FRP PRODUCT MAKING

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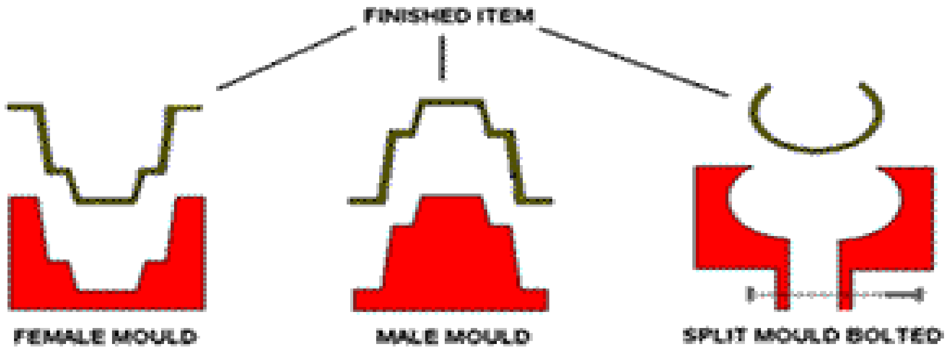
Making Moulds

Moulds fall into two groups – male and female. Glassfibre is laminated on the outside of a male mould and on the inside of a female mould. The desired finish whether it be smooth or textured will be on the side nearest to the mould. A female mould would be used for example to produce car body parts, boat hulls etc where the finish has to be on the outside. A male mould would be used for example on baths, shower trays etc where the finish has to be on the inside.



The Plug / Mastermould

- To produce a mould you need a pattern or former commonly called a “plug” – an exact replica of the finished item.

- The plug can also be an existing item i.e. motorbike or car panel, canoe, dinghy etc but be wary of infringing copyright. Usually you will have to make the plug from scratch.

- The plug can be made from almost any material as long as it is made rigid, accurate, dimensionally stable and set on a solid foundation.

The Plug / Mastermould (Cont.)

- It is necessary to have slight taper on side walls of your plug so that the mould can be removed easily. Typically a large mould would need to be a rigid wood frame covered in hardboard, plywood or MDF, clay or plaster can be used and reinforced with wire netting and Hessian , as toolmakers we tend to manufacture from wood, before applying the primer, fill in any grain, holes, dints and joints as any defects will show on your finished mould.
- Hammer down any nails using a punch and counter sink, any screws or nails cover using polyester body filler, the surface must be smooth and free from blemishes.
- You can then cover with several coats of Durabuild surface primer, when cured overnight, this can then be smoothed using fine grades of wet and dry then polished to a very high sheen, the plug should then be washed with warm soapy water in the event of any residue being left from the polish, then treated with the necessary release agents, recommended is 12 coats of solid a carnauba based wax, applying in 1 hour intervals minimum.

PLUG / PATTERN

PLUG / PATTERN

HOVERCRAFT MOULD
(Split Mould)

The Plug / Mastermould (Tips)

- When you are making the plug, the finish you achieve will be the mirrored on your mould, the mould surface can be reworked with wet and dry paper then polished to a high sheen if needed, but the less work you can do the better, and the better the mould will perform. Ideally you want a high gloss finish to your plug to ensure minimal rework, using porous materials no matter how good you seal will give a substandard mould finish even after polishing.

FINISHED PRODUCT

TOOLS & MATERIALS

Resin Systems

Any resin system for use in a composite material will require the following properties:

- Good mechanical properties
- Good adhesive properties
- Good toughness properties
- Good resistance to environmental degradation

Polyester Resins

- Polyester resins are the most widely used resin systems, particularly in the marine industry. By far the majority of dinghies, yachts and workboats built in composites make use of this resin system.
- There are two principle types of polyester resin used as standard laminating systems in the composites industry.
  - **Orthophthalic** polyester resin is the standard economic resin used by many people.
  - **Isophthalic** polyester resin is now becoming the preferred material in industries such as marine where its superior water resistance is desirable

Polyester Resins (cont)

For use in moulding, a polyester resin requires the addition of several ancillary products. These products are generally:

I. Catalyst
II. Accelerator
III. Additives: Thixotropic; Pigment; Filler; Chemical/fire resistance

Notes

Great care is needed in the preparation of the resin mix prior to moulding.

- The resin and any additives must be carefully stirred to disperse all the components evenly before the catalyst is added. This stirring must be thorough and careful as any air introduced into the resin mix affects the quality of the final moulding. This is especially so when laminating with layers of reinforcing materials as air bubbles can be formed within the resultant laminate which can weaken the structure.
- It is also important to add the accelerator and catalyst in carefully measured amounts to control the polymerisation reaction to give the best material properties. Too much catalyst will cause too rapid a gelation time, whereas too little catalyst will result in under-cure.
- Colouring of the resin mix can be carried out with pigments. The choice of a suitable pigment material, even though only added at about 3% resin weight, must be carefully considered as it is easy to affect the curing reaction and degrade the final laminate by use of unsuitable pigments.

Vinylester Resins

Vinylester resins are similar in their molecular structure to polyesters, but differ primarily in the location of their reactive sites, these being positioned only at the ends of the molecular chains.

As the whole length of the molecular chain is available to absorb shock loadings this makes vinylester resins tougher and more resilient than polyesters.

The vinylester molecule also features fewer ester groups. These ester groups are susceptible to water degradation by hydrolysis which means that vinylesters exhibit better resistance to water and many other chemicals than their polyester counterparts, and are frequently found in applications such as pipelines and chemical storage tanks.

Epoxy Resins

The large family of epoxy resins represent some of the highest performance resins of those available at this time. Epoxies generally out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation, which leads to their almost exclusive use in aircraft components.

As a laminating resin their increased adhesive properties and resistance to water degradation make these resins ideal for use in applications such as boat building. Here epoxies are widely used as a primary construction material for high-performance boats or as a secondary application to sheath a hull or replace water-degraded polyester resins and gel coats

Gelcoat

Even though gelcoats were not used in the early days of the GRP industry the need for resin-rich surfaces to protect structural laminates was an established practice :

- to improve the durability of components
- to protect the laminate from the environment
- to reduce fibre pattern
- to provide a smooth aesthetic finish
- to eliminate the need for painting

Gelcoat

A gel coat would normally have about 3 times more thixotrope than a typical laminating resin.

Gelcoats are available in brush and spray versions and are best put down at a thickness of 0.5mm (approximately 500 g/m^2).

If they are too thin, poor cure occurs and fibre pattern will result. If they are too thick, crazing and cracking can occur and the laminate will be more susceptible to reverse impact, star cracking damage.

CATALYST

Catalyst must be mixed with both gelcoat and lay-up resin to start the curing process. 2% of catalyst (hardener) is added according to weight (i.e. 20cc of catalyst per kilo of resin), 1% of catalyst can be used with resin, but not with gelcoat, this small amount of catalyst is used in hot weather to stop the resin curing too rapidly. Never mix up more resin than is needed at one time. You will need to work faster on hot days to prevent the resin curing too fast.

Catalyst is an organic peroxide and is corrosive and irritating to skin so protective clothing and gloves must be worn when handling catalyst and resins, if any should make contact with skin wash immediately under a running tap. If splashed into eyes flush them with running water for at least fifteen minutes and seek medical advice. As a preventive measure it is advisable that goggles are worn when using catalyst and resin.

PIGMENT

Pigment paste is used to colour the resin, in a ratio of not more than one part pigment to ten parts resin, by weight i.e. 100gm of pigment to one kilo of resin. A lower ratio will be adequate for more dense pigments such as black. Add pigment before mixing catalyst.

Release Agents

- Prevent the laminating materials from bonding to the moulds.

- Whether release agents are incorporated into the resin matrix or applied externally to the mould surface, correct selection canoptimise not only cycle time, but also consistency of surface finish maintaining detail, minimising post mould operation prior to painting or bonding, even helping with fibre wet out.

- Conventional waxes and polishes such as car wax should not be used as they contain additives to which the resin will bond.

Acetone

- Use acetone to clean brushes and remove resins.
- Do not use acetone on skin.
- Acetone is highly flammable and must be kept away from sparks and naked flames.

GLASS REINFORCEMENT

- **Glass fibre** is the most widely used reinforcing material.
- It accounts for almost 90% of reinforcements used in polymer engineering composites. It has good strength and stiffness, good retention of mechanical properties at high temperature, corrosion and moisture resistance, and is relatively inexpensive.
- A number of glass compositions are commonly used for the production of fibres depending on different application requirements.

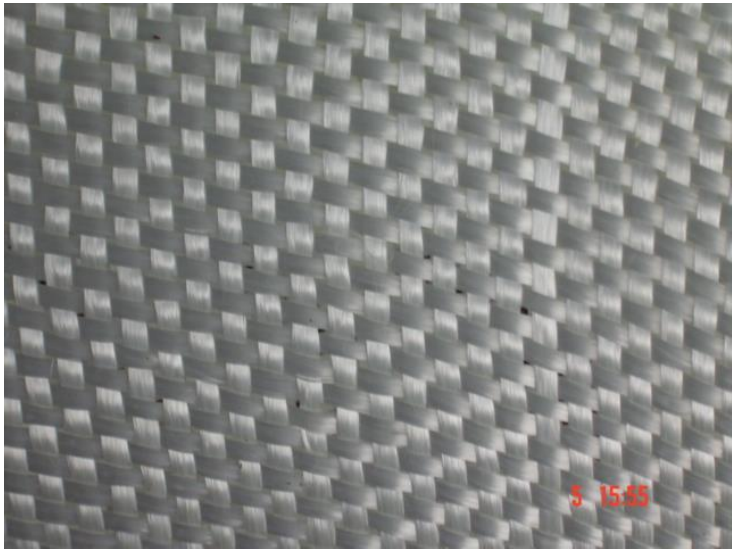
CHOPPED STRAND MAT (CSM)

- It can be seen from Figure 1 that the continuous filament forms the basis of most reinforcements. With no further processing other than cutting to lengths of about 50 mm, these short pieces are deposited by machine on a moving conveyor belt and held and held together with a gluing compound (Powder or Liquid Binder) to form a continuous sheet of chopped strand mat of variable thickness.
- This material is specified by weight: 300, 450, 600 and 900 g/m2 are popular weights of CSM. Note that as total weight and width of rolls is similar, the length of mat will decrease as the weight per square metre increases.
- The side of the material is slightly smoother than the other which reflects the smooth side of the conveyor belt on which the mat was made. It is the rougher side which should be placed down when laminating.

FIGURE 1

GLASS WOVEN ROVING (GWR)

- This is the other popular reinforcement. It is purchased in a similar form to CSM and is again specified by weight. Standard specifications are 18 oz per square yard (600 g/m2) and 24 oz (800 g/m2).
- WR also gives a higher glass per unit volume ratio than CSM which reduces the amount of resin needed. Approximate resin to glass ratio for CSM is 2.5:1 by weight (30% glass) and for WR is 1.25:1 (45% glass).



Glass cloth

- This has a similar appearance to woven roving but on a finer scale. It is available in various widths from rolls down to 25 mm. These smaller sizes, which are known as glass tape, give an indication of its uses which are, for the narrow sizes, bonding of joints and small repairs or in full sizes for giving high strength with a smooth finish and where good draping qualities are required in areas of compound curvature.
- It is more expensive than WR and normal weight specifications are in the range of 110–400 g/m2.

Laminating Techniques

A guide for laying up (laminating) fibreglass reinforcement into a pre- prepared mould.

- Apply a layer of catalysed (2 - 3% by volume) gelcoat to the mould.

- Once the gelcoat hardens to a tacky finish, but does not rub off onto fingers, you can begin adding layers of glassfibre matting. Be aware that although the gelcoat can seem to have fully cured, some corners and crevices can be still wet, wait for these to dry.

Laminating Techniques (Cont.)

- Have all your materials and equipment ready before starting lay-up procedure but only mix resin as required and not too much at one time.
- Using catalysed resin, wet out gel coated area, lay over first sheet of fibreglass matting and using a stipple motion wet out this first layer (do not paint side to side this will cause the fibres to separate).
- Apply more resin if necessary, making sure the mat is totally wet through. Using a metal paddle roller work out any air and consolidate the matting to the gelcoat.
- When the first layer is completely layed nice and flat to the gel coat repeat this action for the remaining layers.
- It is recommended that if applying more than three layers, it is best to let the first layer cure to prevent heat being generated by the curing process as this can cause pre-releasing and warping to the item.

Laminating Techniques (Tip)

Usually a laminate will have a smooth side (side nearest the mould) and a rough side, the rough surface can be made smoother by adding a surface tissue or flo-coat, gel coat with a wax additive.

Whilst laying-up the resin it is already going through its curing stage and it is advisable that if the resin begins to appear thicker and unworkable while laminating, that you flatten out any matting and clean tools thoroughly with acetone to prevent the laminate and tools being ruined by premature curing, mix a fresh batch of resin then continue. Remember that acetone is highly flammable – DO NOT smoke near or expose acetone to sparks or flames.

Laminating Techniques (Tip)

When the finished laminate is cured but still green (not too hard) it can sometimes be trimmed using a Stanley knife, hardened, it can be cut using a hack saw or diamond wheel cutter (safety gear and breathing masks must be worn while cutting GRP). Remove from the mould using wooden or plastic wedges but be careful to avoid scratching the laminate or the mould, alternatively carefully use a pair of mole grips and a tyre lever. If the mould has been properly waxed the laminate should quite easily be removed. Keeping a mould sufficiently waxed should make removing further laminates easy and prolong the life of the mould.

Equipment

- **Tools and accessories will vary depending on the project but the following are usually required:-**

  Mixing containers: cups and buckets made from a suitable plastic which will not be attacked by resin

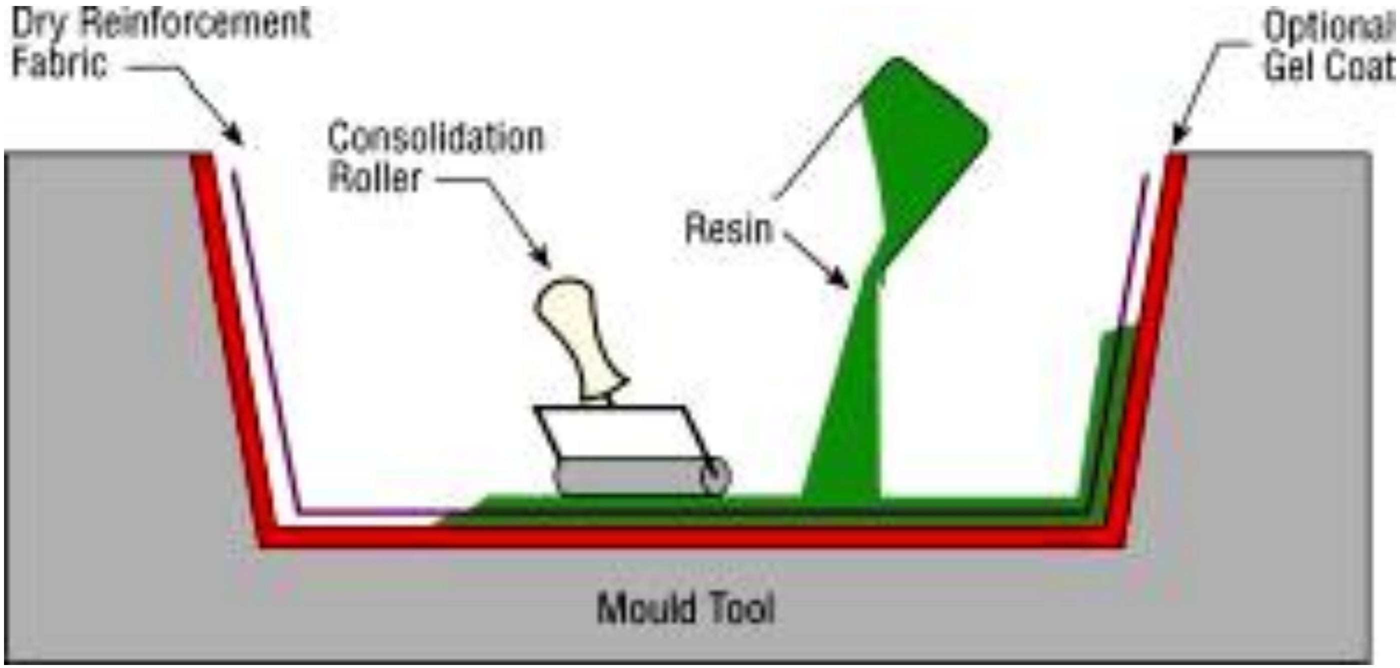
  Brushes and / or Rollers: These are used to apply resin. Use only rollers made for GRP work, conventional decorating rollers are not suitable as the glues used on them will be attacked by resin.

  Metal Rollers: For rolling out air pockets in the resin and glassfibre layers.

  Catalyst Dispenser: Use a specially designed dispenser for safety, catalyst should not come into contact with eyes or skin.

  Rubber Gloves: These should be worn in conjunction with barrier creams to protect the hands from glassfibre materials and chemicals.

Wet/Hand Lay-up



Description

Resins are impregnated by hand into fibres which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

Wet/Hand Lay-up (Cont)

- ***Materials Options***:

Resins: Any, e.g. epoxy, polyester, vinylester, phenolic.

Fibres: Any, although heavy aramid fabrics can be hard to wet-out by hand.

Cores: Any.

Wet/Hand Lay-up (Cont)

- ***Main Advantages:***

i) Widely used for many years.

ii) Simple principles to teach.

iii) Low cost tooling, if room-temperature cure resins are used.

iv) Wide choice of suppliers and material types.

v) Higher fibre contents, and longer fibres than with spray lay-up.

Wet/Hand Lay-up (Cont)

- ***Main Disadvantages***:

  i) Resin mixing, laminate resin contents, and laminate quality are very dependent on the skills of laminators. Low resin content laminates cannot usually be achieved without the incorporation of excessive quantities of voids.

  ii) Health and safety considerations of resins. The lower molecular weights of hand lay-up resins generally means that they have the potential to be more harmful than higher molecular weight products. The lower viscosity of the resins also means that they have an increased tendency to penetrate clothing etc.

  iii) Limiting airborne styrene concentrations to legislated levels from polyesters and vinylesters is becoming increasingly hard without expensive extraction systems.

  iv) Resins need to be low in viscosity to be workable by hand. This generally compromises their mechanical/thermal properties due to the need for high diluent/styrene levels.