

**Production of rubber mouldings by
Injection-Transfer-Moulding (ITM)**

Item	Contents	Page
1.	General	2
1.1	Transfer-Moulding (TM)	2
1.2	Injection-Transfer-Moulding (ITM)	3
1.2.1	ITM with non-temperated transfer chamber	4
1.2.2	ITM with temperated transfer chamber	4
2.	Process technology	5
2.1	Use of non-temperated transfer chambers	6
2.2	Use of temperated transfer chambers	7
2.3	Control	8
2.4	Low-flash production	9
2.5	March of temperature	10
3.	Production examples	11
3.1	Production of covering caps	11
3.2	Production of profile seals	14
3.3	Production of stop buffers	17

V. Krell
Head of development / design

1. General

Utilizing moulds in which the mass is being distributed by means of transfer chambers (also called transfer pot, ITM-pot) is very advantageous for the production of rubber mouldings in large quantities. The use of transfer chambers in the transfer moulding technique has already been put into practice for a long time. Injection-Transfer-Moulding has resulted from adopting this principle to an injection moulding machine what then simplifies realization of automation and quality control.

1.1 Transfer-Moulding (TM)

In this procedure the elastomer not being vulcanized is placed into the open transfer chamber. Then the chamber is closed and the clamping pressure becomes effective on the whole mould. Due to the resulting internal pressure in the ITM-pot, the elastomer flows into the cavities. After the vulcanization time has ended, the moulded parts can be removed from the cavities and the material from the transfer chamber.

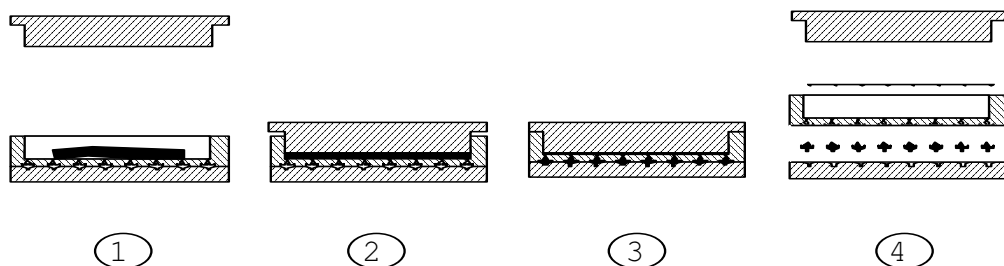


Fig.1: Transfer-Moulding

- 1 - Transfer chamber opened, elastomer inserted
- 2 - Transfer chamber closed
- 3 - Mould is closed under high pressure
- 4 - Removal of the moulded articles,
cleaning of the transfer chamber

1.2 Injection-Transfer-Moulding (ITM)

Transferring the transfer-moulding technique to an injection moulding machine makes a more efficient production possible.

In the ITM-process, elastomer dosing and feeding is made by the injection unit. So the raw material is transported in economical dosage as well as optimally preheated and homogenized into the transfer chamber.

Thus, the compound preparation is fully automatic and controllable. Failures on account of wrong feeding and preheating are excluded, quality control is, like in the standard injection moulding process, also possible. Accessories like cutting and dosing units or pre-heater are superfluous.

Owing to the reproducible compound preparation, the elastomer can be taken into the mould at a higher temperature level what reduces the cure and as a result the cycle times.

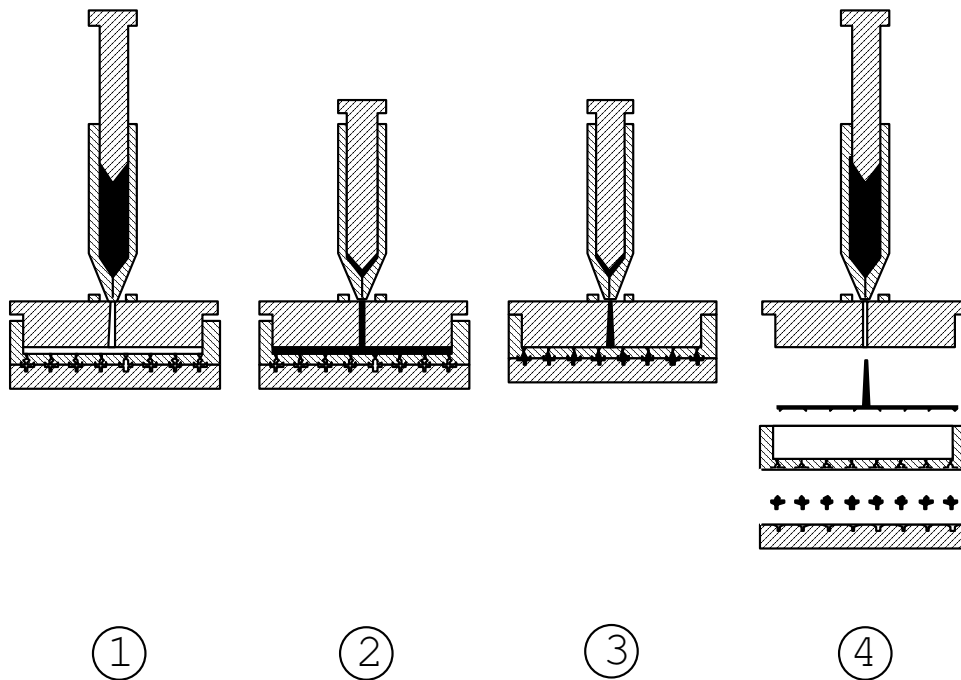


Fig. 2: ITM with non-temperated transfer chamber

- 1 - Mould closed, elastomer dosed and homogenized
- 2 - Transfer chamber filled
- 3 - Cavities filled by transfer stroke
- 4 - Removal of the moulded articles, cleaning of the transfer chamber

1.2.1 ITM with non-temperated transfer chamber

The herein described and most simple alternative of the ITM-process ensures a reduction of the cycle time as well as a slight raw material saving due to a more exact dosage.

Due to the low viscosity at vulcanisation temperatures, the pressure demand and as a result the required clamping force of the injection moulding machine are the lowest when using non-temperated ITM-pots. By renouncing of temperation lines, the cavity center distance can be reduced to a minimum what leads, with the transfer chamber being of constant size, to a maximum number of cavities and to a maximum output of articles.

The vulcanisation in the transfer chamber, however, causes still a relatively great share of waste. Therefore, as far as expensive materials or a difficult disposal situation are concerned, temperated transfer chambers have to be used.

1.2.2 ITM with temperated transfer chamber

The thermal separation of ITM-moulds into a hot forming part and a temperated transfer area prevents the vulcanization in the ITM-pot. Apart from the material and waste savings, the operation cycle "pad removal" together with the works involved is omitted. There is, however, less room for cavities available because of the required heating and temperation equipment.

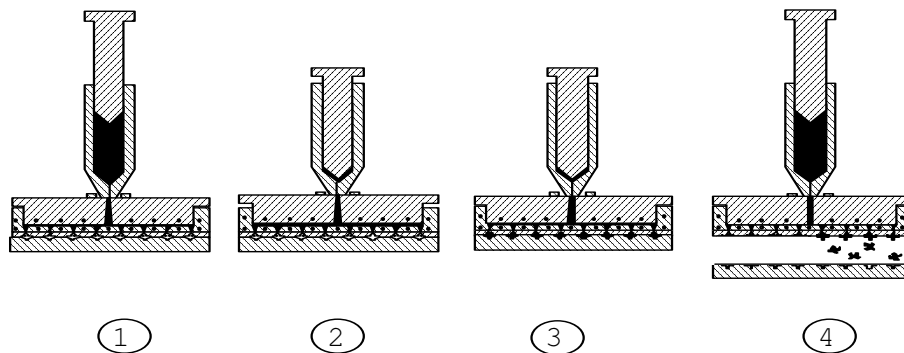


Fig. 3: ITM with temperated transfer chamber

2. Process technology

The Injection-Transfer-Moulding offers some essential advantages compared to "normal" injection moulding moulds. Many cavities can be assembled very closely, without complicated distribution systems and respective pressure losses are becoming necessary. A difficult balancing of runners is neither required. During the transfer stroke the same pressure is prevailing at all spots of an ITM-pot. This is the decisive condition for an even filling of the cavities.

The deciding factor for the production of low-flash articles exists due to the special area ratio (pls. refer to item 2.4).

The most important components for an automatic production are schematically represented in the following:

Here the following designations are valid:

- 1 - Injection moulding machine of the series D 969 resp. D 968 for articles with inserts
- 2 - Demoulding unit (possibly in the mould)
- 3 - ITM-mould
 - 3.1 - Mould platen
 - 3.2 - Mould platen
 - 3.3 - ITM-cylinder
 - 3.4 - ITM-piston
 - 3.5 - Moulding
 - 3.6. - ITM-pad

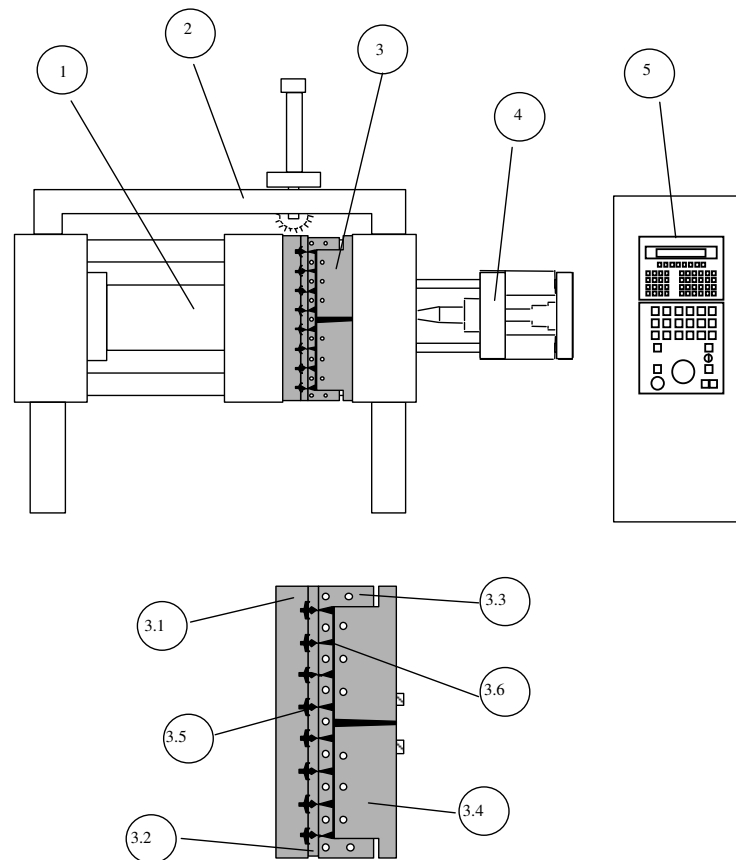


Fig. 4: The most important components of a production system

2.1 Use of non-temperated ITM-pots

Due to the movement between ITM-piston and ITM-cylinder together with the high temperature, these two components are exposed to stronger wear. This may lead to jamming, if using unsuitable material. These damages can be avoided by applying the right materials, suited surfaces and coatings.

For the operation of non-temperated ITM-moulds, a too strong cooling of the ITM-cylinder has to be excluded, otherwise this component will shrink. As a result there would be no clearance between piston and cylinder and the above problems may occur. Using an additional heating will prevent these parts from unwelcome jamming. For a flash-free production the moulds to be used must not be too stiff. Only thin mould platens can lie on top of each other, so that no material flows into the split line and flash is avoided. If cavity inserts are utilized, sufficient axial play has to be borne in mind.

2.2 Use of temperated ITM-pots

Perfect temperature guiding is required for a constantly low-flash operation of moulds with tempered transfer chamber. Especially as for the transition between transfer chamber and mould platens, a high temperature difference has to be available in a narrow area (pls. s. item 2.5). Temperature changes may not take place in continuous operation as well as in the event of production stops.

Also in this case the mould platens must not be too stiff. Cavity inserts or nozzles have to dispose of axial play, in order to lie on top of each other, so that no material flows into the split line.

Moreover, sufficient sealing between ITM-piston and cylinder is necessary for an impeccable function. The centrings have also to work with the existing temperature differences between mould platens and transfer chamber.

Generally the first start-up of a new ITM-mould with tempered pot is more labour-intensive than in case of a normal injection moulding mould. After successful start-up resp. optimization, the ITM-moulds can be operated very easily and safely. Important in this connection is a constant manipulation time. If the manipulation times fluctuate, a modified tear-off behaviour of the runners may arise what causes a faulty part production in the following cycles. It may take several cycles to recuperate an excellent production.

The use of automatic equipment is therefore not only interesting for economical reasons, but also important for the article quality.

2.3 Control

For a production under optimum conditions a special ITM-runoff control is required. Controlling the pad thickness is of essential importance, when using tempered transfer chambers.

The injected volume can never be exactly the same as the volume of the articles. If the injected volume is slightly larger than the article volume, a gradual pad thickening in the transfer chamber will be the result. Subsequently the clamping unit can no longer reach its final position and the mould monitoring interrupts the automatic mode. If the injected volume is too small, the pad thickness diminishes steadily, the transfer chamber is pushed together up to the mechanical stop and the articles are under-filled.

The limit stop for the injection movement can be made via the stroke measurement of the clamping unit. This way the transfer chamber will always be filled to a certain extent. Then the above mentioned problems cannot occur anymore.

The filling of the mould cavity is carried out by means of transfer stroke and performed in three phases. The first two phases are to be considered as injection phases. The third phase works like a dwell pressure phase. All described settings are being input on a corresponding screen page (fig. 5):

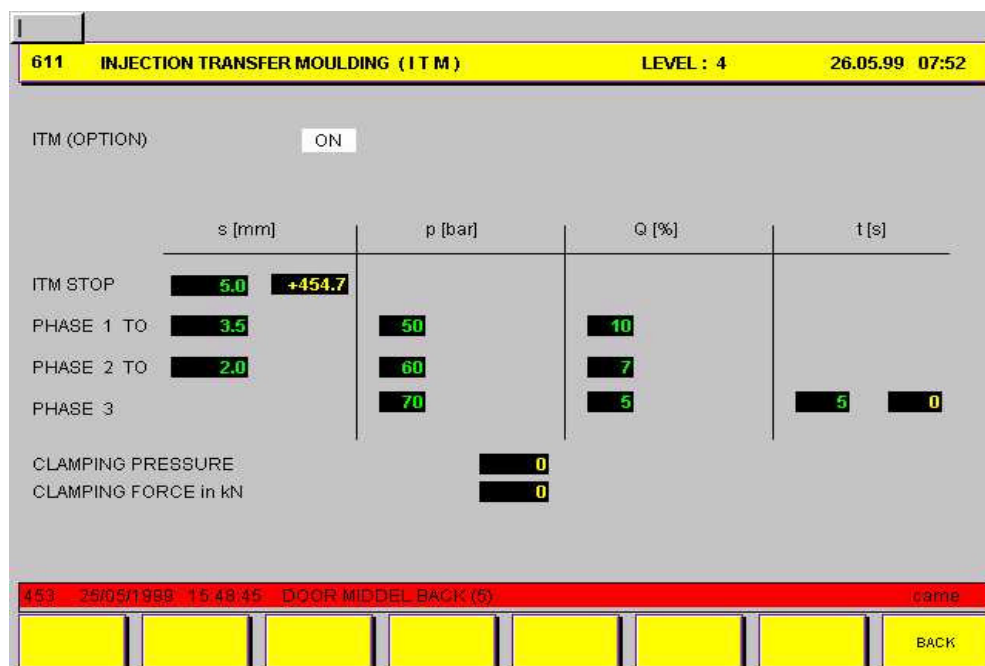


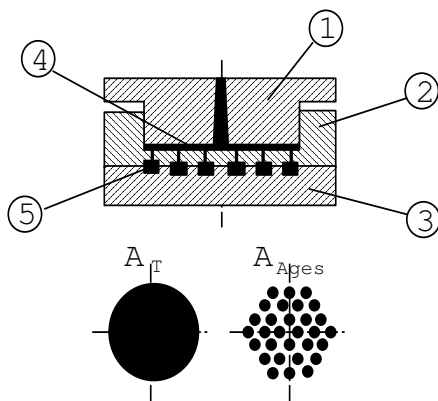
Fig. 5: Screen page ITM

2.4 Low-flash production

On account of the special conditions offered by the ITM-moulds, production of low-flash articles is feasible. As for "normal" injection moulding moulds, an increasing mould internal pressure creates a reduction of the surface compressing in the split line.

As far as the ITM-moulds are concerned it is exactly vice versa.

Due to the area ratio between transfer chamber (A_T) and projected area of the article (A_{Ages}), the surface compressing rises, with an increasing internal pressure, proportionally to the pressure. Thus, the decisive condition for a low-flash production is given.



- 1 - ITM-piston
- 2 - ITM-cylinder
- 3 - mould platens
- 4 - transfer chamber
- 5 - cavities
- A_T - projected area transfer pot
- A_{Ages} - projected area of whole article
- p - internal pressure
- p_T - internal pressure transfer chamber
- p_A - internal pressure article
- F_{FP} - surface compressing in the split line

Fig. 6: Pressures in the ITM-mould

When the transfer phase ends :

$$p_T = p_A = p$$

i. e. the pressure in the whole mould is compensated.

The surface compressing is then calculated as follows:

$$F_{FP} = p^*(A_T - A_{Ages})$$

During the transfer phase the pressure in the ITM-pot is at any rate higher than the internal pressure in the cavities. This causes an additional increase of the surface compressing. The level of the pressure difference between transfer chamber and cavities depends on the flow properties of the compound and the transfer speed.

2.5 March of temperature

Moulds without tempered transfer pots are in general operated with the same temperatures on the different platens.

It must only be seen to it that, due to too strong cooling during demoulding, jammed mould parts at the ITM-cylinder are avoided. Possibly an additional heating would be reasonable.

For the safe operation of tempered ITM-pots an exact temperature guiding is indispensable.

For this the temperature of mould platen and ITM-cylinder plate has to be constant across the whole cross section (Fig. 6, A,B,C resp. D,E). The temperature rise from the transfer pot to the forming cavity platens should take place rather quickly (Fig. 6, F).

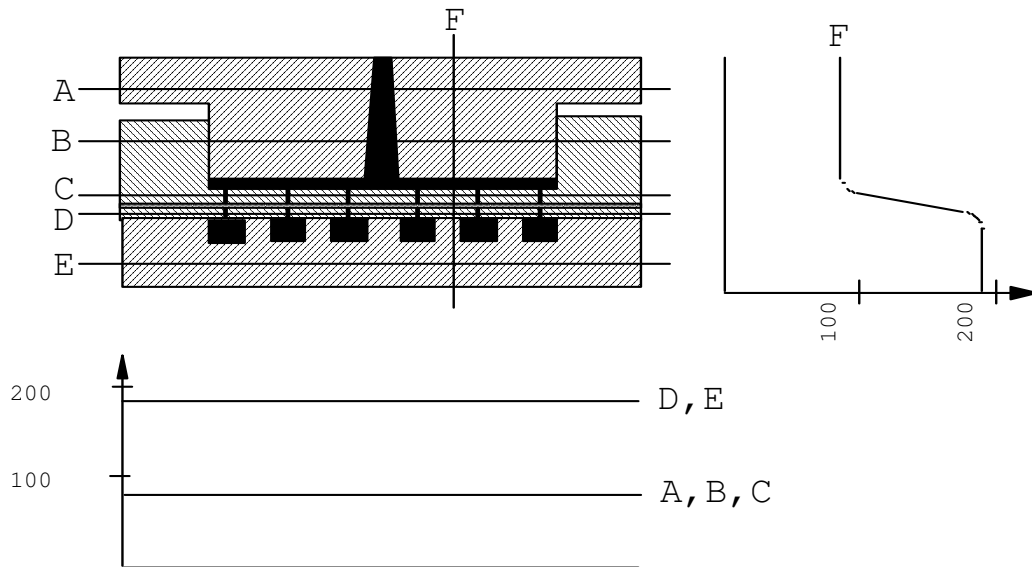


Fig. 7: Idealized march of temperature for moulds with tempered ITM-pot

3. Production examples

3.1 Production of covering caps

Covering caps are required in large quantities for the automobile production. For a perfect function a surrounding and precise sealing edge is important. The requirements for handle and point are less.

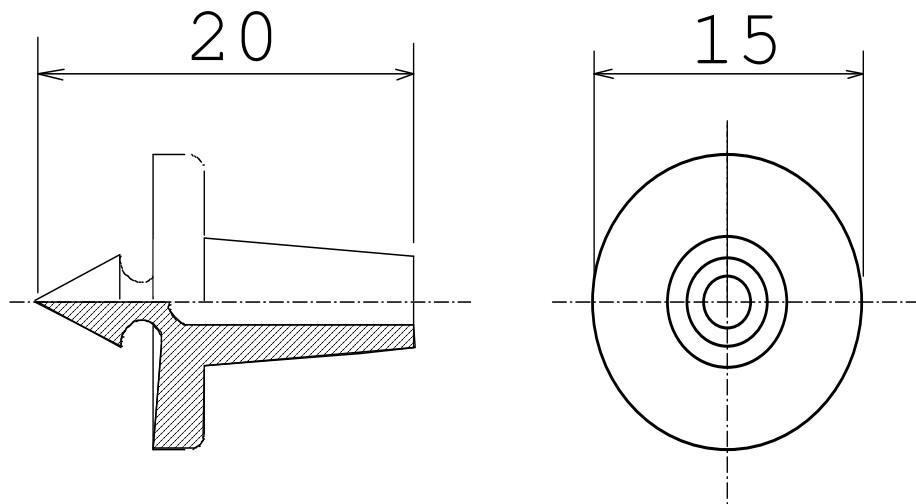


Fig. 8: Covering Caps

A partly vulcanized nipple can be accepted owing to the insignificant functionality of the point. A runner can be renounced of. Thus direct injection via ITM-pot is the best solution, since there will be no waste in the course of this production. The finished parts are removed via rotating rubber lips from the mould platen. The following figure represents schematically 3 production stages.

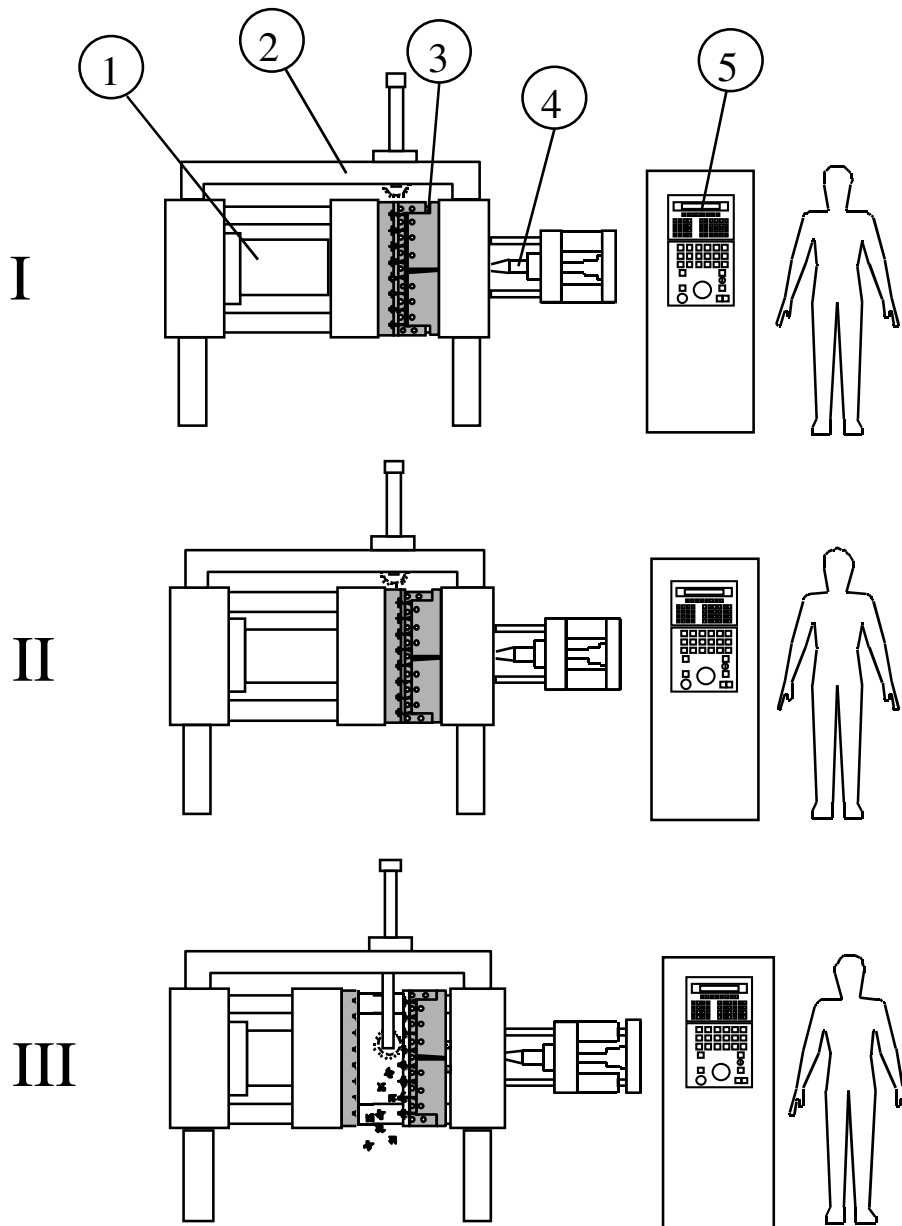


Abb. 9: Production of covering caps

-
- I - Injection into the transfer chamber, thereby opening of the clamping unit.
 - II - Transfer stroke for cavity filling
 - III - Article demoulding via rotating rubber lips
-
- 1 - Horizontal injection moulding machine of the series D 969 with 2500 kN clamping force
 - 2 - Demoulding module with rotating rubber lips
 - 3 - 96-cavity ITM-mould with tempered transfer chamber
 - 4 - FIFO-injection unit
 - 5 - DRC-machine control with special ITM-program

3.2 Production of Profile Seals

In regards to the below described production of profile seals, a maximum output connected with a quality which has not to be reworked, were of top priority.

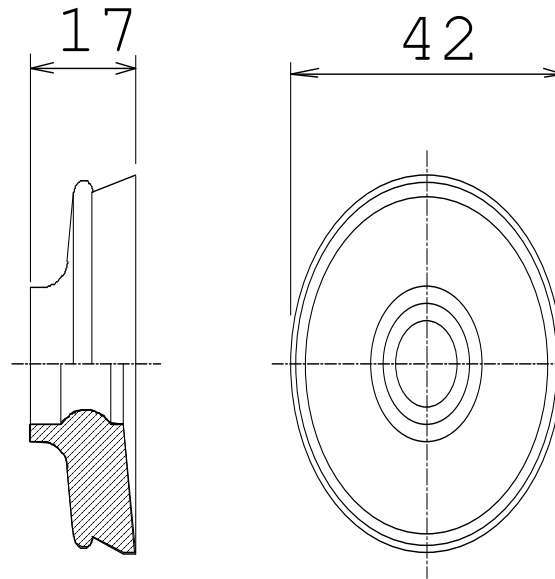


Fig. 10: Profile Seal

Owing to the smaller cavity centre distance and the lower pressure consumption needed when using a non-temperated transfer chamber, the number of cavities can be increased considerably using the same clamping force. The resulting cost reduction for inexpensive materials is far higher than the cost increase due to more material consumption.

Due to the complex article contour, injection is only possible at specified points. Further marks at the article caused by ejectors are not acceptable. Production with demoulding out of a centre plate, which is in this case extremely thin, is not realizable due to the small article tolerances and the cooling of the centre plate to be expected during demoulding.

Owing to a demoulding through the injection points a centre plate is not needed. The articles are ejected by pins after removal of the ITM-pad.

Some of the production steps are schematically represented in the following figure.

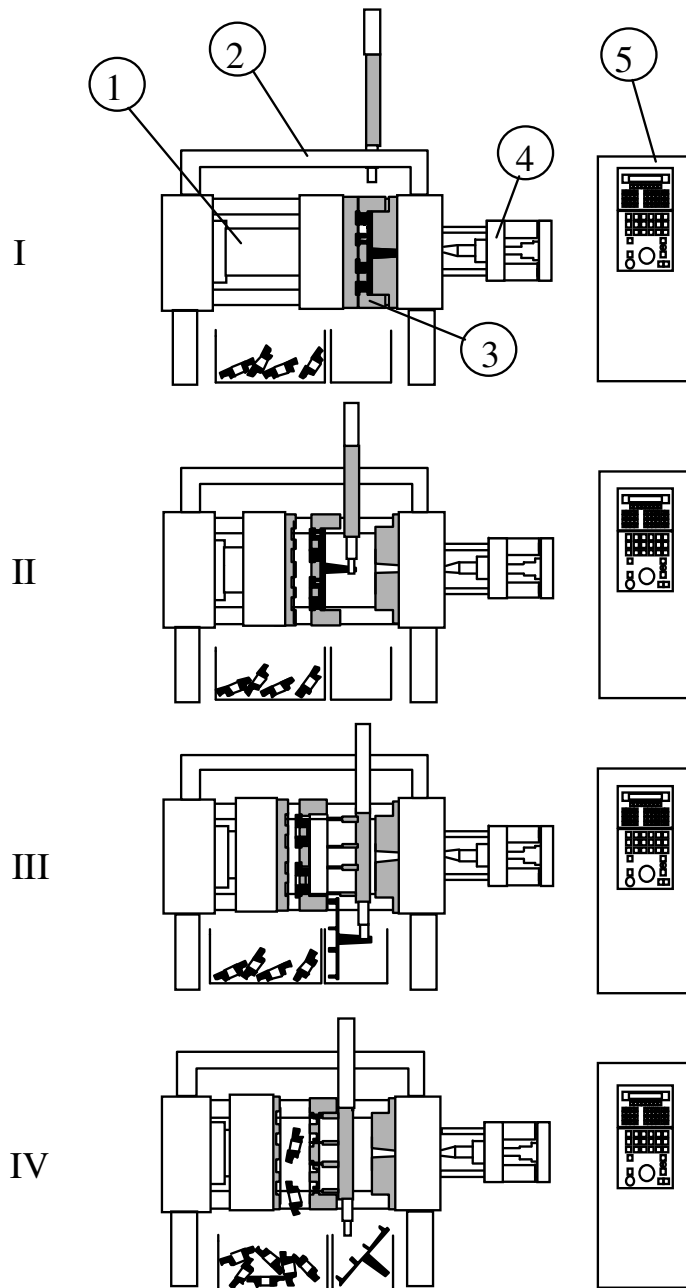


Abb. 11: Production of profile seals

-
- I - Cavity filling by Injection-Transfer-Moulding
 - II - Removal of ITM-pad by a handling unit
 - III - Deposit of pad and placing of ejection pins
 - IV - Ejection of articles by means of the runners
-
- 1 - Horizontal injection moulding machine of series D 969 with 2500 kN clamping force
 - 2 - Demoulding module
 - 3 - 29-cavity ITM-mould
 - 4 - FIFO-injection unit
 - 5 - DRC-machine control with special ITM-program

3.3 Production of stop buffers

Stop buffers to be used at low temperatures are sometimes made of silicone.

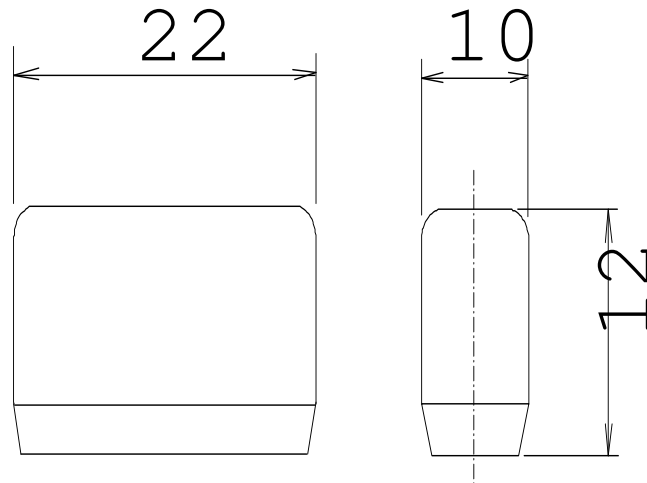


Fig. 12: Stop buffer

Due to the more and more difficult disposal situation and the comparatively high material costs, the use of a tempered transfer chamber is economically and ecologically reasonable.

A partly vulcanized injection point is the result of direct injection. During the automatic assembly of the parts, operation failures are possible due to these gluey injection nipples of varying size. Also possible imprints of partly vulcanized nipples caused by the falling of the articles on top of each other in the box might lead to these failures. Therefore direct injection is not recommendable.

Owing to injection of two articles via tunnel gate through an ITM-nozzle there is only insignificant sprue left. The separated demoulding and the separation of sprue and article is possible by means of independent ejector systems.

Some production steps are schematically represented in the following figure:

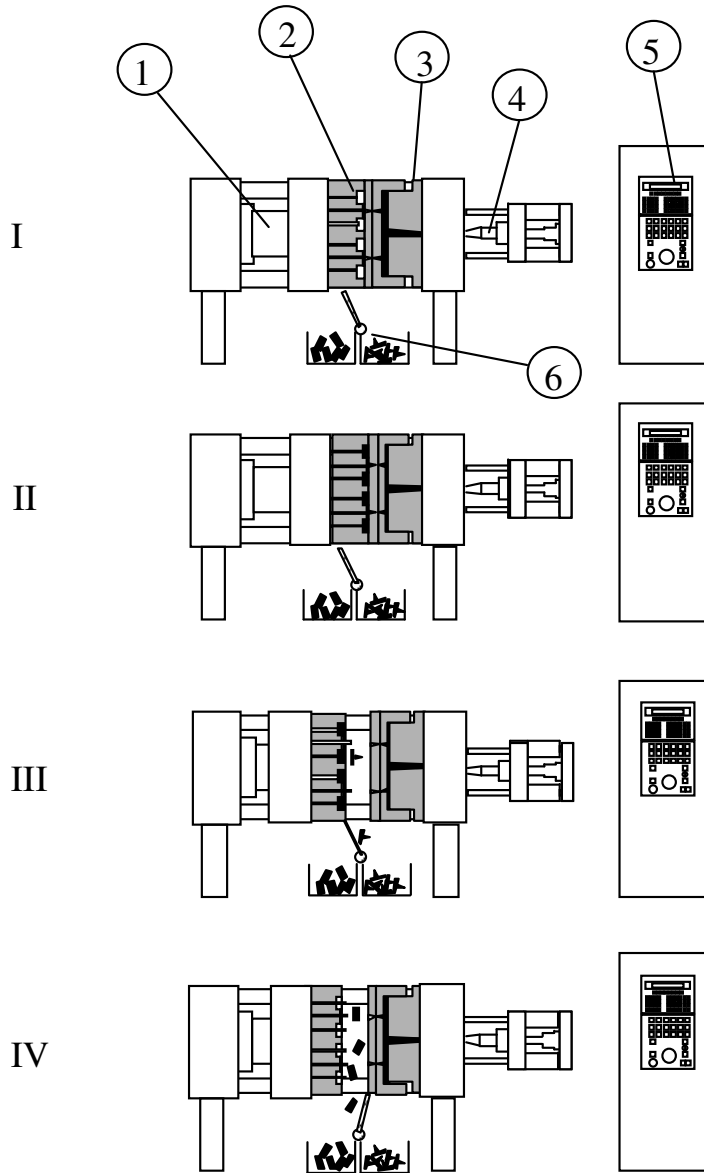


Abb. 13: Production of stop buffers

-
- I - Injection into the transfer chamber and subsequent opening of clamping unit
 - II - Transfer stroke for cavity filling
 - III - Ejection of runners
 - IV - Ejection of articles
-
- 1 - Horizontal injection moulding machine with 2500 kN clamping force
 - 2 - 88-cavity ITM-mould with special ejector system
 - 3 - Tempered transfer chamber
 - 4 - FIFO-injection unit
 - 5 - DRC-machine control with special ITM-program
 - 6 - Separation of sprue and article