Fibre-reinforced plastic (FRP).

Fibre-reinforced plastic (FRP) (also fibre-reinforced polymer) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, basalt or aramid, although other fibres such as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, construction industries and ballistic armor.

The moulding processes of FRP plastic begins by placing the fibre preform on or in the mold. The fibre preform can be dry fibre, or fibre that already contains a measured amount of resin called "prepreg". Dry fibres are "wetted" with resin either by hand or the resin is injected into a closed mold. The part is then cured, leaving the matrix and fibres in the shape created by the mold. Heat and/or pressure are sometimes used to cure the resin and improve the quality of the final part. The different methods of forming are listed below.

Bladder moulding

Individual sheets of prepreg material are laid up and placed in a female-style mould along with a balloon-like bladder. The mould is closed and placed in a heated press. Finally, the bladder is pressurized forcing the layers of material against the mould walls.

Compression moulding

When the raw material (plastic block,rubber block, plastic sheet, or granules) contains reinforcing fibres, a compression molded part qualifies as a fibre-reinforced plastic. More typically the plastic preform used in compression molding does not contain reinforcing fibres. In compression molding, A "preform" or "charge", of SMC, BMC is placed into mould cavity. The mould is closed and the material is formed & cured inside by pressure and heat. Compression moulding offers excellent detailing for geometric shapes ranging from pattern and relief detailing to complex curves and creative forms, to precision engineering all within a maximum curing time of 20 minutes.

Autoclave / vacuum bag

Individual sheets of prepreg material are laid-up and placed in an open mold. The material is covered with release film, bleeder/breather material and a vacuum bag. A vacuum is pulled on part and the entire mould is placed into an autoclave (heated pressure vessel). The part is cured with a continuous vacuum to extract entrapped gasses from laminate. This is a very common process in the aerospace industry because it affords precise control over

moulding due to a long, slow cure cycle that is anywhere from one to several hours. This precise control creates the exact laminate geometric forms needed to ensure strength and safety in the aerospace industry, but it is also slow and labour-intensive, meaning costs often confine it to the aerospace industry.

Mandrel wrapping

Sheets of prepreg material are wrapped around a steel or aluminium mandrel. The prepreg material is compacted by nylon or polypropylene cello tape. Parts are typically batch cured by vacuum bagging and hanging in an oven. After cure the cello and mandrel are removed leaving a hollow carbon tube. This process creates strong and robust hollow carbon tubes.

Wet layup

Wet layup forming combines fibre reinforcement and the matrix as they are placed on the forming tool. Reinforcing Fibre layers are placed in an open mould and then saturated with a wet [resin] by pouring it over the fabric and working it into the fabric. The mould is then left so that the resin will cure, usually at room temperature, though heat is sometimes used to ensure a proper cure. Sometimes a vacuum bag is used to compress a wet layup. Glass fibres are most commonly used for this process, the results are widely known as fibreglass, and are used to make common products like skis, canoes, kayaks and surf boards. **Chopper gun**

Continuous strands of fibreglass are pushed through a hand-held gun that both chops the strands and combines them with a catalysed resin such as polyester. The impregnated chopped glass is shot onto the mould surface in whatever thickness the design and human operator think is appropriate. This process is good for large production runs at economical cost, but produces geometric shapes with less strength than other moulding processes and has poor dimensional tolerance.

Filament winding

Machines pull fibre bundles through a wet bath of resin and wound over a rotating steel mandrel in specific orientations Parts are cured either room temperature or elevated temperatures. Mandrel is extracted, leaving a final geometric shape but can be left in some cases.

Pultrusion

Fibre bundles and slit fabrics are pulled through a wet bath of resin and formed into the rough part shape. Saturated material is extruded from a heated closed die curing while being continuously pulled through die. Some of the end products of pultrusion are structural shapes, i.e. I beam, angle, channel and flat sheet. These materials can be used to create all sorts of fibreglass structures such as ladders, platforms, handrail systems tank, pipe and pump supports.

RTM & VARTM

Also called resin infusion. Fabrics are placed into a mould which wet resin is then injected into. Resin is typically pressurized and forced into a cavity which is under vacuum in RTM (Resin Transfer Molding). Resin is entirely pulled into cavity under vacuum in VARTM (Vacuum-Assisted Resin Transfer Molding). This moulding process allows precise tolerances and detailed shaping but can sometimes fail to fully saturate the fabric leading to weak spots in the final shape.

Advantages and limitations

FRP allows the alignment of the glass fibres of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibres can increase the strength and resistance to deformation of the polymer.

Glass reinforced polymers are strongest and most resistive to deforming forces when the polymers fibres are parallel to the force being exerted, and are weakest when the fibres are perpendicular. Thus this ability is at once either an advantage or a limitation depending on the context of use.

Weak spots of perpendicular fibres can be used for natural hinges and connections, but can also lead to material failure when production processes fail to properly orient the fibres parallel to expected forces.

When forces are exerted perpendicular to the orientation of fibres the strength and elasticity of the polymer is less than the matrix alone.

In cast resin components made of glass reinforced polymers, the orientation of fibres can be oriented in two-dimensional and three-dimensional weaves. This means that when forces are possibly perpendicular to one orientation, they are parallel to another orientation; this eliminates the potential for weak spots in the polymer.