LED auxiliary lenses are a classic product for injection-compression processes (figures: Arburg)

Impressive Experience

Process Design. Controversial discussions are heard time and again as to which mold type – hydraulic or spring-loaded cavity frame – should be used in a particular case for injection compression molding with the main machine axis. It is well worthwhile in all cases to focus the arguments on the product and the process technology.

ROLF-UWE MÜLLER

With a spring-loaded cavity frame, the spring characteristic of the spring assembly is determined from the compression stroke during the mold proving phase. In practice we find practically linear as well as extremely progressive characteristics [1]. The characteristic influences or even determines to a certain extent the process control.

With a multi-cavity injection compression mold with hydraulically loaded cavity frame **(Fig. 1)** the gate and runner system is integrated into the cavity frame. In the area of the cavities, the compression stamp cores pass through the cavity frame. The mold is closed during the compression stroke with the machine main axis. The compression cores thereby generate the holding pressure directly in the cavity.

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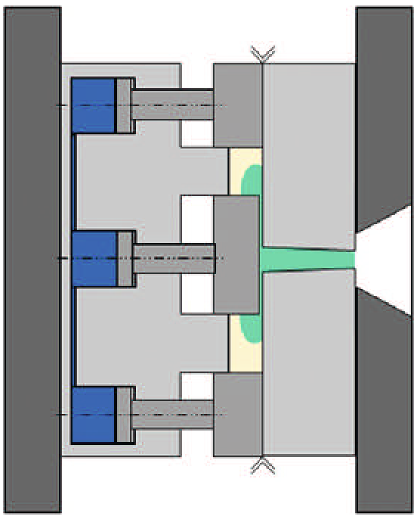

Fig. 1. Principle diagram of an injection-compression mold with hydraulically loaded cavity frame (blue = hydraulic oil)

This makes certain demands on the core puller hydraulics and the cavity frame:

- The cavity frame has to make a movement relative to the compression cores when moving to the compression starting position.
- The locking force at the main parting line must be built up during the injection phase.
- The locking force during the compression phase has to be maintained with the machine's main axis (clamping unit).
- The hydraulics have to be depressurized before the mold is opened.

The basis for determining the necessary locking force are effective buoyancy lifting forces during the injection phase and

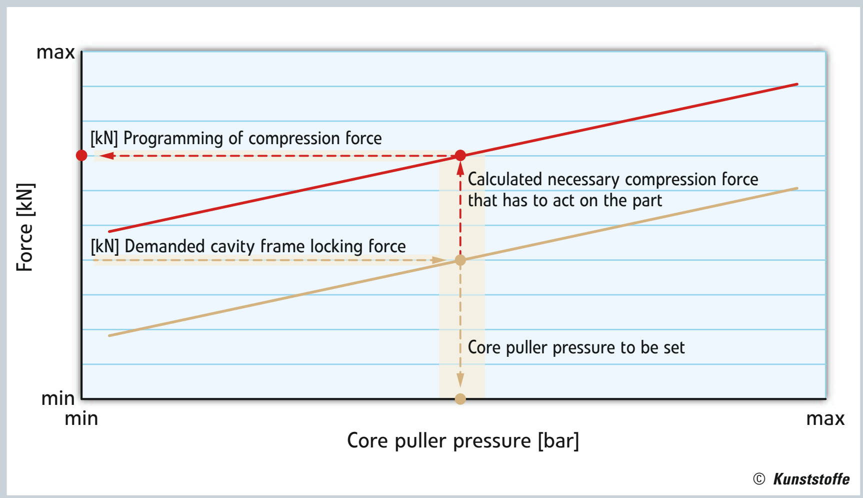

Fig. 2. The mold data show very clearly the relationship between the locking force and the core puller hydraulic pressure

effective buoyancy forces during the compression phase with material-typical cavity pressures.

The size of the hydraulic cylinder is determined during the mold design phase. Several cylinders can also be used in parallel.

Limited Compression Stroke, Temperature-controlled Hydraulic Cylinders

As a rule, a graphic representation of the design setting range can be found in the mold manual from which the machine setter can read off the necessary core puller pressure range and the design compression force range (**Fig. 2**). Note that these are indicative values that ensure safe start-up of the injection compression mold.

With a hydraulically loaded cavity frame, the compression stroke is essentially limited by the stroke of the hydraulic cylinders. As a rule, however, the designer limits the maximum stroke to a range expedient to the process.

In practice, both single-acting and double-acting hydraulic cylinders are used. The hydraulic cylinders have to be thermally insulated from the mold and/or cooled in order to ensure that the maximum admissible temperature of the machine's hydraulic oil is not exceeded. The difference between the mold temperature and the maximum admissible oil temperature lies for optical applications typically in the range from 60 to 100 K. If several hydraulic cylinders are used, care must be taken that they are controlled absolutely symmetrically in order to ensure synchronous movement of the cylinders.

Hydraulics versus Spring Systems

The air remaining in the hydraulic system during filling with hydraulic oil can endanger commissioning of the mold. This leads to a demand for being able to vent every cylinder individually. Good thermal management in conjunction with a hydraulic venting system is the best precondition for successful mold commissioning and a lasting stable production process.

By analogy with the spring characteristics of a spring-loaded cavity frame [1], “force characteristics” are recorded for the machine dry run with a hydraulically loaded cavity frame during commissioning of an injection compression mold. In one typical example, four different hydraulic pressures were set (**Fig. 3**). It was shown that the force characteristics are straight lines with a gradient of zero. Consequently – and by contrast with spring-loaded systems – the whole compression stroke is available for the process. The locking force of the cavity frame can be changed during the process by varying the hydraulic pressure.

Which of the two systems – hydraulic or spring-loaded – should be used in a particular case is the subject of controversial discussions time and again. Hydraulics holds the advantage where high locking forces are required. As a rule, however, the arguments of both sides balance one another out (**Table 1**). It is well worthwhile in all cases to focus the arguments on the product and the process technology. Key points here are:

- The adjustability of the cavity frame locking force, and
- the opening behavior of the cavity frame.

One of the main arguments in favor of the hydraulically actuated cavity frame is that it can be depressurized before the mold is opened so that the mold opens first along the main parting line. The status of the compression core, cavity frame and injection molding system is therefore frozen before the mold is opened. That is

> **! Sequel**
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> **Main Axis Injection Compression Molding**
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> The article on “injection-compression molds with cavity frame” deals only with the functions of injection-compression molds with hydraulically loaded cavity frames. Spring-loaded cavity frames of injection-compression molds had already been discussed in an earlier article [1].

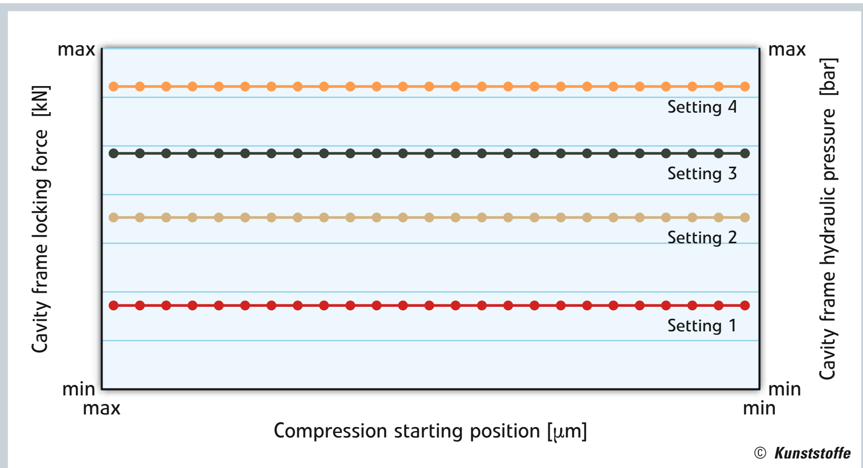


Fig. 3. Locking force of the cavity frame over the available compression stroke in relation to the hydraulic pressure. The force characteristics are straight lines with a gradient of zero, so that consequently the whole compression stroke is available for the process

not the case with the spring-loaded cavity frame. Movements of the elements relative to one another must be expected when opening the mold along the secondary parting line. With certain parts this can result in demolding problems or in deformation of the injection moldings during the opening phase.

The fact that spring-loaded cavity frames are more widely used than hydraulically actuated cavity frames is due equally to the simpler mold design as to the fact that they operate independently of the injection molding machine hydraulics.

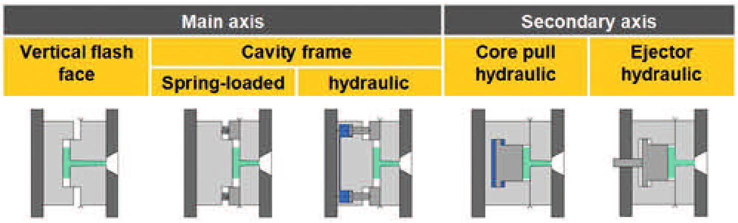
Required Machine Configuration

The core puller controller of the injection molding machine is used to control the hydraulic cavity frame. Due to the shift of the oil volume during the compression phase, the hydraulic oil must not be trapped during this process phase. Hydraulically regulated core puller systems satisfy this requirement.

Molds with hydraulically actuated cavity frames can generally also be used on electric injection molding machines such as the Allrounders of the Arburg Alldrive range as long as they have the core pull option. The integrated small hydraulic accumulator makes a separate hydraulic power pack superfluous. The core puller controller together with the associated quality control is completely integrated into the machine controller (Selogica) and thus permits maximum process control.

! Process Technology

The design of the compression mold determines the machine-side compression function. In order to achieve a variable cavity volume, there are a number of possibilities. Based on the machine movements, a distinction is made between two processes.



Main axis injection compression molding: Here, the compression movement is achieved via the clamping unit. The cavity can be sealed via a precision-machined flash face or alternatively via an axially moveable compression frame. This frame already contacts the parting line before the mold is fully closed, sealing off the cavity to the outside. The compression frame is pressed into position either by means of spring force or hydraulically. Main axis injection compression molding is primarily used for planar components with even wall thicknesses. Undercuts or openings perpendicular to the compression direction are problematic. Furthermore, mold concepts with compression frames also permit the compression of partial surfaces.

Here, the buoyancy forces acting on the areas of the component which are not compressed must be absorbed by the compression frame. The pressing force generated via the spring or hydraulic action is significantly lower than the locking force. The process window during the compression of partial surfaces is therefore very restricted using the main axis.

Auxiliary axis injection compression molding: During auxiliary axis injection compression molding, the buoyancy forces, in contrast, are absorbed by the locking force. This process is therefore particularly suitable for the compression of partial surfaces. Here, the compression movement takes place within the cavity via a moving core. The core-pull functions or the ejector are used for this purpose. Compression via the clamping unit, however, provides the advantage of power reserves which are ten times higher than the available auxiliary axis forces. The precision that can be achieved depends largely on the repeat accuracy of the compression movement, and consequently also of the clamping unit.

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Conclusion

Injection-compression molds with a so-called cavity frame are predominantly used for injection-compression molding with the machine main axis The cavity frames are loaded by spring force or hydraulic pressure and thus generate the locking force necessary along the main parting line during compression.

Spring-loaded and hydraulic systems exist side-by-side on the market. The arguments in favor of and against the two systems should be evaluated purely from the process engineering point of view. Hydraulic cavity frames require a regulated hydraulic interface fully integrated into the controller of the injection molding machine. The necessary compression forces and the characteristic of the cavity frames must always be known for professional commissioning of an injection-compression mold. ■

Hydraulic cavity frame	Spring-loaded cavity frame
Hydraulic venting necessary	
Thermal load on the oil must be considered	
More complex programming in the machine sequence	Simpler programming, only compression symbols required
Locking force in the main parting line can be varied via the hydraulic pressure	Locking force in the main parting line is dictated by the installed springs
Controller core puller function required	
Additional pressure relief valve required	Mold opens first along the secondary parting line
Potential hazard of oil vapors cannot be ruled out	Potential hazard of spring fatigue or spring breakage

Table 1. The arguments for and against hydraulic or spring-loaded systems roughly balance one another out

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