Closed Mould Processes

Comprehensive Solutions that make a difference
CLOSED MOULD PROCESSES

THE MOST CURRENT CLOSED MOULD PROCESSES ARE:

- Infusion
- RTM (Resin Transfert Moulding)
- RTM-Light

They are called «closed mould» processes, in opposition to Hand Lay-Up and Spray-Up «open mould» processes, because resin is not in direct contact with the workshop air but is processed only when mould is tightly closed, so that no Volatile Organic Compound or Styrene is released in the air.

Wet compression, which is not really a closed mould process, is also taken into account here because it has the same product requirements as RTM, RTM-Light and Infusion.

PROCESS COMPARISON

<table>
<thead>
<tr>
<th></th>
<th>INFUSION</th>
<th>WET COMPRESSION</th>
<th>RTM-LIGHT</th>
<th>RTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERIES (FOR 1 SHIFT)</td>
<td>1 to 2 parts/day</td>
<td>2 to 8 parts/day</td>
<td>2 to 8 parts/day</td>
<td>4 to 20 parts/day</td>
</tr>
<tr>
<td>PART SIZE AND SHAPE</td>
<td>Up to 100m² Low to medium complexity</td>
<td>Up to 15m² Low to high complexity</td>
<td>Up to 75m² Low to high complexity</td>
<td>Up to 15m² Low to high complexity</td>
</tr>
<tr>
<td>PART SURFACE APPEARANCE</td>
<td>Finish on one side</td>
<td>Finish on both sides</td>
<td>Finish on both sides</td>
<td>Finish on both sides</td>
</tr>
<tr>
<td>MOULDS</td>
<td>Lower mould often in composite Upper mould = consumable bag</td>
<td>Composite</td>
<td>Composite</td>
<td>Composite or composite-concrete or metallic</td>
</tr>
<tr>
<td>INVESTMENT INDEX</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>400 to 1000</td>
</tr>
</tbody>
</table>

END-MARKETS USING CLOSED MOULD PROCESSES

*Closed mould processes are used in various applications such as wind blades, marine, silos and tanks, buses and trucks, leisure, etc.*

Closed mould processes are frequently used in Europe and in North America, mainly limited at some significant players in Latin America and still not so frequently used in Asia Pacific.
The Infusion process consists in impregnating one or several layers of reinforcement placed in a composite mould and covered by an air tight plastic film used as upper mould. The resin is drawn by vacuum into the reinforcement between mould and film and is not in contact with the air of the workshop (« closed mould » process). Once the resin is cured, the plastic film can be removed and should be thrown away after one use.

Reinforcements used in infusion are mainly Uni-Directional, Multiaxial, Woven Roving and Unifilo® mat but some 3 dimensional complexes can be used as well. A flow media can be laid on the top of reinforcements stack to help the resin to flow on the surface before impregnating layers in depth. For low thickness parts, surfacing flow media might not be necessary when reinforcement’s in-plane permeability is high enough. Infusion allows to make very big parts such as boat hulls or windmill blades, with glass content up to 70%.

ECR20A and ECR70A are two examples of E-CR glass veils (20 g/m² and 70 g/m² respectively) that provide a smooth surface on an infused part.

Multiconform®, Multimat® Lite and Multicore® products: are 3-Dimensional complexes made of glass reinforcement layers on both faces and a synthetic core or a glass + PE knitted core. They can be used in infusion when part complexity is high or in areas where a high glass content is not necessary. They are also appropriate for sandwich structures in a version with glass on one side only.

Unifilo® U813, U816, U850, U852, U614 chemically bonded continuous filament mats show an outstanding permeability (in the range of 10⁻⁹ m²). They are used both as a flow media and as a reinforcement material.

Uniconform® mat is a soft and binder-free continuous filament mat. When used with a surfacing flow media, it shows a high transversal permeability and can be impregnated through high thicknesses.

Combination products can be made of:
- a Woven Roving stitched with chopped strands to address in one single layer a mechanical function (Woven Roving) and a cosmetic function (chopped strands). FlowRoTM is the corresponding brand name available in the US.
- a Multiaxial stitched with a Unifilo® mat to address in one single layer a mechanical function and a resin flow function (Unifilo® mat). FlowTex® mat is the corresponding brand name available in the US.

Uni-Directionals and Multiaxials allow to reach very high glass contents and orientation controlled mechanical properties. ELT 850, ELTM 600/300, EXB 602, EQX 1168 are examples of 0/90° or Multiaxials possibly with stitched chopped strands.

Carbons: CBX 400 12k, R 400 C 12k are examples of products from the full range of cost-effective carbon fibre reinforcements – Multiaxials, Woven Fabrics and Unidirectional tapes.

Woven Rovings from 200 g/m² up to 900 g/m² allow to reach high glass content and mechanical properties.
Making Composite Moulds by Infusion

Composite moulds are generally made by Hand Lay-Up and/or spray of a highly filled resin. Moulds can also be made by infusion to reach high glass content, stiffness, high impact resistance and very good ageing after numerous repeated exothermal peaks.

OCV™ businesses propose the full range of products necessary to build a high quality and robust mould in infusion:

First layer, starting from the model, can be obtained by Hand Lay-Up of glass veils ECR20 or ECR70 or chopped strand mat M113 100g/m² or 200g/m² to get an optimal surface appearance of the mould.

Then, all structural layers can be moulded in one shot by infusing, from a surfacing removable flow media, a stack of Uniconform® mat and fabrics or multiaxial layers. Uniconform® mat allows infusing easily 12 000g/m² for example, to get a 17 mm thick laminate of 55% glass ratio. Woven Roving or multiaxials should be used where even higher mechanical properties are necessary.

Multicore® or Multiconform® products one side may be used in the same infusion step for sandwich areas where foam or plywood stiffeners increase dimensional stability and handling easiness of the mould.

Resin Transfer Moulding

The Resin Transfer Moulding process consists in injecting a resin into a closed mould where one or several layers of reinforcement have been dressed before mould closing. Resin injection pressure ranges from several bars to several tens of bars and the moulds have to be very stiff to withstand injection pressure with no deformation. They are often made of steel or aluminium but can also be made of concrete resin or composite with an electro-deposited metallic skin. Moulds are temperature controlled so as to accelerate resin curing and to shorten cycle time. A high capacity press may be necessary to open and close the heavy moulds. Injection is generally made from one single central point but several well located injection points may be a better option for big parts or complex shapes. Reinforcements need to be very stable and resist “washing effect” due to high injection pressure.

RTM process allows to use filled resin with low shrink additives for an excellent surface appearance of the finished part.

OCV™ Product Range for RTM

Glass veils ECR20A and ECR70A are two examples of E-CR glass non woven that provide a smooth surface on an infused part. They are 20 g/m² and 70 g/m² respectively (but other surface weights are available) and both have a low solubility binder to prevent fibre washing during infusion.

Multimat® product is a 3-Dimensional complex with a 100% glass knitted core and chopped strands stitched on both faces. Multimat® is a market reference in term of stretchability and mould dressing easiness.

Unifilo® U813, U816, U850, U852, U614 chemically bonded continuous filament mats show an outstanding permeability (in the range of 10-9 m²). They are very often used as a local reinforcement to help the resin to fill in the mould cavity.

Unifilo® U720, U740 and U750 mats have a thermoplastic binder that allows hot preforming. Unifilo® preforms are very well adapted for high series RTM and can be available with a glass or synthetic surfacing veil for improved surface appearance.

Uniconform® mat is a soft and binder-free continuous filament mat. Appropriate for low to medium complexity shapes, it allows to reach high glass content (up to 55%). It is soft and shows good surface appearance.

Woven Roving, Uni-Directionals and Multiaxials can also be used as local reinforcements or for structural parts.
The Light Resin Transfer Moulding process consists in injecting a resin into a composite closed mould where one or several layers of reinforcement have been dressed. The closure of the mould can be made mechanically or thanks to vacuum applied between two seals in the mould peripheral flange. Injection pressure is generally lower than three bars and in most cases, resin starts to fill in a peripheral channel before impregnating the reinforcement layers toward one or several vents, sometimes connected to another vacuum port to help the resin flow. In that case, the process is called “vacuum assisted RTM-Light”.

RTM-Light can be used to make small composite parts such as boxes, seats and benches, covers, console supports, etc. but allow also to mould wide deck if moulds are well designed.

### OCV™ PRODUCT RANGE FOR RTM LIGHT

#### Glass veils

ECR20A and ECR70A of 20 g/m² and 70g/m² respectively (other weights available) allow an improved surface appearance.

#### Multimat®

Product is a 100% glass 3-Dimensional complex that may be used for high complexity shapes and high glass content requirements.

#### Multimat® Lite

Product is a 3-Dimensional complex composed of light knitted core made of glass and Polyethylene filament stitched with chopped strands layers on both faces. Multimat® Lite mat has an impressive stretch ability and capacity to adapt to complex mould but also has an outstanding resistance to compression that allows the resin to flow easily even when composite mould are soft and tend to deflect with vacuum.

#### Multiconform®

Mat is a 3-Dimensional reinforcement made of binder and stitching-free continuous filament mat outer layers and non-woven Polypropylene core. It is suited for low to medium complexity parts and shows an excellent surface finish.

#### Multicore®

Mat is a 3-Dimensional complex with chopped strands outer layer stitched with a non-woven Polypropylene core. It is also available with chopped strand on one side only and is very appropriate in that case for sandwich structures.

#### Uniconform®

Mat is a binder free continuous filament mat that suit RTM-Light application for high glass content need in a high permeability version.
WET COMPRESSION OR PRESS MOULDING

This process consists in placing one or several reinforcement layers into the mould cavity, spraying or pouring resin on and closing the mould by press or by hand with a peripheral vacuum. The pressure applied onto the resin by the mould when closing makes the resin flow and impregnate the reinforcements.

OCV™ PRODUCT RANGE FOR WET COMPRESSION

Glass veils ECR20A and ECR70A of 20 g/m² and 70g/m² respectively (other weights available) allow an improved surface appearance.

Multimat® product is a 100% glass 3-Dimensional complex that may be used for high complexity shapes and high glass content requirements.

Multimat® Lite product is a 3-Dimensional complex composed of light knitted core made of glass and Polyethylene filament stitched with chopped strands layers on both faces. Multimat® Lite mat has an impressive stretch ability and capacity to adapt to complex moulds.

Multiconform® mat is a 3-Dimensional reinforcement made of binder and stitching-free continuous filament mat outer layers and non-woven Polypropylene core. It is suited for low to medium complexity parts and shows an excellent surface finish.

Multicore® mat is a 3-Dimensional complex with chopped strands outer layer stitched with a non-woven Polypropylene core. It is also available with chopped strands on one side only and is very appropriate in that case for sandwich structures.

Uniconform® mat is a binder-free continuous filament mat that shows a very high transversal permeability in wet compression process. It can be compressed to reach high glass content but keeps a nice surface finish thanks to high solubility sizing.

FIRE RESISTANT APPLICATIONS

OCV™ businesses have a unique range of closed mould reinforcements made of glass fibres only, with no synthetic cores, that allow to reach high fire resistance level when used with an appropriate resin. Woven Rovings and Multiaxials are used for high glass content and simple shapes whereas Uniconform® and Multimat® mats are easy to adapt on complex shapes. They have synthetic material ratio lower than 1% by weight (glass fibre sizing and possibly stitching yarns) and provide an optimal behaviour in fire resistance test.
ADVANTEX® IS THE MOST ENVIRONMENTALLY FRIENDLY E-GLASS

BORON TRADITIONAL E-GLASS

BORON-FREE ADVANTEX® GLASS

OCV™ BUSINESSES PRODUCE ADVANTEX® GLASS

- With Lower Environmental Footprint:
  - a boron-free glass
  - a fluorine-free glass

- Most OCV™ products are manufactured with Advantex® glass today. On-going conversion programs are driven in our manufacturing plants to have all our products made with Advantex® glass. They aim at continuously reducing air emission environmental impacts.

YOUR GLOBAL PARTNER FOR COMPOSITE SOLUTIONS

- Facilities in 15 countries worldwide
- More than 9,000 employees
- More than 15 languages
- 39% of Owens Corning revenue
- www.owenscorning.com/composites
### OCV™ PRODUCT RANGE FOR CLOSED MOULD PROCESSES - SUMMARY

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>SURFACE WEIGHT (g/m²)</th>
<th>ROLL WIDTH (CM)</th>
<th>INFUSION</th>
<th>RTM</th>
<th>RTM-LIGHT</th>
<th>WET COMPRESSION</th>
<th>TOOL BUILDING BY INFUSION</th>
<th>FIRE RESISTANT APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unifilo® UB13, UB16, UB50, UB52, UB14</td>
<td>225 to 900</td>
<td>50 to 300</td>
<td>Yes</td>
<td>Local patch</td>
<td>Local patch</td>
<td>For simple shape</td>
<td>Yes</td>
<td>Depending on binder content</td>
</tr>
<tr>
<td>Unifilo® UT20, UT740, UT750</td>
<td>300 to 900</td>
<td>50 to 300</td>
<td>/</td>
<td>Preforms</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Uniconform®</td>
<td>450 to 2400</td>
<td>125 or 250</td>
<td>With surface flow media</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>With surface flow media</td>
<td>Yes</td>
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<tr>
<td>Multiconform®</td>
<td>780 to 2050</td>
<td>125 or 250</td>
<td>if high glass content not necessary</td>
<td>Low to medium complexity shape</td>
<td>Low to medium complexity shape</td>
<td>Low to medium complexity shape</td>
<td>One side version for sandwich areas</td>
<td>No</td>
</tr>
<tr>
<td>Multimat®</td>
<td>1 100 to 2700</td>
<td>125 or 250</td>
<td>/</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>/</td>
<td>Yes</td>
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<tr>
<td>Multimat® Lite</td>
<td>735 to 2010</td>
<td>125 or 250</td>
<td>if high glass content not necessary</td>
<td>Low to medium complexity shape</td>
<td>Low to medium complexity shape</td>
<td>Low to medium complexity shape</td>
<td>One side version for sandwich areas</td>
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<tr>
<td>Multicore®</td>
<td>480 to 2050</td>
<td>125 or 250</td>
<td>if high glass content not necessary</td>
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<td>Yes</td>
<td>Yes</td>
<td>One side version for sandwich areas</td>
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<tr>
<td>Woven Roving</td>
<td>200 to 900</td>
<td>125 or 250</td>
<td>Yes</td>
<td>Locally</td>
<td>Locally</td>
<td>Locally</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Combination Flowrotm™ - Flowtex™</td>
<td>400 to 1500</td>
<td>125 or 250</td>
<td>Yes</td>
<td>Locally</td>
<td>Locally</td>
<td>Locally</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Uni-Direc tional s and Multia xials</td>
<td>400 to 1600</td>
<td>125 or 250</td>
<td>Yes</td>
<td>Locally</td>
<td>Locally</td>
<td>Locally</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Carbons</td>
<td>200 to 800</td>
<td>125 or 250</td>
<td>Yes</td>
<td>Locally</td>
<td>Locally</td>
<td>Locally</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>C- or Advantex® Non-Wovens</td>
<td>20 and 70</td>
<td>5 - 210</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

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