



RTM Light

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The Choice for RTM Light

Achieving a better part performance, a cleaner working environment and reduced styrene exposure and emissions are major challenges for the composites industry. For that reason the need for improved working processes has been a priority for manufacturers for many years, and has resulted in the development of resin systems with low styrene emissions and low styrene content.

RTM Light is one of the processes filling the gap in production volumes between open moulding, like Hand lay up and Spray up (HLU/ SU) and press moulding, like Sheet Moulding Compound (SMC).

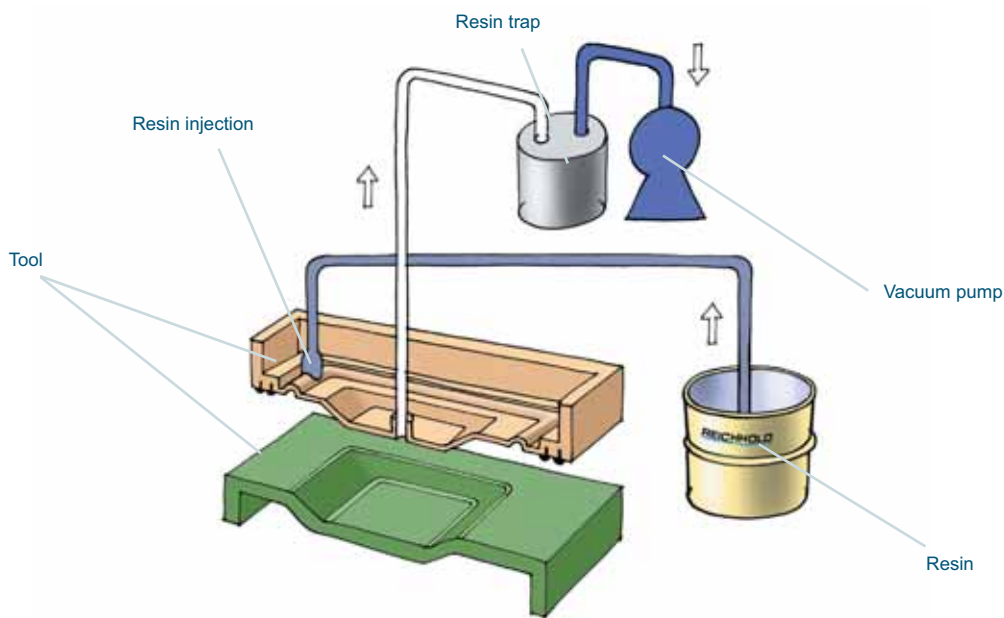


RTM Light is suitable for small production series of composites components of miscellaneous shapes and sizes with low investment outlay.

The Process in Steps

RTM Light moulding processes are widely used in the composites industry for manufacturing high quality components. These processes typically consist of the following steps:

- Preparation of the mould tool (can be with or without a gelcoat)
- Placement of reinforcement and/ or core materials in the tool
- Tool closure
- Resin injection or drawing into the mould
- Saturation of the reinforcements
- Curing
- Demoulding of the finished part



This guide will help to better understand the benefits and limitations of RTM Light processes and allow easier decision making on process parameters and key raw materials.

Benefits of RTM Light

RTM Light, also known as Vacuum Assisted Resin Injection (VARI), uses vacuum to draw resin into the mould, while at the same time the resin can be injected under moderate pressure.

Vacuum may also be used to clamp the two mould halves. The use of moderate pressures typically means that a less heavy male mould can be used compared with Pressure RTM and SMC moulding processes.

Advantages	Details
Considerably reduced styrene emissions	System closed during injection
Capable of producing 2 smooth surfaces	Gelcoat on both sides possible
Medium control part tolerance	Still small tolerances in thickness due to flexible upper mould
Lower labour intensity	No hand labour during injection
Cleaner production	More pleasant work environment (closed mould system)
Improved GRP part properties and part reproducibility compared to Hand lay up and Spray up	Higher content and orientation of reinforcement possible
Reduced cycle times possible	For more complex products, thicker laminates, sandwich constructions and large products
Filled systems can be used	Combination of vacuum and pressure during injection

Points of Attention	Details
Mould and tooling design influence the flow	Good tooling know-how required
Preform and reinforcement alignment is critical	Design limitations (draw angles and radii)
Requires matched leak-proof moulds, higher mould/ tooling costs	Need flexible and tough male mould and rigid female mould compared with the single male mould of Hand lay up and/ or Spray up
Higher reinforcement cost	Typically more sophisticated fabrics and roving/ fabric combinations are used compared to Spray up

Process Overview



The process requires a rigid female mould and a semi-rigid male top mould. The mould closure occurs by applying vacuum aided by simple clamping mechanisms.

After preparation of the mould (with mould release, optional gelcoat), the reinforcements are applied and the mould is closed with a clamping system.



The resin is usually injected at low pressure (max. 1 bar) into a peripheral channel surrounding the part, and vacuum is applied to an exit port near the centre of the part.



The low net closing pressure and low internal mechanical forces enable use of lightweight tools. For that reason it is possible to use tools similar (or adapted from) open moulding tools without significant extra investment.



When the reinforcement package is fully impregnated with resin, the resin feed is cut off. Still under vacuum, the laminate is left to cure.

For larger series runs it is possible to work with several female moulds and one semi-rigid male top mould.

Product Selection Considerations

When selecting and designing the optimised combination of resin and reinforcement, there are two important parameters to consider:

- The end product requirements (mechanical and physical properties)
- The process requirements (desire to optimise manufacturing speed, labour, quality and emissions)

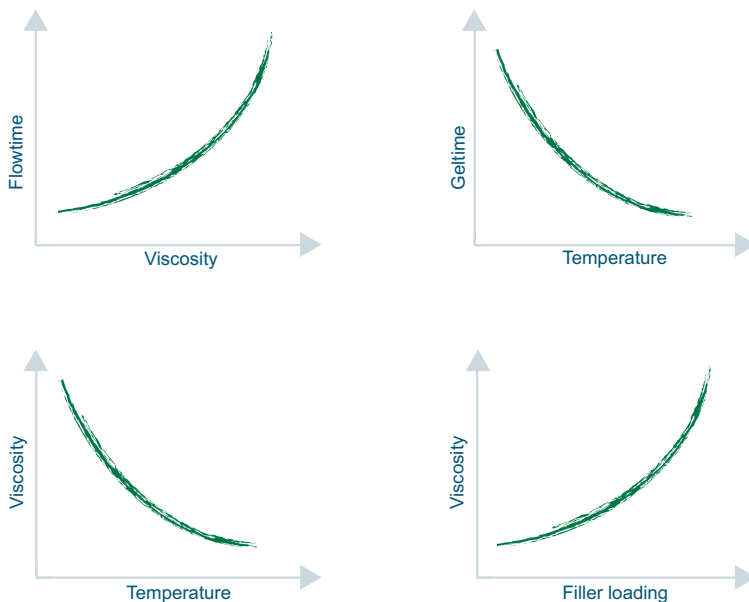
The overall laminate strength and stiffness are determined by the laminate thickness, the combination of reinforcements and obviously by the resin matrix that holds the reinforcements. Further local strengthening and stiffening may be obtained by using tailored fabric/ reinforcement combinations or by the inclusion of ribs.



Resin Selection

Laminate mechanical properties are primarily determined by the reinforcement package. Heat resistance, electrical properties, fire retardant properties, and surface quality etc. are mostly determined by the resin system. Also longer term properties, such as water resistance, weathering resistance, heat ageing, fatigue resistance etc. are primarily influenced by the resin system selected.

Once the reinforcement package has been selected in line with both the end use and process requirements, the base resin system is selected so that desired short term and long term properties can be obtained. A wide range of base resins are available ranging from orthophthalic polyesters to Vinyl Esters covering different end use requirements. Reichhold offers resins for standard applications as well as those aimed at higher heat, chemical resistance and fire retardant behaviour.



Viscosity

For RTM Light a low viscosity is often required to reduce fill times. The optimum viscosity will depend on the reinforcement package and tool design, as these will affect the behaviour of the flow front. A viscosity ranging between 100 – 250 mPa.s. is often quoted as suitable for RTM Light.

Filler particle size and distribution will have an effect on flow performance. Large particles can be filtered out by the glass reinforcement and can also cause rapid settling on storage. Flow, settling and surface finish issues with filled resins can sometimes be improved by the use of the wetting and air release additives.

Reactivity

The curing system of a resin plays an important part in part quality and production optimisation. The geltime should be long enough to ensure complete filling of the mould, with a small safety margin to allow for possible machine stops during injection. Once the mould cavity is filled the resin should ideally cure rapidly to allow shorter cycle times and rapid mould turnaround.

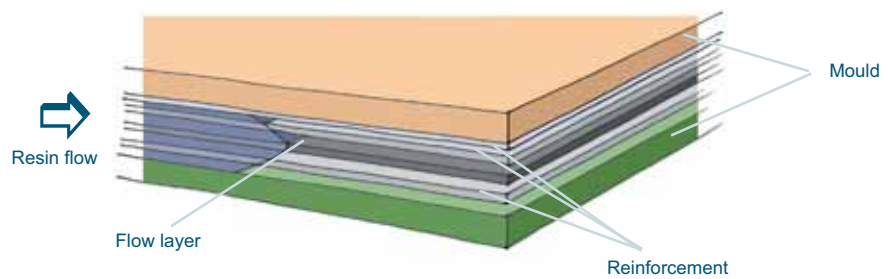
Reichhold offers resin systems meeting a wide variety of process requirements, including optimal flow and impregnation rates, fast cure systems for high production rates and low exotherm systems for parts with improved surface appearance.

Reinforcement Selection

It is recommended to use a reinforcement build-up that provides a combination of good flow and required laminate mechanical properties. If it is required to produce a part with complex design and difficult angles, reinforcements with good drape-ability should be used.

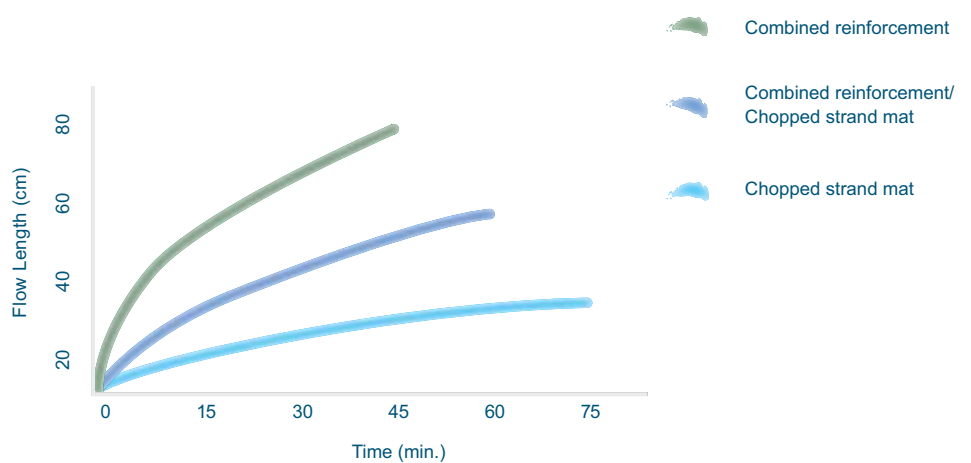
When producing part with vertical surfaces, it may be necessary to attach the glass to the mould to avoid it moving out of position.

Flow through the reinforcement



Different reinforcements can have different flow properties. In general there is an inversely proportional relationship between the flow properties and the mechanical properties. Finding the right balance between the two is often the best solution. For example one or more layers of a mat with good flow properties are placed in the core of the reinforcement package acting as a flow layer, whilst the rest of the reinforcements (e.g. chopped strand mat) will provide mechanical strength.

Flow properties



Dedicated reinforcement products are available for RTM Light processes including types where a flow layer is covered by two layers of standard reinforcement and stitched together.

Reinforcements for Improving Surface Finish

A surface veil, tissue or synthetic felt is sometimes used for improving surface finish. The selected material needs to have good drape-ability and flow in order to avoid air entrapment near the surface. A synthetic surface layer is recommended if a more resin rich surface layer is desired, or when parts without a gelcoat will be exposed to harsh environments.

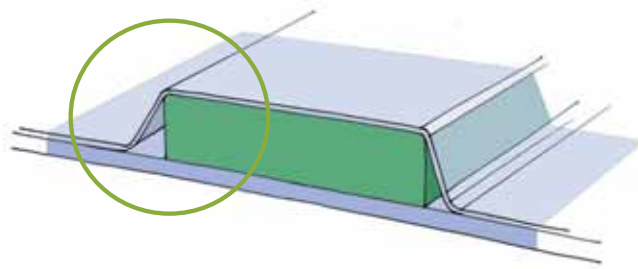
Core Materials

Inserts and cores can be placed in the mould prior to injection. Care must be taken in the design to ensure accurate positioning and to ensure even part thickness on both sides of the core.

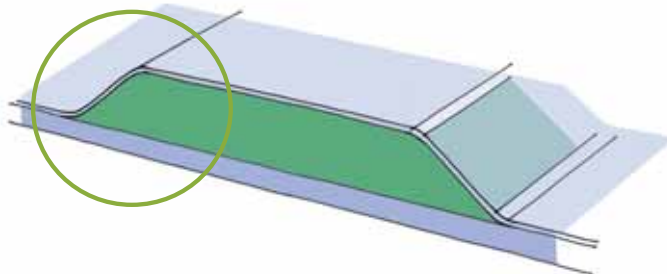
A good bond is required between resin and insert (chemical or mechanical), and this may require pre-treatment, perforation or resin coating of the insert.

Core materials should have tapered ends/ edges to avoid the sharp transition between the sandwich and single skin laminate. This sharp transition often results in resin rich areas which can lead to excess shrinkage and high peak exotherms.

Incorrect radius



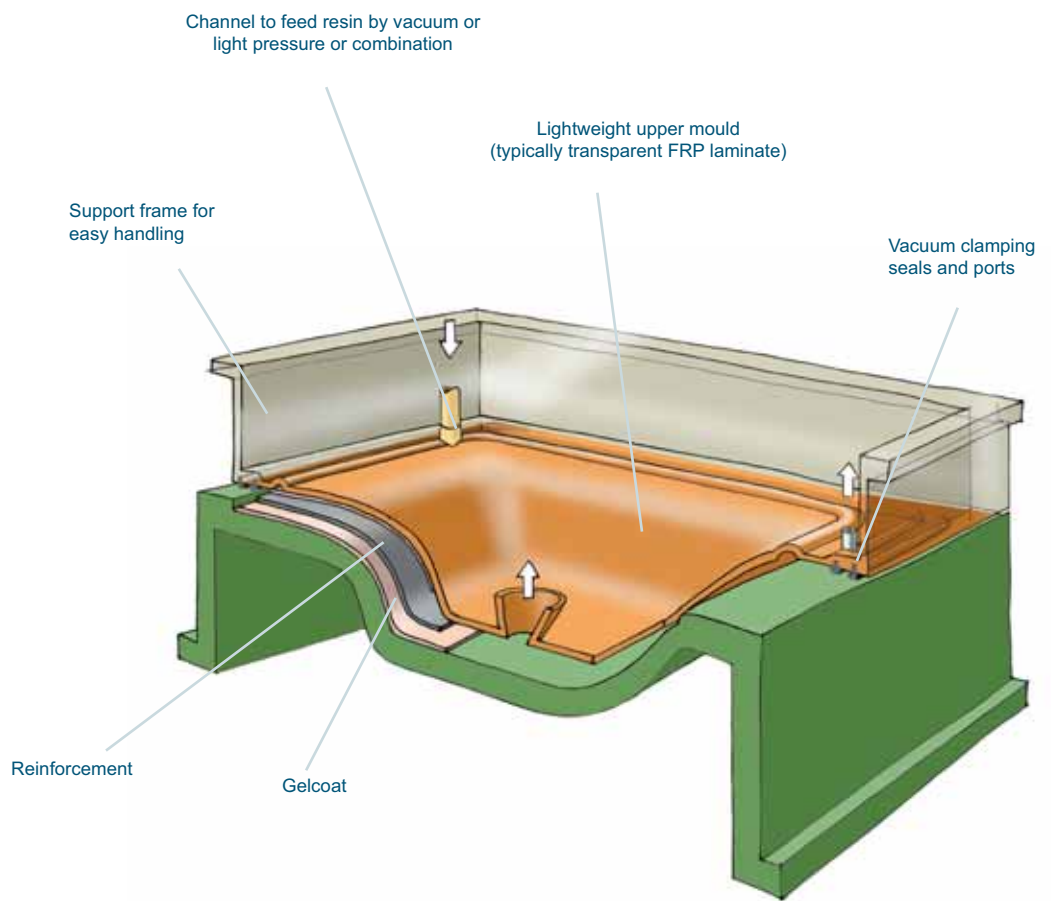
Correct radius



In many cases it is required to drill/ nail holes in the core to ensure the resin flows with the same speed on both sides of the sandwich core.

The temperature in the laminate can be relatively high during cure. Therefore the heat resistance of the core material must be high enough to avoid collapse of the core during cure.

Mould Setup



The RTM Light method is typically considered cost effective for production of 50-1500 parts per tool per year.

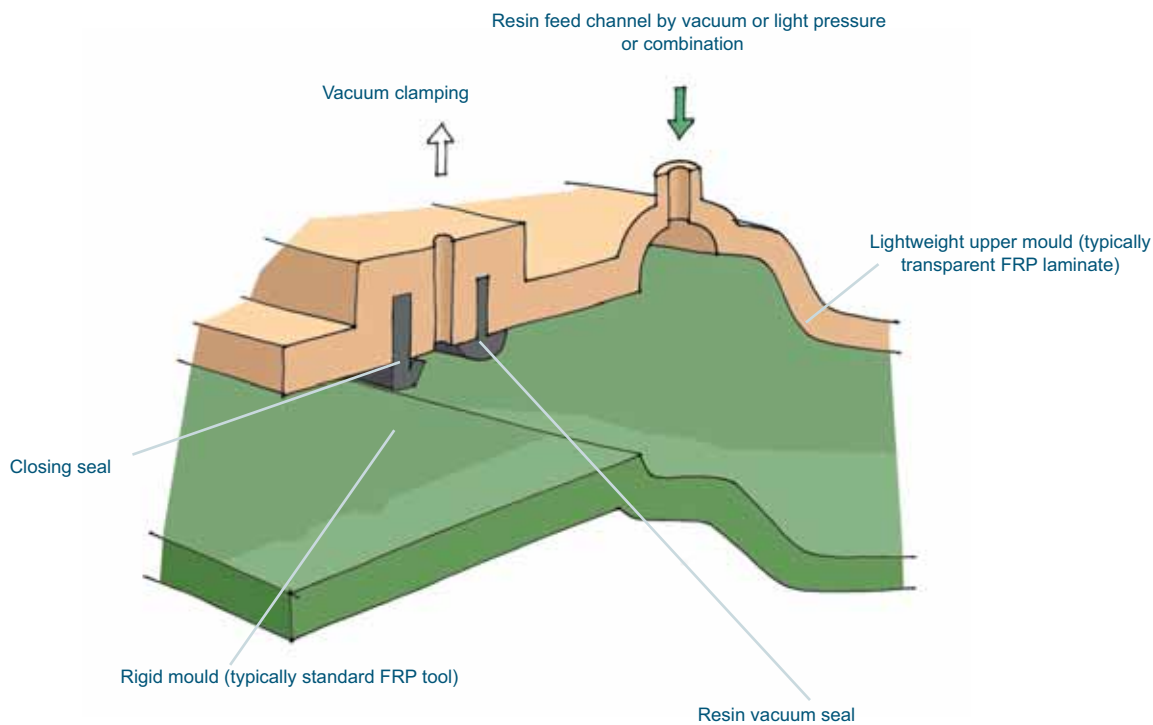
Mould Details

The use of vacuum for mould filling, means that RTM light moulds are subjected to relatively low pressures. For that reason they can be constructed lighter and less rigid in comparison with moulds used for Pressure RTM or for SMC moulding processes. However similar design principles still apply. Also the moulds must be robust enough to withstand production handling.

A RTM Light tool typically consists of a relatively stiff under mould (standard FRP mould, produced with PolyLite® Profile Tooling system), and a semi-rigid, transparent, upper mould (typically produced with a high quality Vinyl Ester resin).

A key requirement is an extended peripheral flange area to give space for the vacuum closing seals and resin feed channel. Resin injection port(s) are located into the feed channel, and vacuum port(s) located near the centre, all depending on injection strategy.

The use of semi-rigid tools relies on low injection pressures (between 1-3 bar). This avoids the risk of mould deterioration or deformation that can lead to poor dimensional consistency.



Two parallel rubber/ silicon seals are fixed in/ on the flange of the mould to enclose an area used for vacuum closure and the flange is equipped with vacuum connections to pull the closing vacuum between these seals.

Resin is normally fed by peripheral injection. A flow vacuum is applied to one or more central ports creating the necessary under-pressure to draw resin into the cavity. Peripheral injection gives faster fill times and is preferred to central injection.

Injection Strategy

One of the challenges in RTM Light is to choose the right 'injection strategy'. This includes parameters such as where to place the injection/ vacuum points and the choice of reinforcement. The placement of the injection point must be carefully decided and is usually located at the furthest point. The geometrical centre is a good first choice for evaluating injection point options. For larger or more complex parts several injection points can be considered with the object of reducing filling time and avoiding air-entrapment.

Good seals

The closing vacuum seals must be perfectly leak-free and able to hold a stable vacuum pressure (-0.9 bar). The seal between the piece cavity and the closure cavity must also be leak-free. The closure vacuum is higher than the flow vacuum (0.5 bar) so there is a risk of resin migration if the seal is not intact. All seals have to be in good condition, clean and securely glued into channels in the tool. All resin injection and flow vacuum attachment point must also be leak-free to avoid any air intake.

Feed channel

The peripheral feed channel design is important. It must be a sufficient size to allow the free flow of resin, but not so large as to cause excessive exotherm. It must be of even dimensions to ensure an even distribution, and far enough away from the part to avoid stray fibres bridging into it.



Thickness design

Extra care must be taken in the tool building process to achieve an accurate thickness. This is desirable in order to avoid preferential flow, resin/ fibre rich areas and consequent variation in exotherm, or issues with air entrapment. Several materials, often in combination, can be used to achieve the correct cavity dimensions.

The surface aspect of the material used determines the rear surface aspect of the part. Sheet wax, plywood, laminates are all used depending on the shape and importance of the rear surface aspect. Often a well-finished smooth laminate is also a good alternative, giving a stable surface and less difficulty around curves and angles.

Closing surface area

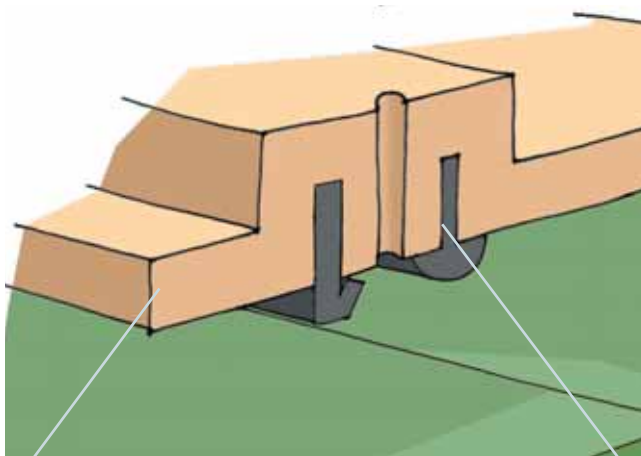
The clamping pressure must always be higher than the pressure inside the cavity. The closing surface has to be sufficiently stiff and robust to avoid deformation in the technical area or across the part.

The injection vacuum has to be lower than the clamping vacuum pressure. The fact that there is little net closing pressure and low internal mechanical forces means that lightweight tools can be used. This means that tools similar to open moulding tools or adapted from open moulding tools can be used without significant extra investment.

Equipment

The external vacuum closure seal is made of neoprene rubber of either a Wing shape or O ring type.

The internal seal which divides the piece/ cavity from the closure area should be made of silicone rubber to improve cleaning and extend the life of the seal which is in contact with the resin. The most common shape of this seal is the mushroom shape.



External Seal
Wing -or O - shape type

Internal Seal
Mushroom -or O - shape type

Vacuum Pump

For RTM Light a vacuum pump capable of pulling at least 1 bar is required. Pallet pumps are most commonly used and are characterised by their flow capacity in m³/hour. For most workshops a 25 m³/hour pump rating is sufficient.

In principle the RTM process does not consume very high resin volumes per shot. Multiplication of moulds and tubes which may have minor leaks can quickly reduce effective pump capacity causing unwanted pressure drops and closure problems.

Agitators and mixers

A simple air driven agitator or drum mixer is useful to disperse liquid additives into resins and ensure filled resins are homogenous prior to use.

In larger operations, especially when adding filler to resin, a high speed mixer and a day tank can be cost effective. If the tank is fitted with heating capability, this can help achieving consistent production times. Typically this will relieve the heaters on the injection machines which are often too small to be fully effective.

Equipment

Injection machines

RTM Light can be started simply using gravity feed, which requires no investment apart from the vacuum pump. For small parts a simple pressure pot system attached to an existing compressor can also be used. For larger production series and for increased part to part consistency a dedicated injection machine will offer improved process control.

The type of part and the required cycle time will determine what type of kind of equipment is required. For some products it may make sense to use several moulds and a larger vacuum pump, instead of faster moulds cycling via an injection machine.

Useful accessories are:

- Online heater: This is useful for an accurate process control, constant viscosity and reactivity.
- Stroke counter: This allows accurate control of the injected amount for each part, and keep an eye on overall resin consumption.
- An automatic injection head with automated line flushing with air/ solvent, will allow much cleaner operation by avoiding resin spills between parts.

Demoulding Curing and Post Curing

A part that demoulds easily will always be more efficient in production. A good design of the part to start with (with correct draft angles), in combination with the help of a release agent is desired.

It is important that the part is not demoulded before the part's mechanical properties have reached a certain level in order to avoid damage to the part. This can be expressed as a minimum level of cure after which demoulding can take place. Barcol 934-1 values between 30 and 40 generally indicate an acceptable cure level, values below 20 indicate the part is insufficiently cured and may be damaged during demoulding.

When the reactivity is too high (very short time from gel to peak), the peak exotherm temperature will also be high which can result in damage of the part and or mould. High exotherm temperatures during processing can leave micro-cracking or high residual stresses in the part and cause part discolouration. The tool surface degrades also faster, causing the onset of gloss loss and surface cracking.

Curing systems for room temperature moulding of normal thickness pieces (2-5 mm) typically use cobalt/ amine accelerators systems and MEKP, AAP or blends. For thicker parts alternative peroxides giving lower exotherm can be effectively used.

After de-moulding of the part, the state of cure has normally not reached the optimum level. It is therefore always recommended to consider a post-curing period at an elevated temperature after de-moulding, before the part is put into service or subjected to more rigorous handling.

Quality Control

Raw material control

Viscosity control

Resin viscosity controls the speed of wetting and filling of the fibre reinforcements. Resin manufacturers supply resins within a quoted viscosity range at a particular temperature using a variety of test equipment. A simple check using a thermometer, stopwatch and a flow cup can help maintain consistency, especially when fillers or additives are being used.

Geltime and reactivity

The geltime must be long enough to allow the tool to be filled completely before the crosslinking of the resin begins. It is recommended to make a quick check on geltime in the working area at actual ambient temperature. This will require:

- Balance or graduated container (500/ 1000 ml)
- Pipettes (1-10 ml)
- Thermometer (alcohol or thermocouple)
- Stopwatch

Temperature control (workshop, resin, mould)

For increasing process consistency, ambient temperature in the workshop should be recorded. This temperature will affect resin viscosity and curing, and therefore should be kept as constant as possible for high part-to-part consistency.

- Thermometers (general use, immersion and surface thermocouple probes)
- Infra-red non contact temperature gun



Composite control after demoulding

The Barcol 934-1 hardness meter gives a rough indication of the state of cure of the part on demoulding by testing surface hardness.

Even with the best quality control system in place, different problems and difficulties can occur during processing, with defects in the finished product as result. For advice about trouble shooting, please contact your Reichhold Technical Service representative.



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