90
Grilon ELX 40 HNZ	230–240	100–140	230–240	225–240	40–80
Grilamid L20 ANZ	220–240	120–140	220–230	220–230	20–60
Grilamid L25 ANZ	220–240	120–140	220–230	220–230	20–60
Grilamid LV-2 ANZ	220–240	120–140	220–230	220–230	20–60

Melt temperatures:

Through the melt temperature the melt strength can be adjusted within certain limits. Increasing the melt temperature by 20 °C will lower the melt strength by 20 – 30 %. For the PA6 blowing types the melt temperature should always be above 230 – 235 °C if smooth surfaces are to be obtained.

2.4 Parison swelling

«Parison swelling» is defined as the change of diameter after the die exit. No values of general validity can be stated for it, because a great number of parameters are involved. Only tendencies can be indicated here:

- The lower the melt temperature, the greater the swell (depending on the die geometry, see Fig. 5).
- The higher the melt strength, the greater the swell.
- The higher the extrusion speed, the greater the swell.
- The gentler and slower the melt is formed into the required diameter, the less the swelling.

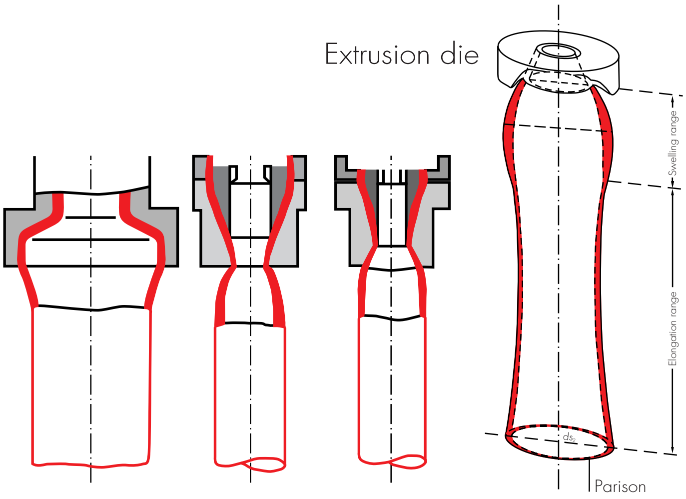

Fig. 5: Tube swell versus die design and schematic presentation of swell and elongation behaviour.

Nevertheless it can be said that polyamides have a lower swelling than polyethylene and polypropylene.

Table 3:

Material	Wall thickness [mm]	Extrusion pressure [bar]	Swell [%]
Grilon R50 HNZ	2	100	5
	2	200	10
	4	100	7
	4	200	13
Grilon RVZ-15H	2	100	13
	2	200	11
	4	100	12
	4	200	6

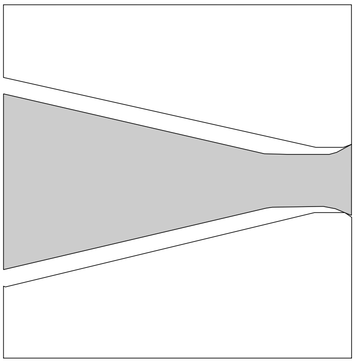

Fig. 6: Schematic 55 mm die for swelling test in Fig. 7.

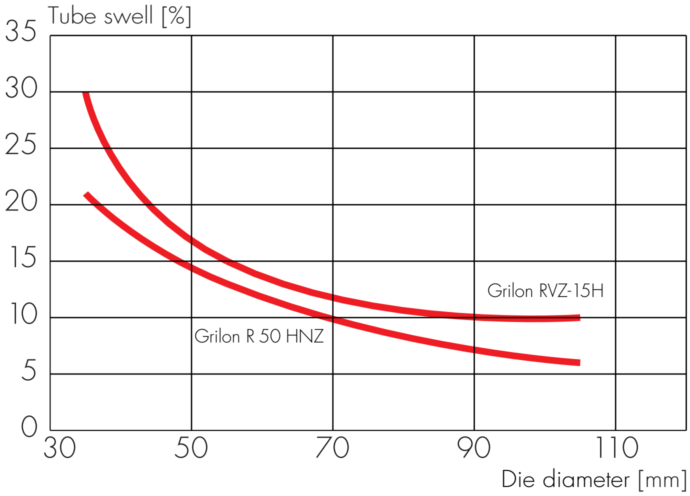

Fig. 7: Parison swell in tests on a BFB8-30 with a 2.5 litre head.

2.5 Blow-up ratio

The «blow-up ratio» is defined as the ratio between the diameter of the parison and the diameter of the finished part. If the parison has a diameter of 60 mm and the finished part 120 mm, the blow-up ratio is 2:1.

The blow-up ratio has considerable influence on the mechanical properties and above all on the shrinkage. It can be said that with an increasing blow-up ratio the orientation of the molecules and fibres increases in radial direction. This effect may be used deliberately in order to obtain isotropic shrinkage (see Fig. 9) or improved orientation of glass fibres in radial direction for example.

Even with unfavourable part geometry (e.g. sharp edges etc.) it is possible to achieve blow-up ratios of 4:1 with unreinforced materials and 2:1 with reinforced materials. With an adequate part geometry it may be possible to achieve higher blow-up ratios, such as 6:1 with unreinforced materials and 4:1 with reinforced ones.

2.6 Shrinkage

The shrinkage of blow-moulded articles has the same rules as in injection moulding. We speak of process shrinkage and post-shrinkage. Process shrinkage is measured after the part cools, while post-shrinkage appears only after some days or weeks. It can be stated that shrinkage increases with rising demoulding temperatures (see Fig. 8), while the radial shrinkage decreases with a higher blow-up ratio (see Fig. 9).

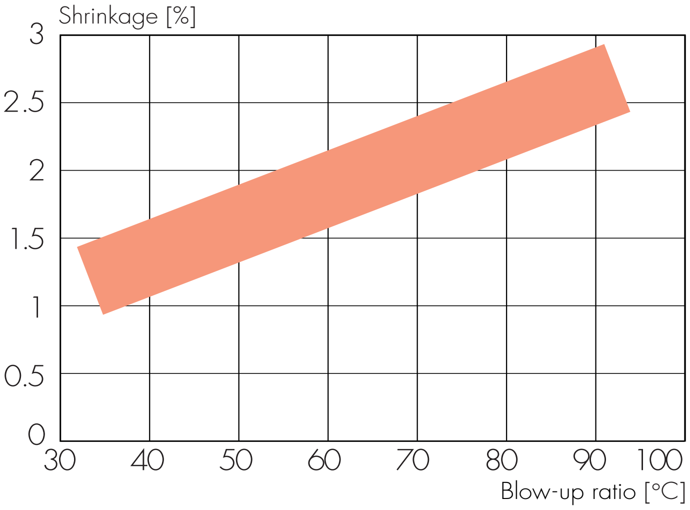

Fig. 8: Shrinkage versus demoulding temperature

All polyamide blowing materials show very little post-shrinkage, like they do in injection moulding, because the moisture uptake compensates the post-crystallization.

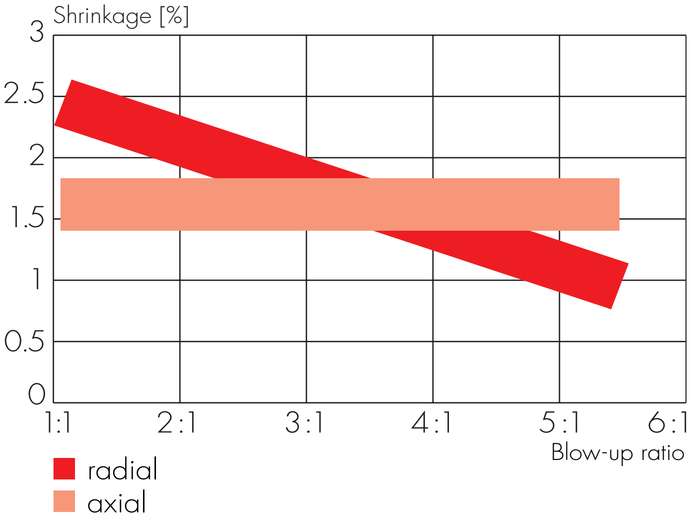

Fig. 9: Shrinkage of Grilon R50 HNZ versus blow-up ratio axial and radial

2.7. Recycling

Conventional blow moulding processes always produce reground material. The proportion of this can be greatly reduced by the 3D technologies described in the next section.

The blowing materials supplied by EMS-GRIVORY all behave very well under repeated recycling. In the regrind tests as shown in Fig. 10, 100 % recycled material was used without any blend-in of virgin material.

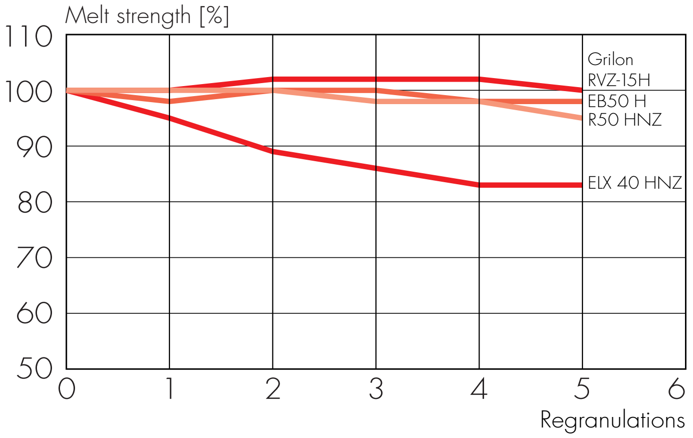

Fig. 10: Alteration of melt strength versus number of regranulations

The regrind must be used at once, before it can take up moisture. If the regrind is not mixed with the virgin material and processed at once, it must be put through renewed drying.

Experience has shown that with up to 50 % regrind no processing problems or altered mechanical properties are to be feared, provided there is no improper treatment or extreme processing conditions (such as excessive shearing etc.). If, however, higher proportions of reground material are used, the melt strength, pinch-off seam strength etc. may be impaired, resulting in unsatisfactory product quality.

3. Machinery for polyamide blow moulding

3.1. Extrusion blow moulding technologies for technical parts

Conventional blow moulding involves:

- The extrusion of a parison vertically
- Moulds closing amound parison
- Blowing
- Pinch-off of article

There is no manipulation of parison.

There are two existing methods for standard blow mouldings. The first consists in extruding the parison continuously under the conveying pressure of the extruder. With the second variant, the plastic melt is first delivered into an accumulator and then extruded through this. The melt accumulator may be integrated in the extrusion blowing head or located outside between the extruder and extrusion head. When using a melt accumulator it is important to assure the FIFO principle (first in, first out) for polyamides. If no FIFO head is employed, the melt will spend a lot of time in the accumulator because not every extrusion will consume the entire melt quantity. Consequently there will always be a certain amount of melt left in the accumulator, leading to long retention times and the production of articles of inferior quality.

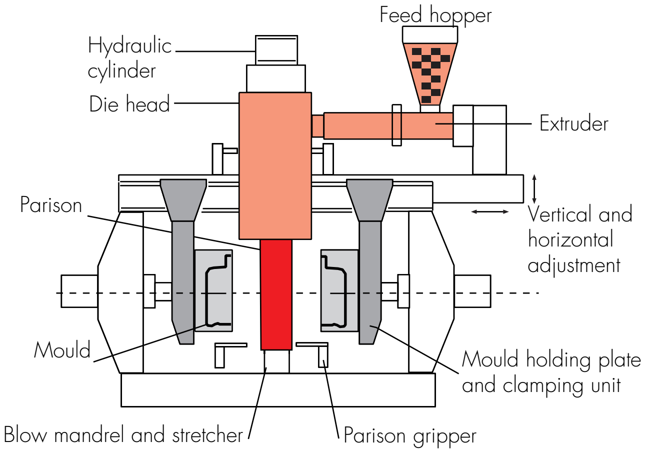

Fig. 11: Components of a blow moulding machine

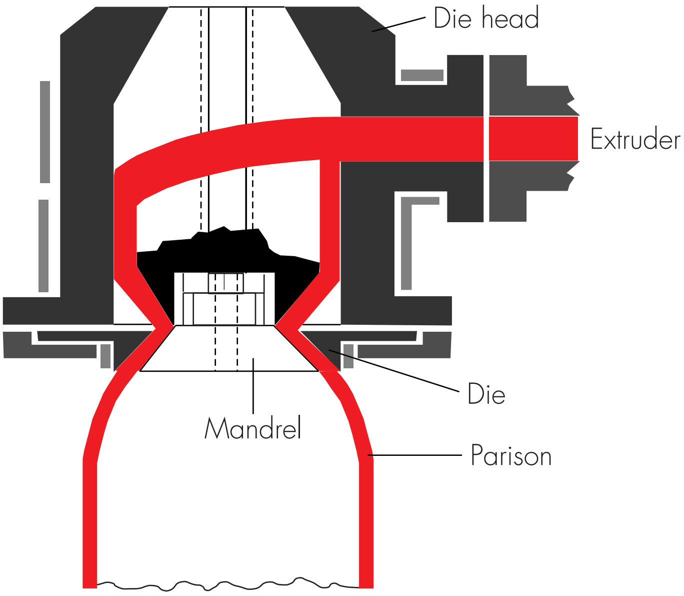

Fig. 12: Chematic continuous extrusion blowing head

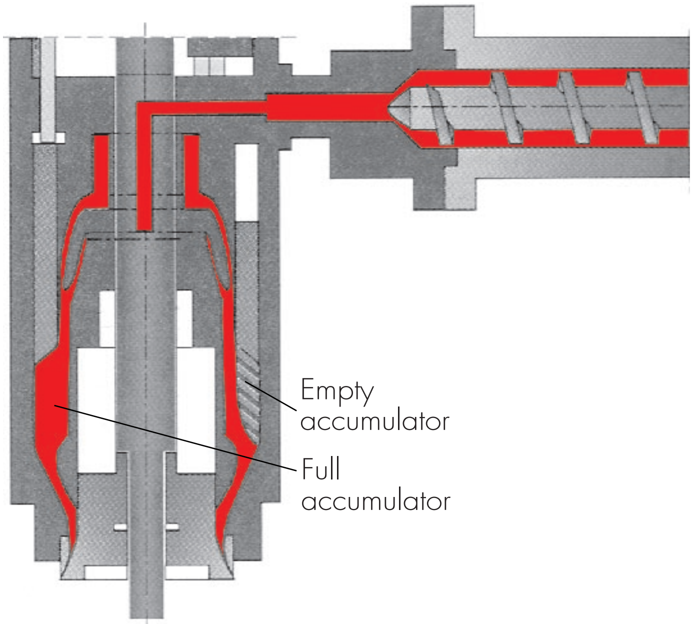

Fig. 13: Schematic FIFO accumulator head

3D technologies:

3D technologies are processes that place the parison in the mould using mechanical devices or air. This is why the flash proportion is limited to the beginning and end of the part (see Fig. 14).

Fig. 14: Blow moulding produced by the conventional process (left) and 3D blow moulding (right).

As may be seen from Fig. 14, the 3D technology offers some advantages:

- Less flash
- No pinch-off line in stressed zones
- Less energy demanded owing to lower parison weight
- Smaller extruder diameter
- Smaller melt accumulator
- Lower clamping forces

Although 3D blow moulding represents a relatively new technique for the production of technical parts, many different systems have been developed meanwhile, e.g.:

- Robot manipulation with vertical mould (Fischer/W. Müller, Krupp Kautex)
- Manipulation by moving mould parts (Voigt)
- Placing the parison in a horizontal mould by:
  - – robot manipulation (Krupp Kautex)
  - – movable extruder (Excell)
  - – movable slanting mould (Placo)
  - – movable die (Yamakawa)
- Placing the parison after preforming (Meico, Etimex)
- Suction blowing (Tahara)
- Air-assisted suction blowing (ABC)

It is not intended to discuss the individual process technologies further. The EMS-GRIVORY blowing types can be used with all the mentioned processes.

Nevertheless, it should be stated that important is the fact that due to the placing technique longer contact times before blowing up are entailed, when using horizontal moulds. This mould contact leads to freezing of the material and hence poor surfaces.

Sequential blow moulding:

Sequential blow moulding involves a succession of two or more materials in the extrusion direction. First may come typically a glass-fibre-reinforced type like Grilon RVZ-15H.1, followed by a soft component such as Grilon ELX 40 HNZ, and finally the glass-fibre-reinforced type once more.

When processing two or more materials it is important to run the material with the greatest swell (with polyamides the soft component) always inside, in order to avoid excessive diameter differences on the parison. The soft materials supplied by EMS-GRIVORY are optimized to the hard components so that combinations may be used freely.

Coextrusion blow moulding:

By coextrusion blowing a component built up from a number of layers is produced. At present only two-component machines are available for air ducting parts. Consequently applications are restricted to two layers. Yet the production of multilayer systems is quite conceivable, as it is in the packaging industry. Recently big machines have been introduced for making plastic fuel tanks with 6 layers.

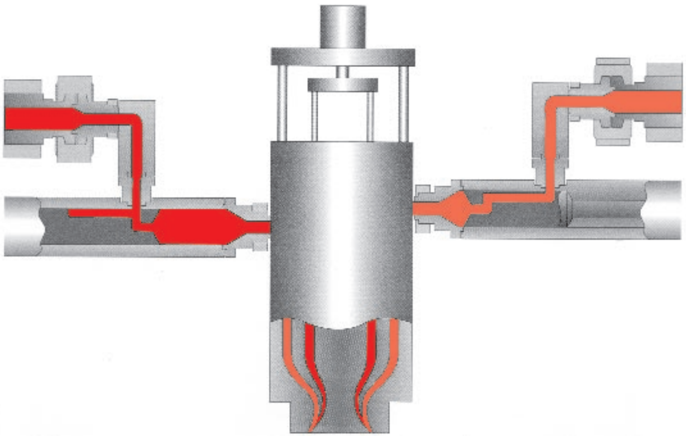

Fig. 15: Sequential blowing head with external melt accumulators

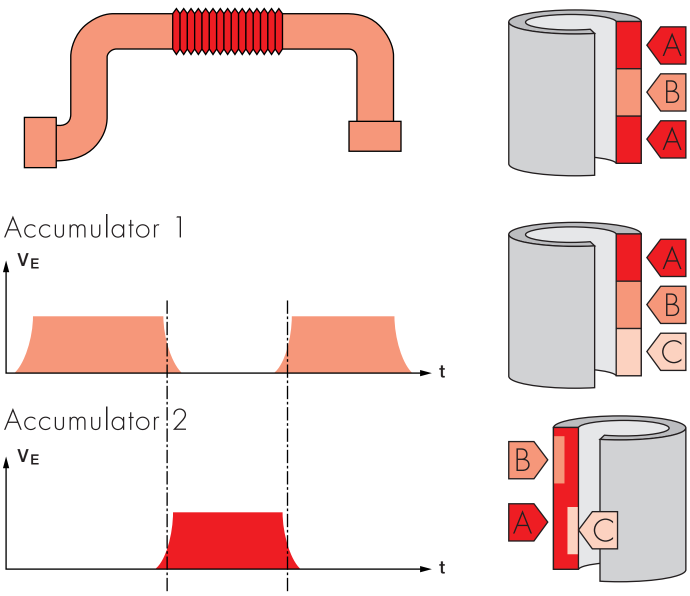

Fig. 16: Extrusion principle and further typical combination possibilities with sequential coextrusion

3.2. Extrusion blow moulding heads

As already described in connection with conventional blow moulding, it is important to use FIFO blowing heads when processing polyamide.

To be also noted is that polyamide blow moulding types have higher viscosities than standard polyethylene so that higher pressures build up in the head. This must therefore be designed for high-viscosity products.

The distributor system should preferably be a mandrel head with double cardioid curves. This way glass-fibre-reinforced products can be worked optimally too. The cardioid curve distributor is designed for the viscosity behaviour of polyamide. Compared to polyethylene, polyamide has a lower structural viscosity causing a different distribution of the melt in the cardioid curve.

Spiral distributor systems are not well suited for working glass-fibre-reinforced plastics. Consequently their use is very limited.

Spider heads cause through their spiders a lengthwise orientation of the glass fibres in reinforced plastics and subsequently create weaknesses in the moulding. Besides, the fibres can no longer be oriented radially during the blow-up step. If possible, the glass fibres should be orientated along the main stress axis and not lie lengthwise.

3.3. Screw configuration

Screw geometry:

Various screw concepts are used, depending on the machine maker. It can be claimed that EMS-GRIVORY blow moulding materials may be used with almost any screw geometry. Nevertheless, some designs are better than others. For working polyamide optimally, the following facts are to be considered:

- Shearing must be kept low.
- No mixing and/or shearing parts may be used.
- Screw length should be 22 – 26 times the diameter.
- A too short feed zone causes pulsating feed.
- A too short compression zone will lead to poor melting and low feed rates.
- The higher the melting point, the longer the compression zone must be.
- The higher the material viscosity, the lower the compression zone must be.

As already mentioned, there are various concepts. The simplest one employs the standard 3-zone screw without grooves like in injection moulding. With this concept the melt temperature can be easily controlled, allowing constant operation. None the less, it is marred by a lower feed rate than with a grooved feeding zone.

Other machine makers generally use grooved feeding zones in conjunction with different screw concepts.
One of these has a 3-zone screw with low compression (K=1.5 – 2). The usage of barrier screws has recently increased and also has found its way to blowing machines as well.

The best way to arrive at an optimal plasticizer configuration is to talk to the machine supplier.

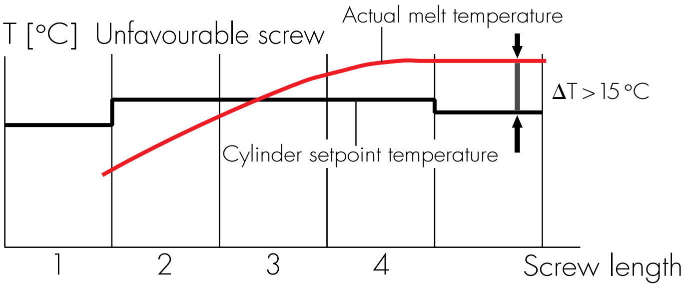

Fig. 17a: Melt temperatures attainable with an unfavourable screw

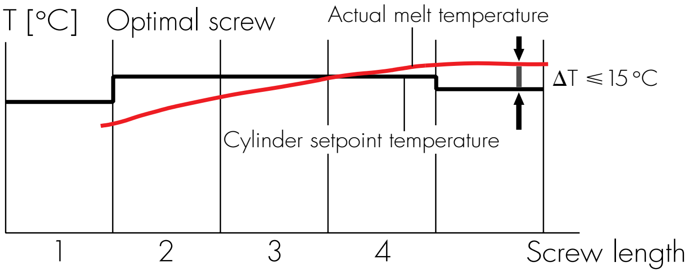

Fig. 17b: Melt temperatures attainable with an optimal screw

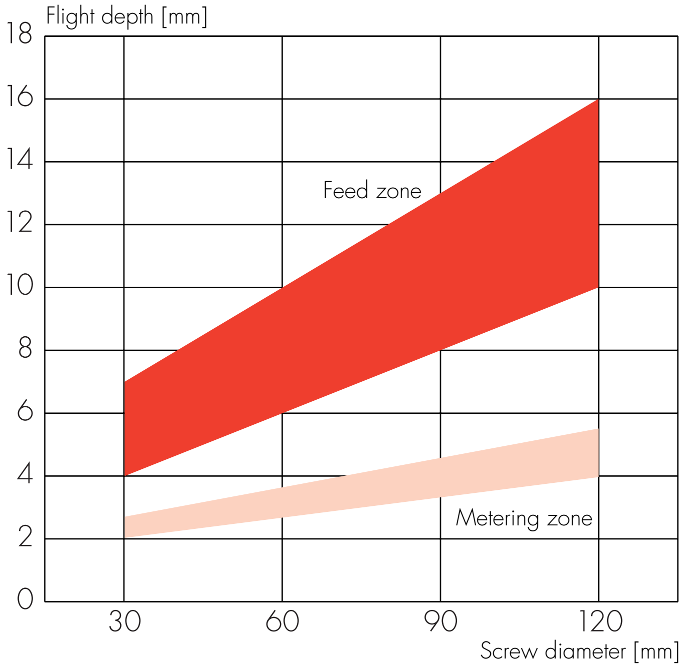

Fig. 18: Recommended flight depths for polyamide screws

Grooved bush geometry:

When using grooved feeding zones one adverse property of polyamide shows itself: polyamide granulate are very hard compared with polyethylene granules. Accordingly the grooves must be adapted to this. It must reach a certain compression of the granulate grains, which is not allowed to exceed a certain limit. If a grooved feeding zone is used for polyamide as it is for polyethylene, the screw may become blocked, especially when starting the machine. Blocking is rather rare with the unreinforced types such as Grilon R50 HNZ, but more critical with the reinforced types which have a high fibre content.

To prevent blocking when starting the extruder, attention must be given to following points:

- Warm up the granulate at 80 – 130 °C (preferably having been dried before).

- Start at low speed (3 – 8 rpm).
- Warm up the grooved feeding zone to 100 – 180 °C (by oil heating).

The driving power needed depends on the combination of the grooved feeding zone and screw geometries. If there is high material compression in the grooved feeding zone, a high drive input will be necessary too.

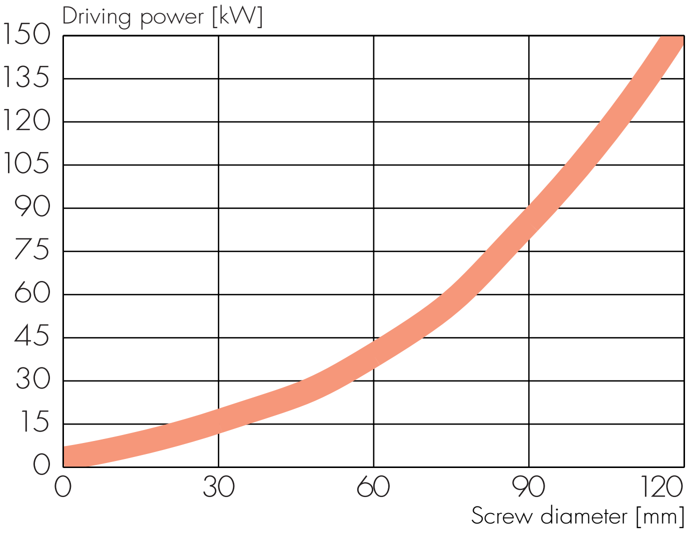

Fig. 19: Average driving power needed for processing polyamide

A typical grooved feeding zone for working polyamide has a length of 2 – 3 diameters, a groove depth of 0.01 – 0.1 diameters at the hopper, and 0.05 – 0.1 D grooves. The groove section may be sawtooth-shaped or rectangular, though here the screw geometry has a strong influence.

Finally it must be said that the grooved feeding zone and screw have to be very well adapted to each other if optimal processing is to be achieved. This especially represents a challenge for the machine maker.

3.4. Tooling

Mould material:

The tooling depends heavily on the used process technology. Nevertheless, it can be said that the pinch-off must always be made of steel because light metals have insufficient lifetime. This is particularly true when working with glass-fibre-reinforced materials. The tool steels are the ones used in injection moulding.

Pinch-off geometry:

Various pinch-off geometries have been developed for polyethylene processing. For polyamides a geometry including a compression zone must be selected. If the usual pinch-off geometries without compression are used, good pinch-off geometry and strength cannot be obtained with polyamides. The compression zone is needed to promote an intermingling of the polyamide melts.

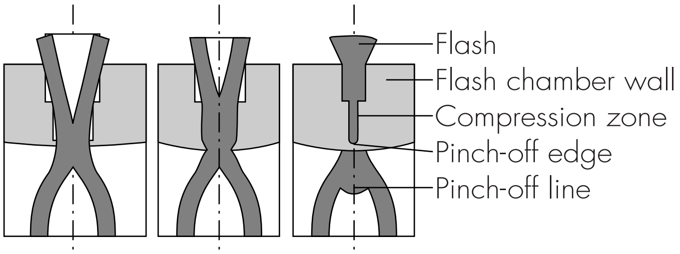

Fig. 20: Pinch-off formation with compression zone

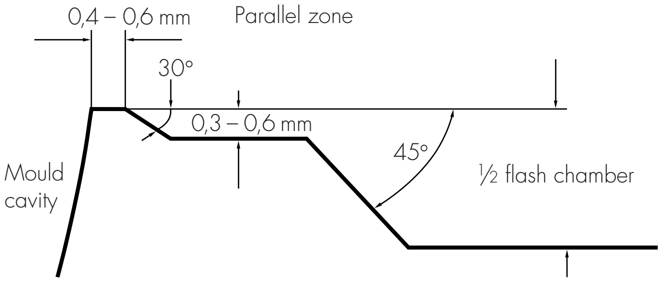

Fig. 21: Recommended pinch-off geometry for polyamide processing

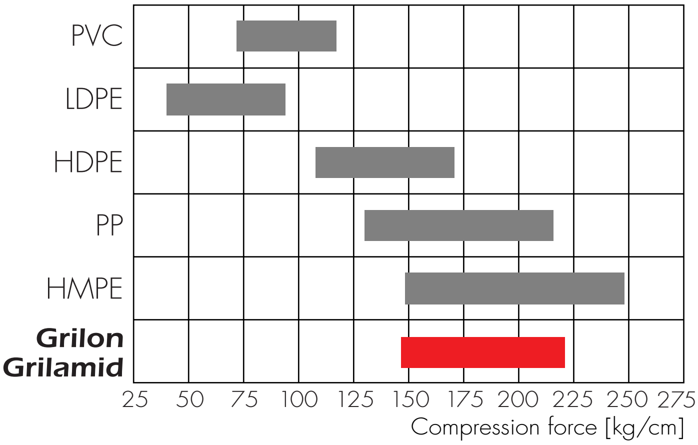

Fig. 22: Compression forces measured with the recommended pinch-off geometry of Fig. 21

4. Integration of joined parts

The pinch-off forces are determined with the pinch-off geometry indicated above (Fig. 21). These forces are in the same range as for HD-PE and PP. Following parameters influence the values:

- Mould clamping speed
- Melt temperature
- Parison wall thickness
- Melt strength

Welding joined parts is particularly important in the 3D technique because the inserting of the parison makes it more difficult to integrate terminal lugs or similar parts in one step. Consequently they must be fixed differently. To achieve this there are two possibilities:

- Insert and over blowing
- Welding afterwards

Insertion:

Insertion may be limited by design circumstances or processing difficulties. Insertion is suited when working polyamide 12 because cold parts can be inserted. These must be clean (free of oil, mould release agents etc.). The cold inserted parts weld on when the parison is blown around them. To obtain very good welding, however, the polyamide 12 must be heated too. This is not the case with polyamide 6. Here the inserted parts must be heated and blown around as quickly as possible to obtain a durable weld.

Heating the inserted parts is a difficult business. Because of this, the joined parts are often attached afterwards, e.g. by welding with a heating element, when working with PA6.

Heating element welding:

The welding methods applicable depend on the parts to be joined, i.e. rotationally symmetric parts may be rotation-welded too, while other parts can be joined by many other welding techniques.

Generally speaking, all EMS-GRIVORY blow moulding materials are adequate for all welding processes.

The heat element welding deserves special mention, because it is frequently used with blow mouldings.

All blow moulding materials can be welded by heating element. Since blow moulding grades are not particularly good for injection moulding, injection moulding grades should be used. EMS-GRIVORY supplies following grades for this:

Table 4:

Flexible Grades	Unreinforced Grades	Reinforced Grades
Grilon ELX 23 NZ	Grilon A28 NZ Grilon BC 70	Grilon PVZ-15H Grilon PVZ-3H Grilon PV-3H Grilon PV-5HH
Grilamid ELY 60 Grilamid ELY 2475	Grilamid L25 H	Grilamid LV-3H

This also means that a special material is available for one particular requirement. Certainly choosing the right material is important, but right process management is another very important fact. A properly conducted welding process should be done as follows:

1. Tighten the parts
   The parts to be joined need tightening because they are usually distorted and must therefore be levelled first. Normally this is path-controlled.

2. Deep heating
   This involves creating a melt reservoir about 1 mm deep. Deep heating is performed almost pressureless, i.e. the position is held constant after tightening.

3. Joining
   Joining involves removing (withdrawing) the parts to be joined from the heater and the actual joining. Withdrawing must be done as quickly as possible, as must also the joining, though the contact of the joined parts must not be too fast, otherwise the melt will be displaced too severely. Here a two-speed welding machine is an advantage. Withdrawing and bringing together must be accomplished speedily, while the actual joining should be slow.
   Joining is mostly path-controlled to ensure a certain melt displacement though without forcing the entire melt out of the welding zone.

The welding machine may also be force-controlled or force-path-controlled depending on the machine maker.

Heating element welding is divided into two different temperature ranges:
- Standard temperature welding
- High-temperature welding

In the standard process, temperatures from 260 to 290 °C on the mirror are used, while high-temperature welding exceeds 330 °C. At temperatures of 260 – 290 °C PTFE can still be used as antistick layer, though its working life is limited to 0.5 – 1.5 hours, after which the film must be changed. Special mirrors are used in high-temperature welding, so that no special PTFE film is required.

5. Processing problems and trouble shooting

5.1. Parison failures

Problem	Cause	Trouble Shooting
Parison diameter too big	Die too big	• Use a smaller die • Lower the extrusion rate
	Parison swelling to big	• Lower the extrusion rate • Raise the die temperature • Raise the melt temperature • Optimize flow channel on die • Use another EMS-GRIVORY type
Parison diameter too small	Die too small	• Increase extrusion rate • Use a bigger die
	Parison swelling too small	• Raise the extrusion rate • Lower the die temperature • Lower the melt temperature • Use another EMS-GRIVORY type
Different wall thicknesses in circumferential direction, and parison runs slantwise	Die head and die ring off-centre	• Recentre the die ring • Optimize cardioid curve
	Head heated unevenly	• Check head heater bands and optimize if necessary
	Unfavourable flow channels	• Optimize head flow characteristic
Parison strongly elongated	Inadequate melt strength	• Adapt wall thickness profile • Increase basic gap • Lower the melt temperature • Raise extrusion rate • Use an EMS-GRIVORY type with higher melt strength
	Material too moist	• Dry the material better
	Excessive shearing in extruder head or screw (melt temperature too high)	• Optimize flow channel in head or screw
Parison runs with slant	Die ring off-centre	• Centre the die ring
Lengthwise groove or thin place on parison and moulding	Flow line from torpedo head (does not apply to accumulator head)	• Optimize the spiders
	Die fouled up	• Clean the die
Several unequal lengthwise grooves (inside or outside) or thin places on moulding	Die damaged	• Recondition the die
	Die fouled up	• Clean the die
Several similar lengthwise grooves or thin places on moulding	Spider head, strainer spider legs too thick or flowability unfavourable	• Optimize legs hydraulically • Lower the extrusion rate • Raise the head temperature
Rolling inwards	Die ring too hot – Core too cold	• Optimize the head heating
	Insufficient wall thickness	• Increase wall thickness at start of extrusion
Rolling outwards	Torpedo head or core too hot – Die ring too cold	• Heat the die ring more
	Insufficient wall thickness	• Increase wall thickness at start of extrusion

Problem	**Cause**	**Trouble Shooting**
Lateral folds (locally)	Local advancing	• Reduce extrusion rate • Optimize head hydraulics
Local rough strips parts	Machine does not reach temperatures above 230 °C	• Raise heating of machine
Lumps, specks	Material contaminated	• Purge extruder/head longer
	Material builds up	• Raise or lower the melt temperature • Reduce drying temperature/time
Rough outer surface	Material solidifies in air	• Raise extrusion rate • Raise melt temperature • Raise die temperature
	Material decompressed	• Raise melt temperature • Optimize flow channel of die
	Irregular flow front	• Reduce extrusion rate
Rough inner surface	Material decompressed	• Optimize die entry so that material is decompressed only at die exit
Many small bubbles retarded after nozzle exit	Excessive moisture content	• Material needs drying
	Decomposed material	• Purge extruder, head • Shorten material retention time
Large bubbles immediately after nozzle exit	Air inclusions	• Raise extrusion pressure (accumulator charging pressure) • Use screw geometry with higher compression • Provide throttling between extruder and head
	Material shortage	• Refill material sooner
	Decomposed material	• Purge extruder, head • Shorten material retention time
Discoloration	Contamination with extraneous material	• Use virgin feedstock and purge out the equipment
	Material overstresed thermally	• Lower the melt temperature • Optimize the screw (no mixing or shearing parts,…) • Use less regrind stock • With high regrind proportion add heat stabilizer • Eliminate dead points in the flow channel • Optimize accumulator tolerances
	Material is partially oxidized	• Lower the melt temperature • Reduce shearing in head and extruder • Use heat master batch

5.2. Part failures

Problem	**Cause**	**Trouble Shooting**
Wall thickness to high	Parison too thick	• Adapt wall thickness profile • Reduce basic gap
Wall thickness to low	Parison too thin	• Adapt wall thickness profile • Increase basic gap
	Parison lengthens too much	• (see: parison strongly elongated)
Insufficient wall thickness in zone close to nozzle	Insufficient melt strength	• Increase extrusion rate • Adapt wall thickness profile • Lower the melt temperature • Use an EMS-GRIVORY type with higher melt strength
Inconsistent wall thickness at circumference	(see: parison with unequal wall thickness at circumference)	
	In 3D blow moulding	• Use radial wall thickness control
Insufficient wall thickness in corners	Melt strength too low	• Reduce melt temperature • Use an EMS-GRIVORY type with higher melt strength
	Unfavourable part geometry	• Optimize preblowing • Optimize parison position to mould • Round off the corners
Local rough or bright places	Parison touches the mould	• Raise mould temperature • Reduce parison diameter • Reposition extruder above mould • Optimize tube manipulation (in 3D blow moulding)
	Poor mould venting	• Optimize mould venting
Surface with specks/scales	Material contaminated with foreign matter	• Purge extruder/head • Optimize local temperature differences in head
Hollow parts burst during blow-up	Insufficient wall thickness	• Raise wall thickness on parison
	Excessive blow-up ratio	• Reposition extruder above mould • Optimize mould clamping position • Optimize part geometry • Increase the nozzle diameter
	Insufficient clamping force	• Raise clampinmg force • Reduce blowing pressure • Enlarge flash chamber • Optimize pinch-off zone geometry • Use machine with more clamping force
	Parison collapses	• Earlier preblowing • Adapt blow-up pressure/time
	Pinch-off edges too sharp	• Round off pinch-off edges slightly or adapt
Big weight variations	Inconsistent feed	• Mix regrind and virgin material • Adapt grooved feeding zone and cylinder temperature

Problem	**Cause**	**Trouble Shooting**
Mould parting appears as elevation	Blowing pressure too high	• Reduce blowing pressure
	Insufficient mould clamping force	• Raise mould clamping force
	Blowing air supplied too early	• Increase blowing air delay
Step on part	Mould offset	• Match mould halves
Poor pinch-off welding strength	Bad pinch-off welding geometry	• Reduce clamping speed • Reduce preblowing pressure • Match preblowing time to mould delay
	Bad pinch-off zone geometry	• Adapt pinch-off zone geometry
	Melt temperature too high/low	• Adapt melt temperature
	With low heat-stabilized types	• Preblowing with nitrogen • Admix heat stabilizer
Pinch-off weld not centred	Extruder positioned off-centre	• Centre the extruder
	Parison not seized evenly by the mould	• Optimize the mould synchronization • Optimize extruder position
	Parison runs slantwise	• (see: parison runs slantwise)
Pinch-off weld not in permitted range	Parison too big	• Reduce preblowing • (see: parison diameter too big)
	Extruder not positioned correctly	• Reposition extruder
	Mould clamps unevenly	• Optimize mould synchronization
	Parison runs slantwise	• (see: parison runs with slant)
Flash difficult to part from moulding	Pinch-off edges worn	• Touch up pinch-off edges
	Mould does not close completely	• Increase clamping force • Reduce blowing pressure
	Insufficient clamping force	• Increase clamping force • Optimize pinch-off zone geometry at maximum clamping force • Enlarge the flash chamber • Use a machine with more clamping force
Incomplete blow-out	Insufficient blowing air pressure	• Raise blowing air pressure
	Blow-out time too short	• Extend blow-out time
	Mould not vented	• Prevent mould venting
	Melt temperature too low	• Raise the melt temperature

Problem	**Cause**	**Trouble Shooting**
Blowing needle pricks poorly	Unfavourable pricking point	• Move pricking point to pinch-off seam
	Pricking speed too low	• Reduce throttling on cylinder • Clean blowing needle • Fit quick vent on opposite side • Extend advance
	Blowing needle runs badly in the mould hole	• Centre the needle in the hole • Clean mould hole or blowing needle • Enlarge the mould hole
	Blowing needle too blunt	• Sharpen or replace blowing needle
	Blowing needle too thick	• Use thinner blowing needle
	Blowing needle stroke too short	• Lengthen blowing needle stroke
	Material already solidified	• Shorten the pricking delay • Raise the melt temperature
	Material can be elongated too much	• Increase the pricking delay • Reduce the melt temperature
	Blowing needle to hot	• Provide additional needle cooling
	Material clings to blowing needle	• Clean the blowing needle • Cool the needle better
	Needle blows too soon	• Increase blowing air delay
Severe distortion	Moulding demoulded too hot	• Increase blowing time • Lower the mould temperature • Lower the melt temperature • Provide after-cooling station
	Uneven wall thickness distribution	• Optimize wall thickness profile • Increase blowing time • Reduce the mould temperature locally
	Uneven cooling	• Optimize mould cooling • Increase the blowing time
Moulding sticks in the mould	Mould too hot	• Lower the mould temperature
	Cooling time too short	• Increase the blowing time
	Deposits in the mould	• Clean the mould
Hollow mouldings break after demoulding	Poor pinch-off weld strength	• (see: poor pinch-off weld strength)
	Blow-up ratio too high	• Optimize the part geometry • Optimize the mould mounting position • Reposition the extruder above the mould
	Poor blowing pressure venting	• Improve venting

5.3. General mistakes

Problem	**Cause**	**Trouble Shooting**
Extruder blocked	Material cannot be compressed	• Raise grooved feeding zone and cylinder temperatures • Preheat the material • Start extruder at low speed and refill slowly till feed is constant • Add lubricant (only for starting) • Optimize grooved feeding zone and screw combination • Reduce the groove depth • Lengthen the screw feed zone • Use smooth cylinder • Do not use tapered feed bush
	Heating insufficient in feed zone	• Provide more heating
Extruder runs without plastification	Grooved zone too hot	• Reduce grooved zone temperature
	Unfavourable granulate form	• Add regrind stock
	Too much lubricant	• Use more virgin material
Extruder pumps	Plug in extruder due to extremely high viscosity	• Raise the melt temperature • Raise the extrusion pressure • Use EMS-GRIVORY type with less melt strength
	Extrusion pressure too high or too low	• Adapt extruder feed pressure • Optimize flow channels in accumulator head
	Inconsistent feed	• Add regrind stock • Improve mixing of virgin material and regrind
	Unfavourable screw geometry	• Use polyamide screw
	Unfavourable grooved feeding zone geometry	• Optimize geometry of grooved feeding zone • Use smooth parison cylinder
Inconsistent feeding time	Inconsistent material feed	• Adapt grooved zone temperature • Improve mixing of new material and regrind
Material forms on the die	Material deposits due to decompression at die exit	• Optimize die flow channel
Pronounced fuming	Moisture content excessive	• Dry the material
	Melt temperature too high	• Reduce the melt temperature
	Excessive shearing	• Adapt extruder or head
Machine lacks sufficient clamping force	Blowing pressure too high	• Reduce the blowing pressure
	Machine too small	• Reduce the blowing pressure • Enlarge the flash chamber • Use a bigger machine
	Flash zone needs too much force	• Make pinch-off edges sharper • Reduce compression in the pinch-off zone
	Flash chamber too small	• Make flash chamber deeper

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