BASICS OF ELASTOMER INJECTION MOULDING
How to have injection moulding machines and processes under control – successfully! The DESMA manual about the basics of injection moulding provides you with an overall picture. This is comprehensive know-how available for direct use in your work: up-to-date, compact and especially clear with many graphics and diagrams.

A smooth and safe production. Even with the latest technologies. You can get informed about the basic knowledge of project engineering and materials, production and moulds, but also about all DESMA machines and innovations and their successful use in the optimized injection moulding process. Contents from practice for practice that not only industry newcomers and trainees can take advantage of, but experienced specialist as well who can update and selectively expand their skills.

We provide you with further support for your work by way of DESMA training offers and the forward-looking DESMA e-training: www.e-training.desma.biz

The team DESMA wishes you good success!
Planning a mould part production typically begins with the consideration which manufacturing concept or automation level would be ideally suited in the specific case. The type of article, the envisaged production quantity as well as raw material costs (elastomer compound) are decisive factors when taking one’s choice. It is always the objective to achieve optimal article quality at minimum manufacturing costs. The comparative calculation must therefore not lack the costs for energy, maintenance, waste and the like.

Quick answer with DESMA CoolApp

Whether and when the usage of a cold runner system is profitable can be swiftly determined with DESMA CoolApp. This CoolApp application developed by DESMA and free available allows for waste savings to be easily calculated when using a cold runner system. These savings are calculated automatically by selecting the adequate cold runner and amortization period is exactly defined. A comprehensive program for article calculation and cavity layout is also made available and thus completes its efficiency.

Almost simultaneously the precise compound recipe is being determined. Above all, the material has to ensure technical product requirements, but also must be easily to process and affordable. It is important that the processing properties of the individual material batches do not strongly fluctuate.

As soon as an appropriate manufacturing concept and an appropriate compound recipe are found, the injection mould and the required machine can be elaborated respectively designed as second step.

After having completed all components, the exact (optimum) process control is established by way of injection tests in the course of which the fine-tuning of the injection mould is also carried out – e.g. optimization of the material distribution onto the individual mould cavities, of injection and/or venting. Compound, mould, machine and process control eventually determine product quality, manufacturing costs and hence profitability of production. Only when these factors are optimally synchronized, a perfect result can be expected.
Various additions have to be added to the rubber base material (base polymer) in order to be able to produce an elastic and long-life end product. Only the addition of a cross-linking agent (sulfur, peroxide, etc.) makes the processing to the elastic end product (vulcanisate) possible. Other substances improve resistance to wear and aging stability. The processing properties as well can be optimized by way of suitable additions. The workable material is therefore called “elastomer compound”. If not being cross-linked and at ambient temperature, consistency of this compound varies between viscous (LSR silicone), plasticine-like (solid silicone) and solid (rubber). With increasing temperature, the flowability of the compound improves almost proportionally. However, the heat input also reduces the latent period after which the chemical cross-linking (vulcanization) starts. In this process, solid compounds (cross-linking points) between the individual macro molecules of the base polymer gradually develop. This drastically reduces the flowability of the mass, and the material response gradually changes from plastic to elastic. This reaction starts earlier and develops faster at higher temperatures. Stopping the heat input permits the cross-linking reaction to be aborted prematurely. Thus depends on the compound recipe, the mass temperature curve, and the required degree of vulcanization. With thick-walled products, in particular, you must bear in mind that the cross-linking process continues after demoulding for a short while (while the product is cooling down), since a lot of heat is still stored in the product. With a medium wall thickness, this “postvulcanization” is approximately 10%. To achieve the required final quality, the products can also be post-vulcanized or fully cured in a curing oven. Due to the lower machine hour rate, this frequently results in lower costs. The vacuum oven also permits specific degassing.

**2.1 Vulcanization**

With increasing temperature, the flowability of the compound improves almost proportionally. However, the heat input also reduces the latent period after which the chemical cross-linking (vulcanization) starts. In this process, solid compounds (cross-linking points) between the individual macro molecules of the base polymer gradually develop. This drastically reduces the flowability of the mass, and the material response gradually changes from plastic to elastic. This reaction starts earlier and develops faster at higher temperatures. Stopping the heat input permits the cross-linking reaction to be aborted prematurely. The maximum possible cross-linking density (~ 100 % cross-linking degree) is limited by the compound recipe / the cross-linking agent in the compound.

To avoid cross-linking before or during cavity filling, „retarders” are added to the compound. After the mould has been filled, however, the reaction shall start and progress as fast as possible. „Accelerators“, that take effect with the cross-linking reaction, help here. The required vulcanization or cure time thus depends on the compound recipe, the mass temperature curve, and the required degree of vulcanization. With thick-walled products, in particular, you must bear in mind that the cross-linking process continues after demoulding for a short while (while the product is cooling down), since a lot of heat is still stored in the product. With a medium wall thickness, this „postvulcanization” is approximately 10%. To achieve the required final quality, the products can also be post-vulcanized or fully cured in a curing oven. Due to the lower machine hour rate, this frequently results in lower costs. The vacuum oven also permits specific degassing.
2.2 COMPOUND TEST

Vulcameter Test (MDR)

Standard test procedure for production release after the compound has been produced.

- Rheological and precuring behaviour at constant temperature
- The small amplitude and low frequency produce only minimum shearing / friction
- Corresponds to the process flow in the CM process (vulca-presses)

Since the mass temperature development in injection moulding is not constant, and the shear rate is much higher, the determined data cannot be used directly for setting the injection moulding machine.

However, the torque curve and a little experience permit at least the approximate processing properties of a compound to be assessed. Such a statement is possible for the following points:

a) Flowability during injection (necessary pressure)
b) Processing time (max. injection time)
c) Vulcanization rate (necessary cure time)

The known cure time optimization systems / cure time calculators also use (among other things) cure-meter data to maintain the article quality at a constant level, even at changing production conditions.

Measuring mixers (from Brabender, for example)

The measuring mixer is another, less known, test method. Its structure is very similar to the compounder. The mass temperature can thus be measured exactly during the test. The higher resolution permits changes to be detected that are still in the range of the measuring fluctuations of the cure-meter.
3. PRODUCTION METHODS

3.1 VULCA-PRESSES (CM PROCEDURE)

1. Insert the cold compound into the mould cavity
2. Closing and pressing of the mould (cavity filling)
3. Vulcanization
4. Open the mould, demould the article, cleaning the split lines

**BENEFITS** | **DISADVANTAGES**
--- | ---
Low investment costs | Very long cycle time
Simple technique | Irregular cross-linking
High number of cavities possible | Reworking necessary
Small compound shearing | High waste proportion (flash)

**Blank preparation necessary**

3.2 TRANSFER PRESSES (TM PROCEDURE)

1. Insert cold compound into the transfer pot
2. Closing and pressing of the mould (cavity filling)
3. Vulcanization
4. Open the mould, demould the article and transfer sheet, cleaning

**BENEFITS** | **DISADVANTAGES**
--- | ---
Shorter cycle time | More complex moulding techniques
More regular cross-linking | Higher costs
High number of cavities possible | High waste proportion (transfer sheet)
Low-flash articles possible | **Blank preparation necessary**

3.3 INJECTION MOULDING (IM PROCEDURE)

**with hot runner**
1. Closing and pressing of the mould
2. Injection process (cavity filling)
3. During vulcanization time: plasticizing and dosing of the compound
4. Open the mould, demould the article and runner, cleaning

**BENEFITS** | **DISADVANTAGES**
--- | ---
Very short cycle time | High investment costs
Regular cross-linking | Lower possible number of cavities
Automatic intake and dosing | Without CRB: much waste
Articles without reworking possible, With FlowControl cold runner block without waste!

**with cold runner block**
1. Closing and pressing of the mould
2. Injection process (cavity filling)
3. During vulcanization: plasticizing and dosing the compound
4. Open the mould, demould the article and runner, cleaning

**BENEFITS** | **DISADVANTAGES**
--- | ---
Flexible moulding techniques | More complex moulding techniques
More regular cross-linking | Higher costs
High number of cavities possible | Higher possible number of cavities
Low-flash articles possible | **Blank preparation necessary**

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8. This project was supported by the following companies.
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