

Overview of Manufacturing PMC's

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Abstract: composite materials are those materials which are made by combining two or more materials with unique properties. Polymer matrix composites are one of the most important composites which are used in various industries due to their light weight, high stiffness and high strength. Because of its advantages it is important to know the manufacturing techniques of PMCs. PMCs are used by automotive, pharmaceutical, sports and aerospace industries. This paper gives detailed review of different methods of manufacturing Polymer Matrix Composites. These methods are more effective in making special shapes west bullet proofs, boat bodies and heavy cylinders. All methods require special conditions which should be maintained during manufacturing process to get the desired product with unique required properties.

Keywords: Stiffness, Strength, Polymer Matrix Composite, Manufacturing.

I. INTRODUCTION

Composite materials are made by combining two different materials having unique properties to achieve the best properties suitable for various applications. Polymer matrix composite is one of the various types of composite materials possessing its own properties for various applications. As composite material is made by adding two phases that are matrix and reinforcement fibers, in polymer matrix composites, polymers are taken in matrix phase and the other suitable materials are taken in the form small fiber particles. Thermosetting resins are the most widely used polymers in PMCs. Matrix material serve several functions in the composites. They provide bulk form of product, hold the fiber particles in place and distributes load uniformly throughout the matrix phase. Commonly used reinforcement fibers are glass, carbon and Kevlar. Advanced polymer matrix composites use boron, carbon, Kevlar as reinforcing fibers in with epoxy as the matrix.

Polymer matrix composites are used in automotive industries which benefits reduction in weight and also some time reduces the production cost of the vehicle parts. Most common parts made by PMCs are exterior body panels, components under the hood, battery trays and protective shields. In marine application, the composites are for making power boats and sailing yachts. The reason for the use of composites in marine application is relatively less cost as compared to wood and metal work, less skill of operator and increased life time with less damage to the manufactured parts. Because of various advantages the composites are also used in aerospace applications which need needs high strength and less weight.

II. MANUFACTURING METHODS OF POLYMER MATRIX COMPOSITS (PMC'S)

There are several manufacturing methods for processing polymer matrix composites. The method selected based on type materials we select and application required. The various methods are hand layup method, Autoclave method, filament winding method and reaction molding.

A. Hand layup method

It a method in which the mold is prepared as one side open with the required shape. The fibers of reinforcement are layed on the surface and matrix material in the form of gel is painted over the fibers. This painting is continued until the required thickness is obtained. It is the most economical process which involves less equipment. Because of this process is done by hand, we can have a better control on the fiber orientation in the matrix material. The molds can be made up of wood, sheet metal, plaster and FRP composites. The molds are coated with gel to get the better surface quality. This is the

oldest commonly used manufacturing process. Most of the aerospace composites are made by hand layup method. This method is used to make polyester and epoxy resin parts such as boat hulls, tanks and vessels.

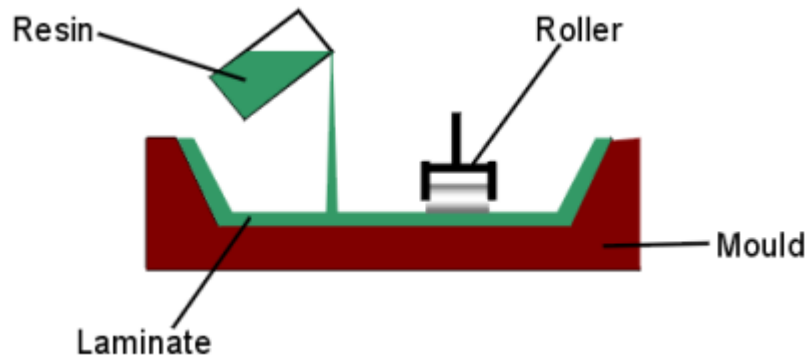


Fig. 1 Hand Lay Up Method

B. Autoclave method

Autoclave method is process of part molding by one of the open molding methods in which the part is cured by a subsequent application of vacuum, heat and inert gas pressure. The molded part is first placed into a plastic bag, from which air is exhausted by a vacuum pump. This operation removes air inclusions and volatile products from the molded parts. Then heat and inert gas pressure are applied in the autoclave causing curing and densification of the materials. Autoclave curing enables fabrication of consistent homogeneous materials. The method is relatively expensive and is used for manufacturing high quality aerospace products.

An autoclave is a closed vessel in which processes occur under simultaneous application of high temperature and pressure. This process needs high pressure. Composites cure under heat and pressure provides a superior part because the voids are reduced due to the pressure. The part is placed in the pressure vessel, and heated, pressure is applied simultaneously.

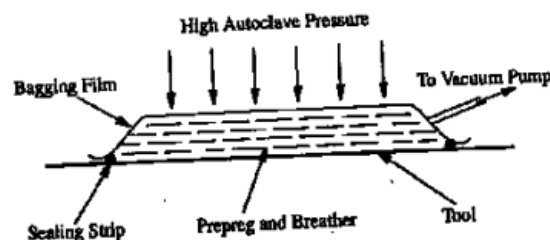


Fig. 2 Autoclave Method

Vacuum bagging can be used in an autoclave. Thermoset composites are cross linked and thermoplastics are melted. The pressure helps bond composite layers, and removes more voids in matrix. Very large parts can be made. But it is highly expensive.

C. Filament winding method

It is a method which involves continuous filament of reinforcement material wound around the mandrel in layers. It is used for making round cylindrical parts. A tape of resin impregnated fibers is wrapped over a rotating mandrel to form a part. These windings can be helical or hooped. Parts vary in size from 1'' to 20'. Winding speeds are typically taken as 100m/min. The winding tensions are 0.1 to 0.5kg. High strengths are possible due to winding designs in various directions. This process can be automated and provides high production rate. High strength and different sizes of products can be made. It has a control of strength in different directions. But complex shapes cannot be obtained. The surface is poor. This method is used for making pressure vessels, storage tanks pipes. Also used to produce rocket motors, launch tubes, drive shafts etc.

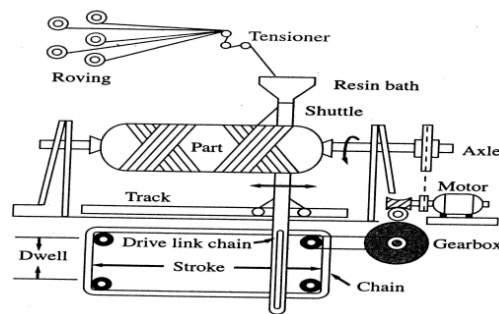


Fig. 3 Filament winding method

D. Reaction moulding method

Two reactive ingredients are pumped at high speeds and pressures into a mixing head and injected into a mold cavity where curing and solidification occur due to chemical reaction. Stack of laminate consists of fibers impregnated with sufficient thermoplastic matrix and polymer films of complementary weight to give the desired fiber volume fraction in the end product. These are then consolidated by simultaneous application of heat and pressure. Generally, a pressure of 6 to 12 MPa, a temperature in between 275⁰C to 350⁰C and dwell time of up to 30 minutes are appropriate for thermoplastics such as polysulfones and polyetheretherketone.

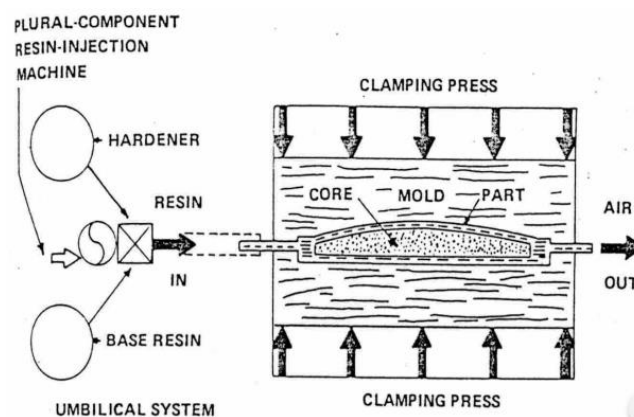


Fig. 4 Reinforced thermoset injection with fiber combination

III. CONCLUSION

Polymer Matrix Composites are used in various industries which is making design and development of PMCs more important. Apart from introduction to the polymer matrix composite, this paper explains about various techniques of making Polymer Matrix Composite. It reviews the processing techniques of PMCs like Autoclave method, Filament Winding method and Reaction injection molding method. It also provides the applications of the processes used make various parts related to different industries.

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