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Wet layup

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Introduction[edit | edit source]

Wet layup involves pouring liquid resin and laying dry fibers onto a single sided mold tool, working the resin into the fibers using a roller or squeegee. Typically done with glass fibers and polyester resins this process is best suited for large, low volume and/or prototype parts. The laminate is usually cured at room temperature without a vacuum bag, but depending on application and desired outcome elevated temperatures and vacuum bagging may be used.[1][2]

Significance[edit | edit source]

Wet layup is considered the oldest method of composite production[2] and also the least expensive, due to low tooling costs, no need for ovens and inexpensive materials. Making wet layup ideal for prototyping and producing low quality parts.

Process Demonstration[edit | edit source]

The video below provides an introduction to the wet layup process. It provides a brief overview of how to perform a wet layup and compares the effects of curing with or without a vacuum bag.

Process Description[edit | edit source]

The mold is treated with release agent, typically poly(vinyl acetate) (PVA) or liquid wax. Alternatives, such as PTFE, silicon or polyester films are sometimes used. Once the release has dried or cured sufficiently it is common to apply a layer of gel, typically 0.02 to 0.04 inches thick, which is then cured. Liquid resin is then poured onto the surface of the tool and a layer of fiber is applied onto the resin. The fiber mat is then worked with a squeegee or a roller so that the mat can become fully saturated with the resin, this also works to remove entrapped air and excess resin. Resin and fiber are then applied in this sequence until the desired number of layers has been applied. Oftentimes a core material, such as foam, is added to provide additional thickness at reduced weights, and the layup can proceed on top of the core material. Sometimes a final layer of resin is applied to provide a smoother surface finish to the outside of the laminate. Some key aspects of wet layup are discussed below.[1][2][3]

Mold Tools[edit | edit source]

Wet layup uses an open single sided tool. The tool side of the part will have a smoother surface finish than the outside, which will be slightly rougher. Tool design is either a female or male tool, depending of which side requires a better surface quality. The female tool will provide a better surface finish on the outside of the part, typically used for boat hulls. A male tool provides a better surface finish on the inside, to be used for bathtubs.[1]

Mold tools are usually the most costly piece of equipment for this type of layup. Therefore, wood is usually used for low volume production or prototyping as it is a cheap material which is easily workable. For higher quality and volume production steel or aluminum may be used. Tools are designed to determine the part shape and surface finish, but it is also important to consider accessibility for the layup to be performed.[2]

Gels[edit | edit source]

Gel coats applied to the tools before layup starts are used to determine the surface properties of the final product. Mainly, the gel coat is used to provide a smooth surface finish to the part, but it is also used to determine other properties such as: flexibility, blister resistance, stain resistance, weatherability and toughness. Pigments are also added to the gel coat to determine the color of the final part. Typical gel coat thickness is 0.02 to 0.04 inches.[1]

Resins[edit | edit source]

Polyester and vinyl ester are the main resins used for this type of production. They provide good mechanical, chemical, electrical properties, dimensional stability, ease of handling and low cost. Epoxies may also be used, but are more expensive and usually require heat to cure.

The resin's properties can be easily altered by using additives to alter cure temperatures, flexibility and various physical properties of the cured product. Thixotropic agents may also be added to control the viscosity of the resins, this is important for layups that are performed at steep angles to prevent the resin from running. However, a high viscosity is usually preferred so that the resin can sufficiently wet the fibers.

A catalyst is added to begin the cross linking reaction before the layup can begin. Both accelerators and inhibitors may be added to control the cure more carefully, eg. if a large part is created a slow cure is desirable for a long pot life of the resin such that it can be applied to the part.[1][2][3]

Fibers[edit | edit source]

Wet layup typically uses E-glass fiber mats which are either woven or chopped into 1 to 2 inches and randomly distributed. Other fiber types such as Kevlar, carbon or aramid can also be used. The thickness of the fiber mats combined with the number of layers determine the thickness of the laminate, denser weaves can be used to build thickness quickly, but comes at the cost of being more difficult to impregnate with resin and place into smaller radii of the tool. [4]

Wetting the fiber mats fully with resin is important to achieve the desired properties of the laminate once it has cured, a benefit of using glass fibers is that once they become wetted with resin they become translucent and it is possible to see voids and remove them. The most common method is to use a simple roller or squeegee to work the resin into the fibers, a variation of these tools and techniques have been created to assist the operators in the process. For example, a roller that dispenses resin internally, saturating the roller beforehand or by spraying the fiber mats with resin instead of pouring. Another method of ensuring fiber impregnation is to apply resin to the fiber mat on a plastic sheet before placing the mat onto the layup, or use dedicated machinery to apply resin to the fiber mat. This gives better control of the fiber volume ratio, can improve production rates and assist in laying up steep tools.[1][2][3]

Cure[edit | edit source]

Wet layup laminates are usually cured at room temperatures, this allows for large parts and inexpensive tooling, with the downside of the resin starting to cure during the layup operation. This can also allow for the laminate to be cured in stages, allowing for cores to be used without resin saturating the core material. The cure reaction is usually exothermic so laying up in stages is often used to control heat generation from the cure reaction so that the resin polymer is not degraded due to exotherm conditions. Another reason to control the cure temperatures is that residual stresses can present themselves in the laminate due to matrix shrinkage and the CTE of the matrix is much higher than the fibers.

Variations in the cure procedure include using elevated temperature to cure the parts quicker, less than 200 F, by utilizing heat lamps or forced air convection. This increases crosslinking rate in the resin and sometimes a simple oven is built using plywood and foam. This causes a tradeoff between production rate and the quality of parts to be created. Vacuum bags can be used during cure to improve consolidation and uniformity, however this increases cost and production time.[1][2][3][5]

Advantages[edit | edit source]

- Room temperature cure
- No vacuum needed
- Inexpensive tools
- Large parts can be made
- Good for prototype production
- Versatile process

Disadvantages[edit | edit source]

- Labor intensive
- Voids, resin rich and resin starved areas are common
- non-uniform quality
- Labor skill dependent
- Styrene emissions from the resin is a health hazard

Application[edit | edit source]

- Vehicle components, such as utility vehicle hardtops
- Leisure boats
- Construction members
- Windmill blades
- Pipes, storage tanks, and vats
- Electrical equipment
- Bathroom interiors and pools

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References

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2. ↑ [2.0] [2.1] [2.2] [2.3] [2.4] [2.5] [2.6] [Ref] Eckold, Geoff (1994). "Design and Manufacture of Composite Structures Chapter 6 Manufacture": 268. doi:10.1533/9781845698560.251.

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About **Help**

For polymer matrix composites (PMCs), resin refers to the matrix; the continuous material phase that binds the reinforcement together, maintains shape, and transfers load. Resins are divided into two main groups: thermosets and thermoplastics.

Engineered materials (designed to have specific properties) made from two or more constituent materials with different physical or chemical properties. The constituents remain separate and distinct on a macroscopic level within the finished structure.

In composites processing, viscosity is an indicator of how easily the resin matrix will mix with the reinforcement and how well it will stay in place during processing. The lower the viscosity, the more easily resin flows. Resin viscosity ranges considerably across chemistries and formulations.

By scientific definition, viscosity is a measure of a material’s resistance to deformation. For liquids, it is in response to imposed shear stresses.

The continuous material phase that binds the reinforcement together, maintains shape, transfers load, protects the reinforcement from environment and damage, and provides the composite support in compression.

Desirable characteristics:

- Moisture/chemical resistance
- Low density
- Processability