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Study of Important Manufacturing Processes used for Composite Materials

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Abstract —*Composites are the important engineered materials made from two or more different materials, which has significantly different physical and chemical properties and which also remain distinct and separated at the microscopic level within finished structure. Composite materials have boundless engineering application where strength to weight ratio, low cost and ease of fabrication are mainly required. They have properties which could not be achieved by any of the constituent materials. Composites include a wide range of the products for different application ranging from aerospace, sports, electronics industries, construction, automobile components, furniture and insulation panels made from different fibers, and textiles. The evolution of composite materials has given an opportunity to various designers to use new and better materials resulting in cost reduction, increase in efficiency and better utilization of available resources. Manufacturing of composites becomes more important when new product designs and shapes pose tougher dimensional and performance constraints such as surface finish, dimensional tolerances & material removal rate etc. Also the introduction of new fibers, with different bio resins and additives may well result in an expansion in their use into more diverse, and technically demanding application areas. The aim of this paper is to study the current scenario of manufacturing composites.*

Keywords-Composite *material*, Metal Matrix composite(MMC),Nano particles.

1.INTRODUCTION

Composites were seen dates back to the middle age when our ancestors invented bricks by mixing strawand clay. The straw was used as the fiber reinforcement and the clay was used for matrix. Butnow the composites are produced by the selection of the right reinforcement with the right matrixdepending on the end uses.
Two or more chemically differentconstituents combined macroscopically toyield a useful material which is called composite material. One constituent is called reinforcing phase and the one inwhich the reinforcing phase is embedded is called matrix.The addition ofhigh strength, high modulus refractory particles to a ductilemetal matrix produce a material whose mechanical propertiesare intermediate between the matrix alloy and the ceramicreinforcement.

1.1 Advantages of Composite Materials

Composites can be very strong and stiff, yet very light in weight, so ratios of strength-to-weight and stiffness-to-weight are several times greater than steel or aluminum.

- High specific strength and
- High specific stiffness Long fatigue life
- High creep resistance
- Low coefficient of thermal expansion
- Low density
- Low thermal conductivity
- Better wear resistance
- Improved corrosion resistance
- Better temperature dependent behavior

1.2 Disadvantages of Composite Materials

•Properties of many important composites are anisotropic - the properties differ depending on the direction in which they are measured – this may be an advantage or a disadvantage
•Many of the polymer-based composites are subject to attack by chemicals or solvents, just as the polymers themselves are susceptible to attack
•Composite materials are generally expensive
•Manufacturing methods for shaping composite materials are often slow and costly.

1.3 Functions of the Matrix Material

•Provides the bulk form of the part or product made of the composite material
•Holds the imbedded phase in place, usually enclosing and often concealing it
•When a load is applied, the matrix shares the load with the secondary phase, in some cases deforming so that the stress is essentially born by the reinforcing agent.

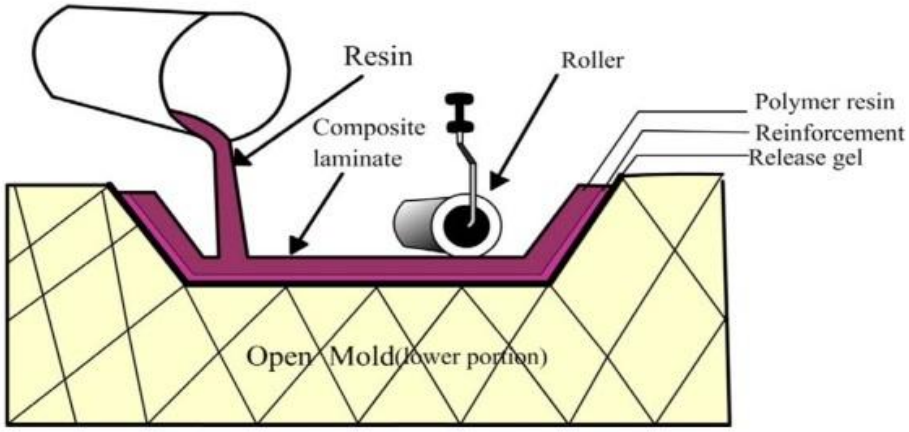
1.4 Functions of the Reinforcement

Function is to reinforce the primary phase.Imbedded phase is most commonly one of the shapes Fibers ,Particles,Flakes.In addition, the secondary phase can take the form of an infiltrated phase in a skeletal or porous matrixExample: a powder metallurgy part infiltrated with polymer.

2.Manufacturing of Composites

- Open Process
  - Hand Lay-up
  - Spray Lay-up
  - Filament Winding
- Closed Process
  - Compression moulding
  - Pressure Bagging Method
  - Vacuum Bagging
  - Resin Transfer Moulding (RTM)
  - Centrifugal Casting
- Continuous process
  - Pultrusion
  - Braiding

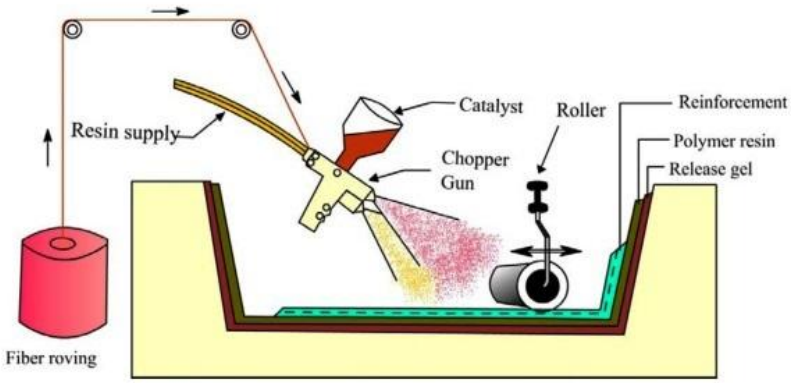
Hand Lay-up Method



- Release gel is sprayed to avoid sticking of polymer to the plastic mould.
- Plastic sheets are used at the top & bottom of the mould plate to get good surface finish.
- Woven, knitted, stitched fibers are put in the mould.
- Then impregnation of resin is done by using rollers and brushes.
- Curing time is approx 24-48 hrs.

It is best suited for thermosetting polymer

Spray Lay-up Method



- Extension of hand lay-up method.
- Spray gun is used to spray pressurized resin & reinforcement which is in the form of chopped fiber.
- A Roller is rolled over the sprayed material to remove air trapped into the layups.
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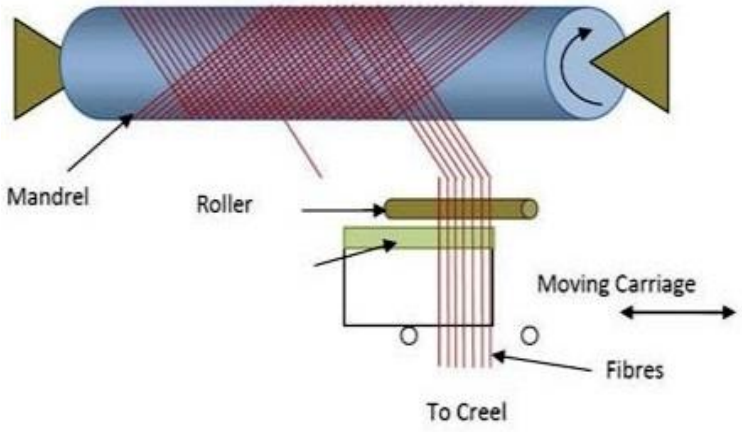
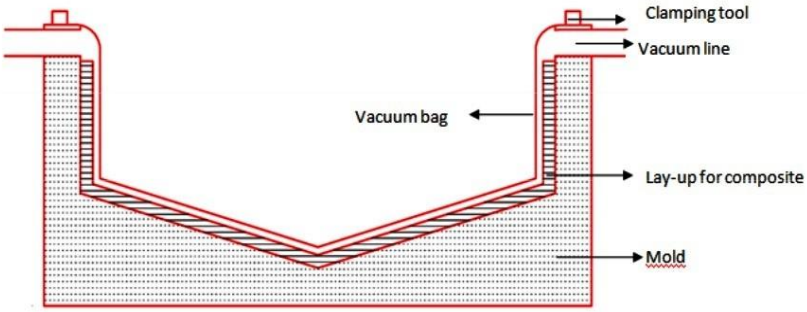
Filament Winding Method



This process is primarily used for hollow, generally circular or oval sectioned components, such as pipes and tanks. Fibre tows are passed through a resin bath before being wound onto a mandrel in a variety of orientations, controlled by the fibre feeding mechanism, and rate of rotation of the mandrel.

- This is primarily used for hollow, circular and oval sectioned components.
- Fibers are passed through a resin bath before being wound on to a mandrel in a variety of orientations controlled by feeding mechanism & rate of rotation of mandrel.

Vacuum Bagging Method



This is basically an extension of the wet lay-up process described above where pressure is applied to the laminate once laid-up in order to improve its consolidation. This is achieved by sealing a plastic film over the wet laid-up laminate and onto the tool. The air under the bag is extracted by a vacuum pump and thus up to one atmosphere of pressure can be applied to the laminate to consolidate it.

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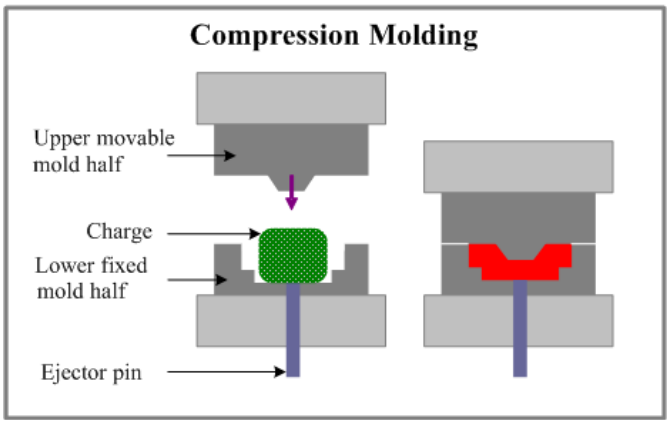
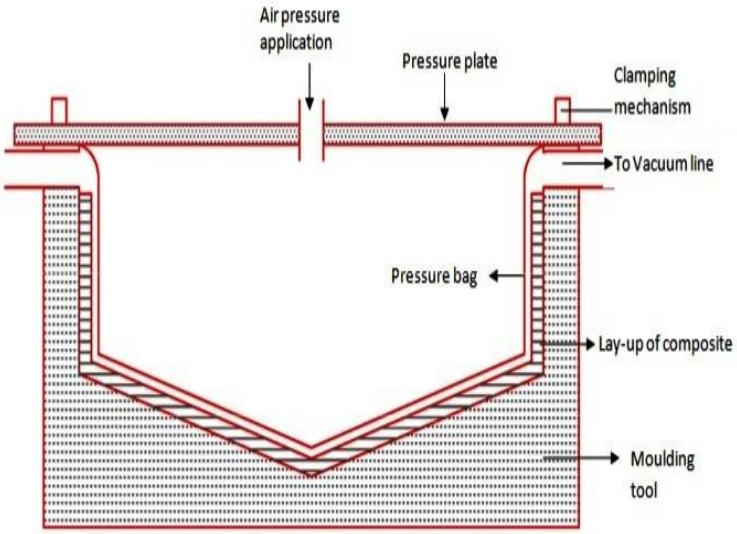
Compression Molding



Compression molding is a high-pressure method used for molding high strength glass fiber reinforcements.This process includes the weighed charge is placed in the bottom half ofthe mold. The charge may be bulk molding compound or sheet moulding compounding which aremixture of chopped glass strands and resin. The two halves of the mold are closed then heated to 2500 to 4000 F. The pressure of 60-100 bar is applied to the charge. The heat and pressure are maintained until the molding material come in contact with all mold areas and cured.

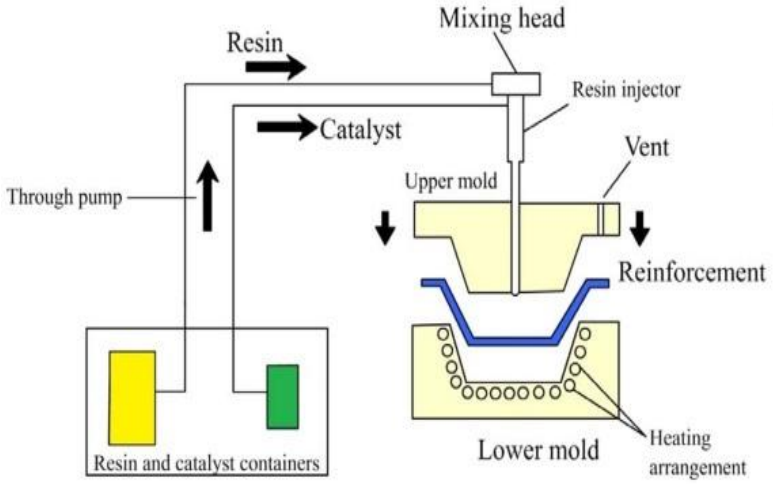
- Compression molding process also used for producing composite from unconventional fibers.
- Unconventional fibers like flax, hemp, sisal etc are combined with the fiber of the thermoplastic polymer to form nonwoven fleece.

Pressure Bagging Method



- This process is same as the vacuum bagging with the only difference of air pressure.
- Air pressure is applied to eliminate entrapped gases and excess resin.
- Pressurized steam is also used instead of which removes excess air as well as provides curing to the composite part.

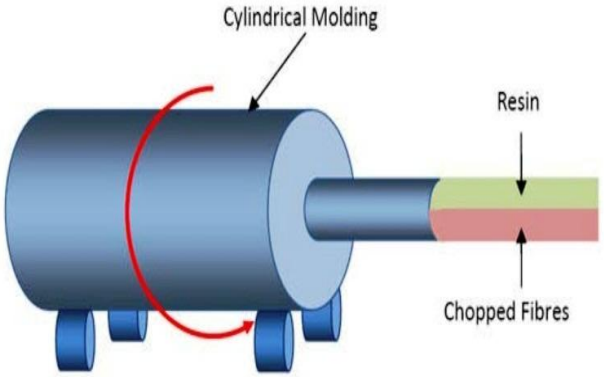
Resin Transfer Moulding (RTM)



Fabrics are laid up as a dry stack of materials. These fabrics are sometimes pre-pressed to the mould shape, and held together by a binder. These 'preforms' are then more easily laid into the mould tool. A second mould tool is then clamped over the first, and resin is injected into the cavity. Vacuum can also be applied to the mould cavity to assist resin in being drawn into the fabrics. This is known as Vacuum Assisted Resin Injection (VARI). Once all the fabric is wet out, the resin inlets are closed, and the laminate is allowed to cure. Both injection and cure can take place at either ambient or elevated temperature.

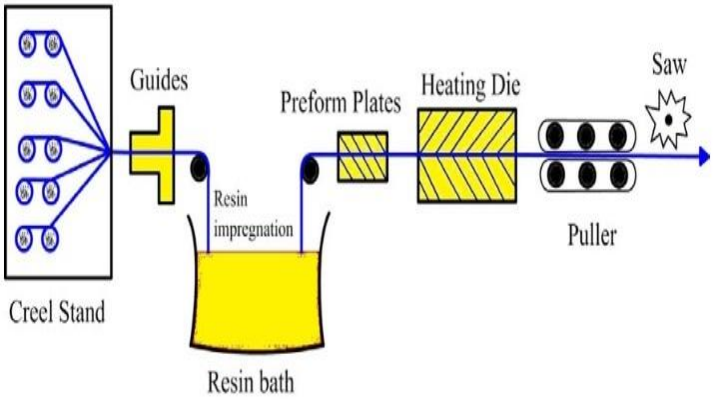
- Resin is pumped in to the mould through ports and air is displaced through other vents.
- Resin flow can be enhanced by using a catalyst as an accelerator and vacuum application.

Centrifugal Casting Method



- Chopped fibers and resin is sent under pressure to the cylindrical moulding.
- Due to centrifugal action mixture get deposited on wall of the cylinder.
- Suitable for small hollow cylindrical products.
- The finish of the inner side is not good**.**

Pultrusion Method



Fibres are pulled from a creel through a resin bath and then on through a heated die. The die completes the impregnation of the fibre, controls the resin content and cures the material into its final shape as it passes through the die. This cured profile is then automatically cut to length. Fabrics may also be introduced into the die to provide fibre direction other than at 0°. Although pultrusion is a continuous process, producing a profile of constant cross-section, a variant known as 'pulforming' allows for some variation to be introduced into the cross-section. The process pulls the materials through the die for impregnation, and then clamps them in a mould for curing. This makes the process non-continuous, but accommodating of small changes in cross-section.

- Fibers are pulled through a bath of liquid resin.
- Then the fibers wetted with resin are pulled through a heated die.
- The die shape used in this process is the replica of the final product.

Finally finished product is cut to length

Braiding process

Braiding process is a manufacturing technique of reinforcement for composites which competes well with filament winding, pultrusion, and tape lay-up but also the weaving process unable to produce non-orthogonally reinforcement. In this process a braiding loom deposits continuous, intertwined fibres to create a desired reinforcing braid architecture and offers several advantages like control over the fibre deposition angle and fast fibre deposition rate.

- Braiding in its simplest form is the interlacing of continuous fibres to produce a tubular fibre pre form.
- The highly automated braiding process provides economies of scale and repeatable production at the leading edge of composites.

3. Conclusion

Composites include a wide range of the products for different application ranging from construction, automobile, sports,aerospace, electronics components, furniture and insulation panel made from
different fibers, particles and textiles. Considerable growth has been seen in the manufacturing and use of composites made in different applications. The selection of required technique is given by type of composites, applications, quality parts, size of production, costs, etc.
The high property of composites and large applications of them led to change the metal parts with composites in cutting-edge ranges of economy.

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