

COMPOSITE REPAIR USING VARTM TECHNIQUES

Ronald Sterkenburg and Peng Hao Wang

Department of Aviation Technology, Purdue University, West Lafayette, IN 47906, USA.

Introduction

Student researchers and faculty of the Aviation Department at Purdue University developed a structural repair technique that utilized a VaRTM impregnation method that could be used to repair carbon fiber or fiberglass honeycomb or solid laminate structures [1]. Four different applications of the VaRTM repair method were discussed that are easy to accomplish when the technician mastered the basic VaRTM process. The first application (figure 1) directly applied the repair patch to the airframe structure and the patch is impregnated and cured on the aircraft at room temperature or elevated temperature using oven, heater blanket, or lamps. This is the preferred method for thin skin honeycomb structure.

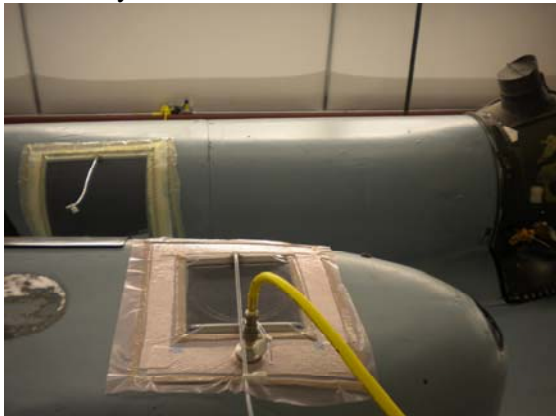


Fig. 1 Direct application of VaRTM on airframe.

The second application (figure 2) was used to prepare a patch using the aircraft structure as a mold, this method is used if secondary bonding or bolting is required or preferred. The third application (figure 3) is to prepare a “splash tool”, traditionally splash tools are made with plaster and the VaRTM method is a direct replacement, which is easier to accomplish and results in a better tool surface. The fourth application is to prepare a debulked B staged laminate that can be used to repair structural beams, stringers, and frames.

Technicians only have to learn one method of repair and four different objectives can be accomplished.



Fig. 2 Patch preparation for secondary bonding or bolting application.

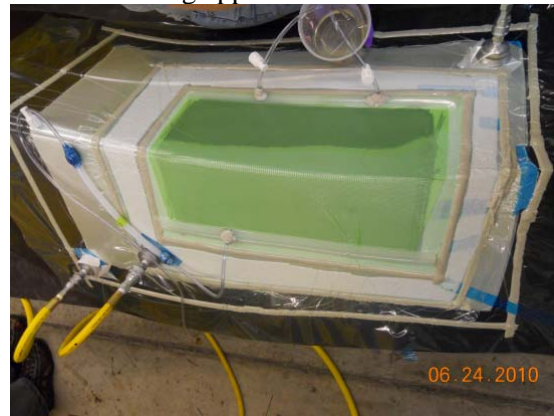


Fig. 3 “Splash” Mold preparation using VaRTM.

Approach

The basic VaRTM impregnation technique that has been used extensively in the ship building industry to build fiberglass boat hulls for decades [2]. More recently it has also been used to manufacture larger aerospace structures because VaRTM is a more economical process than the autoclave process which has been the quality standard for many years. The restriction of VaRTM for aero structures has been the higher void content, although new VaRTM

techniques have reduced the void content to below 2% [3]. A few modifications were made to the basic process to improve volume fraction, consolidation, control of flow front, and improved surface finish. A new custom made resin delivery system and resin transfer materials were developed to impregnate the repair patch. The following information is a short description of the repair process for application 1, the instructions for application 2, 3, and 4 are similar with minor alterations.

Table 1 VaRTM Repair Instructions

Step	Description
1	Investigate the damage, mark off the affected area, and remove moisture.
2	Remove damaged honeycomb core material and install new core.
3	Prepare the aircraft surface for bonding.
4	Install titanium sealing patch over new core.
5	Cut the repair plies to the desired size and tackify the plies together in the correct ply orientation. Tackify the scrim to the bottom of the patch.
6	Apply peel ply and transfer medium.
7	Apply delivery system and double seal vacuum bag.
8	Impregnate the patch using VaRTM.
9	Cure the patch: room temperature or elevated temperature with a heating blanket.
10	Prepare patch for painting and apply paint system.

Results

The structural repair patch was successfully installed on a helicopter fuselage using the first application method. A panel shear test apparatus was developed to perform a shear test of a 21 x 21 inch honeycomb panel to validate the repair strength of the repair patch. The test results indicated that the panels that were repaired with VaRTM first application process were stronger than the original test panels. A photomicrographic method was performed to determine the void content of the VaRTM technique and to estimate the fiber volume

fraction. The photo indicated an acceptable void content.

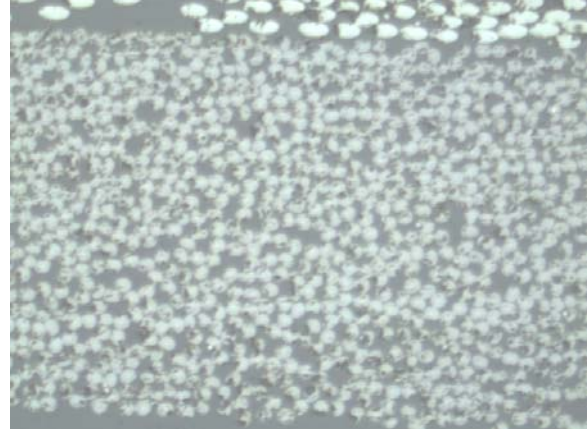


Fig. 4 Photomicrography of VaRTM sample.

Conclusions

The VaRTM process for the repair of structural damage is a rugged and proven repair concept that requires minimum skill level and repair equipment. One VaRTM process can be used to accomplish four different repair techniques.

References

1. Wang, P. H., Sterkenburg, R., Rahm, B. J. & Dubikovsky, S. (2010). An Innovative repair method for composite aircraft using VaRTM techniques. *ATEC Journal*, 33, 11-15.
2. Wang, P. H., Sterkenburg, R., Buland, E. M., & Dubikovsky, S. (2010). *Assessing the effectiveness of UVcured VaRTM repairs for composite aircraft*. Proceedings of the 7th Asian-Australasian Conference on composite materials, Taipei, Taiwan.
3. Sterkenburg, R., Rahm, B. J., & Dubikovsky, S. (2010). *A titanium and carbon fiber hybrid repair patch using vacuum assisted resin transfer molding*. Proceedings of the 2010 SAMPE technical conference, Seattle, Washington.