ENGEL

Watermelt

TECHNICAL INFORMATION

WATERMELT

Watermelt:

A New Way for Efficient Production of Thick-Wall Parts

Introduction:

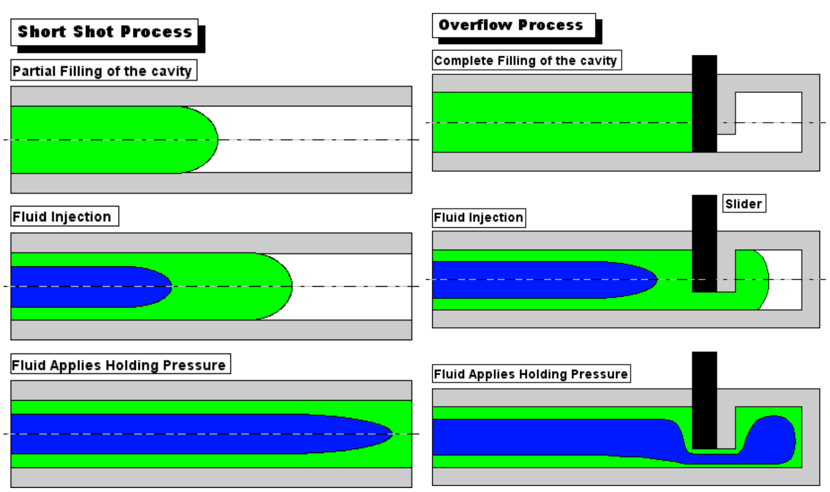
Gas Assist (Gasmelt) established itself as a cost-effective solution to mold thick parts, but the search for a different medium with better cooling properties has never been abandoned. By reinventing the Water Injection Technique, an old idea has been born again for injection molding. The goal of the development was to reduce cycle times for thick rod-shaped part designs. Due to the higher cooling ability of water over gas, cycle times can be shortened molding with Watermelt, when compared to the same parts molded with Gasmelt.

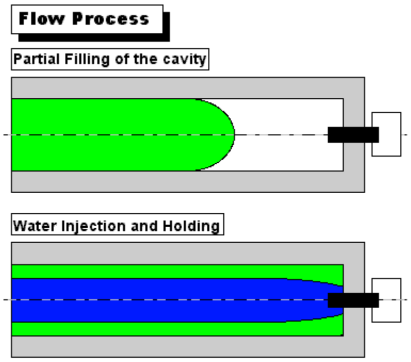
The Advantages

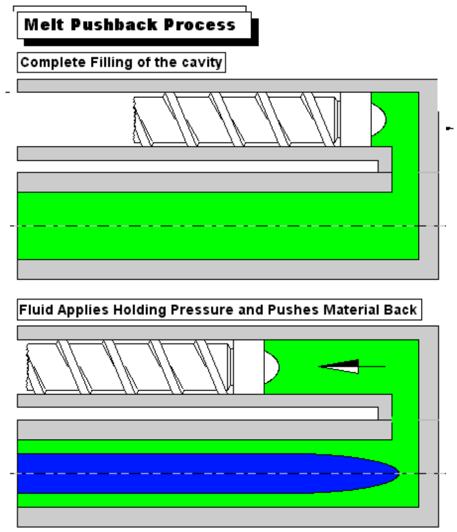
- Cycle time reduction up to 75%
- No nitrogen costs
- Evenly distributed wall thickness
- Less material accumulation remaining in the part
- Less tendency for finger effects in large flat-shaped parts
- No material slugs in long hollow channels
- Less tendency for surface marks

The Process

There are numerous ways of introducing water into the molded part. Water injection has the same basic process variations as 'Gasmelt', with some special enhancements that can only be achieved with the water injection technique. One of the most common techniques used is the *"Blow Up" ("Short-Shot Process").* Please refer to the process schematic left. Fluid is introduced into the melt to aid in the completion of filling out the part. Holding pressure is applied with the fluid inside the part. The thicker the part, the more heat can be absorbed by the fluid, and the greater the reduction in cooling time. Another variation often used is the "Overflow" process.







The advantage of the “Overflow” process is the ability to manufacture parts with class A surface quality. This is difficult to achieve with the “Short-Shot” process, as the parts often show flow marks. These flow marks are generated when the flow front stops or hesitates after filling and before the water/gas is introduced into the melt. When using the “Overflow” process, the water forces the material to fill a second cavity with the displaced material. If necessary the material can be reground and added to the virgin material as regrind.

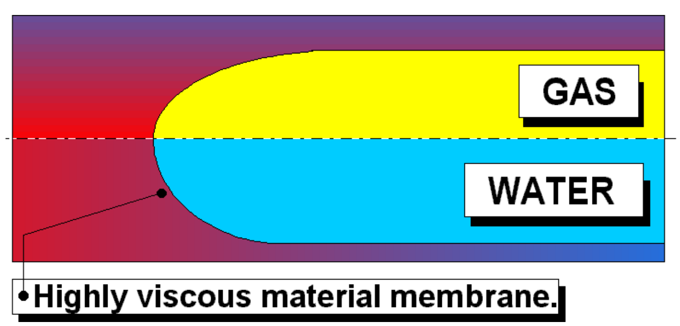
Both the principles of “Overflow” and “Short Shot” can be combined with the water flushing through the part (“*Flow Process”*) for an even greater increase to the cooling effect of the fluid. Using the “Flow Process” the greatest possible cycle time reduction can be achieved. A fourth process variation is described as “*Push Back”*. Using this method, the part will be filled completely before the fluid is introduced. After either a very short or no delay time, the fluid is introduced and pushes the material back into the barrel.

To ensure that no water is left in the part when using any of these four processes, the Watermelt unit switches from water to pressurized air after the hold time, to dry the hollow section in the part created by the fluid. This method works well with polymers being processed, which are demolded at low temperatures. This process step can be omitted, if materials are used which require high mold temperatures. In this case the temperature inside the part might be so high that the water turns into steam and escapes out of the part or forces any remaining water out of the part.

Watermelt vs. Gas Assist

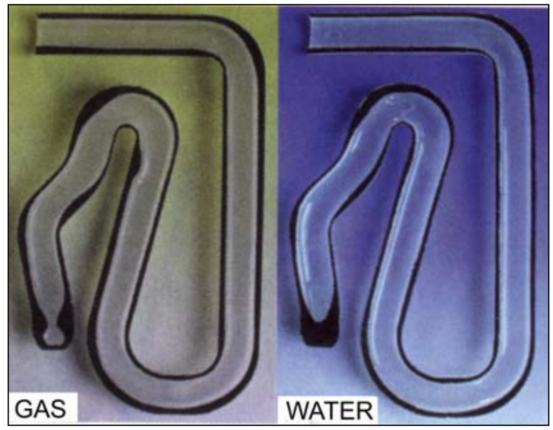
It is a known fact that material viscosities have an impact on residual wall thicknesses. Additionally, due to the different viscosities of gas and water, residual wall-thicknesses are less when using water in comparison to gas.

One theory attributes this smaller residual wall thickness to higher heat transfer through the water inside the part. The water increases the viscosity of the melt at the flow front and forces the melt to move forward instead of being pushed to the side, resulting in a smaller residual wall thickness (Picture 1). Both processes show, that as soon as the fluid (water/gas) passes a section of the part, no more major material movement occurs. The residual wall thickness is also influenced by some process parameters like delay time (between end of filling and fluid introduction). Picture 2 shows the different residual wall thicknesses of two similar parts, molded with two different core materials (gas and water). From the examples shown, it can be seen that after tight bends (sharp 90°, tight 180° bend) there are major differences between Gas Assist and Watermelt.

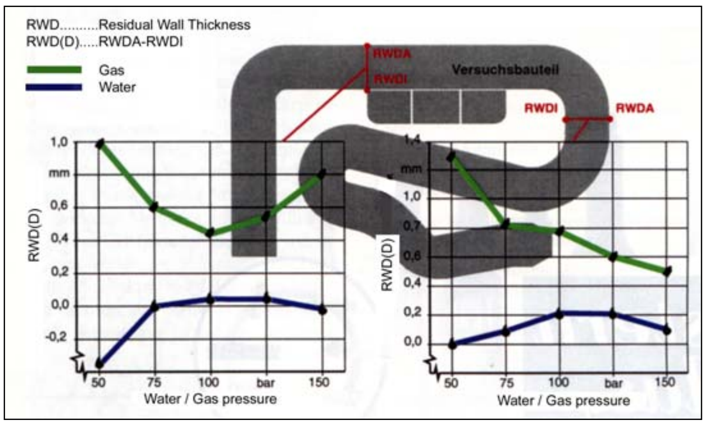


Picture 1: Highly viscous membrane forces the material forward instead of being moved to the side.

As a rule, parts with very tight or sharp bends should not be designed for use with either the watermelt or gasmelt process. Trials have shown that the hollow section in the part is more centrally located when using water as the fluid instead of gas. Graph 1 shows the differences in the inner and outer residual wall thicknesses after and in tight bent sections throughout the part. With the material used, in this case PP, the differences are not that big, but a tendency in the difference between gas and water can be seen. Detailed investigation of the flow characteristics in those bent sections also made clear that water seems to be a lot more influenced by mass inertia than gas. Water shows, under certain process conditions, the tendency to keep the flow direction once taken, on account of mass inertia, whereas gas always tends to flow in the direction of the lowest resistance.



Picture 2: Resulting residual wall thicknesses using gas/water as the fluid.



Graph 1: Comparison of residual wall thicknesses between Gas Assist and Watermelt.

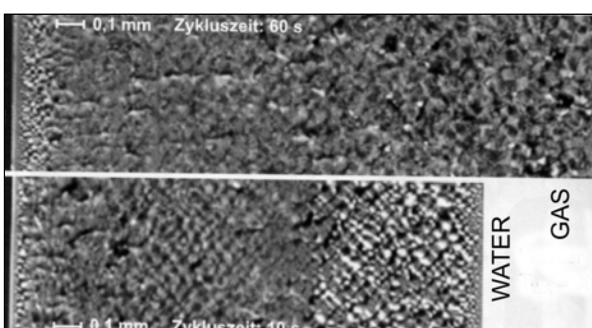
Advantages and Challenges of Watermelt

The biggest advantage of Watermelt is the dramatically reduced cooling times.

According to the formula below for calculating the cooling time, cooling time increases exponentially with

$$t = \frac{s^2}{\pi^2 \cdot a_{eff}} \cdot \ln\left(\frac{4}{\pi} \cdot \frac{T_M - T_W}{T_e - T_W}\right)$$

the wall thickness of the part. By comparing the same wall thickness using Watermelt instead of gas assist would result in only a quarter of the cooling time than that needed for gas assist. The reason for this amazing reduction is, in this case, the heat is carried off by the water inside the part and by the mold surface on the outer side of the part. Therefore, it is possible to calculate the cooling time with the expected residual wall thickness of the part, whereas



Picture 3: Crystalline structure of Gas Assist and Watermelt.

when using gas assist the heat can only be carried off from one side of the part. In this case, it must be calculated with twice the expected residual wall thickness. The other positive effect on this efficient cooling, is a much better crystalline structure (Pict.3, smaller spherulites) in the plastic used because of the faster heat transfer (less time for the spherulites to grow). One potential challenge with the Watermelt process is that if not enough water pressure is applied in the part, there is a possibility of voids forming in thick wall sections. In these areas, the gas tends to foam the plastic. Other potential issues could include leakage during set-up of the mold, as well as the necessity to remove the water in a separate production step if the part is not produced with water recovery.

Fields of Application and Examples

Similar to gas assist, Watermelt can be a solution if warpage, sink marks and high material costs are an issue for the production of these parts. The main target applications for Watermelt are thick walled, rod-shaped parts. Prior to the Watermelt process being utilized, the application should be carefully checked to confirm it's suitability to the process.
The table below is a list of possible applications where the Watermelt process could be beneficial. The following examples give an overview of what has been molded so far with this technology.

Automotive Industry
Handles & Armrests, gas pedals, frontend struts, roof racks, gear levers, wiper arms.

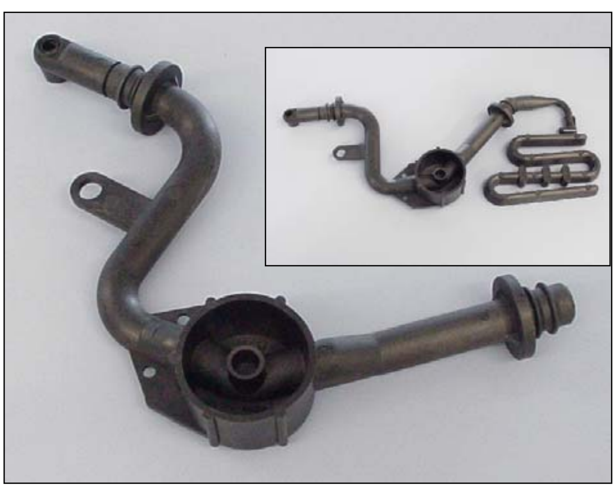
Appliances
Parts for washing machines, dishwashers, handles, continuous floor heaters

Office Furniture
chairlegs, pedestals for office chairs

Computer Equipment
Feed rollers (Printers, copy machines

Sport/Consumer Goods
Hockey sticks, carrying handles for child seats

Medical Products
Hollow needles and dilators



Automotive Cooling Water Pipe

Overflow Process:
Material: Glass Filled Nylon 6.6

Chain Saw Handle

Flow Process:
Material: 30% Glass Filled Nylon
Using the flow process, cycle time was dropped from 61 sec. to 30 sec (a drop of 48%).

Automotive Air Support System

Overflow Process:
Material: Standard Grade PP

Water Unit

For the injection of water, several solutions are available today. The most common technologies are piston injectors, pressure accumulators or hydraulic pumps. Injection via Rams is well known from the Gas Assist Process, but not as easy to transfer to Watermelt. This principle could lead to leakage, wear and costs as well as repeatability issues. Pressure accumulators are well known from water hydraulics and readily available on the market. Downstream control valves can control the water flow rate and the refill of the accumulators from a reservoir

supplied by a precompression pump. It is also possible to use water hydraulic units with compressed air pumps.

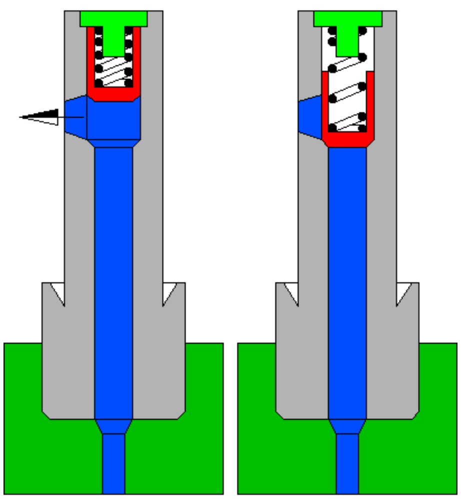
The ENGEL Watermelt unit uses a reciprocating pump, driven by a frequency controlled motor, to inject the water. This set-up enables the volume of water flow to be precisely controlled.

The unit is equipped with a stand-alone control, which can also be directly connected to the machine control via an interface. When connected to the machine control, the complete operation and quality control data of the unit can be set-up and viewed on the machine control screen.

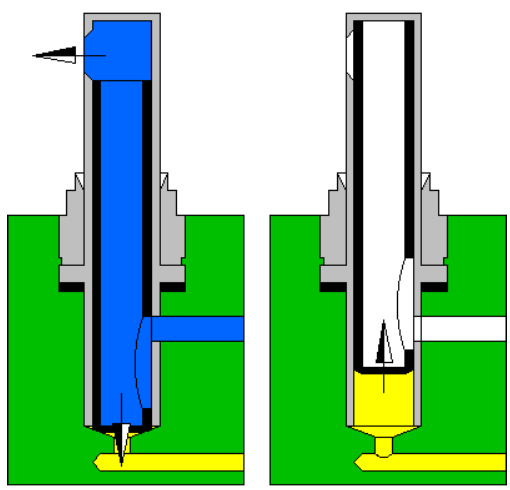
The technical data for the **EWM 30/200** unit is shown in the table right. Further sizes will be available in the near future, to fit the different needs for cost-effective production.

Max. Water Injection Pres.	200 bar / 2900 psi
Max. Water Flow	30 l/min 7.9 gal/min
Min. Water Supply Pres.	4 bar / 58 psi
Cooling Water Supply	10 l/min 2.6 gal/min
Electrical Power	12 kW / 12 kW
Unit Weight (dry)	700 kg / 1543 lbs
Length/Width/Hight	1100/1600/1650 mm 43/63/65 inch

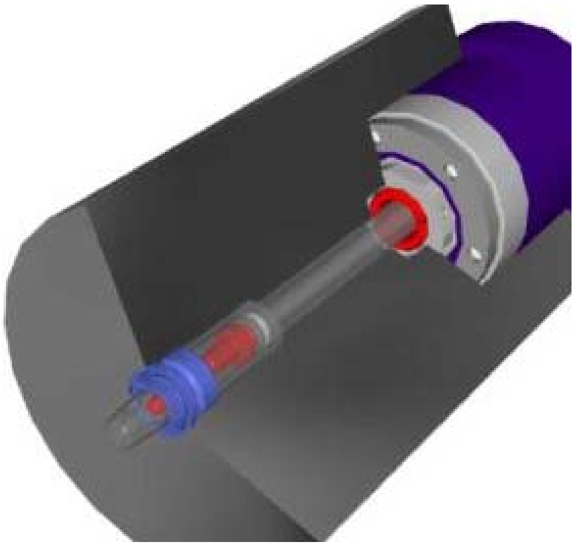
Water Injectors



In-mold mounted injectors can be used to introduce the water into the part. Due to different flow rates, most gas injectors available at this time are not suitable for Watermelt. Some of these existing injectors can be used after slight modifications. There are different types of injectors available, depending on which process variant is used.



If the "blow-up" process is used, and the water will remain in the part during the injection molding process, to be removed in a different production step, the injector type described below can be used. It is a spring loaded type injector, which allows no recovery. The second type of injector can be used with all process variations. Basic function is a forced open by the water and a controlled closing with air. This allows the injector to be activated at any time during the molding process. Schematics above show how this injector type works.



Since high operating air pressures are necessary to actuate these injector types, which is not always available at a production site, focus was spent on developing a hydraulically driven injector. This injector can be run with core pull hydraulics, that can be easily installed on an injection molding machine. Another advantage of this type of injector is the possibility to exchange the injector tip in the cavity without removing the whole injector. This allows fast and easy adjustment to different tip geometries.
Hydraulic systems deliver enough pressure to securely actuate and seal the injector, and are well known as a reliable operating system for shut-off nozzles. The picture left shows this type of injector in a 3D view.

Prospects

The goal of reducing cycle times in injection has existed since the beginning of injection molding. Different approaches were made to achieve this goal. Reducing wall thicknesses using gas assist has been just one of the successful approaches in the past, Watermelt is the next step in reducing cycle times dramatically.
Watermelt can be adapted to already existing gas assist parts, and evenmore to those types of products which are not economically producible with gas assist at the current time. Watermelt as a process is still in a phase of development, and the acceptance of this process is highly dependent on how injection molders accept water as a processing medium. Furthermore, the process is limited to rod shaped designed parts, which in most cases are produced today with gas assist. Actual trials at ENGEL have shown great processing advantages for the Watermelt process and further development will continue to take place.
Engel Canada Inc. will have a Watermelt unit available by summer 2002, which is available for mold tests at the processing lab in Guelph, Ontario. Along with the Watermelt unit, a demonstration mold will be available, which is equipped with changeable inserts, to better adapt to different investigated geometries.

For further information please contact at ENGEL Canada

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