Fiberglass and Composite Material Design Guide

The purpose of this design guide is to provide some general information on fiberglass and composite materials and how to design products with these materials. If you have more specific questions, please contact our engineers at Performance Composites and they will gladly assist you.

Composite Materials

Composites materials are made by combining two materials where one of the materials is a reinforcement (fiber) and the other material is a matrix (resin). The combination of the fiber and matrix provide characteristics superior to either of the materials alone. Some examples of composite materials are plywood, reinforced concrete, fiberglass & polyester resin, and graphite & epoxy resin.

Composite materials are very versatile and are utilized in a wide variety of applications. The most widely used composite material is fiberglass in polyester resin, which is commonly referred to as just fiberglass. Fiberglass is lightweight, corrosion resistant, economical, easily processed, has good mechanical properties, and has over 50 years of history. It is the dominant material in industries such as boat building and corrosion equipment, and it plays a major role in industries such as architectural, automotive, medical, recreational, and industrial equipment. Please see table 1 for a comparison of cost and properties of commercial grade composite materials to aluminum, steel and wood.

TABLE 1

	Fiberglass & polyester	**Graphite & epoxy**	**Wood (Douglas fir)**	**Aluminum 6061 T-6**	**Steel, Mild**
Cost $/LB	$1.80	$8.00	$0.60	$4	$.50
Strength, yield (psi)	30,000	60,000	2,400	35,000	60,000
Stiffness (psi)	1.2×10^6	8×10^6	1.8×10^6	10×10^6	30×10^6
Density (lb/in^3)	.055	.065	.02	.10	.30

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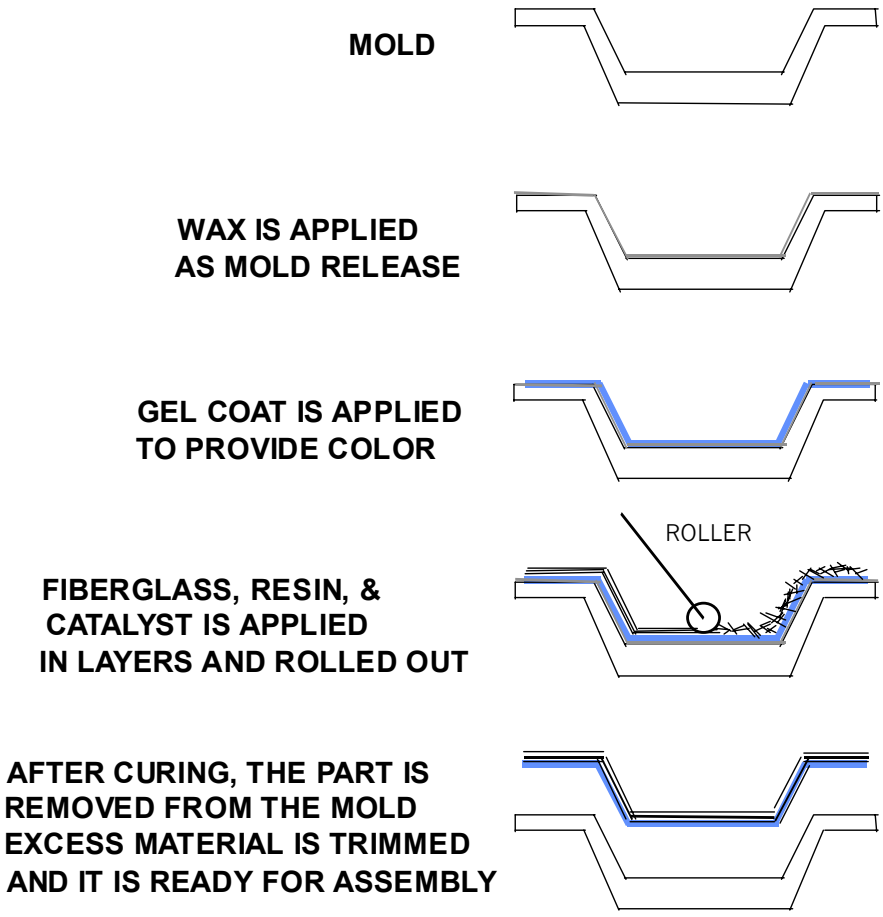
Manufacturing process

The most common manufacturing process for fiberglass is the wet lay-up process using an open mold. The shape of the part is determined by the shape of the mold, and the mold surface is typically in contact with the exterior of the part. Mold release is first applied to the mold to prevent the fiberglass part from adhering to the mold. Then gel coat, which is pigmented resin, is applied to the mold to give the part color. Fiberglass and resin are then deposited on to the mold and the fiberglass is compressed by rollers, which evenly distributes the resin and removes air pockets. Multiple layers of fiberglass are deposited until the desired thickness is achieved. When the resin is cured, the part is removed from the mold. Excess material is trimmed off, and the part is ready for paint and assembly. There are also closed mold processes for making fiberglass parts. Please visit our website www.performancecomposites.com for more information.



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Design Information

Like any material, fiberglass has advantages and disadvantages, but in applications such as corrosion, low volume production, very large parts, contoured or rounded parts and parts needing high specific strength, fiberglass is the material of choice. Fiberglass is a designer's material, because the parts can be tailored to have strength and or stiffness in the directions and locations that are necessary by strategically placing materials and orienting fiber direction. Also the design and manufacturing flexibility that fiberglass offers, provides opportunities to consolidate parts and to incorporate many features into the part to further reduce the total part price. Some general design guidelines are listed below:

Material thickness	Typically range from 1/16" to 1/2". Can use sandwich construction to achieve lighter and stiffer parts.
Corner radius	Recommend 1/8" or larger
Shape	Will duplicate the shape of the mold. Can be heavily contoured
Dimensional tolerance	Tool side can be ± .010" of the tool Non Tool Side ± .030"
Surface finish	Tool side can be class A Non Tool side will be rough, but can be smoothed out Can be gel coated painted, or use any other surface coating
Shrinkage	.002 in/in
Electrical properties	RF Transparent Excellent insulating characteristics Can provide EMI shielding through conductive coating
Fire retarding	Resins available in fire retardant applications meeting various ASTM classes & smoke generation requirements
Corrosion	Resins available for corrosion applications, especially for hot brine, most acids, caustics, & chlorine gases

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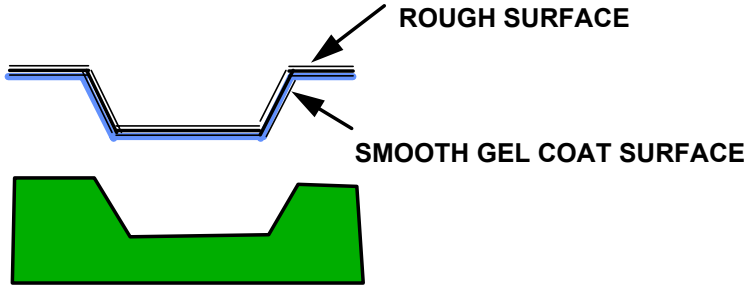
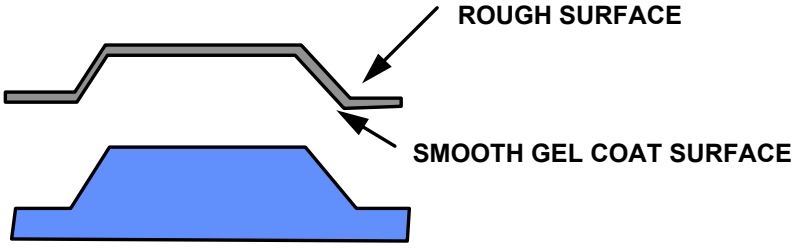
Tooling

Tooling or molds are used to define the shape of the fiberglass parts. The fiberglass part will pick up all shapes and features of the molds; therefore the quality of the part is heavily influenced by the quality of the mold. The molds can be either male or female. The female molds are the most common and they will produce a part with a smooth exterior surface while a male mold will produce a smooth interior surface (please see drawing below).



FEMALE MOLD



MALE MOLD

For very short production runs (less than 10 parts), temporary molds can be made from wood, foam, clay or plaster. These molds are economical and can be fabricated quickly, which will allow inexpensive prototype parts to be fabricated. For larger volume production, molds are typically made with fiberglass. These molds have a life expectancy of 10+ years and 1000+ cycles. Fiberglass molds are inexpensive and usually cost 5 to 10 times the price of the part.

The mold is a mirror image of the part. To create a mold, a master (plug) is required. The master can be an actual part, or can be fabricated out of wood, foam, plaster, or clay. The exact shape and finish of the master will be transferred to the mold. Once the master is completed, it is polished, waxed and the mold is built up on the master. The fabrication technique of the mold is similar to fabricating a fiberglass part except that tooling materials (gel coat, resins, and cloth) are used to provide a durable mold that has low shrinkage and good dimensional stability. Once the mold is laminated, it is reinforced with wood, fiberglass or metal structure to ensure that it retains the proper shape. Then the mold is removed from the master and put into production.