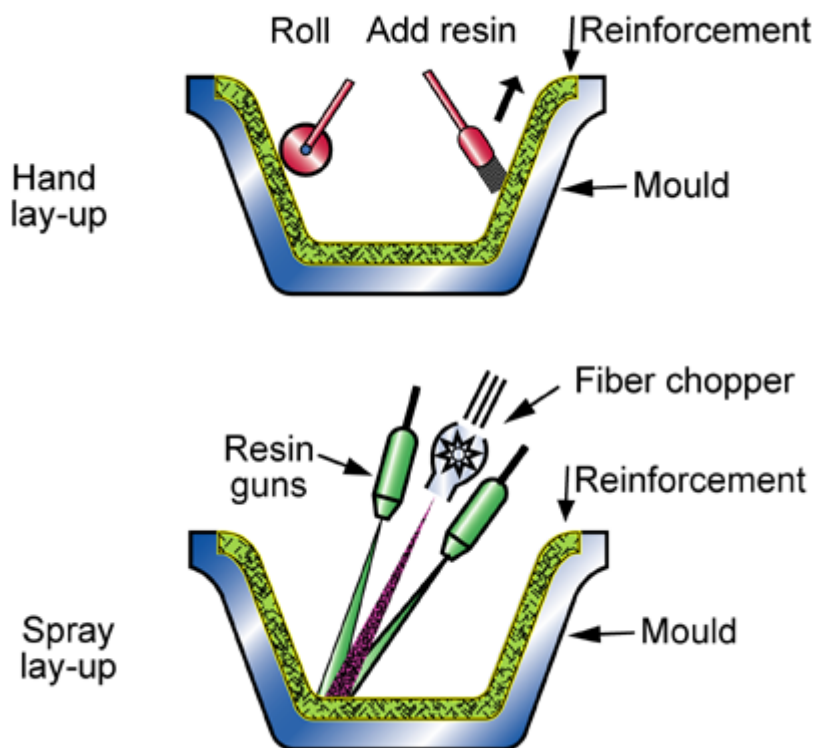


## Description

### Process schematic



### The process

In HAND LAY-UP, an open mold (made of glass-reinforced polymers, wood, plaster, cement or light metal alloys) is coated with a resin to give a smooth surface skin. When this has cured, a layer of reinforcement (woven or knitted glass or carbon fiber) is laid on by hand, resin is applied by a brush or spray gun, and the layer is rolled to distribute the resin fully through the fibers. The process is repeated, layer by layer until the desired thickness is reached. The type of weave influences its ability to take up double curvature ("drapability"): random mat ('glass wool') and knitted fibers have good drapability; weaves with straight wefts do not. Flame retardants and inert fillers are added to reduce cost and improve properties. In SPRAY-UP a resin mixed with chopped fibers is sprayed into the mold; it is used for large components where the reinforcement fraction need not be large.

## Material compatibility

Composites



## Shape

Circular prismatic



Non-circular prismatic



Flat sheet



Dished sheet



Hollow 3-D



## Economic compatibility

Relative tooling cost	low
Relative equipment cost	low
Labor intensity	high
Economic batch size (units)	1 - 500

### Physical and quality attributes

Mass range	2.2 - 1.32e4 lb
Range of section thickness	78.7 - 394 mil
Tolerance	31.5 - 78.7 mil
Roughness	* 0.0197 - 0.126 mil
Surface roughness (A=v. smooth)	A

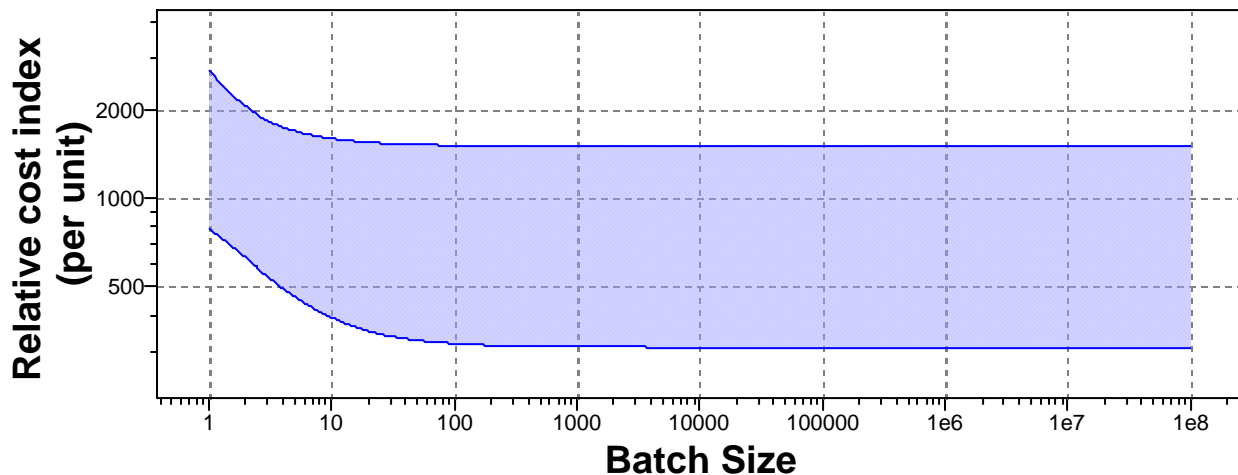
### Process characteristics

Primary shaping processes	✓
Discrete	✓
Prototyping	✓

### Cost model and defaults

Relative cost index (per unit)	* 312 - 1.51e3
--------------------------------	----------------

Parameters: Material Cost = 3.63USD/lb, Component Mass = 2.2lb, Batch Size = 1e3, Overhead Rate = 150USD/hr, Discount Rate = 5%, Capital Write-off Time = 5yrs, Load Factor = 0.5



Material Cost=3.63USD/lb, Component Mass=2.2lb, Overhead Rate=150USD/hr, Capital Write-off Time=5yrs, Load Factor=0.5, Discount Rate=5%

Capital cost	* 82 - 820 USD
Material utilization fraction	* 0.8 - 0.95
Production rate (units)	* 0.1 - 0.5 /hr
Tooling cost	* 82 - 1.64e3 USD
Tool life (units)	* 200 - 1e3

---

## Supporting information

### Design guidelines

Lay-up methods give the greatest freedom to exploit the potential of fiber-reinforced polymers. They are generally limited to shapes with high surface area to thickness ratios. Ribs, bushes and foam panels inserts are all

### Technical notes

The resin systems are all thermosetting, based on polyesters, epoxies, vinyl esters or phenolics. The reinforcement is commonly glass fiber but carbon and natural fibers, such as jute, can also be used.

### Typical uses

Both processes are used to make boat hulls, building panels, vehicle bodies and monocoque bicycle frames, ducts, tanks, sleighs, tubs, shower units, casings and shells.

### The economics

The process is continuous, allowing automation and minimizing labor

### The environment

Open molds lead to evaporation of resin, creating a health hazard: adequate ventilation is

## Links

---

MaterialUniverse

---

Reference

---