Lecture 5.2: Composite Materials: Classification and Applications

Synthetic fiber reinforced polymer composites:

Synthetic fiber based composites incorporates synthetic fibers as reinforcement with thermoset or thermoplastic polymer matrix. Details of constituents are given in figure 1. Recently composites are emerging as a viable alternative to traditional materials in wide range of applications such as automotive industry, railways, aerospace and marine application. PMCs are also finding its space in sports goods (Fishing Rods, Tennis Rackets, Bicycles etc.) and musical instruments (Guitars, violin bows, Woodwinds etc.). Soft magnetic such as sensors screens, frequency convertors etc. are also incorporating polymer matrix composites. Light weight property of composite materials makes them favorable choice for automotive parts because weight of the automobile body has direct influence on fuel economy.

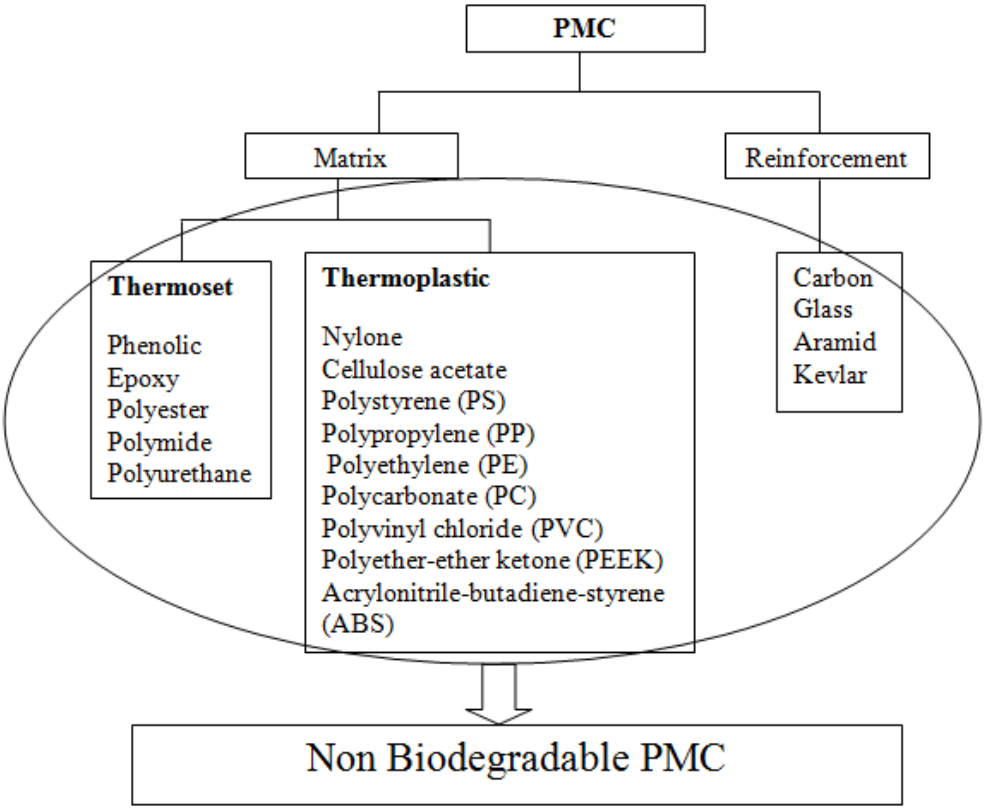

Figure 1 Matrix and reinforcements of PMCs

Corrosion resistant property of the PMCs makes them eligible for marine application and other ground piping system and storage. Now, PMCs are also used as a material in turbine

blade production especially for wind energy sector. Though these composites possess high structural properties and currently capture a large application area but the main drawback associated is that these composites are non bio-degradable in nature which has led to the development of environmental friendly natural fiber polymer composites.

Natural fiber reinforced polymer composites:

Petroleum- based synthetic fibers, resins and composites are non-biodegradable and cause major ecological, environmental and global energy crisis. Due to high environmental awareness and tight environmental rules and regulations these days, bio-based composites are emerging as an alternative to synthetic fiber based composites and now most of the work is focused on replacing synthetic fibers, like glass with fully bio-degradable environmentally friendly lignocellulosic natural fibers. Moreover, these natural fibers provide a viable and abundantly available substitute to expensive and non-renewable synthetic fibers. The 'green composites' in which natural fibers (like flax, abaca, bagasse, banana, kapok, kenaf, sun hemp, hemp, jute, henequen, pineapple leaf fiber and sisal) reinforced polymer matrices (both from non-renewable and renewable resources) prove to be competitive or even better alternatives than synthetic fibers (glass, carbon, aramid) reinforced composites. Natural fibers reinforced polymer bio-composites have attracted more and more attention due to ecological and global energy problems. Due to their relative cost-effectiveness, their ability to recycle, light weight and comparable properties, research attention have been focussed towards the development of superior quality natural fiber reinforced composites. The use of natural fibers in polymer composites has increased.

Natural fiber based polymer composites are either partially bio-degradable or completely bio-degradable composites. In case of partially bio-degradable composites, natural fibers are reinforced with petroleum based synthetic polymers. These polymers are non-biodegradable in nature. Completely bio-degradable composites use natural fibers reinforced with bio-degradable polymers. Example of bio-degradable polymers are poly lactic acid (PLA), poly vinyl alcohol etc. These composites are also known as green composites. Most widely used natural fibers are plant fibers which are obtained from different parts of the plant. The complete classification of plant fibers is given in figure 2. Some of the animal fibers and mineral fibers are also gaining interest in the recent past.

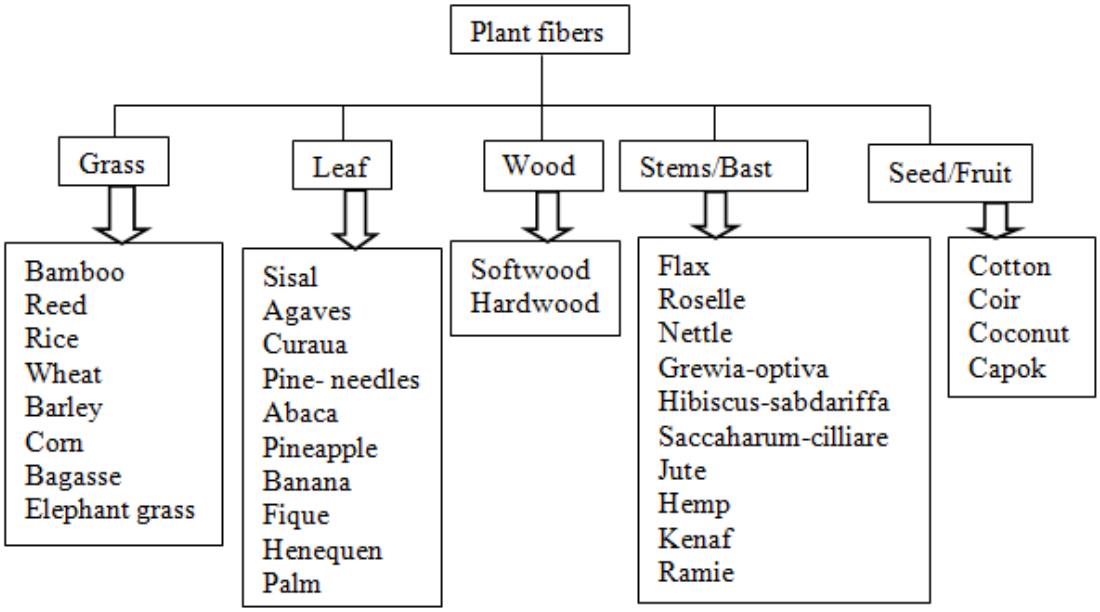

Figure 2 Classification of plant fibers.

Classification based on geometry of reinforcement:

All type of composites discussed in the above section can also be further classified according to the type of reinforcement used. The detailed classification is given in figure 3. Fibrous composites are those which contain reinforcement in the form of fibers. Continuous fiber composites incorporate long fibers. Long fibers may be oriented in one direction only, known as uni-directional composites. When fibers are reinforced in woven mat form, these are known as bi-directional composites. Discontinuous fiber composites incorporate short fibers. These short fibers may be in random orientation or preferred orientation fashion. Particulate composites incorporate reinforcement in the form of particles and this particle reinforcement may observe a random or preferred orientation in the matrix. In filler composites, composites are filled by a secondary material along with the main reinforcement. The percentage of filler material is quite less than the main reinforcement. Particle fillers are the most commonly used filler materials to improve the properties of matrix materials. Flake composites incorporate reinforcement in the form of flakes. These flakes primarily have a two dimensional geometry and possesses an appreciable thickness. In case of laminated composites, fibers in the mat form are reinforced with matrix. These reinforcing mats may be randomly oriented fiber mat, uni-directional fiber mat or bi-directional (woven) fiber mat. In case of hybrid composites, two or more different types of reinforcing materials are incorporated within the matrix. The purpose of hybrid composites is to manipulate the

properties of resulting composite as per the specific requirement. For example, incorporation of SiC to the glass-epoxy composites is a type of hybrid composite.

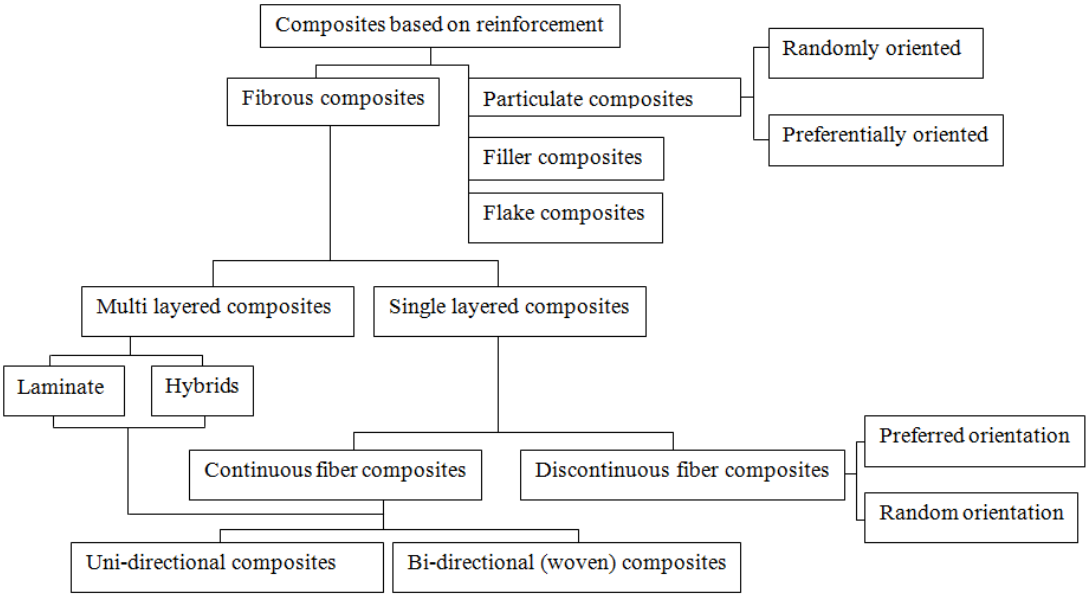

Figure 3 Classification based on reinforcement.