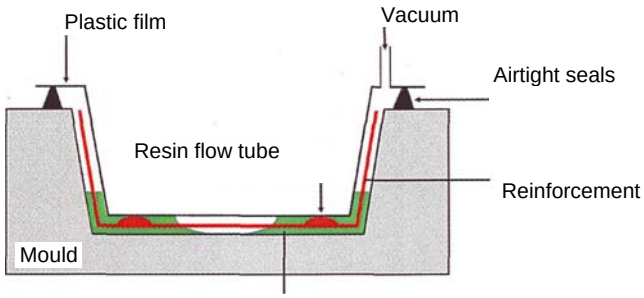
INFUSION MOULDING

DESCRIPTION

In this process dry fibre reinforcement is impregnated in a mould. The fibres are covered with a film: a vacuum is created between the mould and the film, and the resin is then drawn in by vacuum pressure to impregnate the fibres.



ADVANTAGES

- High fibre to resin ratio, avoiding air bubbles.
- Cleaner working for operators, no contact with resin, no gases given off.
- Precise control over laminate thickness.
- Improved mechanical properties of resulting composite.

DISADVANTAGES

- Process little used outside aeronautical and nautical industries.
- Higher production cost than for contact moulding.

SELLING POINTS

- Consistency of manufacture (composition/thickness/weight) from one piece to the next.
- Increased weight.
- Quality of the composite (free from air bubbles and dust).
- Resulting quality and reliability of craft.

increased weight = lower centre of gravity = improved stiffness under sail

higher fibre/resin impregnation rate = increased mechanical strength

- Helps to protect the environment and improve working conditions.

Vacuum sealing film

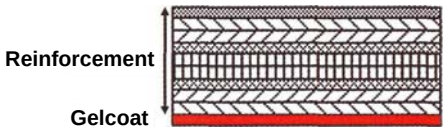
VACUUM BONDING/SANDWICH STRUCTURE

DESCRIPTION

Once the first facings have been applied, the adhesive is applied to the first layers of material, followed by the sandwich core (balsa or PVC foam), then a layer of polyane film. The polyane film is made airtight and a vacuum is then applied. This provides the pressure needed to facilitate bonding. The air is actually removed through a pipe fitted in the polyane film, using a reverse-run pump.

Monolithic material

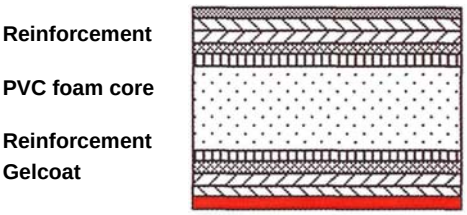
Describes a laminate obtained by simple layering of reinforcing fibres (glass, twaron, etc.).



Monolithic indicates that all layers in the zone concerned are structural layers in their plane. Monolithic contrasts with sandwich.

Sandwich structure

A structure comprising a core of light material (balsa, foam, honeycomb) enclosed on both main facets by a skin of laminate. The combination creates a very light structure with very high rigidity properties.



Unfortunately such materials also present a number of weaknesses, such as a potentially high vulnerability to shear, and vulnerability to shock and delamination. Different kinds of skin and core can be used, providing a great variety of combinations.

Core

In the composites industry this mainly refers to a low-density material between two structural skins (of laminate or metal). The most common cores used are: aluminium honeycombs, aramide (Nomex) or polypropylene, PVC foams, polyurethane foams and balsa.

ADVANTAGES

- Quality of bond (free from air bubbles, constant pressure).
- Better insulation.
- Greater impact resistance.
- Increased longitudinal rigidity of hull under equal displacement.

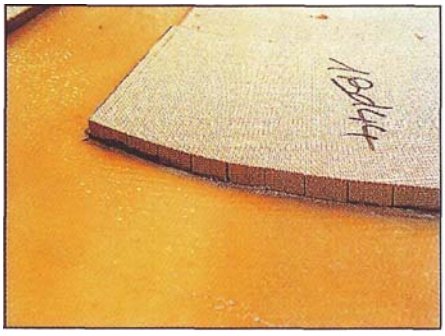
DISADVANTAGES

- Difficult to implement.

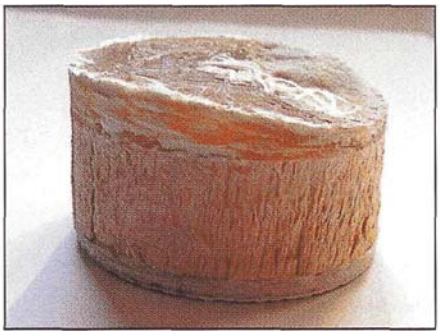
SELLING POINTS

- Quality of the composite (free from air bubbles).
- Better insulation.
- Greater impact resistance.
- Increased longitudinal rigidity of hull under equal displacement.
- Uses closed-cell PVC foam, which is much less affected by moisture than balsa.

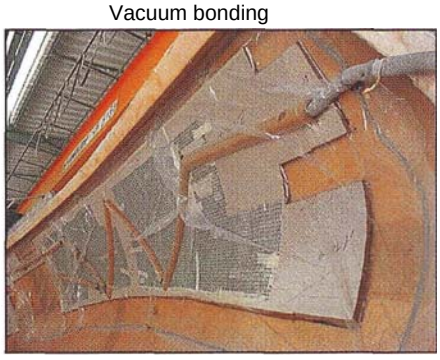
PVC foam core



Sandwich structure



Vacuum bonding



POLYMER/RESIN MATRICES (PART 1)

DESCRIPTION

Resins are the basic organic products which, once mixed and combined with other products, produce solid polymers (after polymerisation).

Polarised resins act as a matrix.

They fall into two categories, "thermoplastic" and "thermosetting", according to the effect of heat on their properties.

The term "thermoplastic" refers to a polymer which can be repeatedly softened by heating and hardened by cooling. Typical thermoplastics include nylon, polypropylene, polyethylene and ABS.

The term "thermosetting" describes a polymer which can only be worked once: once polymerised, it cannot be softened by melting or by solvents.

Although there is a wide range of different resins in use in the composites industry, most structural items are manufactured with three main types of resin: polyester, vinylester and epoxy.

The most widely used resins are:

- For mass-market composites: unsaturated polyester resins.

- For high-performance composites: vinylester and epoxide resins.

POLYESTER RESINS

Thermosetting resin very widely used in the composites industry, in particular in the ship-building industry.

The polyester resins used are unsaturated. The liquid polymer can harden under various conditions (heat, light, catalyst, etc.).

In practice, hardening is achieved by adding a catalyst (organic peroxide), which produces three-dimensional cross-linking, generally accompanied by a significant degree of shrinkage and a high level of exothermic heat generation.

A great variety of polyester resins with differing properties are available, all being combinations of different acids, glycols and monomers.

Polyester resins can however be classified into two main categories:

1) Orthophtalic polyester resin, which is the standard low-cost resin used in numerous applications.

2) Isophthalic polyester resin, which is now becoming the preferred resin in industries such as boat-building, where its greater resistance to water is an advantage.

DCPD (Dicyclopentadiene) RESIN

Resin with a low styrene content, enabling optimal impregnation of the reinforcing fibres, and a better surface appearance.

ADVANTAGES (of polyester resins)

- These resins are very well-suited for impregnating glass fibre.
- Fairly low-cost.
- Fairly rapid hardening, with no elimination of secondary products.
- They can be moulded without using pressure, hence their label of "contact" or "low-pressure" resins.
- They can be used in a wide range of conditions and applications (temperature, moisture, etc.).

DISADVANTAGES (of polyester resins)

- Polyester resins have a limited storage life, as they harden naturally over longer time periods.
- Their mechanical properties are only average compared to epoxide resins.

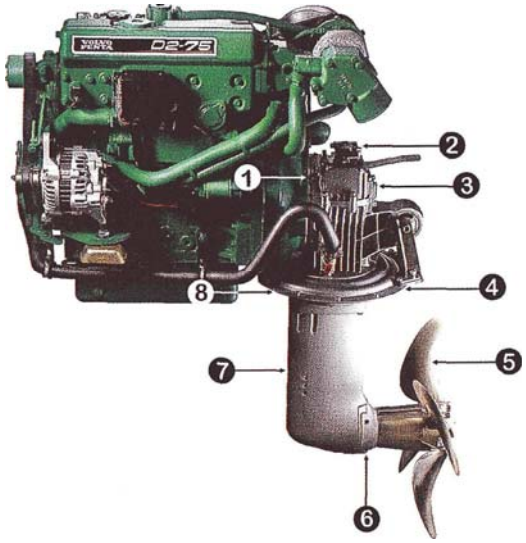
SELLING POINTS

-

SAILDRIVE MOUNTING

DESCRIPTION

Volvo Penta's Saildrive transmission was a completely new technological concept when it was introduced in 1973. It made the job of boatbuilders much easier, and also offered leisure sailors improved comfort combined with reduced vibrations. With the new 150 S transmission, Volvo Penta has managed to increase the power range of the Saildrive transmission to 75 hp.



1. Electrically isolated from engine
2. Change and check oil from on board
3. New upper gear housing (ratio 2.2:1)
4. Single rubber insulated gland (low noise, minimal vibration)
5. Large selection of propellers available
6. Two-part anode
7. Length increased by 25 mm
8. Can be installed with engine facing either forward or rear.

DISADVANTAGES

- More expensive than shaft-mounted systems.
- Requires annual check of neoprene transmission seal.
- Increased risk of corrosion between the differing materials used.

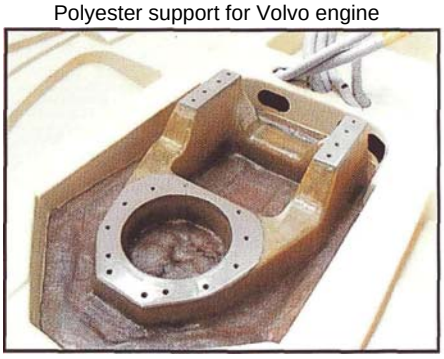
ADVANTAGES

- *Smooth profile:* designed for low drag (all the boats that took part in the Volvo Ocean Race were equipped with standard Saildrive transmissions).
- *Silent* and practically vibration-free in operation, for comfortable sailing. A single rubber insulated gland prevents vibration noise from being transmitted to the hull.
- *Simple and compact* combined engine/transmission system.
- *Simple installation:* easily and quickly installed, no time-consuming shaft alignment and only one opening required in the hull, for both transmission and water intake. The engine can be swivelled through 180° for multiple mounting options.
- *Eliminates problems with driveshaft vibration,* noise, propeller shaft alignment and leaks in the stern post tube (more reliable, safer).
- *Completely watertight:* using a Saildrive transmission completely avoids the leaks conventionally associated with the gland.
- *Improved sailing characteristics* thanks to better weight distribution (centring).
- *Optimal thrust:* optimal efficiency thanks to the propeller shaft being totally horizontal.
- *Improved rudder performance* at low speeds.
- *Easy servicing:* no need for annual shaft angle check and possible realignment. Transmission oil check and change can be carried out from on board. No need to remove the propeller when the zinc anode needs replacing, since the Saildrive uses a split anode.
- *Large selection of propellers available,* including a folding 4-blade model.

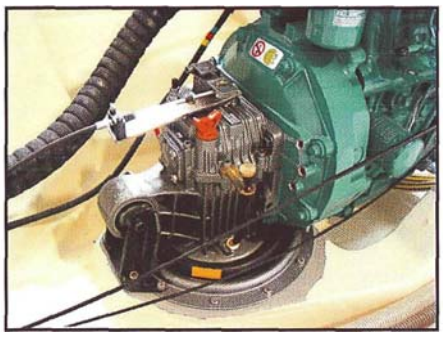
SELLING POINTS

- Low-water resistance, less drag.
- Simple and compact combined engine/transmission system.
- Eliminates problems with driveshaft vibration, noise, propeller shaft alignment and leaks in the stern post tube (more reliable, safer).
- Reduced noise levels.
- Improved sailing characteristics thanks to better weight distribution (centring).
- Improved manoeuvrability thanks to horizontal propeller thrust.
- Improved rudder performance at low speeds.

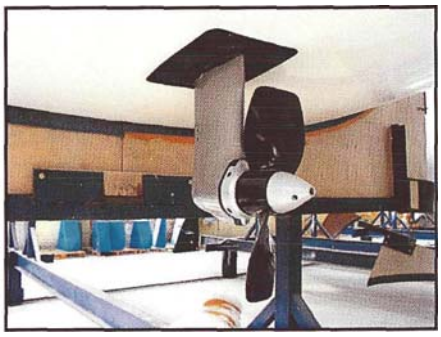
Polyester support for Volvo engine



Reverser and seal



Saildrive



IMPREGNATION CONTACT MOULDING

DESCRIPTION

The term "moulding" covers all operations required to produce a composite component, as follows:

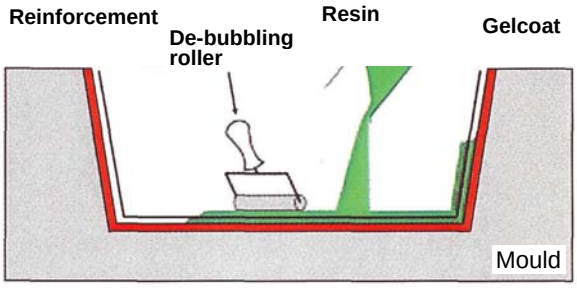
- *Layering* - the stage of the manufacturing process in which the various layers are laid down one after another, paying attention to the position, orientation and sequence set out in the layering plan, to form the component.

- *Compacting* - in this stage pressure is applied to a set of layers to achieve greater homogeneity and cohesion and to ensure the mechanical properties of the final laminate.

- *Polymerisation* - this is a chemical reaction, dependent on time and temperature, which causes the matrix or the resin to solidify irreversibly.

Contact moulding is the simplest production method for reinforced plastics. Low-cost moulds can be used.

After applying a release agent (wax) to the surface of the mould, the laminate is produced by laying down reinforcing materials in the mould cavity and impregnating them with catalysed resin.



Trapped air is driven out using rollers or brushes. Several layers or strata of glass fibre or other reinforcing material are used to achieve the desired thickness.

No pressure is applied during the polymerisation phase.

ADVANTAGES

- Process has been widely used for many years.
- Simple process to train.
- Low tooling-up cost for ambient-temperature moulding.
- Very wide choice of materials and suppliers.
- Uses continuous fibres, high fibre/matrix ratio compared to projection (spray) moulding.

DISADVANTAGES

- The resin/catalyst mix, the reinforcement/matrix ratio and the quality of the composite are heavily dependent on the operator's experience.
- Particular measures are required to ensure safe working conditions.
- High investment (air extraction systems) required to limit styrene emissions and comply with new European standards.
- Need to use low-viscosity resins to facilitate manual application. This generally impairs their mechanical and thermal properties because of high levels of thinner/styrene.

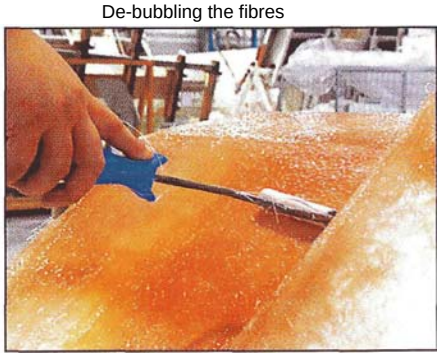
SELLING POINTS

- This process has been widely used for many years, hence manufacturers are thoroughly familiar with the process and can produce high-quality composites.

Impregnating the fibres

Hull mould

De-bubbling the fibres



COUNTER-MOULDED HULLS AND DECKS

DESCRIPTION

HULL COUNTER-MOULD

This is a polyester form which is attached to the floor of the hull in order to:

- Enhance the hull structurally by creating longitudinal and transverse ribs.
- Achieve consistent positioning of wooden bulkheads.
- Facilitate internal fitting-out of the hull.

	D34	*D385*	*D 40*	*D 44*
Counter-moulded hull	yes	yes	yes	yes
Floor members laminated to hull	yes	yes	yes	yes
Keel reinforcement	yes	yes	yes	yes

Note:

The use of floor members laminated to the hull in the ballast area (see illustration, below right) enables the forces produced by the ballast to be taken up by the floor members without placing strain on any adhesion joints.

The internal space aft of the ballast area in a counter-moulded hull is reinforced with dense wood in order to avoid the polyester component breaking due to excessive strain when the vessel heels.

DECK COUNTER-MOULD

This is a polyester form which is attached to the underside of the deck, in order to:

- Enhance the deck structurally by creating longitudinal and transverse ribs.
- Achieve consistent positioning of wooden bulkheads.
- Facilitate internal fitting out of the deck.

	D34	*D385*	*D40*	*D44*
Deck type	Injection	Injection	Injection	Infusion
Counter-moulded deck	no	no	no	yes

ADVANTAGES

- Increased productivity (assembly, bulkhead positioning, structure, finishing).
- Ability to fit electrical wiring and ducts for optional features.
- Gelcoat finish.
- Easier cleaning and maintenance.

DISADVANTAGES

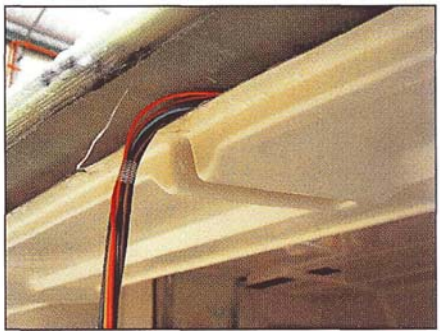
- Tooling-up is expensive, requires multiple moulds.
- Difficult to repair when damaged (heeling).
- Difficult to trace source of leaks.
- Possible accumulation of water between hull and counter-mould.
- Difficult to run extra cables or ducts.

SELLING POINTS

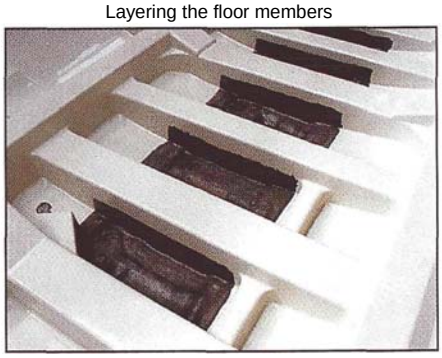
- Gelcoat finish.
- Easier cleaning and maintenance.

Hull counter-mould

Counter-moulded deck/Electrical wiring



Layering the floor members

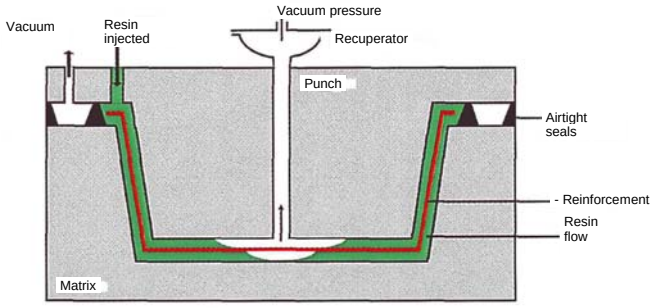


INJECTION MOULDING

DESCRIPTION

Injection moulding involves filling the cavity formed between matched moulds, referred to as matrix (female mould) and punch (male mould or counter-mould), by causing resin (which may be charged with another material) to flow through fibre reinforcement.

Injection= filling a cavity



The pressurised resin flows regularly inward from the edge of the mould to a central point. The regularity of flow depends on the constancy of packing of the reinforcement in the space between the moulds.

The injection pressure together with the vacuum pressure created determine the rate of injection.

The permeability of the reinforcing material is determined by the voids between the fibres after they have been laid and the moulds assembled.

The following precautions need to be taken:

- The mould must be perfectly sealed; no leaks can be allowed.

- As the injection process depends on a vacuum, all connections to the mould must be thoroughly airtight.

- A sufficient quantity of material (resin) must be injected.

- The resin flow rate, the amount of catalyst, and flow times must all be carefully monitored and controlled.

ADVANTAGES

- Rapid setup and manufacture (increased productivity).
- Cleaner working for operators, no contact with resin, no gases given off.
- Precise control of quantity of resin used.
- Precise control over laminate thickness.
- Identical thickness and weight from one piece to the next.
- Gelcoat finish on both faces.

DISADVANTAGES

- Requires very careful implementation (manufacturing specifications must be followed scrupulously).
- Need to employ qualified and trained staff.
- Requires careful monitoring during manufacture (pressure, vacuum, resin flow, laying of fibre, etc.).
- High cost of tooling-up (requires complex adjustment between male and female moulds).

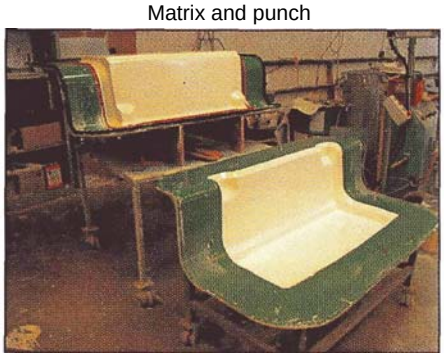
SELLING POINTS

- Consistency of manufacture (composition/thickness/weight) from one piece to the next.
- Increased weight.
- Quality of the composite (free from air bubbles).
- Flawless external and internal gelcoat finish.
- No need to resort to tricks to cover up the coarseness of layering.
- High-quality assembly (fewer adjustments) thanks to precisely-calibrated manufacture.
- Resulting quality and reliability of craft.

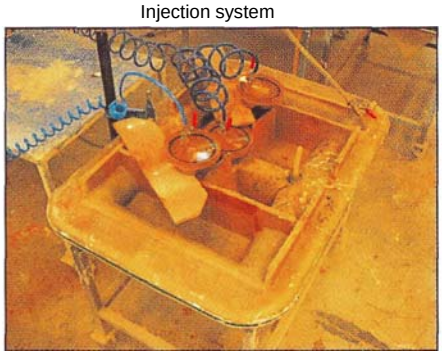
increased weight = lower centre of gravity = improved stiffness under sail
higher fibre/resin impregnation rate = increased mechanical strength

- Helps to protect the environment and improve working conditions.

Matrix and punch



Injection system



Injection-moulded components