

MANUFACTURING METHOD OF BRAMHA RESIN AND CARBON COMPOSITE LAMINATES FOR VARIOUS QUALIFICATION TESTS

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Abstract—At present Carbon/Glass fiber composite structure are widely used with Epoxy Resin. Epoxy resin is employed primarily for fabricating high performance composites with best physical properties, corrosion properties, superior electrical properties, smart performance at elevated temperatures, smart adhesion to a substrate or a combination of these edges. Epoxy resins are used with variety of fibrous reinforcing materials as well as glass, carbon. Epoxies are compatible with most composite producing processes significantly various types of molding, filament winding and hand lay-up.

Light weight and high strength composite material thus made promotes aerospace and missile industries to replace metallic structure. However, there are limitations on their use in thermal environment having maximum temperature range of 120-1500C. Also glass fiber composites are subject to considerable water absorption. This limitation is imposed by Epoxy matrix in composite structure. A new indigenous herbal matrix/resin named 'BRAMHA' has been developed for fabrication of glass/carbon fiber reinforced composite materials. Since it is made from wheat, cereals, proteins, starch mixed with natural gum, it is categorized as "Herbal" resin. Vacuum Assisted Resin Transfer molding (VARTM) composite fabrication process is used for preparation of carbon & glass fiber laminates. This resin is then compared with epoxy for its various physical & mechanical properties such as pure resin shear strength, water absorption, and sand erosion. The strength tests like tensile at room and at elevated temperatures; compression test and inter-laminar shear strength are conducted. The test results obtained show that BRAMHA resin has superior properties than presently used Epoxy resin

The above tests are carried out at Advanced Composite Division (ACD) National Aerospace Laboratory (NAL) Bangalore and Composite Research Center (CRC) DRDO-R & D E, Pune

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I. INTRODUCTION

Now a day's Epoxy resin is used primarily for fabricating high performance composites with superior mechanical properties, resistance to corrosive liquids and environments, superior electrical properties, good performance at elevated temperatures, good adhesion to a substrate or a combination of these benefits. Epoxy resins are used with a number of fibrous reinforcing materials including glass, carbon. Epoxies are compatible

with most composite manufacturing processes particularly vacuum-bag molding, autoclave molding, pressure-bag molding, compression molding, filament winding and hand lay-up. Small weight and high strength composite materials thus made promotes aerospace and missile industries to replace metallic structure. However, there are limitations on use of epoxy in thermal environment having maximum temperature range of 120-1500C. Also glass fiber epoxy composites are subject to considerable water absorption. Low heat distortion temperature (HDT) and glass transition temperature (T_g) also limits the use of epoxy composites in aerospace applications like space shuttles, fireproof materials in military and ballistics, subzero and cryogenic applications. [2]

Recently, a new indigenous herbal matrix/resin named 'BRAMHA' has been developed for fabrication of glass/carbon fiber reinforced composite materials. Since it is made from wheat, cereals, proteins, starch mixed with natural gum, it is termed as "Herbal" resin or bio-composite. From preliminary inspection it has been observed that this resin, when combined with the carbon and glass fibers to form the composite structures, has some physical and mechanical properties superior than the epoxy composites. Thus the aim of this paper is to put some light on various desirable properties of this new 'herbal' resin and its feasibility for aerospace, ballistic and marine applications so as to evolve self-reliance in aerospace sector.

II. MANUFACTURING METHOD ADAPTED FOR BRAMHA RESIN

The process of curing of conventional resin such as epoxy takes hours of time and thousands of temperature to cure prepegs or composite laminate. For the preparation of Brahma resin, a novel method is adapted. In this method, wheat or any other material mentioned above is boiled continuously for minimum 40 minutes by mixing with water. Then the mixture is fed to the crushing machine where it is crushed continuously for 10 minutes. After crushing, the mixture is taken into the pressing machine where it is pressed so that the pure solvent or glue is separated from the solid or un-dissolved residue. This process is carried for nearly 10 minutes. Then the pure solvent separated from it which is semi liquid in state is taken to another pot. It is mixed with water & kept as it is for 1 day. The mixture is then again fed to the crushing so that thorough mixing occurs & finally we get the glue or resin as an extract.

There are total 11 ingredients in the composition of this Bramha resin which purely made from natural organic materials. For any resin to cure it within a particular time some additional chemicals are need to be added. They are as follows,

Hardeners

These are the chemicals, which react with resin to form a perfect solid mass or cure the resin according to the required shape of mold. For this resin as it is found as a kind of polyester, MEKP (methyl ethyl ketone peroxide) is used as a hardener.

Accelerators

Accelerators are nothing but the chemicals, which enhance or promote the speed of chemical reaction between resin and hardener depending on the size and shape of mold. For this Bramha resin, cobalt octoate is used as an accelerator. Both hardener and accelerator are required in a proportion of very small quantities as within range of 1% to 5% of quantity of resin

III. CARBON & GLASS FIBERS AS REINFORCEMENT

The theoretical strength of a given type of solid is determined by the strengths of the atomic or molecular bonds that hold the solid together. Although the practical strengths of solids are determined by the defects, which they contain, it is necessary to seek materials with the strongest chemical bonds if we are to have the best chance of exploiting the principle of composite materials construction

Glass fibers

Glass fibers are manufactured by drawing molten glass into very fine threads and then immediately protecting them from contact with the atmosphere or with hard surfaces in order to preserve the defect-free structure that is created by the drawing process. Glass fibers are as strong as any of the newer inorganic fibers but they lack rigidity on account of their molecular structure. The properties of glasses can be modified largely in composite materials is ordinary borosilicate glass, known as E-glass. The largest volume usage of composite materials involves E-glass as the reinforcement. S-glass has somewhat better properties than E-glass, including higher thermal stability, but its higher cost has limited the extent of its use [1]

Carbon fibers

By oxidizing and pyrolysing a highly drawn textile fiber such as polyacrylonitrile (PAN), preventing it from shrinking in the early stages of the degradation process. Subsequently hot stretching it, it is possible to convert it to a carbon filament with an elastic modulus that approaches the value we would predict from a consideration of the crystal structure of graphite, although the final strength is usually well below the theoretical strength of the carbon-carbon chain. Thickness of carbon fibers used in preparation of laminates is 0.3mm. [1]

IV. FABRICATION OF COMPOSITES

To incorporate the Bramha resin for VARTM process, some experiments are performed related to curing time, pressure to be applied on actual laminate. 3 different samples A, B, C of 100gm resin with 1% hardener and 0.5% accelerator in sample „A“, 1% accelerator in sample „B“ and 1.5% accelerator in sample „C“ on weight basis are mixed and kept for curing. When time taken for curing by these 3 samples is measured, it is found that sample „A“ takes 2 hours to cure, sample „B“ took 45 minutes and sample „C“ took 30 minutes. Depending on these results sample „A“ is chosen for VARTM process because longer curing time is most essential in case of VARTM process

Hand layup method:

For preparation of laminates from Brahma resin at first “hand layup”, a simple & easy method is used. This method is used, as we required only limited no. of specimen of fixed size & geometry. For making these specimens, molds are prepared from 10 mm thickness & 2 inch width aluminum plate. Aluminum plates are selected due to the reason that they do not get adhere to the glue or resin from which we are going to prepare the laminates & specimen can be removed easily from the mold after curing. Additional 2 inches distance along length is added for easy handling, removal and proper gripping of specimen. Carbon & glass fibers are used in the form strips cut from mats. Molds are placed on perfectly horizontal surface to have uniform resin flow & continuity throughout the length of the specimen.

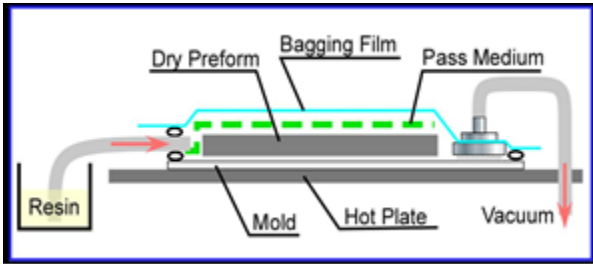
First, a thin layer of resin is placed uniformly in mold. Then first strip of fiber mat is placed above the resin. Then again, second layer of resin is placed over the first layer of fibers. Second strip of fiber mat is then placed over the first layer of resin. This process is continued until required thickness is achieved. The top of the mold is then covered by another perfectly flat aluminum plate and a load of 10- 15 kg is applied on it so that perfectly compact specimen can be prepared and air cavities or bubbles get removed. Also additional glue is getting removed.

Major Defects Found in the Laminates Prepared By Hand Layup:

While making laminates external force or load was not applied on it. Due to this, perfect compaction or attachment of fibers to the resin was not achieved. Presences of air cavities or small holes which are formed due to the release of volatile gases during curing have reduced the strength of the laminates. These holes are trapped in the laminates and also acting as crack promoting zones which in turn promotes the failure of specimen before reaching to its ultimate tensile strength carrying capacity

Vacuum assisted resin transfer molding (VARTM)

The laminates are fabricated by Vacuum infusion widely known as Vacuum Assisted Resin Transfer Molding (VARTM). The main advantages of VARTM, compared to open molding process such as hand lay-up or spray-up, are higher fiber content and an improvement of the laminate quality due to a better impregnation of the perform



Vacuum infusion widely known as Vacuum Assisted Resin Transfer Molding (VARTM) is a widely used molding process for the manufacture of large composite structures. Its popularity is partly due to the low cost of the tooling and the environmental safety, the process eliminates more than 90% of the volatile organic compound emitted by unsaturated polyester resins. In addition, low operator involvement increases the repeatability of the process compared to open mold techniques such as hand lay-up or spray-up and the components are of relatively high fiber content, up to 60% by volume. It is increasingly popular in the transportation, marine and wind power generation industries

VARTM is part of a family of molding techniques called liquid composite molding. It involves the infusion of a low viscosity resin into a dry fibrous preform placed on a stiff mold and covered by a flexible membrane. The main advantages of VARTM, compared to open molding process such as hand lay-up or spray-up, are higher fiber content and an improvement of the laminate quality due to a better impregnation of the preform. Operator involvement is less critical, leading to higher quality and consistency. Existing hand lay-up – spray-up molds can be modifying for use in VARTM. There is no limitation in part dimensions and it is possible to produce components from 1 mm thick to more than 100 mm thick.

In this process, the resin is driven by a vacuum to fill the mould. A wide variety of products is now manufactured using this method, ranging from small armrests for buses to large components for water-treatment plants. In closed mould VARTM processing, the resin is injected into a closed-cavity containing a fiber preform. The impregnation of the resin is a complex process and is greatly influenced by several factors, such as the orientation of the fibrous preform, mould temperature, resin viscosity, and injection pressure, etc.

During laminate fabrication by this process, resin is transferred by vacuum pressure. Release film is used

before fiber kept on the mould, so that the composite laminate would not be stick to the mold plate. Peel ply is applied on the release film to remove laminate easily after curing. Layers of fiber of required quantity and orientation is sandwiched in peel plies and kept on the mould. Mesh is applied on the peel ply so that the uniform distribution of resin could be achieved during infusion. Vacuum pump is attached to create vacuum force at one end. Resin is supplied from another end, so that resin can be flow with the force of vacuum. This whole process is covered with vacuum bag and the vacuum bag is sealed to mould by using sealant as shown in Figure.[3]

Discussions

As we know if some of defects that are still present in the current laminates, then will give a try on new combinations of fibers, their orientations, hardener and accelerators, curing time etc. Tensile, compressive and inter laminar shear properties of unidirectional fiber laminates as per ASTM standards will find out. [5]

Results obtained will be compare to currently used epoxy. However, this is only the beginning stage or primary stage in the direction of final targeted application. To use this resin for aerospace applications, marine or at commercial level for automobiles some more tests must be taken such as tensile test at high temperature and various qualification tests.

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