DuPont Engineering Polymers

Blow Moulding Processing Manual

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Blow moulding processing manual

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1 DuPont resins for blow moulding

1.1 Why blow mould engineering resins?

There are many reasons why engineering resins have become established in blow moulding applications, for example:

- Cost and weight reduction
- Recyclability (replaces rubber for example)
- Innovation:
  - Multifunctional parts
  - Reduce number of parts in the engine compartment
- Higher temperature requirements
- Easier assembly and disassembly
- Reduce number of materials
- Improve performance
- Reduce noise
- Availability of special resin grades designed for blow moulding

DuPont offers a wide range of engineering resins types for blow moulding including:

HYTREL®	Polyester elastomer
CRASTIN®	PBT polyester
ZYTEL®	Nylons 6, 66, and alloys
SELAR® RB	Barrier resin

New grades are continuously being developed, so please contact your local DuPont representative for the latest product literature. All DuPont resins are supported by comprehensive Technical Service in the areas of:

- Basic data
- Design (C.A.D.)
- Processing
- Testing.

1.2 ZYTEL® nylon resins for blow moulding

ZYTEL® nylon resins are thermoplastic polyamides having properties that place them high on the list of engineering plastics. They are tough and chemically resistant, and moulded articles retain their performance at elevated temperatures. The ZYTEL® resins listed below have excellent parison melt strength and good drawability for blow moulding. Some grades are reinforced with glass fibres to increase their tensile strength, stiffness and dimensional stability. There is also a flexible nylon alloy available. All ZYTEL® blow moulding grades are especially compatible with each other for use in sequential co-extrusion blow moulding – for example in hard/soft segment air ducts etc. (see section 2.4).

ZYTEL® blow moulding resins

ZYTEL® BM7300THS	Unreinforced PA6
ZYTEL® BM73G25THS	25% glass reinforced PA6
ZYTEL® BM73G15THS	15% glass reinforced PA6
ZYTEL® BM7300FN	Unreinforced, PA6 flexible nylon alloy
ZYTEL® CFE8005HS	Unreinforced PA66
ZYTEL® EFE7340	15% glass reinforced hydrolysis resistant PA66
ZYTEL® EFE7341	20% glass reinforced hydrolysis resistant PA66

1.2.1. ZYTEL® resins – rheology

ZYTEL® blow moulding resins have been developed to provide excellent melt strength in the parison during the push-out and moulding operation. This requires very high viscosity at low shear rates, typically in the range of shear rates from 0-10 s^{-1}. At higher shear rates which are encountered in the plastification of the resin in the screw and barrel of the machine, there is a reduction in viscosity which helps to minimise the screw torque and required motor power.

Figures 1 (below) and 2 (following page) show the apparent viscosity/shear rate curves for the ZYTEL® blow moulding grades measured at appropriate melt temperatures. All resins were dried to a moisture level of below 0,05%. Higher levels of moisture will significantly reduce the viscosity levels across the range of shear rates.

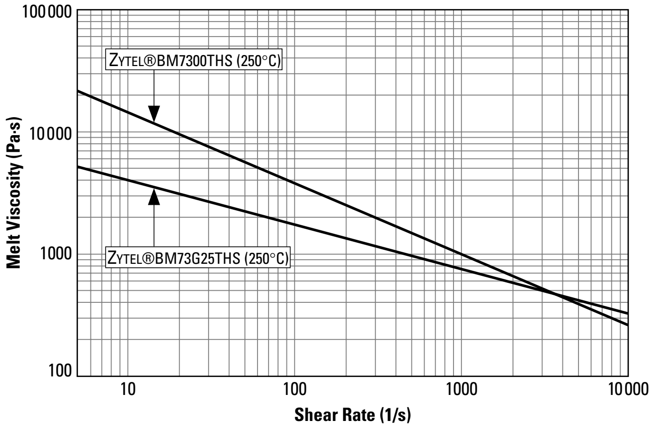


Fig. 1 **Melt viscosities of various ZYTEL® nylon 6 grades**

Table 1

Nylon type	ZYTEL® grade	Typical MFI at 21,6 kg g/10 min	Temperature
PA66 unreinforced	CFE8005 BK	25-35	280 °C
PA66 15 % glass fibre	EFE7340 BK	30-40	280 °C
PA66 20 % glass fibre	EFE341 BK	50-60	280 °C
PA6 unreinforced	BM7300T BK	20-30	250 °C
PA6 flexible alloy	BM7300FN BK	40-50	250 °C
PA6 25 % glass fibre	BM73G25T BK	25-35	250 °C

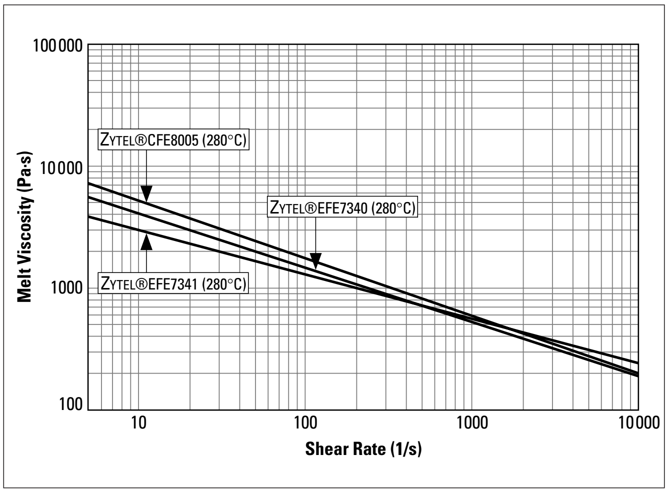


Fig. 2 **Melt viscosities of various ZYTEL® nylon 66 grades**

Melt index (MFI) values have been measured on ZYTEL® blow moulding resins and are shown in Table 1. The measurements were made at a weight of 21,6 kg and at a temperature close to the typical processing temperature for each grade. MFI results based on different conditions are not comparable.

Please note that MFI is not considered to be a reliable indication of melt strength for nylon materials (especially glass reinforced) due to effects of moisture and other factors. For this reason it is advisable to use the values with caution.

1.3 HYTREL® and CRASTIN® polyester resins for blow moulding

1.3.1. HYTREL® polyester elastomer

HYTREL® thermoplastic polyester elastomers (TEEE) are high performance, flexible polymers, with exceptional properties such as:

- High and low temperature performance
- Excellent oil and hydrocarbon resistance
- Toughness and tear resistance
- Dynamic (flex fatigue) performance
- Noise reduction
- Excellent sealing (low creep) properties

Special HYTREL® grades have been developed for good parison stability and other properties required for blow moulding. Applications include:

- CVJ boots
- Suspension and steering boots
- Air ducts
- Vent pipes

Listed below is part of the range of HYTREL® blow moulding grades.

	Hardness (Shore D)	Main applications
HYTREL® HTR8105	47	CVJ Boots
HYTREL® HTR5612	50	Suspension and steering boots, CVJ boots
HYTREL® HTR8223	45	CVJ boots, suspension and steering boots
HYTREL® HTR4275	55	Air ducts, vent pipes
HYTREL® BM6574	65	Air ducts, vent pipes (higher temperature)
HYTREL® BM5576	55	Air ducts, vent pipes (higher melt strength)

1.3.2 HYTREL® resins – rheology

Figures 3 and 4 show apparent viscosity/shear rate curves for some of the HYTREL® blow moulding resins. The higher viscosity grades are designed for longer parts such as air ducts, while the lower viscosity (higher melt index) grades are formulated for use in CVJ boots, suspension and steering bellows.

Melt Index (MFI) values for these HYTREL® blow moulding resins are given in Table 2 below. Please note the test weight and temperature used as measurements made under different conditions are not comparable.

Table 2

Hytrel® grade	Hardness (Shore D)	Typical MFI at 5 kg g/10 min	Typical MFI at 2,16 kg g/10 min	Temperature
HTR4275 BK	55	2,0	0,5	230 °C
BM5576 BK	55	1,2	0,3	230 °C
BM6574	65	–	0,5	270 °C
HTR5612 BK	50	–	3,0	230 °C
HTR8105 BK	47	–	2,0	230 °C
HTR8223 BK	45	2,5	0,4	230 °C

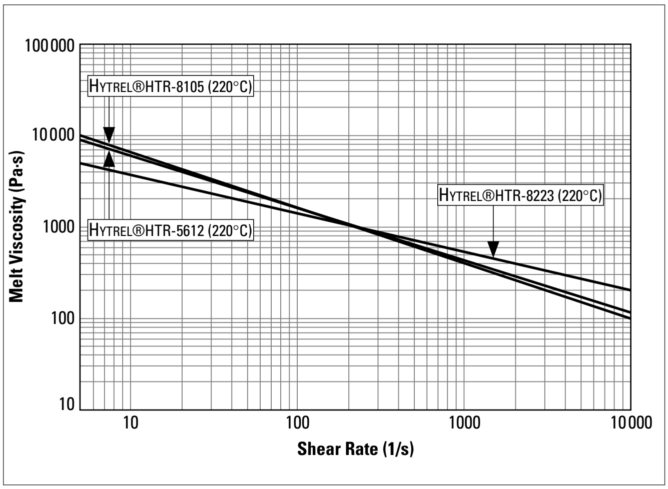


Fig. 3 **Melt viscosities of various Hytrel® grades**

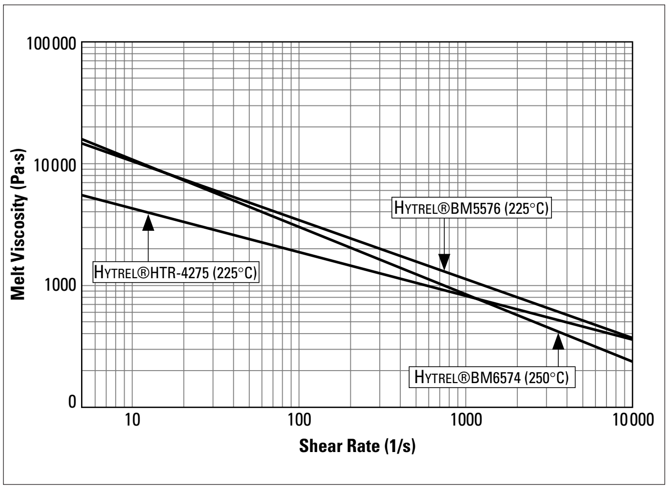


Fig. 4 **Melt viscosities of various Hytrel® grades**

1.3.3 Crastin® PBT polyester resin

Crastin® PBT polyester resins are high performance engineering polymers which are particularly useful in automotive blow moulded applications for the following reasons:

- Good stiffness and strength, especially at elevated temperatures
- Excellent toughness and impact strength
- Good oil, hydrocarbon and overall chemical resistance
- Low moisture absorption and excellent dimensional stability
- Compatible with Hytrel® in hard/soft combination mouldings

Two special Crastin® grades have been developed for blow moulding:

Crastin® ST820 (for smaller parts)

Crastin® BM6450 (high melt strength, for larger parts)

1.3.4. Crastin® resins – rheology

The apparent viscosity/shear rate curve for Crastin® BM6450 BK is shown in Figure 5 below.

Crastin® BM6450 BK has a typical Melt Flow Index (MFI) value of 11g/10 minutes measured with 21,6 kg weight at a temperature of 250 °C.

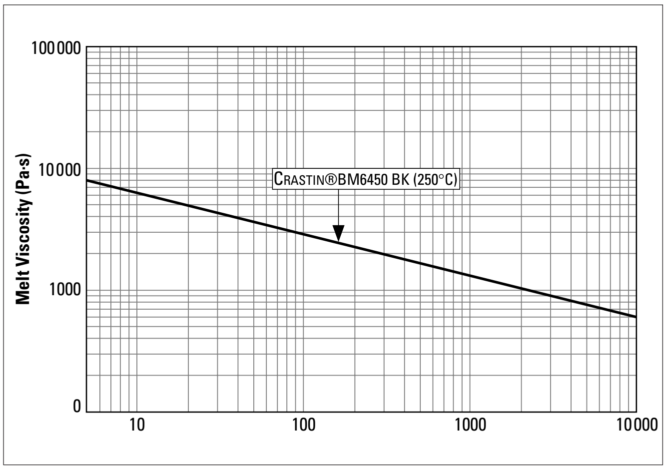


Fig. 5 **Melt viscosity of Crastin® BM6450**

2 Description of blow moulding process

2.1 General

All blow moulding processes consist of 3 stages:

1. Plastification of the thermoplastic resin granules, normally by means of a single screw extruder.
2. Production of a molten "pre-form" – either an extruded tube or "parison" in the case of so called **extrusion** blow moulding, or an injection moulded "pre-form" in the case of **injection** blow moulding.
3. Inflation of the parison or "pre-form" (usually with air) in a blowing mould, followed by a demoulding and a part trimming operation.

It is not intended to provide detailed descriptions of all the above processes and machine types on the market, but the following information may be useful to differentiate the more important aspects of each technology in relation to the use of engineering resins in blow moulding.

2.2 Continuous extrusion machines

In this process the extruder screw runs continuously, plasticising the granules and pumping the resin melt through the head and die to produce a vertical "parison" which hangs from the die. When the parison reaches the required length, the mould closes round it and immediately the parison is cut, while the mould is quickly transferred to the blowing position where a blowpin inflates the parison to fill the mould cavity. Meantime the next parison is being extruded. The process requires that the extrusion speed must be exactly controlled so that each parison reaches the required length in the time it takes the mould to complete its blowing and cooling cycle. Parison wall thickness and hence part wall thickness, is controlled by a multi-point "parison programmer" which operates via hydraulics to adjust the die gap during the extrusion process.

2.3 Accumulator head machines

The continuous extrusion process, though simple and cost effective for many applications has the inherent disadvantage that the parison must hang under gravity for the full length of each moulding cycle, This demands extremely good melt strength in the resin, especially for long mouldings.

By incorporating an "accumulator head", which acts like a reservoir and push-out piston, it is possible to accumulate enough resin inside the head for one part, so that the part "shot" can be pushed out quite rapidly immediately before the mould closes round it to start the moulding cycle. The extruder screw can be stopped and started as required to fill the accumulator in time for the next push-out and moulding operation. The accumulator head machine, as well as helping to minimise the effects of parison stretching in long parts, can also be useful for moulding semi-crystalline engineering resins when rapid cooling or oxidisation of the parison surface may cause problems when those materials are moulded in continuous extrusion machines.

2.4 Co-extrusion and sequential 3-D blow moulding

Co-extrusion blow moulding involves the simultaneous extrusion of two or more compatible resins in layers through the parison wall. This allows, for example, the incorporation of special layers for permeation barrier, or the use of a layer of "regrind" material in the part wall. Multiple extruders are therefore needed to feed each material to the special co-extrusion head, which can be designed either for continuous extrusion or accumulator head operation.

Sequential blow moulding can be considered as a development of co-extrusion blow moulding where the layers are "switched on and off" in a programmed way. This allows production of parts which combine sections made from two or more resins, for example hard, rigid sections in one material and soft flexible bellows in a different material.

DuPont Engineering resins which are compatible with each other and suitable for sequential coextrusion blow moulding include the following polyamide (nylon) and polyester resin combinations:

	Hard component	Soft component
Nylons:	ZYTEL® BM7300T, BM73G15T or BM73G25T	ZYTEL® BM7300FN
Polyesters:	CRASTIN® BM6450	HYTREL® HTR4275

A major disadvantage of conventional blow moulding processes is that they are not ideally suited to the blow moulding of long narrow components in 3 dimensions, such as air ducts, without producing excessive scrap and very long undesirable pinch-offs at the mould closing lines. This fact led to the development of the so-called "3-D" blow moulding processes which essentially describe 3 different systems for achieving similar results.

The 3-D processes are normally combined with sequential blow moulding to make hard-soft combinations in a single moulding.

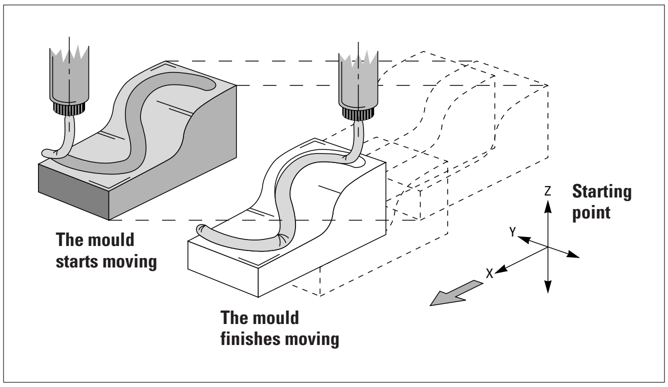
“Laydow” process

In this system (see Fig. 6) the parison is extruded vertically onto a horizontally fixed mould half, in such a way that the emerging parison is made to follow the path of the mould cavity by either moving the complete extruder head and die or alternatively moving the mould half (with extruder fixed). The parison is kept partially inflated with support air to prevent its collapse, until such time as the complete cavity has been filled, when the top half of the mould is closed over the lower half and the parison is fully inflated by inserting a blowing needle. The result is a moulding with virtually no scrap (except at each end) and no inherently weak “pinch-off”.

The disadvantage of this process for engineering polymers is the relatively long time during which the parison is in contact with only one half of the mould, leading to premature freezing-off of the parison surface.

However, this can be mainly overcome by use of high mould temperatures which may require the use of oil heaters.

Movable mould



Movable die head

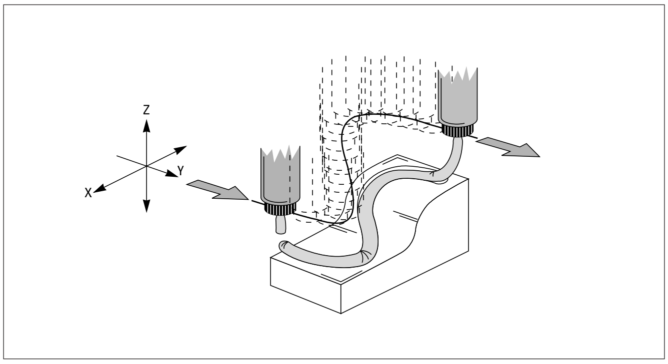


Fig. 6 **3-D “laydown” process**

“Parison manipulation” process

This technique is a development of a conventional blow moulding (normally accumulator head) process, whereby the extruded parison in “manipulated” by a combination of robots and moving mould segments in order to make it conform to the 3-dimensional mould cavity. The parison is normally removed from the die by a robotic “gripper” which then places it over the blow pin, or (in the case of subsequent needle-blowing) in one part of the multi-segment mould. Programmed movements of the robot arm and closing mould segments then position the parison in the cavity until finally the mould is completely closed and the parison is blown to produce the finished part. Although it may exhibit some of the problems of the “laydown process” this process seems to be generally more suitable for semi-crystalline engineering polymers.

3D “Suction” process

Here (Fig. 7) a basic accumulator head machine (with or without coextrusion/sequential facility) is used in combination with a specially designed mould having an air suction device connected to it. The process operates by extruding the parison into the cavity through an opening in the top of the **closed** mould, at the same time as a vacuum is applied at the lower end of the cavity. This suction and supporting airflow through the mould helps to pull and guide the parison until it reaches the lower end of the mould. At this point the parison is blown, either through a blow pin in the centre of the parison die, or by means of a needle which is inserted at some point in the parison.

This process is particularly suited to smaller diameter air ducts or pipes, especially where there is little change in diameter or cross section along the part length.

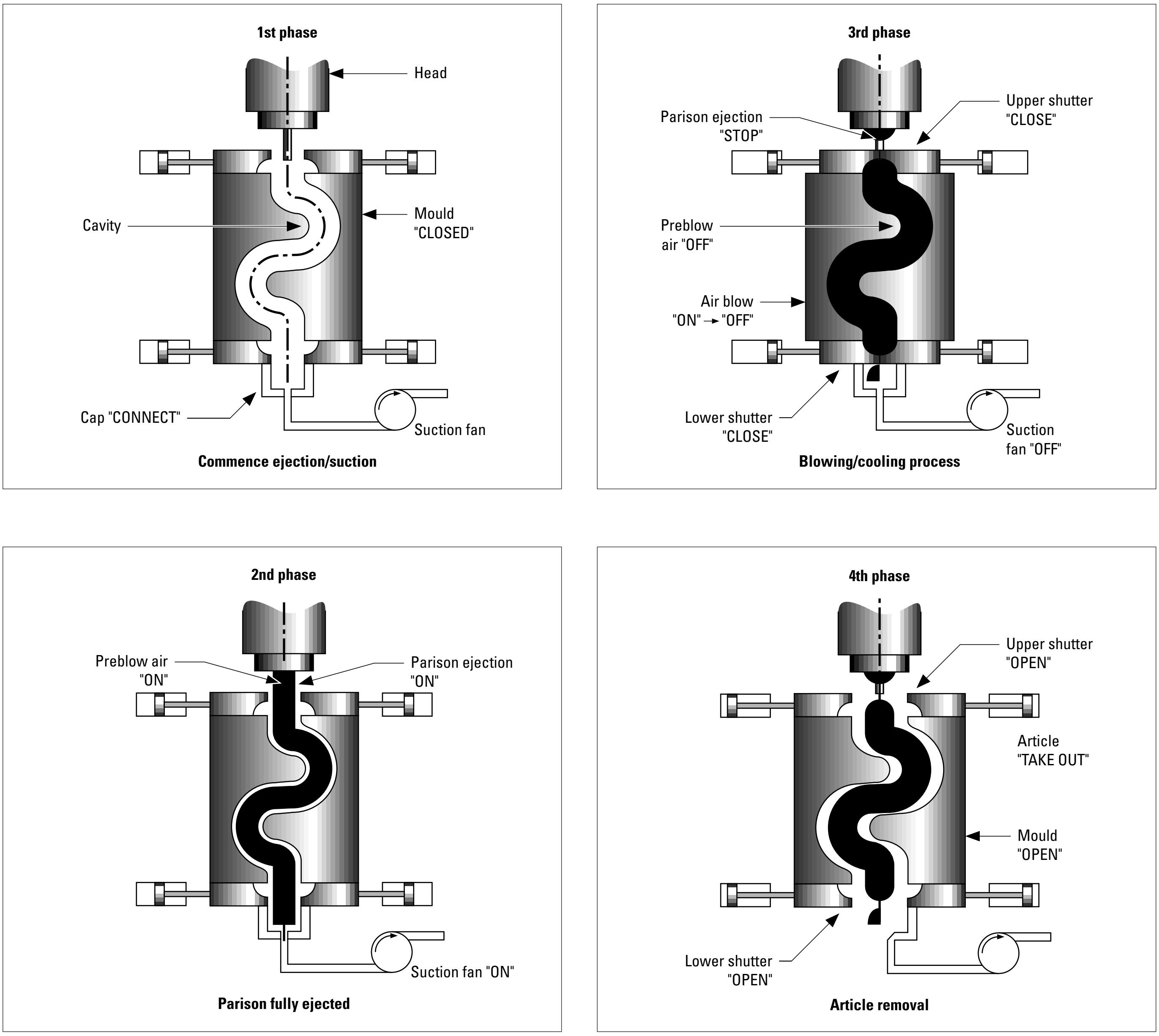


Fig. 7 **Suction blow moulding process.** (Diagram and process description courtesy of Fischer W. Müller Blasformtechnik)

2.5 Injection blow moulding

Injection blow moulding (IBM) is frequently the process of choice in the packaging industry, for example in the high volume production of small containers at fast cycle times. However it is also appropriate for the same reasons with small technical mouldings in engineering resins. This process has the advantage of more precise control of dimensions and tolerances. Examples where this process is used for engineering resins is in moulding CVJ boots (automotive drive joint covers) in HYTREL® polyester elastomers.

The injection blow moulding of HYTREL® CVJ boots involves the use of a relatively conventional injection moulding system to produce moulded “preforms” on a solid core. After the injection phase, the preform is then removed from the mould still on its core, under precise temperature control (close to its melting point), and positioned in a blowing mould where it is blown off the core into the blow mould cavity. Finally, the part is removed from the blow mould, usually without any final trimming being required.

It is normal practise for two or more cavity moulds to be used in the IBM process. Very good control of temperatures, particularly in the injection mould and core, is essential to ensure proper formation of the final blown part.

For specific recommendations for injection blow moulding of HYTREL® see section 4.10.

3 The blow moulding machine – Important considerations

DuPont blow mouldable resins have been processed in many types of blow moulding machines. This section will be devoted primarily to intermittent extrusion (accumulator head) and continuous extrusion blow moulding. However, for HYTREL® in particular the injection blow moulding and Pressblower®[1] process are frequently used to make CVJ boots and similar small parts. Recommendations relating to these specific processes are made in section 4.10.

3.1 Screw and barrel design

Screw design is very important for engineering resins because most of them have high energy requirements. This usually means that a gradual compression screw with a high L/D (length/diameter ratio) is recommended. To achieve a stable process, high capacity, and homogenous melt, the screw should ideally have an L/D of at least 24 with a compression ratio between 2,7 and 3,5:1 (as measured by depth of feed zone divided by depth of metering zone). Shorter screws may give inhomogenous mixing, and improper compression ratios can cause problems such as overheating of the melt, surging, or air entrapment. A nose cone rather than a square cut-off at the end of the screw is preferred. The use of so called "high output" polyethylene screws (normally associated with intensely cooled grooved barrel feed sections) are not recommended for ZYTEL®, HYTREL® or CRASTIN®. Because of the sharp melting point of these materials a gradual compression and shearing action is needed to properly melt and homogenise the resin which is best achieved in a 3-zone screw and smooth barrel (cylinder design). It has been found that certain designs of grooved barrel can give irregular flow with softer HYTREL® grades and can also result in high motor torque and screw stoppage with more crystalline nylon resins. However, where grooved barrels are used, it may be necessary to use a lower compression screw than that indicated above, and to raise temperatures in the grooved section of the barrel (which is normally water cooled).

It is not recommended to use high shear mixing devices (e.g. Maddock) for HYTREL®, as this leads to high local heat build up and consequent difficulty to control melt temperature and maintain uniform viscosity. However some low shear mixing sections on screw tips may be beneficial.

Further details of recommended screw designs can be provided by your DuPont technical representative.

Materials of construction

Generally, corrosion resistant metals are not required for processing ZYTEL®, HYTREL® or CRASTIN®. Normal nitrided steel surfaces are usually adequate and give good service life. However for glass reinforced resins, barrel surfaces and screw flight land surfaces should be of a type to provide good wear resistance.

Xaloy 100/101 or 800 types (or equivalent) barrels have shown excellent resistance to wear by glass fibres. Nitrided barrel surfaces, on the other hand, do not withstand abrasion by glass fibre reinforced nylons and often exhibit spalling (surface flaking) after short-term use. Nitrided barrels are therefore not recommended for continuous processing of glass reinforced nylons.

For screws, flight lands hard surfaced with an alloy such as Stellite have been found to resist wear better than either flame hardened or nitrided flights. Hard chrome plating of the other surfaces of the screw is also recommended.

Additional information

The use of breaker plates with screen packs should not be used on blow moulding machines during the processing of engineering resins.

3.2 Manifold/adapter design

After the end of the screw, in the machine adapter section, a rupture disc or equivalent device should be installed as a means of relieving high system pressure. High pressure could be caused by material "freeze-off", material degradation and off-gassing, as well as viscous effects. A pressure sensor should be fitted at this point to monitor extruder performance and also to activate an automatic extruder drive shut off when the pressure approaches the equipment manufacturer's recommended limits.

The melt flow channels between the very end of the screw and the entrance of the die head must be carefully designed so that the flow is streamlined and will have sufficiently high velocity against the wall to minimise resin stagnation at the wall. Slow flow or hold-up spots can cause polymer degradation resulting in gels and deposits which could partially dislodge over time.
A proper manifold design will avoid these problems.

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[1] Registered trade name of Ossberger Maschinenfabrik GmbH.

3.3 Accumulator and continuous extrusion head design

Accumulator head design

The accumulator head should be of “first-in/first-out” design. Material “hold-up” in the flow channels will result in longer thermal exposure that could decompose the material. The accumulator head re-knit section should also provide good parison re-knit strength where flows are divided and later merged together again.

Good control of the temperatures in the material flow channels of the accumulator head is of particular importance – see section 3.7.

Continuous extrusion head designs

Extrusion head design considerations for continuous extrusion blow moulding machines follow the guidelines given for accumulator head machines.

3.4 Die/head tooling design

The die/head tooling design will influence several parison characteristics:

- Parison Diameter
- Swell (increase of thickness and diameter)
- Parison wall thickness
- Parison surface finish

Parison diameter will be mainly determined by the die diameter and by the parison “swell” and “sag” (stretching under gravity).

Other factors which control these characteristics are melt temperature and other resin properties, as well as extrusion (push-out) speed, and die/pin geometry.

Figures 8 and 9 show illustrations of convergent and divergent die tooling designs with effects of parison diameter and thickness “swell”.

The relative angles of the die and pin tooling will influence the degree of parison programming response. Table 3 gives typical values for diameter and thickness swell ratios for some Zytel®, Hytrel® and Crastin® grades, although actual swell behaviour should be accurately determined by running machine trials with the proposed machine/material combination.

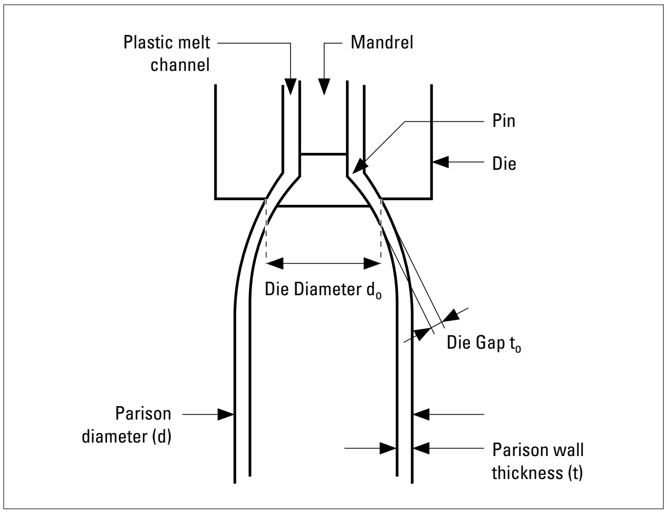

Fig. 8 **Divergent head tooling**

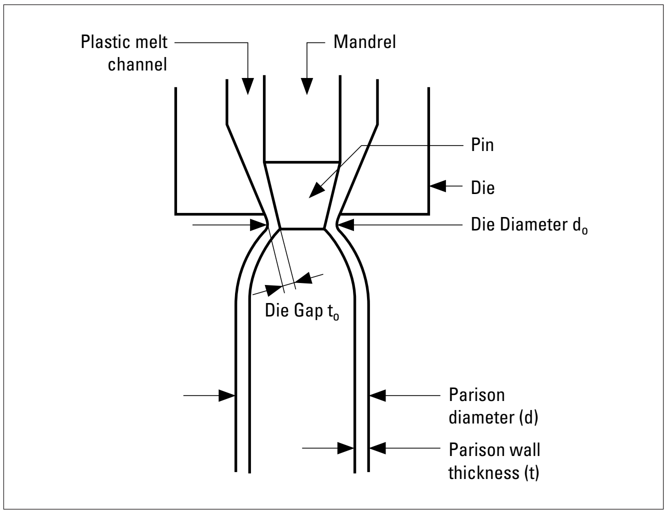

Fig. 9 **Convergent head tooling**

$$\text{Parison thickness “Swell”} = \frac{t}{t_0} = Ts$$

$$\text{Parison diameter “Swell”} = \frac{d}{d_0} = Ds$$

Table 3

	Divergent tooling		Convergent tooling	
	Ts	Ds	Ts	Ds
Zytel® BM7300T	1,5-2,0	1,1-1,4	1,5-2,0	1,2-1,6
Zytel® BM73G25T*	1,0-1,2	0,9-1,1	1,0-1,2	1,0-1,2
Hytrel® HTR4275	1,5-2,0	1,1-1,4	1,6-2,1	1,4-1,8
Crastin® BM6450	1,3-1,7	1,0-1,2	1,4-1,9	1,2-1,5

* Note: Glass reinforced grade

3.5 Parison cutters

Depending on the type of machine, it may be necessary to cut the hot parison. Normally a hot cutter of the "hot knife" or "hot wire" design can be used with HYTREL®, CRASTIN® and unreinforced ZYTEL®. However, for glass reinforced ZYTEL® it may be necessary to substantially reinforce the hot knife to prevent damage or breakage by the extra stiffness of the glass fibres in the parison.

3.6 Mould clamping force

Moulds should be designed and machines selected so that the clamping force is 75-225 N/cm^2 of projected part area and 500-5000 N/cm of pinch length.
The lower pressures may be required when running aluminium moulds and pinch-off sections. Pressure requirements also depend on details such as pinch-off configuration, flash pocket and landing pad designs, and parison wall thickness. For more information on mould design see section 6.

3.7 Temperature control

Proper control of temperatures in a blow moulding machine is of particular importance. The melt temperature should be uniform from shot to shot, otherwise inconsistent parison melt strength could cause wall thickness variations in the part. There should be no large areas of unheated metal in the head, or in the connecting zones between cylinder and head. Any "cold spot" will result in cold skin or blockages due to "freeze-off", when processing semi-crystalline engineering resins.

The heater bands should be of sufficient wattage to easily maintain the recommended temperature settings in all zones.

As stated earlier grooved barrel designs are not normally recommended for engineering polymers but if a water cooled grooved barrel section is being used, it will normally be necessary to control the temperature in the range 80-150°C. depending on the material being processed. In the case of nylons in particular, this temperature should be 150°C minimum, otherwise excessive motor torque will be developed. It may be necessary to achieve this using a hot oil temperate control system. Cooling water to the feed throat should be provided in order to reduce the chance of material bridging below the feed hopper.

Ammeters on each heating zone with proper alarms and automatic shut-offs are recommended to assure proper control and monitoring.

3.8 Auxiliary equipment

Dessicant dryers, Granulators

See "Handling of blow moulding resins", section 5.

Incorporation of mould inserts.

Metal or plastic parts are sometimes required to be pre-loaded into the mould before each blow-moulding cycle.

In the case of metal inserts, these are usually mechanically keyed into the blow moulded part during the blowing cycle, or they may be pre-coated with a suitable bonding agent to promote adhesion. Plastic inserts should be made from the same (or at least compatible) resin as the blow moulded part. It may be necessary to preheat the inserts in an oven to achieve bonding during the blow moulding operation.

Mould temperature controllers

Suitable chilled water or in some cases hot water or oil systems should be used to maintain mould temperatures in accordance with recommended settings (see: Operating conditions, section 4).

Ventilation/fume extraction

For most grades of ZYTEL®, CRASTIN® and HYTREL®, normal ventilation equipment which is typical of good industrial practice is adequate to ensure trouble free processing. However, with blow moulding machines involving large exposed parisons and especially during start-up and shut-down purging operations, it is recommended that localised extraction is provided above the head and around the purging area. In addition, for some resin types, good extraction should be provided to eliminate any unpleasant or excessive fumes, especially during manual trimming operations.

4 Machine operating conditions

4.1 Quick reference. Summary of processing conditions for DuPont blow moulding resins

Table 4 provides guidelines for processing conditions including pre-drying requirements. Typical shrinkage values are also shown, although it is recommended that actual shrinkage should be accurately predicted for new moulds by making trials with the selected resin in another similar mould. This is because in practice the part shape, wall thicknesses and blow-up ratio can significantly affect shrinkage of blow-moulding resins.

As for many semi-crystalline resins, low moisture content is essential for good control of viscosity. This is especially true for nylons and it is strongly recommended that the figures in Table 4 are considered as maximum moisture levels for good blow moulding results. Please refer to section 5.3 for further details of drying and handling of regrind material.

4.2 Barrel temperatures

Table 4 shows optimum **melt** temperature which should be maintained for good processing in the blow moulding machine. These temperatures should ideally be achieved at the end of the barrel/screw, so that the subsequent temperature control zones (adapter, head, etc.) are used only to maintain the molten resin at the same temperature – without adding or taking away heat – as it passes through the head to the die.

In order to reach the desired melt temperature at the end of the screw, it is normally necessary to set barrel temperatures between 5-15°C below the optimum melt temperature in order to allow for some overheating due to screw shear. Please refer to section 3.1 which discusses the importance of correct screw design, which can have a major effect on controlling temperatures, as well as achieving homogeneous melt characteristics in engineering polymers.

Table 4 – Summary of processing recommendations for blow moulding resins

		Drying requirements					Shrinkage1), %	
Resin type and grade	**Material type**	**Max. % moisture**	**Temp.°C/ time**	**Process melt temp. range,°C (mid-point)**	**Mould temp.°C**	**Mould clamping force N/cm pinch length**	**Length**	**Width**
Hytrel® HTR4275	TEEE	0,02	100-120/2-3 h	215-225 (220)	10-50	800-1200	2,2-2,7	1,5-2,0
Hytrel® HTR5612	TEEE	0,02	100-110/2-3 h	210-225 (215)	10-50	800-1200	2,2-2,7	1,5-2,0
Hytrel® HTR8105	TEEE	0,02	100-110/2-3 h	210-225 (215)	10-50	800-1200	2,2-2,7	1,5-2,0
Hytrel® HTR8223	TEEE	0,02	100-110/2-3 h	210-225 (215)	10-50	800-1200	2,2-2,7	1,5-2,0
Hytrel® B5576	TEEE	0,02	100-120/2-3 h	215-225 (220)	10-50	800-1200	2,2-2,7	1,5-2,0
Hytrel® BM6574	TEEE	0,02	100-110/2-3 h	230-240 (235)	10-50	800-1200	2,2-2,7	1,5-2,0
Zytel® CFE8005	PA66	0,05	110-120/4-6 h	270-280 (275)	70-120	1500-3000	1,2-1,7	2,3-2,8
Zytel® EFE7340 EFE7341	PA66 15% glass PA66 20% glass	0,05	110-120/4-6 h	270-280 (275)	70-120	1500-3000	0-0,5	1,0-1,5
Zytel® BM73G25T	PA6 25% glass	0,05	110-120/4-6 h	230-240 (235)	20-120	1500-3000	0	0,5-1,0
Zytel® BM7300FN	PA6 flexible alloy	0,05	80 max./6-7 h	225-235 (230)	20-60	800-1200	2,4-2,8	2,4-2,8
Zytel® BM7300T	PA6 rigid	0,05	110-120/4-6 h	230-240 (235)	20-120	1500-3000	1,0-1,5	1,8-2,5
Crastin® BM6450	PBT	0,03	100-120/2-3 h	235-245 (240)	20-60	800-1200	1,8-2,3	1,5-2,0

1) Measured on 1 litre bottles.

Exact shrinkage value will depend on average wall thickness and shape of part. Use lower value for ~ 1 mm wall, higher value for >4 mm wall.

Note: For Injection blow moulding of Hytrel® resins, please refer to section 4.10.

4.3 Adapter, head and die temperatures

Engineering resins tend to have sharp melting points which means that manifolds/adapters, head and die zones should be uniformly heated to avoid cold spots where the molten resin could suffer changes in viscosity or even “freeze-off”. There should not be any large areas of unheated metal in these areas of the blow moulding machine. In addition, all heaters should be large enough in heating capacity to ensure that all zones reach their start-up temperature settings in a reasonable time period and the temperature is subsequently controlled within a few degrees of the set-point at all times. This will also require that the thermocouples are properly located in deep pockets within the body of the adapter/head/die section. As stated in section 4.2 the ideal situation is to achieve the desired melt temperature at the end of the screw, after the final barrel zone. The objective of the various heater zones in the adapter and the head should be to maintain that value, without adding to, or reducing the melt temperature. In other words, these zones should not be used to compensate for poor screw design or wrong barrel temperature settings!

Optimum temperature settings in the adaptor, head, and die zones should be based on the Table 4 “Process Melt Temperature” (mid-point) for each type of resin and grade. Once the temperatures have been set, it is important to allow enough “heat soak” time to achieve uniform and stable temperatures throughout the various zones on the machine. If, during normal machine operation, it is noticed that any of the actual temperatures fall significantly below the set points, the cause of this should be investigated. Some possible causes may be:

- failure of a heater band or connections
- dislodged thermocouple
- sudden external source of cooling (e.g. draught from open door)
- other cooling effect – for example some machines have airflow through the head for part blowing.

Die temperature is normally set in a similar way to the head temperature, although a higher temperature (5°-20°C) may be used to improve surface finish (including “sharkskin” or melt fracture effects) and to reduce push-out pressures and die swell. It may also help too improve pinch weld strength with certain resins.

4.4 Accumulator push-out pressures and speeds

Push-out pressures may be limited by machine design and safety considerations and there is no “optimum” pressure for different grades or types of DuPont resins. However, the pressures which are measured with any one machine/head/die combination will obviously depend on:

- Type/grade of resin
- Viscosity of resin (as determined by melt temperature, moisture content etc.)
- Die gap (as set by die tooling dimensions and parison programme)
- Die geometry (shape)
- Die temperature
- Push-out speed

Push-out speed (or pre-set push-out pressure) should normally be as fast as possible for most engineering resins. This is for the following reasons:

- Minimise parison sag (stretching) especially with long parisons
- Minimise surface oxidation (which may effect pinch welds)
- Minimise surface cooling (for better surface finish – after moulding)

There may be a need to limit the push-out speed if the parison shows signs of melt fracture (or “sharkskin”), or for reasons of machine design/safety.

4.5 Parison programming

Multi-point parison programming is standard on most blow moulding machines and it allows control of parison wall thickness along the length of the parison by opening or closing the die gap according to a pre-set programme. The use of parison programming is necessary to compensate for any tendency for the parison to stretch under gravity, particularly with longer parts, as well as to position the optimum thickness of material at each point along the length of the part.

The “profile” which is adopted for programming the parison for any given mould is determined during moulding trials.

4.6 Mould temperature

Guidelines for mould temperature settings are given for each type of DuPont engineering resins in Table 4. These temperatures are selected taking into account some important criteria such as:

- The need to minimise overall cycle time
- The rate of "freeze-off" of the material when in contact with the mould, which may affect surface finish in some materials (hot mould may give better surface finish)
- The shrinkage rate of the material
- Pinch-weld strength, which may be optimised by use of a hot mould

Special processes such as certain 3D blow moulding may require higher temperature moulds than those indicated in Table 4 – see section 2.4.

4.7 Start-up procedures

Normally, the machine should have been run empty when shut-down, in accordance with the procedure outlined in section 4.8. If previously used for ZYTEL® or perhaps other engineering resins, it should have been purged with high density polyethylene prior to shutdown. If the machine was shutdown after purging with (for example) HYTREL®, then the following procedure also applies. However if thermally unstable materials such as PVC were previously in the machine, then it is recommended that temperature limits for these materials should not be exceeded until the machine is first warmed up and purged with high density polyethylene. In general the start up procedure is:

1. Set all machine temperatures at the suggested running temperatures given in Table 4 for the appropriate resin type
2. Allow the temperatures to reach set point, then allow to "soak" for an additional 1-3 hours, depending on the size of the machine. If any machine does not reach the controller set point temperature within a reasonable period, the relevant heating and control circuits should be checked out (see also section 4.3).
3. Keeping the feedhopper closed, start the screw and using low speed initially, make sure to check motor current and melt pressure instruments where provided, to ensure there is no blockage or other problem associated with a slug of cold material in the machine.
4. Once the screw is turning (slowly) and there is no evidence of blockages etc. then open the hopper to allow resin granules to enter the screw feed section.
5. Monitor the screw torque through drive motor current and also any melt pressure transmitters. Gradually increase screw speed to normal running speed, again watching motor current and melt pressure.
6. It may be beneficial to turn the screw and cycle the accumulator head (where fitted) at a faster than normal rate as part of this start-up procedure, in order to help purge the machine of any old resin or polyethylene which may be difficult to clear from the adapter, head and die sections.
7. Ensure that all foreign material or polyethylene "skin" has been completely eliminated from the machine by checking the surface of the parison, both visually and by scraping with a suitable blade or other instrument.
8. Start moulding using established conditions and make adjustments as necessary.

4.8 Purging and shutdown

For short term stoppages (say between 15 mins and 3 hours) it is recommended that the machine is run empty by closing the feed hopper slide and pushing out all material from the barrel and head. Maintain normal temperature settings in all zones. Start up should be followed by purging out all residual stagnant material with fresh resin. For situations where the machine will be stopped for more than say 2-3 hours the following purging and shutdown procedure is recommended, depending on which type of resin is being moulded.

ZYTEL® (PA6 and P66 types):

- Close hopper slide and continue running machine until all resin is cleared from the barrel and from the accumulator head (if fitted).
- Introduce high density polyethylene through the screw and head and continue running it through the machine until all traces of ZYTEL® are purged from the machine. Running the machine at faster speeds than normal may help to accelerate the purging process. Run all polyethylene out of the machine before shutting it down and switching off heaters.
- The purging time (and quantity of polyethylene needed) may be significantly reduced by the use of a suitable proprietary purging compound. For example, Extru-Clean®[1)] purging additive has been found to be successful with both PA6 and PA66 types of ZYTEL®. Always follow the procedures recommended by the suppliers of the purging compound.

[1)] Extru-Clean® is available from: Annecat Plastics, P.O. Box 10841, Aston Manor, 1630 South Africa, and agents in other countries.

Follow up the use of purging compound by a quantity of high density polyethylene, running it through the machine until clean, then empty the barrel and head (accumulator) before shutting down the machine.

CRASTIN®

CRASTIN® may be purged from the machine prior to shutdown by following the procedure recommended for ZYTEL®. However, when it is planned to start up the machine again with CRASTIN® (or HYTREL®) it is suggested that the following process will make it easier to start-up and minimise the time and material required to achieve a clean parison:

- Close hopper slide and run all CRASTIN® out of the barrel and accumulator head (where fitted)
- Introduce some HYTREL® HTR4275 through the machine until all traces of CRASTIN® have been purged through the die. Maintain normal CRASTIN® processing temperatures. If preferred, regrind or scrap HYTREL® blow moulding resin may be used
- Optional: Follow the blow moulding HYTREL® grade with a short purge of HYTREL® 4056 grade. This low melting point grade will ensure that any residual material left in the machine after shutdown is easily melted during the start-up process, thereby reducing the material and time needed for start-up.

HYTREL®

Where it is planned to re-start the machine again with HYTREL®, then it is helpful to purge the machine with a low melting point grade of HYTREL® such as 4056 (without lowering temperatures from normal running settings). Run the machine at high speed to assist purging, and then after a few minutes, empty the barrel and switch off the heaters. The residual low-melting HYTREL® in the head will make start-up faster and easier.

When more complete purging is required, for example if the machine is to be re-started with a different resin, then HYTREL® may be purged with a high density polyethylene (as for ZYTEL®).

4.9 Secondary operations

There are a variety of secondary operations that can be performed on blow moulded parts, for example:

Trimming

Part trimming is the most common secondary operation. If the parts are trimmed by hand, then this should be done while the parts are hot, to minimise the effort required. Automatic trimming using shear cutters and appropriate “masks” or fixtures to hold the part may be used for rigid materials. Alternatively circular sections can be trimmed using rotating cutter blades.

Welding

DuPont blow moulding resins have been designed for good welding performance, and have been tested using commercially available welding equipment. For best results it is recommended that the following points are observed when welding parts:

- Mouldings should have minimum moisture content (in particular nylon materials). They should either be welded within a few hours of moulding, or they should be kept in a hot-air oven (80-100°C) for several hours prior to welding.
- Hot plates should be kept clean and preferably TEFLON® coated (only suitable for temperatures up to 290°C). Where TEFLON® coating is not possible, automatic wiping or wire brushing of the plate surface between welds may be appropriate.
- Plate temperatures and pressures during melt-back phase should be adjusted to give a good bead of molten resin, without spreading it away from the melting zone. Normally, the hot plate should be set to a temperature 40-70°C above the nominal melting point of the resin being welded (refer to Table 4).
- Minimise time between removal of the hot plate and pushing together the two parts being welded.

Further advice on welding may be obtained from welding machine manufacturers, or through your DuPont representative.

4.10 Special conditions for injection blow moulding and Pressblower® (Ossberger) operation

These processes are preferred for moulding CVJ boots in HYTREL®, but are also suitable for other smaller, high volume part production. However, injection blow moulding is not normally suitable for ZYTEL® materials.

Injection Blow Moulding – HYTREL®

Table 5 gives suggested processing conditions for CVJ boots in HYTREL® HTR8105 on a typical multi cavity injection blow moulding machine. It should only be used as a guide, since temperatures and other parameters will be different from machine to machine, and for different HYTREL® grades.

It is also necessary to use special mould and core surface treatments (textures and release coatings) for HYTREL®. Details should be obtained from the machine manufacturer or from your DuPont technical representative.

Table 5 – Injection blow moulding conditions

HYTREL® HTR-8105BK

Process parameter	Typical range
Barrel temperatures,°C	
Rear	220-240
Centre	220-250
Front	220-250
Nozzle	220-250
Melt temperature,°C	225-250
Parison hold temperature,°C	95-170
Core rod temperature,°C	150-190
Screw, RPM	80-120
Parison moulding cycle, seconds	
Injection	0,5-4,0
Hold	1-10
Blow air pressure, bar	5-15
Blow moulding cycle, seconds	
Blow	4-10
Exhaust	3-5
Total cycle time, seconds (based on 3-station operation making 3 boots per cycle)	10-15

Pressblower® (Ossberger) process – HYTREL®

Table 6 below shows suggested processing conditions for CVJ boots in HYTREL® HTR8105 on a 50 mm screw Ossberger SBE 50 machine. Parameters may be different from these values, depending on the design of the part, the mould construction, and the actual HYTREL® grade being used.

Table 6 – Blow Moulding Conditions: Ossberger SBE 50 Machine

HYTREL® HTR-8105BK

Process parameter	Typical range
Barrel temperatures,°C	
zone 1 (rear)	205-215
zone 2	215-225
zone 3	225-235
zone 4 (front)	225-235
Head/die temperatures	
bottom	225-235
middle	225-235
die	240-255
die cone	240-255
Screw RPM	40-45
Parison extrusion speed	25 mm/s (constant)
Max parison pulling speed	100 mm/s
Die gap	100 % = 3,3 mm
Typical cycle time	15-20 s
Calculation of pin/die diameter	
Blowing mandrel (=small neck int., dia)	"X" mm
Extrusion pin diameter	"X" + 1 mm
Extrusion die diameter	"X" + 1 + (5,5 to 6,5) mm

5 Handling of blow moulding resins

5.1 Effects of moisture

All polyamide and polyester resins are affected by the presence of moisture in processing, and must be dried to a low level of moisture prior to blow moulding. However, since polyamides generally absorb higher quantities of moisture, they are particularly sensitive to moisture pick-up and consequent effects on viscosity. The moisture can significantly effect viscosity, even though the level is not high enough to show up as bubbles or other defects in the molten parison.

Figures 10 and 11 below show the amount of moisture pick-up in typical blow moulding grades of Zytel® PA66 and Hytrel® in 50% R.H. air at room temperature. Higher humidity or temperature will increase the rate and ultimate level of moisture absorption.

The effect of moisture on the viscosity of blow moulding nylon grades can be seen in Fig. 12, which is typical for most of the Zytel® PA6 and PA66 types.

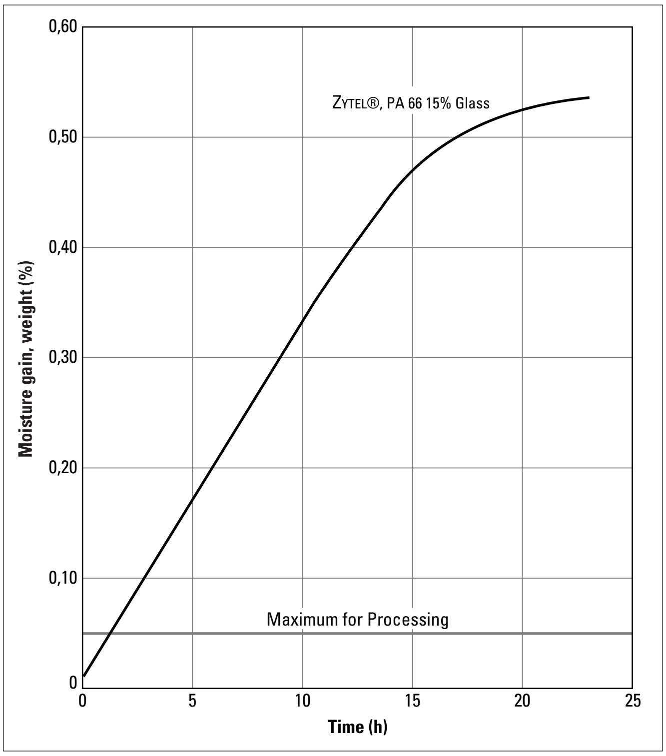

Fig. 10 **Moisture absoption, 50% RH at room temperature**

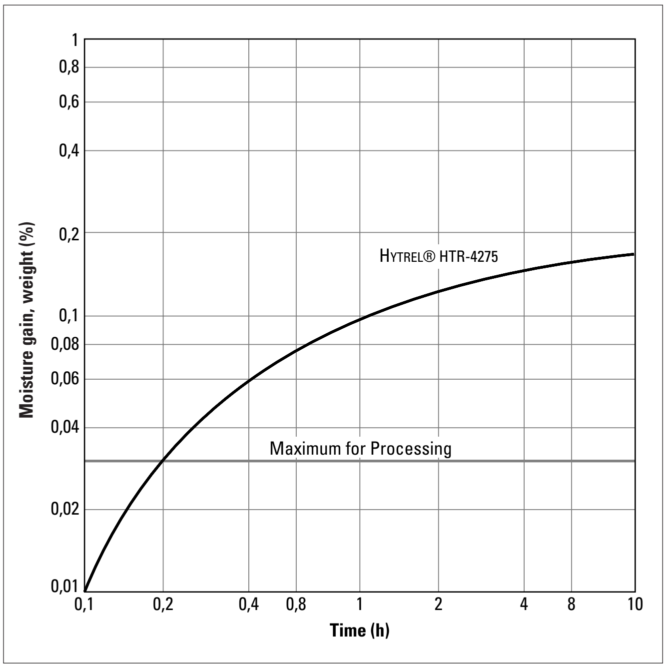

Fig. 11 **Moisture absoption, 50% RH at room temperature**

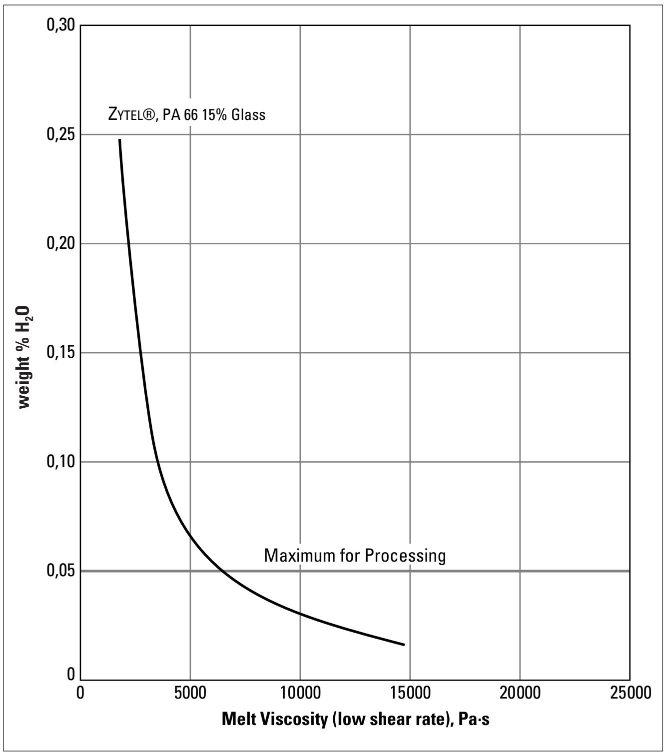

Fig. 12 **Melt viscosity vs. weight % H_2O**

For Hytrel® and Crastin® the change in viscosity is not so severe, but there is some effect, mainly due to the hydrolytic degradation of the polyester resins when moisture is present during processing.

The maximum recommended levels of moisture for blow moulding DuPont engineering resins are given in Table 4. Generally it should be no more than 0,05% for Zytel® grades or 0,03% for Hytrel® and Crastin® grades. As can be seen from Figs. 10 and 11 above, these moisture levels can be reached very quickly when fully dried material is exposed to typical atmospheric conditions, so it is essential that dried material is transferred quickly to the machine hopper, then suitably protected from further moisture pick up. The best way to achieve this in practice is by use of dessicant dryers mounted on the machine hopper, or connected to the hopper by a sealed piping system. It is also recommended that a device for accurately measuring granule moisture content (down to below 0,01%) is available for routine moisture checks where engineering resins are regularly being blow moulded.

Further advice on moisture measurement can be obtained from your DuPont representative.

5.2 Drying

As indicated above, it is necessary to ensure very low levels of moisture in both nylon and polyester resins before blow moulding. To achieve these low moisture levels, a dessicant (dehumidifying) air dryer is essential, since the more basic “hot air” dryer cannot usually dry to these conditions unless operated under vacuum (vacuum ovens could also be used, but normally their capacity is insufficient for blow moulding output rates).

Many suitable dehumidifying dryers are available on the market. However it is important to check (at regular intervals and whenever drying performance is suspect) that a dew point of –25°C, or lower, is being achieved. It is strongly recommended that a dew point meter is available for such routine checks.

Guidelines for drying time and temperature are given in Table 4 for most DuPont blow moulding resins. Actual drying time required may vary from those indicated, depending on initial moisture content.

Dryer hopper capacity should be adequately sized for the required residence time prior to moulding. This can be calculated from the expected throughput rate (kg/hour) and using a bulk density value[1] of 0,6 kg/litre for ZYTEL® and 0,7 kg/litre for HYTREL® and CRASTIN® resins, for example:

Production throughput: 90 parts/hour × 300 g each [2]	= 27 kg/hour
Required drying time (Table 4, ZYTEL® PA6)	= 6 hours
Required dryer hopper capacity	= 162 kg ZYTEL® = 162 × 0,6 = 97 litres

So dryer hopper capacity should be 100 litres capacity (minimum).

5.3 Regrind

The handling of regrind material is closely related to the effects of moisture. It is important therefore that all regrind is either re-used quickly after moulding (for example in a closed-loop system which automatically recycles trimming and flash to the moulding machine hopper), or else thoroughly dried before use, if it has been allowed to pick-up moisture over a longer period.

Table 4 shows recommended drying times and temperatures for DuPont engineering resins. However it may be necessary to dry regrind material (especially nylons) for considerably longer than this, depending on the moisture content of the regrind.

The maximum amount of regrind (% by weight) which can be added to virgin resin in the blow moulding process will depend on the resin grade. Since there is always some thermal degradation during moulding, it follows that some loss of mechanical properties may result from use of an excessive amount of regrind – depending on the **quality** of regrind (in terms of possible thermal degradation). Another limitation on the amount of regrind which can be used comes from the screw feeding characteristics of the regrind – badly cut (very irregular size and shape) regrind may not feed properly, unless mixed with a high % of virgin resin.

In general, maximum regrind levels suggested for DuPont engineering polymers are as follows:

ZYTEL® PA6 and PA66 types, including glass reinforced:	60%
CRASTIN® and HYTREL® types, for airduct and similar applications:	60%
HYTREL® used for CVJ boots:	30%

With some grades it is likely that regrind behaviour in processing will be different from that of virgin resin, in its viscosity (melt strength) and die swell characteristics. For this reason it is important that the level of regrind used should be maintained at a constant % during part production. Should it become necessary to run with lower, or higher, levels of regrind the machine parameters may need to be adjusted accordingly.

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[1] Bulk density value for regrind will be significantly lower than for virgin resin.
[2] Assumes all scrap is immediately re-used. If not, add weight of scrap not re-cycled.

5.4 Bulk Storage

For high volume manufacture utilising several machines in continuous production, it may be economical to consider bulk delivery and storage of resins. Depending on the grade and logistics, various forms of bulk shipment may be available from DuPont, such as:

- 500 kg boxes
- 800 or 1000 kg octabins
- Special containers (typically 18 or 20 tonne)

Resin supplied in each of these forms conforms to normal DuPont sales specifications for moisture content, and is sealed against moisture pick-up in shipping by suitable moisture barrier packaging material. Procedures for handling boxes and octabins at the moulding machine should ensure that excessive moisture does not enter the resin after the package has been opened, and before all the resin has been transferred to the dryer hoppers. For example, it is suggested that only a small hole is made in the plastic liner for insertion of a suction pipe which will transfer the granules pneumatically to the dryer. This hole should be re-sealed tightly when the resin is not being consumed.

For transfer of container shipments to storage silos, a dry-air pneumatic system should be used to avoid unnecessary moisture pick-up. Inside the silo, the air space above the granules must be kept charged with dehumidified air from a dessicant system. The granules should be fed to the moulding machines through a closed piping system, passing through a suitably sized dryer – either individual dryers for each moulding machine, or a larger single unit feeding a manifold system connected to each machine. In some cases, especially with nylons, a combination of bulk dryer (which can be hot air type) plus individual dessicant dryers may be preferred.

6 Mould design guidance

6.1 General

Mould design for blow moulding resins is basically similar to that of other resins, such as polyethylene. The main additional considerations should be: pinch-off design and material of construction, blow up (draw) ratio, shrinkage allowances and cooling.

6.2 Materials of construction

As for most blow mouldable resins, moulds may be constructed from one or more of the following materials:

- **Steel** (machined or cast)
- **Aluminium** (machined or cast)
- **Beryllium Copper** (machined or cast)
- **Kirksite** (low melting metal alloy – usually only for prototypes)
- **Filled epoxies** (prototypes or small production runs)
- **Cast polyurethane** (usually only for prototypes)

The correct choice will depend mainly on economics, life expectancy and speed of fabrication. Some considerations may be worth pointing out:

- For glass reinforced grades, the pinch off (at least) should be machined from steel to prevent damage and wear from the abrasive nature of glass fibres.
- Steel is more robust and may therefore be better to withstand long term production, especially when considering operator cleaning of mould surfaces and possible damage when removing deformed parts etc. (engineering resins are usually harder than polyethylene, for example).
- Because of their semi crystalline nature, and high melting points, heat transfer is important in blow moulding engineering resins. For this reason aluminium and beryllium copper moulds and inserts may be advantageous (especially in fast cycling processes like injection moulding of HYTREL® CVJ boots).

6.3 Blow-up (draw) ratio

Blow-up or draw ratio in the blow moulding process is the ratio of the initial surface area of the parison to the total expanded surface area of the moulded part.

Sharp corners and other areas resulting in an effective draw ratio greater than 4:1 (3:1 for glass reinforced resins) should be avoided in the mould design. If this ratio is too high it can cause poor part performance due to thinning of wall sections and tearing of the parison during the forming process. Blow-up ratio should be minimised where possible close to the parting line/pinch-off location.

6.4 Mould shrinkage allowances and part dimensions

Part shrinkage is significantly higher in blow moulding than in injection moulding and in particular there is a significant difference between "flow" direction and "transverse" direction with glass reinforced resins.

Typical shrinkage allowances are given for DuPont engineering resins in Table 4. The exact amount of shrinkage for a particular resin grade will depend on:

1. Wall thickness	(thicker = more shrinkage)
2. Melt temperature	(higher = less shrinkage)
3. Mould temperature	(higher = more shrinkage)
4. Processing conditions	(for example push-out speed and die/orientation effects)

Of all these, the most important factor is wall thickness, and it follows that variations in wall thickness through the part can result in some warpage of the finished moulding. Control of wall thickness during moulding is therefore quite critical. There will also be some post-mould (additional) shrinkage, which is usually quite small. Also, with nylon resins there will be some "negative" shrinkage due to moisture absorption in the moulded part.

All these factors mean that it is strongly recommended that final shrinkage allowance for mould design should be based on experience and from measurement made with the same resin in a similar mould configuration.

6.5 Pinch-off designs

All DuPont engineering resins are designed for good pinch weld behaviour. However, good pinch-off design is important to achieve maximum strength in the pinch-off part of the moulding (some mouldings, for example those made with most 3-D moulding processes, do not contain a pinch-off in the finished part).

For engineering resins, the preferred design is usually the so-called "double dam" type, which helps to develop the necessary pinch pressure and forces molten resin back into the weld area. This prevents the formation of a "V" notch inside the moulding, which can be a source of weakness.

A typical design of this type is shown in Fig. 13 below. Other designs, including the conventional “single dam” configuration have also been used successfully with DuPont resins and may be perfectly suitable in cases where maximum strength in the pinch weld area is not critical.

L = 0,5 to 1 × Parison wall thickness
DPD = 2 to 4 × Parison wall thickness
DL = 1 to 2 × Parison wall thickness
FW = large enough to hold maximum Parison “flash” after pinch-off
D = 0 to 0,5 mm. Depending on required ease of trimming
DD = D + (0,5 × Parison wall thickness)
FD = 1,5 to 2 × Parison wall thickness

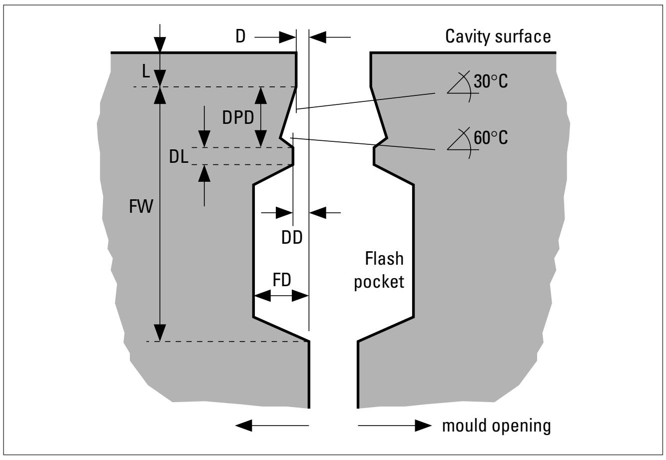

Fig. 13 **“Double Dam” Pinch-off Design**

6.6 Other mould considerations

It is not intended to provide extensive mould design recommendations since these are best left to competent blow mould tool manufacturers who have many years of experience in this area. However, the following points are particularly important for successful blow moulding of engineering polymers.

- Mould cooling should be well designed due to the fact that engineering polymers have a high heat capacity because of their semi-crystalline nature. The cooling should provide an even mould temperature over the surface during moulding, since uneven cooling rates in the part can lead to warpage.
- Venting of the mould cavity must be provided in order to prevent poor surface reproduction, or surface defects in moulding. In some cases, sufficient venting can be provided by the use of a non-polished surface (for example sand-blasting or “texturing”), but where the cavity is large or deep it is normally necessary to provide special vent “plugs” (sintered metal) or slit vents. Venting at the mould parting line may also be provided by slight relief of the cavity edge, leading into an adjacent vent channel.
- Mould surface finish can affect the venting of the cavity (see above), but for some resins (such as HYTREL®) it can help with part ejection from the mould. In this case a sand (grit) blast surface is preferred to a polished surface. A highly “textured” surface can also be used successfully to hide any surface blemishes which might be seen on a smoother surface – these blemishes are sometimes the result of uneven cooling or shrinkage effects in the part as it cools.
- Relief angles, undercuts etc: Due to the high shrinkage of engineering resins, it is important to avoid designs where the shrinkage of the part could “lock” the part in the cavity after cooling, and result in difficulty to eject the part. This is a potential problem for both rigid resins (for example, glass reinforced ZYTEL®) and more rubber-like resin like HYTREL®.

If you would like additional advice on tool or part design, please consult your DuPont technical representative.

7 Troubleshooting guide

The following table shows some of the more common problems which may be encountered in blow moulding DuPont engineering resins. The "most likely" or simplest causes are listed first and may sound obvious, but quite often these are ignored or not properly checked out!

FAULT	CAUSE	SOLUTION
Bubbles in melt	Moisture	Dry resin
	Wrong screw design (air entrapment)	Fit suitable screw
Poor melt strength	Moisture	Dry resin
	Melt temperature too high	Check with needle pyrometer and correct to recommended value. If actual melt temperature greatly exceeds set temperatures, see below
Excessive melt temperature (significantly above set temperatures)	Faulty temperature controllers or thermocouples	Repair/calibrate controllers and thermocouples
	Wrong screw design	Fit correct screw
Unmelt or "cold" appearance in parison	Temperature set too low	Raise temperatures – see recommended settings for resin
	Insufficient "heat soak" time before start-up	Allow longer "heat soak"
	Faulty heaters, thermocouples or controllers	Repair/calibrate as necessary
	Inadequate heater capacity for engineering resin (especially in zones between cylinder and head, or in head/die zones)	Upgrade heater size or provide thermal insulation
	External (or internal) cooling of head/die by air draught or leakage	Eliminate source of air cooling
Inside surface of parison is rough (outside may be O.K.)	Core pin too cold	Consider fitting core heater Check if air flow through core/pin is excessive
	Melt fracture	Increase die temperature (only) Reduce push-out speed/pressure Check die/design (internal angles too severe, for example)
Outside surface of parison is rough (inside may be O.K.)	Die too cold	Raise die temperature/check set point is being held
	Melt fracture	See solution for "inside surface" above
Poor pinch weld	Contamination from previous or purge material	Purge for longer before starting Moulding. Temporarily raise head/die temperatures if required to accelerate purging.
	Melt or surface temperature too low	Raise temperatures – try only die temperature first. See below: "Parison hanging too long"
	Parison hanging too long before mould close	Push out faster Reduce delays in mould closing
	Poor design of pinch-off area in mould	Redesign mould pinch-off

FAULT	CAUSE	SOLUTION
Uneven screw output	Granules “bridging” below feed hopper	Check water cooling to throat area
	Feeding problem in screw zone 1	Check set/actual temperatures are correct Raise first screw zone temperature significantly (e.g. 20-30 °C) Check screw design
	Too high regrind usage	Reduce % regrind used
	Restriction or unmelted material after screw/barrel	Check temperatures and pressures Raise temperatures if necessary
Parison rolls onto face of die (does not drop down)	Too low die temperature	Check die heater Raise die temperature
	Incorrect die geometry	Improve die design

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