Demag Plastics Group

Injection Compression Moulding

Processes – Machine Technology
Process Control – Applications

ICM

Applications for injection compression moulding

- IMD parts
- Foamed parts
- Thin-walled packaging
- Optical parts
- Decorated back-injected parts
- Finely textured surfaces
- Mechanically loaded LFT part

Advantages and applications

Injection compression moulding (ICM) aside from reduced material shear and less orientation, offers numerous qualitative advantages for injection-moulding parts. ICM also permits a reduction in injection pressure, clamping force, and cycle time. Added to this is often an improved hold pressure effect, which minimises sink marks and warpage.

Advantages of injection compression moulding for the process

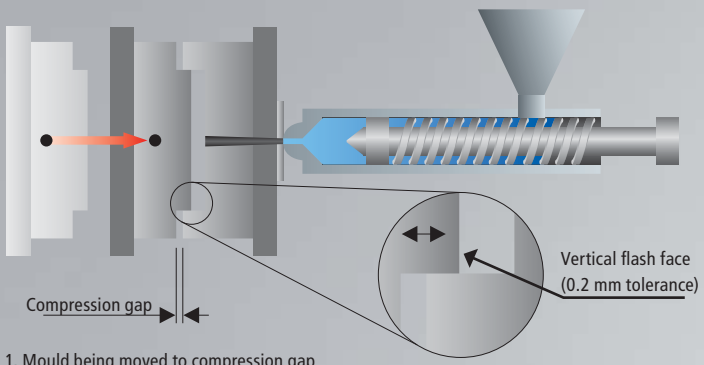
- Compensates shrinkage by compressing the melt through the clamping movement
- Distributed, uniformly acting holding pressure
- Reduces holding pressure time, shortens cycle times
- Permits overpacking of cavity
- Reduces clamping force requirements
- Less orientation and molecule alignment during injection
- Easier and faster mould filling through improved venting
- Less material shear

Advantages of injection compression moulding for moulded part properties

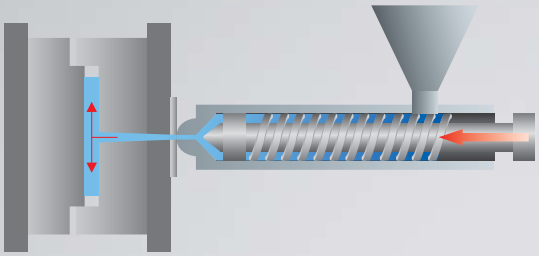
- Eliminates sink marks with thicker wall sections and at the end of the flow path
- Reduces to warpage susceptibility improves long-time dimensional stability
- Reduces stresses in mats or films in direct back injection for decorative parts
- Reduces fibre degradation in parts made of long-fibre-reinforced thermoplastics (LFTs) and, consequently, improved mechanical part properties
- Improves optical properties in the case of transparent parts

There is a trade-off between the numerous advantages and the extra expense for the machine and mould as well as restrictions in terms of part geometry:

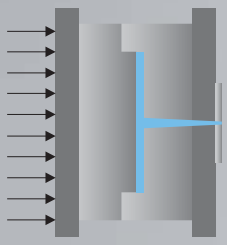
- In addiction the IM machine requires an injection compression control system whose extra price, however, is frequently exaggerated
- The physical design of the mould must be adapted to injection compression moulding in order to prevent the melt from penetrating into the parting line. There are a number of technical solutions to overcome this problem
- Undercuts or penetrations across the compression direction are problematic
- Only components that are of very great depth in the injection direction are very difficult to produce by injection compression moulding



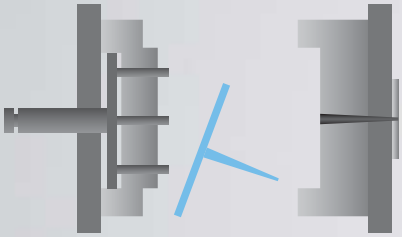
1. Mould being moved to compression gap



2. Melt being injected into a pre-enlarged cavity

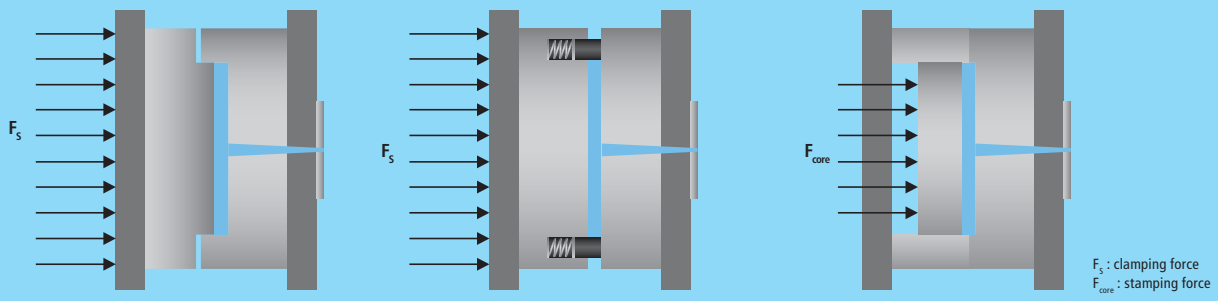


3. Melt being compressed by clamping movement of machine



4. Cooling, opening and ejection

ICM moulds require special physical design



Vertical flash face | Stamping frame | Stamping plug

Principle and variants

Basically, the sequences of the ICM process variants are similar and easy to understand because all the process involves is an additional stroke of the clamping unit:

1. Close mould to compression gap.
2. Inject and fill cavity 80 – 95 % (equivalent to 100 % or more of the final volume)
3. Sequential or simultaneous compression by the closing movement of the mould.
4. Post-compression (if required), cooling, opening, and ejection

Compression is effected either by the closing movement of the mould only or by the movement of an individual mould element activated by a hydraulic core pull function – called core stamping.

New mould concepts

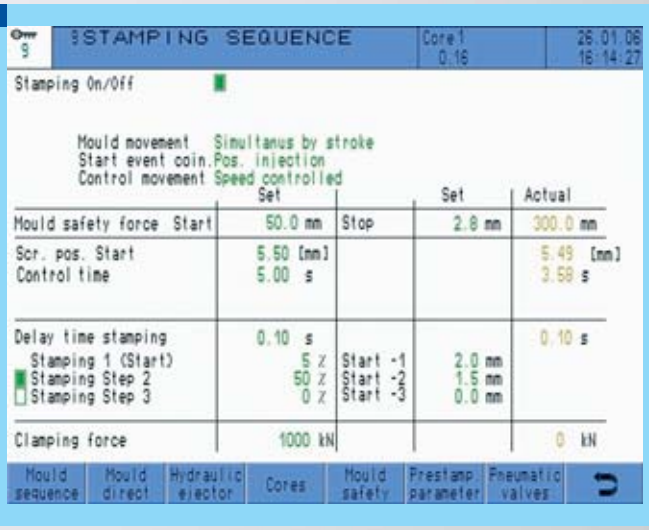
Mould designs have recently been distinctly improved. The classic vertical flash face is increasingly being replaced by stamping-frame concepts or by designs of guided intermediate plates. In some cases, coining and stamping variants of ICM have established themselves.

Compression and intermediate opening

Aside from the basic functions, it is possible to use some additional options in injection compression moulding, for instance, pre-compression and intermediate opening. Pre-compression serves to form the decorating materials. Intermediate opening may be necessary where the mould is initially closed somewhat more than necessary for ICM in order to prevent jetting and ensure laminar flow during injection. Intermediate opening may also be helpful in foaming in order to permit expansion of the melt.

ICM CONTROL

1



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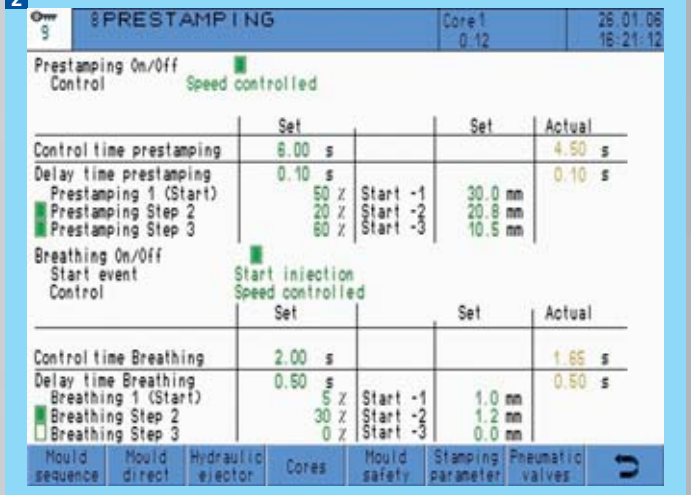
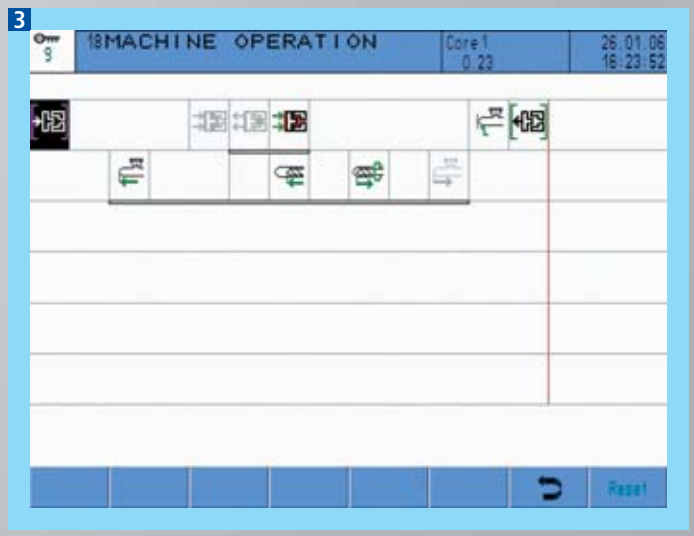


Variety and transparency

Demag Plastics Group's ICM control system is a selectable feature permitting a machine with ICM control to be used as a standard injection moulding machine. ICM control is available at two levels of sophistication:

- As sequential ICM control with injection and compression taking place in sequence.
- As simultaneous ICM control with compression taking place in parallel with injection and with pre-compression and intermediate opening functions.

3



Sequential ICM control is essentially an extension of the NC4 or NC5 controller. As such it is available for all Demag machines of the Concept, System, Systec, IntElect, and Titan series. The **extended ICM control**, which imposes additional requirements on drive technology, can be integrated into the all-electric IntElect without any problem. In the case of the hydraulic machines, it would be necessary to look into the cost of configuring the hydraulics in each specific case.

Integration into the NC4 controller

There are three screen pages in the NC4 control system of the Demag machines to manipulate injection compression moulding. The options summarised on the screen pages 9 ("ICM control") and 8 ("Pre-compression/intermediate opening") are easy to understand. The ICM control is, of course, fully integrated in the screen page 18 ("Flexible machine sequence").

1 Screen page 9: ICM control

The many options for modes, starting events, etc, are selected by means of drop-down menus. These provide the operator with a host of process variants through the use of different combinations. All important parameters, such as mould protection, compression speed, travel points, and many other functions are visible at a glance. As a protective function for the ICM process, ICM control provides monitoring time settings as well as delay time settings to 1/100 second accuracy.

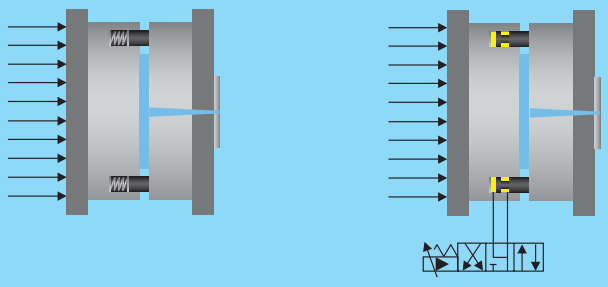
2 Screen page 8: Pre-compression/intermediate opening

Programming switches with monitoring and delay time settings are provided for pre-compression and intermediate opening as are various options for their starting events.

3 Screen page 18: Flexible machine sequence

All ICM functions, namely, compression, pre-compression and/or intermediate opening, and all associated movements are fully tied into the familiar presentation of machine sequences. Thus, the operator has the complete process sequences displayed on one page.

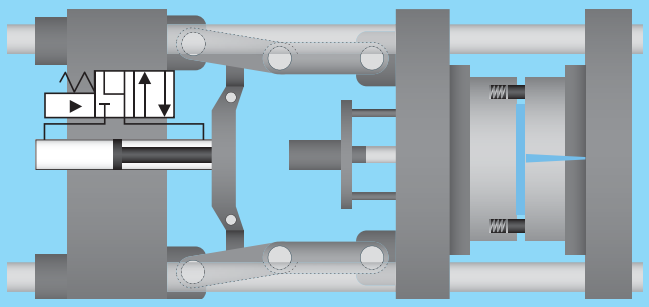
Stamping frame control via spring pre-stressing or core pull control



Spring pre-stressing
+ Simple and low-cost system
+ Small mould height
– Pre-stressing force variable only by changing springs
– Force line is non-linear

Core pull control
+ Linear force distribution
+ Pre-stressing force variable
+ Constant force distribution
– Higher costs

Carriage fixing via locking circuit



+ Hydromechanical locking of compression gap
+ Stepped clamping force possible
+ Carriage fixing also with injection pressure increasing

– Only possible on toggle machines
– Additional hydraulic power pack required

Merits and demerits of clamping principles in injection compression moulding have to be taken into account in selecting an injection moulding machine

Full hydraulic injection moulding machine			Toggle injection moulding machine	
+/0	Two/three-platen configuration	**Design**	Three-platen configuration	0
+/0	Small/medium	**Space requirements**	Medium	0
+	Hydraulic	**Clamping principle**	Hydromechanical	++
++	100 % of clamping force	**Compression force**	Abt. 50 % of clamping force	–
+	Exact, but no mechanical advantage	**Compression gap positioning**	Extremely accurate due to mechanical advantage of toggle	++
0	Difficult, mainly when operating with small compression gaps	**Control of ICM stroke**	Good control also for small compression gaps	++
+	Hydromechanical	**Force transmission**	Mechanical	++
0	Hydraulic	**Carriage locking**	Hydromechanical	+
–	None	**Clamping force reserve**	10 – 15 %	++

++ most advantageous + advantageous 0 indifferent – disadvantageous

Full hydraulic and toggle

By relying on the clamping unit of injection moulding machines ICM offers the advantage of a substantially higher force reserve compared to stamping plugs in the mould. In contrast to hydraulic two-platen machines, toggle clamp units transmit the force uniformly and centrally into the mould with – in contrast to widely held prejudices – a clearly sufficient compression force. The toggle has proved advantageous especially in filling asymmetrically arranged cavities or cavities with long-flow paths. The special kinematics of the toggle provide extremely accurate mould movements near the locking range and, consequently, permit highly accurate positioning for small compression gaps and efficient management of the ICM processes. The simultaneous variant of ICM control on Demag machines incorporates two interesting special functions: **carriage fixing via locking circuit** enables the crosshead of the toggle to be arrested, and the **stamping frame acting via the core** pull control can be operated by means of a hydraulic cylinder in order to obtain variable settings of a defined back pressure.

ICM control retrofits

ICM control is not limited to new machines. All existing Demag machines with an NC4 controller (DIAS or C-DIAS-CPU) can be retrofitted with the sequential ICM control. Retrofitting the extended ICM control on hydraulic machines mostly also calls for a hydraulic system retrofit.

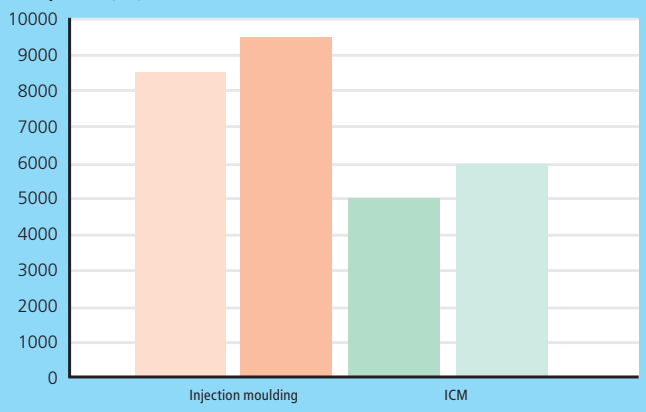
APPLICATIONS

IMD parts

Mechanically loaded LFT parts

▲ IMD parts ▼ Thin-walled packaging articles

Clamp force reduction when moulding PP by ICM process



Flow behaviour	easy	poor	easy	poor
Type of process	Injection moulding		ICM	
Compression rate (%)	-	-	99	99
Clamp force (kN)	8,500	9,500	5,000	6,000

ICM in practice

The number of ICM applications is increasing – for IMD-decorated parts, for mechanically loaded plastic elements in automobile building, for very thin-walled packaging articles, for optical and foamed parts as well as for moulded parts with a finely textured surface or for direct back injection for textiles, etc, for decorative components. In the case of many important applications, injection compression moulding provides positive technical or economical benefits.

IMD parts: In the case of in-mould decoration (IMD), ICM reduces film stresses during filling and creasing in the border areas of the moulded part because it permits the film to smooth out at critical points. ICM also improves surface appearance.

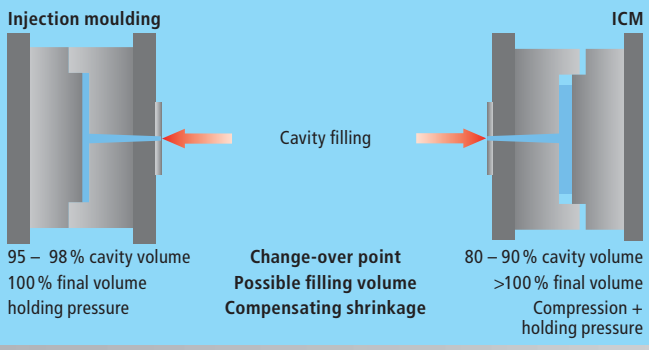
Mechanically loaded LFT parts: ICM reduces fibre degradation during injection and reduces the susceptibility of the moulded part to warping. In addition it improves mechanical properties, reduces mould wear, and generally shortens cycle time.

Thin-walled packaging products: ICM, when applied to thin-walled packaging products tends to further reduce the necessary injection pressure and minimal wall thicknesses and, consequently, to further increase the possible flow-distance/wall-thickness ratios. ICM improves venting of the mould and, in the case of inmould labelling (IML), reduces the stressing of labels and inserts. Overlapping of clamping and injection movements is apt to further reduce cycle time in the case of fast-cycling injection moulding.

Optical moulded parts: Faster injection into the open mould, the possibility of over-packing – in order to control shrinkage right from the start – as well as the very uniform and long-action holding pressure in injection compression moulding combine to reduce internal stresses in the moulded part, and improve its optical properties and light defraction.

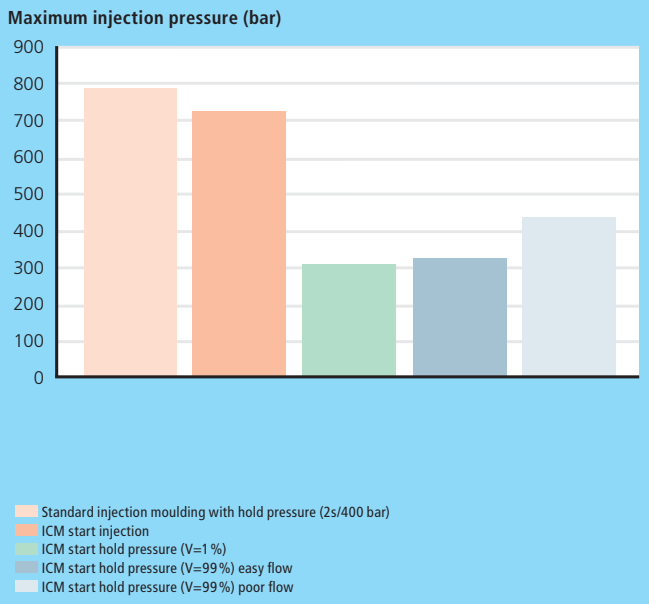
Direct back-injected parts: The reduction in injection pressure reduces stresses in films or mats in direct backing injection and reduces the problem of creasing. Due to the lower clamping force required, it is possible to mould larger components on a wide-platen machine. Generally, ICM offers greater freedom to the designer when applied to backing injection decoration. ICM control permits preforming of

Advantage of process through overpacking

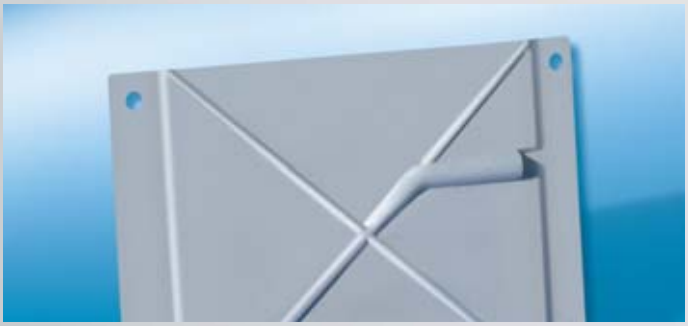


Optical moulded parts

Injection pressure reduction through ICM applied to direct backing injection



▲ Decorative backing-injected parts ▼ Foamed moulded parts



the decorative materials by means of a preceding compression stroke.

Finely textured surfaces: ICM moulding ensures exact and uniform duplication of micro-textures on the moulded part surface – especially at the end of the flow path. It facilitates combining different textures and improves the degree of reproduction.

Foamed parts: Intermediate opening prevents premature foaming of the melt, where chemical blowing agents have been added or mechanical blowing has been applied. The more homogenous pressure conditions in the mould and the more uniform holding pressure have an influence on the cell structure and improve venting as well as surface quality.

Finely textured surfaces

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The responsibility to ensure that everything runs smoothly

Many moulders today operate three shifts, some on 365 days of the year – this calls for a maximum of availability of the machines, spare parts, and service support.
Backed by highly skilled service teams, advanced spare parts logistics, and multiple service levels to address a customer's specific needs, we provide total support world-wide: from straightforward inspections through comprehensive maintenance, and extended warranties for high capacity utilisation levels to emergency hotline support, and training of your personnel.
Full documentation and a digital catalogue ensure that spare parts are delivered to you in a minimum of time, usually within a few hours. Users of older machines can have them upgraded by our retrofit service at fair prices, for instance, by state-of-the-art control software or for specialised injection-moulding processes. In short, the Demag Service provides you with whatever support you need to complete your jobs efficiently and to schedule.

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