ENGEL

GASMELT

ING. HARALD EBENHOFER

TECHNICAL INFORMATION

GASMELT - Special innovative process in injection moulding technology

With the Gasmelt process, Engel has in recent years further developed the internal gas pressure technology for the purposeful creation of cavities in injection moulding parts through gas injection.

The foremost priorities of the development lay

- in the optimisation of the process,
- creation and testing of user-specific process variants,
- in the construction of powerful units with user-friendly control concepts and extensive auxiliary equipment.

With this, customers today can rely on Engel's extensive process know-how and tried-and-tested solutions for the realisation of new product ideas. This is especially important since the formation of cavities and wall-thickness through reference to practical know-how for similar cases of application can only be estimated, and later influence through process management is only possible within tight limits. The choice of material has a greater influence on the formation of wall-thickness than does the process management.

Above all, by the design of moulded components and tools, as well as by the choice of the best process variants, the attainable surface quality must be especially taken into consideration.

Surface defects can occur through

- Jetting as a result of injection onto thick-walled sections,
- Melt stoppage when switching over from melt injection to gas injection,
- Remaining material accumulations due to insufficient cavity formation,
- Drifting of gas bubbles in thin-walled areas as a result of volume shrinkage of the plastic melt during cooling ("Finger effect").

For the user, the successful usage of the Gasmelt technology results in the following interesting advantages:

- Minimisation of sink marks and warpage through even gas-pressure distribution throughout the cavity,
- Reduction of mould clamping force at the production of large-surface injection moulding parts with mounted gas-duct distributor ribs, e.g. door side pockets in private motor vehicles,
- Shortened cooling time since during the holding pressure phase no further hot melt is pushed in and contraction of the moulded part away from the mould wall is prevented by the active gas pressure,
- Saving of mould costs through constructive simplification of moulded parts,
- Simplification of manufacture through the substitution of multi-part modules and the formation of functional cavities.

Furthermore, there are many thick-walled moulded parts or moulded parts with material accumulations that, due to qualitative or economical reasons, cannot be produced with conventional injection moulding technology.

Figure 1: *Private motor vehicle - Side protection strip*

Figure 2: *Handle for glass cabinet*

1. Special solutions

The continually increasing quality demands and special moulded part designs have lead to the development of process-specific special solutions. The choice of the best process variant for the respective application is part-specific and is dependent upon the respective specific requirement profile.

1.1 Blow-up process

The blow out method is known as the standard gas pressure system technology.The cavity is partly filled with a defined amount of melt and then the complete mould cavity is filled out by the subsequent injection of gas with a pressure of 30 to 400 bar. After the formation of the cavity the gas pressure takes over the function of the holding pressure.

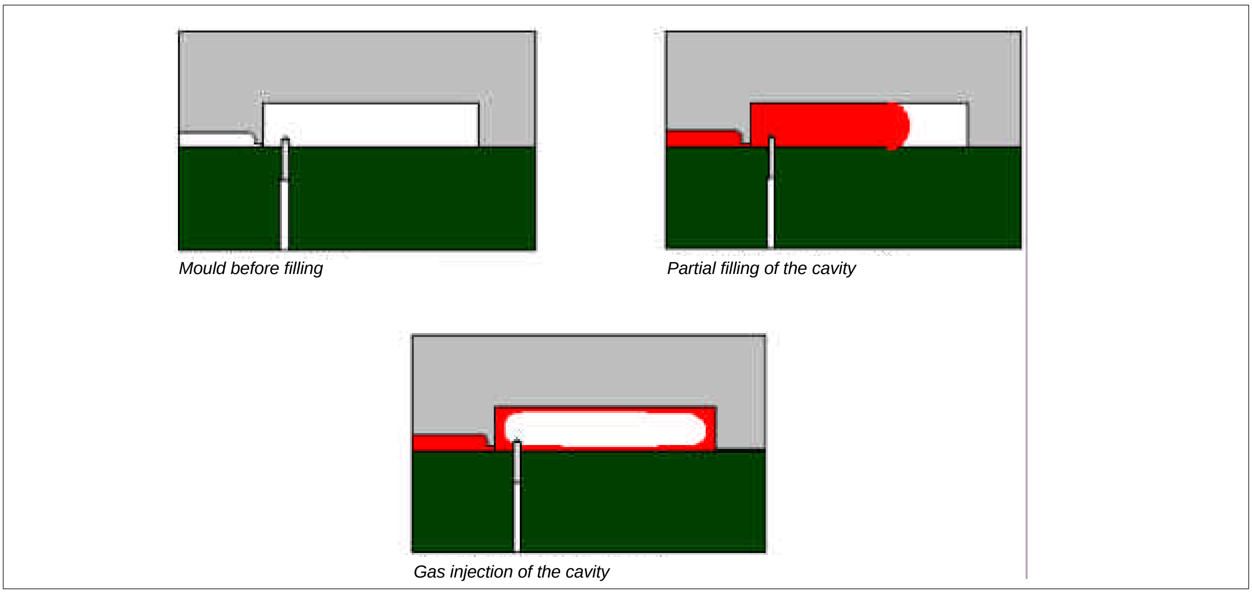

Figure 3: *Scheme blow-up process*

1.2 Blow-out process

The blow-out process is connected with a fundamental change to the course of the process. The cavity, completely filled with melt, is impinged upon at the end of the flow run with nitrogen. With this, the melt is displaced from the area of the core into the screw antechamber or into an overflow (adjacent cavity). Surface defects, that can otherwise occur with critical materials and colorants, or with highly polished mould inserts during the switch-over period between melt and gas injection, can be prevented with this procedure variant. A possibility of influencing the formation of the wall-thickness is provided via delayed blowing out.

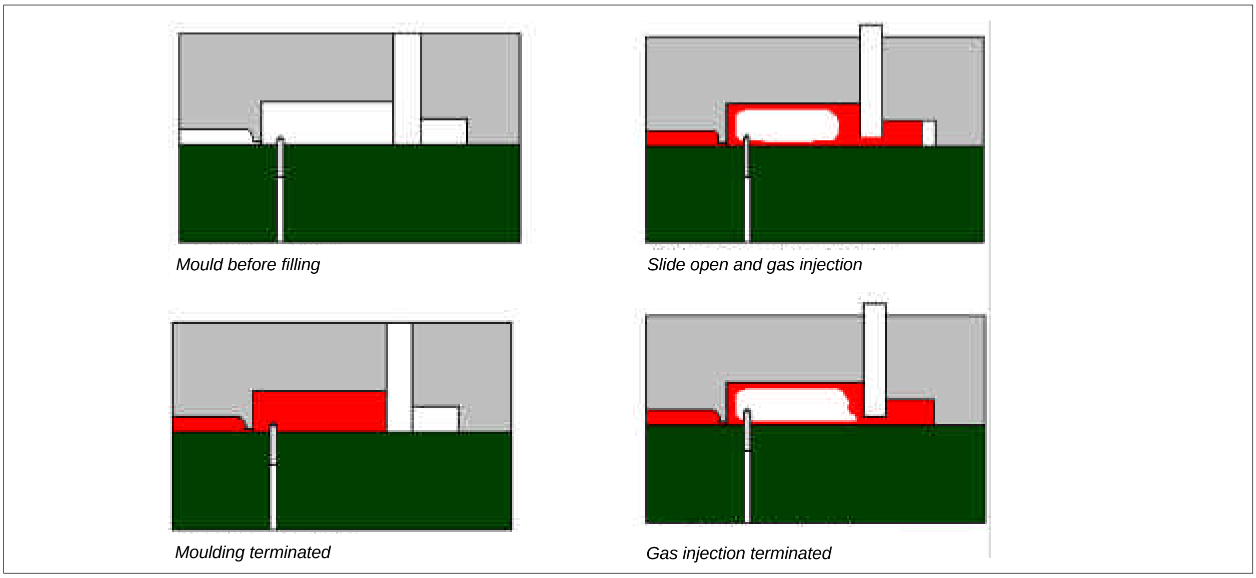

Figure 4: *Diagram Blowing out procedure*

1.3 Gate sealing

With a special gate sealing program the otherwise existent hole at the point of injection can be closed. This program can only be used in combination with the Gasmelt machine nozzle developed by **ENGEL.**

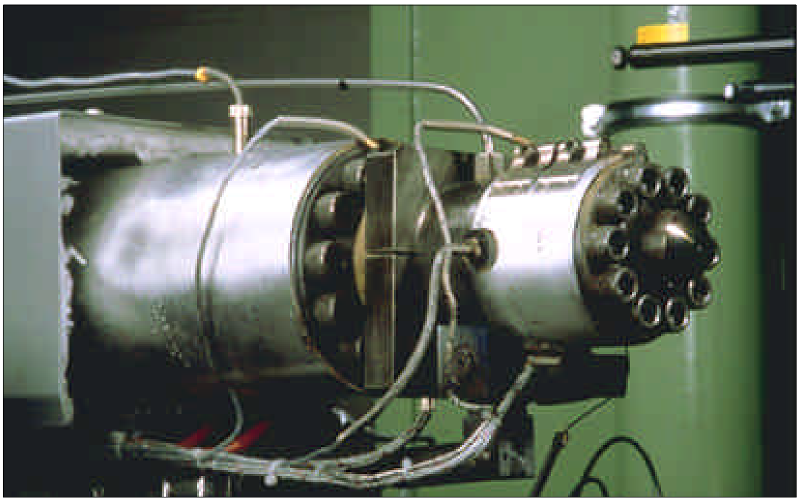

Figure 5: *Gasmelt machine nozzle*

1.4 Gasmelt technology with adjustable cavity volume

With flat moulded parts with partial thickenings above all, the flow pattern must be matched with the required cavity formation when injecting onto thin-walled areas, as well as with the existing amount of melt at the moment of gas injection when injecting onto thick-walled areas. With more complex moulded parts this is not resolvable, even with the assistance of flow analysis programs. With the injection onto thick-walled areas and successful partial filling of the cavity, the melt can often no longer be displaced by gas injection and by the existing gas pressures of up to 400 bar into the thin-walled areas that have large flow path/wall thickness ratios. Furthermore, the gas pressure acting on thick-walled areas often delivers no insufficient holding pressure for the thin-walled areas. For such cases, the first step is to fill the cavity volumetrically or to compress the melt to a given pressure level (Figure 3). Subsequently, one enlarges the cavity volume in the desired area immediately or after the expiry of a delay time to achieve the intended cavity formation. The mould elements are thereby moved forcibly backwards or pressed backwards by the gas pressure. The gas injection takes place directly onto the desired position via a Gasmelt mould nozzle.

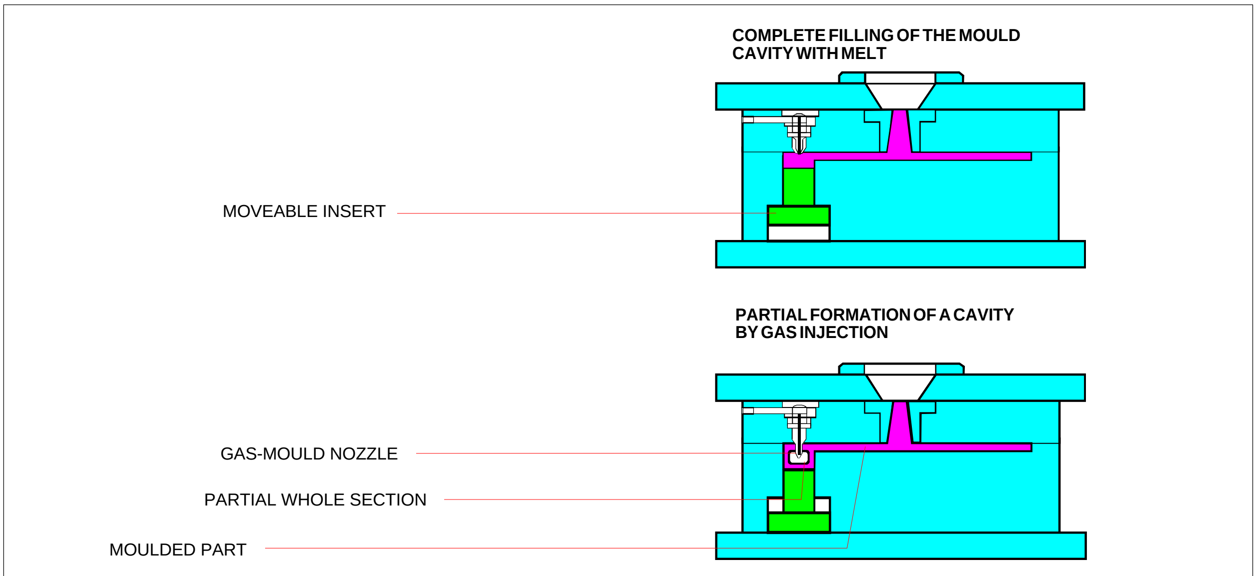

Figure 6: *Diagram Adjustable cavity volumes*

1.5 Multiple gas injection and gas injection for multicavity tools

The gas can also be blown in at several points in the mould. This allows the purposeful creation of cavities there where they are actually required. This has the advantage that ribs, which are used exclusively to transport the gas and are not required for the functioning of the part, can be dispensed with.On large mouldings like bumper bars one can use various gas pressure units to realize independent gas profiles both at different times and different places at the tool. This can also be of advantage if independent gas pressure profiles on multicavity tools should be used.

2. Gasmelt units

ENGEL offers the correct Gasmelt unit for every application case. Series in different designs and sizes are available.

- single station units
- single station units in compact execution
- central units

The technical concept, design and user comfort of these systems has been finely tuned to Engel's modern machine programme. Over 200 Gasmelt units are already in use worldwide.

2.1 Gasmelt compact units

The gasmelt compact units are in two sizes available. They are built for smaller nitrogen volumes and for parallel movements on maximum two machines.The concept of compact units is very similar to the concept of central units.

On the smaller sized units the gas pressure unit however is not a separate unit but integrated in the compact unit and can therefore only be used as a single station unit. On the larger sized units all above applies but one can also integrate external gas pressure control units.

The basic, most cost-effective version of the unit is already equipped with a control unit for the compressor system as well as with a small control unit for the integrated gas pressure controller unit.

Also included in the basic version is an interface to the **ENGEL** machine control unit for actuating the gas pressure control unit in the system.

Excluding the execution with external gas pressure control units. In this case only the control unit for the pressure intensifier is integrated.

This model, with integrated small control unit and gas pressure control unit interface, enables the user of the unit to be able to switch the operating mode to internal as well as external.

A very big degree of flexibility for the user is provided with this system design since in external mode he can utilise the advantages of the software integrated in the Engel machine control system for the gas pressure control unit, and can also, in internal mode, use the Gasmelt unit in combination with any type of injection moulding machine without any big expenditure. For toolmakers which use the gasmelt unit only to test run newly developed moulds we have in the basic small version the gas reclaim station not integrated in order to achieve an attractive price.

This gas reclaim station can be bought optional however.

On the larger gasmelt compact unit the gas reclaim station is standard and a second gas pressure control circuit can be obtained additionally.

Figure 7: Gasmelt compact unit „Expert“

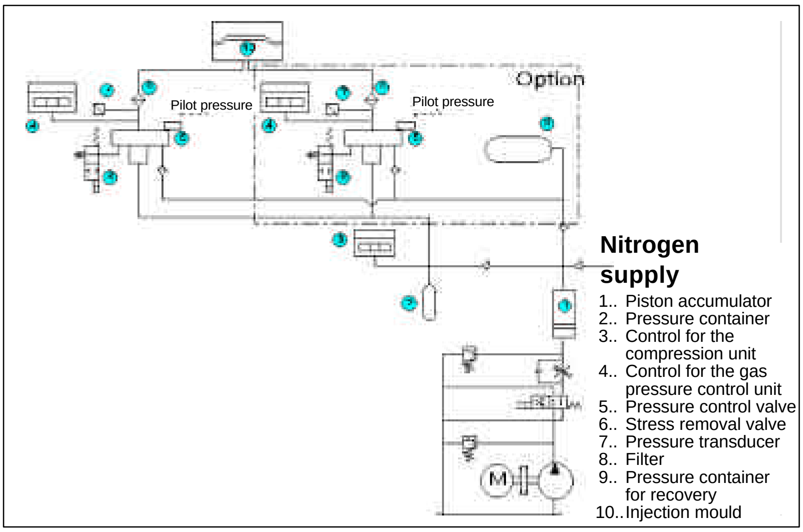

Figure 8: *Scheme Gasmelt compact unit „Expert“*

2.2 Single station units

Since many years we have our reliable gasmelt high pressure units in two sizes with a gas pressure of up to 400 bar in use.

This unit, with control system in a mobile control cabinet is recommended:

- for starting up in this process technology,
- for simple retro-fitting on existing machines,
- for flexible use on different machines.

When purchasing a new machine, the control system for this unit can also be completely integrated into the machine control system. With this solution, the optimised setting data for the Gasmelt unit can be stored on a diskette together with the machine values. Through this integration however, the flexible use of the unit is no longer given.

In the single units the advant-ages of the pressure intensifier principle are used:

- Less nitrogen and energy consumption through the use of multi-stage gas reclamation, patented by Engel,
- Control of the injected gas volume by cushion monitoring by means of stroke measurement on the pressure intensifier piston,
- Rapid regulation of rising and falling gas pressure profiles via servo valve hydraulics.
- Console and connections for 2 nitrogen bottles.

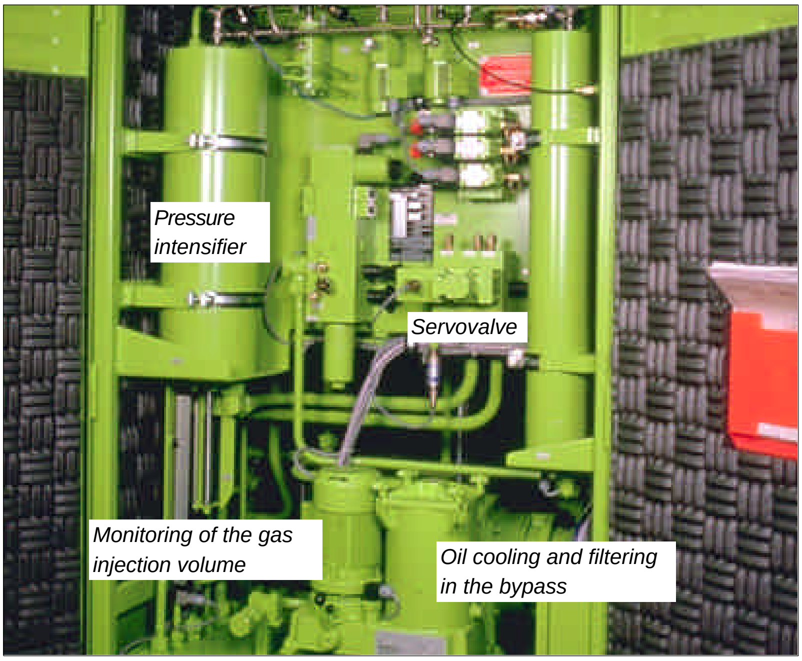

***Figure 9:** Look into a single Gasmelt high-pressure unit*

2.2.1 Functioning principle

The nitrogen supply of the units takes place via customary gas bottles 1, bottle bundle, liquid nitrogen tanks or production of nitrogen units. Via the piston-type accumulator 2, the gas in the pressure intensifier 3 is compressed to a predeterminable prestress pressure. Thus an emptying of the gas bottles to 15 bar is possible. The gas injection is started on reaching a given screw position on the injection moulding machine. With a brief overlapping of the melt filling and gas injection phase, melt standstills and thus surface defects on moulded parts can largely be avoided. The given gas pressure profile is regulated via the servo valve 4 and the gas pressure sensor 5. Thus gas pressure changes that would otherwise occur e.g. as a result of increases in gas temperature through heat absorption from the melt are eliminated. A stroke measurement system on the pressure intensifier enables, similar to the cushion monitoring on the injection moulding machine, a monitoring of the injected gas volume. Thus gas losses occurring during the course of production as a result of breakthrough at the flow front of the melt or leakage in the feed or in the nozzle system are recognised immediately and error messages in plain language are output on the control unit. After the expiry of the gas holding pressure time a gas feedback results via a built-in filter 6 into the pressure intensifier and piston-type accumulator. Only about 10 - 15% of the nitrogen get lost through the relief to ambient pressure. With the gas reclamation principle patented by Engel thus considerable savings in the cost of nitrogen are possible.

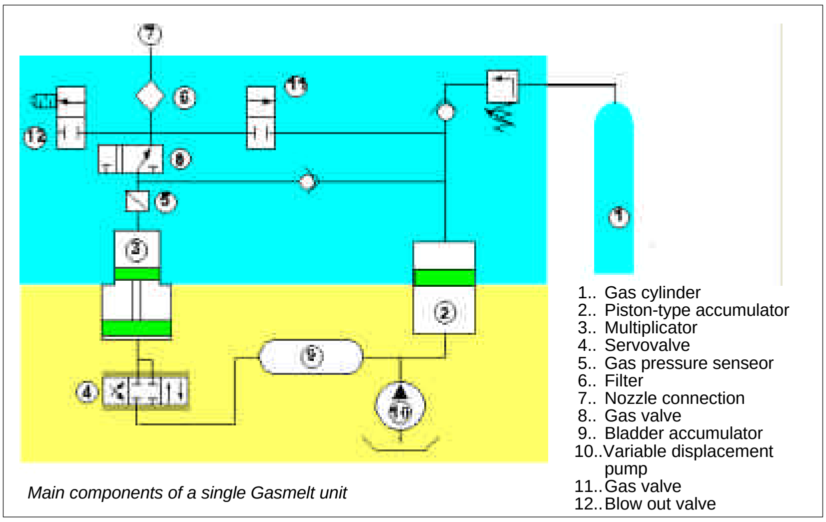

***Figure 10:** Scheme single Gasmelt high-pressure unit*

2.3 Central units

In recent years, in order to supply several injection moulding machines with nitrogen high pressure from one compressor station, **ENGEL** has developed powerful Gasmelt central units.

The features of the central unit are:

- Central compressor station with hydraulically driven piston compressor and pressure intensifier
- High-pressure container for nitrogen extraction
- Own EC 100 S-GM control system integrated in the compressor unit
- Effective gas pressure up to 400 bar
- Connection with the gas pressure control units via high-pressure pipes, low-pressure pipes for nitrogen reclamation
- One-stage nitrogen reclamation in pressure accumulator
- Supervision of the whole system via our own control unit.

Figure 11: *Gasmelt high-pressure central unit*

2.3.1 Function principle

With this type of system two separate connections are provided for the supply of nitrogen, either from the bottle or from a liquid nitrogen tank system. The minimum incoming pressure however must not fall below 25 bar at either connection. If this is the case, the incoming pressure monitoring will cause the system to switch itself off.

If the integrated controller EC 100 S-GM is set to a charge pressure set value and the supply to the system is via nitrogen bottles, then during the first sequence the stop valve 7 opens and prefills the pressure container 3. If the desired charge pressure is reached due to the prevailing pressure in the bottle, then the stop valve 7 closes again. If the bottle pressure is insufficient for reaching the charge pressure set value, then both the piston-type accumulator 1 and the pressure intensifier 2 compress the charge alternately until the charge pressure is reached.

As long as the piston-type accumulator 1 is in operation, the gas cooler 6 integrated into the pressure pipe is also active in order to increase the endurance of the seals in the pressure intensifier 2.

During the load cycle, primarily nitrogen is extracted from the reclamation container 4. If the pressure in the reclamation container 4 falls under 25 bar, then the remaining amount necessary for the load procedure is fed from the bottles by opening the valve 7.

Gasmelt Central systems may be optionally equipped with an emergency supply which guarantees the pressure supply of the gas pressure control units to the injection moulding machine in case of an possible breakdown in the system. The emergency supply is a purely electrical function which is independent of the Gasmelt control system EC 100 S-GM. Via a manually actuated toggle switch, the stop valve 7, which is mounted on a separate bottle connection for the emergency supply of nitrogen, and the relief valve 8 are activated.

Merely the pressure in the bottle can be utilised with the use of this function, which however in most cases is sufficient for repairing the cause of the breakdown on the Gasmelt unit.

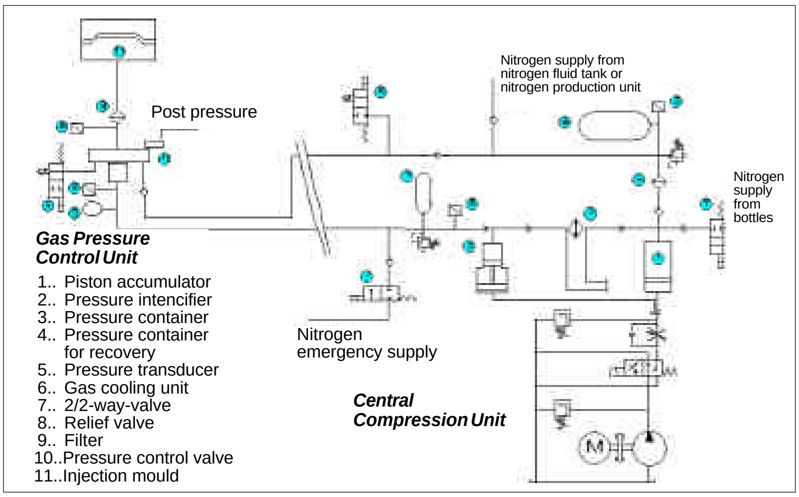

Figure 12: *Scheme Gasmelt high-pressure central unit*

2.4 Gas pressure control unit

The name „Gas pressure control unit" is to be interpreted as meaning separate control modules, which, in combination with Gasmelt central units, are mounted directly onto the injection moulding machine. On the gasmelt compact units the gas pressure control units are integrated into the pressure intensifier units.

The main component of the gas pressure control unit is a proportional gas pressure valve 1 with pneumatic pilot control stage (up to 8 bar compressed air required). It is mounted on the injection moulding machine as a separate module and supplied with highly compressed nitrogen from the Gasmelt central unit. The software necessary for the control of gas pressure is integrated into the machine control system. Regulation of the set pressure stages takes place with the help of the pressure transducer 3 via a PI-current regulator module, input pressure monitoring is guaranteed via a separate pressure transducer. The linearisation program of the machine control system automatically determines and stores the characteristic valve curve. The valve is protected from soiling by plastic particles during reclamation by a filter 10. The reduction of the gas pressure to ambient pressure takes place on completion of nitrogen reclamation, in the reclamation container of the Gasmelt central unit via the relief valve 8.

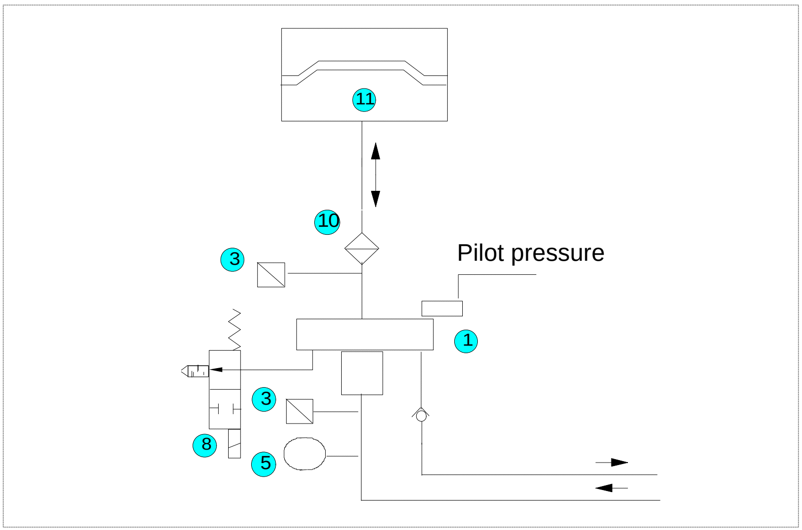

Figure 13: *Main components of a gas-pressure controller unit*

3. Patent situation

The patent situation has calmed down lately quite considerably. This applies mainly for the blow out of plastic into an adjoining cavity. An old Japanese patent from Asahi Dow of 1975 was found in which the blow out method into an adjoining lockable cavity was demanded. Therefore the present patent application of Messrs. GAIN/ USA has no real weight anymore. An uncertainly exists still with the export of GID parts into USA because GAIN has existing patents for the BLOW UP method. To avoid a long and expensive lawsuit in USA, ENGEL can offer a licence agreement with Messrs. Gain.

The licensee pays a single fee of U$ 35.000,00 patent costs to Gain USA for every machine unit. He is than entitled to use all patents of GAIN.

Further there is the patent of CINPRESS LTD. for the blow up method. By this method a precisely defined amount of nitrogen is pressed via a pistonsystem with a given speed profile into the tool. ENGEL can offer for this system a licence agreement with CINPRESS LTD. which includes all other patent rights for a single fee of DEM 15.000,00 per unit. When exclusively one pressure profile is used as in combination with either ENGEL compact units or central units via gas pressure control units from ENGEL than no breech of the process patent occurs.

4. Gasmelt - Summary of units

Single units

Machine Designation	EGM HD 230/330***	EGM HD 300/330	EGM HD 500/400
	Compact	Compact	Compact
Gas volume *	230 cm³	300 cm³	500 cm³
Max. gas pressure	330 bar	330 bar	400 bar
Max. preload pressure	-	-	-
Cycle-time for reloading	60 sec	60 sec	60 sec
max. N2-recovery	85%	85%	85%
Pressure mulitplier	-	-	0,8 lt
Piston-type accumulator	1,5 lt	2,5 lt	5 lt
Pressure container	2,5 lt	2,5 lt	5 lt
Recovery container	10 lt	10 lt	24 lt
reqd. N2-input pressure	30 bar	30 bar	25 bar
Drive power	2,2 kW	5,5 kW	7,5 kW
Oil contents	30 lt	40 lt	100 lt
Cooling water requirement	0,6 m³/h	0,6 m³/h	0,8 m³/h
Max. cooling water temp.	20 °C	20 °C	20 °C
Weight**	250 kg	500 kg (550 kg)****	950 kg (1000 kg)***
Length x Width x Height (mm)	800 x 600 x 1700	1550 x 1000 x 1700	1000x1700x1750

Abbreviations: EGM = ENGEL Gasmelt - HD = High Pressure - *at maximum gas pressure - **without oil contents - ***Data valid for compact units with recovery - ****Weight with a second integrated gas pressure control unit

Central units

Machine Designation	EGM HDZ 1200/400	EGM HDZ 3000/400
Gas volume *	1200 cm³	3000 cm³
Max. gas pressure	400 bar	400 bar
Max. preload pressure	200 bar	200 bar
Cycle-time for reloading	50 sec	60 sec
max. N2-recovery	90%	90%
Pressure mulitplier	2,4 lt	6,0 lt
Piston-type accumulator	10,0 lt	20,0 lt
Pressure container	20,0 lt	50,0 lt
Recovery container	24,0 lt	50,0 lt
reqd. N2-input pressure	22 - 25 bar	22 - 25 bar
Drive power	18,5 kW	37 kW
Oil contents	160 lt	400 lt
Cooling water requirement	1,5 m³/h	1,3 m³/h
Max. cooling water temp.	20 °C	20 °C
Weight**	1200 kg	2800 kg
Length x Width x Height (mm)	1850 x 950 x 1750	2000 x 1500 x 2400

Abbreviations: EGM = ENGEL Gasmelt - HD = High Pressure
Z = Central unit - *at maximum gas pressure - **without oil contents

Extraction units

Nitrogen extraction unit	EGM N 12	EGM N 18	EGM N 24
Trough put***	12 Nm³/h	18 Nm³/h	24 Nm³/h
Max. supply pressure	30 bar	30 bar	30 bar
Purity of nitrogen	98%	98%	98%
Volume buffer-container	50 ltr.	50 ltr.	100 ltr.
reqd. Air input pressure	6 - 7 bar	6 - 7 bar	6 - 7 bar
reqd. amount of air	44 Nm³/h	64 Nm³/h	84 Nm³/h
Drive power	2,2 kW	2,2 kW	5,5 kW
Weight	700 kg	750 kg	800 kg
Length x Wigth x Height (mm)	1900 x 900 x 2000	1900 x 900 x 2000	1900 x 900 x 2000

Abbreviations: EGM = ENGEL Gasmelt - N = Nitrogen extraction unit
***Trough put at maximum supply pressure