Polymer Matrix Composite by Vacuum Assisted Resin Transfer Molding

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POLYMER MATRIX COMPOSITE BY VACUUM ASSISTED RESIN TRANSFER MOLDING

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ABSTRACT

In general, composite manufacturing processes have more variations compared to the metal manufacturing processes due to the larger raw material and manufacturing processes variations. Vacuum-assisted resin transfer molding (VARTM), one of a commonly used composite manufacturing processes, is becoming more popular due to its low cost tooling and environmental friendly operating conditions. Currently, most commercial products manufactured by VARTM are developed based on the user's experience and involve repeated experiments.

***KEYWORDS**-Vacuum Assisted Resin Transfer Molding, composites, carbon fibers, epoxy resin, polyamides.*

1. INTRODUCTION-Composites are one of the most widely used materials because of their adaptabilityto different situationsandtherelativeeaseofcombinationwithothermaterialstoservespecificpurposes and exhibit desirable properties.

Too much advancement in the technology of engineering materials, especially fiber-reinforcedpolymercompositeshasbeen achievedinthepastdecades.Scientists andresearchersarecontinuouslysearchingfornewmethodsformakingproductswith low density, high strength, and high stiffness to weight ratio, excellent durability, and design flexibility.Inmanyfields,such as aircraft, automotive, marine, and other industriesthat needmanystructuralcomponents, compositematerials haveattractedagreatdealof attentions[2, 3]. Two types of manufacturing techniques, open-moldingandclosed-molding, are typically employed to make composites. Open-molding is a relatively simplemanufacturingmethod.However, duringtheopen-moldingprocess,hazardousair pollutantsmaybeemitted.Theclosed-moldingtechniqueisbecomingmorepopulardue toitslowhazardousemissions.

Among all the closed-molding techniques, vacuum assisted resin transfer molding (VARTM)processeshaveseveraladvantagescomparedtoitsrelative—resintransfer molding(RTM):(1)theexactfitofthevacuumbagtothepreformdrasticallyreduces resinrichareasand(2)lowinjectionpressure(Maximum 14.7psi)isrequired.Thelow injectionpressureallowsfortheuseoflow costtoolingduringprocessing.The filling processoftheliquidresinisgovernedbyse veralfactors,suchas injectiongate/vent design, temperature and material properties. These factors are key to achieving good part quality. Designing optimal RTM/VARTM processes inter field

ms of minimizing cycle time avoiding dry spots and increasing they ie ld of successful parts have been done in this

2. EXISTING TECHNIQUES- Types of Composite fabrication Methods:

- Wet Lay-up/Hand Lay-up
- Filament Winding
- Pultrusion
- Resin Film Infusion (RFI)
- Spray Lay-up
- Resin Transfer Moulding (RTM)
- Seemann Composites Resin Infusion Moulding Process (SCRIMP)
- Vacuum Assisted Resin Transfer Moulding (VARTM)

3. DESCRIPTION OF VARTM TECHNIQUE- The VARTM process back to 1989 when the process was used as a lower cost alternative to autoclaving. Ever since a version of VARTM has been patented by Seeman Composites, whose process came to be called as Seeman Composite Resin Infusion Molding Process (SCRIMP), the composite manufacturing industry has tried hard to incorporate this version of VARTM process for the manufacture of a variety of composite structures. SCRIMP differed from traditional VARTM in that it made use of a distribution medium, which enabled the vacuum within the mold to be used to draw resin into the mold cavity and wet the fibers. SCRIMP was the first process that enabled the use of a distribution media thus saving labor, time and producing better quality of the parts [4].

The VARTM process began as a low cost process, which was primarily catered to the marine industry. Over the years, VARTM has been considered as an efficient manufacturing process. In keeping with this trend of utilizing low cost manufacturing methods for high quality parts. According to the figure, the marine industry has been using traditional manufacturing techniques like VARTM that is low cost and not very high quality. But, the aerospace industry requires higher quality parts, which require higher temperature and pressures to process that results in increasing the cost of producing the part. In the last few years, the combining of these technologies have occurred due to considerable progress made in the development of newer materials for the processes, like the resin systems which previously needed high temperature and pressure to cure thereby increasing the cost. As a result of this merging, VARTM is increasingly being used or experimented with, in the aerospace industry.

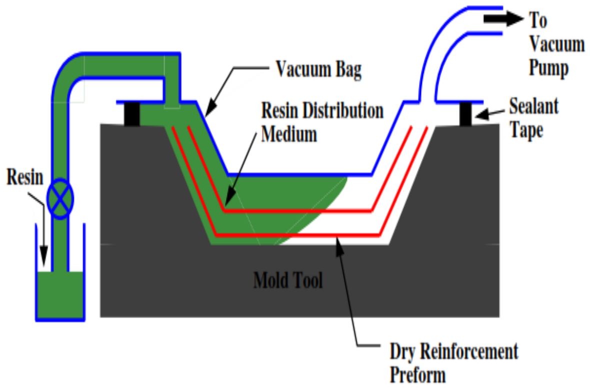

Figure 1-VARTM process

Advantages of VARTM Technique-

-Voids 0-2%

- Time-saving and cost-effective

-Less post fabrication work (Peel ply removal and surface finishing)

-Good surface detail and accuracy

-Can mold in fittings, hardware and foam cores

-Less wasted material

4. RESULTS AND DISCUSSIONS-

BULK DENSITY OF THE DEVELPOED POLYMER MATRIX COMPOSITE

The bulk density (weight/volume) of the developed composite was measured according the ASTM standards, the dimensions of the sample were measured by digital vernier caliper for volume and the weight is measured by digital balance.

The bulk density of the sample developed by VARTM with epoxy resin and carbon fiber was found 1.236 gm/cm^3, However, sample prepared hand lay-up or manually with polyester resin have the density 1.109 gm/cm^3 which shows that the density of the composite developed by VARTM is higher than the composite prepared manually which means the resin impregnation of the VARTM is better than the other methods or conventional resin transfer methods. For the comparison of density of different samples prepared by different curing methods, as given table no.1.

Table 1 Bulk Density comparison table

S. N.	Name of the sample and preparing method	Density (gm/cm^3)
1.	Composite of epoxy +carbon fiber by VARTM cured at hydraulic press	1.236
2.	Composite of epoxy +carbon fiber prepared manually cured at hydraulic press	1.206
3.	Composite of polyester +carbon fiber by VARTM cured at hydraulic press	1.185
4.	Composite of polyester +carbon fiber prepared manually(hand lay-up) cured at hydraulic press	1.109

COMPARISON OF MICROSTRUCTURE BY OPTICAL MICROSCOPE OF THE COMPOSITE DEVELOPED BY VARTM AND PREPARED MANUALLY (HAND LAY-UP METHOD)-

In this study the microstructure of the polymer composite developed by VARTM and manual (Hand lay-up) compression moulding methods compared. These images of both type of composite were taken by the Carl Zeiss microscope at 10 ×magnification .The images of the composite prepared by VARTM are shown in fig 2.

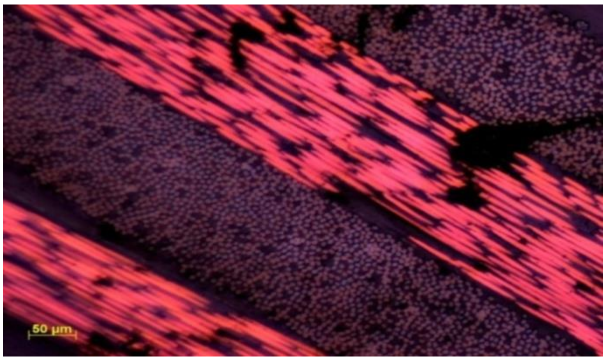

Fig. 2 optical image of the sample prepared by VARTM

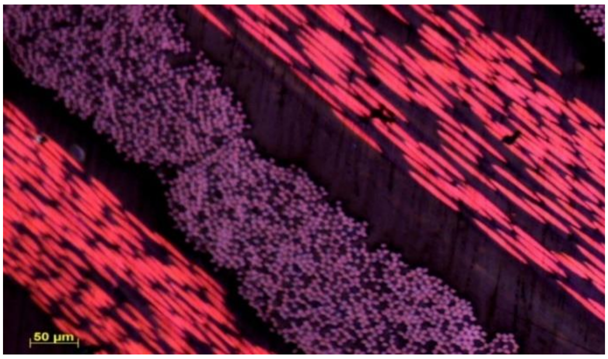

Fig. 3 Optical image of the sample prepared by Hand lay-up method

However, in case of composite prepared by hand lay–up method, there is a lot of difference in microstructure. Fig. 3, the fiber and matrix are not uniformly distributed. There is gap between parallel and 90^0 orientation in the composite. This is due to air which entrap between the film layer, in which resin in filled but no compaction. Figure shows that the matrix and fibers are uniformly distributed in composite. Also from fig 3, it is clear that there are number of voids are developed due to uneven distribution of fiber and matrix.

5. CONCLUSIONS:

1. In the present work efforts are made to develop the vacuum assisted resin transfer moulding process for the preparation of defect and void free polymer matrix composites.
2. The bulk density and mechanical properties of polymer matrix composites compared made from hand lay-up technique and vacuum assisted resin transfer moulding technique.
3. Bulk density of carbon fiber composites made by VARTM is higher as compared to hand lay-up method.
4. It is just the preliminary approach to develop the vacuum assisted resin transfer bagging process.
5. Once, it was successful in vacuum assisted resin transfer bagging process. Further the vacuum assisted resin transfer moulding process will be developed for the fabrication of composite.

REFERENCES:

[1]Info.lu.farmingelle.edu/depts./met205/composites.

[2]P.K.Mallick,Fiber-Reinforced Composites: Materials, Manufacturing, and Design, MarcelDekker,Inc.1993.

[3]T.G.Gutowski,*Advanced Composite Manufacturing*, John Wiley&Sons, 1997.

[4]www.ncat.edu/~sasmith/C2.pdf