Lecture 5.9: Pre-pregging and Sheet Molding Compounds

Pre-pregging

Sometimes, fibers are initially saturated with resinous materials (thermosetting) which keep the fibers in place. These pre-impregnated layups of the fibers are known as prepregs. Prepregs are further used in composite processing. Depending upon the fiber positions, prepregs are known as uni-directional, bi-directional prepregs etc. In case of uni-directional prepregs, all the prepregs can be stacked in one orientation to achieve a composite laminate whose properties will be good in a particular direction. To process a composite laminate, whose properties will be almost same in all directions, prepregs are stacked in various directions. These prepregs are available as tapes, cross-plied sheets and fabrics. Curing is carried out during or after shaping. Prepregs are fabricated with continuous filaments rather than chopped random fibers which increases strength and modulus. When pre-pregs are stored for further processing, a removable backing support is provided to avoid sticking of layers. These backings also provide an additional means to keep the fibers in place. These prepregs can be developed from synthetic fibers (glass, carbon, aramid) and natural fibers (Curaua, flax, hemp etc.). Polyesters, phenolics, poly vinyl esters, polyamides and epoxy resins are used as resinous material for pre-preging. Some of the thermoplastics such as Polyphenylene sulphide (PPS), Polyetheretherketone (PEEK), and Polyethyleneimine (PI) are also used for specific applications. Carbon fibers are used in aircraft parts, sport goods etc. Aramid fibers are used in making bulletproof vest application. Glass fiber prepregs are commonly used in electrical circuit boards.

The processing of prepregs involves simple steps which are as follows:

1. The fibers are drawn from the fiber creel onto a belt through a fiber guide where fiber are flattened and aligned.
2. After the fiber positioning, two top and bottom backing sheets (usually polyethylene sheets) coated with resin of sufficient thickness are brought together with fibers. A release gel is used on the surface of backing sheets for smooth removal of these sheets after processing.
3. The coated resin on the backing sheets may contain fillers, additives and catalyst as per the requirement.
4. Now, all these layers of backing sheet and fibers are compacted with rollers repeatedly.
5. Controlled heating may be provided to slightly cure the resin but too much heating will cause too stiff prepregs.

6. The sheet is trimmed and stored as a prepreg in a cool dry place.

7. If resin is in solid form instead of liquid at room temperature, then a solvent is used to dissolve the resin. Dissolved resin is applied on the fibers and the most of the solvent is removed during heating stage.

**Application**

Prepregs are used in wide variety of application such as aerospace goods, interiors, sporting items, medical application, rocket nozzles, automotive body parts, fishing poles etc.

**Advantages of Prepregs**

1. Porosity and void content is low.
2. There is better control over fiber weight fraction in the composite.
3. Processing cost is low.
4. Better control over the thickness of the laminate.
5. High strength to weight ratio due to application of long fibers.
6. Part uniformity is high.

**Disadvantages of Prepregs**

1. Extreme care is required during packing and storage of prepregs.
2. Refrigeration is required for storage of prepregs.

**Sheet molding compounds**

Sheet molding compounds (SMC) process is one of the main processing methods for fiber reinforced polymer composites. Initially, continuous SMC sheets are fabricated with short fibers impregnated with resin system. Continuous fiber roving is chopped into short fibers which fall at uncured resin poured onto a continuously moving belt. The schematic of sheet molding compound process is shown in figure 1. Sometimes, catalyst and additives are mixed with resin and the mixture is poured onto the moving belt. The fibers are distributed in completely randomly oriented fashion on the belt. These SMC sheets are stored for a definite period of time to achieve dimensional stability and consistency. SMC sheets are cut as per the structure of the product to be produced to the rough dimensions. These sheets are placed in a heated mold at a specific constant temperature. Due to heating, polymer losses its viscosity and fills the mold completely. Curing of the component is done at some specified
temperature. After certain period of time, component is taken out from the mold and finished through trimming for end product. Most commonly, continuous glass fiber roving is chopped and incorporated with resin. Carbon and other fibers can also be used depending upon the part to be produced from SMC sheets. The most commonly used resin materials are polyesters, poly vinyl esters with cross linking agents such as styrene and acrylic resin material. Some filler materials such as clay, calcium carbonate and other low cost or wastes are incorporated in the resin to reduce overall cost and to increase dimensional stability. Generally, peroxides are used in the resin as a catalyst to enhance the curing properties of the resin. Sometimes, thickening agents are also used to increase the viscosity of resin. Sheet molding compounds are more common raw materials for compression molding process. Commonly available SMC sheets contain either randomly oriented short fibers, combination of unidirectional fibers with randomly oriented short fibers and mixture of randomly oriented short fibers with continuous fibers in specific orientation.

Figure 1 Sheet molding compound manufacturing process.
APPLICATION

This technique is used for many application areas like automotive, electrical, electronics, sanitary ware, furniture and other structural components.

Advantage:

1. SMC method is used to produce near net shape.
2. Rate of production is high.
3. It is a low cost high volume production technique with moderate strength.
4. Part reproducibility is excellent.

Disadvantage

1. High Fiber-volume fraction in the composite is not achieved.