Vacuum Assisted Resin Transfer Moulding (VARTM) based Modelling and Testing to predict the bending performance omega beams

Rahul Venkatesan[1] and Rafath Abdul Nasser[2]

[1, 2] Research Students, Department of Aerospace Engineering and Khalifa University, Abu Dhabi, UAE

Keywords: (OOA): Out of Autoclave FEA: Finite Element Analysis CAD: Computer Aided Designing ANSYS: Simulation software CFD: Computational Fluid Dynamics

ABSTRACT

Autoclave techniques and Out-of-autoclave (OOA) techniques drawing researchers interests due to the ease of manufacturing composite parts. Hsiao, K. T. et. al. [1] compared the VARTM process and membrane based VARTM process with particular emphasize on the mould filling, cure kinetics and fibre preform compaction, spring in, dry spot and micro void formation. Moreover, the peculiar aspect of membrane based VARTM to allow the gas and impermeable to the resin makes it a unique means to avoid the dry spot formation [1]. Mittelstedt, C. et. al. [2] investigated the closed form buckling analysis of the composite plates braced by omega stingers. The buckling analysis was performed by the interpolation scheme in an analytical manner which was validated by the finite element computations [2]. However, Bayldon, John M. et. al [3] predicted saturation effects using an improved compaction model due to compaction pressure in the partially saturated region. Yoon, Myung-Keun. et. al [4] used an analytical model to predict the gravitational effects to predict the flow and pressure distribution thickness of uniform thickness preforms under vacuum infusion conditions. It was found that the analytical study can be used for design and optimization of VARTM process [4]. Zeng, Xuesen. et. al [5] computationally predicted using finite element simulation to correlated the vacuum assisted resin transfer moulding with the bending performance of the beams. It was found that the bending performance relies on the cohesive contact to model the delamination initiation and propagation [5]. Vacuum assisted resin transfer moulding (VARTM) has attracted the researcher attention in recent years due to its low cost and eco-friendly process with minimum capital investment. The omega beam stiffeners that are extensively used in aerospace structure especially along the fuselage and spar is one of the important load bearing structures. In this project, omega beams are manufactured using vacuum assisted resin transfer moulding and subsequently tested by four point bending test. The four-point bending test of three different omega beams was investigated in this project and results of load v/s displacement was subsequently validated by finite element modelling using a commercial software using ANSYS-Fluent. It was found that the delamination point was observed at different loading conditions at different locations for the three omega beams. This could be attributed to the effect of change in location of load application on the omega beam and the associated flexural rigidity. Finite element analysis in the computational validation also revealed that the omega beams can withstand suitable loads and the delamination point has got direct relation with the load application point of the omega beam. The maximum extension of the beam was also observed to be 30 mm in finite element modelling which is similar to the experimental test. Moreover, aerospace structures namely fuselage can be supported by omega beams which makes the structure withstand shear loads and bending moments provided it is placed in the right location.

Figure 1a and 1b : *Thermoset resin injection and uni-directional flow mesh layup through vacuum pressure*

EXPERIMENTAL VALIDATION

Figure 2a and 2b : *Three point testing experimental setup and point of delamination when specimen fails under loading*

COMPUTATIONAL VALIDATION

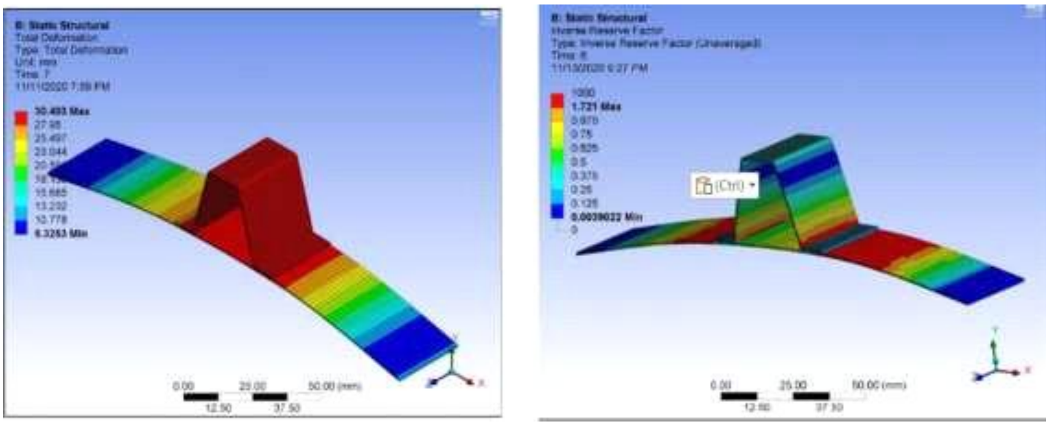

Figure 3a and 3b: *Isometric view of deformation highlighting regions of critical loading*

REFERENCES

1. Hsiao, K.T. and D. Heider, 10 - Vacuum assisted resin transfer molding (VARTM) in polymer matrix composites, in Manufacturing Techniques for Polymer Matrix Composites (PMCs), S.G. Advani and K.-T. Hsiao, Editors. 2012, Woodhead Publishing. p. 310-347.
2. Mittelstedt, C. and M. Beerhorst, Closed-form buckling analysis of compressively loaded composite plates braced by omega-stringers. Composite Structures, 2009. 88: p. 424-435.
3. Bayldon, J.M. and I.M. Daniel, Flow modeling of the VARTM process including progressive saturation effects. Composites Part A: Applied Science and Manufacturing, 2009. 40(8): p. 10441052.
4. Yoon, M.-K., et al., Vacuum Assisted Resin Transfer Molding (VARTM) Process Incorporating Gravitational Effects: A Closed-form Solution. Journal of Composite Materials, 2005. 39(24): p. 2227-2242.
5. Zeng, X., P. Schubel, and J. Lorrillard, Modelling VARTM process induced variations on bending performance of composite Omega beams. Composites Part A: Applied Science and Manufacturing, 2016. 90: p. 371-379.

ACKNOWLEDGEMENTS

The author would like to thank Khalifa University sponsorship to conduct our research in Aerospace Research and Innovative Center (ARIC) the support of lab assistant Mr. Bittu Scakaria and using experimental facilities like cutting machine and three-point bending testing machine in Aerospace Research and Innovative Center (ARIC).