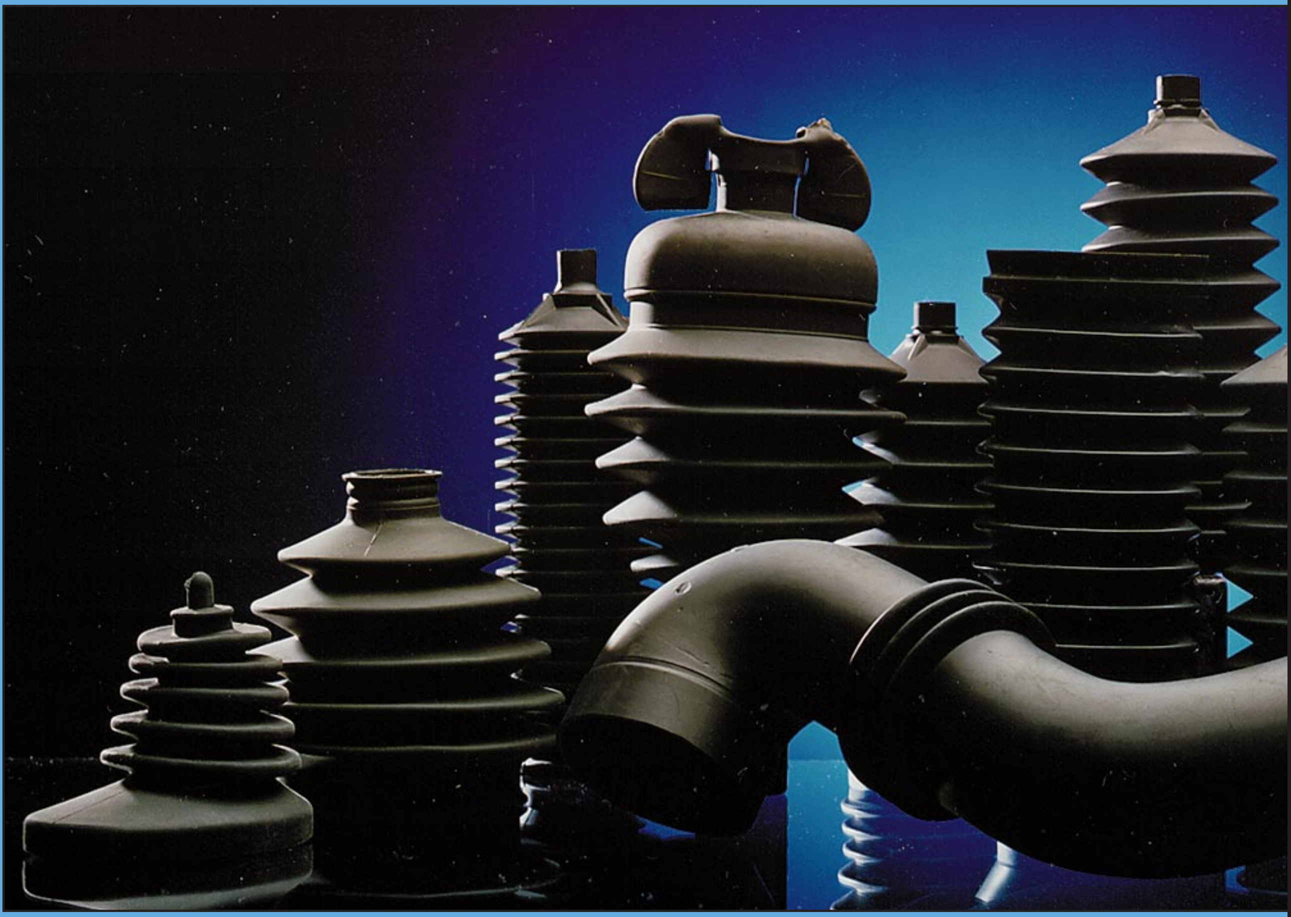
Sarlink

Guidelines for the blow moulding of Sarlink



DSM THERMOPLASTIC ELASTOMERS

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Introduction

Sarlink® 3000 and 4000 are two families of thermoplastic vulcanisates (TPV) based on dynamically vulcanised EPDM rubber particles dispersed in a polypropylene matrix.
Because of this morphology, Sarlink thermoplastic vulcanisates combine the performance characteristics of widely used thermoset rubbers, such as EPDM and polychloroprene, with the ease of plastic processing.

Sarlink 3000 and 4000 offer a large range of properties valuable to the end user. For instance:
✓ resistance to high temperature
✓ resistance to low temperature
✓ excellent flexural fatigue endurance
✓ high impact strength
✓ excellent resistance to chemicals and solvents
✓ excellent resistance to weathering
✓ good electrical properties
✓ high tear resistance
✓ low tension and compression set
✓ good resistance to oils (particularly harder grades).

Besides their interesting performance characteristics, Sarlink thermoplastic vulcanisates, which are fully compounded, ready-to-use pellets, offer the following processing advantages compared to thermoset rubber:
✓ no compounding
✓ no vulcanisation
✓ low capital investment.
✓ easy processing on standard thermoplastic equipment for extrusion, injection moulding and blow moulding
✓ fast processing (short cycle times)
✓ thermal stability/wide processing window
✓ low energy consumption
✓ recycling of scrap generated during processing
✓ recycling of parts after service life
✓ excellent control of product quality and dimensional tolerances
✓ in-line colourability
✓ easy weldability (profiles, sheeting...)
✓ material combinations by co-extrusion, co-injection or co-blow moulding to produce hard/soft articles, solid/sponge profiles...

The Sarlink 3000 family is available in hardness ranging from 40 Shore A to 50 Shore D. The Sarlink 4000 family is available in hardness varying from 50 Shore A to 50 Shore D.
Sarlink 4000 offers better elastic properties, (lower compression set) than equivalent Sarlink 3000 grades.

In addition to standard types, a wide range of speciality grades are available, including: flame retardant, low smoke; pharmaceutical; adhesive grades, which adhere to e.g. polyamide; high flow grades; UV stabilised grades, etc.

Because of its combination of excellent finished part properties and easy processing, Sarlink thermoplastic vulcanisates have found many applications in a wide range of markets, including: automotive, building and construction, electrical, mechanical rubber goods, medical, leisure....

Sarlink thermoplastic vulcanisates are widely used in many blow moulded parts such as rack & pinion steering gear boots, shock absorbers, strut covers, steering column cover, (3D sequential) automotive air ducts, cable ducts and many other applications in all market segments.

This brochure is a guideline for the blow moulding of Sarlink and shows an overview of the different blow moulding techniques.
A checklist for troubleshooting is available on the last pages. ■

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The principles of blow moulding

Introduction

Blow moulding is the established technique for the production of hollow articles such as bellows and airducts. There are three major techniques for this process:

- ✓ extrusion blow moulding
- ✓ press injection blow moulding
- ✓ injection blow moulding.

Extrusion blow moulding is the most widely used technique. Sarlink is very suitable for blow moulding because it has excellent melt strength and a high blow ratio. Sarlink gives a significant weight reduction compared to thermoset rubber and Sarlink is fully recyclable. Table 1 shows an overview of application and material combinations.

Continuous extrusion blow moulding

The principle of the extrusion blow moulding process is that a parison, which is formed by continuous extrusion of material and rotating of the screw in the barrel is clamped between two halves of a mould, cut-off and inflated with air to fill the mould. The mould is cooled so that the product is frozen into the mould shape, while still under air pressure. The mould is then opened and the part removed.
Due to the high melt stability and large blow-ratio (up to 4.5 for the high hardness grades) of Sarlink, large blow moulded articles can be made. The processing steps are shown in figure 2.

Application	Material
Rack & pinion steering gear boots	Sarlink 3190B, 3139DB, 4190B, 4139DB, 4149DB
Shock absorber, strut cover	Sarlink 3170B, 3180B, 4190B
Steering columm cover	Sarlink 3190B, 4190B
Automotive air ducts 1dimensional Automotive air ducts 3dimensional	Sarlink 3180B, 3190B, 4180B, 4190B, flexible part, PP stiff part
Cable duct	Sarlink 3160B, 3170B

Table 1: Examples for possible Sarlink/application combinations.

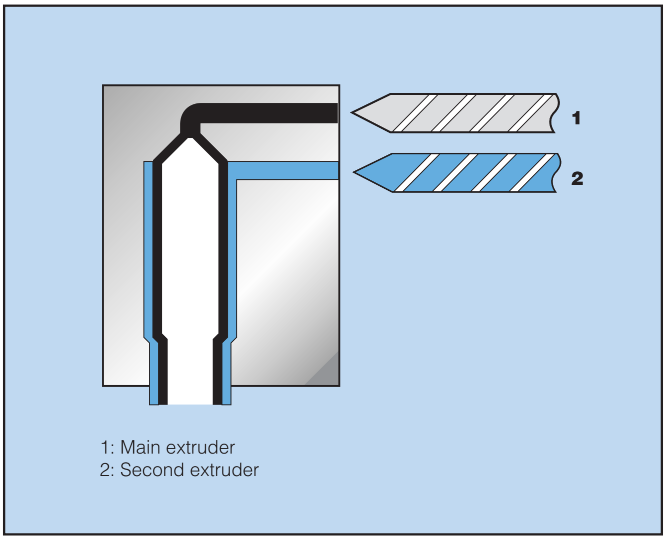

Fig. 1 - Two layer co-extrusion blow moulding.

Multi-layer/sequentional co-extrusion blow moulding

Several polymers can be extruded in a multi-layer parison. The equipment is based on continuous extrusion or equipment with a melt accumulator. The thickness of each individual layer can be varied. Sarlink can be used in this kind of process to create e.g. a soft touch or rubber-like layer on polypropylene. The principles of the multi-layer extrusion blow moulding system are shown in figure 1.
The different materials can also be extruded sequentially. This is accomplished by reducing layer thickness to zero for one layer at a time in an alternating pattern. This technique is used to create hard-soft combinations. Automotive air ducts with flexible ends and rigid pipe sections are produced with this process. ■

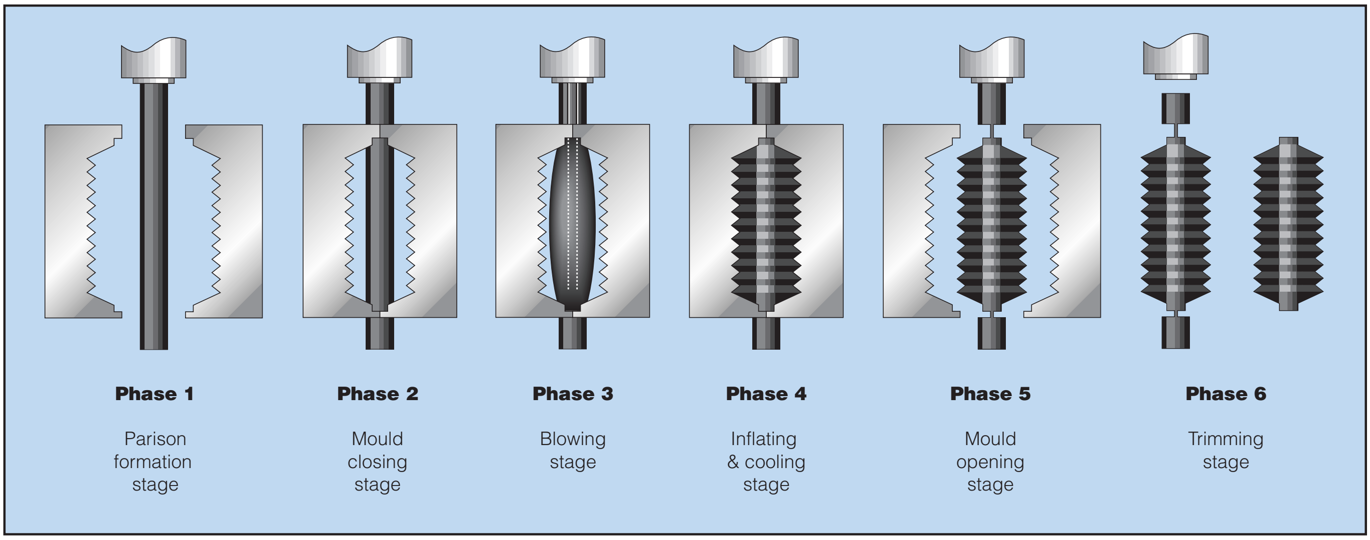

Fig. 2 - Overview of the extrusion blow moulding process.

Injection blow moulding

The injection blow moulding process is based on an injection moulded preform instead of a directly extruded parison in the extrusion blow moulding process. This process has the advantage of producing injection moulded ends which have better control of dimensional tolerances. These machines are typically arranged in 3 or 4 stations which perform individual process steps. In the first station the preform is injection moulded. The machine is indexed to the second position where the preform is inflated into a blow moulding cavity. In the third station the parts are ejected off the core rod. In the fourth station the core rods are tempered. This process is typically used to produce high production volume parts such as rack & pinion boots.

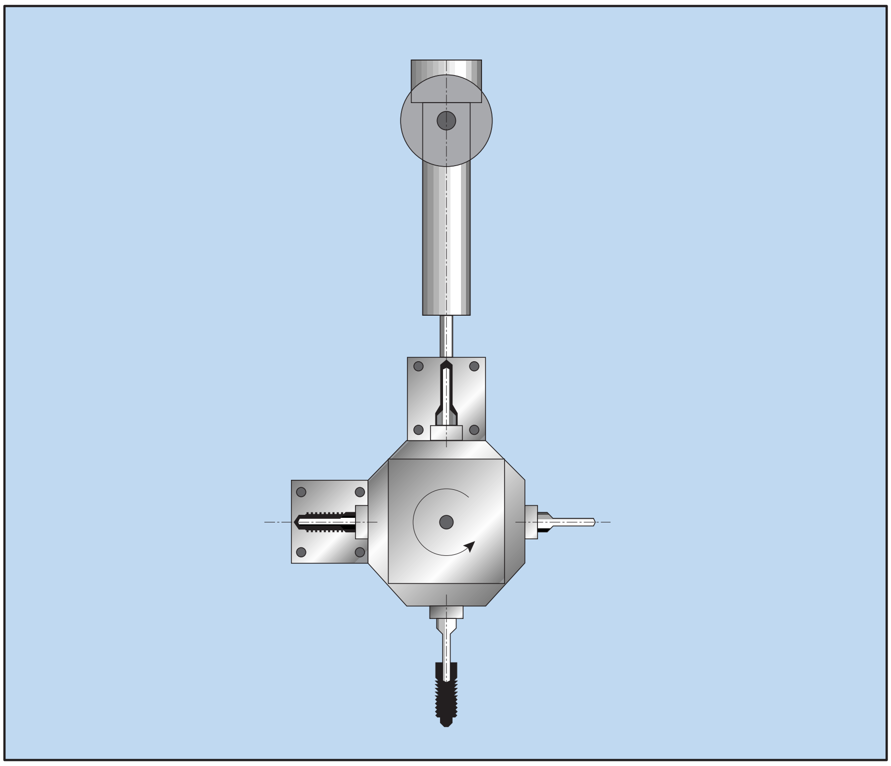

Fig. 3 - Injection blow moulding.

3D blow moulding

This process is typically used for automotive air intake ducts. An advantage of three dimensional blow moulding is that it is possible to make complex parts without generating flash along the edges. There are different techniques to make 3D articles. Figure 4a shows the process with a movable mould, figure 4b shows the movable head system on a fixed mould.
The parison can also be put into the mould by manipulating the parison with a robot.

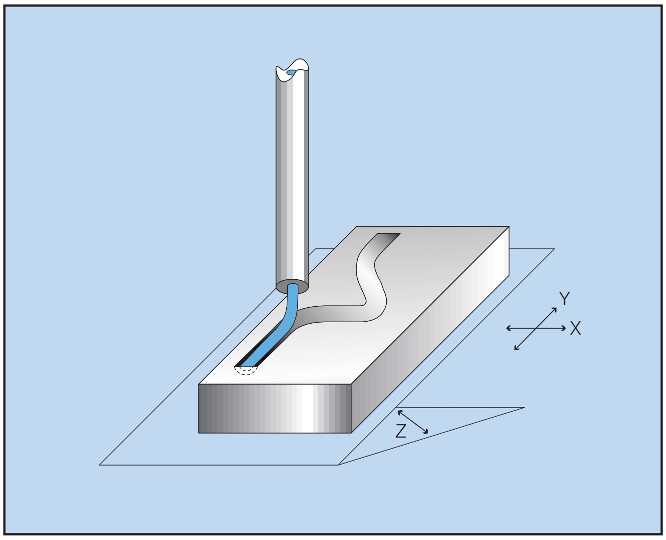

Fig. 4a - Example of 3D blow moulding with movable mould.

Suction blow moulding

In this blow moulding process the parison is sucked in the (closed) mould by a vacuum pump. This pump is connected to the bottom of the mould. The filling process of the mould takes place very rapidly (typically within a second). When the mould is filled, the parison is inflated via an injected blow needle. This blow needle is injected on the top side of the parison.

The advantage of this blow moulding technology is that it is possible to produce 3D blow moulded parts on standard extrusion blow moulding machines after a (small) change of the mould and the addition of a vacuum pump.
One disadvantage of this system is the impossibility to produce complex 3D geometries.
Another disadvantage is that the part diameter is limited. Figure 5 shows a simplified representation of the suction blow moulding system.

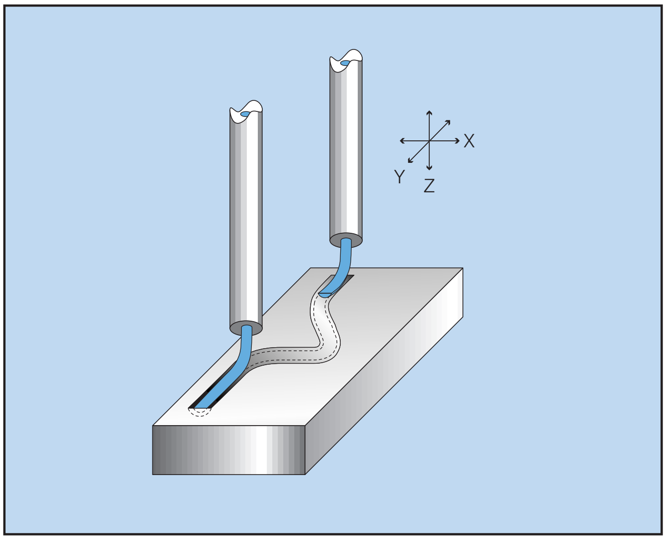

Fig. 4b - Example of 3D blow moulding with movable head.

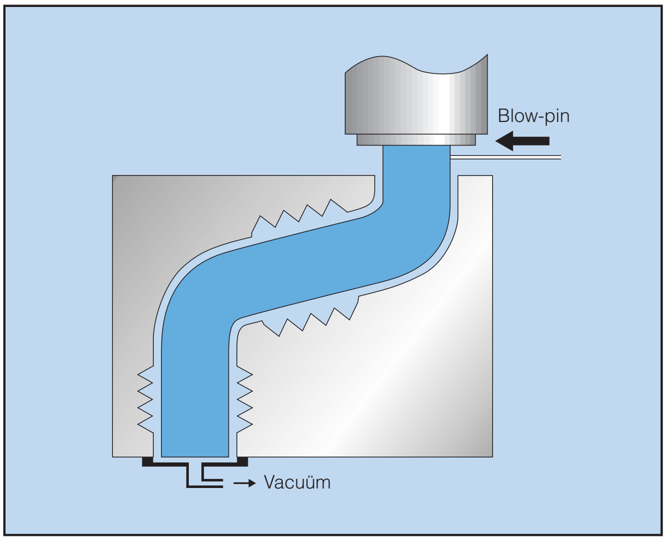

Fig. 5 - Suction blow mouiding.

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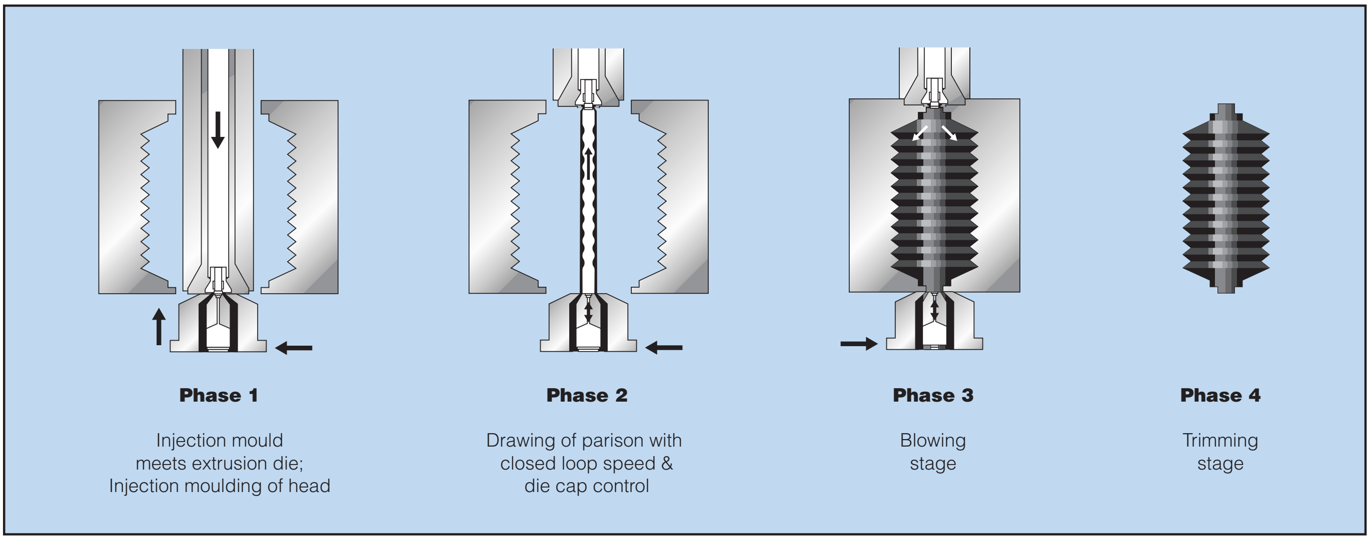

Fig. 6 - Press injection blow moulding system of Ossberger.

Press injection blow moulding

Sarlink is an excellent material to use in a press injection blow moulding system. This process is also known as the Ossberger process®, named after the equipment manufacturer. In this process the extruder initially fills a small injection mould which produces the end fitting of the part. This mould is then lifted vertically while extruding a parison against the force of gravity. The wall thickness is adjusted during the extrusion process by varying the die gap. The mould closes around the injection mould and the parison, and the parison is blown into the mould cavity. The mould opens and the part is removed for trimming. The principle of this press injection blow-moulding system is shown in figure 6. ■

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Characteristics of the typical blow moulding equipment for Sarlink

Sarlink can be processed on existing blow-moulding equipment without further modification. However, in order to obtain the best blow moulding performance, or if dedicated equipment for processing Sarlink has to be purchased, it is recommended to take the following items into consideration.

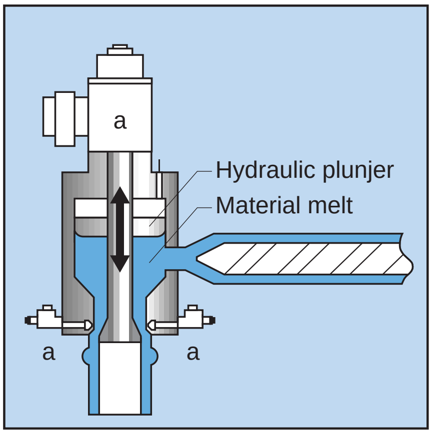

Fig. 7- Accumulator head design.

Screw design

General purpose screws. For the processing of Sarlink a single stage, three zone polyolefin type metering screw is adequate.
The optimum general purpose screw design is as follows:

- ✓ feed zone: this zone should be relatively short, about 25 % of the total screw length
- ✓ transition section: recommended is a transition section with a length of about 25 % of the total
- ✓ metering section: about 50 % of the total screw length is recommended, in order to provide adequate shear mixing
- ✓ L/D ratio of 24:1 to 32:1 is recommended. Shorter screws should be avoided
- ✓ compression ratio of 3:1 is recommended.

Mixing pins or shear segments are often used with general purpose screws to improve melt homogeneity and dispersion of colourants and additives.

Barrier screws. The use of a low shear barrier screw will provide the higher throughput and improved melt quality. A generous barrier clearance is used (typically 1.5 to 2.0 mm). The barrier section should be followed with a Maddock mixing section to further homogenise the melt.
Consult DSM for further design recommendations regarding barrier screws.

Head and die design for continuous extrusion blow moulding

Head design. Polyolefin head designs are also recommended for Sarlink. Important factors in head design are:

- ✓ streamlined design
- ✓ uniform temperature control
- ✓ programmable die parison wall thickness control.

In cases where large parisons are necessary an accumulator head is preferred. The principle of this head design is that the molten material will be stored in the head, prior to the formation of the parison. The parison will be formed by pressing the material out of the head (melt ram). The minimum accumulator capacity should be greater than the part weight plus the flash. The maximum accumulator capacity should not be greater than 3 times the part weight plus flash.
The accumulator head design is shown in figure 7.

Die design. The die can be converging or diverging, depending on head design and on required parison diameter. Smaller parts are typically run with diverging head tooling. Figure 8a and 8b shows the difference between a diverging and converging die.

The use of equipment with programmable parison wall thickness control is preferred. This will allow for compensation of parison sagging due to the forces of gravity: if a long, or heavy parison is extruded with constant thickness, it will be thicker at the bottom end, and thinner at the top. Consequently the bend of the finished part will be thinner and constitute a weak point. To correct this, it is possible to vary the wall thickness of the parison during the extrusion by moving either the internal or external part of the die.

Die dimensions

The outer diameter of the extrusion die (d_{die}) is equal to the outer diameter of the requested parison ($d_{extrudate}$) devided by 1 plus the die swell devided by 100.

$$d_{die} = \frac{d_{extrudate}}{(1 + \frac{\text{die swell})}{100}}$$

The minimum parison outer diameter is the ratio of the finished part outer diameter divided by the blow-ratio of the used Sarlink grade.

The parison diameter should be chosen so that the parison enters easily into the mould and minimizes the required blow ratio.

Die swell. Die swell for Sarlink 3000 and 4000 series products ranges from 0 to 15 %. The die swell is low for low hardness grades. Die swell is also influenced by the shear rate through the die. As the flow rate increases the die swell will increase. Lower melt temperatures will increase the die swell.

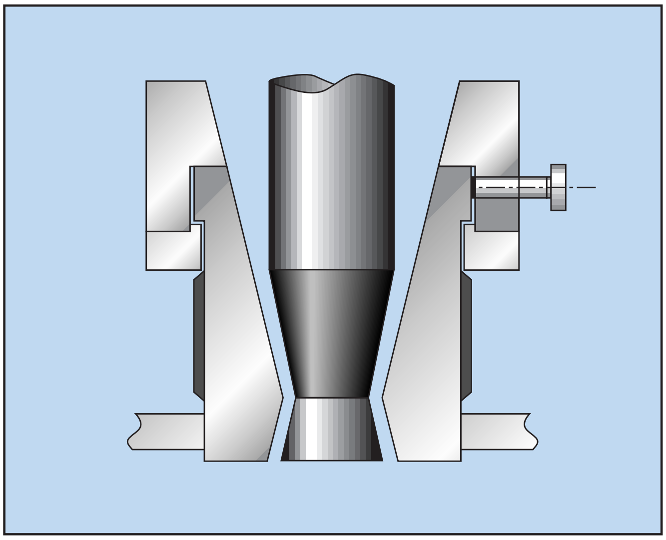

Fig. 8a- Diverging die design.

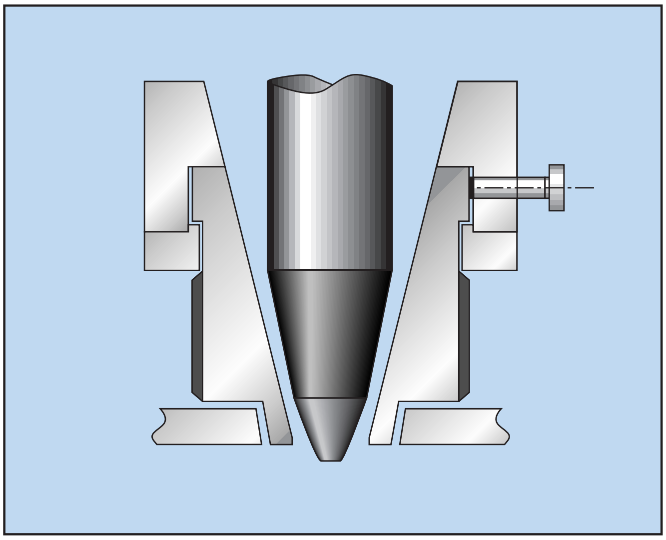

Fig. 8b- Converging die design.

Mould design

Blow mould cavity material. Aluminium materials are typically used for Sarlink. Cast or cut aluminium can used. Machined (cut) moulds are often more expensive to produce but are more durable. Pre-hardened steel material can be used for high volume production to reduce wear.

Venting of the mould. Venting of the mould is necessary in order to allow for escape of air and optimally following the shape of the mould.
For Sarlink parting line vents are recommended, with a depth of 0.05 to 0.08 mm. Vents to the outside can be much deeper from 0.25 mm to 0.40 mm. Incavity vent plugs are used for convoluted moulds or for larger parts which require more air flow to vent.

Cooling of the mould. For large moulds, it is advisable to have several cooling zones. Most intensive cooling should be located in the pinch relief section, where the material is the thickest. Small moulds should have a single cooling circuit. Recommended mould temperatures are 10 to 40 °C.

Shrinkage

Shrinkage is the contraction in volume dimension of the material in the mould as a result of cooling and crystallisation. This cooling can take place by the blowing process, but mainly by direct cooling to the wall of the mould.

The approximate shrinkage of Sarlink in a blow moulding process for a wall thickness of a part, up to 2 mm, will be 1.5 % for the soft grades, below 75 Shore A and 2 % for the high hardness grades. ■

Processing conditions for optimal blow moulding of Sarlink

Drying and storage of Sarlink

In exposure to air Sarlink granules may pick up moisture to a slight degree. The presence of moisture in the granules produces porosity in the parison, leading to parison failure during the blowing stage.
It is therefore recommended to store Sarlink carefully and to dry both virgin pellets and regrind before blow moulding.

Recommended storage conditions. Suggested storage conditions for Sarlink are:
- ✓ store Sarlink bags closed and undamaged in a non-humid environment
- ✓ open bags just before use
- ✓ close the bags securely when the whole content has not been used completely
- ✓ bring cold granules to ambient temperature in the processing room while keeping the bags closed.

Recommended drying conditions:
- ✓ dry minimal 2 hours at 80 °C (or 3 hours at 70 °C especially for softer grades)
- ✓ longer drying times may be required for regrind or flame retardant Sarlink thermoplastic vulcanisates.

Drying is best accomplished in a desiccant dryer, preferable mounted on the hopper. External units with automatic air conveying may also be used.

Use of regrind

Sarlink 3000 and 4000 thermoplastic vulcanisates have excellent melt stability, and all scrap generated during processing can be recycled provided it is kept clean. High levels of regrind can be used.

The viscosity of Sarlink decreases slighty after reprocessing. For this reason, it is recommended during production to blend a constant level of regrind within the virgin material in order to keep processing conditions constant. Addition of regrind has no negative influence on surface quality, as mentioned in the 'drying' paragraph.

It is recommended to dry recycled material before reuse to avoid porosity in the parison.

Colouring of Sarlink

Natural colour Sarlink can be coloured by addition of a suitable colour masterbatch. Polypropylene based masterbatches offer the best compatibility with Sarlink, but may slightly increase the hardness. Low density polyethylene based masterbatches are also suitable. Recommended level of colour masterbatch in Sarlink: 1 to 5 % by weight.

During blow moulding, dispersion of the colour masterbatch can be improved if needed, by utilising a mixing screw.

Temperature settings

Material melt temperature. A melt temperature in the range of 185 °C to 220 °C is optimal for blow moulding of Sarlink. If the temperature is too low a rough surface will appear, parison stability will be improved but blow-ratio will be reduced.
A high melt temperature will result in a lower stability of the parison due to lower melt strength, which will result in less control of wall thickness of the blow moulded part.

Barrel temperatures. For blow moulding of Sarlink the material should be processed in the range of 185 °C to 220 °C. For soft grades low temperatures are recommended. Wide variations in cylinder temperatures should be avoided. Typical barrel temperatures for Sarlink are shown in table 2.
If possible the feed throat of the barrel should be cooled with water to avoid agglomeration of the pellets and to facilitate the feeding. If cooling is not available, it is recommended to keep the first zone of the barrel below 190 °C. Fine-tuning of the temperature settings is dependent on the blow-ratio, parison length and grade used.

Processing temperatures (°C)			
Hardness	**40 A**	↔	**50 D**
Barrel zone 1	180	↔	195
zone 2	190	↔	200
zone 3	195	↔	210
Head:	200	↔	215
Die:	200	↔	215
Mould:	10-40	↔	10-40

Table 2: Recommended temperature settings for blow moulding Sarlink.

Screw temperature control. Internal heating or cooling of the screw is not recommended.

Mould temperature. Blow moulds are typically cooled with water. Recommended mould temperatures range from 10 °C to 40 °C. Higher mould temperatures will improve surface quality but will increase the cooling time.

Internal part cooling. For large parts with a lengthy cooling cycle the part can be cooled by circulating air through the part. This is accomplished by means of two blow pins, one for air supply and the other to vent.

Blowing parameters

Pre-blowing. Pre-blowing may be necessary to prevent collapsing of the parison during closing of the mould or by gravity.

Blowing pressure/time. Rapid blowing into the mould is preferred. Actual blow speed should be defined experimentally. The optimal blow speed is influenced by parison, part design, wall-thickness, temperature settings and blow-ratio.
Blowing pressure of 0.3 to 0.7 MPa is recommended for maximum part definition and adequate heat transfer. The volume and pressure of the air should be maintained throughout the cooling cycle prior to mould opening.

Blow-ratio. From the hollow parison the product is formed by expansion of air. The blow-ratio (maximum part finished outer diameter divided by die outer diameter) of the parison is dependent on:

- ✓ the parison temperature
- ✓ the parison thickness
- ✓ the hardness of the Sarlink grade used .

An overview of the blow-ratio of Sarlink is shown in table 3.

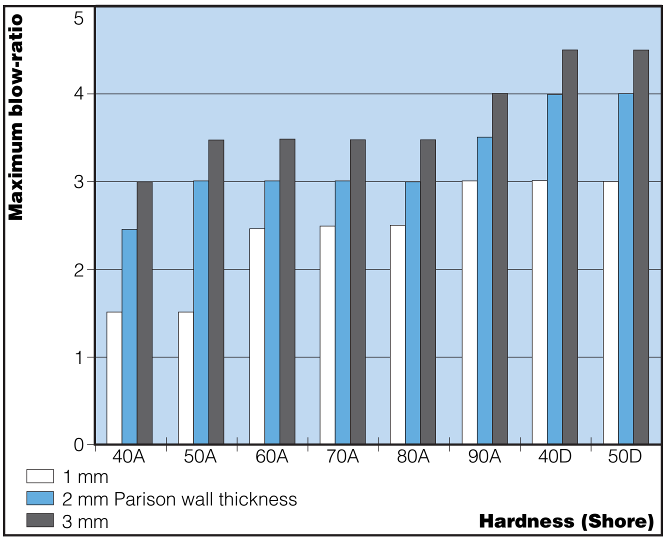

Table 3: Maximum blow-ratio of Sarlink, as function of the parison wall thickness.

Maintenance of the equipment

Purging of equipment before processing Sarlink. To avoid contamination, the blow moulding equipment should be cleaned before processing Sarlink. Polyethylene or polypropylene of low melt index are recommended. Purge at a temperature of 200 °C.
This cleaning operation is particularly important if the equipment has been used previously for PVC or POM/acetals.

Equipment shut down and cleaning. At the end of the production, run the hopper and screw empty of Sarlink. Purge the extruder thoroughly with polyethylene or polypropylene if change over to another material is anticipated. The use of high viscosity polyolefins will speed up the purging process.

Perform a general clean up of the hopper and any pneumatic conveying lines to remove residual fines. Clean the mould and protect the mould for corrosion.

Ancillary equipment

Equipment typically used for PE or PP, such as toothed circular saws, may not be suitable for soft Sarlink grades, because of its rubber-like nature. Sarlink parts are best trimmed with razor blades. For the lower durometer grades, hot knifes are recommended in order to get an optimal surface. These soft parts should be supported during cutting to avoid distortion. Rotating knife systems are typically used to trim ends of cylindrical parts. ■

Appendix 1

Troubleshooting table for the extrusion blow moulding of Sarlink

Problem	Cause	Solution/corrective action
Unstable parison	Melt temperature too high	Decrease cylinder temperatures
		Decrease head/die temperatures
	Die not central	Centre die and pin
	Die/head dirty	Clean die
Parison is running to one side	Pressure differences of the parison as it leaves the die or circumference temperature differences in the melt when the parison is formed and leaves the die	Centre die and pin
		Check head and die heaterbands
Rough mouldings/surface	Material too cold	Raise cylinder temperatures (check heater-bands)
		Raise head/die temperatures (check heater-bands)
		Decrease extrusion speed; longer heating period
	Mould too cold	Increase mould temperature
	Head/die dirty	Dismantle pin and die and clean; polish if neccessary
	Dispersion problem	Use screw with more compression
		Decrease hopper-side temperature
Blown parts contain unmolten particles	Inhomogeneous temperature distribution in the melt or material is in general too cold	Increase cylinder temperatures
		Increase die/head temperatures for melting
		Decrease extrusion speed
		Increase back pressure if possible
		Mixing elements
	Dispersion problem	Use screw with more compression
		Add mixing element to screw
Blow problems	Impossible to blow parison	Dry granulates
		Dry regrind
		Increase or decrease blow pressure
	Blow ratio too low	Change to higher hardness
		Increase parison wall thickness
		Decrease or increase material melt temperature
		Change die tooling to increase the parison diameter

Problem	Cause	Solution/corrective action
Weld lines	Weld lines visible or cracks on part and parison formed in spider	Increase melt temperature Increase die temperature Purging or cleaning of head/spider/die
Flashing	Flash of material on part	Decrease blow pressure Increase clamp force Decrease melt temperature
Contamination in parison/part	Dirt in equipment	Purge to remove degraded material
	Dirt in regrind	Decrease barrel/head temperature
	Burned/degraded material	Reduce overall cycle time
Silver streaks or voids in parison	Water vapour enclosure, material contains moisture	Use dry material; pre-dry material Dry regrind if used