Innovative into the Future – BOY-Injectioneering

Elastomer processing

What is an Elastomer?

The term "elastomer" describes the material's property of being highly mouldable already under low pressure and of springing back into its original form when the pressure is released. Although plastic materials are also highly mouldable under low pressure, they remain moulded after pressure release.

Therefore, the term "elastomer" describes the material's most vital property without expanding on material-specific characteristics. High elasticity can be achieved by very different materials.

In plastics technology, three essential groups are distinguished:

- chemically crosslinked elastomers
- thermoplastic elastomers
- silicones

The basic structure of all three elastomer groups consists of long molecular chains whose basic structure and sidechains determine particular properties. The molecular chains are movably connected at room temperature and can slide along each other in the elastomer's basic form.

Chemically crosslinked Elastomers

By adding further materials and catalysts, the sidechains become reactive and form (usually under the influence of heat and pressure) chemical links to the sidechains of adjacent molecular chains. This process is often called vulcanisation. From the movably connected chain molecules develops a netted macromolecule which, although easily mouldable, will spring back into its original form when released. Since the sidechains' chemical links cannot be resolved by heating, a vulcanised elastomer cannot be melted again. Very high temperatures result in the decomposition of the netted elastomer.

Thermoplastic Elastomers

These are thermoplastic materials which can receive elastic properties in various ways. Most movably connected chain molecules have sidechains at certain points which form physical bonds to the sidechains of other chain molecules. These bonds hold the chain molecules in place so that they cannot slide towards each other. Another kind of thermoplastic elastomers is based on plastic blends. When heated the adhesive mechanisms (physical bonds) are dissolved and the plastic melts like a thermoplastic. The moulding of these elastomers follows the same procedure as with a thermoplastic material.

Silicones

Silicones possess the unique characteristic of having alternately silicon and oxygen in their main molecular chain instead of carbon. Due to this unique characteristic, silicone has a high temperature resistance and a low glass transition temperature. Thus it is ultraflexible over a wide temperature range. Additionally, the material is transparent in its basic form.
Through a catalyst, silicones become chemically crosslinked and thus, like vulcanising elastomers, do not melt.

Hereafter, this brochure exclusively refers to chemically crosslinked, carbon-based elastomers, since the three groups of elastomers are very different in their respective processing.

Elastomers
Conditioning of the Material

In their basic form, the classic as well as the synthetic elastomers are plastic moulding masses which consist of organic long-chain molecules. These molecules can move towards each other, which takes place under the effect of heat and becomes easier with increasing temperature.

In order to achieve a material of high technical quality, a number of additives are added to the basic elastomer which, on the one hand, cause the chemical crosslinking of the chain molecules and on the other hand optimally adapt the elastomer's properties to its planned use. About 15 to 30 different additives are common in elastomer blends.

Typical components of a finished elastomer compound:

- vulcanisation accelerators
- aging inhibitors
- fillers
- plasticiser
- processing additives
- softening agents
- blowing agents
- further materials for achieving certain properties

An elastomer composition which is mixed in kneaders, open rolls or less frequently extruders, is called a compound. Depending on the type of kneader used, the finished compound arrives in bulks, as sheet or sometimes as a continuous belt.

For further processing, the bulks are rolled out and, as well as the sheets, are cut into strips. In this form or as continuous band the compound is processed in injection moulding machines.

The different types of Elastomers

Next to natural rubber and the first synthetic rubbers mentioned above, there is a large number of different rubber materials available today. All of them have certain outstanding properties which make them uniquely suited for specific applications.

By means of the nomenclature abbreviations the structure of the material's main molecular chain is described as the central feature (see table below).

Last letter	Chem. structure of main chain	Example
R	Unsaturated carbon chain	NR, BR, CR,NBR
M	Saturated carbon chain	ACM, EPDM, FPM
N	Carbon / Nitrogen chain	
O	Carbon / Oxygen chain	ECO, GPO
Q	Carbon / Silicon chain	MQ, FMQ
U	Carbon / Oxygen / Nitrogen chain	AU, EU
T	Carbon / Sulphur chain	EOT
Z	Carbon / Nitrogen / Phosphor chain	FZ, PZ

The Processing

Next to the classic compression moulding and transfer pressing methods, injection moulding is used more and more frequently, particularly for complexly shaped elastomer components. Through the conditioning of the material in a plasticising cylinder the elastomer is brought to a high energy level already before moulding so that often significantly less vulcanisation time is necessary in the machine.

Since closed machines are usually used in the injection process and the pressure within the cavities is regulated via the holding pressure of the injection moulding machine, injection moulded form parts have a significantly better dimensional consistency than form parts produced with the compression moulding method.

The mechanical properties of injection moulded elastomer components are also superior to those of compression moulded form parts. This is due to the effective homogenization of the compound in the plasticizing unit and during injection in the gate system.

Although injection moulding machines are usually more complex and expensive than pressing tools, one essential advantage is the possibility of automating the injection moulding process. The material supply as well as the demoulding is fully automated and safe in most cases. Especially for big series of complexly shaped parts this is a decisive economic factor.

BOY injection moulding machines for elastomer processing

Due to their concept, BOY injection moulding machines are very well suited for the processing of elastomers. The injection units, which are largely dimensioned in relation to the clamp force, and the cantilevered clamping unit with dimensionally stable clamping platens provide the best conditions for elastomer-specific requirements.

BOY injection moulding machines are ideally suitable for elastomer processing

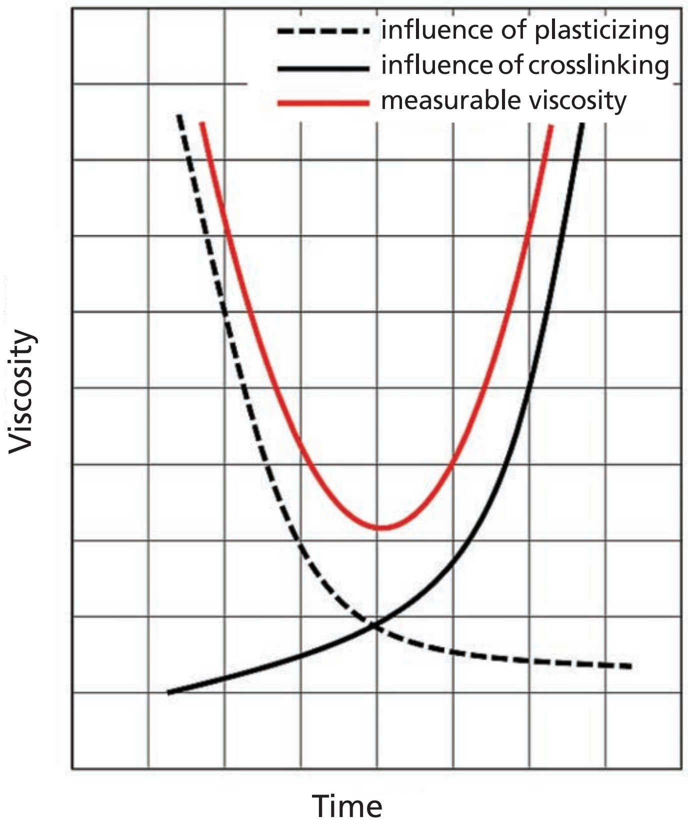
The BOY – control system is the same as the control used in thermoplastic processing. All functions necessary for the elastomer injection moulding are implemented. Additionally, a comprehensive process documentation is included in the standard scope of supply. Extensive additional functions for the automated demoulding of elastomer components are also available.

In addition to machines with horizontal clamping units, we also offer insert moulding machines with vertical clamping units and fixed lower clamping platen. These machines are particularly suitable for composite components such as for example elastomer-metal form parts. The following options assist the manufacturing of elastomer products:

- Evacuation by vacuum
- Brushes and spraying
- Stuffer for feeding the elastomer masses
- Coining and breathing functions
- Precision coining gap control

The Injection Moulding Process

Unlike the processing of thermoplastics, elastomer processing is not an exclusively physical melting, moulding and cooling process. The compound is a not-yet-crosslinked basic material which only attains its elasticity and thus its dimensional stability through crosslinking.



Viscosity of the elatomer during the injection moulding process

During the injection moulding process, this chemical crosslinking reaction (vulcanisation) occurs under the influence of pressure and high temperature and transforms the plastic material into an elastic dimensionally stable product. In the course of this reaction the viscosity of the material is substantially changed.

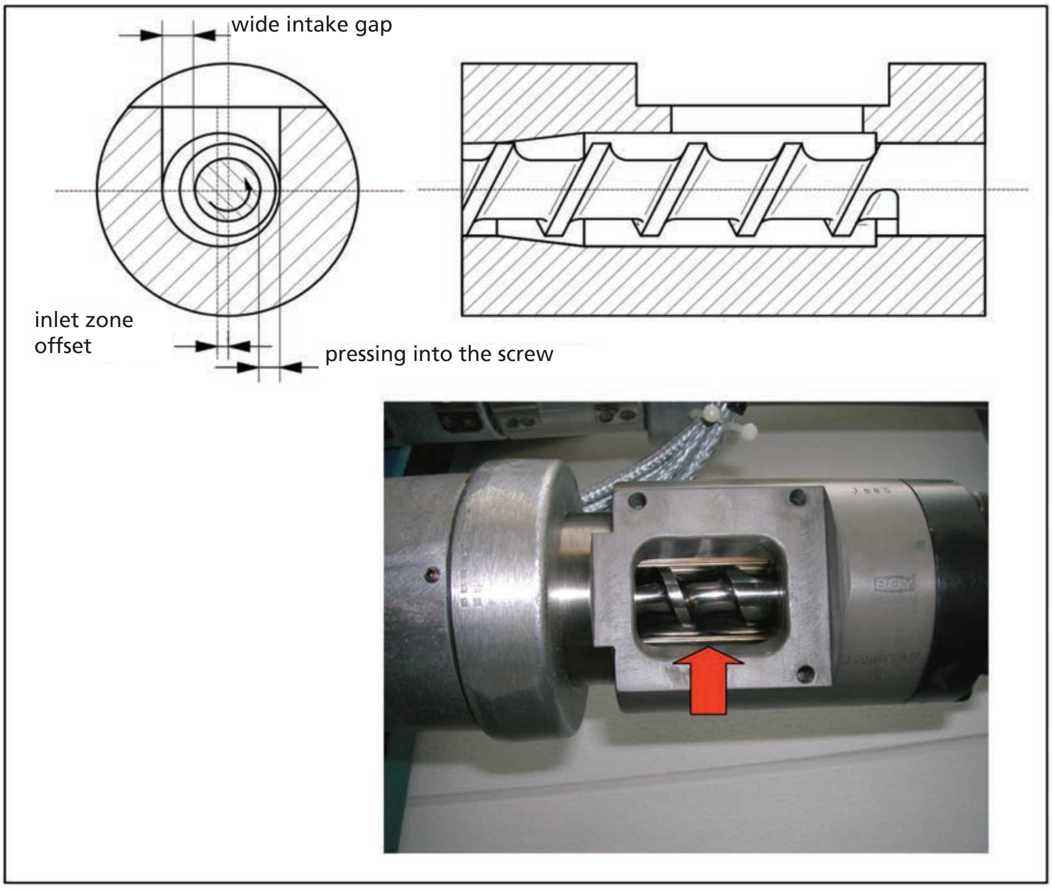
Through the heating and the kneading in the plasticising cylinder as well as through the injection process, the elastomer is very effectively and consistently supplied with energy. This energy results in a distinct decrease in viscosity.

Simultaneously, the crosslinking reaction starts. The crosslinking reaction takes place under the high shearing energy input during injection, the high mould temperature and the pressure which is first created by the screw and then increasingly by the elastomer's thermal expansion. The viscosity increases again. The elastomer compound's effective viscosity is the sum of the two viscosity changes.

Inside the cavity, the future elastomer form part receives its final form.

As soon as the form part has reached a sufficient level of stability, it can be demoulded. It is not necessary for the vulcanization to be entirely completed at this point. Due to the high temperature, the crosslinking reaction will also continue outside the mould.

The Individual Process Steps



Feed section of the elastomer unit

The Plasticising Process

The plasticising begins when the elastomer material is drawn into the plasticising unit. In order to securely draw the stripe of compound into the plasticising unit, the inlet zone must be of a particular geometry allowing the screw to seize the material which is usually considerably thicker than the screw channel depth. Constructionally, this is done through an eccentric widening of the inlet zone on the screw's inlet side. The following list indicates the pitch depth of the feed zone for the respective screw diameter:

- Ø 16 mm = 3.2 mm
- Ø 22 mm = 4.4 mm
- Ø 28 mm = 5.6 mm
- Ø 32 mm = 6.0 mm
- Ø 38 mm = 5.9 mm
- Ø 42 mm = 5.9 mm

With the rotation of the screw, the material is pressed into the screw channel and transported into the plasticising cylinder.

Depending on the type of elastomer, the plasticising cylinder is adjusted to a temperature between 60°C and ca. 95°C. In addition to this temperature increase the screw forms and kneads the elastomer material.

In addition to this temperature increase, the screw forms and kneads the elastomer strand, which results in additional heating of the material, by friction.

Additionally, the screw's core diameter increases towards the screw tip. Thereby, the flow cross-section is reduced, pressure is built-up in the transported material and the kneading process is intensified.

Thermoregulated nozzle

The screw's geometry results in a default cross-section for the material drawn in. The material strand's cross-section should thus be smaller than that of the screw channel in the inlet zone of the plasticizing unit, but larger than the screw channel's cross-section at the end of the screw. The following table indicates the maximum cross-section area, as well as the width and thickness of the strip material.

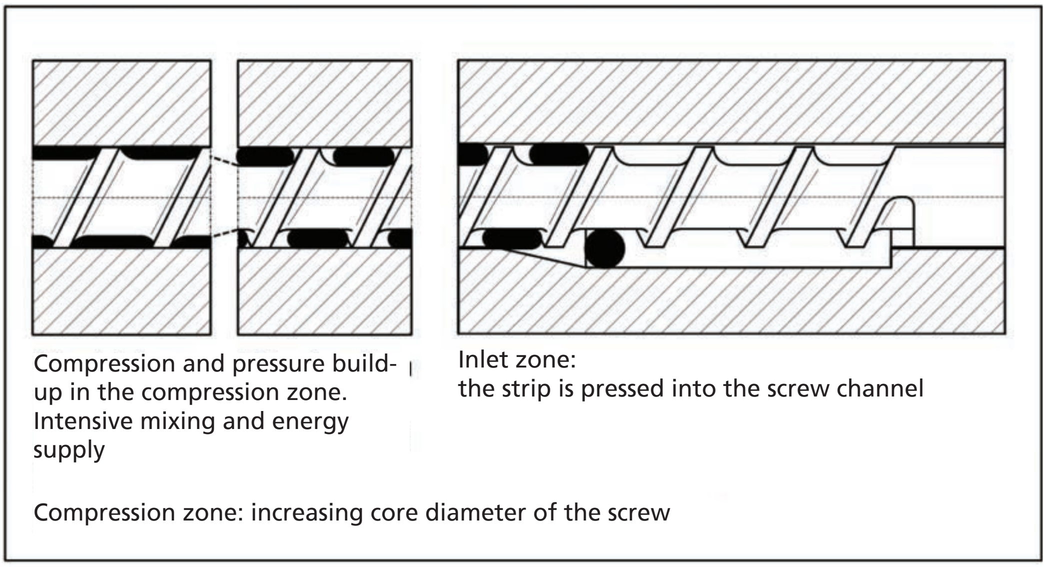
Screw-diameter	Cross-section area in mm²	Width x thick-ness in mm
16 mm	max. 51.2	16 x 3
22 mm	max. 96.8	24 x 4
28 mm	max. 156.8	26 x 6
32 mm	max. 192.0	32 x 6
38 mm	max. 226.1	37 x 6
42mm	max. 237.4	39 x 6

The material's cross-section should be constant for the screw feeding to achieve high reproduction accuracy. Therefore, especially for small plasticising units, extruded strands are recommended. They are available as continuous belts and do not show the same cross-section fluctuations as strands cut from sheets.

Further, the consistent strand diameter makes the venting of the material in the plasticising unit. Through the continuous increase of the screw's core diameter, the air is largely pumped back towards the intake opening.

At the front of the screw, homogenously warmed and mixed elastomer compound is now streaming through the nonreturn valve into the screw's antechamber. During the dosing, the plasticising unit rests against the mould and the rubber injected into the mould during the previous cycle seals the mould so that the screw's antechamber is closed.

Through the continuous feed of the screw, sufficiently high pressure is built-up in the screw's antechamber for the screw to be continuously pressed shut during dosing. The injection volume for the produced elastomer part is measured via the return of the screw. When the switch position "dosing end" is reached, the screw rotation and thus the dosing procedure is turned off. In order to reduce the high pressure in the screw's antechamber, the screw is pulled back by a short stroke.



Inlet and Compression of the Elastomer Strip

After this "decompression", the plasticising unit can be detached from the hot injection moulding machine. This is necessary in order to prevent too much heat from flowing from the ca. 180°C hot mould into the water-thermostated plasticising unit and thus uncontrollably supplying the elastomer with energy, which could cause the cross-linking reaction to occur too early.

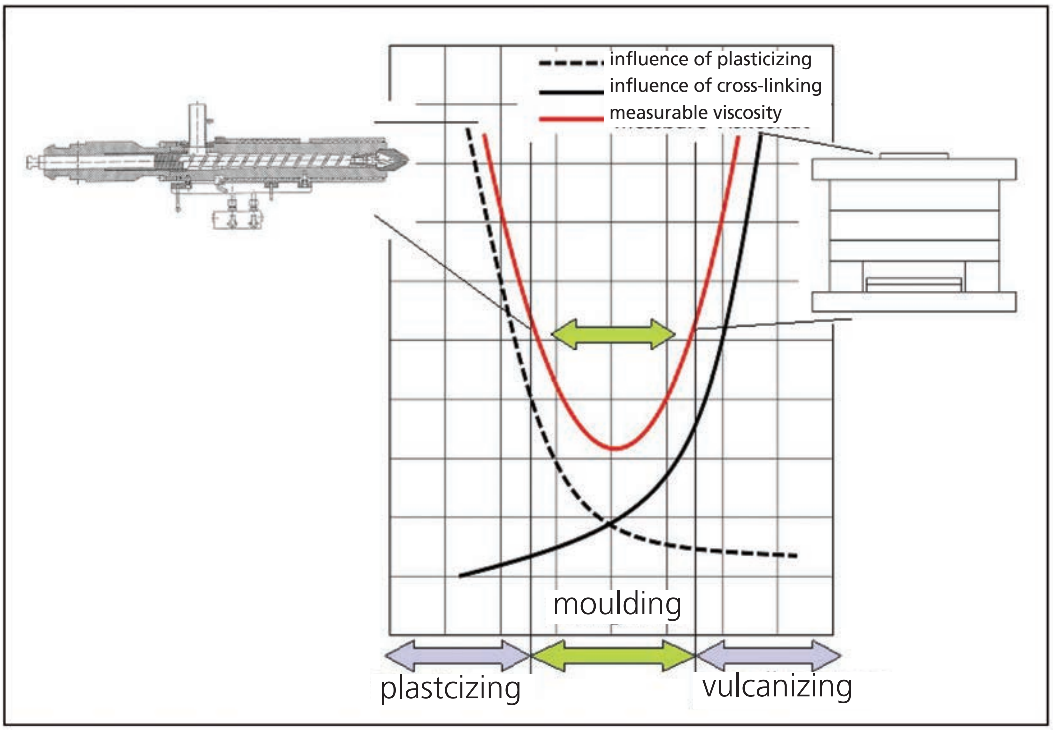
The material dosed in the plasticising cylinder is now ready for the moulding process (injection process) which can start as soon as the previously produced form part is removed from the mould.

The Injection Process

As soon as the empty mould is closed and the clamping force is built up, the plasticising unit moves towards the mould's sprue bushing and the injection process is started. As an option, in order to prevent air traps, before the injection process, the empty cavity is evacuated using a controllable vacuum pump. Subsequently, the injection process is started.

The screw is now moved forward without rotation. On the first millimetres of the stroke, the nonreturn valve at the screw tip closes so that the screw now works like a piston. The elastomer compound stored in the screw's antechamber is pressed into the ca. 180°C hot mould through the nozzle borehole. Inside the mould, the material flows through the gating system at high flow speed so that the rubber is supplied with high frictional energy and high thermic energy during flow. Narrow flow cross-sections ensure a very continuous and effective energy supply. In this phase, the viscosity of the rubber decreases very quickly and ideally reaches its minimum with the injection into the moulding cavity.

The processor can regulate the energy supply via the injection speed and the mould temperature. The necessary injection pressure results from the chosen injection speed and is a measurement for the supplied mechanical energy.



Process Sequence in the Viscosity Diagram

The injection speed influences the quality of the form part to a high degree. For a good surface quality, a higher injection speed should be chosen which could, however, cause stronger edges (mostly near the gate) through the resulting higher injection pressure.

Since air in the cavity must be pressed out of the mould during injection, too high injection speed can lead to air pockets resulting in burns on the form part (diesel effect). Constructional solutions within the mould should prevent the building of air pockets to a large extent.

The Holding Pressure Phase

As soon as the moulding cavities are fully filled, the injection phase ends and the holding pressure phase begins. Since the rubber is no longer flowing, the high pressure is no longer needed to overcome the flow resistance.

A static pressure is maintained inside the cavity so that no material can flow back into the gate system. Since the rubber expands inside the hot mould, the machine must maintain counter-pressure. This pressure is significantly lower than the injection pressure.

The necessary holding pressure is dependent on the wall thickness of the form parts and the cross-sectioned runner.

The Vulcanisation Phase

In fact, vulcanisation already starts during the plasticising, since the rubber is already brought to a higher energy level there. In terms of procedure, however, only the time after the holding pressure phase until the demoulding of the form part is referred to as vulcanisation time.

At this point, the vulcanisation must have progressed so far that the form parts can withstand the high mechanical load and the resulting deformation during the demoulding without any damage.

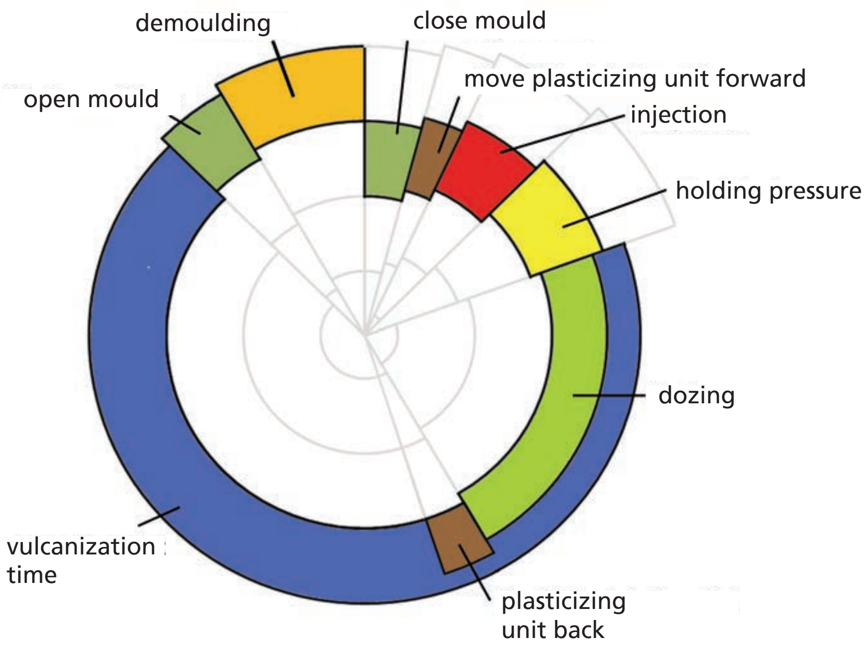
Outside the mould, the parts can fully vulcanize due to the process heat.

The Demoulding

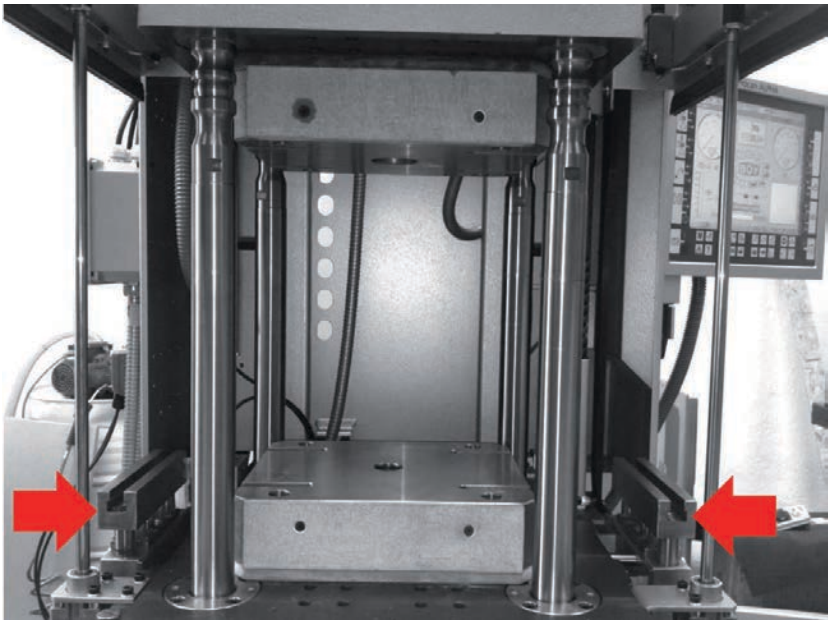
In the injection moulding process, the demoulding should be automated in order for the process consistency to be at its highest level and for the product quality to achieve its highest consistency as well.

During the demoulding, the high elasticity of the elastomer must already be taken into account during the construction of the mould. Since great undercuts are very common on elastomer form parts, simple ejector pins, commonly used in thermoplastic processing, are often not sufficient. On the other hand, undercuts can often be demoulded by stretching the form part.

Hydraulic ejectors, blow-out devices, brush devices or removal systems which can be operated via the machine control, are available to the user for the demoulding process. There is also the possibility of connecting handling systems or robots with intelligent control systems to the machine.



Schematic Procedure of an Injection Moulding Process



Core lifter on a BOY 35 E VV. Synchronously moving lifting device with T-slot bars for fixing of mould plates.

Core lifter (option)

Core lifter are used to open different mould levels during the mould opening to enable the demoulding of parts. Thus e.g. the runner can be released in one mould level while the moulded parts are directly separated from the sprue in another mould level. With the aid of the core lifter, parts with larger undercuts can also be easily demoulded

Core lifters comprise of two mechanically-synchronized hydraulic cylinders attached to the side of the moving platen. Bars with T-slots are fixed to the moving rods for assembly of mould platens. The demoulding sequence, as well as the travel paths, pressure and speed of the core lifter, are programmed in the machine control.

Basic brush device

Brush devices

Brush devices are suitable to demould flat, soft parts. Thereby, a rotating brush roller is moved past the cavity plates at a specified pre-tension. The moulded parts in the cavity plates are demoulded by the striking bristles of the rotating brushes. In particular, in combination with the coining process (refer to Coining) the brush devices are often used, because here, not only the moulded parts are reliably demoulded, but also the complete overflow.

In addition to the demoulding function, the mould plates are also cleaned using the brushes. In the event of heavily bonded rubber compounds, a separating agent can also be sprayed onto the mould plates by the brush devices.

Brush devices are available in different configurations. A basic system with brush lifting and a brush roller is suitable for demoulding the moulded parts from the cavity mould plate.

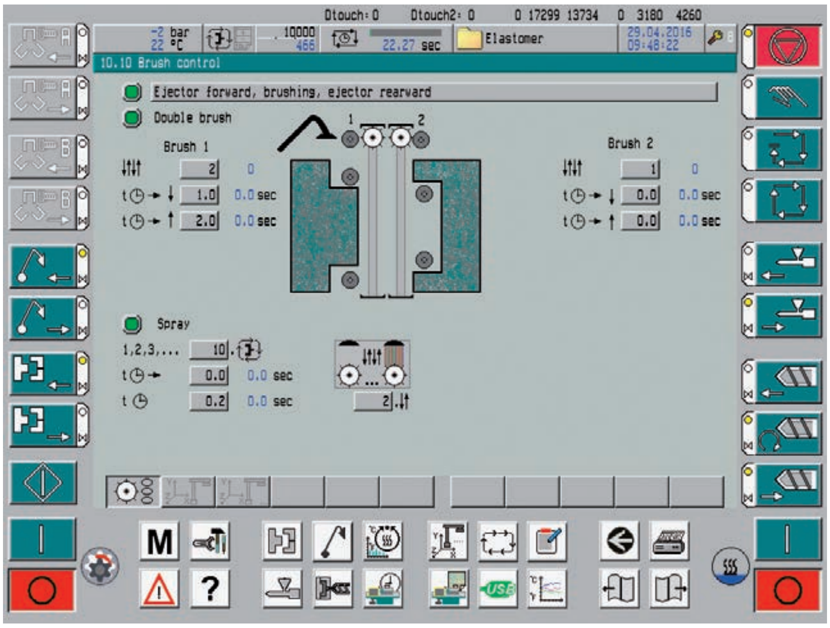
A frequently used alternative is the basic system with two brush rollers. With this arrangement, the brushes operate opposing, so that moulded parts can be removed by the brushes from both halves of the mould.

In case moulded parts or sprue respectively sprue and moulded parts are removed by brushes in two separated mould levels, this can be carried out by a dual brush system. Hereby, for each mould level, a brush device is provided which is equipped with rotary brushers.

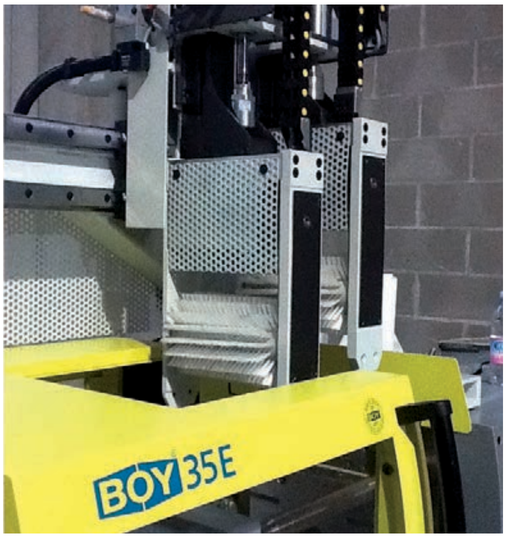
Depending on the demoulding concept of the mould, it can be necessary to carry out different brushing sequences. Basic standard sequences and spraying processes can be carried out using a brush control integrated in the machine control. Different, fixed pre-programmed sequences can be selected.

For individual brushing processes a handling control, internally in the machine, can be used. It permits the programming of brush processes using an arbitrary sequence. The settings of the brush control, or the handling control, are always saved in the respective setting data protocol for the moulded part so that, in the event of using the corresponding mould again, the data is immediately available. Only path positions that are mechanically adjusted must be adapted.

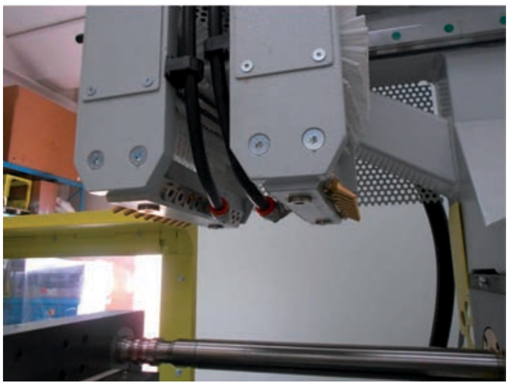
Extremely complex sequences and brush devices, which have servo-driven motion, require its own control which communicates with the injection moulding machine via a handling interface EM 67.



Screen page Brush control in the machine control Procan ALPHA



Dual brush system


Spraying device beneath the brush rollers

Special Procedures

Compression-Injection Moulding

Compression-injection moulding is particularly suitable for flat, thin-walled parts. Air pockets and weld lines can be prevented with this procedure. It is frequently used in the production of o-rings and membranes.

During compression-injection moulding the mould is not fully closed. In the parting plane, a gap of 0.1 to 3 mm, depending on the form part, remains. The elastomer compound is injected so that a round "cake" forms in the centre of the mould which covers about a third to half of the cavity area.

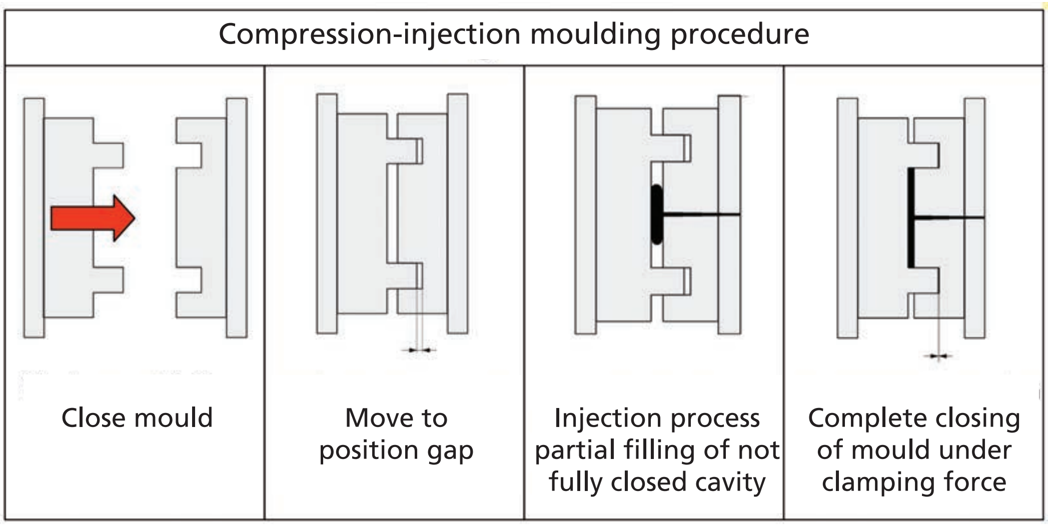
At the end of the injection process, the mould is closed with the clamping force and the screw is kept under pressure in order to prevent the material from flowing back into the plasticising unit.

In the mould's parting plane, the cake is pressed outwards. Through the hot mould and the pressure-induced friction the viscosity of the compound decreases and the vulcanization takes place.

A thin coat forms between the cavities during compression-injection moulding in which the form parts hang. It is important for the parts' dimensional stability that the coat has an accurately reproducible thickness. For a constant thickness over the entire injection-moulded part a very solid construction of the compression-injection mould is importance.

Around the form parts cutting edges and squish edges are arranged which make it possible to remove the parts from the coat in a deburring machine without great effort.

Compression-injection moulded o-rings



Schematic of the coining sequence

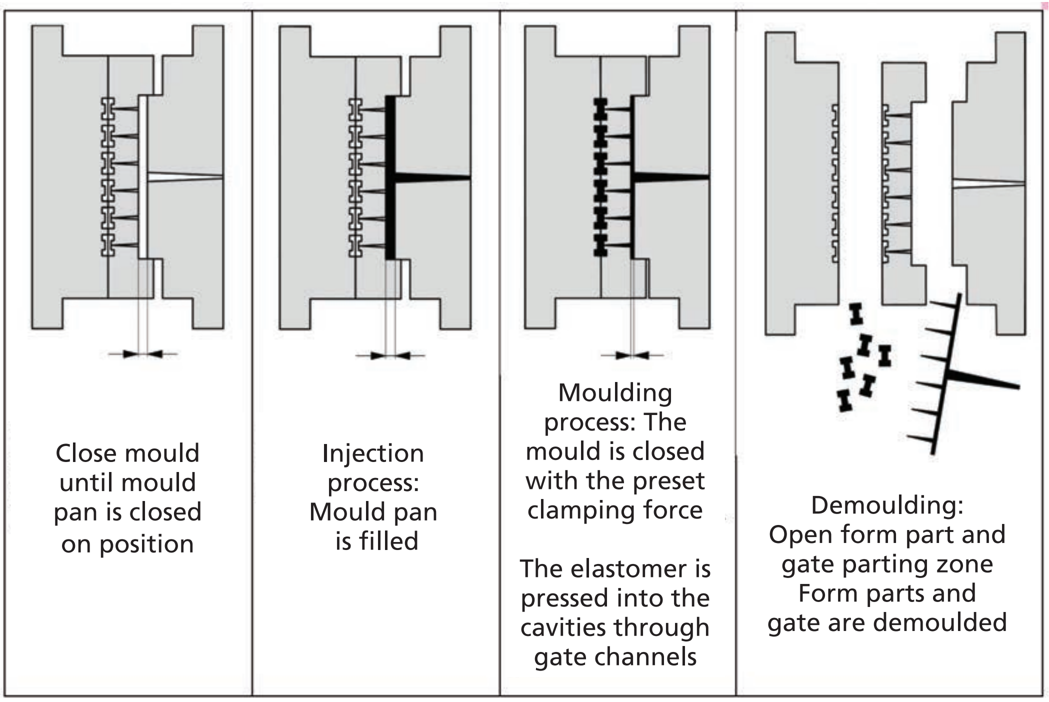
Transfer Moulding

Also here the mould is closed safe for a gap. The transfer moulding process works with moulds which have two parting planes. In the first parting plane near the gate there is a round transfer pan which is filled with the rubber mass during injection. During the moulding process (close mould under clamping force), the elastomer in the pan is pressed into the cavities in the second parting plane via gate channels.

In this way and with a good mould design, a large number of closely placed form parts can be produced free of flash, since the lifting forces are always stronger in the gate parting plane than in the form parting plane due to the larger projected area.

Since a big gate lobe always accrues in standard-ITM procedures in addition to the form parts, the ITM procedure is commonly combined with a temperature-controlled transfer pan which is insulated against the hot moulding platens with an insulating board. This prevents the rubber from crosslinking in the transfer pan. Sprue waste can be completely prevented at higher tooling output. But since the elastomer's energy level must be kept lower in the transfer area, the crosslinking reaction in the cavities takes a little bit longer than in the standard ITM.

Transfer coined plugs



Schematic of the transfer coining

Evacuation

The evacuation is used to suck the air out of the mould. Particularly with complexly shaped, strongly three-dimensional form parts, a constructional solution for the ventilation of moulding posts is not always possible.

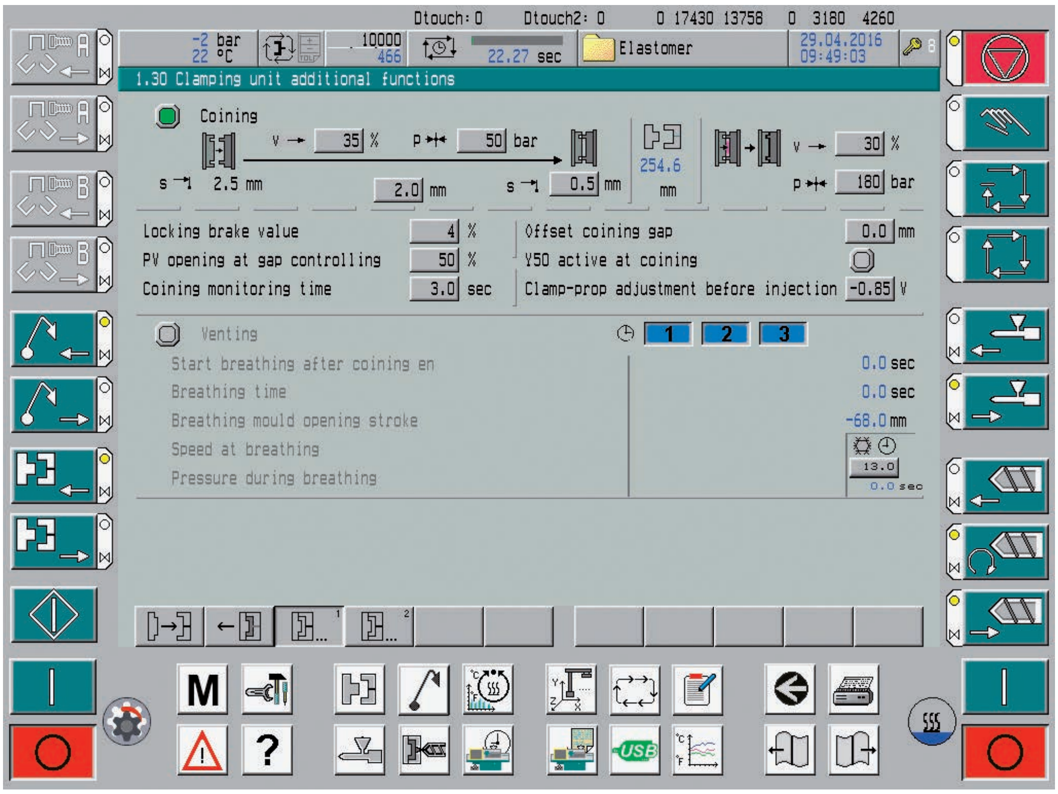
When the mould is closed, the air is evacuated for an adjustable amount of time via a switching valve before and during injection. For this purpose, about 0.5 mm deep channels are milled around the moulding inserts at a distance of about 3 to 5 mm from the cavity. The bars are finely sanded so as to suck the air from the cavities with as little resistance as possible.

In order to evacuate effectively, the mould's cavity area must be sealed. In the parting zone this is usually done with a high temperature resistant ring seal. Also ejector pin openings must be sealed. By putting the machine nozzle against the mould the cavity area is sealed on the side of the nozzle. After the injection delay, the injection begins. The vacuum should remain turned on until the mould filling.

Precision coining gap control

It can also be useful to evacuate the cavity area during the coining process. In particular with flat parts with different wall thickness configurations (e.g. diaphragms), air pockets can develop, which can be reliably prevented with the aid of the evacuation. In order to seal the cavity area for the evacuation process the mould is not completely closed only till it gets in contact with the seal of the mould. It is now important to keep the not completely closed mould reproducable previously in this defined position during the injection process.

During injection, the injected material coining cake generates an increasing lifting force to the moving side of the mould, whereby, the coining gap slightly opens at the standard coining control. This can result that the cavity area no longer seals and evacuation is no longer effective. In order to ensure that the coining gap remains constant, despite the increasing lifting force, the option „Coining gap control" is provided by using this control, the position of the moving half of the mould is controlled measured during injection and actively kept in the predefined set gap position.



Coining with coining gap control / evacuation with switch-off via a vacuum switch

Breathing

Ventilation is used to let gaseous spin-offs from the rubber mix and air (mainly when moulding form parts) out of the mould. For this purpose the mould is temporarily relieved during injection or (and) in the pressure holding phase so that it opens by a fraction due to the internal pressure. Sometimes the mould is also opened to a certain stroke. The ventilation process is repeated several times if necessary.

Breathing is not possible during the coining sequence. As soon as coining is activated, a breathing process can still be carried out, time-dependent, after the coining has ended. With the coining function switched on, the setting possibilities for the breathing change.

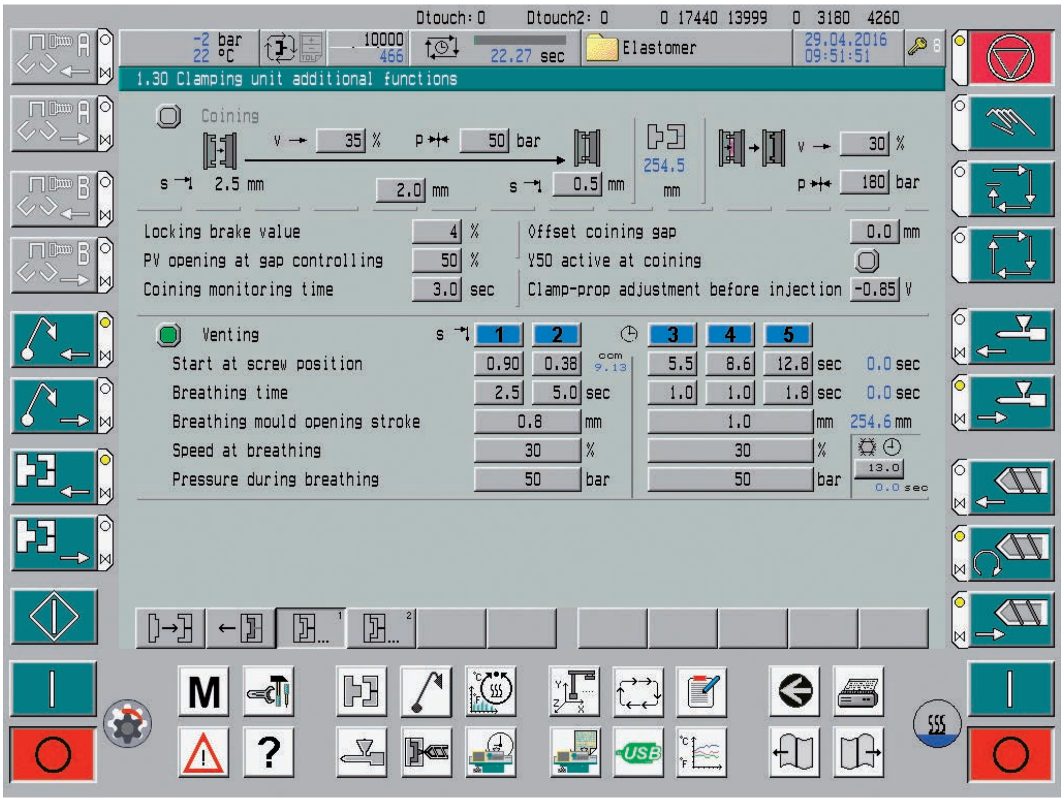
Multiple breathing

In order to ensure gaseous spin-offs across the complete injection and vulcanization process. the option „Multiple breathing path and time-dependent" can be used.

Using this function, active breathing can be activated at one or two stroke positions during injection. After completion of the injection process, up to three time-controlled breathing sequences can be set during the vulcanizing time.

Option multi-breathing stroke / time-dependent

Breathing processes are then useful if low molecular (gaseous) split up products form generate during vulcanization.



Screen page Breathing / Multiple breathing

Equipment for elastomer processing

Stuffing units

Very soft rubber compounds as well as solid silicone moulding compounds are often very pasty already as a primary product. Material strips made of these materials for use in the injection moulding machine are thus not sufficiently tearing-proof to be continuously drawn in by the rotary screw. The results are constantly tearing material strands and uncontrollable plasticizing processes.

Stuffing units are offered in order to enable a secure and continuous production of these materials. A cylinder is attached to the feeding zone of the plasticising cylinder into which the elastomer can be filled in the form of cylindrical blocks. During the dosing, the material is pressed by a hydraulic cylinder into the plasticizing cylinder. Depending on the size of the machine, stuffing units can be provided with a volume of 2 l to 15 l.

Hydraulic driven stuffing unit on top of a plasticizing unit

Heating platens assembled to the machine

If the machine is exclusively used for the manufacture of flat parts – e.g. O-rings or diaphragms – it provides the option to permanently install heating plates onto the mould fixing platens of the machine and only change the mould platens.

For this purpose, heating platens are provided that are insulate towards the machine and have options of attachment for the mould platens. Alternatively, magnetic heating platens can also be provided.

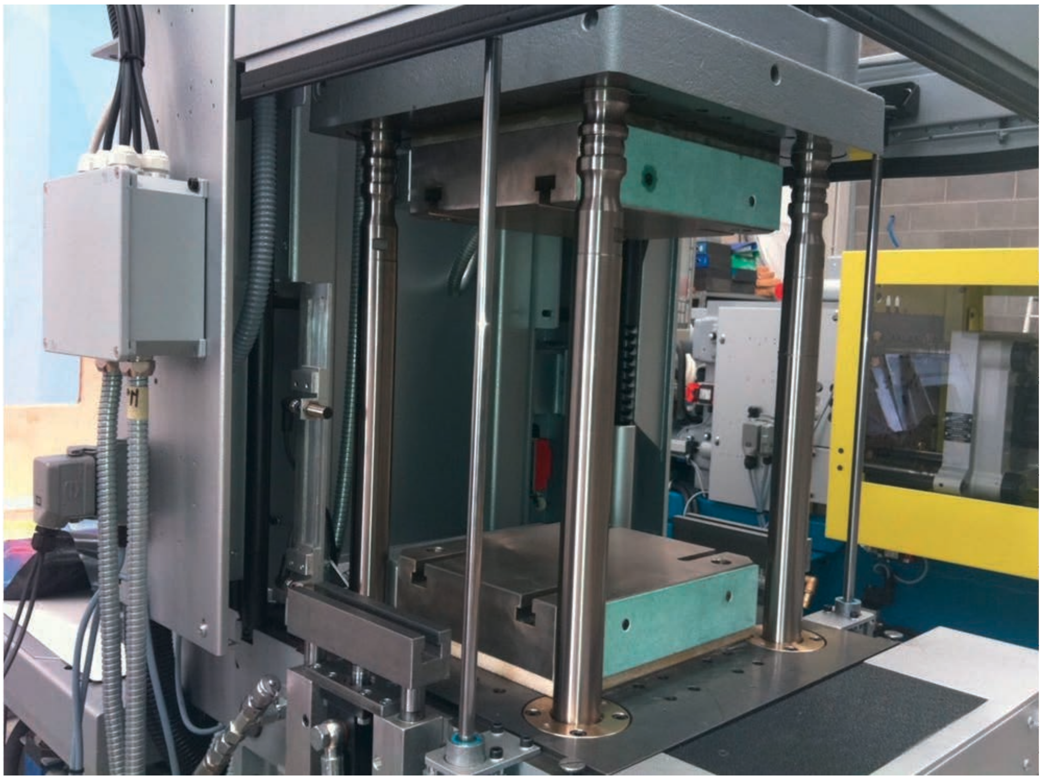
The heating platens each have two temperature regulating circuits that are directly controlled by the injection moulding machine. When using the heating platens, it has to be considered that the machine is equipped with a thermoregulated extended nozzle. The length of the nozzle has to be in accordance to the immersion depth due to the thickness of the heating platens. Furtheron the nozzle has to be thermoregulated to avoid heat transfer from the heating platens. For moulds with a cold runner system, the heating platen on the nozzle side cannot be used.

Tempering the plasticizing cylinder

The plasticizing unit is temperatur controlled by a separate temperature control device. Energy is added to the elastomer by kneading and compressing in the plasticizing unit. By the two water temperature controlled jackets (BOY XS: only one jacket) energy is added from the outside.

The general processing temperature of cross linking elastomers is usually between 60°C to 90°C. The special advantage of temperatur controlling by liquide machine is that excessive energy possibly generated by friction can be absorbed. In the majority of cases, operation is carried out using a constant temperature over the entire length of the plasticizing cylinder.

For the optional thermoregulated nozzle (application with heating platens), another temperature controlled circuit is provided (also provided for a cold runner system). Temperiature control units with data interfaces can be operated from the machine monitor. The actual values of the water temperature measured are indicated for each cycle and saved in the process documentation.

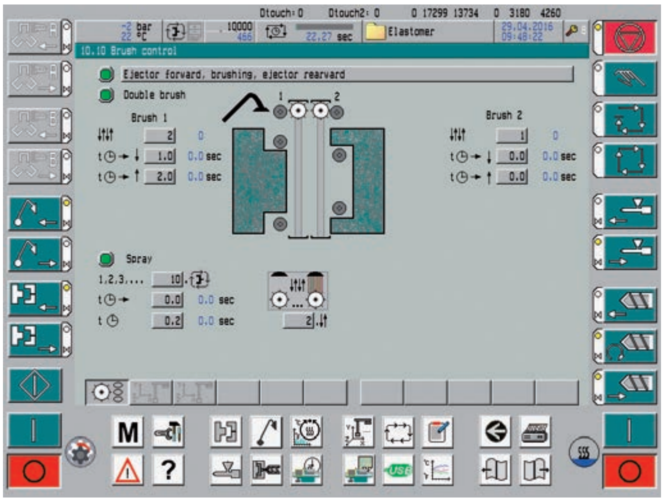


BOY 35 E VV with heating platens (mould fixing by T-slots) and core lifting device.

Mould Design

Demoulding

Typical elastomer injection moulded parts are often considerably more complex than form parts produced with classic moulding methods. Since they should usually work fully automated, the automatic demoulding should be taken into account in the arrangement of the parting planes. An ejection system suitable for demoulding elastic form parts and possible mould release agents should be provided for in the mould.



Integrated Brush Control

The individual ejectors should be monitored so that through their way of demoulding they do not cause the elastomer part to be bent at a different place in the mould. Stripper plates are often a better solution.

Core lifter

Due to the material's high elasticity, large undercuts can be demoulded. But during the stretching it must always be ensured that there is enough room for the material to deform in order to prevent the stretched material form shearing off. Often the blowing in of compressed air helps to support the stretching and make the sliding off the core easier, since a strong adhesion between the elastomer and the form core can cause the form part to turn inside out. Large undercuts, which occur for example on bellows, are usually demoulded with compressed air combined with a support cylinder which is inserted into the form part with a handling device. It is the support cylinder's task to support the stretching when the bellow is inflated so that the form part is not damaged through overstretching and can safely be demoulded via the undercuts.

Usually, flat parts such as o-rings and membranes must not show flow lines and ejector marks. Therefore, compression-injection moulding is often used for these parts. The form parts and the compression-injection film can be detached from the mould with a brushing device. Instead of rotating brushes, flexible rubber blades or simple strippers can be used. The central gate rod is often held in the moving platen by a strong undercut. In order to safely demould the sprue as well, it is often moved forward by an additional ejector during brushing. A brushing device can be operated via the machine control.

Gate system

The gating system consists of the central gate rod and the distribution system in the parting plane. The distribution channels must be arranged so that all cavities can be reached under the same flow conditions (same flow length, same number of deflections).

When filling the cavities, care must be taken that the escaping air is not enclosed in the elastomer, but is able to escape in a controlled way via the parting plane or ejector borings. Should this not be possible, a vacuum can be produced in a sealed mould via the evacuation control before the injection.

Cold runner systems are increasingly replacing the gate system vulcanising with the form part. In a cold runner system the prepared elastomer is transported to the hot cavity in a water thermostated piping system so that the form parts can be moulded directly without any sprue. The additional effort in the mould is justified through a saving in material and the cancelled disposal of unusable elastomer waste. A further advantage can be seen in automated processes. The problem of sprue demoulding disappears completely, whereby the handling system becomes significantly easier and more reliable.

Coldrunner distributer with 16 nozzles
Source: Ökologische Kautschuk Technologie s.r.o.

Design of the Sprue Bushing

The contact surface between the nozzle of the plasticising cylinder and the sprue bushing of the mould must remain tightly sealed under the high pressure needed in the injection process.

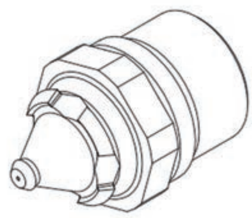
In order to achieve this without further sealing elements, the mould's sprue bushing usually has a spherical cap with a 40 mm radius. The nozzle radius is slightly smaller (35 mm). In this way both sealing surfaces touch each other on the smallest possible circumference with an extremely high surface pressure which can be regulated with the nozzle contact force adjustable at the machine.

The sprue bushing's opening always has to have a slightly larger diameter than the nozzle bore of the plasticising unit in order to make sure that the sprue can later be demoulded from the sprue bushing without an undercut between the machine nozzle and the mould.

Sprueless nozzle for elastomers

The sprueless nozzle for elastomers is designed for use on the BOY XS / XSV with a 16 mm elastomer unit. With this nozzle elastomer parts can be manufactured on one-cavity moulds without sprue and without cost-intensive use of a cold runner.

The nozzle is optimized in the area of the contact surface so that the heat transfer from mould to nozzle is minimized. Due to the very short construction length, additional cooling of the nozzle is not required. Operation is similar to an open standard nozzle. In the event of problems with the material compound, for cleaning purposes, the nozzle can be quickly removed by a central connection thread.



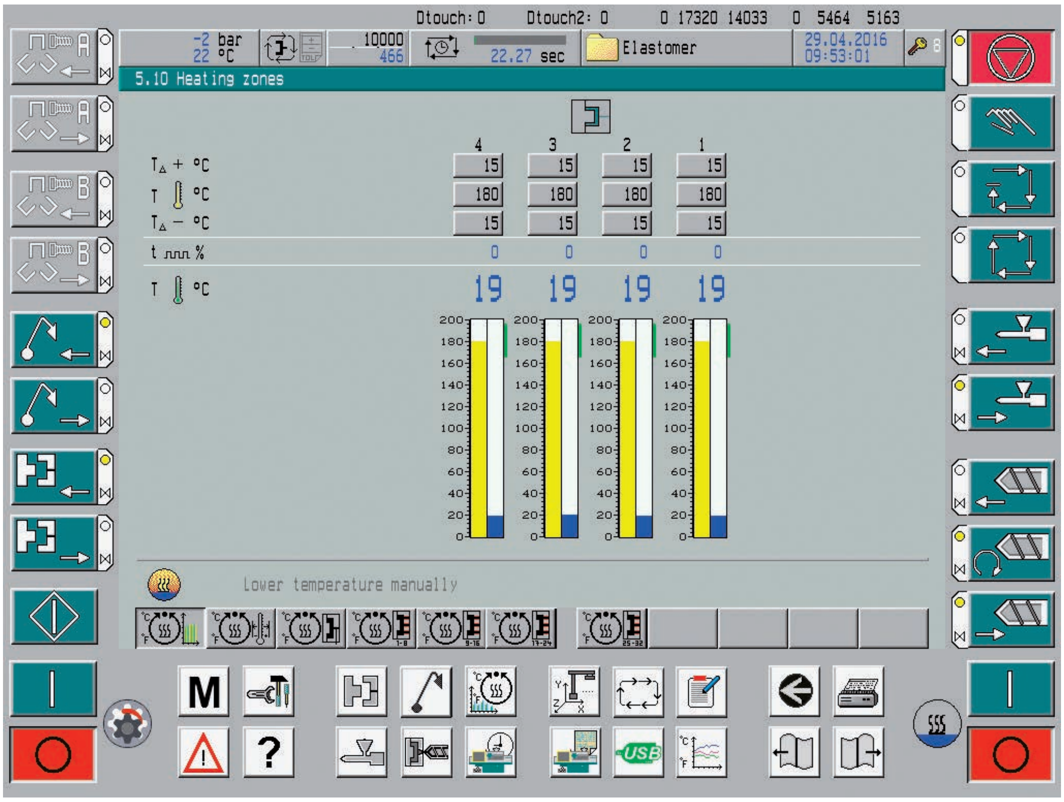
Sprueless elastomer nozzle

Heating the mould

Injection moulding machines are usually heated electrically. In this way an even temperature in the cavity areas can be achieved with little effort. Heating cartridges in the moulding plates are the most direct and most economic heating possibility. With low heat output the mould can be quickly heated and with the correct arrangement of the cartridges and the temperature sensor, the temperature can be precisely regulated via the injection moulding machine's efficient temperature controls.

Here an effective insulation of the mould is also important, since too great heat loss can have a negative effect on the even temperature distri-bu-tion within the mould. The insulating boards should not be thinner than 6 mm.

Very simple moulds are often tempered with heating boards. Since the heating elements are arranged far away from the cavities, significantly higher installed thermal capacity is necessary for the heating boards than in directly heated moulds (moulding plates). Since the size of these heating boards is determined by the size of the largest moulds used, high heat emissions around the mould are the result when smaller moulds are used.



Mould tempering with the injection moulding machine's controls

Technical Data

		BOY 2C S		BOY 2C M	BOY 2C L	BOY XS	BOY 22A	
Injection unit		81	96	205	370	14	52	
Screw diameter	mm	22	28	32 / 38 / 42	42	16	22	28
Max. stroke volume (theor.)	cm³	30.4	58.5	96.5 / 136.1 / 166.3	214.7	8	30	49
Max. spec. injection pressure	bar	2656	1639	2127 / 1508 / 1235	1724	1760	1732	1069
Max. screw stroke	mm	80	95	120	155	40	80	
Nozzle force / contact press.	kN	24		66	65	20	48	
Nozzle retraction stroke	mm	205		210	250	100	180	
Screw torque	Nm	180		280 / 350	500 / 530	100	220/360	
Clamping unit								
Clamping force	kN	-		-	-	100	220	
Tie bar clearance	mm	-		-	-	160 (diag. 205)	254	
Max. platen distance	mm	-		-	-	250 (opt. 200)	400	
Min. mould height	mm	-		-	-	100 (opt. 50)	200	
Centering diameter	mm	-		-	-	60	110	
Mould opening force	kN	-		-	-	15	40	
Mould closing force	kN	-		-	-	10	17.6	
Max. ejector stroke	mm	-		-	-	50	80	
Ejector force pushing/pulling	kN	-		-	-	8.4	18,1/12	

		BOY 25E		BOY 35E		BOY 50E	
Injection unit		69	82	81	96	69	82
Screw diameter	mm	22	28	22	28	22	28
Max. stroke volume (theor.)	cm³	30.4	58.5	30.4	58.5	30.4	58.5
Max. spec. injection pressure	bar	2277	1405	2655	1639	2739	1639
Max. screw stroke	mm	80	95	80	95	80	95
Nozzle force / contact press.	kN	48		48/ HV 24		48	
Nozzle retraction stroke	mm	205		205		205	
Screw torque	Nm	130	180/300	130	180/300	180/300	
Clamping unit							
Clamping force	kN	250		350		500	
Tie bar clearance	mm	254		280x254		360x335	
Max. platen distance	mm	400		500		650	
Min. mould height	mm	200		200		250	
Centering diameter	mm	110		110		125	
Nozzle immersion depth							
Mould opening force	kN	17.6		29.5		38	
Mould closing force	kN	17.6		21.4		24.4	
Max. ejector stroke	mm	80		80		80 (130) (150)	
Ejector force pushing/pulling	kN	18,1/12		18,1/12		20,4/13,5 (20,4/13,5) (42,7/30)	

Technical Data

		BOY 55V				BOY 60E				
Injection unit		82	205			69	82	205		
Screw diameter	mm	28	32	38	42	22	28	32	38	42
Max. stroke volume (theor.)	cm^3	58.5	96.5	136.1	166.3	30.4	58.5	96.5	136.1	166.3
Max. spec. injection pressure	bar	1405	2127	1508	1235	2277	1405	2127	1508	1235
Max. screw stroke	mm	95	120			80	95	120		
Nozzle force / contact press.	kN	48	66			48	48	66		
Nozzle retraction stroke	mm	205	210			205	205	210		
Screw torque	Nm	180/300	390/490			180/300		390/490		
Clamping unit										
Clamping force	kN	550				600				
Tie bar clearance	mm	360x335				360x335				
Max. platen distance	mm	550				650				
Min. mould height	mm	250				250				
Centering diameter	mm	125				125				
Mould opening force	kN	38				38				
Mould closing force	kN	24.4				24.4				
Max. ejector stroke	mm	80				80 (130) (150)				
Ejector force pushing/pulling	kN	20,4/13,5				20,4/13,5 (20,4/13,5) (42,7/30)				

		BOY 80E			BOY 100E			
Injection unit		205			205			370
Screw diameter	mm	32	38	42	32	38	42	42
Max. stroke volume (theor.)	cm^3	96.5	136.1	166.3	96.5	136.1	166.4	214.7
Max. spec. injection pressure	bar	2127	1508	1235	2127	1508	1235	1320
Max. screw stroke	mm	120			120			155
Nozzle force / contact press.	kN	66			66			65
Nozzle retraction stroke	mm	210			210			250
Screw torque	Nm	390/490			390/490			700/735
Clamping unit								
Clamping force	kN	800			1000			
Tie bar clearance	mm	430x360			430x360			
Max. platen distance	mm	725 (900)			725 (900)			
Min. mould height	mm	250			250			
Centering diameter	mm	125			125			
Mould opening force	kN	65			65			
Mould closing force	kN	47.2			47.2			
Max. ejector stroke	mm	130 (150)			130 (150)			
Ejector force pushing/pulling	kN	20,4/13,5 (42,7/30)			20,4/13,5 (42,7/30)			

Available elastomer units

Machine	EUROMAP	Diameter (mm)					
		16	22	28	32	38	42
BOY 2C S	100-81		X				
BOY 2C S	100-96			X			
BOY 2C M	100-205				X	X	X
BOY 2C L	100-370						X
BOY XS	100-14	X					
BOY 22A	220-52		X	X			
BOY 25E	250-69		X				
BOY 25E	250-82			X			
BOY 35E	350-81		X				
BOY 35E	350-96			X			
BOY 50E	500-69		X				
BOY 50E	500-82			X			
BOY 55V	550-82			X			
BOY 55V	550-205				X	X	X
BOY 60E	600-69		X				
BOY 60E	600-82			X			
BOY 60E	600-205				X	X	X
BOY 80E	800-205				X	X	X
BOY 100E	1000-205				X	X	X
BOY 100E	1000-370						X
Rubber strips reference values							
Diameter (mm)		5 bis 8	12	16	16	17	18
Querschnittsfläche (mm²)		51.2	96.8	156.8	192.0	226.1	237.4
Width (mm)		16	22	28	32	38	39.9
Height (mm)		3.2	4.4	5.6	6.0	5.95	5.95

Optional Equipment

- elastomer plasticising units with various diameters
- adjustable nozzle contact force over entire cycle
- runnerless nozzle for XS/ XSV
- thermoregulated extended nozzle
- stuffing unit with protective covering
- mould installation height decreased by 50 mm
- core pull system 1- or 2-fold
- core lifter
- injection-compression moulding and mould ventilation
- precision coining with gap control
- blow-out device 1- or 2-fold
- interface package: serial/ heating devices – USB/ printer – Ethernet/OPC
- 4 freely programmable inputs/outputs
- additional plugs in different combinations
- standardised handling device interface (EUROMAP 67)
- interface for integrated handling device (instead of EUROMAP 67)
- sliding table for vertical systems
- temperature controller
- interface for vacuum pump
- interface for brush control
- interface for ejector plate fuse
- energy monitor
- 4 control zones with increased heat output for mould heating
- heating plates
- various brush systems

Modification in design and
equipment reserved
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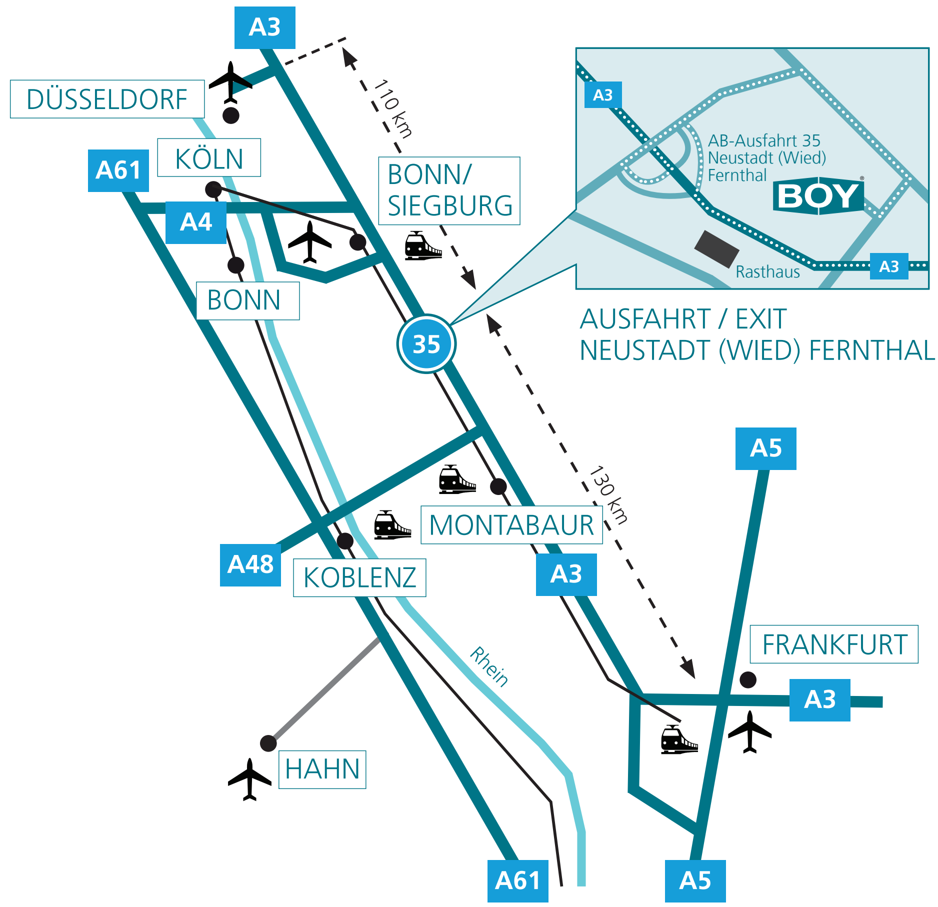

Spritzgiessautomaten

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